

Perugia, Italy July 2-13, 2007



IAG

**INTERNATIONAL ASSOCIATION OF GEODESY
ASSOCIATION SYMPOSIA AND WORKSHOPS**

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Abbreviations

IAG	International Association of Geodesy
IAGA	International Association of Geomagnetism and Aeronomy
IAHS	International Association of Hydrological Sciences
IAMAS	International Association of Meteorology and Atmospheric Sciences
IAPSO	International Association for the Physical Sciences of the Oceans
IASPEI	International Association of Seismology and Physics of the Earth's Interior
IAVCEI	International Association of Volcanology and Chemistry of the Earth's Interior
CLiC	Climate and Cryosphere
Ev-K2-CNR	Everest-K2 CNR Committee
GEWEX	Global Energy and Water Experiment
HKH-FRIEND	Hindu Kush-Himalayan Flow Regimes from International Experimental and Network Data
IABO	International Association for Biological Oceanography
IACS	International Association of Cryospheric Sciences
ICACGP	International Commission on Atmospheric Chemistry and Global Pollution
ICASVR	International Commission on Atmosphere-Soil-Vegetation Relations
ICCE	International Commission on Continental Erosion
ICCL	International Commission on Climate
ICCLAS	International Commission on the Coupled Land-Atmosphere System
ICCP	International Commission on Clouds and Precipitation
ICDM	International Commission on Dynamic Meteorology
ICGW	International Commission on Groundwater
ICIMOD	International Center for Integrated Mountain Development
ICMA	International Commission on the Middle Atmosphere
ICRS	International Celestial Reference System
ICSIH	International Commission on Snow and Ice Hydrology
ICSW	International Commission on Surface Water
ICT	International Commission on Trac
ICWQ	International Commission on Water Quality
ICWRS	International Commission on Water Resources Systems
IGAC	International Global Atmospheric Chemistry
IGS	International Glaciological Society
ILP	International Lithosphere Program
INQUA	International Union for Quaternary Research
ION	International Ocean Network

IRC	International Radiation Commission
PUB	Prediction in Ungauged Basins
SCAR	Scientific Committee on Antarctic Research
SEDI	Study of the Earth's Deep Interior
SPARC	Stratospheric Processes and their Role in Climate
UCCS	Union Commission for the Cryospheric Sciences
UNESCO	United Nation Educational, Scientific and Cultural Organization
UNITAR	United Nations Institute for Training and Research
WMO	World Meteorological Organization

Session code naming

The first letter of the session codes indicates whether the session is a Union, a Joint Interassociation or a single Association sponsored event, the second letter indicates the type of event: Symposium (S) or Workshop (W). For Joint events, the second letter indicates the Lead Association (with the abbreviations listed below) and the third indicates whether a session is a Symposium (S) or a Workshop (W). In some cases (namely IAGA, IAHS) Association session codes have an extra codification referring to a specific Theme or Division.

U	UNION
J	JOINT
G	IAG
A	IAGA
H	IAHS
M	IAMAS
P	IAPSO
S	IASPEI
V	IAVCEI

Some examples:

US002

is a **Union Symposium**; **JGW001** is a **Joint IAG Workshop** with IAG as the Lead Association;

MS003

is an Association (IAMAS) **Symposium**. **AS III 020** is an Association (IAGA) **Symposium** sponsored by its **III** Division.

GS001**Symposium****(2481 - 2541)****Convener :** Dr. Hermann Drewes**Co-Convener :** Prof. Athanasios Dermanis

Reference Frames

GS002**Symposium****(2542 - 2756)****Convener :** Dr. Pieter Visser, Dr. Urs Marti, Prof. Christopher Jekeli**Co-Convener :** Prof. Shuhei Okubo, Dr. Nico Sneeuw

Gravity Field

GS003**Symposium****(2757 - 2843)****Convener :** Prof. Veronique Dehant**Co-Convener :** Dr. Cheng-Li Huang

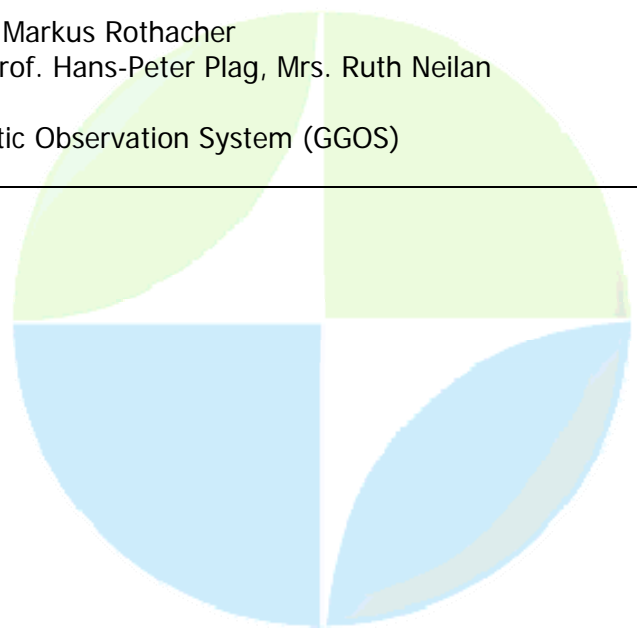
Earth Rotation and Geodynamics

GS004**Symposium****(2844 - 2966)****Convener :** Dr. Sandra Verhagen, Prof. Chris Rizos

Positioning and Applications

GS005**Symposium****(2967 - 2993)****Convener :** Prof. Markus Rothacher**Co-Convener :** Prof. Hans-Peter Plag, Mrs. Ruth Neilan

The Global Geodetic Observation System (GGOS)



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****2481 - 2541****Symposium
Reference Frames****Convener** : Dr. Hermann Drewes**Co-Convener** : Prof. Athanasios Dermanis

The symposium will deal with the subjects covered by IAG Commission 1 and the related services. Establishment, maintenance, improvement of the geodetic reference frames. Advanced terrestrial and space observation technique development . International collaboration for the definition and deployment of networks of terrestrially-based space geodetic observatories. Theory and coordination of astrometric observation for reference frame purposes. All aspects of theory are also included. (See also Symposium GA5.)

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Oral Presentation****2481****A mid-ocean ridge fixed absolute reference frame: Comparison and analysis****Dr. Shuanggen Jin***Astro-Geodynamics Center Shanghai Astronomical Observatory, Chinese Aca.Sci IAG***Jong-Uk Park**

Absolute plate motions represent movements of plates relative to the mesosphere. To describe displacements of the lithosphere, two different absolute frameworks are used, the hotspots and the mean lithosphere. The first is based on the assumption that hotspots are fixed relative to the mesosphere (Morgan, 1972). The second is defined by the no-net-rotation condition (NNR) (Solomon and Sleep, 1974). However, both absolute reference frames are referred to the mesosphere and furthermore not strictly absolute with some deficiencies. Therefore, it requires a new absolute reference frame. As the mid-ocean ridge is symmetrically spreading, the mid-ocean ridge may be fixed relative to the mesosphere. In this paper, we develop new absolute models of plate motion relative to the three main mid-ocean ridges using the ITRF2000 velocity field: the east Pacific Ridge fixed PRF-ITRF2000VEL model, the Southern mid-Atlantic ridge fixed SRF-ITRF2000VEL model and the Northern mid-Atlantic ridge fixed NRF-ITRF2000VEL model. Analyzing and comparing these absolute motion models, it has been shown that the east Pacific and mid-Atlantic ridges are spreading at the average 10.9 mm/yr rate, indicating that these mid-ocean ridges are still relatively moving.

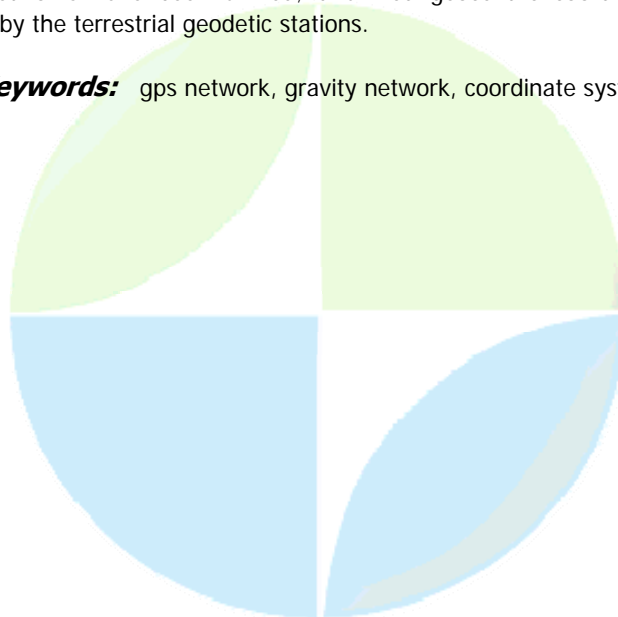
Keywords: absolute plate motion, mid ocean ridge, itrf2000vel

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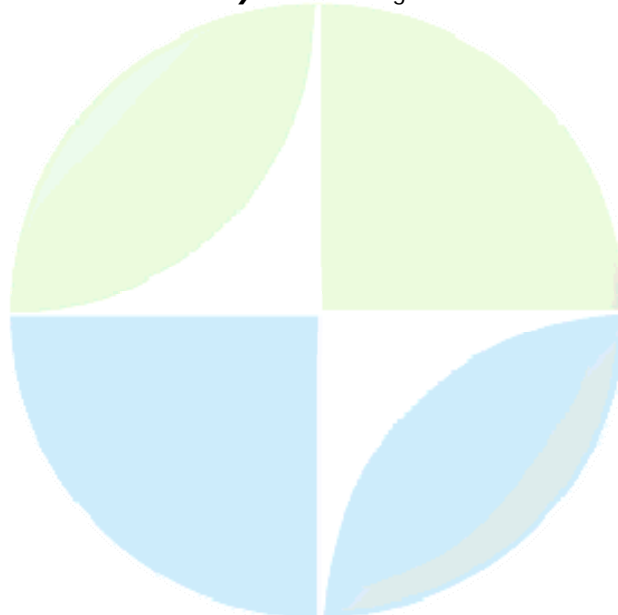
(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Oral Presentation****2482****Chinese geodetic control network 2000*****Prof. Yuanxi Yang****Geodesy and Navigation Xi'an Research Institute of Surveying and Mapping IAG****Junyong Chen, Min Wang, Yanping Zhang, Yingzhe Tang, Hui Li, Pengfei Cheng,
Fenghua Sun, Peng Zhang, Chunxi Guo***

2000 national geodetic control network of China is a national fundamental geodetic project which contains mainly (1) establishment of an accurately GPS control network; (2) establishment of an accurately national gravity control network; and (3) combined adjustment of the national astronomical-geodetic control network and GPS network. In the establishment of the national GPS network, 3 rotational and 1 scale parameters based on the IGS station coordinates, are introduced to absorb the systematic errors and datum errors among the different observation sessions and different GPS networks; the variance component estimation is applied to compensate the stochastic model errors; and the robust estimation method for correlated baselines is employed to resist the influences of outliers on the adjusted coordinates. In this way the estimated coordinates and the evaluated variance components are less affected by the systematic errors and/or the outliers. The new established national gravity control network firstly covers the parts of the southern Chinese sea, Hong Kong and Macao, strengthens the density of the gravity control points of the west and north-west parts of China, and unifies the different gravity measurement networks. Some additional parameters are introduced in the functional model to compensate for the systematic errors and datum errors of different gravimeters and different gravity networks. The robust estimation method is also applied in the adjustment of the national gravity network. In the combined adjustment of national astronomical-geodetic control network and 2000 GPS network, the astronomical and geodetic measurements more than 50 years have been collected and fused based on the established geocentric coordinate datum, nearly 50000 station coordinates are obtained in the new geodetic system. By using the personal computer, more than 200000 unknown parameters and more than 500000 measurements are successfully solved within one hour. The optimal weight ratios are obtained by applying the regret variance component estimation in the super scale geodetic networks. As the results, the 2000 National GPS Control Network with the accuracy of 3cm and 2000 National Gravity Control Network with the accuracy of are established; the astronomical-geodetic networks and GPS networks have been unified; a unified geocentric coordinate system has been realized and densified by the terrestrial geodetic stations.

Keywords: gps network, gravity network, coordinate system

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Oral Presentation****2483****Recent achievements of SIRGAS Working Group I*****Dr. Claudio Brunini****Facultad de Ciencias Astronómicas y Geofísicas Universidad Nacional de La Plata IAG*

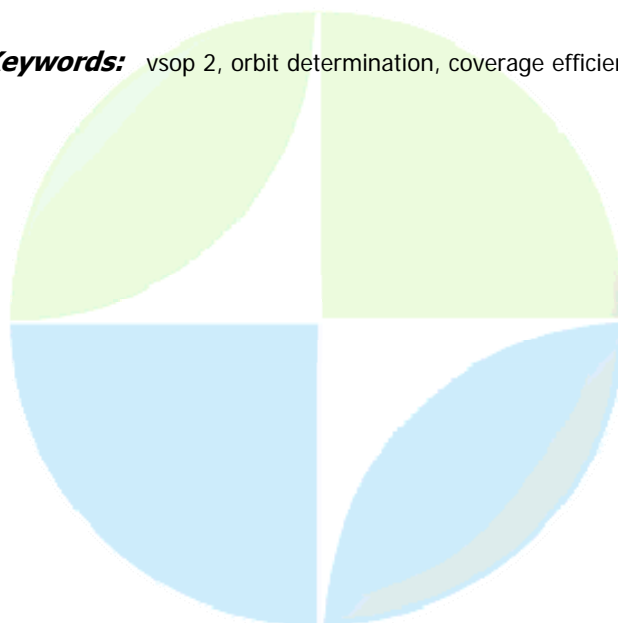
An accurately realized and consistently maintained terrestrial reference frame (TRF) is necessary for many studies devoted to understand the complex Earth system. In order to fulfill these requirements, the International Association of Geodesy promotes, through its Commission 1, a worldwide effort that involves many groups and institutions all over the world. In this context, the SIRGAS (Sistema de Referencia Geocéntrico para las Américas) has been working, since 1992, for the definition, realization and maintenance of the TRF in the Latin-American countries. SIRGAS activities are coordinated by three Working Groups (WG): WG-I is intended to realize and maintain a continental reference frame according to the uppermost geodetic standards; WG-II mandate consists to make the frame easily available to the users by means of national densifications; and WG-III is responsible for the definition and realization of the vertical reference frame for the continent. WG-I commitments have been initially accomplished by means of two continental-wide campaigns performed with GPS in 1995 and 2000. In the meanwhile, a network of continuously observing GPS receivers has been deployed in the continent and an IGS Regional Network Associated Analysis Center for SIRGAS was established under the responsibility of the Deutsches Geodätisches Forschungsinstitut. Nowadays, WG-I is driving a process aimed to: i) build up the capacity to cope with modern geodetic systems in Latin American countries; and ii) extend the usefulness of the observational infrastructure of SIRGAS beyond reference frame maintenance. To accomplish the first objective, experimental analysis centers have been installed in the Instituto Nacional de Estadística, Geografía e Informática (Mexico); the Instituto Geográfico Agustín Codazzi (Colombia); the Instituto Brasileiro de Geografia e Estatística (Brazil); the Instituto Geográfico Militar (Argentina); and the Universidad Nacional de La Plata (Argentina). To fulfill the second objective, an experimental service to compute and deliver hourly ionospheric maps for SIRGAS has been installed in the last institution previously mentioned. This contribution summarizes the current status both WG-I initiatives. Almost one year of results from the experimental analysis centers are presented and discussed including both, network computation and Ionospheric maps.

Keywords: sirgas

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Oral Presentation****2484****On the Possibilities of Geodetic Study with VSOP-2****Dr. Erhu Wei***Spacial geodesy Satellite application IAG****Liu Jing-Nan, Kulkarni Madhav. N, Li Zhenghang, Shi Chuang***

Space Very Long Baseline Interferometry (SVLBI) is primarily a radio astronomical technique, which extends conventional VLBI baselines into the space. Its potential applications in global geodesy include interconnection of celestial and terrestrial reference frames, and orbit determination using the delay and delay rate observables. With the launch of the first SVLBI satellite HALCA of the VLBI Space Observatory Programme (VSOP), Japan, this technique has been realized. The Geodesy Demonstration Experiment (GEDEX) is designed to explore the feasibility of the geodetic applications of SVLBI. The VSOP project is designed for astrophysical research, and its physical characteristics and orbit characteristics do not fit for geodetic and geodynamical studies, which require a satellite with a regular shape, smaller area/mass ratio, a longer lifetime, and the precision of orbit determination should reach the level of survey (better than a few cm). But the shape of HALCA is quite irregular, its Area/mass ratio is bigger, the precision of orbit determination is within 10 meters (Frey et al. 2002), and its operational lifetime was about 5 years. HALCA does not fit for frequently changing observing objects. So it cannot provide observations aiming at more radio sources, which are required for geodetic and geodynamical studies. Therefore a new SVLBI satellite system should be found for geodetic and geodynamical studies. Following the success of the VSOP, a next generation space VLBI mission, currently called VSOP-2, is being planned in Japan with international collaboration for a launch as early as late 2011 and lifetime of at least 5 years. For VSOP-2, higher observing frequencies, cooled receivers, increased bandwidths and a larger telescope diameter will result in gains in resolution and sensitivity by factors of 10 over the VSOP mission. The possibility of including a rapid slewing capability for the spacecraft is also being pursued, so that observations using the phase-referencing technique will enable the sensitivity to be improved even further. The result of GEDEX indicates that the orbit determination precision of space VLBI satellite is one of the main problems for geodetic study, therefore this investigation studies several technologies which possibly will be able to determine the orbit of VSOP-2 satellite, and the results are presented. The efficiency of tracking VSOP-2 by VSOPs telemetry stations and networks is studied, and the results are presented.

Keywords: vsop 2, orbit determination, coverage efficiency



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Oral Presentation****2485****Extension of ITRF2005 for Precise Orbit Determination (DPOD2005, LPOD2005), Realization and validation*****Dr. Pascal Willis****Direction Technique Institut Geographique National IAG****J.C. Ries, F.G. Lemoine, E.C. Pavlis, L. Soudarin, N. Zelenski***

Recently, the new ITRF2005 solution was released by the IERS, providing updated station coordinates for many of the GPS, SLR, DORIS and VLBI tracking stations. However, this set of coordinates is not complete; several new tracking stations were not included, some velocity determinations can be improved using more recent tracking data or collocation information with GPS, and some sites had insufficient data to reliably determine both position and velocity. For precision orbit determination applications, particularly for the various altimeter satellites, a complete set of usable station coordinates is required. Following a similar study (DPOD2000) done for DORIS with ITRF2000, we propose here new coordinates data sets for DORIS (DPOD2005) and Laser tracking stations (LPOD2005), both being consistent with ITRF2005. In a first step, we show a limited numbers of cases for which positions or velocities in ITRF2005 should not be used directly for POD applications. We also propose a list of tracking periods for which data should not be used for POD purposes. We also propose additional or updated station positions and velocities consistent with ITRF2005 for all tracking stations that were not included in the original ITRF2005 computation. Finally, we test several reference frames for precise orbit determination: original ITRF2005, extension of ITRF2005 (this study), as well as some individual DORIS and SLR realizations. Results will be shown in terms of technique residuals, orbit overlaps, orbit centering, altimeter crossovers,..

Keywords: terrestrial reference frame, doris, laser

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Oral Presentation****2486****The continuation of height anomalies into masses revisited****Mr. Daniele Sampietro***Polo Regionale di Como Politecnico di Milano***Fernando Sans**

This paper suggests a new more rigorous method than the one present in literature, to convert height anomalies into geoid undulations. First of all the classical process, represented by the usual N-Z term depending on elevation and on Bouguer anomaly is discussed: particularly the assumptions adopted in this reasoning are carefully described. We present then a slightly more accurate approach. This second method has been tested on real data in Italy and even if the magnitude of N-Z reaches up to 1.66 m. in the Italian Alps with smaller, but still significant, values in other regions, the differences between the new method and the classical one vary from about thirty centimeters in mountainous areas to few millimeters in other regions. Also included is a more rigorous than the traditional way, to continue gravity into masses and hence to compute the integral mean gravity along the plumbline.

Keywords: height anomalies, geoid, downward continuation

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Oral Presentation****2487****Reprocessing a Regional GPS network in EUROPE*****Dr. Christof Voelksen****Bavarian Academy of Sciences and Humanities BEK IAG*

The Bavarian Committee for International Geodesy (BEK) has been a Local Analysis Centre (LAC) for the EUREF Permanent Network (EPN) since 1995. The analysed network covers the northern part of the Mediterranean region, where several tectonic features can be found. During the past 10 years of analyzing GPS data the processing strategies, the realisations of the global reference system and models for correcting different physical effects have been improved and changed. All these modifications had a significant impact on the coordinate estimation over the past years. It is therefore not surprising that time series of coordinate changes always reveal such modifications and may hide tectonic events. A group from the TU Munich, TU Dresden and the GFZ Potsdam took an effort to reprocess a global GPS network to derive consistent coordinates of stations as well as orbits and EOP's in the in the IGB00 applying absolute PCV for the antennae. The reprocessed orbits and EOP's had been made available to the BEK. Based on these products a network of roughly 65 sites has been reprocessed for period of 8 years. The presentation will focus on the improvement achieved by applying consistent products, strategies and models.

Keywords: gps, reprocessing, euref

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(G) - IAGA - International Association of Geomagnetism and Aeronomy

GS001

Oral Presentation

2488

Determination of a Global Reference Frame Based on a Reprocessed GPS Network

Mr. Mathias Fritsche

Institut für Planetare Geodäsie, TU Dresden IPG

Axel Rike, Reinhard Dietrich, Markus Rothacher, Peter Steigenberger

The International Terrestrial Reference Frame (ITRF) is intended to be a realization of the International Terrestrial Reference System (ITRS). As a contribution to an ITRS realization TU Dresden and TU Munich/GFZ Potsdam reprocessed a global GPS network of more than 200 stations covering the time span from January 1994 to December 2005 in a joint effort. A global GPS-only reference frame is determined as an important product of the reprocessing using a rigorous combination of daily normal equations. Our concept of the realization of the global terrestrial reference system follows the center of mass approach in consideration of seasonally changing surface loads. The stability of our reference frame will be evaluated based on the obtained long-term trends of station coordinates, load-induced deformation estimates and homogeneous time series of station positions. The geophysical implications of these results will be addressed. Finally, we will compare our solution with other recent terrestrial reference system realizations.

Keywords: gps



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Oral Presentation****2489****Satellite Laser Ranging biases and Terrestrial Reference Frame scale factor****Dr. David Coulot**
LAREG IGN***Philippe Berio, Dominique Fraudy, Olivier Laurain, Pierre Exertier***

The Satellite Laser Ranging (SLR) technique plays an important role in the International Terrestrial Reference Frame (ITRF) computation. Indeed, until the last ITRF realization (ITRF2005), this space-geodetic technique provided the origin (geocenter) and the scale factor (with the VLBI technique) of this reference frame. Due to the piecewise behaviour of the scale factor time series computed from the International Laser Ranging Service (ILRS) official combined solution, SLR just provided the origin of ITRF2005: the scale was only provided by VLBI. As SLR produces the most accurate estimations of the fundamental gravitational constant GM, it should produce a stable scale factor. Although SLR is not as much limited by atmospheric propagation as GPS, DORIS and VLBI are, its range biases can induce inaccuracies on the station vertical component time series and, consequently, on TRF scale factor. In this paper, we demonstrate that SLR biases must be estimated during any data processing. We also present a rigorous method to compute these biases. Finally, we show that computing range biases really improves the SLR TRF scale factor estimations.

Keywords: terrestrial scale factor, satellite laser ranging, range biases

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(G) - IAGA - International Association of Geomagnetism and Aeronomy

GS001

Oral Presentation

2490

The International Terrestrial Reference Frame (ITRF): Past, Present and Future

Dr. Zuheir Altamimi

Laboratoire de Recherche en Géodésie Institut Géographique National IAG

The almost 2 decades history of the continuous progress and improvement of the establishment of the International Terrestrial Reference Frame (ITRF) is reviewed. The contribution of the four space geodesy techniques (VLBI, SLR, GPS, DORIS) to the ITRF will be discussed in terms of their network geometry, datum definition, systematic errors and the quality of their solutions. The advantages of time series of station positions and Earth Orientation Parameters as input to the ITRF elaboration, starting with the ITRF2005, will be emphasized. The future development of the ITRF in the framework of the IAG Global Geodetic Observing System (GGOS) will be addressed in terms of positioning performance taking into account the future user requirement that is believed to be 1 cm positioning accuracy anywhere anytime.

Keywords: reference system, reference frame, itrf

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I T A L Y



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Oral Presentation****2491****Non-polar variations of latitudes and their mechanism****Prof. Yury Barkin***Laboratory of Gravimetry Sternberg Astronomical Institute IAG*

The new astrometry phenomenon - displacements of latitudinal circles (connected with its spherical surface) caused by deformations of the Earth surface. This phenomenon is a dynamical consequence of the small relative polar motions of the core relatively to the mantle of the Earth. The phenomenon of translation of latitudinal circles (in parallel plane) of the corresponding parallels with simultaneous change of their radius is characterized directly by polar (and not only polar) displacements of the centre of mass of the Earth (Barkin, 2002). This phenomenon is expressed in the definite variations of angular distances of latitudinal circles from the unperturbed position of equator circle. The dynamic research of deformations of a surface of the Earth due to relative displacement of the core and the mantle of the Earth (Barkin, 2002; Barkin, Shatina, 2005) and the data of satellite observations (Blewitt et al., 2001) has shown that the latitude Q of latitudinal circle (relatively to its unperturbed position on the sphere of the Earth) varies under the law $dQ = [26.7 t + 44.3 \cos(V) + 10.0 \cos(W)] \cos Q$, where amplitudes are given in micro seconds of arc (Ms), velocity of trend is given in Ms/yr, the time t is measured in years (from the beginning of year), and arguments V and W are measured in degrees and calculated under formulas $V = 360 t - 56$ and $W = 720 t - 207$. Thus, angular distances between any two latitudinal circles on surfaces of the Earth vary cyclically with annual, semi-annual, and generally and with other periods, and test secular drift (Barkin, 2005). Figuratively speaking the original phenomenon of "wrinkling of the Earth surface" is a process of cyclic changes of its "mimicry" and "general sading". The trend of latitudinal circles occurs on a direction of the core trend (in considered model to the North Pole). The velocity of trend is proportional to the sine of latitude. The equator circle tests maximal annual displacement (in March it is displaced on 44.3 Ms to the North, and in August - September on as much to the South). At Moscow latitude the similar displacement are characterized by amplitude 24.4 Ms. Quantitative evaluations of variations of angular distances between any two from latitudinal circles and linear distances between two stations of observations, including located on one meridian have been obtained. So between the stations located at latitudes (degrees) 30 and 90 in northern hemisphere the length of the base line tests the annual oscillation with amplitude of 3.4 mm and small trend with velocity 2.1 mm/yr. The data of the spectral analysis of temporal series of coordinates of geocenter on DORIS observations (Tatevian et al., 2004) specify existence of other cyclicities in variations of latitudinal circles. On the basis of developed geodynamic model (Barkin, 2002) we obtain that other possible variations of latitudes of latitudinal circles with significant amplitudes can be observed: with amplitude 74 Ms (with period about 2.1-2.3 yr); 70 Ms (3.6-3.8 yr); 103 Ms (the period of 7.5-8.0 yr); 70 Ms (471 days); 65 Ms (1.6 yr); 50 Ms (the period 6.9 days). References Barkin, Yu.V. (2002) Explanation of endogenous activity of planets and satellites and its cyclicity. *Izvestia cekzii nauk o Zemle. Rus. Acad. of Nat. Sciences*, Issue 9, December 2002, M.: VINITI, pp. 45-97. In Russian. Barkin, Yu.V., Shatina A.V. (2005) Deformation of the Earth's mantle due to core displacements. *Astronomical and Astrophysical Transactions*, v. 24, No. 3, June 2005, pp. 195-213. Blewitt G., Lavallee D., Clarke P., Nurutdinov K. (2001) New global mode of Earth deformation: seasonal cycle detected. *Science*, V. 294. pp. 2342-2345. Tatevian S.K., Kuzin S.P., Kaftan V.I. (2004) Comparison of geocenter variations derived from GPS and DORIS data. Report of EGU (25-30 April 2004, Nice, France).

Keywords: latitudes, variations, non polar

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Oral Presentation****2492****The relationship of the AHD to a Global Geoid****Dr. Arthur H W Kearsley***Surveying & SIS University of NSW, Sydney, Australia IAG***Ramesh Govind, Geoff Luton**

The IAG ICP1.2 workshop in April 2006 proposed a resolution to the IAG General Assembly to define the geopotential of the geoid (W_0) directly by observation. This proposal has yet to be accepted by the international community, but it has much merit, as one of the drawbacks of the current definition is the difficulty in physically locating the global geoid in Earth space. This paper uses the concept proposed above to find the relationship between this W_0 and the Australian Height Datum, the surface which used historically as the reference for heights in . We find the shift from the current geoid to that proposed to be about 0.5 m. We also estimate the effect this shift has upon both the (i) globally defined geoid and (ii) the locally defined geoid, since the heights of the gravity stations in the Australian context relate to AHD, so any change in their datum maps into the local geoid heights. In (i) the global bias introduced into the geoid heights by the change in W_0 systematically is about 5 mm, while in (ii) the impact of such datum change is local (because of the distortions in the AHD wrt an equipotential surface), and ranges between +/- 10 mm.

Keywords: w_0 , globalgeoid, ahd

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I T A L Y



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Oral Presentation****2493****On the strengths of SLR observations to realize the scale and origin of the terrestrial reference system*****Dr. Detlef Angermann****Deutsches Geodtisches Forschungsinstitut Mnchen DGF I AG****Horst Miller***

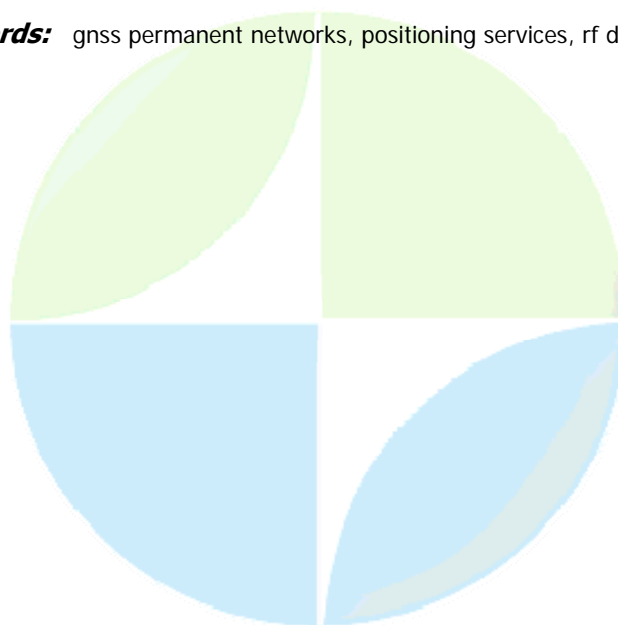
SLR observations provide a direct and unambiguous measurement of the distance between space objects and terrestrial ground stations. The optical laser ranging observations are also less affected by atmospheric effects than microwave techniques (e.g., GPS, VLBI, DORIS). Thanks to these characteristics combined with the high quality of the solutions for the orbits of the satellites, SLR is in the unique position to provide a highly accurate realization of the origin and the scale of the terrestrial reference system. However, SLR suffers from a relatively sparse distribution of tracking stations in particular on the Southern hemisphere and also from several changes in the network constellation. We have computed various SLR solutions with different network constellations and time periods to investigate the effect on the estimations for the scale and the origin. The SLR solutions can be also affected by technical problems of the laser ranging systems, which may require the estimation of station- and time-dependent range biases. It was recently found that for a number of SLR stations (that have used the Stanford event timer), corrections in the order of several millimeters up to 2 cm have to be applied to the range observations. We have reprocessed all SLR data (back to 1993) by applying the Stanford counter corrections according to the ILRS table to investigate their effect on the SLR solutions, in particular for the scale and origin. Finally we have compared the results of the different SLR solutions with the ITRF2005.

Keywords: slr, origin, scale

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Oral Presentation****2494****A zero order network of permanent GNSS stations for the positioning services in Italy: some hypotheses and tests*****Dr. Ludovico Biagi****DIAR Politecnico di Milano IAG****Stefano Caldera, Mattia Crespi, Ambrogio Maria Manzino, Augusto Mazzoni, Marco Roggero, Fernando Sans***

In these years, GNSS permanent networks finalized to real time and post processing positioning services are under development in Italy; for administrative reasons, the permanent networks are projected, created and managed at a local scale, corresponding to Italian Regions; at present less than 10 (over 20 regions) are already operating and distributing data to the user community. A permanent network materializes and distributes a reference frame to the user community; as already stated in previous papers, in order to guarantee that the local neighbouring permanent networks distribute consistent reference frames, they should share a common infrastructure, i.e. they should be adjusted and monitored in a common zero order permanent network, by following a common set of adjustment rules. From a theoretical point of view, the global IGS network and the IGS adjustment guidelines constitute the natural shared infrastructure; however, from a practical point of view, the IGS permanent stations cannot constitute the shared zero order network because they are not homogeneously distributed in Italy; moreover IGS has not the scope of monitoring local subnetworks, while the zero order network should also provide a sort of governing board for the local networks. Actually, the natural choice is to establish a zero order permanent network at a national scale; this network should be adjusted and monitored in the global IGS network in order to provide the link between it and the local networks; moreover the zero order network is the needed frame to check the consistency between local neighbouring networks. In order to fulfil these scopes, the zero order network should satisfy several scientific and technical requirements, from the network design to the network monitoring choices. The present paper focuses on these topics: the Italian situation is analysed and a numerical test is presented. In this, a set of about 60 permanent stations has been chosen according to a good design criterion and their data for a two months period have been analyzed; the underlying models have been discussed and validated.

Keywords: gnss permanent networks, positioning services, rf distribution



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Oral Presentation****2495****Toward consistent weekly determinations of Earth Orientation Parameters and station coordinates*****Dr. Daniel Gambis****SYRTE Observatoire de Paris IAG****R. Biancale, A. Pollet***

Robust combinations in which both stations coordinates and Earth Orientation Parameters (EOP) are simultaneously computed will replace the current determination in the future. Since the beginning of 2005, GRGS is conducting a coordinated program with this objective. Observations derived from the various techniques are processed in different French institutes with a unique software. Weekly normal equations are cumulated in Paris Observatory with a delay of a few months. After a period in which the effects of various critical parameters, minimum constraints for stations, EOP continuity constraints and techniques weights were investigated, an optimal strategy has emerged leading to ensure the overall consistency as well as the accuracy and the long-term stability of the reference frame and EOP. The presentation will focus on the analysis of both products, EOP and weekly time series of station coordinates and their comparison to current determinations



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Oral Presentation****2496****Systematic analysis of 2-D and 3-D coordinate transformations with least-squares and total least-squares methods*****Dr. Jianqing Cai****Institute of Geodesy Universitt Stuttgart IAG****Nico Sneeuw, Ronggang Guo***

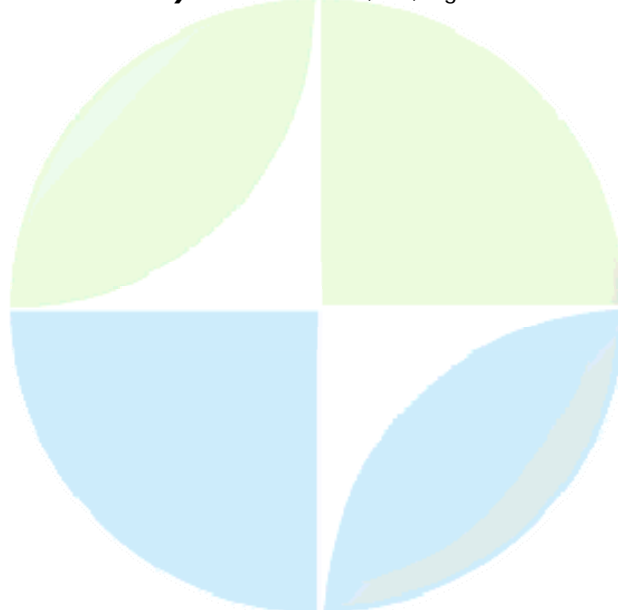
Total Least Squares (TLS) is a method of fitting that is appropriate when there are errors in both the observation vector and in the design matrix in computational mathematics and engineering. This method is also referred as Errors-In-Variables (EIV) modelling or orthogonal regression in the statistical community. The TLS/EIV principle was studied by Adcock (1878) already more than one century ago. Nowadays the Total Least-Squares method is also applied to coordinate transformations in which old local coordinates with lower accuracy need to be transformed to a higher precision newer network. Here the Total Least-Squares method is reviewed with respect to the solution by making substantial use of the singular value decomposition (SVD). Then, as an alternative transformation procedure, this solution is implemented and applied in estimating the 6-parameter affine transformation and 7-parameter Helmert transformation parameters with 131 collocated points in Baden-Wuerttemberg, which are with both Gauss-Krueger coordinates in German geodetic reference system (DHDN) and UTM coordinates in the ETRS89 datum. Comparing these results with those from the conventional LS method, we analysed and discussed the advantages but also the shortcomings of TLS method.

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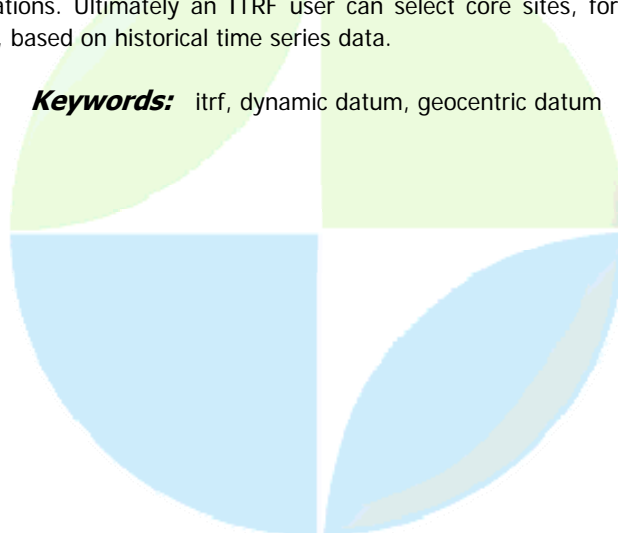
(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Oral Presentation****2497****Reanalysis and extension of the ILRS weekly solutions: towards an ILRS-TRF*****Prof. Erricos C. Pavlis****JCETUMBC and NASA Goddard Univ. of Maryland, Baltimore County IAG****V. Luceri***

Satellite Laser Ranging (SLR) contributes to the realization of the International Terrestrial Reference Frame (ITRF) for over two decades. The origin of the ITRF is realized through the estimated coordinates of its defining set of positions and velocities at epoch. Driven by numerous geophysical processes, continuous mass redistribution within the Earth system causes concomitant changes in the long-wavelength terrestrial gravity field that result in geometric changes in the figure described by the tracking station network. The newly adopted ITRF approach allows the simultaneous estimation of these variations at weekly intervals, either through a geometric approach during the stacking step or a dynamic approach during the data reduction step. To complement these improvements at the ITRF production level, the ILRS Analysis Working Group has adopted some additional improvements in the data reduction of the future as well as the historical SLR data, with interim results presented here. At a first step, the newly adopted atmospheric refraction model of Mendes-Pavlis [2004] has been utilized throughout the reanalysis. This results in a more consistent scale definition and allows the proper utilization of all SLR data at any wavelength, without the need for additional bias adjustments that weaken the final result. In a parallel second step, we have extended our analysis to include past data since the early days of the SLR network, thus allowing the simultaneous estimation of accurate and consistent positions and velocities for tens of sites that are presently unavailable from the official ITRF2005 results. This extension of the spatiotemporal span of SLR data used in the new product will have beneficial implications for the final result, since it takes advantage of the long and uninterrupted operation of some key core sites with high quality data and the coverage of very tectonically complex areas that are presently void of SLR tracking sites. This new revision of the weekly products is a first step towards the official ILRS contribution for the next ITRF release. We will also present a brief list of additional improvements we envision for this next release.

Keywords: ilrs slr, itrf, lageos

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Oral Presentation****2498****Investigations into a dynamic geocentric datum*****Dr. Jian Wang****School of Surveying & Spatial Information Systems The University of New South Wales
Sydney****Junqiang Wang, Craig Roberts, Jinling Wang, Samsung Lim***

Traditional geodetic geocentric datums are static and do not consider the surface changes due to tectonic motion. A dynamic geocentric datum could present a datum consisting of coordinates and velocities of the sites, which would provide users with realistic positions of sites within a network changing as a result of tectonic motion. It is, in essence, a four dimensional dynamic datum, which takes the spatial and temporal non-linear deformation of the global plates into consideration. The ITRF (International Terrestrial Reference Frame) is conventionally realized by an assumption of constant velocities for a set of global tracking sites. In reality, the assumption is not consistent with the non-linear effects caused by some unpredictable motions such as seismic, earthquake or volcanic effects. The geodetic coordinate time series play an important role in ITRF realization, which reflect a variety of geophysical phenomena as well as noise. This paper proposes a new scheme to analyze these geodetic station coordinate time series for ITRF realization considering non-linear tectonic motion. The noise properties of geodetic coordinate time series are crucial to estimate positions, velocities, and their stability and uncertainties. Non-linear study of geodetic position time series using a shift invariant-wavelet transform model is used to separate the noise sources of the geodetic position time series. Thereafter, periodic information and jumps with respect to the time span are detected and interpreted. A dynamic model for simulating the evolution of a specific site is suggested based on an Extended Kalman filter (EKF) model. Two basic difficulties are investigated. Firstly, how to provide a velocity field model with these site time series, especially when unpredictable motion occurs. Secondly, the Kingking and Bilinear interpolation models, which provide different levels of accuracy of the datum for different target-oriented users, are considered here for velocity field interpolation and extrapolation. This issue of different accuracy levels is a rarely mentioned issue but is crucial for some applications. Details and applications are discussed. Finally an investigation into a decision-making based system for presenting the 4-dimensional ITRF using feature information based on historical data and update information is given. A GIS based ITRF realization scheme is proposed using the best features of GIS spatial and temporal analysis modeling. The system can choose core sites for ITRF automatically or user-specified, update a dynamic datum automatically and provide users with datums of a specific precision for different reference stations. Ultimately an ITRF user can select core sites, for a particular task, with some prior knowledge, based on historical time series data.

Keywords: itrf, dynamic datum, geocentric datum

(G) - IAGA - International Association of Geomagnetism and Aeronomy

GS001

Oral Presentation

2499

Vertical reference frames - report of IAG Inter-Commission Project 1.2

Dr. Johannes Ihde

Geodesy Federal Agency for Cartography and Geodesy IAG

Based on the classical and modern observations, the ICP1.2 on Vertical Reference Frames had to be studied the consistent modelling of both, geometric and gravimetric parameters, and provide the fundamentals for the installation of a unified global vertical reference frame. The objectives of ICP1.2 are: - To elaborate a proposal for the definition and realization of a global vertical reference system - To derive transformation parameters between different regional vertical reference frames - To establish an information system describing the various regional vertical reference frames and their relation to a world height system. Result of the works is a proposal for conventions about the definition and realization of a global vertical reference system. The continuation of the necessary work for an implementation of this concept will be discussed. The realization of a global vertical reference system needs to be based upon the combination of positioning using geodetic space techniques, levelling, gravity, tide gauge observations and a global gravity model.

Keywords: global vertical reference, world height system



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Oral Presentation****2500****Robust estimation of spherical harmonic coefficients from scattered data****Mr. Jasper van Loon***Delft University of Technology DEOS IAG***Mark-Willem Jansen, Juergen Kusche**

A common problem in geodesy consists of computing a set of spherical harmonic (SH) coefficients of some continuous field from scattered, possibly heterogeneously distributed data. An important example is the derivation of global-scale deformation pattern from GPS-, VLBI-, tide-gauge or other point-wise observations. Another example is the estimation of geopotential SH coefficients from sparsely distributed observations or in the presence of data gaps. A central issue in the analysis of these data is the robustness of the method with respect to outlying observations. This is in particular true for smaller data sets, or those with isolated data site locations (e.g. islands), as gross errors in such data points may considerably distort the estimation of SH coefficients. Of course, it may be questioned whether spherical harmonics are the proper way in approximating a field at all in this situation, and other approaches might be more suitable, but on the other hand often SH coefficients are desirable because of physical interpretation or comparison with independent information. Least-square (LS) methods are usually favoured over integration approaches in this situation. However, LS is not robust against outliers in a statistical sense. Here we will investigate robust Maximum-Likelihood (M-) estimators for the purpose of deriving SH coefficients. Different influence functions will be used. Real networks will be analyzed with respect to robustness and breakpoint, and closed-loop simulations will be provided. M-estimates will be compared with LS-estimates in realistic situations.

Keywords: m estimation, spherical harmonics, outlier treatment



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Oral Presentation****2501****Reference systems, reference frames and the geodetic datum*****Dr. Hermann Drewes****Deutsches Geodaetisches Forschungsinstitut IAG*

Reference systems are defined by constants, conventions, models, and parameters which serve as a basis for the mathematical description of physical phenomena or processes. A well-known example is a three-dimensional, geocentric Cartesian coordinate system with an equatorial orientation given by the Earth rotation vector at a specified epoch and the scale given by the SI meter. A reference system is materialized by a reference frame, i.e., a number of physical points with coordinates computed from geodetic measurements according to the definition. In a terrestrial reference system these are monuments at the Earth surface. The unequivocal realization requires a set of (given) datum parameters providing the relation between the observations and the unique reference frame. The number of datum parameters must not exceed the necessary quantity, and must not be affected by the measurements or by the reference frame. The paper discusses problems occurring in the realization of a terrestrial reference frame and methods to verify the realization by the datum parameters.

Keywords: reference system, reference frame, geodetic datum



(G) - IAGA - International Association of Geomagnetism and Aeronomy

GS001

Oral Presentation

2502

A rigorous intra-technique combination procedure for terrestrial reference frames

Prof. Hansjoerg Kutterer

Geodaetisches Institut, Leibniz Universitaet Hann. University professor IAG

Xing Fang, Manuela Krgel

Today it is common practice to derive terrestrial reference frames (TRF) by the combined analysis of the following space-geodetic techniques: VLBI, GPS, SLR, DORIS. The applied procedure consists of two steps: after the combination of intra-technique solutions from different analysis centres for each space-geodetic techniques a final inter-technique solution is derived. Various validations and cross-check calculations show today a high consistency in the range of several millimetres for recent solutions of the International Terrestrial Reference Frame (ITRF). However, there is one significant shortcoming which has neither been addressed nor resolved in a satisfactory way up to now: intra-technique solutions are considered as independent in the further analysis steps although they are based on identical observation data. In general this yields biased estimates and too optimistic precision measures. In order to overcome this problem a rigorous mathematical estimation procedure is outlined which takes into account both the identity of the original observations and some individual operator-software noise induced by the respective analysis centre. The focus of this study lies on the analysis and discussion of typical VLBI sessions to show the benefit and the potential of the new procedure for intra-technique combination.

Keywords: terrestrial reference frames, stochastic model, quality



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Oral Presentation****2503****Impact of the network effect on the origin and scale: case study of Satellite Laser Ranging.****Mr. Xavier Collilieux***LAREG IGN France***Zuheir Altamimi**

The study of stations non linear motion requires being able to discriminate between the local motion of every station and their global motion (e.g. geocenter motion). A common used approach consists in estimating Helmert parameters with respect to a secular reference frame. But if the network is small or not well distributed, the global parameters, and mainly the translation and scale parameters, wont be rigorously decorrelated from the station displacements. The distribution of the currently operating Satellite Laser Ranging (SLR) stations is one example of such a network. We propose in a first part to evaluate how much the network effect impacts the SLR station displacement estimated with such a method. As GPS stations are well distributed and are part of a larger network, they are used to illustrate and quantify that effect. We evaluate that this effect is responsible for a scatter of about two millimetres in the height displacement. We suggest in a second part to use GPS results to constrain the estimation of SLR station displacements in order to improve the estimation of the Helmert parameters.

Keywords: slr, gps, network effect

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Oral Presentation****2504****The permanent tide in height systems****Dr. Jaakko Makinen**
IAG**Johannes Ihde**

A realization of a world height system, i.e. an International Vertical Reference Frame, is expected to provide geopotential values at 3-D positions, presumably with coordinates consistent with the International Terrestrial Reference Frame ITRFxx. According to the current IAG recommendations (1983), the geopotential values should be specified in the zero tidal system, i.e., they should contain the potential of the permanent deformation of the Earth (but not the tide-generating potential). And then complications arise since the ITRFxx coordinates are given in a tide-free system i.e. the permanent tidal deformation of the Earth has been removed from them. In view of the large number of applications attached to the ITRFxx coordinates, the change of the practice might imply large practical problems. This despite the fact that by definition the International Terrestrial Reference System ITRS, of which the ITRFxx are realizations, retains the permanent tidal deformation, as recommended by the IAG. The time average of the tide-generating potential is due to exterior masses. If it is retained in geodetic quantities, they require special treatment when the data is input to boundary value problems. This has been in fact the motivation for the adoption of the zero tidal system. However, for some applications of a world height system, for instance oceanography and relativistic clock rates, it does not play a role where the potential is coming from. For them only the total potential counts, and then the mean tidal system is the relevant one. We discuss the implications of the continued co-habitation of different tidal systems, and various scenarios for the adoption of a unified system across geodesy.

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Oral Presentation****2505****A first attempt to embed VLBI gravitational deformations into the Invariant Points definition at Medicina****Mr. Abbondanza Claudio***DISTART Geodesia Universit degli Studi di Bologna (Italy)***Montaguti Simonetta, Negusini Monia, Sarti Pierguido, Vittuari Luca**

A geometrical definition and consequently a proper estimation of space geodetic invariant points are needed when dealing with local tie computation for combining multi technique reference frames. Up to now an indirect method at the co-located site of Medicina was being effectively applied in order to estimate the VLBI invariant point (IP) within the procedure of local tie vectors estimation. Nevertheless, the IP is defined with respect to the moving and the fixed axis of the antenna; such an estimation relies on a pure geometric modelling which involves a least square fitting of canonical planar curves produced through rotational motions of the antenna. This approach would be theoretically feasible providing the non rigid behaviour of the structure is neglected. Since gravitational deformations induce a distortion of the shape of the VLBI dish, the estimation of the Invariant point could be considerably biased. A first attempt of merging the information about gravitational deformation of the telescope determined with terrestrial and laser scanning surveys and the results of the IP indirect measurement approach is presented. In particular, this study aims at highlighting and quantifying possible discrepancies between a purely geometrically ideal and a more practical and realistic approach, through an evaluation of the deformations experienced by the VLBI telescope.

Keywords: local ties, invariant points, vlbi**PERUGIA
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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Oral Presentation****2506****Status of the European Reference Frame (EUREF)****Mr. Joao Torres**
*SPUIAGG SPUIAGG IAG****Zuheir Altamimi, Claude Boucher, Elmar Brockmann, Carine Bruyninx, Alessandro Caporali, Werner Gurtner, Helmut Hornik, Ambrus Kenyeres, Jaakko Mkinen, Hans V. D. Marel, Jaroslav Simek, Johannes Ihde, Heinz Habrich, Guenter Stangl, Hermann Seeger, Georg We***

EUREF (www.euref.eu) is the IAG (International Association of Geodesy) Reference Frame Sub-commission for Europe integrated in Sub-Commission 1.3, Regional Reference Frames, of Commission 1, Reference Frames, of the IAG. The activities carried out by EUREF are related with the definition, realization and maintenance of the European Reference Frame, focusing on both the geo-spatial and the vertical components, and have the participation of almost all the European countries. Furthermore, EUREF works in close cooperation with the pertinent IAG components and EuroGeographics, the consortium of the NMCA (National Mapping and Cadastre Agencies) in Europe. This paper describes EUREF, its missions and activities, aiming at upgrading European-wide geodetic reference systems to support both scientific and continental geo-referencing activities, and presents an overview of the status and recent developments related with its core projects. The geo-spatial component of the frame is formed by the EUREF Permanent Network (EPN) and the network of high-precision geodetic reference sites determined by various GPS campaigns. The EPN contributes to the maintenance of the European Terrestrial Reference Frame (ETRF) and the International Terrestrial Reference Frame (ITRF) and is being used as a basis for the development of special projects, namely EPN Time Series Monitoring, Creation of a Troposphere Product and EUREF-IP, this last one dedicated to the development of the standards and the operational means to disseminate GNSS data over the Internet, in the context of the efforts within the IAG towards real-time data dissemination. The vertical component of the frame is the Unified European Levelling Network (UELN), that is being densified and extended by new observations. Similarly to the ETRS89 (European Terrestrial Reference System), a system related to the vertical component is defined, the European Vertical Reference System (EVRS). An overview of the European Combined Geodetic Network (ECGN) is also presented, as a contribution to the IAG project GGOS (Global Geodetic Observation System). The status of the adoption of the systems defined by EUREF - the European Terrestrial Reference System (ETRS89) and the European Vertical Reference System (EVRS) - by the European countries and organisations as official systems will be presented as well.

Keywords: euref, regional reference frames, gnss permanent network

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Oral Presentation****2507****Report on the work of the Inter-Commission Project ICP 1.1 Satellite Altimetry****Dr. Wolfgang Bosch**
IAG

According to its objectives the Inter-Commission Project ICP1.1 focussed on studying rationale, feasibility and scope of an International Altimeter Service in order to serve scientific and operational applications of satellite altimetry. These considerations were performed by an International Altimeter Service Planning Group which communicated by an E-mail list, set up a collaborative web site and met five times for business meetings. The conclusions were a broad consensus that an International Altimeter Service (IAS) is a mandatory component of Global Earth Observing Systems which should be realized as collaboration between data providers, archive and product centres, research laboratories, space agencies and users. The implementation of IAS was endorsed by GLOSS, IAG and IAPSO. Detailed Terms of References for IAS were drafted. However, the organizational overhead found no acceptance by groups already providing services. After a review of the implementation strategy the focus was laid on pilot projects to be initiated by an Integrating Office. A corresponding Call for Proposals was issued January 2007. A review and selection of proposals has been performed and one of the applicants is recommended for approval by the Executive Committees of IAS and IAPSO.

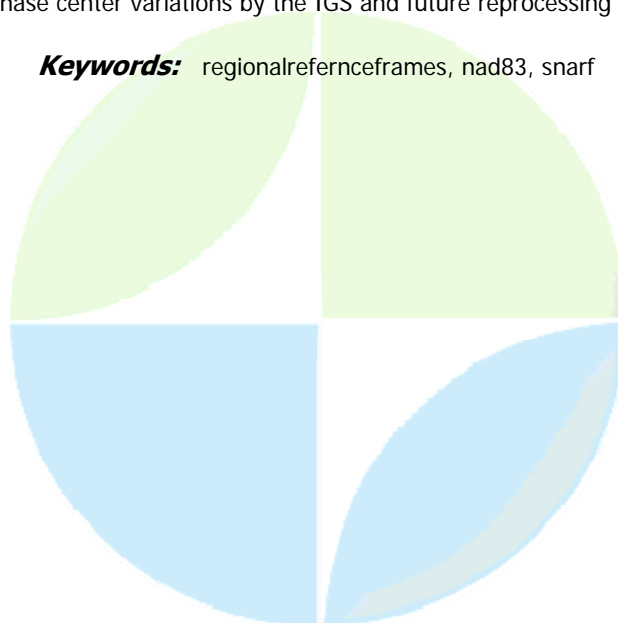
Keywords: inter commission project, icp11, satellite altimetry

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Oral Presentation****2508****Regional reference frames for North America: Current status and future plans of Subcommittee SC1.3c*****Dr. Michael R. Craymer****Geodetic Survey Division Natural Resources Canada IAG****Richard Snay***

In collaboration with the IAG community, its service organizations and the national geodetic organizations of North America, IAG Subcommittee SC1.3c on Regional Reference Frames for North America provides international focus, cooperation and coordination for issues involving the geodetic reference frames and control networks of North America. These issues include the establishment, maintenance, future evolution and inter-relation of reference frames for North America and the specification of consistent standards and guidelines. There are presently three working groups under this regional subcommittee: WG1 North American Reference Frame Densification (NAREF), WG2 Stable North American Reference Frame (SNARF), and WG3 Reference Frame Transformations. The goal of the Subcommittee and its WGs is to provide consistency in the realization and inter-relation of reference frames throughout the continent. Over the past four years, there has been much activity in each of these WGs, especially since the introduction of ITRF2005. In particular, the NAREF densification network has evolved from a network of a few hundred stations to nearly 1000. Weekly NAREF solutions are produced in ITRF from a combination of several regional contributions and made available to the public via the IGS. Periodic velocity solutions are also estimated based on these weekly solutions, the last of which was contributed to the ITRF2005 densification effort. In response to the requirements of the Plate Boundary Observatory for the EarthScope project, a new plate-fixed reference frame was determined for North America. Known as the Stable North American Reference Frame (SNARF), this reference frame is seen as a possible successor to the currently adopted North American Datum of 1983. In addition to defining a reference frame fixed to the stable part of North America, SNARF also provides a model of glacial isostatic adjustment determined using a novel technique that combines GPS velocities with a geologic model of GIA. Finally, the recent introduction of the ITRF2005 has resulted in the updating of transformations to NAD83, the currently adopted reference frame for Canada and the U.S. The future plans of these WGs will also be discussed, in particular, the consequences of the adoption of absolute phase center variations by the IGS and future reprocessing efforts.

Keywords: regionalreferenceframes, nad83, snarf

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Oral Presentation****2509****Report of the Intercommission Committee on Theory*****Dr. Peiliang Xu****Disaster Prevention Research Institute Kyoto University IAG****Athanasios Dermanis***

The Intercommission Committee on Theory (ICCT) was formally approved and established after the IUGG XXI Assembly in Sapporo, to succeed the former IAG Section IV on General Theory and Methodology and, and more importantly, to actively and directly interact with other IAG Entities. Recognizing that geodetic observing systems have advanced such that geodetic measurements can be collected with unprecedented high accuracy and quality, can readily cover a region of any scale up to tens of thousands of kilometres, consist of non-conventional data types, and can be provided continuously, the ICCT (1) strongly encourages frontier mathematical and physical research, directly motivated by geodetic need/practice, as a contribution to science/engineering, and to Geodesy in particular; (2) provides the channel of communication amongst the different IAG entities of commissions/services/projects, on the ground of theory and methodology; (3) helps the IAG in articulating mathematical and physical challenges of geodesy as a subject of science and in attracting young talents to geodesy; and (4) encourages closer research ties with and directly gets involved with relevant areas of the Earth Sciences, bearing in mind that geodesy has been playing an important role in understanding the physics of the Earth. In this report, we will try to summarize how we try our best to achieve the set goals and what has been achieved. In addition to briefly report the major ICCT activities during the past four years, we will also briefly summarize the work done by the ICCT internal and/or joint working groups.

Keywords: intercommission, committe



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Poster presentation****2510****Analysis of the bias between TOPEX and GPS vTEC determinations*****Dr. Claudio Brunini****Facultad de Ciencias Astronmicas y Geofisicas Universidad Nacional de La Plata IAG****Francisco Azpilicueta***

Since TOPEX vertical TEC (vTEC) measurements became available, several validation studies against vTEC determinations from other sources have been carried out. Many of these studies have identified a vTEC constant bias between +2 and +5 TECU when compared to GPS and DORIS vTEC determinations (TOPEX greater than the others). Based on La Plata Ionospheric Model, global vTEC maps have been computed on a day-to-day basis for the years 1998 and 1999, and comparisons against TOPEX vTEC determinations have shown a constant bias ranging from +3 to +4 TECU. The available documentation relative to the computation of TOPEX products reports that a correction of +15mm is applied to the final range computed. This correction is applied empirically, i.e. without any analysis of the source and without any study of the implications of it on TOPEX vTEC determinations. In the present contribution, we show that with slight changes on the constant corrections used in TOPEX processing algorithm that are applied to TOPEX measurements on each frequency, TOPEX vTEC bias disappear and the +15 mm range correction is no longer needed.

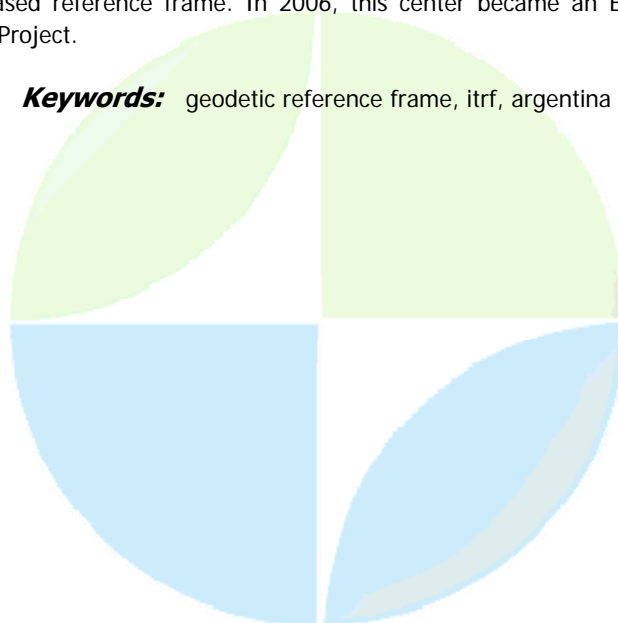
Keywords: ionosphere, topeX, gps

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Poster presentation****2511****Adoption of an ITRF 2005 based frame as the National Geodetic Reference Frame Of Argentina*****Prof. Sergio Cimbaro****Geodesy Military Geographic Institute****Eduardo Andrs Laura***

We present the development of a new Geodetic Reference Frame for Argentina based on ITRF 2005, permanent GPS stations, and the campaign measurement of approximately 180 GPS points distributed throughout Argentina. In May 1997, Argentina officially adopted its first GPS derived Geocentric Reference Frame, POSGAR 94 (Posiciones Geodsicas Argentinas 94), which was based on WGS 84 and campaign GPS measurements. It was measured during two GPS campaigns in 1993 and 1994 in the form of a network having baselines about 200 Km long from which 127 points, distributed throughout Argentina, were determined. The GPS processing was performed with commercial software. In the time since POSGAR 94 was adopted ongoing advances in GNSS technology, an expanding network of open data permanent GPS stations around the world, and advances in the development of very rigorous and accurate scientific data processing programs have made improvements in precision of more than an order of magnitude possible. During the last few years this progress has become asymptotic, with little variation in the transformation parameters between the latest ITRF solutions. In addition to the improved precision, modern Geodetic Reference Frames also have to take into account plate motions and crustal deformations. Considering that a National Geodetic Reference Frame must provide results with a precision required by all its users, the precision of POSGAR 94 only partially fulfills this requirement as it provides acceptable precision only for cartographic uses, but is not accurate enough for geodetic studies. Thirteen years after its measurement, therefore, POSGAR 94 can no longer meet the needs of all the users of the Argentine National Geodetic reference Frame, and the development of a new frame has become necessary. The installation and continued expansion of a network of permanent GPS network in Argentina and the use of scientific processing software by several Argentinean institutions, present the opportunity to develop a new high precision national geodetic reference frame for Argentina. In March 2005, the Argentine Military Geographic Institute created a center for scientific GPS data processing using the GAMIT-GLOBK package to develop and maintain a high precision GPS based reference frame. In 2006, this center became an Experimental Processing Center of the SIRGAS Project.

Keywords: geodetic reference frame, itrf, argentina

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Poster presentation****2512****MASS & MyRTKnet: The Revised Geodetic Definition of GDM2000*****Mr. Soeb Nordin***

The Malaysian Active GPS System (MASS) and Malaysian RTK Network (MyRTKnet) networks are two networks of 18 and 27 GPS permanent stations that were established in 1999 and 2004 respectively. At the end of 2006, the MASS network has been converted to RTK station and become part of MyRTKnet network, by 2008 the network will consist of 78 stations which will cover the whole nation. The datum definition of MyRTKnet is based on ITRF2000@2000.0 and known as Geocentric Datum for Malaysia 2000 (GDM2000). The Sumatran earthquakes that occurred on 26th December 2004 and 28th March 2005 had caused significant deformation to South East Asian region. Early study (26th December 2004 event) has indicated that the horizontal displacement magnitude in Peninsular Malaysia is between 2 and 18 cm with the greater magnitude shown at the northern part of the Peninsular. The Department of Survey and Mapping, Malaysia (DSMM) has been closely monitoring the coordinates time series of MASS and MyRTKnet Networks in order to determine the physical effect of the events on geodetic infrastructures in Malaysia. With the event, attempt has been made to re-compute the coordinates time series of the Malaysian GPS Permanent stations from 1999 till present base on ITRF/IGS 2005 frame with the goals to revise the GDM2000 reference system. The weekly solutions of the coordinates from MASS and MyRTKnet Networks were combined together using Bernese GPS Processing Software Version 5.0 and the coordinates residual are plotted with their respective trend line. From the coordinates time series analyses, the revise GDM2000 coordinates for MyRTKnet network will be based on GPS data from 2006 onwards.

Keywords: myrtknet, gps, timeseries



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Poster presentation****2513****Towards a new vertical reference system for Argentina****Dr. Maria Cristina Pacino**
GEODESY MEMBER IAG**Daniel Del Cogliano, Graciela Font, Eduardo Laura, Silvia Miranda, Paula Natal**

This contribution describes the main results obtained by the Geopotential Origin Working Group (National Committee of IUGG) as well as future tasks for next few years. In order to obtain precise coordinates for the tide gauge benchmarks related to the International Terrestrial Reference System (ITRS), five GPS permanent stations were installed near those lying along the Argentina coastline. Besides, an other tide gauge is being monitored by GPS at the southernmost continental zone of the country. Until now several episodic campaigns were carried out, and vertical velocities were derived from them. Several activities related to the linking of altimetric networks of neighbouring countries, in particular with Chile, were also done. On the other hand, and aiming the computation of geopotential numbers, the closing errors of levelling polygons, in terms of measured differences of level, were completed with potential differences as well as reduced levels from dynamic, orthometric and normal corrections. At this stage, the process to fill in the gravity holes in those stations with lack of gravity measurements was taken in consideration with special care. With regard to the network compensation, different robust methodologies are being tried in order to adjust data that have been measured using different instruments for nearly a century. In order to contribute with the geoid modelling, observations of the vertical deflection of the vertical will be performed.

Keywords: geoid, argentina, altitudesPERUGIA
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Poster presentation

2514

Earth crust deformation map based on continuous GPS measurements in Colombia

Mr. William Martinez
Geodesy Division Chief IAG

Located on the convergence of three tectonic plates, Colombia is one of the most interesting areas for the analysis of observables related to the behavior of system Earth. On this basis, Agustin Codazzi Geographic Institute has established the national reference frame by 32 GPS permanent stations. Weekly computation of coordinates is being carried-out under standard SIRGAS Project processing procedures. Presented velocity model is intended to serve as a support to disaster prevention, Geodynamics, Volcanology and Seismology.

Keywords: deformation map, earth crust deformation, plate velocity

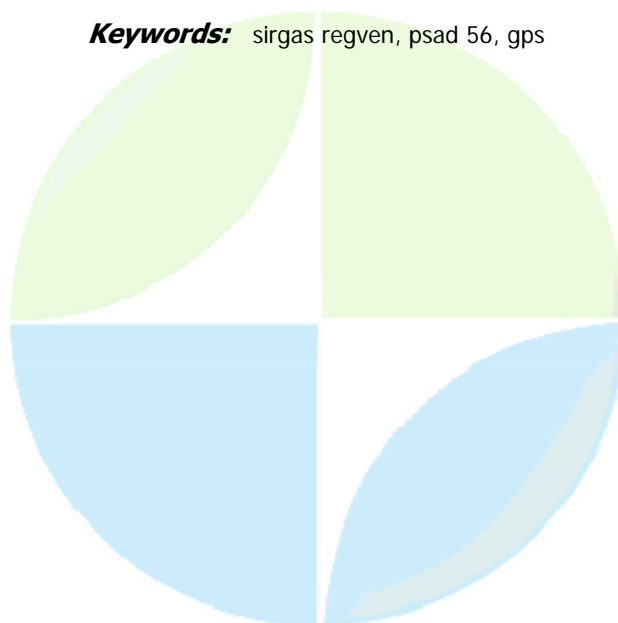
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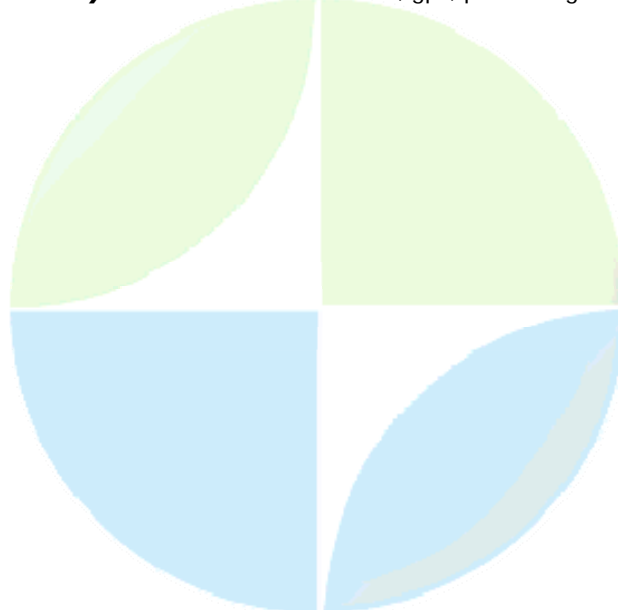
(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Poster presentation****2515****GPS measurements for the establishment of the SIRGAS-REGVEN datum in the morichal operational area*****Mr. Mario Forgione******Jose Borrego, Carlos Vargas, Manolo Reina, Hermes Mendez, Jose Rodriguez***

Since Venezuela started its petroleum activities of exploration and production, many reference systems have been developed in order to organize and map geospatial information, such as wells, oil industry infrastructure among other with special interest for the petroleum companies established across the country. By resolutions of the Environment Ministry (March 3rd, 1999) and of the Energy and Petroleum Ministry (November 17th, 2005) published in the Venezuelan Official Gazette, The Government decrees that the national geodetic community must adopt and use SIRGAS-REGVEN, the new Venezuelan official geocentric datum which will replace the former conventional La Canoa (PSAD56) datum. Petrelos de Venezuela, S.A. (PDVSA), has carried out several studies and special projects since 2001 in order to convert all its geospatial information into the new geodetic reference system. Currently, the Corporate Management of Geodesy, the Eastern Division Reservoir Management, and the Morichal Operational Management, executed as a project in the Morichal Operational Area, which is located in the south-eastern region of Venezuela, the evaluation of coordinates and terrain elevation of an existing database of wells which ended up with the measurements of 1750 wells. This work presents the established methodology to carry out the project, which considered the analysis of the actual database quality vs. the required accuracy, lately the fieldwork and measurement parameters are shown. Subsequently, the processing technique of the GPS Data is displayed, finishing with the analysis of results and the respective conclusions. The final accuracy of the wells positioning is 20 cm, guarantying the geospatial homogeneity and quality of the new database. Trimble 5700 and 4000SSE receivers were used for the project. The software Trimble Geomatics Office Software (V-1.62) was used to process the raw data. The results of this project will allow PDVSA the unification of wells database and geospatial information into a common geodetic reference system, and generate a methodology to evaluate, certify and develop the total implementation of the SIRGAS-REGVEN datum in the Petrelos de Venezuela, S.A. geodata handling processes.

Keywords: sirgas regven, psad 56, gps

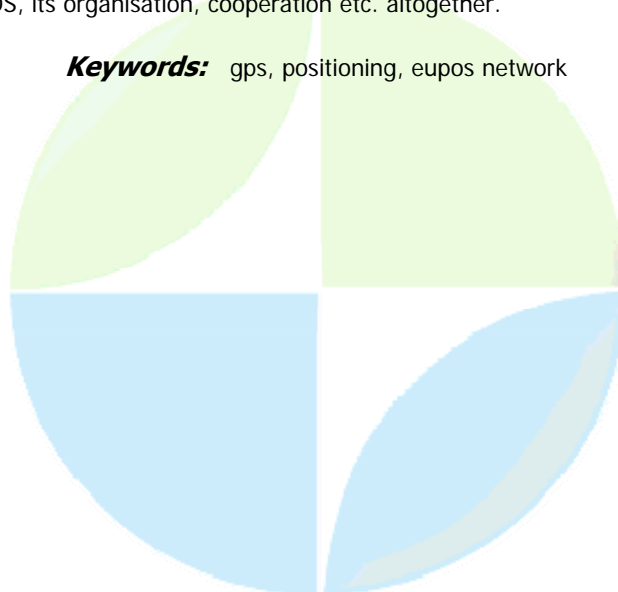
(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Poster presentation****2516****Status of establishment of the polish part of the network of reference stations ASG/EUPOS*****Prof. Janusz Sledzinski****Warsaw University of Technology Institute of Geodesy and Geodetic Astronomy IAG****Wieslaw Graszka***

EUPOS is an initiative and cooperation of currently 15 Central and Eastern European countries (CEE) and two German states that build up a ground based European regional GNSS augmentation system with uniform standards that will cover a territory of about 10 million square kilometers. The Project EUPOS was initiated by the Berlin Senate Department for Urban Development and European Academy of the Urban Development Berlin. The project consists in establishment of about 900 multifunctional satellite reference stations in Central and Eastern Europe. The system will use in future as main signal the signal of the European system Galileo. EUPOS provides high quality differential GNSS information for high precise positioning and navigation. To enlarge and support the EUPOS activities the project EUPOS Interregional Cooperation (EUPOS-IRC) was launched in October 2006. Main aims of this operation are to identify, point out and enable possibilities and benefits of the use and application of GNSS technology in the field of regional development, to establish a long lasting cross-border cooperation between experts in the field of GNSS and geoinformation on the one hand and on the other hand regional policy experts and stakeholders. Nine partners from eight countries coming from the EUPOS initiative form the consortium under the leadership of the Berlin Senate Department for Urban Development. In August 2005 the Head Office of Geodesy and Cartography in Poland has signed the respective agreement on financial support for establishment of EUPOS reference stations in Poland. The respective support is given from structural ERDF EU programme. The detailed technical design of the network is already prepared. In order to cover the whole territory of Poland and to achieve the proper cross-border links there will be finally established about 90 reference stations. According to the agreement the establishment of all stations should be concluded by the end of 2007. The paper describes the EUPOS-IRC operation as well as the current status of establishment of EUPOS stations in Poland, its organisation and cooperation.

Keywords: reference station, gps, positioning

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Poster presentation****2517****EUPOS AND EUPOS INTERREG IIIC two european initiatives of regional cooperation.*****Prof. Janusz Sledzinski****Warsaw University of Technology Institute of Geodesy and Geodetic Astronomy IAG****Anette Blaser, Wieslaw Graszka, Gerd Rosenthal***

The Project EUPOS was initiated in 2003 by the Berlin Senate Department for Urban Development and European Academy of the Urban Development Berlin. It is an initiative and cooperation of currently 15 Central and Eastern European countries (CEE) and two German states that build up a ground based European regional GNSS augmentation system with uniform standards that will cover a territory of about 10 million square kilometers. EUPOS provides high quality differential GNSS information for high precise positioning and navigation usable in a large field of applications: from precise farming and environmental protection, transport and public security, emergency services, machinery and vehicle control, to spatial data infrastructure developers and to geodesy. The International EUPOS Steering Committee (ISC) cooperates with the United Nations Office for Outer Space Affairs (UN OOSA), is represented in the International Committee on Global Navigation Satellite Systems (ICG) and in the Radio Technical Commission for Maritime Services and the exchange of observers is agreed in both EUPOS ISC conferences and EUREF Technical Working Group meetings. To enlarge and support the EUPOS activities transcending technical realisations the project EUPOS Interregional Cooperation (EUPOS-IRC) was launched October 2006, since it is accepted as a European Union INTERREG IIIC Programme operation. Main aims of this operation are to identify, point out and enable possibilities and benefits of the use and application of GNSS technology in the field of regional development, to establish a long lasting cross-border cooperation between experts in the field of GNSS and geoinformation on the one hand and on the other hand regional policy experts and stakeholders. In this context nine partners from eight countries coming from the EUPOS initiative form the consortium under the leadership of the Berlin Senate Department for Urban Development. The co-operation of the EUPOS-IRC programme consists of four components: 1. Management and co-ordination, 2. EUPOS-IRC Know-how Offices promoting Geoinformation in the Context of Regional Policy, 3 Large-Scale Information Exchange and Training, 4. "Planning Sustainable Multi-Sectoral Satellite-Based Geoinformation Applications, User Acquisition, Investment Preparation. The paper describes the EUPOS-IRC operation as well as the current status of EUPOS, its organisation, cooperation etc. altogether.

Keywords: gps, positioning, eupos network

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Analysis of 14 years (1993-2006) of SLR data combination of High (Lageos-1 & -2) and Low (Starlette, Stella, TOPEX/Poseidon & Jason-1) satellites for TRF and EOP study

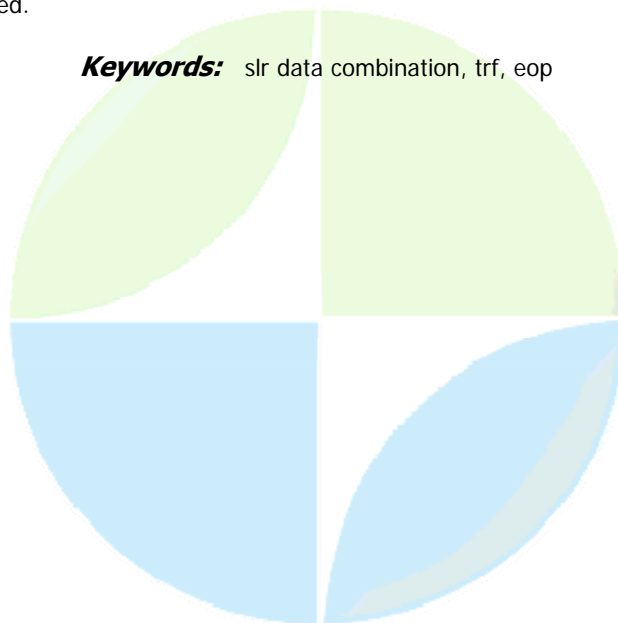
Mr. Bachir Gourine

Division of Geodesy National Centre of Spatial Techniques (CNTS)

Kahlouche Salem, Berio Philippe, Deleflie Florent, Feraudy Dominique, Exertier Pierre

Satellite Laser Ranging (SLR) is one of the headlights techniques of the calculation of the International Terrestrial Reference Frame (ITRF). It contributes to the frame determination by providing time series of terrestrial stations positions (TRF) and Earth Orientation Parameters (EOP). Generally, for such determination, only the measurements on high satellites (Lageos-1&-2) are used. The present work deals with the calculation of International Laser Ranging Service (ILRS) global network and SLR-derived EOP not only based on observations of both Lageos satellites but also on those of Low Earth Orbit (LEO) satellites, namely Starlette and Stella and TOPEX/Poseidon and Jason-1. The orbits of geodetic LEO satellites are less accurate because they are more perturbed by the gravitational and non-gravitational forces than Lageos ones. On the other hand, the orbits of the oceanographic satellites are very precise. The challenge is to achieve best quality on the spatial geodesy products (TRF and EOP) by inter-satellite combination of High and Low satellites data. This objective can be reach by considering the following points: (a) Important quantity of LEO laser measurements which can contribute to well constraint the calculation of ILRS network and EOP, (b) Better determination of SLR station bias and satellite response, (c) Good quality of the recent dynamical models (gravitational and non-gravitational) which allows improving LEO computation. In this paper, the adopted methodology for such determination is based on a multi-satellite semi-dynamical approach, on rigorous weighting of SLR measurements per satellite and per station and on temporal decorrelation method to compute SLR ranging biases. The orbit restitution of the different satellites is carried out by GINS software (GRGS, France) and the laser data processing is performed with MATLO software (OCA & IGN, France), for a period of 14 years (between 1993 and 2006). The preliminary results about the analysis of 14 years SLR data combination, in order to study the Terrestrial Reference Frames (TRF) and Earth Orientation Parameters (EOP), are presented and discussed.

Keywords: slr data combination, trf, eop



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Poster presentation

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**Research on framework sites selection on unite-processing of IGS CORS
and Chinese CORS**

Dr. Jinzhong Mi

Institute of Geodesy and Geodynamics China Academy of Surveying and Mapping IAG

Jiang Zhihao

At present, selection of GPS core stations mainly come from the four standards study of ITRF. So far as the four standards of choose of GPS core stations of ITRF2000 concerned, there are still have some insufficiency. According to our research about Chinese framework site selection, the basic standards is the same to ITRF, namely: 1)Principle of continuity- the station was continuous observing during nearly 3(or more) years; 2)Principle of stability-located in the rigid plate and distant distorted regions; 3)Principle of High precision-the precision of velocity fields is better than 3mm/a; 4)Principle of various results-at least 3 velocity errors of dissimilar analysis results is better than 3mm/a. With above four principles, we particularly emphasized the principles of stability and precision analysis of the time series of GPS fiducial stations. There are two principles as follows: 5)Principle of balance-the fiducial station is well-proportioned distributing throughout our country. 6) Principle of precision consistency- analysis the location precision and the time series, the error and variance of the time series should be consistency.

Keywords: gps framework sites, balance, coherence

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Poster presentation

2520

**Combined adjustment of nationwide astro-geodetic and the national
GPS2000 geodetic control networks**

Prof. Yingyan Cheng

Institute of Geodesy and Geodynamics Chinese Academy of Surveying and Mapping IAG

Pengfei Cheng, Jingzhong Bei

The time span of the observations of Chinese astro-geodetic network is nearly 60 years from early 20th to 80th in 20 century. The position of astro-geodetic points may have moved during this long period, so co-occupied points of these two networks analysis is to be done before adjustment. Also the factors which affect astronomic observation, direction and traverse or distance observation must be analysed in advance, such as earth crust movement, the change of astronomic system, geoid improvement and so on. The paper first introduce the observation types joining in combined adjustment and their accuracy, and then factors analyses stated above would be discussed. The unknown parameters of whole network are about 150 thousands, such large scale data processing of readjustment is very hard and complicated to fulfill in PC computer, so effective solution of large scale sparse matrix and computer program design are discussed here. Because various kinds of observations, such as direction observations of different orders, traverse distance observations, astronomical azimuth observations and 3-D geocentric coordinates of GPS control points, have been involved in the combined adjustment. Helmert covariance component estimation in super large scale network also introduced. Final position accuracy of total 48919 points, baseline accuracy of 565 GPS points, the accuracy of 2146 side and 1046 azimuth are estimated in this adjustment. 46375 points within 0.3m, about 95.5%, 658 points are over 0.5m, about 1.3%, average position accuracy of network is 0.11m.

Keywords: combined adjustment, variance estimation, results analyse



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Poster presentation****2521****Gravity data analysis for the calculation of geopotential numbers in the altimetric network of Argentina*****Prof. Juan Carlos Villella****Geodesy member IAG****Maria Cristina Pacino***

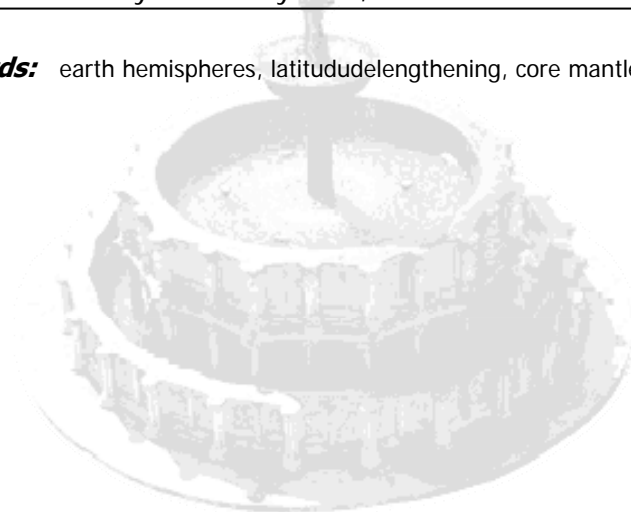
The Argentina levelling network consists of 370 levelling lines composed by 16,320 benchmarks, including 225 nodes. About 85% of the benchmarks in the network have measured gravity values. One of the problems to solve prior to the geopotential number computation is to fill the gravity "holes" properly. The analysis of the gravity data indicates that there are 1,200 "gravity holes" on the lines. Among them, 75% are only one isolated missing value and 50 cases consist of large gravity holes including a few cases of complete lines with no gravity observation. Besides, additional gravity information from different sources (Universities, Research Institutes, Oil and Mining Companies) was also used to conform the complete gravity database of Argentina. The complete data set was taken into account to fill in the gravity holes. The behavior of several variables (Bouguer anomaly, Free Air anomaly, Observed gravity) was analyzed. Different interpolation methods (Kriggin, Minimum Curvature, Inverse Distance to a Power) were tested. The influence of different geographic features (planes, hills, mountains) as well as different rates of data coverage were also analyzed. All these possibilities are shown and the derived conclusions were applied.

Keywords: altitudes, argentina, geopotencial

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Poster presentation****2522****Variations of lengths of latitudinal circles of the Earth and their mechanism****Prof. Yury Barkin***Laboratory of Gravimetry Sternberg Astronomical Institute IAG*

For the first time the possible inversion in change of forms of southern and northern hemispheres of the Earth has been discussed after a prediction of the phenomenon of drift of the Earth centre of mass in the direction to the North Pole with velocity 1-1.5 cm/yr (Barkin, 1995). In the same years the idea about functioning the shell-dynamic mechanism has been stated (Barkin, 1996; 2002). To explain such significant displacement of the centre of mass it is possible only with the help of the mechanism of the forced displacements of the centres of mass of the outer core and elastic mantle of the Earth. Its action inevitably should result in opposite tendencies in change of forms of southern and northern hemispheres and to new phenomena of transportation of atmospheric and oceanic masses between hemispheres of the Earth (new tides) (Barkin, 2002). Later on the basis of given satellite and other precision observations secular tendencies in compression of northern and expansion of southern hemispheres for the first time have been discovered (Shuanggen, Zhu, 2002). Definite dynamic interpretation of this problem has been undertaken on the basis of a model problem about deformations of the elastic mantle at small radial displacement of the core (Barkin, Shatina, 2005). In particular it was shown, that at polar drift of the core with velocity about 50-60 mm/yr the observable inversion changes of lengths of latitudinal circles of the Earth obtain clear dynamical explanation. The possible contribution from other processes of redistribution of masses of the Earth (oceanic and atmospheric masses) thus was not taken into account; therefore the obtained evaluations of lengthening of latitudinal circles appeared overestimated. In report the specification of mentioned results is given and the trends of lengths of latitudinal circles are explained. Using the experimental results of work (Blewitt et al., 2001) about a seasonal mode of deformation of the Earth, we accept, that on a share of the mechanism of displacement of the Earth core it is necessary about 60 % of observable effect. The drift of superfluous mass of the outer core results to slow transportation of oceanic and atmospheric masses from the southern hemisphere to northern hemisphere. By our evaluation it will lead to secular inversion deformation of the Earth according to which subpolar points move downward in northern hemisphere with velocity 1.8 mm / yr. In southern hemisphere opposite tendency is observed. Considering the core trend, its annual and semi-annual oscillations, for variation of length of latitudinal circle with latitude Q we obtain the following model expression: $dL = -[8.5t + 14.1\cos(V) + 3.2\cos(W)] \sin(2Q)$, where amplitudes are given in millimeters (mm), trend in mm/yr, the time t is measured in years (from the beginning of year), and arguments V and W are measured in degrees and calculated under formulas $V = 360t - 56$ and $W = 720t - 207$. The extreme values of lengthening of latitudinal circles are reached at latitudes of 45 degrees. The maximal annual shortening in northern hemisphere takes place at latitude 45 N in March (14.1 mm), and in a southern hemisphere (at latitude 45 S) in August - September. Another's cyclic displacements of the core (their polar components) result in additional variations of length dL . On our evaluations the following periodic variations of length of latitudinal circle 45 S can be observed: with amplitude of 23.6 mm (the period about 2.1-2.3 yr); 22.3 mm (period 3.6-3.8 yr); 32.9 mm (the period of 7.5-8.0 yr); 22.3 mm (471 days); 20.7 mm (1.6 yr); 15.9 mm (the period 6.9 days). References Barkin Yu.V. (1995) About motion of the Earth center of mass, caused by global change of dynamical structure and by tidal deformations. Vestnik Moskovskogo Universiteta, Ser. 3, Fysika, astronomia, Ser. 3, v.36, N 5, pp.99-101. In Russian. Barkin, Yu.V. (1996) Secular Trend of the Earth's Mass Center due to Plate Motion. Vestn. Mosk. Un-ta. Fiz., Astron., Vol. 37, N 2, pp. 79-85 (in Russian). Blewitt G., Lavallee D., Clarke P., Nurutdinov K. (2001) New global mode of Earth deformation: seasonal cycle detected. Science, V. 294. pp. 2342-2345.

Keywords: earth hemispheres, latitudinal lengthening, core mantle interaction



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Poster presentation

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Real Time Monitoring of IGU clock corrections provided by a Web-based User Information Portal

Mr. Michael Opitz

IGG Vienna University of Technology

Robert Weber, Mark Caissy, Veronika Broederbauer

Since 4 years the IGS (International GNSS Service) Real-Time Working Group disseminates via Internet raw observation data of a subset of stations of the IGS network. This observation data can be used to establish a real-time integrity monitoring of the IGS predicted orbits (Ultra Rapid (IGU-) Orbits) and clocks, according to the recommendations of the IGS Workshop 2004 in Bern. The Institute for "Geodesy and Geophysics" of the TU-Vienna develops in cooperation with the IGS Real-Time Working Group the software "RTR- Control", which currently provides a real-time integrity monitoring of predicted IGU Satellite Clock Corrections to GPS Time. Besides RTR-Control estimates the Receiver Clock Corrections of the permanent stations in the global network and allows for the comparison of pseudoranges measured at these stations with theoretical pseudoranges calculated on basis of the IGU-orbits. Thus, the programme can diagnose incorrectly predicted satellite orbits and clocks as well as detect multi-path distorted measurements in realtime. This presentation shows the results of a prototype version of RTR- Control which is in operation since August last year. RTR- Control calculates every 15 seconds Satellite- and Receiver Clock Corrections with respect to the most recent IGU- clocks (updated in a 6 hours interval). The clock estimations are referenced to a stable station clock (H-maser) with a small offset to GPS- time. This real-time Satellite Clocks are corrected for individual outliers and modelling errors. The most recent GPS- Satellite Clock Corrections (updated every 60 seconds) are published in Real Time via the Internet. All other results (station clocks, pseudorange residuals, comparison, etc.) can also be obtained from the webpage. The user group interested in a rigorous integrity monitoring comprises on the one hand the components of IGS itself to qualify the issued orbital data and on the other hand all users of the IGS Ultra Rapid Products (e.g. for PPP in Real Time).

Keywords: igu clocks, real tim monitoring, rtigs



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Poster presentation****2524****Epoch rectification of GPS on benchmarks in Canada****Prof. Georgia Fotopoulos**
*Civil Engineering University of Toronto IAG***Michael Craymer, Earl Lapelle**

A national network of GPS on benchmarks is a valuable source for vertical datum studies and height transformations. In Canada, a subset of 1180 benchmarks of the first-order levelling network has been observed with high accuracy GPS, some co-located with Canadian Base Network pillars and permanent GPS stations. Unfortunately, due to its sheer size in both spatial coverage and number of points, it is impractical to survey the entire GPS on benchmark network over a short period of time. As a result, the network consists of many individual campaigns in patches across the country often done in conjunction with other surveys, such as the various campaigns of the first measurement of the Canadian Base Network. Consequently, the benchmarks have been occupied with GPS at different times over a period of about 15 years. Numerous temporal effects such as ongoing geophysical phenomena and in particular glacial-isostatic adjustment, anthropogenic or naturally induced land subsidence and land deformation introduce distortions in the adjusted heights. The goal of this new work is to compute a new GPS on benchmarks adjustment by taking these temporal effects into account in order to reference the heights to a common epoch. As a first step, only post-glacial rebound is accounted for. This will provide a temporally homogeneous reference network for future vertical datum investigations.

Keywords: vertical datum, gps on benchmarks, post glacial rebound

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Poster presentation****2525****Refining the Brazilian Vertical Datum by integrating satellite altimeter data and local geopotential anomalous component****Prof. Silvio De Freitas**

GEOMATICA FEDERAL UNIVERSITY OF PARANA IAG

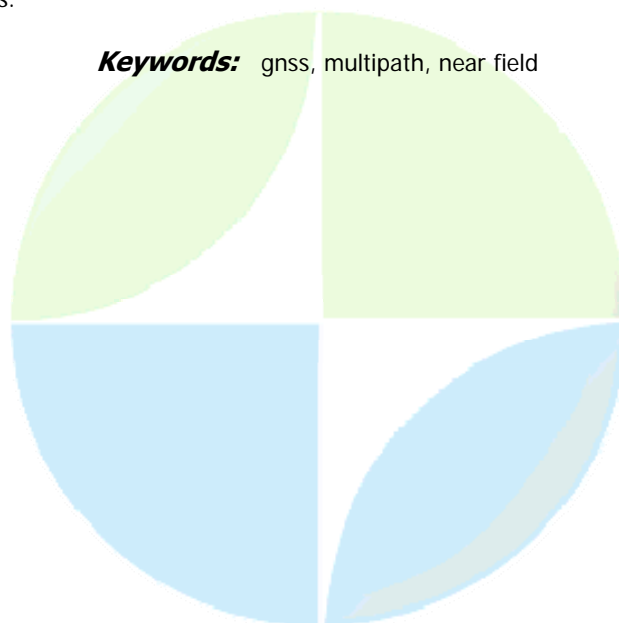
Regiane Dalazoana, Roberto Teixeira Luz, Bernhard Heck, Vagner Goncalves Ferreira, Alessandra Svonka Palmeiro

The main Brazilian Vertical Datum (BVD) was defined by the mean sea level (MSL) obtained from a nine years period of tide gauge sea level (SL) observations in the Imbituba harbor, south Brazil. The mean period of observations was around the epoch 1953.0. Since the original time series for defining the BVD to the present there are large gaps in SL observations. It is clear that the BVD does not fit with the modern requirements for defining a vertical datum in accordance with a global height system. In short, a global height system is based on a global reference equipotential surface (here called global geoid) that can be identified by a reference geopotential value. The two main reasons for the unfitting are the unknown BVD position related to the global geoid, and BVD vertical velocity not considered since its initial realization. Recently, a trend of MSL rising in the BVD was estimated using about 10 years of TOPEX-POSEIDON satellite altimeter data integrated with three tide gauge SL observations at the Datum region by propagating the SL at some off-shore bins of satellite altimeter paths to the coastal region. Because information about SL is absent in several periods at Imbituba the obtained trends are going to be evaluated by using other satellite altimeter data, and extending the period of analysis until the present. Until now, there is no sufficient conventional gravity information available around the BVD to estimate its present shift related to the global geoid. As the present local sea surface topography (SSTop) must be associated with the local geopotential anomalous component in reference to the global geoid, the recent work related to an adequate definition of BVD is based on some methodologies which avoid the use of data based on local geodetic reference systems like gravity anomalies. Thus, gravity disturbances and terrain effects are under investigation as basis to determine the local geopotential anomalous component.

Keywords: global height system, vertical datum geopotential, satellite altimetry

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Poster presentation****2526****Impact of near-field effects on the GNSS Position solution****Mr. Florian Dilner***Institut fr Erdmessung Leibniz University of Hannover***Gnter Seeber, Steffen Schn**

GNSS carrier phase multipath propagation in conjunction with signal diffraction still degrades the accuracy of high precision static and kinematic positioning. The wide range of proposed methods for multipath estimation and mitigation developed during the last two decades clearly underlines the relevance of this issue. Although much effort has been invested in refining antenna designs and in-receiver processing algorithms, multipath signals still seriously affect the GNSS observables. In static applications with highest accuracy requirements (e.g. establishment and densification of geodetic reference frames), a common-used approach makes use of extended observation periods expecting that multipath effects completely average out. However, the hypothesis of zero mean multipath is only valid in the case of short periodic multipath signals caused by distant objects. Actually, long periodic errors due to reflections from the closest vicinity of the antenna are nonzero mean distributed and therefore introduce an unmodelled bias in the estimated parameters. The effect can be simulated using geometrical ray optics. Moreover, reflecting surfaces located in the so-called Fresnel zone of the antenna (near-field region) change the overall electromagnetic properties due to induced currents caused by antenna coupling effects. In modern GNSS terminology, the resulting phase error is generally referred to as near-field effect. The objective of this contribution is to give an insight into the near-field effect with respect to the coordinate domain. In order to reveal patterns of phase errors caused by near-field influences, the Automated Absolute Field Calibration Technique developed by the Institut fr Erdmessung (IfE) of the University of Hannover and Geo++ is used. The approach has proven to be an excellent tool for such investigations. Following a brief description of this technique, calibration results of different antenna setups are presented. Then, the influence of unmodelled near-field phase errors on the positioning domain is analyzed on a local and global scale applying a Kalman filter algorithm. The primary focus is directed toward the height component estimated by long-term static ionosphere-free observations. In mid-latitude locations, the results indicate a systematic height error in the magnitude of 1-2 cm. Since GPS satellite geometry degrades with increasing station latitude, the bias can reach up to 4-5 cm in polar regions.

Keywords: gnss, multipath, near field

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Poster presentation****2527****Realization of a global vertical reference frame a case study for the areas of Germany and the european part of Russia*****Dr. Johannes Ihde****Geodesy Federal Agency for Cartography and Geodesy IAG****Gleb Demianov, Andrey Mayorov, Mariya Yurkina, Martina Sacher, Uwe Schfer, Uwe Schirmer***

In frame of a joint project of the German Federal Agency for Cartography and Geodesy (BKG) and the Federal Agency for Geodesy and Cartography of Russia (Roskartografia) new principles of the realization of a global vertical reference system in connection with precise geoid determination were investigated. The general realization of a Global Vertical Reference System bases on combinations of positioning by geodetic space techniques, levelling, gravity and tide gauge observations with a global gravity model (GGM). To reach a one centimetre accuracy level, the GGM has to be increased local or regional with gravity data. The presented solution bases on a global gravity model, dense gravity data, GNSS networks, the national levelling networks and topographic information. The modelling of contributing geodetic space techniques in ITRF solutions makes sure a global homogeneity for vertical reference system realization and unification. The equipotential surface of the real gravity field with the potential U_0 is considered to be the reference surface of the unique height system. The generalization of the approach for other regions will be considered.

Keywords: height system unification

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Poster presentation****2528****Development of a glonass infrastructure at the Federal Agency of Geodesy and Cartography of Russia (ROSKARTOGRAFIA)****Dr. Heinz Habrich**

IAG

Vladimir Gorobets, Gleb Demiyarov, Victor Zabnev, Georg Weber, Johannes Ihde

Based on an agreement between the Federal Agency of Geodesy and Cartography, Moscow, Russia (Roskartografia) and the Federal Agency of Cartography and Geodesy, Frankfurt at Main, Germany (BKG) from June 2005 both parties decided to develop an infrastructure for the integration of GLONASS in geodetic work. This project aims to determine precise GLONASS satellite orbits and station coordinates by analysis of GLONASS and GPS observations from permanently operating GNSS receivers on the territory of the Russian Federation. It is planned to install a tracking network of up to 20 new GLONASS/GPS stations over Russia and to combine the corresponding observations with other globally distributed GLONASS/GPS sites. The data management accounts for meta data of all observation sites, observation files, product files, and transport as well as archive of all files. It will be realized through a new GNSS data centre at Roskartografia in Moscow with inter-exchange to an existing GNSS data centre at BKG in Frankfurt. It is planned to operate two analysis centres at Roskartografia and BKG to process combined GLONASS/GPS observations of the global tracking network on daily basis. GLONASS satellite orbits, system time difference between GPS and GLONASS and transformation parameters between PZ90 and ITRF will be determined. Roskartografia will apply the results to their geodetic work in Russia. Roskartografia launched in December 2006 the new GNSS data centre, which is now running in a test mode. The software has been provided by BKG in a way that both data centres, at Roskartografia and BKG, look similar to the users. The station list of the new data centre holds currently 8 stations and Roskartografia is now going to establish the routine data flow for the observation files.

Keywords: glonass, data centre

(G) - IAGA - International Association of Geomagnetism and Aeronomy

GS001

Poster presentation

2529

**Completion of the Swiss national triangular transformation network:
Precise transformation between the old reference frame LV03, the new
LV95 and global ones like ETRF**

Mr. Matthias Kistler
IAG

The end of 2006 saw the completion of a basic geographical data-set of the greatest importance for the establishment of the national spatial data infrastructure SDI, the national triangular transformation network. This new data-set permits the elimination of the systematic deformations resulting from the first Federal survey of Switzerland completed in 1903 which reached a maximum of 2 to 3 m as well as the local distortions from the cadastre survey on the cantonal level. Switzerland was subdivided into almost 12'000 triangles, each having its own affine transformation parameters matched to local conditions. In addition, to prove the accuracy of the transformation, the cantonal authorities have measured almost 50 000 control points. The results were excellent: on average, geographical data in Switzerland can now be transformed into the new, error-free LV95 reference frame or in a global one like ETRF with an accuracy of 2 cm. The national triangular transformation network will also be implemented in the Swiss Positioning Service swipos as a new real-time option with GPS correction as well as "old reference frame adaptation": GPS users, who have to work in the old, for many applications still valid LV03 datum, can so position or measure with an accuracy of a few centimetres without establishing a local fit. Furthermore a new software REFRAME including all relevant transformations (position / height) and the geoid undulations for Switzerland was released as client version as well as web service. The accuracy of the transformation can be accessed through a web GIS application for everywhere in Switzerland.

Keywords: national reference frame, transformation, switzerland



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Poster presentation****2530****Strategies for processing GPS densification networks****Mr. Hüseyin Mercan***Geodesy and Photogrammetry Istanbul Technical University IAG***Rahmi Nurhan Elik**

An ever changing planet Earth's surface is covered by a series of crustal plates. Volcanoes and earthquakes continually reshape the continents and seafloor. The evolution of the shapes on the earth's surface are realized according to crustal movements in geological time dimension. The combination of the earth surface and underneath stratum manto is called as litosfer which is consisting of 12 plates moving slowly to different directions. The values of these movements varies depending on the structure of the plates such as the plates surrounding Anatolia. Anatolia states at an earthquake zone and takes place in the intersection of major plates Africa, Arabia and Eurasia, which causes plate movements continuously, and approximately 2-3 cm in a year. Therefore, if the coordinates of any station point on the earth, liked to be defined accurately in an instant time, the velocities of the points must be added to the coordinate values. Because the point coordinates change according to the time, most probable approach should be determined to process and adjust the GPS measurements. In the enclosure of the project of the renovation and condense of Istanbul GPS Network (IGNA); long period GPS measurements (21 March 2005 and 8 September 2005) are adjusted depending on mean weighted observation epoch. There were two GPS measurement sessions which were held between 21 March 2005 29 March 2005 and 3 June 2005 8 September 2005 respectively. However, in this study; instead of the coordinates, GPS baseline vectors of the first order densification points are carried to the reference epoch (2005.0) taking care of the observation date using velocity vectors. The adjustment of the data has been done by a commercial software. It has been reached more realistic coordinate values using this strategy. Moreover, these coordinate values are compared with IGNA 2005 project coordinate outputs, and differences are estimated and interpreted.

Keywords: gps, epoch, velocity

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Poster presentation****2531****Least squares spectral analysis as applied to the adjustment of the national levelling network of Iran****Dr. Mahmood Mohammad Karim***Gravity Field Precise Levelling Network Adjustment IAG****P. Vanicek, Y. Djamour, Y. Hatam, M. Nikkho, S. Arabi, B. Voosoghi, M. Najafi Alamdari***

It is a well known fact that the observed levelling values unavoidably contain systematic errors. Considering this fact into account, in setting up a proper stochastic model, i.e., the variance covariance matrix of the observations of a levelling network, the covariances should be involved. This makes such a matrix to be fully populated. Traditionally a diagonal matrix with elements inversely proportional to the distances between the bench marks of a network is used for this purpose which evidently is not appropriate. The main problem with constituting such a fully populated matrix is modeling the covariances. Several scholars attempted to solve this problem. Here, in National Cartographic Centre (NCC) of , which is responsible for the geodesy as well, a new method through a research construct has been developed in this respect, which later to be used in the adjustment of the national leveling network. In this study the height discrepancies (shown as Dis) between forward and backward runnings of consecutive bench marks took as the observations. Using the observed height differences and gathered auxiliary data some arguments may be defined. Several data series formed such that the elements of each of them were Dis as the functional values of the related argument. Following this way we arrived at a set of linear equations asFor which the multi linear regression technique employed to solve for the trendsand the Least Squares Spectral Analysis (LSSA) and its inverse, that is the Autocorrelation Functions (ACF) to analysis the residuals.Using the latter led us to construct the desired matrix. A MatLab program developed for both methods. This approach satisfactorily was tested in a loop of the leveling network of Iran.

Keywords: lssa, acf

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Poster presentation****2532****Latest Enhancements in the Brazilian Active Control Network****Dr. Luiz Fortes***Directorate of Geosciences Brazilian Institute of Geography and Statistics IAG****Sonia Maria Alves Costa, Mario Alexandre De Abreu, Alberto Luis Da Silva, Newton Jos De Moura Jnior, Joo Francisco Galera Monico, Marcelo Carvalho Santos, Pierre Ttreault***

The Brazilian Network for Continuous Monitoring of GPS RBMC, since its foundation in December of 1996, has been playing an essential role for the maintenance and user access of the fundamental geodetic frame in the country. It provides users with a direct link to the Brazilian Geodetic System - SGB. Its role has become more relevant with the increasing use of space navigation technology in the country. Recently, Brazil adopted a new geodetic system, SIRGAS2000, in February 2005, fully compatible with GNSS technology. The paper provides an overview of the recent modernization phases the RBMC network has undergone highlighting its future steps. From its current post-mission mode, the RBMC will evolve into a real-time network, providing real-time data and real-time correction to users. The network enhanced with modern GPS receivers and the addition of atomic clocks will be used to compute WADGPS-type corrections to be transmitted, in real time, to users in and surrounding areas. It is estimated that users will be able to achieve a horizontal accuracy around 0.5 m (1-sigma) in static and kinematic positioning and better for dual frequency users. The availability of the WADGPS service will allow users to tie to the new SIRGAS2000 system in a more rapid and transparent way for positioning and navigation applications. It should be emphasized that support to post-mission static positioning will continue to be provided to users interested in higher accuracy levels. In addition to this, a post-mission Precise Point Positioningservice will be provided based on the one currently provided by the Geodetic Survey Division of NRCAN. The modernization of the RBMC is under development based on a cooperation signed at the end of 2004 with the University of New Brunswick, supported by the Canadian International Development Agency and the Brazilian Cooperation Agency. The Geodetic Survey Division of NRCAN is also participating in this modernization effort under the same project.

Keywords: active control network, wadgps, sirgas2000

(G) - IAGA - International Association of Geomagnetism and Aeronomy

GS001

Poster presentation

2533

**The Use of GNSS for Reference Frames Report of IAG SG 1.2 and the IGS
GNSS Working Group**

Dr. Robert Weber

Institute of Geodesy and Geophysics University of Technology, Vienna IAG

Carine Bruyninx

For more than 12 years the International GNSS Service (IGS) delivers a large set of high quality products for a huge number of applications e.g. in geodynamics, surveying or atmosphere monitoring. A key objective is to provide users anywhere in the world access to highest level Global Navigation Satellite Systems data, products and resources for scientific applications, through an open data policy. This is naturally dependent upon the availability and performance of the various satellite systems and therefore on the success of ongoing modernization programs of GPS and GLONASS. Recognizing in addition the importance of the upcoming new European satellite navigation system (GALILEO) and the services provided by existing and new SBAS Systems the IGS decided in 2003 to set up a GNSS-Working Group which should closely coordinate with IAG SG 1.2 on the Use of GNSS for Reference Frames. The IGS GNSS WG touched mainly upon the strategies of the International GPS Service for optimizing the future use of multiple integrated GNSS while IAG Study Group 1.2 evaluated and supported the use of Global Navigation Satellite Systems for the definition and densification of the ITRF. The operating GNSS systems allow a huge user community easy access to reference frames very close to the most recent realization of the ITRS. The IAG Services IERS (International Earth Rotation and Reference Systems Service) and IGS provide the necessary products to tie these frames to the ITRF (International Terrestrial Reference Frame), which is based upon a set of estimated coordinates and velocities of stable stations observed by all space techniques. The design of the upcoming European GALILEO system implies that also GALILEO will become a highly valuable technique for the definition and maintenance of the ITRF. This presentation summarizes the work carried out by both Working Groups over the past years.

Keywords: gnss, reference frame



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Poster presentation****2534****Present day velocities estimation for monitoring of regional reference frames by continuous GPS observations****Dr. Juan Carlos Baez**
*Surveying Professor****Silvio Rogerio Correia De Freitas, Hector Parra, Rodrigo Maturana***

From 2000.4, the latest realizations of SIRGAS reference frame, continuous GPS observations from a selected frame of reference stations located in South America were used to observe position variation mainly in the South Andes region. The network used in this experiment consists of 8 stations from the permanent Chilean GPS network, 2 stations of the South American Geodynamic Activities Project, 14 IGS stations, 4 Argentinean Network of Continuous Monitoring and 2 stations of the Brazilian Network of Continuous Monitoring. As a result of the analyses of the time series, signals were found in the north, east and up components. For better comprehension, spectral analysis was also performed in order to obtain the frequency and amplitude of the signals. Annual and semi-annual signals for most of the IGS stations were found in the three components. The obtained velocities for the Andes region are $N=15.8$ 0.9 and $E=30.2$ 1.1 mm/y. For the stations located on the northern part of Chile are $N=14.4$ 0.5 and $E=21.2$ 0.8 mm/y. In the southern part the variations are smaller. $N=-12.5$ 0.8 and $E=0.0$ 0.6 mm/y that could confirm the cinematic changes due to the triple contact of Nazca, Antarctic and South American plates. From the time series, for some of the stations, we also recognised a displacement due to seismic activities. This task is fundamental in order to maintain the consistency of the frame with respect to the definition of SIRGAS 2000, especially in the Chilean tectonic deformation area, where the variations are larger compared with the rest of the South-American plate. The differences for the Andes region are significantly larger than for the stable part of the plate. We compared our results with other geodetic estimations and differences of 9 mm/y were detected. Another comparison was done with the DGF06P01 solution, coming from the RNAAC-SIR, in this case the differences are smaller than 1 mm/y with RMS $N=1.7$ and $E=1.3$ mm/y for most of the stations.

Keywords: geodetic, reference, frame

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Poster presentation****2535****A possible explanation for periodic signals in the formal errors of geodetic station position time series****Mr. Xavier Collilieux**

LAREG IGN France

David Coulot, Zuheir Altamimi, Philippe Berio

Weekly station position time series provided by GPS and SLR analysis centres are known to reveal clear seasonal patterns with few millimetres of amplitude. But the analysis of height residual time series as result from the ITRF2005 analysis has revealed seasonal signatures in the formal errors themselves. We think that these variations may be related to the application of the unit variance factor at the normal equation system resolution level, when the geodetic parameters are processed using geodetic observables. Indeed, earth crust motions such as displacements related to atmospheric loading or hydrological loading, exhibit temporal variations at a wide range of frequencies. But as they are currently not modelled in that processing, they cause variations in the total mean square error, depending on the epoch of the year. As a consequence the variance unit factor varies in time in the same way. This effect will be illustrated thanks to simulation conducted with the SLR data analysis software MATLO.

Keywords: slr, seasonal signals, uncertainties

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Poster presentation****2536****The Portuguese Geodetic Reference Frames*****Mrs. Manuela Vasconcelos****Departamento para a Geodesia Instituto Geografico Portuges IAG****Henrique Botelho, Helena Kol, Joo Casaca***

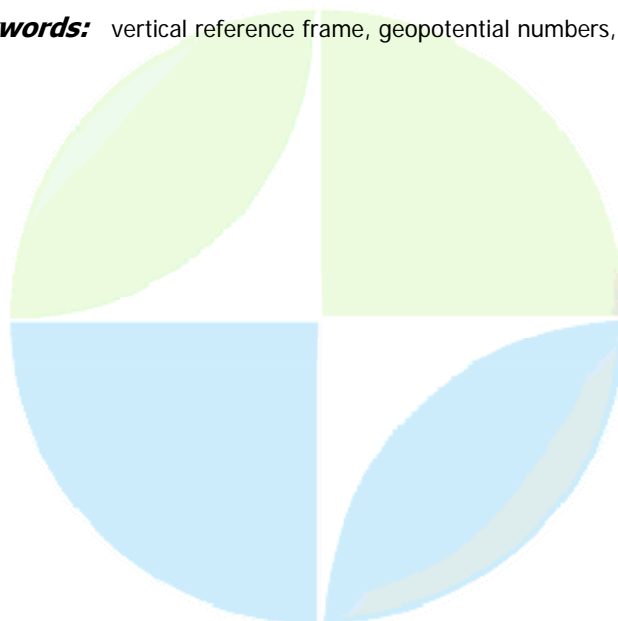
In this poster we will present an overview of the state-of-the-art of the Portuguese Geodetic Reference Frames, covering the Mainland and the Archipelagos of Azores and Madeira. In 1989 participated in the first GPS campaign promoted by EUREF (the IAG Sub-Commission for the European Reference Frame) with the purpose of connecting the European countries. Given that these measurements did not cover appropriately the Iberian Peninsula, a densification network was measured later on in the IBERIA 95 campaign. Between 1999 and 2004 the 1st and 2nd orders geodetic networks (around 1000 trig points) were measured with GPS and connected to the results of IBERIA95. The geodetic network of mainland is now a realization of the ETRS89. In the Azores and Madeira archipelagos a group of points was measured in the international GPS campaign TANGO1994 (Trans-Atlantic Network for Geodynamics and Oceanography). In the subsequent years the geodetic networks of all the islands were measured with GPS and a realization of ITRS93 was established as the reference frame for the archipelagos. In Parallel with this work, a Permanent GPS Network is being implemented. In 1997 the first station was installed in Cascais (CASC), near a tide gauge which is in operation since 1882. The present CGPS network consists of six stations in the Mainland, one in the Azores and another one in Madeira. The CASC, LAGO and GAIA stations are part of the EPN (EUREF Permanent GPS Network) and PDEL, in the Azores, belongs to the IGS (the International GNSS Service) network. The Portuguese Geographic Institute (IGP) is now working on the densification and the upgrade of the CGPS network with two main goals: the maintenance of the national reference frame and to provide a real time precise point positioning service.

Keywords: national reference frame, etrs89

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Poster presentation****2537****Improving Gravity Coverage over Brazilian Fundamental Vertical Network****Mr. Roberto Teixeira Luz***Geodetic Sciences Program (CPGCG) Parana Federal University (UFPR) IAG****Silvio Rogério Correia de Freitas, Bernhard Heck***

Geopotential numbers for the 65 thousand benchmarks (BMs) of the Brazilian Fundamental Vertical Network (BFVN) were not systematically computed yet due to several difficulties. Most of the older BMs were destroyed before 1995, when the new BFVN's leveling lines started to be routinely occupied with gravity surveys by the same geodetic organization. A large number of previous gravity surveys was performed by several institutions, most of them focused to applications in Geology and Geophysics, with different specifications, unknown quality and few coincidences to BFVNs BMs. Thus, BFVN has very few and poorly distributed BMs with homogeneously measured gravity values. Within the activities related to the integration of the South American leveling networks by the SIRGAS Project, it was recommended to use a least squares collocation (LSC) procedure for gravity interpolation at each point of interest. Tests with the computational tool released by SIRGAS Working Group Vertical Datum (WG3) were performed in one of the few areas of BFVN where its lines are relatively recent and have homogeneously gravity measurements over almost all BMs. These tests have shown that the quality of results from such a procedure to Brazilian conditions is degraded by the BFVN's large extension, the inhomogeneity of BMs distribution and the variability of the Brazilian geological characteristics. On the other hand, a much denser distribution of gravity points is achieved when those data from other institutions collected by IAG's Sub-Commission for Gravity and Geoid on South America (SCGGSA) are considered. However, there are undocumented BM coincidences and datum differences which introduce serious difficulties when using these data. Thus, there are also some strategies under investigation aiming at the improvement of systematic errors treatment. The discussion of alternatives for gravity prediction, and the consideration of permanent tidal effects and terrain effects are included among those strategies. Besides these steps, there are additional efforts directly at the source institutions towards the collection of supplementary information which will improve the usefulness of the SCGGSA database. An independent validation of those procedures is under development using the integration of improved coastal satellite altimetry information to tide gauge data.

Keywords: vertical reference frame, geopotential numbers, sirgas



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Poster presentation****2538****Searching for the optimal relationships between SIRGAS2000, South American Datum of 1969 and Crrego Alegre, in Brazil****Dr. Marcelo Santos***Geodesy and Geomatics Engineering University of New Brunswick IAG***Leonardo Oliveira, Sonia Costa, Felipe Nievinski, Mauricio Galo, Paulo Camargo, Carlos Silva, Rodrigo Leandro**

Brazil has moved towards the adoption of a geocentric system, SIRGAS2000. With the adoption of this system, starting in 2005, a great demand was created towards transforming the current data sets from the South American Datum of 1969 (SAD-69), in its two distinct realizations, and the Crrego Alegre frames into SIRGAS2000. The fact that these four frames will co-exist until 2014 creates positives and negatives situations. This paper describes the current efforts towards defining the optimal relationships among these four frames, from the mathematical point-of-view. There are a number of methodologies currently being tested, including least-squares collocation, neural networks and weighted inverse of the distance from control points. The paper also discusses current issues related to the adoption of SIRGAS2000, and the demands of the community of users, from the perspective of their different applications. The work described in the paper has been carried out under the scope of the National Geospatial Framework Project, sponsored by the Canadian International Development Agency.

Keywords: geodetic frames, helmert transformation, modelling of distortions

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(G) - IAGA - International Association of Geomagnetism and Aeronomy

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Poster presentation

2539

Coordinates transformation by "ZONING METHOD" for parameters computing between WGS84 and North Sahara "clarke 1880" Systems

Dr. Kheloufi Nouredine

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The global transforms models (bursa -wolf, molodensky-badekas) are the famous method used to compute transformation parameters between geodetic systems. In our case, for a huge territory like Algeria, these models are not most appropriate to give a good accuracies over these parameters, because information about local geoid over ellipsoid Clarke 1880 is not available but the two dimension models such as geodetic lines, multiple regression , have given best results applied over the Algerian area. That's why we are hold to use a new method to compute the transform parameters with good accuracies, this method is called "zoning" and it consist to delimitate our territory to little zone in order to apply three dimension models (bursa- wolf, molodensky-badekas), in this case we can avoid great geoid undulation which generate errors on computation of parameters and thus give a bad accuracy. These parameters while computed, we can use them to transform a new point over the entire zone, and the results are validated by a computation program called TRANSFOR.

Keywords: geodetic systems, ellipsoid clarke1880, zoning transfor



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Poster presentation****2540****The role of NASA's Global GPS Network in Regional and Global Geodesy****Mr. Oivind Ruud***not sure IGS member*

NASA supports the Global Navigation Satellite System (GNSS) infrastructure through a network of 75 permanent stations called the Global GPS Network (GGN). The GGN is operated cooperatively by JPL and UNAVCO. GGN data are contributed to the International GNSS Service (IGS) global network. GGN stations make up approximately 20 percent of the IGS and are some of its longest running core stations. GGN sites provide 1 to 30 second sampling and a number of stations have available real-time data streams. Data are used to produce highly accurate products that are essential for Earth science research and other multidisciplinary and educational applications. Products include GNSS precise satellite orbits, Earth rotation parameters, global tracking station coordinates and velocities, satellite and tracking station clock information, zenith tropospheric path delay estimates, and global ionospheric maps. These global data and products form the critical framework that regional GNSS networks depend upon. The GGN is currently being upgraded to accommodate additional GNSS observables as they become available including the new GPS L2C and L5 signals, Galileo, and GLONASS. Careful consideration is being made to integrate new equipment and observations without adversely affecting the time series measurements at critical stations. As part of this effort, a special new monument design is being tested at UNAVCO's Colorado test facility. The monument can accommodate multiple antennas that can be used for collocated observations while new site equipment is phased into operation. Also, as an example of combined NSF/NASA funded efforts, recent updates to the UNAVCO developed Translation, Edit, and Quality Control Software (TEQC) supporting GNSS developments will also be discussed.

Keywords: nasa, gps, gnssPERUGIA
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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS001****Poster presentation****2541****Remarks on the ITRF2005 reference frame*****Dr. Giuseppe Bianco******R. Devoti, V. Luceri, C. Sciarretta***

The new geodetic reference system ITRF2005 was constructed by combining time series from all the space geodesy techniques. The consistency with the former ITRF2000 is only assured by constraining the orientations to be identical at epoch 2000.0 and null orientation rates between the two frames, however the translation and its rate were fixed to the SLR solutions and the scale and its rate to the VLBI solutions. This datum definition causes the new reference frame to differ in the z-direction translation rate, drifting at 1-2 mm/yr and inducing a velocity deformation rate (scale rate) on the order of 0.1 ppb. This inconsistencies are not negligible when faced with SLR data, that are directly sensitive to scale and scale rate. Differences induced in the velocity field and core network effects were discussed in order to assess the real stability and accuracy of the new reference frame.

Keywords: remarks, itrf2005, frame

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****2542 - 2756****Symposium
Gravity Field****Convener :** Dr. Pieter Visser, Dr. Urs Marti, Prof. Christopher Jekeli**Co-Convener :** Prof. Shuhei Okubo, Dr. Nico Sneeuw

The symposium will deal with the subjects covered by IAG Commission 2 and the related services: Terrestrial, marine, and airborne gravimetry. Satellite gravity field observations. Gravity field modeling. Time-variable gravity field. Geoid determination. Satellite orbit modeling and determination. All aspects of theory are also included. (See also Symposium JGA1.)


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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2542****An Attempt towards an Optimum Combination of Gravity Field Wavelengths in Geoid Computation****Prof. Hussein Abd-Elmotaal***Civil Engineering Department Minia University, Egypt IAG***Norbert Khtreiber**

The optimum combination of gravity field wavelengths in the framework of geoid computation remains always a hot research topic. Different approaches for such a combination of the wavelengths are existed. The window technique (Abd-Elmotaal and Kuehtreiber, 2003) has been suggested to get rid of the double consideration of the topographic-isostatic masses within the data window in the framework of the remove-restore technique. The modified Stokes kernel with different approaches has been suggested to possibly combine the local data signals with the global geopotential earth models. Both techniques have been used in computing a gravimetric geoid for Austria. The available gravity, height and GPS data for the current research are described. The EGM96 geopotential model has been used. A wide comparison between modified Stokes kernel with different approaches and window techniques has been carried out within this investigation in the framework of the geoid computation. The comparison is made on two different levels; the residual gravity anomalies after the remove step and the computed geoid signals before and after scaling to the GPS/leveling geoid.

Keywords: window technique, modified stokes kernel, geoid determination

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2543****An updated geoid model for Africa****Prof. Charles Merry***Geomatics University of Cape Town IAG*

Precise geoid models are essential for the conversion of GPS-derived heights to heights above sea level. This paper presents an update on an earlier model (AGP2003) of the geoid for Africa, and incorporates new contributions from the KMS02 marine gravity data set, the SRTM30 DEM and long wavelength harmonic coefficients from the Eigen-GRACE CG03C model. A uniform 5' grid of gravity anomalies derived from terrestrial gravity data has been combined with the marine data, and the combined data set has been used with the geopotential model in a remove-restore process. Two-dimensional convolution has been used to compute residual height anomalies from residual gravity anomalies, including the contribution of the Molodensky G1 term. The geopotential model contribution has been restored and the height anomalies converted to geoidal heights. The final result is a 5' grid of geoidal heights covering the land mass of Africa. There are significant gaps in the available terrestrial gravity data. These gaps mean that the accuracy of the final geoid model will be variable and generally less than desirable. Nevertheless good agreement is achieved with GPS/levelling results in western South Africa. The model will also be compared with the forthcoming EGM2006 model.

Keywords: geoid, gravity, geopotential

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2544****Gravity Field and Geoid in the Antarctic Peninsula Region*****Dr. Mirko Scheinert****IAG Commission Project 2.4 TU Dresden IAG****Fausto Ferraccioli, Jan Miller, Tom Jordan, Reinhard Dietrich***

The densification of the terrestrial gravity data coverage and the improvement of the geoid in Antarctica are the main goal of the IAG Commission Project 2.4 "Antarctic Geoid" (AntGP). Due to orbit characteristics gravity data collected by the dedicated satellite missions like GRACE and (upcoming) GOCE suffer the polar gap problem. Furthermore, terrestrial gravity field observations still lack substantial coverage in Antarctica. The status of AntGP will be presented. Within this framework, current and planned international efforts will be reviewed. In this context, especially the International Polar Year 2007/08 (IPY) sees a lot of activities for the realization of respective geodetic-geophysical programs. The anticipated work within various planned IPY projects will help to densify and improve the gravity field in Antarctica. We will especially focus on the work done so far in the region of the Antarctic Peninsula. Terrestrial gravity observation campaigns as well as aerogeophysical surveys will be treated. We will demonstrate the high value of the collected gravity and auxiliary data to carry out a regional geoid determination. The improved geoid will be compared with the global solutions based on satellite data as well as with similar solutions for other Antarctic regions. Additionally, we will discuss the information provided by the gravity data to investigate geophysical questions like the structure of the upper layers of the Earth and to discriminate different crustal zones.

Keywords: regional geoid, antarctica, gravity field**PERUGIA**
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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2545****Flexural isostatic anomalies from the wavelet transform*****Dr. Jon Kirby****Spatial Sciences Curtin University of Technology IAG****Chris Swain***

In many geodetic studies requiring an isostatic anomaly, the locally-compensated Airy and Pratt models are employed. However, it has long been known that the Earth's lithosphere possesses a finite flexural rigidity, meaning surface and subsurface loads are supported by the mechanical strength of the plate, rather than isostatically compensated. Using a new wavelet transform approach, we are now able to reveal spatial variations in the flexural rigidity, which in turn can be used to compute a flexural isostatic anomaly. Here we present results over the Australian and North American continents, comparing the Airy, uniform-rigidity, and variable-rigidity isostatic anomalies.

Keywords: isostasy, lithosphere, wavelets

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2546****Gravity changes caused by tide-generating potential and by internal dislocation in a 3-D heterogeneous earth (2) numerical results****Dr. Wenke Sun***Geodesy The University of Tokyo*

In the previous presentation (Gravity changes caused by tide-generating potential and by internal dislocation in a 3-D heterogeneous earth (1) Theory by Fu and Sun), a new theory is presented to compute gravity changes caused by tide-generating potential and by internal dislocations in a 3-D heterogeneous earth. In this presentation, we report the numerical results. Based on the 3-D lateral inhomogeneous P-wave velocity model (Zhao, 2001), we deduce the 3-D density and S-wave velocity models using the relation of Karato (1993). Using the three parameters of the 3-D heterogeneous earth model, we calculate the tidal factor changes. Numerical results reveal that the density effect is of the same level as that caused by seismic wave velocity models; consequently, they cannot be ignored. The results indicate that the 3-D effect calculated by Molodenskiy and Kramer (1980) for the Ocean-Land model was over-estimated. The maximum gravimetric factor change caused by the 3-D structure is about 0.16%. We also calculate the corresponding effects on tidal gravity for all three kinds of Earth tide: semidiurnal, diurnal, and long-period ones. Compared to the tidal gravity, the gravity variations resulting from those increments are about 0.15% for the semidiurnal tide and 0.1% for the diurnal and long-period tides. As for the co-seismic gravity changes caused by internal dislocations, numerical computations are performed for a location south of Japan, using the displacement and potential changes calculated for a spherically symmetric earth model as inputs. We calculate the co-seismic gravity changes resulting from the six independent dislocations for source depths of 100, 300 and 637 km. Numerical results show that the maximum 3-D effect is about 1.3% compared to the unperturbed one. This value varies concomitantly with the source depth. For seismic problems, the effect of seems to be dominant. In addition, a comparison of results calculated for different 3-D earth models with different truncation indicates that the more detail the 3-D earth model, the greater the 3-D effect.

Keywords: gravity change, 3 d earth, dislocation

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2547****A new method of height datum unification using GPS and gravity data*****Dr. Liming Zhang****Institute of Geodesy and Geophysics Chinese Academy of Sciences IAG****Li Fei, Wu Chen***

Based on the second geodetic boundary value problem (BVP), a new method to determine difference between global height datum and local height datum is put forward. GPS provides ellipsoidal height irrelevant to the local datums, and gravity measurements can be regarded as belonging to Global Absolute Gravity Network (GAGN). In this method, GPS and gravity measurements are taken as basic inputs to calculate the height anomaly relative to global height datum. The GPS and leveling data are used to determine height anomaly relative to local height datum. Then, a local height datum (obtained by GPS/leveling data) can be compared with the global reference surfaces individually. Using this method, the error from the gravity potential model can be weakened or avoided due to making full use of the practical gravity data and GPS data. As an example, we calculate the vertical differences between Chinese height datum 1956 and the Hong Kong height datum 1980, and obtain the value is 0.8970.036m with the gravity potential value of $8.7800.352\text{m}^2\text{s}^{-2}$. The result is consistent with the leveling connection result.

Keywords: height datum, gps gravity, boundary value problem

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GS002

Oral Presentation

2548

Exploring the possibilities for calibrating the GOCE accelerometers by the star trackers

Dr. Pieter Visser

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The Gravity field and steady-state Ocean Circular Explorer (GOCE) is the first European Space Agency (ESA) core earth explorer that is foreseen to be launched at the end of 2007. The primary instruments on board of GOCE are a gravity gradiometer and a GPS receiver. In addition, GOCE will be equipped with an ion engine and star trackers. The gradiometer consists of a orthogonal triad of three pairs of accelerometers, with its center slightly offset from the satellite's center of mass. By taking appropriate combinations of observations taken by the individual accelerometers, by modeling acceleration terms caused by gravity gradients from an a priori low-degree spherical harmonic expansion, and by modeling rotational acceleration terms derived from star tracker observations, biases and scale factors of the individual accelerometers can be estimated. A method to this aim has been implemented and tested with simulated test data. The following accelerometer error sources were taken into account: frequency dependent observation noise, misalignments of the axes of the individual accelerometers, biases and scale factor errors. In addition, the star tracker observations were corrupted by realistic measurement errors. Tests have indicated that scale factors of all six individual accelerometers can be estimated with an accuracy of around 0.01 on a daily basis.

Keywords: gradiometer, calibration, startracker

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2549****Molodenskys theory and modern satellite technologies*****Prof. Elena Mazurova***

The application of satellite methods has made it possible to establish a uniform three-dimensional reference frame on the whole surface of our planet. It means that the Earth's surface can be considered to be known. Therefore at present, one can turn from solving the boundary-value problem formulated by Molodensky (1945,1960) where the boundary-value surface itself is to be determined, to tackling the boundary-value problem of physical geodesy with a known boundary-value surface and another boundary-value condition. Modern satellite measurements allow gravity disturbances to be calculated as accurately as gravity anomalies. With the GNSS-measurements available, the solution of Molodenskys basic integral equation presented in the work has shown that the new type of measurements fits well Molodenskys theory, imposing however only much heavier demands on its precision. But the precision of Molodenskys theory can always be increased. The work also discusses the calculation of the height anomaly from gravity anomalies and gravity disturbances (Stokes and Neumanns formulae, accordingly) as well as that of the deflection of the vertical (Vening Meinesz formula and the modified Vening Meinesz formula). All calculations for the central zone () are done on the basis of FFT (Fast Fourier Transform). The account of the influence of the far zone (of the whole surface of the Earth) while doing calculations of the anomaly of height and that of the deflection of the vertical from gravity anomalies and gravity disturbances is performed by expanding the corresponding gravity anomaly or gravity disturbance into spherical surface harmonic series.

Keywords: gravity disturbances, gravity anomalies, height anomaly



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2550****Modeling the time variations of the Earth gravity field by Ensemble Kalman Filter****Dr. Zhang Zizhan***Institute of Geodesy and Geophysics Chinese Academy of Sciences IAG***Houtse Hsu**

Mass redistribution and transport within the Earth system introduce changes in the Earth gravity field. Studying time variations in Earth's gravity field is important for understanding global mass variability and exchanges among the land, ocean, and atmosphere, especially for subsystems that might otherwise be extremely difficult to detect and monitor. In the past, only the low-degree gravitational changes (very long wavelength gravitational changes) were implemented through analyzing satellite laser ranging (SLR) data. However, these SLR measurements have been limited in resolution because of the geographic distribution of the tracking data and the high altitude of the satellites. The GRACE mission was implemented to provide global measurements of gravity, more importantly, with a much finer spatial resolution and greater accuracy than previously possible. This makes it possible to model the time variations of the Earth gravity field. The time-spatial variations of the Earth gravity field are very complex, and up to now, there is no a priori dynamic model about it. The goal of this paper is that we attempt to build a dynamic model of the Earth gravity field. We firstly construct an initial model by curve fitting, basing on a sequence of monthly gravity field coefficients data sets determined from GRACE data. And then, an Ensemble Kalman Smoother (EnKS) method is used to modify the bias and parameters (e.g. parameter of trend term, annual term, seasonal term) of the initial model with innovational data. Lastly, this dynamical model of the Earth gravity field is represented as Ensemble Kalman Filter due to its simple conceptual formulation and relative ease of implementation. This dynamical model will be significantly important for research of geodesy, geodynamic, oceanography etc. For example, forecasting gravity fields changes, determining the time-varying dynamic ocean topography combined with sea surface height in same space-time domain and so on.

Keywords: modeling, time variations, earth gravity field

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2551****Height datum unification in Greece employing Tide Gauge, Marine Geoid and Sea Surface topography data*****Dr. Georgios S. Vergos****Department of Geodesy and Surveying Aristotle University of Thessaloniki IAG****Ilias N. Tziavos***

Countries like Greece with extensive coastlines and a large number of islands, usually suffer from the absence of a common, for the entire country, vertical reference system. This holds not only for the islands, where hydrostatic leveling has not been applied, but also for distant parts of the country where trigonometric and leveling benchmarks are not tied to the countrys vertical zero, but to a local one usually coinciding with a local tide gauge station. Especially for Greece, no effort has been made until today for a common adjustment of all tide gauge data and for the unification of the countrys vertical datum. The present work focuses on the utilization of available tide gauge and leveling data with computed marine geoid and sea surface topography models to determine a common corrector surface for continental and insular Greece towards the unification of the countrys vertical datum. This surface provides correction values to be applied to local tide gauge data so that the local zero height will coincide with that at the origin of the vertical system. The concept is based on a common adjustment of all aforementioned data in a parametric scheme imposing a condition about the value of the corrector model at the existing vertical origin of the country. Various reference surfaces are investigated and validated against each other and in terms of the prediction error they provide. The results of this work successfully manage to provide correction values for the entire country, so that local heights tied to a local tide gauge station can be referred to the initial point of the countrys vertical datum.

Keywords: height unification, geoid, sea surface topography

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2552****Earth gravitational model to degree 2160: status and progress**

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Simon A. Holmes, Steve C. Kenyon, John K. Factor

The development of a new Earth Gravitational Model (EGM) to degree 2160 is progressing with the availability of improved versions of the 55 global gravity anomaly database and with improved versions of GRACE based satellite-only solutions. After resolving several issues related to (mostly) land data availability, our efforts have now focused on four specific research and development areas. (1) The estimation of an improved ocean-wide set of altimetry-derived gravity anomalies (based on improved Mean Sea Surface and Dynamic Ocean Topography models). (2) The re-iteration of the global 55 gravity anomaly database estimation, using a reference model to degree 2160 and a formulation that aims to predict gravity anomalies that will be band-limited to degree 2160. (3) The implementation and validation of an alternative approach for the analytical continuation, which is based on a Taylor series expansion with gravity anomaly gradients computed iteratively from the harmonic coefficients themselves. (4) The refinement and calibration of the error estimates that accompany our combination solution. We will present preliminary (test) solutions designed to explore the various aspects associated with these four areas, along with their evaluation. This evaluation is accomplished primarily through the comparison of various model derived quantities with independent data and models (GPS/levelling implied geoid undulations, deflections of the vertical, etc.). We will present comparisons of the model-implied Dynamic Ocean Topography to other contemporary estimates (e.g., from ECCO). We will also present indicators internal to each solution (e.g., residuals, power spectra) and comparisons involving their lower degree portion (e.g., $N_{max}=60, 120, 360$) to existing models, which also serve to gauge the performance of these solutions. In addition, we will discuss the availability of preliminary solutions that will be provided to the Joint IAG/IGFS Working Group for evaluation.

Keywords: gravitational models, high degree, harmonic expansions



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2553****The Role of the Atmosphere for Satellite Gravity Field Missions****Dr. Thomas Gruber***Inst. für Astronomische und Physikalische Geodäsie Technische Universität München IAG***Thomas Peters, Lieselotte Zenner**

In view of the precision of measurements taken by current and future satellite gravity field missions, the role of the atmosphere becomes more and more important for their analysis. Traditionally, in satellite derived static global gravity field models, the total mass of the Earth is considered to be the sum of the solid Earth mass and the water masses in land (hydrology), oceans, ice (continental ice and sea ice) and atmosphere. The total mass is reflected in the GM value (gravity constant times Earth mass). For the static fields either GM (or a correction) is estimated (depending on the observation types available) or it is fixed by an a-priori value. As the whole system Earth is mass conserving in principle GM should be constant over time. Any time dependency of GM could only be caused by wrong estimates for GM (or the corresponding zero degree coefficient of the spherical harmonic series). For analysis of the time variable gravity field the situation is more complex, because masses are fluctuating at various temporal and spatial scales and are exchanged between components of the Earth system. Disregarding mass variations inside the solid Earth (e.g. by earthquakes, mantle convection, etc.) the water cycle represents the major source of mass variations, of which the atmosphere plays the most prominent role (by pressure field variations, by forcing ocean circulation, by precipitation and evaporation). In order to take into account such temporal variations for gravity field analysis the sampling pattern of the satellite mission and its sensors in addition play a crucial role. This means that during gravity field recovery the known part of mass variations with respect to the mean value have to be modelled independently and corrected for in order to avoid aliasing of temporal signals into the resulting fields. In contrast, unknown time variable mass variations have to be estimated. Both approaches are applied nowadays in the GRACE data analysis simultaneously. The paper reviews the role of the atmosphere for static and time variable gravity field modelling and provides an error analysis related to the modelling as well as related to uncertainties in the atmospheric data.

Keywords: gravity field missions, atmosphere

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GS002

Oral Presentation

2554

Definition of local geoidal potential and datum height difference of Turkish National Vertical Control Network (TUDKA99)

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Orhan Firat, Coskun Demir, Bahadir Aktug, Ayhan Tekgul, Ahmet Direnc

The determination and use of height require the definition of a reference surface, which is called the vertical datum, preferably a equipotential surface. The definition of the vertical datum is made by assigning values to a number of vertical control points. In classical approach considering the geodetic tools available at that time, vertical datums have been established by using local or regional data. Thus, a number of local (national) vertical datums are currently in use in the world. The determination of the geopotential differences between the local vertical datums and the development of a world height system has been the debated for about two decades. These geopotential numbers referred to a unique datum point, are then compared, at leveling points with known ITRF positions, to the geopotential numbers evaluated from the global gravity field model (e.g. EGM96). This estimated datum geopotential is then used to compute a datum (geopotential) height offset with respect to the adopted W_0 of the global datum. This type of datum geopotential determination was applied in Turkey with available GPS/leveling stations. There are 197 GPS/Leveling stations, covering a sufficiently large area in order to avoid EGM resolution error. The geoidal geopotential of the Turkish Vertical Datum is found to be 63636858.32 m²s⁻². This shows that local height datum determined at Antalya tide gauge station is 23.7 cm +/- 11.3 cm lower than the reference surface specified by the geoidal geopotential 63636856.0 m²s⁻².

Keywords: height system, geopotential, vertical datum



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2555****The linearized GBVPs; quantitative estimates with square integrable data****Prof. Fernando Sansò**
diar politecnico di milano IAG

The theory of GBVPs provides the basis to the approximate methods used to compute global gravity models. A standard approximation procedure is least squares, which implicitly assumes that data, e.g. gravity disturbance or gravity anomaly, are given functions in $L^2(S)$. We know that solutions in these cases exist, but uniqueness (and coerciveness which implies stability of the numerical solutions) is the real problem. Conditions of uniqueness for the linearized fixed boundary and Molodensky problems are studied in detail. They depend on the geometry of the boundary; however the case of linearized fixed boundary BVP puts practically no constraint on the surface S , while the linearized Molodensky BVP requires the previous knowledge of very low harmonics, for instance up to degree 24, if we want the telluroid to be free to have inclinations up to 70 degrees.

Keywords: fixed boundary bvp, linearized molodensky bvp, uniqueness stability

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2556****On a refined global topographic correction to gravity disturbances****Dr. Peter Vajda***Geophysical Institute Slovak Academy of Sciences IAG***A. Ellmann, B. Meurers, P. Vanček, P. Novk, R. Tenzer**

Several aspects of defining and compiling anomalous gravity data needed in gravimetric inversion or interpretation are discussed. Emphasis is placed on global evaluation of the topographic correction to the gravity disturbance. The evaluation of this topo-correction, which adopts the reference ellipsoid as the lower boundary of topographic masses, is challenged by the existence of areas of negative ellipsoidal (geodetic) heights of the topographic surface both on the dry land and on seas. This challenge is tackled by replacing the reference ellipsoid, serving both as the lower boundary of the topographic masses and as the upper boundary of the normal masses that generate the normal potential and normal gravity, by a reference spheroid below the ellipsoid, the so called reference quasi-ellipsoid. The adoption of the quasi-ellipsoid results in a benefit of making the gravitational part of the normal potential harmonic below the reference ellipsoid down to the level of the quasi-ellipsoid. The stripping of the unwanted global gravitational effect of water between the reference (quasi-)ellipsoid and sea level on oceans is treated also. Stripping is outlined also for the global effect of sea water down to the sea bottom, and for additional geological elements such as lakes, glaciers, sedimentary basins, isostatic mountain roots, etc. All of this is performed in the context of the gravimetric inverse problem. Numerical examples of the discussed effects are given for a region covering both the ocean and rugged mountains, in north-western Canada.

Keywords: topographic correction, gravimetric inverse problem, gravity data interpretation



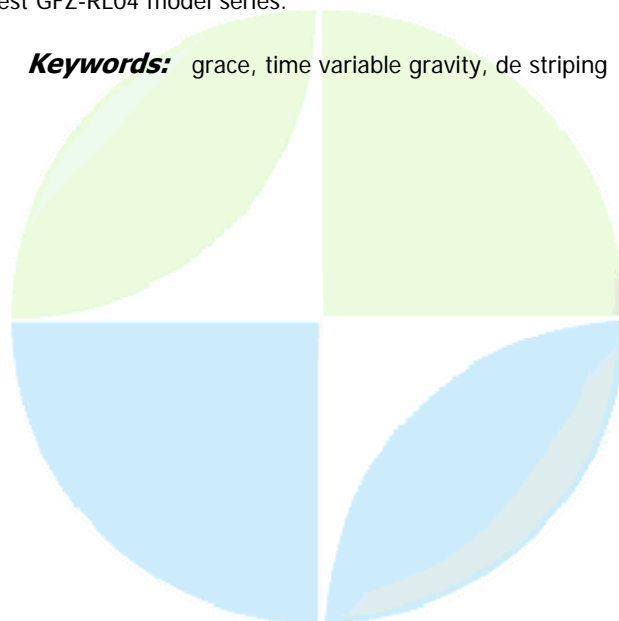
(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2557****Calibration of the CHAMP and GRACE Accelerometers****Dr. Sean Bruinsma***Terrestrial and Planetary Geodesy CNES IAG***F. Perosanz, R. Biancale**

This study focuses on the determination of accelerometer biases and scale factors of the satellites CHAMP and GRACE. Several strategies to apply a priori constraints to these unknowns, which are estimated on a daily basis, are presented including a new approach to recover very precise relative biases from raw GRACE accelerometer observations. The effect of the gravity field on the calibration parameters is equally evaluated. In case of CHAMP, the calibration parameters of the along-track and normal axes, using all mission data so far, are estimated using the most recent IERS 2003 standards and the EIGEN-GL04C gravity field model; the radial axis is not operating correctly, and this acceleration is derived from the measured along-track acceleration and a model for the drag coefficient. The validity of this method was verified using the GRACE accelerometers. The determination of the calibration parameters of the GRACE SuperSTAR accelerometers, which are an order of magnitude more sensitive than STAR on CHAMP, requires a very high level of precision (below 10^{-9} m/s²). An inverse method in which the full set of parameters (accelerometers, K-band, GPS, state vectors, gravity model,) is estimated simultaneously is classically adopted. The GRACE-A and B calibration parameters are (sometimes highly) correlated because the satellites have identical shapes, are flying in the same orbit but separated by about 220 km, and the spacecraft positions are linked by k-band range-rate observations. A second method, based on the comparison of the two co-orbiting satellite accelerometer measurements, allows the determination of the relative bias very precisely. The impact on the absolute accelerometer calibration and the orbit determination, as well as on the derived gravity field coefficients, is evaluated. The relative calibration revealed a high sensitivity to temperature variation of the GRACE accelerometers.

Keywords: accelerometer, calibration

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2558****Approximate decorrelation and non-isotropic smoothing of time-variable GRACE gravity field models*****Dr. Juergen Kusche****Geodesy and Remote Sensing GeoForschungsZentrum Potsdam IAG****Roland Schmidt***

We propose a new method for approximately decorrelating and non-isotropically filtering of the monthly gravity fields provided by the Gravity Recovery and Climate Experiment (GRACE) twin-satellite mission. The procedure is more efficient than conventional Gaussian-type isotropic filters in reducing stripes and spurious pattern while retaining the signal magnitudes. It will be applied to GRACE-derived fields based on the latest GFZ-RL04 model series. As it is well known, in order to derive geophysical signals on scales of a few hundred to a few thousand km from GRACE level 2 monthly gravity field solutions, some sort of filtering is required to counteract the effect of increasing noise in the shorter wavelength coefficients of these models. The common approach is to filter the published solutions, that is to convolve them with an isotropic kernel that allows an interpretation as smoothed averaging. The downside of this approach is an amplitude bias and the fact that it neither accounts for the variable data density that increases towards the poles where the orbits converge nor for the anisotropic error correlation structure that the solutions exhibit. This has led Swenson and Wahr (GRL, 2006) to proposing a post-processing decorrelation algorithm based on an empirical signal correlation model for the GRACE solutions, which is then followed by isotropic smoothing in the second step. Here a one-step post-processing procedure for the published level 2 products will be outlined, which allows to take the above mentioned effects as well as the actual orbital geometry into account. This leads to a series of regularized approximate decorrelation transformations applied to the monthly solutions, which enable a successive smoothing to reduce the noise in the higher frequencies. This smoothing effect may be used to generate solutions that behave, on the average over all possible directions, very close to Gaussian-type filtered ones, however, with a much larger reduction of the unwanted characteristic striping patterns. Along with a description of the procedure, the presentation will highlight the localizing and smoothing properties of our non-isotropic kernels by comparisons with Gaussian kernels in terms of the kernel variance and the amplitude damping for a predefined signal. We consider geophysical models as well as GRACE-derived fields based on the latest GFZ-RL04 model series.

Keywords: grace, time variable gravity, de striping

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2559****Improved resolution of a GRACE gravity field model by regional refinements*****Mrs. Annette Eicker****Institute of Geodesy and Geoinformation University of Bonn*

The available GRACE models have provided us with an unprecedented accuracy in gravity field determination. Nevertheless the projected GRACE baseline accuracy has not been achieved yet. One reason out of many could be the insufficient modelling of the satellite data by a global representation by means of spherical harmonics. To extract the signal information present in the satellite and sensor data to full content, it seems reasonable to improve global solutions by regional recovery strategies. Especially in the higher frequency part of the spectrum the gravity field features differ in different geographical areas. Therefore the recovery procedure should be adapted according to the characteristics in the respective area. In the approach presented here in a first step a global gravity field represented by a spherical harmonic expansion up to a moderate degree has to be derived. It is then refined by regionally adapted high resolution refinements being parameterized by splines as space localizing base functions. In this context a special attention is paid to the signal to noise ratio in different geographical areas. The approach is demonstrated by examples based on the analysis of the original GRACE Level 1B data.

Keywords: grace, regional

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Oral Presentation

2560

Evaluations of CSR-RL04 GRACE Gravity Field Models

Dr. Srinivas Bettadpur

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Csr Level-2 Team

The GRACE Release-04 gravity field data products from UTCSR are considerably improved compared to the previously available Release-01 products. This improvement has been realized through improvements in background gravity models as well as algorithmic changes in the GRACE data processing. These improved products have been available to the user community since late Feb 2007, through the NASA PO.DAAC and the GFZ ISDC archives. The interpretation of RL-04 products is slightly different when compared to RL-01. Besides the improvement in quality, a different set of background gravity field models have been applied to the data before the RL-04 products were created. This leads to a potential change in the way these products must be interpreted. This paper will describe the ways in which the RL04 and RL01 data products are similar and are different. The influence of changed background models will be particularly highlighted. The paper will summarize the feedback received from the user community on the applications of these new data products. The error estimates of the RL-04 fields and their effect on interpretation will be presented.

Keywords: grace, gravity, time variability

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2561****Comparison of time series from superconducting gravimeter with hydrological models of various spatial extents and GRACE****Dr. Heikki Virtanen**

IAG

Mirjam Bilker-Koivula, Jaakko Mkinen, Maaria Tervo, Jenni Virtanen, Bertel Vehvilinen, Markus Huttunen, Risto Mkinen

We have used the record of the superconducting gravimeter (SG) at Metshovi. As hydrological models we use the highly accurate hydrological model for Finland, the Watershed Simulation and Forecasting System (WSFS) of the Finnish Environment Institute, and the global models CPC and GLDAS. Besides, they are compared with variations in the regional gravity field from monthly GRACE solutions. SG gravity residuals are strongly correlated with local groundwater level and with the total water storage in Finland. A key question for the SG observations is the separation of the attraction of near-field water storage from the loading effect of the regional water storage, as the two are strongly correlated and the size of the former depends on very local hydrogeology around the SG. We used observations of local groundwater, precipitation, soil moisture and model calculations to correct the local gravity effect. In addition, variation in the level of the Baltic Sea influence the GRACE and SG datasets.

Keywords: superconducting gravimeter, hydrological models, grace

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GS002

Oral Presentation

2562

**Kalman smoothing filter algorithm design for moving vector gravimetry:
first results of field experiments using the LIMOG system**

Dr. Jerome Verdun

LABORATOIRE DE RECHERCHES EN GEODESIE INSTITUT GEOGRAPHIQUE NATIONAL

Bertrand De Saint-Jean, Henri Duquenne, Jose Cali, Jean-Pierre Barriot

We are developing a light moving vector gravimetry system (Light MObile Gravimetry system) consisting of three fixed accelerometers coupled with a 4-antenna GPS receiver for attitude determination, and one additional dual frequency GPS receiver for precise positioning. Until now, two field missions have been carried out for testing the system, one on land and the other on the sea, where gravity reference values are available for both. System performances are mainly governed by sensor specifications such as bias, scale factor and noise for accelerometers, environmental conditions like vehicle vibrations or atmospheric disturbances in airborne gravimetry and GPS data processing. In dynamic mode, the precision of GPS-determined positions depend strongly on estimation of integer ambiguities, length of GPS station bases or electromagnetic disturbances due to multipath, which can also perturb the estimation of attitude angles using a multi-antenna GPS receiver. The influence of such phenomena have to be minimized as far as possible by using well-suited gravity processing methods with the view to reach a few mGal precision. This presentation outlines a complete computational method for integrating dynamically acquired accelerometer measurements and GPS-determined positions and attitude angles in order to estimate the short wavelength components of the gravity vector disturbance by post-processing. A Kalman smoothing filter is developed based on the navigation equation related to the Earth-fixed reference frame, and involving the covariance matrices of accelerometer, GPS measurements, and also long wavelengths of the gravity field. The Kalman smoothing filter is applied on the data acquired during the two field missions and the resulting gravity disturbance values are compared to gravimetric reference values regarding their precision. We conclude by giving some practical considerations about our processing method and possible improvements of both the system and the processing.

Keywords: mobile gravimetry, attitude determination, kalman filter



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2563****Can local quasi-geoids be determined uniquely from local gravity data?****Prof. Roland Klees***DEOS Delft University of Technology IAG***Ilya Prutkin**

We consider the problem of local quasi-geoid computation from terrestrial gravity data. We show that this problem is not uniquely solvable if gravity anomalies and/or gravity disturbances are used as input data. This non-uniqueness may be the main contributor to the systematic differences between GPS/leveling and gravimetrically computed quasi-geoids usually reported in literature. We derive a mathematical description of the kernel of the gravity anomaly and the gravity disturbance operator, respectively. The non-uniqueness can be removed when directly observed disturbance potentials or height anomaly data are available. This type of information can be provided by GPS and leveling. The associated problem is a Cauchy BVP for the Laplace equation, which is known to be uniquely solvable but very unstable. We propose several methods to solve this BVP. The solution has to be added to the gravimetrically computed quasi-geoid in order to get a unique quasi-geoid. We apply the technique to gravity and GPS/leveling data on the territories of the Netherlands and Germany. We show that our solution is superior to the commonly used correction surfaces and that the latter fail to model the non-uniqueness sufficiently well.

Keywords: boundary valueproblem, gps leveling, localquasi geoidmodeling

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2564****A data-driven approach to local gravity field modeling using spherical radial basis functions****Prof. Roland Klees***DEOS Delft University of Technology IAG****Ilya Prutkin, Tobias Wittwer***

We propose and apply to real data a new methodology for local gravity field modeling from terrestrial gravity data and GPS/leveling data using Spherical Radial Basis Functions (SRBFs). In a first step, a gravimetric quasi-geoid is computed from terrestrial gravity data using least squares. A data-adaptive strategy is utilized to select the optimal number, horizontal position, and depths of the SRBFs. Variance Component Estimation is used to determine the optimal regularization parameter and the proper weights of user-defined observation groups. The algorithms are optimized to allow the processing of large data sets, which are typical for local quasi-geoid modeling. The combination of the gravimetric quasi-geoid with GPS/leveling data is formulated as a Cauchy boundary value problem for the Laplace equation. Using real data, we demonstrate the excellent performance of the new methodology. A comparison with Least Squares Collocation and the classical approach based on the Stokes integral with kernel modification and a parametric correction surface to model differences between GPS/leveling data and the gravimetric quasi-geoid shows superior results in terms of accuracy and numerical efficiency.

Keywords: gravity, quasi geoid, gps leveling

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2565****BVP, Global models and the residual terrain correction****Mr. Daniele Sampietro***Polo Regionale di Como Politecnico di Milano***Mohamed Elhabiby, Fernando Sans, Michael G. Sideris**

The integral of Stokes, or similar formulae used to estimate models of the gravity fields, are based on the solution of the external boundary value problem for the disturbing potential T . This approach requires the disturbing potential T to be harmonic on the geoid, which implies that there are no masses outside the geoid. When solving this problem with the remove-restore procedure, we have to compute the long wavelengths using a set of spherical harmonic coefficients (global model) and the short wavelengths using topographic heights and the residual terrain correction (RTC). When performing this operation, a certain inconsistency arises. This paper suggests a new procedure to better harmonize the various steps involved in solving the geodetic boundary value problem (BVP). First, we investigate whether it is equivalent or not to use as a reference surface, when smoothing Δg , the surface obtained using a block or a moving average operator. After that, we look more closely to the procedure of reducing data to the reference surface. In particular, a new smart sequence that allows moving data always in free air is proposed. The procedure is validated through several numerical tests in mountainous areas in Europe and in Canada.

Keywords: boundary value problem, remove restore

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2566****Evaluation of the terrain-generated gravitational potential and its directional derivatives by combination of analytical formulae and numerical integration*****Dr. Dimitrios Tsoulis****Department of Geodesy and Surveying Aristotle University of Thessaloniki IAG****Pavel Novak, George S. Vergos, Martin Kadlec***

High-resolution local digital elevation models (DEMs) permit evaluation of terrain-related gravitational quantities, such as the terrain correction to ground gravity, with an unprecedented accuracy. In addition, given the increasing availability of new high-resolution global DEMs such as the SRTM with 30x30 m resolution for selected parts of the Earth, investigations and assessments of the short-wavelength gravity field spectrum becomes an issue of high demand. The terrain-related gravitational signal can be combined for precise gravity field modeling with the long-wavelength gravity field spectrum provided either by gravity-dedicated satellite missions CHAMP and GRACE or by other available Earths gravity models such as EGM96. This contribution concentrates on numerical evaluation of terrain-related gravitational quantities, such as the potential and its directional derivatives, by merging two different modeling and computational strategies: planar and spherical approximations of the terrain. While the former model is sufficient over limited regions offering a very detailed representation and computational accuracy for the critical area around the computation point, the latter model is indispensable for larger distances from the computation point. The evaluation of the terrain-related parameters is tested over selected areas in Europe with different complexity of the Earths topography, varying resolution of the DEM and laterally-varying density of topographical masses. Results of numerical tests are used for formulation of recommendations that could be followed for reduction and interpretation of gravity data.

Keywords: gravity, terrain, reductions

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2567****Combination of gravimetry, altimetry and GOCE data for geoid determination in the Mediterranean: evaluation by simulation****Prof. Riccardo Barzaghi**
*DIAR Politecnico di Milano IAG***Adriano Maggi, Nikolaos Tselfes, Dimitrios Tsoulis, Ilias N. Tziavos, Georgios S. Vergos**

Local geoid determination is traditionally carried out in sea areas using gravity anomaly and altimetry data. This determination can be aided by the data of missions such as GOCE. The satellite gravity field mission GOCE will deliver data including estimates of the gravitational potential and its second order derivatives. These data will contain information of unprecedented accuracy for the low and medium frequencies of the Earth's gravity field. In order to assess the performance of the combination of heterogeneous data for local geoid determination, simulated data for the area of the central Mediterranean sea are analyzed. These data include ground gravity, altimetry, GOCE observations of second order derivatives and potential estimates obtained by the energy conservation method. The GOCE data are also processed with the space-wise approach for error modeling and filtering purposes. The processing of these data with different techniques (fast collocation, collocation in windows) shows that the GOCE data improve the results for areas not well covered with other data types and for any long wavelength errors of the reference model used. The importance of combining heterogeneous data is verified by these simulations, where the spectral characteristics of the contribution of each individual data set can be identified.

Keywords: mediterranean geoid, goce gravity mission, altimetry

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2568****Periodic components of water stock changes from GRACE and global hydrology models*****Dr. Roland Schmidt****Department 1: Geodesy and Remote Sensing GFZ Potsdam IAG****Svetozar Petrovic, Johann Wnsch, Franz Barthelmes, Jrgen Kusche***

In order to better separate the hydrologically induced part of the temporal gravity variations seen in GRACE-based gravity models, a characterization of the expected hydrological signals is required. Since these contain significant periodic variations, a reliable identification of such harmonic components in the time series of GRACE-derived surface mass anomalies will be of importance for hydrology modeling when incorporating the GRACE estimates of the continental water stock changes. To this end, we apply an Empirical Orthogonal Function (EOF) analysis in combination with an enhanced method to detect harmonic waves of arbitrary periods to time series of GRACE-based surface anomaly maps and to state-of-the-art global hydrology models. Since our analysis method for the detection of harmonic waves is not restricted to multiples of some fixed basic period as is for Fourier-type of analysis, the obtained spectra allow for a more meaningful interpretation of the GRACE-based results. The contribution will present the applied methodology as well as results (for global grids and for selected river basins) which show a good agreement for the periods and phases of the most pronounced signals between hydrology models and GRACE.

Keywords: time variable gravity, grace, hydrology

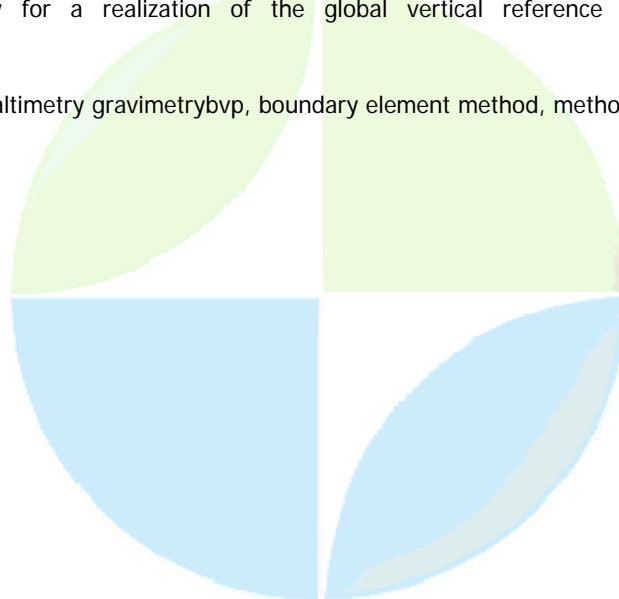
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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2569****Numerical solution of the Fixed Altimetry-Gravimetry BVP using the Direct BEM Formulation****Dr. Robert Cunderlik***Dept. of Mathematics Slovak University of Technology IAG***Karol Mikula**

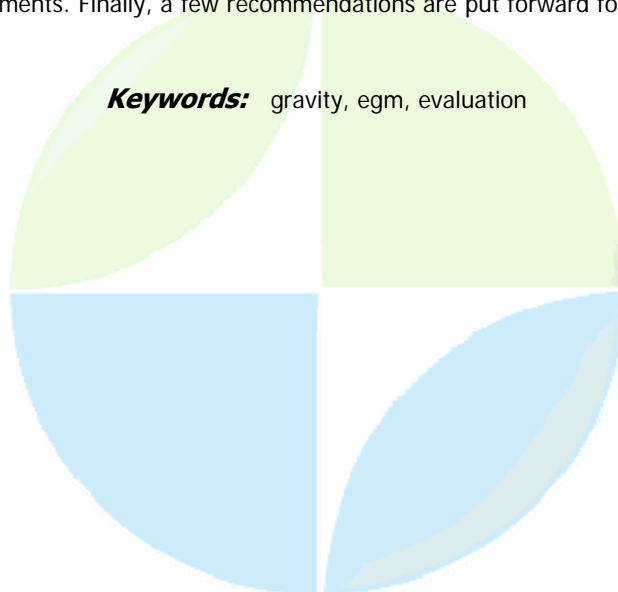
A direct formulation of the boundary element method (BEM) for the Laplace equation can be derived through the application of Greens third identity or through the method of weighted residuals. Both methods lead to the same integral relationship that represents a superposition of the single-layer and double-layer potential. Such boundary integral equation (BIE) can be applied to the mixed boundary conditions (BC) defined by the altimetry-gravimetry boundary value problem (AGBVP). In our approach we use; (i) the Dirichlet BC at oceans and seas where the disturbing potential is calculated on a mean sea surface (MSS) using the global geopotential models (GGMs) and spherical harmonics, and (ii) the oblique derivative BC at continents in the form of surface gravity disturbances that can be obtained from terrestrial gravimetric measurements followed by the precise satellite positioning. Their 3D positions together with MSS models available from altimetry determine the Earths surface as a fixed boundary. In our approach the collocation technique with linear basis functions is applied in order to discretize BIEs and derive a linear system of equations. The input surface gravity disturbances at collocation points are so far generated from GGMs. Vertical coordinates, i.e. ellipsoidal heights, are interpolated from a combination of the global topography model SRTM30 and GGM. The oblique derivative BC are projected to the Neumann BC. Large-scale computations are performed on parallel computers. Enormous memory requirements are reduced by an elimination of the far zones interactions. This allows integration over the all Earths surface with high resolution. Such approach gives a precise numerical solution of the fixed AGBVP at collocation points directly on the complicated Earths surface. The surface gravity disturbances at oceans and seas and the disturbing potential at continents are the direct numerical results. They are compared with values evaluated directly from GGM using the spherical harmonics. The paper discusses some computational aspects of the proposed approach (e.g., aconvergence of the numerical solution, conditioning of the stiffness matrix and a numerical complexity of BEM) as well as its advantages for the global gravity field modelling. A use of globally homogeneous surface gravity disturbances instead of globally inhomogeneous gravity anomalies is emphasized. Its importance especially for a realization of the global vertical reference system could not be underestimated.

Keywords: fixed altimetry gravimetrybvp, boundary element method, method of weighted residuals



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2570****Review of evaluation methods and test results for the quality assessment of Earth gravity models*****Dr. Jianliang Huang****Natural Resources Canada Geodetic Survey Division, CCRS IAG****Christopher Kotsakis***

For the past five years, a great number of satellite-only static Earth Gravity Models (EGMs), based mostly on CHAMP and GRACE measurements, have been developed by many research teams worldwide. Several hybrid global EGMs have also been determined, incorporating GRACE/CHAMP long- and medium-wavelength gravity field information, along with additional terrestrial gravity and satellite altimetry data. The culmination of this revolutionary stage that is experienced in global gravity field modeling is expected to come from the National Geospatial Intelligence Agency (NGA), which is developing a new ultra-high degree EGM, complete to degree and order 2160, that is capable of representing gravity field features with a spatial resolution of 5' by 5'. The evaluation and the quality assessment of such EGMs is a most critical aspect, in view of their utilization for various geodetic and oceanographic applications at global, continental and/or regional scales. The error estimates that are commonly associated with these models often puzzle users due to the fact that EGM differences do not always conform to their formal error estimates, or to their degree of agreement with other types of external control data. A joint working group, under the title Evaluation of Global Earth Gravity Models, was established between the International Gravity Field Services and Commission 2 of IAG in 2005. Its main objectives are to develop standard validation and calibration procedures, and to perform the quality assessment of GRACE-, CHAMP- and GOCE-based satellite-only and combined solutions for the static Earth gravity field. The external control data sets that are used for such purposes include mainly GPS and levelled orthometric/normal heights, airborne and surface gravity data, mean oceanographic sea surface topography (SST) models in conjunction with altimetric sea surface heights, orbital tracking data from various geodetic and altimetry satellites, and astro-geodetic vertical deflections. Members of this group have conducted extensive evaluation tests with the various EGM releases over the last few years. In this review report, we present a summary of the standard requirements for performing a comprehensive EGM evaluation through internal error analysis and external validation/calibration methods. The test results obtained from the group members are also summarized and analyzed in terms of these requirements. Finally, a few recommendations are put forward for future EGM evaluation work.

Keywords: gravity, egm, evaluation

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2571****Recovery of temporal gravity field variations from GRACE data with the range-combination approach****Mr. Xianglin Liu***Delft Institute of Earth Observation and Space Delft University of Technology, The Netherlands IAG***Pavel Ditmar, Qile Zhao**

A set of monthly Earth's gravity field models has been computed for a time interval spanning more than one year. The models are derived from GRACE inter-satellite range measurements with an original range-combination approach. The approach is based on a functional model that connects gravity field parameters with a linear combination of range measurements at three successive epochs. Computation of such a combination is approximately equivalent to a 3-point double numerical differentiation. The data processing scheme consists of two major steps. In the first step, precise purely dynamic orbits of GRACE satellites are computed on the basis of an a priori force model and accelerometer data, the latter one being simultaneously calibrated. In the second step, the computed orbit is used to obtain residual (observed minus computed) range measurements, which is the input to form the residual range combinations. The computed monthly models are compared with those produced earlier by other research groups as well as with the gravity field variations expected from global hydrological models. The comparison shows that the computed models show weaker artifacts than those published earlier.

Keywords: garce, range combination, monthly gravity field model

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2572****Assessment of GPS observables for gravity field recovery from GRACE****Dr. Adrian Jggi***Astronomical Institute University of Bern IAG***Gerhard Beutler, Lars Prange, Rolf Dach**

The two GRACE satellites provide the ideal platform to study the performance of different kinds of GPS-derived kinematic positions or position-differences for gravity field recovery (GFR). In the framework of the most recent activities in the field of GFR at the Astronomical Institute of the University of Bern, Switzerland, we investigate several, alternative GPS-derived observables to identify an optimum contribution of the GPS-part to GFR. We use undifferenced or doubly differenced GPS data to perform kinematic precise orbit determination. In a subsequent step, use is made of the derived orbit positions or the inter-satellite baseline vectors for GFR. We focus in this study on potential achievable benefits when using precisely recovered baseline vectors from GPS, e.g., due to the possibility to resolve the carrier phase ambiguities to reduce systematic errors. We also check whether other than the classically used carrier phase measurements (reconstructed with the P-code) should be used for GRACE precise orbit determination to reduce random errors in the GFR.

Keywords: gravity field determination, grace, gps

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2573****Precise spaceborne accelerometry on board the GRACE mission*****Dr. Jakob Flury****Center for Space Research University of Texas, Austin IAG****S Bettadpur***

Electrostatic accelerometers with unprecedented sensitivity are one of the core sensor systems of the GRACE gravity field satellite mission. Similar instruments, with even higher performance requirements, will be launched on board the GOCE mission in September 2007. In the case of GRACE, it is known from simulations that the accelerometer accuracy is critical for the determination of the large spatial scales of the gravity field and of temporal gravity variations. We present an analysis of GRACE accelerometer data and their accuracy in various parts of the frequency spectrum. This includes a better understanding of various effects of micro-accelerations within the satellite with periods of few seconds, e.g., due to heater elements. Results show a very high sensor sensitivity. This could prove interesting for the investigation of atmosphere variability along the GRACE orbits. It is also relevant for the upcoming gravity field determination from GOCE data, for which the accelerometer sensitivity at high frequencies is even more critical than for GRACE.

Keywords: gravity, accelerometer, satellite



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2574****5 years of GRACE time variable geoid models****Dr. Richard Biancale**
*Space Geodesy CNES IAG***J-M Lemoine, S Bruinsma, F Perosanz, G Balmino**

Since 2005, level-1b data of the GRACE mission are made available to the scientific community with a short delay. They cover now with almost no discontinuity a 5-year period from which we can really infer unmodelled variations and tendencies of mass changes. Intersatellite K-band range-rate data (derived from K-band range measurements) are classically used for modelling the time variable geoid. Their precision allows us to model geoid variations at 10-day intervals and at a spatial resolution of 400 km. Nevertheless the signal below 600 km resolution has to be stabilized, which can be done without any distortion of the signal at lower wavelengths. Moreover SLR Lageos data have been used as well in order to stabilize terms of degree 2. These models are presented in terms of surface mass variations from which mean monthly models are inferred and can be used advantageously for precise orbit computation. These models serve as a basis together with the last monthly GFZ models for the new generation of EIGEN-5S and -5C models expanded in spherical harmonic degrees up to 150 and 360 respectively.

Keywords: grace, gravity

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GS002

Oral Presentation

2575

Analysis of a two-dimensional matched filter to detect mass anomalies in the Earth's gravity field using local gradiometry.

Mrs. Tin Lian Abt

School of Earth Sciences Ohio State University IAG

Puttipol Dumrongchai, Christopher Jekeli

The objective is to detect the location of a mass anomaly from the observations of a local gravity gradient field. Assuming that the sought signal generated by the anomaly is known, a matched filter is designed to locate the mass anomaly in a field, which, in addition, contains signals from a geologic background and random instrument noise. Data are correspondingly simulated on a two-dimensional evenly spaced grid. The performance of the matched filter is tested under aspects such as applying different gravity gradient components and their combinations, implementing various fields of geologic background and altering the signal strength. Furthermore, it is analyzed to what extent the matched filter can detect not only the horizontal location of the anomaly but also its depth and its orientation. The results of the simulations are statistically tested and presented in illustrations.

Keywords: matched filter, gradiometry, mass anomaly



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2576****The impact of littoral aerogravity on coastal geoid heights****Dr. Daniel Roman**
IAG

Aerogravity and lidar data were collected in the northern Gulf of Mexico as a part of the Gravity-Lidar Study of 2006 (GLS06). The gravity data were reduced by the Naval Research Laboratory, while NASA Goddard Space Flight Center processed the lidar data to estimate the instantaneous ocean surface nadir to each flight. A separate paper discusses the reduction of the aerogravity data and integration with other surface gravity data held by the National Geodetic Survey. The improved gravity were used to generate a refined geoid model that better fits local ocean observations at tide gages and along the lidar profiles. Additional ocean surface information was obtained from a dynamic ocean topography (DOT) produced for the region at the time of the observations by NOAA's Office of the Coast Survey and by the VDatum suite of transformation surfaces. The VDatum utility mapped the tidal surface variations throughout the region. Then geoid model in conjunction with the DOT model were compared to the mean tide levels (MTL) at the tide gages, and these two plus the VDatum tool were used to compare to the instantaneous ocean surface observed by the lidar. Comparison with MTL provided evidence that there was a dm-level improvement in the geoid model. More significantly, absolute errors were estimated to be about 30 cm as seen by a bias between the geoid and DOT. This indicates remaining errors in any of these three models that must be explained to obtain cm-level accuracy for the whole system of models.

Keywords: geoid, littoral, ocean topography

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2577****Numerical integration of ocean tides for an improved de-aliasing of GRACE gravity field models****Dr. Wolfgang Bosch**
IAG**Roman Savcenko**

GRACE gravity field modelling requires subtracting the potential of ocean tides. For this process two error sources are addressed: (i) Global ocean tides models perform rather well in deep ocean areas; however the tidal regimes in shallow water still exhibit significant errors. The sampling characteristic of GRACE causes alias effects such that the signal and errors of ocean tides don't average out in monthly gravity field solutions. (ii) As a common practice, spherical harmonic representation of global ocean tide models is used to subtract the effect of the tidal potential for GRACE gravity field solutions. This band limited representation of tides causes Gibbs effects and can't properly account for the coastal step function of the tidal water level. The present investigation suggests a numerical integration approach in order to estimate the impact of both error sources. We analyse the effect of specific (regional) improvements for some tidal constituents of the FES2004 ocean tide model and investigate the errors of the GRACE gravity fields due to the spherical harmonic representation of ocean tides.

Keywords: ocean tides, grace, de aliasing

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2578****Analyzing two approaches for integral inversion of ground gravity in local geoid computations****Dr. Pavel Novak***Department of Geodesy and Geodynamics Research Institute of Geodesy, Top. and Cart. IAG***Jianliang Huang**

Despite recent advances in global gravity field modelling through gravity-dedicated satellite missions, local ground gravity data maintain their role for determination of precise and high resolution local geoid models. Standard methods in solving geoidal undulations from discrete ground gravity are based on their integral inversion by Green's surface integrals that represent solutions to boundary-value problems of potential theory. In the traditional approach, reduced gravity is first continued to some simple reference surface that is consequently used as a fixed boundary for integral inversion of continued gravity into the disturbing gravity potential. Thus, two integral equations are solved for with the first one representing an inverse problem with rather complicated numerical evaluation. Besides stipulating the mass density distribution of topographical masses, this step can be considered as a major difficulty for geoid determination from ground gravity. This approach is compared with an alternative solution that combines continuation and inversion of anomalous gravity in one integral equation. Both approaches are used for evaluation of a local geoid model over a test region in the Canadian Rocky Mountains. Models computed by the two alternative approaches are compared relatively for stability and computational efficiency. The models are also evaluated for their external accuracy by using levelling benchmarks with measured GPS heights available over the test region.

Keywords: local, gravity, modelling

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2579****Ellipsoidal collocation****Mrs. Lisa Pertusini**
*DIAR Politecnico di Milano***Mirko Reguzzoni, Fernando Sans, Giovanna Sona**

Collocation theory finds a direct application in a spherical set up, in the sense that, up to now, the concept is used along with spherically invariant covariance functions. These functions propagate naturally from surface spherical covariances to spatial harmonic covariances. The same concept cannot be used in an elementary way with an ellipsoidal set up, because a covariance function that is homogeneous in the angular ellipsoidal distance has not a homogeneous harmonic continuation. In fact the variances of the ellipsoidal harmonic coefficients depend not only on the degree but also on the order, thus losing the numerical advantage of working with degree variances. However, by exploiting a convenient approximation of Legendre functions of second kind, the dependence on the order can be expressed in such a way that, at least in a topographic layer, a numerically feasible collocation algorithm can be implemented. This prevents the distance between data surface and reference surface from varying in an improper and systematic way, as it happens in spherical approximation. A comparison between spherical and ellipsoidal collocation is performed on a simulated data set.

Keywords: ellipsoidal harmonics, collocation

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2580****An attempt for an Amazon geoid model using Helmert anomaly****Dr. Denizar Blitzkow***Transport Engineering University of So Paulo IAG***Denizar Blitzkow, Ana Cristina Oliveira Cancoro De Matos, Ilce De Oliveira Campos, Artu Ellmann, Petr VančEk, Marcelo Carvalho Dos Santos**

This paper describes the computation a geoid model for the Amazon Basin (GEOAMA) limited by 5N and 10S in latitude and 70W and 50W in longitude. The software package SHGEO developed by the University of New Brunswick-Canada was used for the calculation. The geoid model was derived using the following data: digital terrain model SRTM v.2.0 with 3" grid, the gravitational field of the Earth EINGEN-G104S1, degree and order 150, derived from GRACE satellite, and terrestrial gravity data. These data are basically observed along the rivers. For GEOAMA validation the longitudinal profiles of some rivers over the basin derived from two geoid models (EGM96 and GFZ-EPUSP) combined with geodetic heights from 22 GPS stations close to the tide gage stations and 6 virtual stations with TOPEX/POSEIDON altimetry data were used. The results show good agreements with the GFZ-EPUSP and EGM96 profiles and with the average of the main river gradient (20 mm/km).

Keywords: geoid, altimetry, gradient

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GS002

Oral Presentation

2581

Vertical reference frames - report of IAG Inter-Commission Project 1.2

Dr. Johannes Ihde

Geodesy Federal Agency for Cartography and Geodesy IAG

Based on the classical and modern observations, the ICP1.2 on Vertical Reference Frames had to be studied the consistent modelling of both, geometric and gravimetric parameters, and provide the fundamentals for the installation of a unified global vertical reference frame. The objectives of ICP1.2 are: - To elaborate a proposal for the definition and realization of a global vertical reference system - To derive transformation parameters between different regional vertical reference frames - To establish an information system describing the various regional vertical reference frames and their relation to a world height system. Result of the works is a proposal for conventions about the definition and realization of a global vertical reference system. The continuation of the necessary work for an implementation of this concept will be discussed. The realization of a global vertical reference system needs to be based upon the combination of positioning using geodetic space techniques, levelling, gravity, tide gauge observations and a global gravity model.

Keywords: global vertical reference, world height system



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2582****Spatiotemporal resolution of multi-satellite missions****Dr. Nico Sneeuw***Institute of Geodesy Universitaet Stuttgart IAG***Mohammad Ali Sharifi**

Sampling the Earth from single-satellite missions or single-orbit formations is necessarily limited by the mandatory balance between spatial and temporal resolution. A short repeat period leads to sparse ground-track spacing. Conversely, dense satellite coverage can only be attained at the cost of time resolution. For GRACE time variable gravity monitoring, the balance is struck at monthly time resolution with spatial scales larger than several hundred kilometres. For future gravity field missions, though, Earth science communities are pushing for ever higher resolution, both in time and space. A logical consequence of these demands would be multi-satellite multi-orbit missions. We investigate the basic parameters that determine space-time resolution. Elementary closed-loop simulations demonstrate how future mission concepts might benefit from multi-satellite configurations.

Keywords: satellite geodesy, future mission concepts

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2583****The quasi-geoid determination in a cm level in Middle-East China****Dr. Quande Zhang***Geodesy National Geomatics Centers of China IAG***Peng Zhang, Zhicai Li**

The pastly determined geoid in Middle-East China is relatively low in the precision due to lower-precision and sparser ground-based observation data. In the recent 5 year, the State Bureau of Surveying and Mapping (SBSM) of China has made some large projects to improve the regional quasi-geoid determination in the uniform datum and specification, particularly in Zhe-Min-Gan provinces from 2003-2004 and North China from 2004-2005 as well as these areas in Middle and eastern China from 2005-2007 by the cooperation with the local suverying Bureas. More than 6000 GPS/level points within average 20km spatial resolution were surveyed in the cm level precision and over 200,000 gravity measurements were collected with about 3' resolution. It will contribute to determine the quasi-geoid in a cm level in Middle-East China. These areas comprise 15 provinces and lots cities with an area of 1,900,000 square km, covering 19.8% of Chinese territory. Each project got the better geoid result in cm level, which can be used in practice. However, such geoid was computed in different areas and different times. In this paper we use these observation data and high resolution DEM to uniformly determine the geoid in Middle-East China using remove-restore method. Meanwhile nearly 300 GPS/level check points are used to evaluate the final accuracy. The difference of gravimetric geoids and quai-geoids derived from the different geopotential models EGM96, WDM94 and EIGEN are also further discussed.

Keywords: geoid, gps level, gravity

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2584****GOCE Mission Development Status****Mr. Danilo Muzi***Directorate of Earth Observation European Space Agency IAG***Rune Floberghagen**

The Gravity field and steady-state Ocean Circulation Explorer (GOCE) satellite is scheduled for launch by the end of 2007. It will be the first Earth Explorer Core mission of the Living Planet programme of the European Space Agency (ESA). The primary objective of the GOCE mission is to provide global and regional models of the Earth gravity field and the geoid, its reference equipotential surface, with high spatial resolution and accuracy. The high resolution static gravity field and gravimetric geoid measured by GOCE will stimulate research in a wide range of disciplines spanning studies of ocean circulation, cryosphere, solid-earth physics, natural hazards, geodesy and surveying. In this paper we will present the status of the GOCE development activities, including the status of the tests of the satellite flight model and payload. Furthermore, the main technical features of the satellite and of the ground segment will be presented.

Keywords: goce, gravity, gradiometer

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2585****Regional airborne scalar gravimetry for geoid determination****Dr. Arne Vestergaard Olesen***Geodynamics Department Danish National Space Center IAG***Rene Forsberg**

Today airborne gravimetry is a truly operational tool for gravity mapping and it offers a fast and economic coverage of large areas. Airborne gravimetry may provide an accurate and bias-free extension of satellite gravity models and thus bridge the spectral gap between these models and the fine structure of the gravity field as mapped by the newest digital elevation models (SRTM). Another big advantage of airborne gravimetry is the uniform and seamless coverage of the near-coastal region, a region that so far is only poorly covered in many areas of the world due to shallow water, which do not allow for marine measurements. Satellite altimetry derived models are in general not reliable near the coast. This region is at the same time an area where one may want the most precise geoid due to the high population density and the economic interests related to infrastructure developments here. Danish National Space Center (DNSC) has conducted airborne gravity surveys for more than a decade and this paper describes some of the more recent surveys undertaken by DNSC. Both surveys over marine areas in the Arctic and the North Atlantic region and surveys over land covering all of Malaysia, Mongolia and most recently Ethiopia. The purpose has been to contribute to regional and global models (ArcGP and EGM2007), to provide geoid models for national height systems and reference surfaces for ocean current studies. The measurements were done with a LaCoste & Romberg marine/airborne gravimeter owned by the University of Bergen. This type of gravimeter has an excellent drift characteristic and can when the data are properly processed provide bias-free results also for airborne applications. The main source for a bias in airborne data obtained with stabilized platform systems is the so-called tilt correction, which basically is a modeling of the platform orientation error. The processing algorithm developed at DNSC employ a platform-response-modeling approach to account for this orientation error. This approach seems to give virtual bias-free results.

Keywords: airborne gravimetry, stabilized platform system, geoid



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2586****Frequency-dependent data weighting in airborne gravity data processing****Mr. Bas Alberts***Delft University of Technology DEOS IAG***Pavel Ditmar, Roland Klees**

Airborne gravity measurements are acquired in a dynamic environment, resulting in strong noise in the observations. Typically the noise is colored, i.e. non-uniformly distributed over the frequencies. Because the noise is assumed to be especially high at the shortest wavelengths, but lower than the signal at the longer wavelengths, the data are usually low-pass filtered. However, such filtering can significantly attenuate the gravity signal and thus limit the resolution of the gravity field solution. Therefore, we apply a frequency-dependent data weighting, using a proper noise covariance matrix in the estimation of gravity field parameters. If the noise characteristics are not known a priori, the noise model is estimated using the residuals computed from a preliminary least-squares solution. Because the noise level may change during the flight, a scaling of the noise model is applied for each profile, based on the noise variance. We found that this rescaling significantly improves the estimation of the gravity field parameters. We demonstrate the performance of the developed technique using unfiltered airborne gravity data over the Skagerrak area, acquired during the EU MAST-III project AGMASCO in 1996. The results are compared with those obtained using the traditional approach to airborne gravity data processing.

Keywords: frequency dependent weighting, colored noise, airborne gravimetry



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GS002

Oral Presentation

2587

Study of the detectability of gravity changes caused by Tectonic processes using the space gravity missions

Dr. Mohammadali Sharifi

Surveying and Geomatics Engineering University of Tehran

Gholamreza Joodaki, Nico Sneeuw

The Gravity Recovery and Climate Experiment (GRACE) is the first realization of the LL-SST mission. It has already proved its capability for improving the knowledge of the static earth's gravity field and time-variability of the geopotential models. The preliminary investigations have already shown that a mission of GRACE type can be used for detection of gravity changes due to co-seismic deformation. In this study, we will compare capability of the GRACE mission with other types of the LL-SST configurations for detecting the gravity changes caused by co-seismic deformation.

Keywords: gravity mission, tectonic processes

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2588****Complex, vector and tensor least square collocation methods for over-determined boundary value problems in GOCE data processing****Dr. Zhao Dongming**
*Gravity Field IAG***Wu Xiao-Ping, Zhang Chuan-Ding**

Aiming at the efficient processing of GOCE and ground gravity observations, this study is focused on the Complex, the Vector and the Tensor Least Square Collocation (LSC) methods as well as the Over-Determined Boundary Value Problems (OD-BVPs) using different observations. The commonly-used LSC is extended to the Complex LSC (CLSC) that can handle complex-valued signals. The mathematical model of the solution of CLSC is derived theoretically, and then the emphasis is laid on the structure of the complex covariance matrices. Using the characteristic that the sub-matrix of covariance between longitudinal circles are cyclic Toeplitz matrix, the dimension of the normal equation after FFT can be degraded, and as a result, the inverse problem can be solved. For spherically zonal-distributed data of GOCE, once the mathematical expression of the collocation solution on the orbit sphere of mean radius is established, the problem of data gap in polar areas can be kept off. In LSC, the observations are always enormous, and the covariance matrix is always irregular, which lead to a hard inverse process. In our research, the proposed Vector LSC (VLSC) and Tensor LSC (TLSC) methods deal with vector and tensor as a integral signal respectively and then make use of LSC by constructing vector and tensor covariance functions. In this way, the numerical stability can be greatly improved and the bottleneck problem of huge matrix inverse computation can be solved. For the characteristics of GOCE observations, the common criteria or Generalized Least Square Criteria of the solution to OD-BVPs is set up and applied to the recovery of the Earth's gravity field using the combination of different observations on the ground and at the altitude of GOCE. Through study on the boundary and data types, the methodology for solution to OD-BVPs is established.

Keywords: goce, complex lsc, vector and tensor lsc

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2589****Determination of the transformation function between UEGN and the Hungarian gravity networks****Dr. Lorant Foldvary**

IAG

Lajos Volgyesi, Geza Csapo

In order to determine and investigate Europe-sized gravity features, integration of national gravity networks into the European system is indispensable. In this study transformation function between the Hungarian gravity network, MGH-2000 to the up-to-date version of the UEGN networks has been determined. We have investigated the applicability of 2D analytical surfaces for approximating the networks, and compared with the traditional manner using power series. Results and conclusions of the study are case-sensitive and rather practical.

Keywords: gravity networks, uegn, transformation

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(G) - IAGA - International Association of Geomagnetism and Aeronomy

GS002

Oral Presentation

2590

Precise gravity timeseries and instrumental properties from combination of superconducting and absolute gravity measurements

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Reinhard Falk, Herbert Wilmes, Peter Wolf

Precise monitoring and a conclusive interpretation of temporal gravity variations at a given station is based upon accurate knowledge about the properties of the used instruments. Only the combination of concurrent sets of superconducting and absolute gravity measurements allow both. Whereas absolute gravimeters provide the scale and reference level, superconducting gravimeters enable to determine gravity variations with high sensitivity and temporal resolution. A method is proposed here to derive the scale function and zero drift of the superconducting gravimeter as well as a reliable survey of the instrumental stability of absolute meters with high precision without the need of gravity reductions. In this way it is possible to separate between geophysical signals and instrumental effects in the time series. First results for the stations Bad Homburg (Germany) and TIGO/Concepcion (Chile) presented demonstrating the potential of the technique.

Keywords: superconducting gravimeter, absolute gravimeter, gravity time series



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2591****Exploring linkages between the Wilkes subglacial Basin and the transantarctic mountains with new airborne gravity data*****Mr. Tom Jordan******Fausto Ferraccioli, A.B. Watts, Egidio Armadillo, Charlotte Moss, Hugh Corr, Emanuele Bozzo, Giorgio Caneva, Carl Robinson***

The Transantarctic Mountains form the highly uplifted and glaciated flank of the West Antarctic Rift System. At 3000 km long and with peaks reaching 4500 m high, the Transantarctic Mountains (TAM) are the highest continental rift-flank uplift on Earth. The processes that led to such large-magnitude uplift have been the subject of intense debate and a variety of contrasting models have been put forward over the last two decades. One of the problems in developing such uplift models is that although there is a relatively good gravity and seismic coverage over the adjacent segment of the rift system, much less gravity data is available to study the architecture of the TAM itself and even less data exists over the enigmatic Wilkes Subglacial Basin (WSB) in the hinterland of the TAM. An improved understanding of the TAM and WSB region is particularly timely because mountain uplift may also be linked via forcing and feedback mechanisms to the transition between greenhouse and ice conditions in East Antarctica, and to the later Neogene stability of the East Antarctic Ice Sheet. During the 2005-06 austral summer a major collaborative UK-Italian aerogeophysical survey was flown over the WSB and over the adjacent tectonic blocks of the TAM. A British Antarctic Survey Twin Otter, equipped with airborne radar, aeromagnetic and airborne gravity sensors carried out the survey from bases and remote field camps supported by the Italian Antarctic Programme. Over 60,000 line km of new data were acquired, referring to an area of over 750,000 square km. This represents the largest fully integrated airborne geophysical survey performed so far over this region. In this presentation we will focus primarily on the analysis of newly acquired airborne gravity data for the WSB and adjacent blocks of the TAM. We will present a new free-air gravity anomaly map, a Bouguer anomaly map, which utilised the new bedrock topography, as obtained from our airborne radar data, isostatic residual maps, and preliminary models. Our aim is to address the following open questions: 1) Is the WSB a flexural basin induced by uplift of the TAM, as predicted by some previous gravity models, or could it represent a broad area of extension more similar for example to the Ross Sea Rift?; 2) is the WSB simply a glaciated flexural depression with little to no sedimentary infill, or is it a sedimentary basin linked to controversial deglaciation of East Antarctica during warm periods in the Neogene?; 3) if lithospheric flexure alone should not account for the observed architecture, then what uplift mechanisms may be invoked to explain such large magnitude uplift?; 4) is there evidence from an airborne gravity perspective for major segmentation of the TAM rift flank into discrete crustal blocks?

Keywords: antarctica, gravity, uplift

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2592****The Development of the European Gravimetric Geoid Model EGG07****Dr. Heiner Denker***Institut fuer Erdmessung Leibniz Universitaet Hannover IAG****J.-P. Barriot, R. Barzaghi, D. Fairhead, R. Forsberg, J. Ihde, A. Kenyeres, U. Marti, M. Sarrailh, I.N. Tziavos***

A new European geoid and quasigeoid model EGG07 was developed within the framework of the IAG commission 2 project CP2.1, known as The European Gravity and Geoid Project (EGGP). The EGGP started shortly after the last IUGG General Assembly in Sapporo 2003 and was running during the four-year period 2003-2007. Significant improvements were achieved with respect to the last published European geoid and quasigeoid model EGG97. These improvements include better global geopotential models from the GRACE mission, better digital elevation models (DEMs) in some regions (e.g., new national DEMs, SRTM3), updated gravity data sets for selected regions, updated ship and altimetric gravity data, improved merging procedures for the ship and altimetric data, and the availability of extended GPS/levelling data sets. A major step forward was the creation of a unified European terrain data base with a resolution of 3 x 3, based on existing national digital terrain models (DTMs) and the SRTM data (3 x 3) supplemented by the GTOPO30 and other 30 x 30 data. In addition, significant new or updated gravity data sets were included in the project data base. All available terrestrial terrain and gravity data were combined with a global geopotential model based on the GRACE mission, leading to the new completely revised European geoid and quasigeoid model EGG07. The computations were based on the spectral combination approach with integral formulas evaluated by 1DFFT. The EGG07 model was validated by independent data sets from GPS and levelling, indicating an accuracy potential of 3-5 cm at continental scales in well-surveyed regions.

Keywords: geoid, quasigeoid, egg07

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GS002

Oral Presentation

2593

Time Variability of the European Gravity Field (1997-2006) from GGP SG Data, Compared to GRACE Satellite Data and Hydrology Models.

Prof. David Crossley

Earth and Atmospheric Sciences Saint Louis University IAG

Jacques Hinderer, Caroline De Linage, Jean-Paul Boy

This paper extends in two ways our previous comparisons between ground-based and satellite measurements of the large scale field over Europe. In the first case we go back to the beginning of GGP in 1997 and use the gravity from SGs installed at various sites that are no longer operating (e.g. Brussels, Potsdam) to build up almost 10 years of seasonal changes in the ground gravity, sampled at 6-8 representative stations. This enables us to characterize the primary temporal changes within the data (the first principal component of our analysis) better than with the shorter data sets in the past. Second, we extend the time forward by 2 years to the end of 2006 by including another 2 years of data from GRACE and from the existing GGP stations. As before, we find good agreement between the ground-based and satellite time variability, and also correlations with the large-scale hydrology modelling. This gives encouragement to suggest further comparisons between GRACE (and GOCE) data and the growing number of SGs in Asia that will provide another large scale sub-network of GGP.

Keywords: time varying gravity, superconducting gravimeters, grace

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GS002

Oral Presentation

2594

Development of an Interferometric Laser Ranging System for a Follow-On Gravity Mission to GRACE

Prof. Steve Nerem

CCAR and CIRES University of Colorado at Boulder IAG

P. Bender, B. Loomis, M. M. Watkins, W. Folkner, M. Stephens, J. Leitch, R. Pierce

The Gravity Recovery and Climate Experiment (GRACE) has ushered in a new era for satellite measurements of the Earth system. The tremendous advances made by GRACE have led to an interest in launching a follow-on mission with even better spatial resolution. The spatial resolution can be improved by improving the ranging performance, implementing a drag-free control system, and flying at a lower altitude. This presentation will focus on an effort, funded by NASA's Instrument Incubator Program, to develop an interferometric laser ranging system that we expect to perform near the 1 nm/sec level or better over 5 second intervals, which when coupled with other mission improvements, would improve the spatial resolution to ~100 km for 1 cm water equivalent accuracy. We have built an engineering model of the instrument, and will report results from testing this instrument in the laboratory. The laser system will range directly to the proof mass of the drag-free system, eliminating many of the difficulties associated with post-processing the accelerometer data on GRACE. Using the expected instrument performance, we will also summarize the gravity recovery accuracies expected if the instrument were flown.

Keywords: gravity, grace



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GS002

Oral Presentation

2595

Experiments on the determination of global GRACE-only gravity models at sub-monthly intervals

Dr. Frank Flechtner

Department 1: Geodesy and Remote Sensing GFZ Potsdam IAG

Roland Schmidt, Ulrich Meyer, Karl-Hans Neumayer, Rolf Knig, Jrgen Kusche

Time series of GRACE-only gravity models with a further increased temporal resolution below one month would be very helpful to densify the GRACE-based estimates of time-variable gravity for their application and their validation in geosciences. In order to derive such series several concepts ranging from moving averages, pure subset solutions to a stochastic or functional modeling of the non-static residual gravity signal obtained with GRACE can be considered. At GFZ Potsdam we started to investigate the capabilities and limits of some of these concepts based on 7-daily batches of GRACE data and generated several experimental time series of GRACE-only gravity models with a sub-monthly resolution. The presentation will highlight processing strategies and show results on the performance of these model time series including comparisons to time-variable gravity signals inferred from the standard GFZ-RL04 models, independent data sets (e.g. SLR and GPS-based) and models (e.g. global hydrology).

Keywords: time variable gravity, grace



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Oral Presentation

2596

Assessment of GRACE Temporal Gravity Field Inversion Methodologies for Earth Geodynamic Studies

Dr. Michael Schmidt

*Deutsches Geodaetisches Forschungsinstitut Deutsches Geodaetisches Forschungsinstitut
IAGA*

C. K. Shum, D. Yuan, C.Y. Kuo, Y. Chen, L. Wang, M. Watkins

Numerous processing efforts of the GRACE data have led to substantial improvement of the Level 0, Level 1A/B, and the Level 2 (monthly degree 120, to be extended to degree 160 geopotential solutions) data products by the GRACE Project scientists and the members of the GRACE Science Team. A partial list of notable improvements include improved data processing (inversion, filtering and de-stripping techniques) and modeling (tides, de-aliasing products, geocenter) which produces new release of gravity field products (now at Release 4) by GRACE project and analysis centers, direct processing of KBR rate data as in situ disturbance potential line-of-sight acceleration measurements and using the energy approach or Fredholm's integral for gravity measurements, and alternate inversion techniques including mascon, 2D regional inversion, and spherical wavelets with multi-resolution representation (MRR). In this paper, we report results of comparison of various techniques including the 2D regional inversion, mascons, and the spherical wavelet representation of GRACE observables (KBR and other measurements) to assess their relative merits on examples of Earth geodynamic signals, including coseismic deformation as result of undersea earthquake and hydrologic fluxes.

Keywords: temporal gravity, geodynamics, wavelet

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2597****Optimizing the flight-path for airborne gravimetry campaigns****Dr. Machiel Bos***Faculdade de Ciencias Univerisade do Porto IAG***Luisa Bastos, Joao Catalao, Richard A. Deurloo**

Airborne gravimetry is a cost-effective technique for obtaining gravity observations over a regional area in a short time. It is specially useful in remote areas, where terrestrial gravity measurements are difficult, and also in coastal water zones where other methodologies cannot be applied to derive reliable measurements. Airborne gravimetry is the most promising actual technique to complement the long-wave length information that is being provided by satellites such as GRACE and, in the near future, GOCE, as it provides the short to medium wavelength information of the Earth's gravity field. The most expensive part of an airborne gravimetry campaign is the flight time. It is therefore surprising that almost no literature exists about the optimal design of the flight-path. Of course practical limitations such as the distance to nearest airport, the existence of restricted airspace and the flight altitude always prevent that an ideal flight path can be flown. Nevertheless, it seems desirable to analyze the impact that the flight-path and flight altitude might have in the performance of the method and to derive guidelines for the optimal spacing of the flight profiles for given flight altitude. Nowadays, the required geoid accuracy is 1-5 cm. With the predicted accuracy of GOCE, a model of the degree variance of the Earth's gravity field and the expected accuracy of a strapdown INS/GPS airborne gravimetry system, one can establish the requirements for the flight-path of an airborne gravimetry campaign. For this study we used the Airborne Geoid Mapping System for Coastal Oceanography (AGMASCO) campaign data to derive the noise properties of an INS/GPS system. Furthermore, we used a new regional geoid model of the Azores to simulate the minimum required number of flight segments and their spacing to be able to achieve the above mentioned geoid accuracy.

Keywords: gravimetry, airborne, geoid

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2598****The fennoscandian land uplift gravity lines 1966-2006****Dr. Jaakko Makinen**

IAG

**Andreas Engfeldt, Björn Geirr Harsson, Hannu Ruotsalainen, Gabriel Strykowski,
Tnis Oja, Detlef Wolf**

The Fennoscandian Land Uplift Gravity Lines consist of four east-west profiles across the Fennoscandian postglacial rebound area, along the approximate latitudes 65, 63, 61, and 56N. Repeated relative gravity measurements have been so far performed 19752000 (65N), 19662003 (63N), 19761983 (61N), and 19772003 (56N). The line 63N has most observations. From the measurements along it up to 1993, Ekman and Mkinen (1996) deduced the ratio 0.20 gal/mm between surface gravity change and uplift relative to the Earth's center of mass. Since that time, more gravity measurements have been made, and we present a more complete analysis. From 2003 on, the measurements on the line 63N are continued using absolute gravity techniques.

Keywords: fennoscandia, postglacial rebound, gravity

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2599****Progress towards the GGM03 mean Earth gravity models from GRACE****Prof. Byron Tapley***Center for Space Research University of Texas at Austin IAG****John Ries, Srinivas Bettadpur, Don Chambers, Francis Condi, Stephen Poole***

Earlier this year, the GRACE Release-04 Level-2 gravity field data products were made available to the user community. These products were improved with respect to previous data releases as a result of upgrades to the background gravity field models, and changes in the data processing algorithms. In addition to the monthly time-series of gravity variations, we have also derived mean gravity field estimates during this re-processing. These estimates will eventually lead to the GGM03S (GRACE-only) and GGM03C (GRACE in combination with surface gravity) data products. In this paper, we discuss the candidate mean gravity field data products. A brief overview of the data and processing methods will be provided. The spectral and spatial character of the changes between GGM02 and the candidate GGM03 fields will be discussed. Results from the validation of these fields with respect to independent data will be presented.

Keywords: grace, gravity, mean field

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(G) - IAGA - International Association of Geomagnetism and Aeronomy

GS002

Oral Presentation

2600

Arctic Gravity Project revised: gravity and geoid of the Arctic from surface and airborne gravity, ICESAT and GRACE

Mr. Rene Forsberg

Geodynamics Department Danish National Space Center IAG

Henriette Skourup, Steve Kenyon, Alex Braun

We describe an update of the Arctic Gravity Project gravity grid, covering the region 64-90oN, incorporating new terrestrial gravity data from major regions such as northern Siberia, and improving errors and occasional lack of resolution in the earlier released ArcGP grid using ICESAT-derived free-air anomalies. Free-air anomalies have been generated from 7 months of ICESAT data from the period 2003-5, using an inverse Wiener filtering method and simultaneously estimating sea-ice thickness by combination with a GRACE-based geoid model, a lowest-level filtering scheme, and updated tidal and inverse barometer corrections. The ICESAT-derived gravity data are compared to airborne gravity data sets in permanently ice covered regions up to 86oN, showing accuracies around 5 mGal, thus providing valuable data for checking errors in terrestrial gravity data and filling in data gaps.

Keywords: arctic, gravity, icesat



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2601****Optimization concepts, boundary problems and iterations in the combination of terrestrial and satellite gravity field data****Dr. Petr Holota***Geodesy and Geodynamics Research Inst. of Geodesy, Topogr. and Cartogr. IAG***Otakar Nesvadba**

The purpose of this paper is to discuss a method of combining terrestrial and satellite gravity field data, which in an optimal way exploits gravity field information contained in the solution of boundary problems in a close neighborhood of the Earth. The image of the filtered solution obtained in this way is harmonically extended and assumed regular at infinity. Results achieved so far are briefly reviewed. Subsequently, the approach is considerably generalized in this paper. Effects of the topography of the Earth and the precise structure of the boundary condition for the disturbing potential are taken into account. These refinements are expressed as corrections constructed by means of an iteration method. The starting point is a transformation of the boundary problems considered under a small modification of curvilinear coordinates. In consequence a spherical resolvent operator may be applied at each iteration step. The solution is interpreted in the spectral as well as space domain. In this connection the structure of the respective Greens integral kernel was derived, which enabled to treat also the problem of absence of data in a spherical polar cap. Finally, the discussion is added a numerical experiments and simulations for data derived from the EGM96 and parameters close to the orbit of the expected GOCE mission.

Keywords: data combinations, boundary value problems, optimization

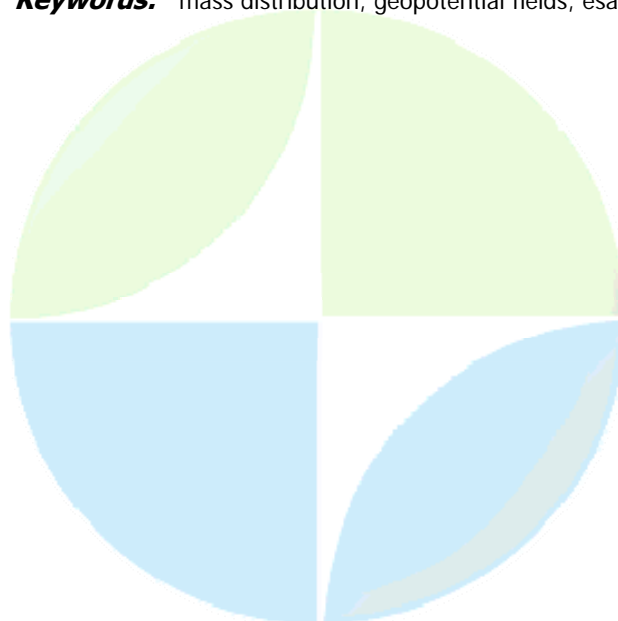


(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Oral Presentation****2602****Monitoring And Modelling Individual Sources Of Mass Distribution And Transport In The Earth System By Means Of Satellites****Dr. Radboud Koop**

IAG

Thomas Gruber, Pieter Visser, Nico Sneeuw, Matt King, Jonathan Bamber, Marc Bierkens, Tonie Van Dam, Martin Losch, Maik Thomas, Michael Kern, Roger Haagman

It has been generally acknowledged that practically all sub-systems of System Earth, both in a static and a time-variable manner, leave a marked influence on geopotential fields, like the gravitational field, through their expression in terms of mass distribution and transport. This applies, on different spatial and temporal scales, to the solid earth, the oceans, the atmosphere, ice, the tides and hydrology. Current and future satellite gravity missions, like GRACE and GOCE, have shown and will show that our understanding of the elements of System Earth, their interactions, interfaces and dynamical processes in the Earth's interior and at the surface will benefit greatly from the improved gravity field knowledge that such missions collect. At the same time, current missions have also shown that it is certainly not a trivial task to unravel all the different sources of mass distribution and transport from the accumulated gravity signal as it is observed. In order to optimally benefit from the high-resolution (both in time and space) and high-accuracy gravity data coming from a possible future gravity mission as follow-on to the current ones, a study has been initiated by ESA to investigate the need for improved geophysical modeling, the type of mission design and scenario needed, and manners to de-alias and separate the different gravity sources from the observations. This study will be performed by a consortium of nine European groups, combining expertise in all relevant geophysical field and satellite gravity missions. The study started beginning of 2007 and will last until end 2008. This paper presents the background of the study, and explains the (simulation) approach that will be taken to address the goals of the study. Major issues that play a role for the latter are the mission concepts, the state-of-the-art geophysical modelling, the use of dedicated spatio-temporal sampling to tackle the separability issue and the use of complementary data and models.

Keywords: mass distribution, geopotential fields, esa

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GS002

Poster presentation

2603

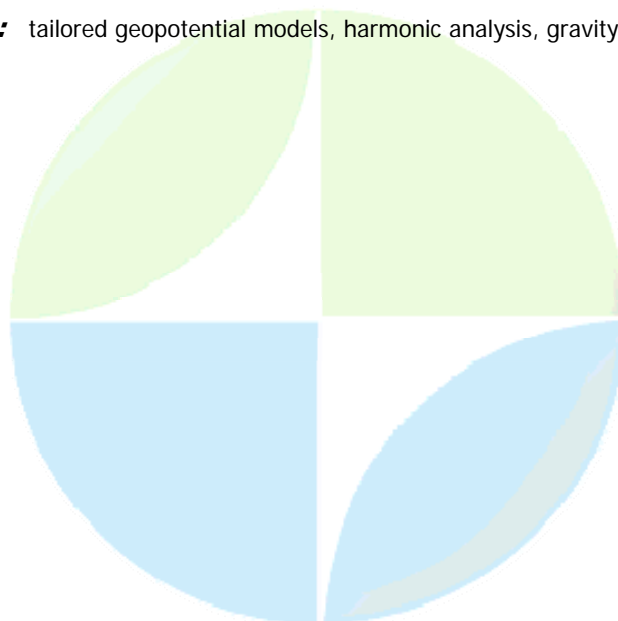
Tailored Reference Geopotential Model for Egypt

Prof. Hussein Abd-Elmotaal

Civil Engineering Department Minia University, Egypt IAG

The quality of the reference geopotential model used in the framework of the remove/restore technique plays a great role in estimating the accuracy of the computed geoid. In other words, if the residual field is biased and has a high RMS, then using such a biased/high variance field in the geoid computation process gives less accurate interpolated quantities, and hence worse geoid fitting to the GPS-levelling derived geoid. Practical studies so far have proved that none of the existing reference geopotential models fit the Egyptian gravity field to the desired extent. Thus, the main aim of this investigation is to have a smoothed gravity field (in terms of gravity anomalies) so that it is, more or less, unbiased and has a significantly small variance by using a high-degree tailored reference geopotential model. The window technique (Abd-Elmotaal and Kuehtreiber, 2003) has been applied within this investigation to get rid of the double consideration of the topographic-isostatic masses within the data window. The high-degree tailored reference model has been created by merging the available gravity anomalies in the area of investigation with the global gravitational data set. Such a global data set has been created by the available EGM96 reference geopotential model (complete to degree and order 360). The merged global field has been then used to estimate the harmonic coefficients of the tailored reference model by a FFT technique using an iteration process to enhance the accuracy of the obtained harmonic coefficients and to minimize the residual field (Abd-Elmotaal, 2004). Since the low order harmonics of the anomalous gravitational potential are to a great extent due to the density disturbances in the upper mantle and even deeper sources, the lower harmonics till a certain degree have been fixed to their values as of EGM96 geopotential model. Different values of such a low degree have been used in this investigation; they are: 20, 36 and 72. Accordingly, three tailored geopotential models have been created within this investigation complete to degree and order 360. The results show that the tailored geopotential models created in this investigation give better residual gravity anomalies (unbiased and have much less RMS). The variance has dropped to its one third in case of using the tailored geopotential models created in this study in the frame work of the remove/restore technique. All three developed geopotential models give practically the same results.

Keywords: tailored geopotential models, harmonic analysis, gravity field recovery



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2604****Investigation of gravity gradients of potential anomaly in Iran territory using GRACE****Dr. Ramin Kiamehr**
*Geodesy PhD Geodesy IAG***Mehdi Eshagh**

Only with satellites it is possible to cover the entire earth densely with measurements of uniform quality within a short period of time. However, due to the low altitude of the satellites, the effect of the individual local mass is strongly damped in the gravity field recovery. The sensitivity of satellite orbit are restricted to a certain degree and order of gravity field but using the space gradiometry methods it is possible to get higher degree and order by the same satellite. Because of sensitivity of gradiometric measurements to the gravity field they can be suitable means for interpreting the Geophysical phenomena. Based on the Petrovskaya and Vershkov (2006) approach, we determined the gravity gradient tensor directly from the spherical harmonics coefficients of the recent GLO4C combined model of the GRACE. In this article we review the procedure for estimation of the gradient components directly from spherical harmonics coefficients then we applied this method as a case study for interpretation of the possible geophysical patterns in Iran. We found an interesting interpretations for the cross components of the gradient tensor and their strong correlation with the deflection of vertical components of the geoid model. Also, the correlation of the gravity anomaly, geoid model and digital elevation investigated versus the gradient components.

Keywords: gradients tensor, global geopotential model, gracePERUGIA
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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2605****Adjustment of the gravity reference network of Estonia****Mr. Tõnis Oja***Department of Physics Faculty of Science IAG*

The establishing of accurate and reliable gravity network is expensive, time-consuming and a technically complicated task. Preparations for solving such a task in Estonia were initiated in 2001. By the end of 2003 the Estonian gravity network of II order was measured as a whole with three relative LCR-G gravimeters. All the relative measurements were based on the three absolute gravity stations established in 1995. On the basis of the collected data a new realization of the national gravity system will be established soon in the near future. However, before the final adjustment of the network, several issues should be covered, e.g. the calibration of relative gravimeters, short and long term changes of gravity field, the choice of epoch and the reductions of observations, the selection of statistical tests and blunder detection algorithm, etc. In the current research I am analyzing those issues and also introducing some solutions for them.

Keywords: network adjustment, gravity network, relative gravimetry



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2606****Calibration of relative LaCoste-Romberg G and Scintrex CG-5 gravimeters
in the Estonian and Finnish calibration lines****Mr. Tõnis Oja***Department of Physics Faculty of Science IAG*

Solid calibration of relative spring gravimeters is a crucial step in obtaining accurate and reliable results in national gravity networks or in geodynamic networks. In this study I analyze the gravity data which I have collected in several calibration lines in Estonia and Finland during the years 2001-2006. Two types of gravimeters were used - LaCoste&Romberg (LCR) metal spring (G-type) and Scintrex quartz (CG-5) systems. Both the linear and nonlinear correctional components of the calibration function have been parameterized and estimated through the linearized least squares adjustment. The time dependency of estimated parameters is studied as well. After making statistically significant corrections to the gravimeters calibration function, I can show noticeable increase in the precision and accuracy of the gravity data measured in the Estonian gravity network and Pltsamaa-Lelle geodynamic line.

Keywords: relative gravimeters, calibration lines

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I T A L Y

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2607****Satellite altimetry over land and coastal zones: a summary of achievements of IAG SG2.3 over 2003-2007*****Prof. Cheinway Hwang****Civil Engineering Dept of Civil Engineering, National Chiao Tung Uni IAG*

This paper presents the scientific achievements of IAG Special Group 2.3. A workshop on land and coastal applications of satellite altimetry was held in Beijing, China in July 2006. Achievements cover the areas of sea level change, coastal tide and current, coastal gravity field determination and land application. Over 2003-2007, numerous waveform retracking techniques have been developed by the SG2.3 members to improve ranging accuracy of altimetry. Improved shall-water tides over such areas as China Seas and Taiwan Strait have been developed and contribute to other fields such as ocean tide loading models of gravity and site displacement. Ocean circulations in the China Seas and Mediterranean also see some advancement with improved altimetry. Several research works are dedicated to lake level changes in the Asia continent, which reveal some major climate signals. Retracked satellite altimeter data, especially those from Geosat and ERS-1 geodetic missions, greatly improve coastal gravity determination. Airborne gravimetry further improves the gravity accuracy at coastal zones. Research activities in the Antarctica using retracked Geosat and ERS-1 altimetry, as well as shipborne gravity, will be presented.

Keywords: altimetry, gravity, sea level

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2608****Accuracy Evaluation for SST Gravity Field Models in China****Dr. Jia Luo***GS002 Gravity Field IAG*

In this paper, with China as the region in research, the potential of the new satellite gravity technique, Satellite-to-Satellite tracking, to improve the accuracy of regional gravity field model is studied. With WDM94 as reference, which has higher accuracy in China, the gravity anomaly residuals of three models, the latest two GRACE global gravity field model (EIGEN_GRACE02S, GGM02S) and EGM96, are computed and compared. The causes for the differences among the residuals of the three models are discussed. The comparison between the residuals shows that in the selected region, EIGEN_GRACE02S or GGM02S is better than EGM96 in lower degree part (less than 110 degree). Additionally, through the analysis of the model gravity anomaly residuals, it is found that some systematic errors with periodical properties exist in the higher degree part of EIGEN and GGM models. And the results of the paper can also be taken as references in the validation of the SST gravity data.

Keywords: sst, gravity, china

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2609

Simulation Research of Satellite-to-Satellite Tracking in Lunar Gravity Field Determination

Dr. Jia Luo

GS002 Gravity Field IAG

In this paper, Lunar Satellite-to-Satellite Tracking technique has been studied and discussed in general. Firstly, assuming that the satellite pairs of SST are in near circle polar orbits, the spectrum relationship between the lunar gravity field and inter-satellite ranging system is established using analytic method. And some simulation examples are analyzed; the suggestions and conclusions are drawn from these analysis. The research results could be taken as a reference for future lunar satellite gravity project to solve the data collection of lunar far side.

Keywords: sst, lunar, gravity

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GS002

Poster presentation

2610

New investigation on the choice of the tailored global geopotential model for Algeria

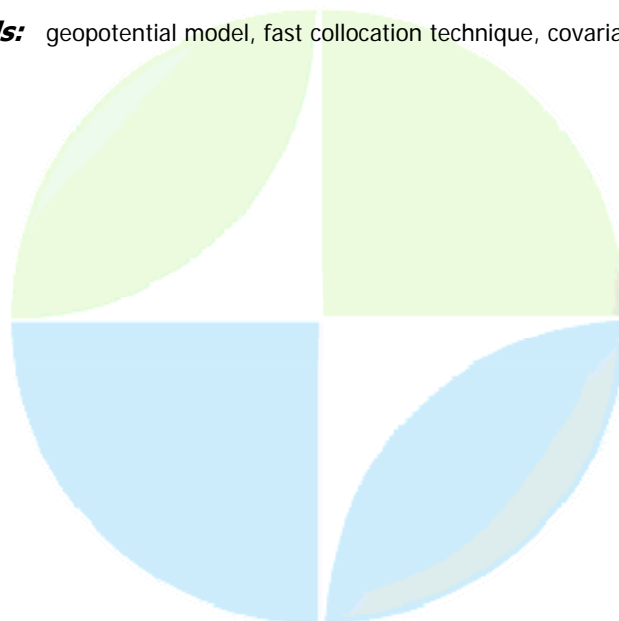
Dr. Sid Ahmd Benahmed Daho

Geodetic Laboratory National Center of Space Techniques IAG

C. L. Merry

The choice of the best geopotential model to reduce geodetic data is one of the critical steps in computing the geoid. Several studies have shown that the geopotential models tailored to regional or local gravity data are best suited for high precision geoid computations. Since 2000 different gravimetric local geoid models have been released and computed by Geodetic Laboratory of the National Centre of Space Techniques for the region of Algeria. During the same time several new Global Gravity Models from the recent satellite gravimetric missions CHAMP and GRACE were released. These models provide a homogeneous and near-complete global coverage of gravity field information and, by consequently, lead to significant improvements of our knowledge of the long wavelength part of the geoid. For the computation of a new gravimetric geoid model for Algeria we need a new investigation on the choice of the best GGM model for the combined solution with local gravimetric data. In this paper, an analysis was carried out to define the geopotential model, which fits best the gravity field in Algeria. In this comparison, five global geopotential models are used: The new GRACE satellite-only and combined models GGM02S, GGM02C, combined CHAMP and GRACE model EIGEN-CG01C, OSU91A and EGM96. The test of the fitting of these high order geopotential models to the gravity field in Algeria is based on the gravity data supplied by the B.G.I., and some of the precise GPS data collected from the international TYRGEONET (TYRhenian GEOdynamical NETwork), ALGEONET (ALGerian GEOdynamical NETwork) projects with baseline length ranging from about 1 to 800 km have been used. The comparisons were made at all gravity and GPS levelled points by calculation of the residual data (i. e. observed data minus model). The statistical parameters considered in this work are the mean, the standard deviation and the smooth covariance function necessary for all estimation by the Fast collocation technique. The data used in this work and their distribution, the computation procedure, the different statistical tests, some conclusions and recommendations will be presented and widely discussed.

Keywords: geopotential model, fast collocation technique, covariance function



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A new vertical datum for Algeria derived from the combination of the local Gravimetric geoid and GPS/Levelling data

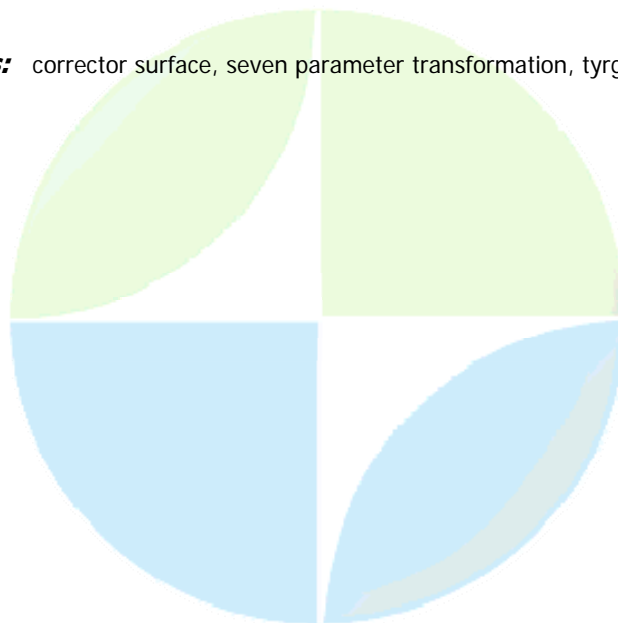
Dr. Sid Ahmd Benahmed Daho

Geodetic Laboratory National Center of Space Techniques IAG

C. L. Merry

In the past, traditional spirit levelling has been used to obtain height information with very high accuracy. By nature, spirit levelling is a very time consuming, costly and laborious task especially in a large country like Algeria where the establishment of a levelling network covering all parts of the country would be impractical from the financial point of view, very arduous in areas with rough terrain and furthermore may not be possible in the south of the country due to the absence of any vertical control. The main objective of this paper is to try to construct of the corrector surface in the north part of Algeria for GPS/Levelling purpose capable to produce orthometric heights with an acceptable accuracy at least for the low order levelling network densification. For this work, a new set of the GPS/Levelling data homogeneously distributed; collected from the international TyrGeoNet (TYRhenian GEOdynamical NETwork) project and the some local GPS/Levelling surveys with baseline length ranging from about 1 to 800 km, have been used to adapt the gravimetric geoid model to GPS/Levelling data. The GPS/Levelling geoidal heights are obtained by connecting the points to the first order levelling network while gravimetric geoidal heights were interpolated from geoid model computed by Geodetic Laboratory of the National Centre of Space Techniques from gravity data supplied by BGI. In addition, we have used a seven parameter transformation model to minimize the datum inconsistencies between our height data and GPS, levelling, and long-wavelength geoid errors. The comparisons based on these GPS campaigns provide after fitting a RMS of the differences 1.4 cm and prove that a good fit in experimental area between the gravimetric geoid and GPS/levelling data using the seven parameter model transformation has been reached and that the possibility exists to develop an empirical surface (corrector surface) in north part of Algeria which relates a given gravimetric geoid model to the reference system of GPS ellipsoidal heights, and to the vertical datum of ones orthometric height system. The main outlines of the Algerian geoid model computed from gravity data supplied by BGI, the available GPS/Levelling data, the developed procedure and the obtained results would be presented and widely discussed.

Keywords: corrector surface, seven parameter transformation, tyrgeonet project



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2612****Towards a new global digital elevation model****Prof. Philippa Berry***EAPRS Lab De Montfort University IAG***Richard Smith, Jennifer Freeman, Jerome Benveniste**

The SRTM dataset provides the first near-global elevation model of the Earth's continental land surface at 3 resolution. This unique dataset is currently used for a range of applications. However, there are a number of known quirks and omissions in these data, for example voids over inland water and erroneous heights from forest canopy; in addition a recently completed global analysis of these data utilising a dataset derived from multi-mission satellite radar altimetry has revealed spatially correlated error signatures probably caused by incorrect heights in ground control points used to seed the solution. This paper presents work currently underway towards an enhanced global elevation dataset, ACE2, a follow-on to the highly successful ACE GDEM. This development utilises over 67 million height measurements derived from multi-mission satellite radar altimetry using an expert system approach to validate, rectify errors and augment the SRTM dataset to derive a full global GDEM.

Keywords: srtm, gdem, altimetry

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2613****The Antarctic Geoid Project (IAG Commission Project 2.4)*****Dr. Mirko Scheinert****IAG Commission Project 2.4 TU Dresden IAG*

The IAG Commission Project 2.4 "Antarctic Geoid" (AntGP) was put into action after the IUGG General Assembly in Sapporo, 2003. It is motivated acknowledging the situation of the terrestrial gravity field coverage in Antarctica: Until now, vast areas of Antarctica are unexplored with regard to gravity measurements. Looking at the dedicated satellite gravity missions like GRACE and GOCE one observes a polar gap problem due to the orbit characteristics featuring inclinations only close to 90 degree. In order to determine the geoid and to densify the gravity field in Antarctica the goal of AntGP is to work towards closing the gaps in terrestrial gravity observations. In this context, the International Polar Year 2007/08 (IPY), which begins at March 1, 2007, provides a framework for broad international and interdisciplinary collaboration. There will be a lot of activities in order to realize geodetic-geophysical programs. This presentation will review the current situation. It will summarize what has been done so far and will give an outlook to planned activities. Especially, there should be a focus on airborne gravity surveys which provide the most powerful method to carry out observations in extended regions.

Keywords: gravity field, antarctica, regional geoid determination



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2614****Self-adaptive choice of a system of localizing base functions for regional gravity field recovery****Prof. Wolfgang Keller***Geodetic Institute University Stuttgart IAG*

For geophysical/hydrological interpretation of data from dedicated gravity field satellite missions a regional gravity field recovery is more important than a global solution. This can be achieved by replacing the usual spherical harmonics, as base functions with a global support, by base functions with a local support or at least rapidly decreasing base functions. Spherical splines or spherical wavelets are frequently used for this purpose. A spherical spline or a spherical wavelet is characterized by two features: * the location of its maximum, * the nature of its decay behavior. Usually the decay behavior is fixed in advance in accordance with same resolution considerations. Then the splines or wavelets are placed so that their maxima form a regular grid in the domain under investigation. In general this strategy leads to an over-parameterization and the necessity to regularize the resulting system of linear equations. The paper aims at a joint optimization of the gravity field representation by localizing base functions not only for * the weights of the individual base functions in this representation but also for * the locations of the base functions and * their decay behavior Using techniques as Genetic Algorithms or Simulated Annealing, known from gravity inversion, it will be shown that for a joint optimization * the necessary number of base functions decreases * the fit improves in comparison with the classical recovery technique.

Keywords: regional recovery, spherical splines, genetic algorithm

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2615****On the principal difficulties and ways to their solution in the theory of gravitational condensation of infinitely distributed dust substance*****Prof. Alexander Krot****United Inst. of Informatics Problems, NAS Belarus Head of Laboratory IAG*

There are principal difficulties in the theory of gravitational condensation and gravitational instability of the infinitely distributed dust substance in space. The gravitational condensation problem of infinitely distributed substance is directly connected with gravitational instability problem [1], [2],[3],[4]. The linearized theory of gravitational instability leads to the well-known Jeans criterion [1],[3]. Nevertheless, some works [5],[6] point to that the infinite homogeneous non-rotating substance can not be in an equilibrium state, therefore, the small disturbances do not manage to form any dense bunches. However, process of planet forming is very long in time, in this connection the Newtonian consideration of locally equilibrium system becomes preferable. The main difficulty of Jeans theory is connected with a gravitational paradox: for an infinite homogeneous substance there is not a potential of gravitational field in accord with the Poisson equation [3]. Because the classic gravitational theory did not give any reply on the gravitational condensation problem, the statistical theory for a cosmological body forming (so-called the spheroidal body model) has been proposed in [7]-[15]. Within the framework of this theory, gravitating bodies have fuzzy outlines, and they are represented by means of spheroidal forms. In the work [9], it has been investigated a slowly evolving in time process of a gravitational compression of a spheroidal body close to an unstable mechanic equilibrium state. The proposed theory follows from the conception for forming a spheroidal body as a proto-planet from planetary nebula; it permits to derive the form of distribution functions for an immovable spheroidal body [7]-[9] and rotating one [13]-[16] as well as their mass density, potential and strength of gravitational field and also to find the distribution function of specific angular momentum for the rotating spheroidal body [16], [17]. It has been shown by Jeans [1], the important law of statistical mechanics can be obtained from equation for evolution of distribution function of a dust-like substance. However, the main problem of self-condensation of an infinitely distributed substance has not been solved by Jeans theory. In this connection this work explains a slowly evolving process of gravitational condensation of a spheroidal body from an infinitely distributed substance. The equation for initial evolution of distribution function of a gas-dust proto-planetary cloud is derived. It is occurred this equation coincides completely with the analogous equation for a slowly compressed spheroidal body [9], [10]. The proposed theory also is applied to exploring formation of planets of Solar system. As a result, the obtained law for Solar system planetary distances generalizes the well-known Schmidt law [2]. The new law gives a very good estimation of real planetary distances in Solar system (the relative error of estimation is 0%; absolute error of estimation is 1.4% besides its maximal value is equal to 11% for Earth) [16]. Moreover, the proposed law shows that Pluto is not a result of Solar system forming. References: [1] Jeans, J. Astronomy and Cosmogony. Univ. Press: Cambridge, 1929. [2] Schmidt, O.Yu. The Origin of Earth and Planets. Acad. of Sci. USSR Press.: Moscow, 1962 (in Russian). [3] Safronov, V.S. Evolution of Protoplanetary Cloud and Formation of Earth and Planets. Moscow: Nauka, 1969 (in Russian); NASA Tech. Transl. F-677, Washington, D.C., 1972. [4] Vityazev, A.V., Pechernikova, G.V. and Safronov, V.S. The Terrestrial Planets: Origin and Early Evolution. Moscow: Nauka, 1990 (in Russian). [5] Lifschitz, E.M. Zh.E.Th.F., vol.16, p.587, 1946 (in Russian). [6] Bonnor, W.B. Monthly Notices Roy. Astron. Soc., vol.117, p.104, 1957. [7] Krot, A.M. Achievement in Modern Radioelectronics (Special issue ?Cosmic Radiophysics?, Moscow), no.8, pp.66?81, 1996 (in Russian). [8] Krot, A.M. Proc. SPIE's 13th Annual Intern.Symp. ?AeroSense?, vol.3710, pp.1248-1259, Orlando, Florida, USA, April 5-9, 1999. [9] Krot, A.M.Proc. SPIE's 14th Annual Intern.Symp. ?AeroSense?, vol.4038, pp.1318-1329, Orlando, Florida,

USA, April 24-28, 2000. [10] Krot, A.M. Proc. SPIE's 15th Annual Intern. Symposium ?AeroSense?, vol.4394, pp.1271-1282, Orlando, Florida, USA, April 16-20, 2001. [11] Krot, A.M. Proc. 53rd Intern. Astronautical Congress: The World Space Congress-2002, Houston, Texas, USA, October 10-19, 2002, Preprint IAC-02-J.P.01. - 11 p. [12] Krot, A.M. Proc. 34th Scientific Assembly of the Committee on Space Research (COSPAR) - The 2nd World Space Congress (WSC-2002), October 10-19, 2002, Houston, Texas, USA. [13] Krot, A.M. Proc. EGS-AGU-EUG Joint Assembly, Nice, France, April 6-11, 2003, Geophysical Research Abstracts, vol.5, EAE03-?-05568, 2003. [14] Krot, A.M. Proc. 54 th Intern. Astronautical Congress (IAC), September 29-October 3, 2003, Bremen, Germany, Preprint IAC-03-J.1.08. ?11p. [15] Krot, A.M. Proc. 35th COSPAR Scientific Assembly, Paris, France, July 18-25, 2004, Abstract-Nr. COSPAR 04-A-00162. [16] Krot, A. Proc. EGU - 2nd General Assembly, Vienna, Austria, April 24-29, 2005, Geophysical Research Abstracts, vol.7, EGU05-A-04550, 2005; SRef-ID: 1607-7962/gra/. [17] Krot, A. Proc. EGU - General Assembly, Vienna, Austria, April 02- 07, 2006, Geophysical Research Abstracts, vol.8, EGU06-A-00216, 2006; SRef-ID: 1607-7962/gra/.

Keywords: gravitational condensation, mass distribution function, gravitational field potential

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Poster presentation

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Coastal and land Applications of satellite altimetry

Dr. Xiaotao Chang

Chinese Academy of Surveying and Mapping State Bureau of Surveying and Mapping IAG

Guo Jinyun, Li Jiancheng, Zhang Chuanyin, Dang Yamin

To improve the precision of satellite altimetry at the coastal and land regions, waveforms are retracked by retrackers, which are designed according to different characteristics of the waveform. At the coastal sea regions, multi-threshold multi-leading edge retracker is used, and then the retracked sea surface heights are transferred to gravity anomaly. Shipborne gravity anomalies are used to validate the results from the satellite altimetry, and then the results are applied to the geodynamical study in the southeast China sea. Over the land, T/P waveforms are retracked to get the desert surface heights of the north China, and GPS RTK measurement are used to validate the retracked results. Then the results are applied to the study of elevation changes over deserts in North China that created sand dust storm.

Keywords: altimetry, waveform retracking, gravity

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2617****Gravity changes caused by tide-generating potential and by internal dislocation in a 3-D heterogeneous earth (1) theory****Dr. Guangyu Fu***Earthquake Research Institute the University of Tokyo IAG***Wenke Sun**

It is well known that tide-generating potential and internal dislocation cause changes in gravity (e.g., Molodenskiy, 1977; 1980; Molodenskiy and Kramer, 1980; Wahr, 1981; Hagiwara et al., 1985; Okubo, 1991; 1992; Sun and Okubo, 1993; 1998; Imanishi et al., 2004). Nowadays, observation accuracy of the advanced development of geodetic observation techniques is pretty high, such as GPS, satellite gravity missions, and absolute and super-conducting gravimetry. The information of Earth's internal three-dimensional (3-D) structure can be detected using geodetic observations. Therefore, proper analysis and interpretation of the geodetic data call for corresponding theories, such as the deformation theory, for a 3-D earth model. In this study we introduce a theory for evaluating deformations caused by an internal or external force in a spherical earth with a 3-D inhomogeneous structure in the mantle. The deformation caused by the 3-D earth model is expressed using the solution for a layered earth model (e.g., PREM) in addition to the effect caused by the small lateral increment. We develop the tidal theory of Molodenskiy (1977; 1980) for a 3-D spherical earth model, and derive expressions to compute effects of lateral density inhomogeneity, which were overlooked in Molodenskiy (1977; 1980). We also present a new theory for computing co-seismic gravity changes caused by dislocations in a 3-D spherical earth. The theory is described using six independent dislocations: a vertical strike-slip, two vertical dip-slips perpendicular to each other, a tensile opening on a horizontal plane, and tensile openings on two perpendicular vertical planes. A combination of the six independent dislocations is useful to compute co-seismic gravity changes resulting from an arbitrary seismic source at an arbitrary position. The effect of dislocation source is special treated from the effect of earth medium.

Keywords: gravity changes, dislocation, tide

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2618****GRACE application to the receding Lake Victoria water level and the Australian drought****Dr. Joseph Awange**
*Spatial Sciences IAG, AGU IAG***Dr.-Ing. Mohammad A. Sharifi, Prof. Wolfgang Keller, Prof. Will E. Featherstone,
Dr. Michael Kuhn**

Lake Victoria in Africa, the worlds second-largest freshwater lake, has been experiencing receding water levels since 2001. As it recedes, more than 31 million people who depend on it for livelihood are facing a disaster. Similarly, Australia is facing its worst drought on record with the livelihoods of a few million people at stake. Gravity Recovery Atmospheric Climate Experiment (GRACE) data for 45 months (i.e., April 2002 to April 2006) are employed to analyse these emerging challenges by measuring variations in stored water in east Africa and Australia. For the Lake Victoria basin, the results indicate a general decline in the basins water level at a rate of 1.83km³/month or equivalent water height of 6.20mm/month since 2002. This confirms that the fall in Lake Victorias water level is caused by a general decline in the catchments water. For this region with sparse terrestrial data, the results present the first independent non-terrestrial diagnosis of the fall of Lake Victoria water level (i.e., the fall is directly related to the decline in the basin's waters). For the case of Australia, the results show that the hydrological signal over Australia is unrealistically variable, which is due to deficiencies in the GRACE data processing and filtering methods, coupled with the likely small hydrological signal in Australia. We therefore recommend that a much more Australia-focussed reprocessing of the GRACE data is needed for any useful hydrological signals to be extracted.

Keywords: grace, australian drought, lake victoria water level

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2619****Solution of the inverse Stokes and inverse Hotine problems to order f for an ellipsoidal boundary*****Prof. Bernhard Heck****Geodetic Institute University of Karlsruhe IAG****Kurt Seitz***

The inverse Stokes problem aims at the determination of gravity anomalies from given geoidal heights N (or disturbing potential T at sea level), while the inverse Hotine problem deals with the transformation of N into gravity disturbances. Most practical solutions of these problems are based on the so-called spherical and constant radius approximations, neglecting the non-isotropic terms in the boundary condition and the ellipticity of the Earth; as a result of these simplifications, the spherical inverse Stokes and Hotine integral formulae are produced. A more precise solution of the inverse Stokes and Hotine problems is achieved by retaining the first order ellipsoidal effects in the boundary condition relating gravity anomalies (or gravity disturbances) and T . These ellipsoidal effects are composed of three constituents, depending on the geometrical flattening f of the reference ellipsoid, the dynamical flattening J_2 of the normal gravity field, and the angular velocity of the Earth's rotation. Analytical solutions of the ellipsoidal problems are derived by transformations from the space domain to frequency domain and back to space domain, retaining first-order terms in f , J_2 and the angular velocity. Several equivalent forms of the solutions are discussed in the paper, based on spherical integral formulae plus specific ellipsoidal corrections. A numerical evaluation based on the EGM96 geopotential model results in estimates of the ellipsoidal correction terms of the order 0.3 mgal. The correction terms show a low-frequency behaviour, dominated by spherical harmonic terms of degree n up to 20.

Keywords: inverse stokes problem, ellipsoidal effects, gravity anomalies



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Poster presentation

2620

Comparison of analytical and numerical methods for the computation of the potential of different mass elements and its first or second derivatives

Mrs. Franziska Wild-Pfeiffer

Geodetic Institute University of Karlsruhe IAG

Bernhard Heck, Kurt Seitz

Topographic and isostatic reduction methods as well as modern concepts of gravitational modelling like the RTM method or the remove-restore technique require the computation of the gravitational effects of volume elements which are usually represented by prisms. In terrestrial and airborne gravity field determination the formulae for the gravitational potential and its first order derivatives have been evaluated, while second order derivatives are related to the analysis of upcoming satellite gravity gradiometry missions of GOCE type. Especially there, the reduction of topographic and isostatic effects within the remove-restore concept is important to produce a smooth gravity field suitable for downward continuation. Another application of topographic and isostatic reductions may consist in the external calibration of the GOCE gravity gradiometer. In this presentation the prism approach is opposed to the tesseroid, the point mass, the mass layer and the mass line. For these 5 different mass elements, analytical and numerical methods are reviewed and discussed. The formulae for the potential, the attraction components and the Marussi tensor elements are derived. These formulae for the different mass elements and computation methods are checked by assuming a synthetic topography of constant height over a spherical cap and the position of the computation point situated on the polar axis. For this special situation an exact analytical solution for the tesseroid exists and a comparison between the analytical solution of a spherical cap and the modelling of different mass elements is possible. A comparison of the computation times shows that modelling by tesseroids with different methods produces the most accurate results in an acceptable computation time.

Keywords: mass elements, analytical methods, numerical methods



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2621****A Molodenskij geoid model in Iran****Prof. Mehdi Najafi-Alamdari**
*Geodesy Assistant Prof. IAG***Seyed Rohallah Emadi, Makan. Abdolazadeh**

Abstract Determination of the geoid with a high accuracy is the main task among researchers in the geodetic community. Precise determination of a regional geoid is usually carried out combining a global geopotential model data with a set of point or mean terrestrial gravity anomalies measured in the region and some topographic information. In this research a primary Iranian gravimetric geoid model has been computed by combination of EGM96 global geopotential model and terrestrial surface gravity anomaly data in grid. We selected the Molodenskij approach, instead of classical Stokes idea, for determination of the quasi-geoid first. The topographical effects in terms of G1 and G2 are computed by a regional available DEM data. The Vanček and Kleusberg modification of the integration kernels were used in order to reduce the contribution of far zone effects. Finally the geoid was restored by correcting the quasi-geoid. The so-determined geoid was then compared with a geometrically determined geoid by GPS at some height network points in the region. The differences in absolute values of the geoid heights were 0.16m maximum, -2.26m minimum, and -0.87m in average on 22 check points.

Keywords: gravimetric, molodenskij approach, quasi geoid**XXIV 2007**
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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2622****Realisation of one centimetre geoid in Klang Valley****Mr. David Chang***Department of Survey and Mapping Malaysia Institute of Surveyors Malaysia IAG***Dr Samad Bin Hj Abu, Mr Soeb Nordin**

For more than 90 years, JUPEM has set up permanent benchmarks throughout the country using precise leveling methodology to provide the users with accurate and precise orthometric (mean sea level) heights. Under the Eighth Malaysia Plan, JUPEM has successfully implemented the airborne gravity survey with the creation of MyGeoid, with an accuracy of 4.5 cm for the whole nation. This geoid model has allowed for the determination of the orthometric height using Global Positioning System (GPS) without the spirit leveling. However, in order to convert the highly precise ellipsoidal height to the orthometric height which is referenced to the geoid without losing the accuracy of the satellite measurement, a centimeter-geoid is required. Determination of a centimeter-level geoid is being driven to match vertical positioning accuracy of satellite techniques such as GPS and GLONASS. This paper seeks to describe a project proposal of development of one centimeter geoid under the 9th Malaysian Plan with the aim to increase the accuracy of the height determination using GPS and other technologies by refining MyGeoid to produce a one centimeter accuracy geoid for the Klang Valley area. The project will involve several components of observation of densely established new control marks at an interval of 500 m and one (1) km grid spacing with GPS and gravity data. Precise leveling data will be carried out at interval of 10 km grid spacing. Through the LIDAR system, the improvements on the digital elevation model will be available. Additional improvements are expected in the adjustment that will provide an improved ellipsoidal height datum. This improvement should significantly reduce the uncorrelated errors associated with residuals deriving from gravimetric geoid and GPS-BM differences. Impending satellite gravity missions will also provide several iterations of global gravity models with increasingly higher spatial resolutions.

Keywords: geoid, gps, preciselevelling

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Poster presentation

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Malaysia Airborne Gravity and Geoid Determination Project

Dr. Samad Abu

Department of Survey and Mapping Malaysia Institution of Surveyors Malaysia IAG

David Chang Leng Hua, Soeb Nordin

The past decade had seen a renewed interest in the determination of geoid on global, regional and local scales. Great strides have been achieved both in terms of theory, techniques and algorithm development in the quest to achieve precise geoids. At the Department of Survey and Mapping Malaysia (DSMM), the national gravity database is continuously being updated. In Peninsular Malaysia, the terrestrial gravity points were less than 2000 in 1989, and now the gravity database has increase to a total number of over 10000 points.. In 2002, under the Eight Malaysia Plan, the DSMM has initiated the implementation of airborne gravity survey with the main objective of creating a precise geoid model at cm-accuracy level for the whole nation. The airborne gravity survey for Phase 1 & 2 covering Sabah, Sarawak and Peninsular Malaysia has since been completed (26th May 2003) at 5 kilometer spacing and the geoid computation exercise has produce Malaysia first ever precise geoid model WMG03C and EMG03C. The result of the least-square collocation error estimates gave an indication of the relative accuracy of the geoid at 5 cm level for Sabah and Sarawak, and 2 cm for Peninsular Malaysia. This paper will describe the preparation of the airborne gravity survey, data acquisition with the airborne gravity system, data processing and the computation of the geoid model, and recommendations for improving the geoid model in the future.

Keywords: geoid, airborne, gravity

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2624****On the feasibility of Biased Kriging*****Prof. Athanasios Dermanis****Department of Geodesy and Surveying Aristotle University of Thessaloniki IAG*

It is well known in statistical theory that biased estimators might have a better performance than unbiased ones in terms of mean square errors. Nevertheless it often turns out that the application of such estimators is not feasible because they require the knowledge of the bias, which typically cannot be derived from data. Kriging is a technique allowing to predict biased random fields without any need to produce an explicit estimate of the non-zero mean. Kriging formulas depend on the so called variogram which we can estimate from data without subtracting a-priori a rough estimate of the field mean. In this context one can also try to build a kriging theory with a larger class of biased predictors yielding in the end a smaller prediction error. The formulas for such predictors show that in addition to the variogram we must estimate another constant which does depend on the bias itself; nevertheless this constant is directly estimable from the data. In other words biased kriging is feasible.

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2625****The fast analysis of GOCE gravity field*****Dr. Xinyu Xu****Wuhan University Postgraduate****Jc Li, Xiancai Zou, Chunbo Fan, Yonghai Chu***

The semi-analytical (SA) approach is proposed for the fast determination of gravity field from GOCE observations, the first Core Mission of ESAs Living Planet Programme, which strives for the determination of a high-accuracy and high-resolution global gravity field model. Based on the application of FFT and introduction of the nominal orbit (circular, exact repeat orbit, uninterrupted measurement time series, and constant inclination), the SA approach can recover the potential coefficients from large observations in short time. This method can give a fast diagnosis of GOCE system performance in parallel to the running of GOCE mission by comparing estimated the noise characteristics of the SGG time series with the gradiometer error PSD (prior). The performance of this method is evaluated using the simulated observations of different cases (ideal and practical). The results in this paper show that this method can also be applied to the practical cases of non-circular, non-repeat orbits and data gaps in the time series of observations by the iteration algorithm, which can eliminate or minish the approximation errors in the observation model.

Keywords: goce, fft, semi analytical

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2626****Fitting the best geopotential model for Argentina: a case study at Patagonia.****Mrs. Ayelen Pereira**
Geodesy member IAG

Recent Earth Geopotential Models (EGMs) represent a great improvement to several applications related with the gravity field modeling. The behavior of some models derived from satellite gravity missions (like EIGENs and GGMs), together with the classic EGM96 is analyzed. The investigation was performed by comparing EGMs with gravity anomalies from observed gravity values as well as geoid undulations calculated with GPS/levelling data. The study was carried out at the southernmost region of Argentina, Patagonia. Since Patagonia is a traditional oil exploration and exploitation area it is relatively well covered with gravity and GPS data. The residual statistic of the comparison of local data with the results from five global models is shown.

Keywords: geopotential, patagonia, egms

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Poster presentation

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Preliminary results of the first campaign of absolute gravity measurements at Polish GNSS stations

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Tomasz Olszak, Andrzej Pachuta, Marcin Barlik, Ryszard Szpunar, Dominik Prochniewicz

A proposal of a network of absolute gravimetric measurements to unify gravimetric level for IGS stations and geodynamic test fields is presented in the paper. Such a network would be useful as a complement of position monitoring at permanent stations as well as a link to ECGN project. Second goal of establishment of the network is connected with geodynamic purposes. During the last two decades there were established in Poland a few local geodynamical test fields on which the gravity survey together with different other geodetic techniques have been applied (e.g. Pieniny Klippen Belt, Central Carpathians, Sudety Marginal Fault). Gravity values at several stations are necessary as precise reference level and for calibration purposes. Preliminary results of the first epoch of gravimetric measurements at the GNSS stations are presented in the paper.

Keywords: gravity, geodynamic



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2628****Improved marine gravity field from satellite altimetry: Case study of the South China Sea****Dr. Lifeng Bao***Department of Dynamical Geodesy Laboratory Institute of Geodesy and Geophysics, C.A.S
China IAG***Yang Lu**

Marine gravity anomalies over the South China Sea on a 2*2 grid have been derived from Geosat and ERS retracked altimeter waveform data, using an improved retracking algorithm. The new altimeter waveform retracker was valid for all satellite altimeter missions and any geographic location even there exists reasonable return signals. The inverse Vening-Meinesz formula with a 1D-FFT method was used to compute gravity anomalies from gridded vertical of deflections, in a remove-restore procedure with the new version Sandwells gravity field as the reference field. The improvement in the accuracy of satellite derived marine gravity fields is investigated in the area, and the derived marine gravity show a good qualitative agreement to the recent ship-measured gravity profile, rms of 4 mgal, better than previous research result from altimetry. A more careful treatment of all altimeter waveform data will result in significant improvements in the global marine gravity field.

Keywords: altimetry, retracking, gravity

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2629****A New Improved Geoid In North Eastern Italy****Dr. Paolo Sterzai***Geofisica della Litosfera Istituto Nazionale di Oceanografia e di Geofisica IAG*

The geoid is the equipotential surface of the Earth gravity field that best approximates the mean sea level. It can be considered the most natural shape of the Earth and it serves as reference surface for many geophysical and geodetic applications. In fact the widespread use of GPS for vertical positioning introduces the necessity to define the separation between the ellipsoidal and orthometric high. A new improved geoid has been calculated in north-east Italy using new land and marine gravity data coupled with new high resolution multibeam bathymetric data. A standard processing procedure has been applied to gravity data in order to compute the Free Air anomaly and the Bouguer anomaly (nominal density of 2.67 g/cm³). The gravity reference datum is IGSN71. Long wavelength geoid undulation has been introduced considering the solution of the geopotential EGM96 global model. The computation has been carried out by the "remove-restore" spectral technique (Stokes approach) using the software GRAVSOFT. The goal of the calculated model was to improve the geoid estimation in the coastal areas, where usually the calculated geoids suffer the lack of gravimetric data as well as a good bathymetry.

Keywords: geoid, adbve

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2630****Combination Method for Computing Terrain Corrections: A case study in a region in Iran****Mrs. Shiva Jalal***Erath Science geophysics faculty IAG***Hossein Zomorrodian**

Various computational techniques for the numerical implementation of the Newtonian attraction integral of the terrain exist. Two methods are the classical prism representation, accurate but tedious, and the Fast Fourier Transform technique which is efficient, but for which certain convergence criteria have to be met. We combine both methods for the computation of terrain corrections for a densely sampled 10 10 km elevation set in the Iran for which the original FFT series is divergent. The computation area is divided into two zones. An inner zone around the computational point, where the vertical component of the Newtonian attraction is computed by summing the individual effect of right rectangular prisms. The outer area is treated with the FFT approach, after an appropriate modification of the kernel function. This modified approach has two positive effects. On the one hand, the convergence of the FFT series is regained, which is not always the case when slopes greater than 45 exist in the terrain. Furthermore, it approximates the terrain correction of the prism summation method better than its linear approximation computed by FFT.

Keywords: terrain correction, fft method, newtonian attraction

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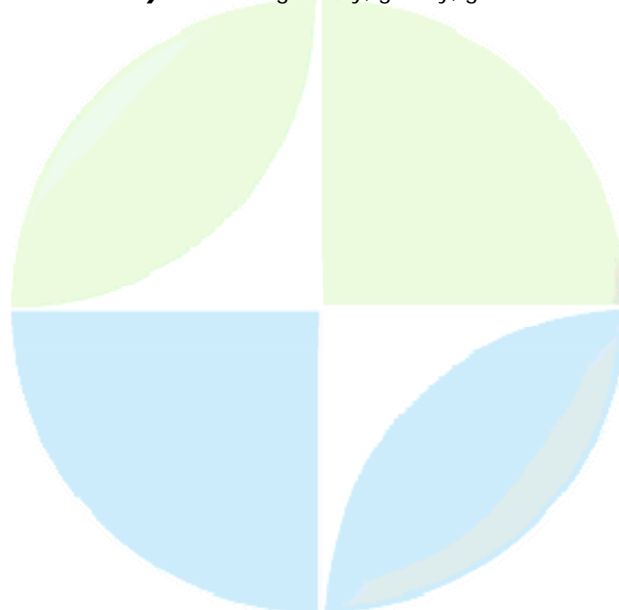
(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2631****Reference frame consistency in CHAMP and GRACE earth gravity models****Prof. Christopher Kotsakis***Dept. of Geodesy and Surveying Aristotle University of Thessaloniki IAG*

Since the launch of the CHAMP and GRACE satellite missions, an increasing number of spherical harmonic models have become available for the long- and medium-wavelength mapping of the Earth's gravitational field. In view of the need for a coherent comparison between such Earth Gravity Models (EGMs) and a detailed evaluation of their predictive capability for various gravity field functionals, it is important to investigate the consistency of their inherent reference frames, especially when their use is intended for high precision studies. Following the methodology described in earlier works by Balmino, Giacaglia, Jeffreys, Goldstein, Kaula, Kleusberg and others, the Helmert transformation parameters between the associated reference frames for several CHAMP and GRACE models are estimated in this paper. In particular, the differences between the spherical harmonic coefficients for a given pair of EGMs are parameterized through a similarity transformation model, whose least-squares adjustment yields valuable information for the origin stability, the orientation consistency and the scale variation between the Earth-fixed reference systems that are associated with the underlying EGMs. Various aspects of the adopted estimation procedure and its results are highlighted, including data weighting schemes, the sensitivity of the results with respect to the selected harmonic spectral band, the correlation structure and accuracy level of the estimated transformation parameters, and the effect of the estimated reference frame inconsistencies on different types of gravity field functionals.

Keywords: grace, champ, reference framePERUGIA
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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2632****Performance Simulations of a GRACE Follow-On Mission Using a Mascon Approach****Mr. Bryant Loomis***Aerospace Engineering Sciences University of Colorado at Boulder***R. Steven Nerem, Scott Luthcke, Dave Rowlands**

The Gravity Recovery and Climate Experiment (GRACE) has been providing monthly estimates of the Earth's time variable gravity field since its launch in March 2002. The GRACE gravity estimates are used to study temporal mass variations on global and regional scales, which are largely caused by a redistribution of water mass in the Earth system. The spatial resolution of the GRACE gravity fields is limited by the accuracy of the satellite-to-satellite ranging instrument. GRACE employs a microwave ranging device with an accuracy of better than 1 $\mu\text{m/s}$. An interferometric laser ranging system has shown the capability to measure range-rate to an accuracy of ~ 1 nm/s or better. This highly accurate ranging system will significantly improve the resolution to which the Earth's gravity field can be recovered from a satellite mission similar to GRACE, thus benefiting many areas of Earth systems research. The purpose of this study is to assess the performance of this instrument for measuring temporal variations of the gravity field. A method for local time variable gravity recovery through mass concentration blocks (mascons) is used. The mascon approach has several advantages as compared to the traditional method where a full set of spherical harmonics is estimated. With the mascon approach, regional solutions can be computed every 10 days as opposed to the full month of data required for a global spherical harmonic solution. This method also ensures that modeling problems from one area of the Earth do not affect the results for another area. Lastly, the mascon approach requires significantly less computational resources than the traditional method and will be more practical for estimating variations in the gravity field at small spatial scales. Performance simulations for a potential GRACE Follow-On mission equipped with the interferometric laser ranging system using a mascon approach are presented. The simulations investigate the effects of various error sources, including the instrument noise, temporal aliasing, and errors introduced by imperfections in the tidal, oceanographic, and atmospheric models.

Keywords: geodesy, gravity, grace

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2633****Mass changes detected from GRACE data in Argentina*****Mrs. Ayelen Pereira****Geodesy member IAG****Rene Forsberg***

Recent satellite gravity missions, specially GRACE, provide monthly gravity field models that reflect the Earth's gravity field variations due to mass transport processes in the oceans and atmosphere as well as continental water storage variations. GRACE can map water storage changes to a height of about 1 centimeter for areas ranging in size on the order of 600 kilometers. The aim of this work is to show the temporal gravity variation of the gravity field detected over the continental territory of Argentina. Tendency as well as Amplitude maps of these variations show important features in two zones. One of them, located at the Patagonia, at glacial regions, and the other one in correspondence with the Parana basin, one of the biggest rivers in the world. The agreement with GPS data was also analyzed.

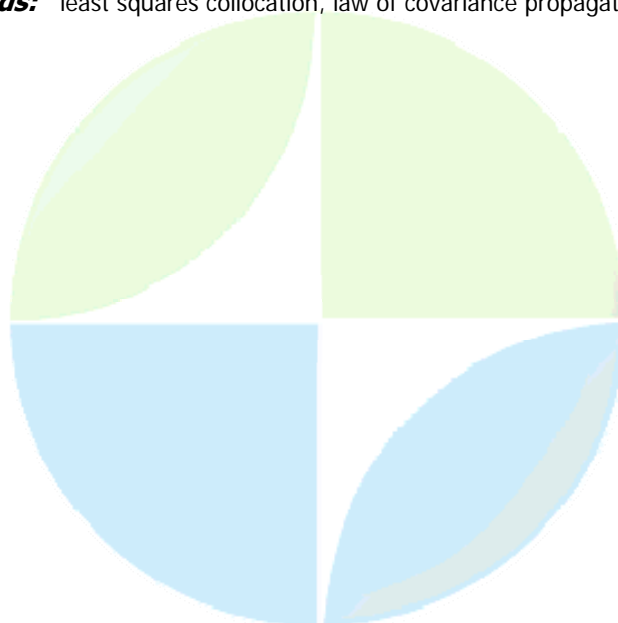
Keywords: grace, argentina, glacial

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2634****The role of the covariance function in least-squares collocation for local gravity field modelling****Mrs. Neda Darbeheshti**
*spatial sciences IAG IAG***Will Featherstone, Wolfgang Keller**

The theory of least-squares collocation (LSC) for local application in physical geodesy seems quite similar to Kriging theory in geostatistics, since both methods follow the principle of unbiased minimum error variance prediction. However, the fundamental difference is that Kriging is based on random-process assumptions, which is a purely stochastic problem, while LSC is a deterministic-stochastic system. In both methods, covariance determination plays the key role in the prediction of quantities. In Kriging, covariances have a statistical interpretation; they just determine the spatial statistical relationship between quantities. In LSC, covariances also carry the analytical deterministic formulation among different gravity field quantities through the law of covariance propagation, or more precisely, the covariance function is a reproducing kernel of Hilbert space in gravity field modelling. Previous works on comparing LSC and Kriging focused on the statistical nature of covariance functions, and tried to develop covariance function modelling with existing methods in geostatistics (e.g., semivariograms and anisotropic models). In this article, we review simple Kriging and cokriging, which are very popular in geostatistics and gaining popularity in some aspects of geodesy. We then show that simple Kriging is one of the LSC applications for regression. Through this comparison, we conclude that using law of covariance propagation for estimation of covariances among different gravity field functionals makes LSC unique among several prediction theories. An example of simulated gravity field modelling with point-masses demonstrates the conceptual difference in covariance modelling in statistical and deterministic-stochastic frames. In a more realistic example, we applied the law of covariance propagation through the Fourier transform of Stokes integral for a simulated mountain gravity field with prisms. Finally, we conclude that applying the law of covariance propagation to covariance functions, which transfer the statistical role of covariance functions to the deterministic-stochastic concept, should be considered more critically in LSC theory.

Keywords: least squares collocation, law of covariance propagation, kriging

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Computation of Geoid and its interpretation in Saurashtra, western India using Gravity data

Mr. Sanjay Prajapati

Science and Technology Indian Institute of Geomagnetism

Bijendra Singh, C.C. Tscherning

The geoidal anomaly is related with the density structure within the Earth. The long wavelength features are associated with deep mass anomalies (core/mantle), while the very short ones correspond to uncompensated topography and lithospheric flexure. In the middle term wavelengths the geoid depends upon the mass anomalies within the lithosphere and is proportional to the first moment of the density anomaly. This can also provide useful tectonic information about lithospheric structure. By applying the Least square collocation technique geoid undulations have been determined by combining a geopotential model, Free-air gravity anomalies and height data in Saurashtra, Western India. A detail terrain model (DTM) has been used for removing the residual terrain effect and the terrain effect. A positive geoidal undulation of 1-2 m has been observed after removing a regional trend from the gravimetric geoid over the Saurashtra Plateau. It has been found that the layered structure of the crust plays an important role in the existence of the geoidal high in Saurashtra region. The layered structure of the lithosphere i.e. Moho is characterized by a thick, high-density crust and as associated geoidal anomalies. The upper mantle also plays an important role in the isostatic equilibrium of the whole lithosphere. Therefore, the effects of crustal structure have also been studied by applying Airy and Pratt-type isostatic models and compared with observed gravimetric geoidal anomalies. The modeling of regional Bouguer gravity also indicates the gravity low is caused by two sources: the crustal root is anomalously dense or upper mantle is anomalously light.

Keywords: gravimetric geoid, isostasy, modeling



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2636****Estimating the time-variable component of the sea surface topography with geodetic data*****Dr. Georgios S. Vergos****Department of Geodesy and Surveying Aristotle University of Thessaloniki IAG****Ilias N. Tziavos***

The determination of the sea surface topography is of significant importance to geodetic applications since it provides the separation between the sea surface and the geoid, thus allowing the determination of altimetric marine geoid models. During the last decade the determination of the stationary part of the sea surface topography has been a subject of intense research both from geodetic and oceanographic point of view resulting in continuously improving models in oceanic as well as closed sea areas. The present work focuses on the determination of the time-variable part of the sea surface topography employing geodetic data and methods in the eastern part of the Mediterranean Sea. Such a model can be used to correct altimetric and tide gauge data for variable ocean effects as well as an input to assimilation models in order to determine the natural properties of the ocean. For the estimation of the variable part of the sea surface topography a marine geoid and two sea surface topography models (a geodetic and an oceanographic one) are combined in a least-squares collocation procedure. During this process the time-varying sea surface topography signal is considered as a stochastic process and is estimated as a product of the combined adjustment of the geodetic and oceanographic sea surface topography models. Various parametric models are investigated during the adjustment procedure and their performance is assessed through their condition numbers, coefficients of determination and accuracy of estimation. The resulting model presents the first solution of that kind for the area under study and signals a new field of cooperation and joint research between geodesy and oceanography.

Keywords: time variable sst, adjustment, collocation



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2637****Analysis of repeated GPS measurements over a geodetic network and a common adjustment of heterogeneous height data*****Prof. Ilias N. Tziavos****Department of Geodesy and Surveying Aristotle University of Thessaloniki IAG****Dimitrios Tsoulis, Vassilios N. Grigoriadis, Vassilios D. Andritsanos, Eleni A. Tzanou***

A three-dimensional GPS network has been established during the last three years in an area around the city of Thessaloniki, Greece, covering the region of Lakes Lagada and Volvi. Most earthquakes hitting the city of Thessaloniki have their epicenters situated in this area and therefore this network is of particular interest to both geodetic and geodynamic applications. In this frame a GPS network consisting of 37 benchmarks (BMs) has been established aiming at the determination of displacements and vertical control. These BMs together with another set of roughly 140 stations in the wider area of Thessaloniki constitute a vertical control network in support of geodynamic, geophysical and geodetic studies. In the aforementioned network of 37 BMs three campaigns have been carried out so far within a two year period aiming at (a) the determination of high-accuracy GPS/Leveling geoid heights in support of geoid modeling and (b) the determination of displacements, shear velocities and stress strains for the test area. The analysis of the GPS measurements as well as the results acquired during the three measurement periods of the network is reported in this paper. Moreover, a common adjustment of gravimetric geoid heights and GPS/Leveling heights is carried out in order to determine an optimal geoid model for the area under study. Finally, since all these stations are part of the second and third order trigonometric networks of the country the GPS/Leveling BMs are used to validate the recent CHAMP- and GRACE-type geopotential models in order to draw some conclusions on the achievable accuracy of the computed geoid model.

Keywords: gps network, geoid, combination

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2638****Robust Trend Estimation from GOCE SGG Satellite Track Cross-Over Differences*****Mr. Focke Jarecki***

The European satellite gravity mission GOCE will realise satellite gravity gradiometry (SGG) by means of an innovative three-axes electrostatic gravity gradiometer in the end of 2007. This newly introduced measurement technique requires revised calibration and validation approaches. Simulated GOCE gradiometric data sets have been analysed successfully in satellite track cross-overs, comparing measurements in the same geographical position by applying suitable interpolation and reduction procedures. Stable parameters of standard error models, like a long-term trend, can be detected from end-to-end test data sets. To apply the cross-over method operationally, e.g. to monitor the gradiometers performance, such parameters should as well be determined from shorter data sets, like single orbit revolutions. Due to single gross errors in the measurements and insufficiencies in the interpolation and reduction approach, standard least-squares estimation is not able to provide optimal results from these shorter data sets. However, robust analysis methods turn out to work well in this context. Here, we show the benefit of robust estimation methods in the analysis of short SGG cross-over data sets. Simulated SGG data with different artificial trends are processed in different subsets. Long-term trends can be obtained for the cross-overs of a single revolution when applying robust estimation. Multiple short- and long-term trends, affecting the long-term reference data and the crossing track under investigation, respectively, can be separated by sequentially applying these methods. The estimation of periodic calibration parameters, especially suffering from undersampling when investigating small data sets, is investigated, too. Anticipating these estimation techniques, cross-over validation offers a fast approach to assess independently the quality of space gradiometry with focus on certain time intervals.

Keywords: goce, satellite gradiometry, validation

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2639****Stokes-like solution to the second geodetic boundary-value problem****Prof. Wei Ziqing***geodetic division Xian Research Institute of Surveying and Mapping IAG*

With the advent of GPS technology it has become viable and practical to determine the geoid using gravity disturbances combined with geodetic heights. The paper deals with the second geodetic boundary-value problem (Neumann's problem). The representation of disturbing potential in spherical harmonics and the Stokes-like formula of disturbing potential on spherical surface are presented, and both the Stokes-like formula for computing the geoidal undulations and the Vening Meinesz-like formula for the deflections of the vertical are derived, the gravity reductions and the indirect effect of the free-air reduction on the geoid are discussed, and finally the removal and restoration procedure is briefly addressed for computing the geoidal undulations and the deflections of the vertical. Keywords: second geodetic boundary-value problem, Stokes-like type solution, gravity disturbances, geodetic heights, GPS

Keywords: second boundary value problem, Stokes-like type solution, gravity disturbances

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2640****Geoid determination combining ground data and satellite-derived global models*****Dr. Roland Pail******Fernando Sans, Norbert Kuehreiber, Mirko Reguzzoni, Bernadette Wiesenhofer***

The incorporation of satellite-related data from the dedicated gravity field missions CHAMP and GRACE into local and regional geoid solutions will stabilize and thus considerably improve them particularly concerning its medium and long wavelength content and by reducing systematic effects such as biases and tilts. In this paper several adaptations of the Least Squares Collocation method to compute an optimum joint solution from local (terrestrial) and global data shall be presented, with special emphasis put to the involved functional and stochastic models. Main aspects will be the problem of different stochastic models for local and global data, the choice of a consistent covariance function, and the adequate stochastic representation of the error covariances of the global gravity field models, which are generally given as fully populated matrices. The methods will be presented and assessed on the basis of a realistic numerical case study. Several scenarios processed in this closed-loop environment will reveal the main error sources of the final combined solution. Additionally, important aspects for a practical realization will be addressed.

Keywords: least squares collocation, data combination

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2641****Three-Dimensional Microgravity modeling of Tehran subway basement.****Mr. Aziz Nasuti***Geophysics Student IAG***Dr. Vahid Ebrahimzadeh Ardestani**

Microgravity surveying has developed considerably over the last ten years and this method is becoming widely used in engineering investigation such as detection of natural and man-made cavities particularly in urban area but in this paper we demonstrate the other application of this method. The sedimentary fill above the basement interface is approximated by an ensemble of 3-D vertical prisms, one placed below each of the observation points. The width and strike length of each of the prisms is made equal to the station spacing and profile interval, respectively. The theoretical gravity anomaly at any point on the XY plane is obtained by computing the algebraic sum of the gravity effects of the prisms. Equations in closed form for the gravity anomalies of 3D prismatic models are derived. Juxtaposed 3-D rectangular/square blocks with their geometrical epicenters on top coincide with grid nodes of a mesh to approximate a sedimentary basin. Efficient methods and a MATLAB program, GRAV3DMOD have been developed for anomaly calculation by solving the equations. The aim of this paper is to determine the 3D topography of basement with regard to density contrast between basement and sedimentary over it. The depths to the basement are adjusted iteratively by comparing the calculated anomalies with the observed anomalies. First, validity of this modeling was examined on the synthetic model and then determination of 3-D basement topography of Tehran subway (Shari'ati -Tajrish line) is presented, this survey consist of 750 gravity stations to cover the whole area. It is considerable that the obtained results from modeling was well corresponded to geotechnical data and geology of the region.

Keywords: microgravity, sedimentary, tehran subway

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2642****The Precise orbital determination of Earth satellites: a tool for investigating the atmosphere ?****Dr. Francesco Vespe***Agenzia Spaziale Italiana Centro di Geodesia Spaziale IAG*

In the present decade Earths explorer missions like CHAMP, GRACE and GOCE are going to dramatically improve the knowledge of the Earths gravity field. Such improvement has lowered indeed the threshold of gravity field uncertainties which affects the orbital motion of Earth satellites. Previously it was demonstrated that subtle effects due to Earth tides, atmospheric drag, solar radiation pressure and general relativity which before were choked by the gravity field uncertainties, now prevails on classical gravity field uncertainties. Thus with the present work we try to prove that the tremendous improvement of the gravity field models could make feasible the use of precise orbit determination of Earth satellites as a tool for sensing a global changes of some key atmosphere parameters like refractivity and extinction. Furthermore the huge number of running Earths satellites and combinations of their orbital parameters (namely the nodes) in a gravity field free fashion (GF-free) can magnify the solar radiation pressure acting on high Earths Satellites (like GPS or Etalon satellites) and its smooth modulation through the Earths atmosphere (penumbra). We would remind that The GF-free technique is able to cancel out with n satellite orbital parameters the first $n-1$ even zonal harmonics of the gravity field. We outline that the GF-free technique was before widely applied for measuring subtle general relativistic effects like the gravitomagnetic field.

Keywords: gravity, atmosphere, penumbraPERUGIA
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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2643****Geopotential number estimation by the use of Digital Terrain Model*****Mrs. Erika Szeghy****Geodesy Geodetic and Geophysical Research Institute of HAS IAG*

The determination of geopotential number from gravity data is essential to the proper adjustment of a precise levelling network. In general, the more gravity data are used for this purpose the more accurate results are expected. For this reason every height difference between staff points should have a corresponding average value of g along the levelling line. In practice this condition requires as many measurements as many staff points are on the line. Usually it means a lot of expensive field work, so the necessary data should be supplied in another way if it is possible. This study is devoted to show a method to find a possible procedure in two steps. First the effect of point density on the accuracy of geopotential number is investigated. Then a method, which is suitable for the completion of the measurements is provided and demonstrated through the example of a local area in the Mecsek Mountains, South-Hungary. It is based on the calculation of the gravitational effect of the surface topography, represented by Digital Terrain Model. The topography is considered as the dominant source of high-frequency gravity change between the measured gravity stations along the levelling line. This method reduces the cost and time of the geopotential number determination; at the same time it keeps the required accuracy, which is the most important aspect in local and regional precise levelling.

Keywords: gravity data, geopotential number, digital terrain model

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GS002

Poster presentation

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Current status of gravity measurements in the Republic of Croatia with the Basic Gravity Network Finalization Project

Mr. Maro Lucic

CGI CGI

Mihajla Liker, Ilija Grgic, Bojan Barisic, Marija Repanic

The Basic Gravity Network (BGN) is foundation for all national gravity measurements. This network consists from 42 points: 6 absolute gravity points (0 Order Gravity Network) and 36 relative gravity points (1st Order Gravity Network). Further densification of BGN shall be carried out by the lower order networks (2st Order Gravity Network). Basic gravity points should be homogeneously spaced over the whole state. In some large countries the distance between gravity points can be bigger than few hundred kilometers. Like the other geodetic networks in the Republic of Croatia, gravity network also followed the trend of connecting at the European level. The result of this trend was UNIGRACE project. Six absolute gravity points have been established (0 Order Gravity Network) during two phases of UNIGRACE project. This points provided reference for all other gravity works in Croatia. After the finalization of UNIGRACE project the main preconditions for gravity network of the first order, that leans on preestablished six absolute stations, were accomplished. In the year 2000. revision of inherited gravity network of the first order was started. The revision showed that the 25 old points could be used for the new, 1st order, gravity network. Also, the 11 new 1st order gravity points were stabilized. With this 11 new points, 25 old and 6 absolute gravity points, the frame for the BGN was founded. The gravity measurements have been performed during year 2003. After processing and measurement adjustment, the gravity value at each point has been obtained. Levelling connection of the absolute and first order gravimetric points at the national levelling network benchmarks wasn't performed. Also, a position of gravity points in respect to existing geodetic network stayed unknown. Quality positional and height defining of gravity points are necessary for calculating different corrections, that are needed for adjusting gravimetric measurements. By implementation of the BGN Finalization Project, along with already finalized projects, the modern gravity fundation of the Republic of Croatia shall be established.

Keywords: basic gravity network, unigrace, croatia



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2645****Precise determination of vertical gravity gradients in the Czech gravity network****Mr. Martin Lederer**
*Gravimetry Gravity Field IAG***Vojtech Plink**

Precise absolute gravity measurements were carried out with the FG5 No. 215 at 15 absolute stations in the Czech Republic between 2002 and 2005 to establish the frame of the new Czech Gravity Network (CGN). The high accuracy of absolute gravity measurements ($\sim 2 \mu\text{Gal}$) is valid in the effective height of the FG5 absolute gravimeters ($\sim 122 \text{ cm}$). A gravity datum at the absolute stations in the CGN is related to the ground. Therefore it is necessary to determine the datum transfer correction for full utilization of this high accuracy. A precise determination of vertical gravity gradients with the help of relative gravimeters were carried out at all absolute stations in the CGN for this purpose. Three different types of relative gravimeters (LaCoste & Romberg G, Scintrex CG-5 and ZLS Burris) were used. The gravimeters measured at 3-5 vertical levels above an absolute point, which allow to detect potential non-linear shape of the gravity gradient. Accuracy about $1 \mu\text{Gal/m}$ was obtained especially for Scintrex CG-5 and ZLS Burris meter after thorough processing of all gravimeters data. Differences between these two precise instruments allow to assume that the accuracy of datum transfer corrections is better than $2 \mu\text{Gal}$ at all absolute stations in the Czech Republic. No important changes in linear shape of the gravity gradient were discovered. Results of vertical gravity gradients will be used for new fine adjustment of the CGN where the level and scale will be derived from absolute gravity measurements.

Keywords: gravity, gradient

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2646****How to detect small hydrological variations in gravity by repeated measurements with field gravimeters?****Mr. Marco Naujoks***Institute of Geosciences Friedrich-Schiller-University Jena IAHS***Adelheid Weise, Corinna Kroner, Thomas Jahr**

For a number of geoscientific research topics it is advantageous to have information on time-dependent local changes in the Earth's gravity field available. Well known examples for this are the monitoring of active volcanoes, land uplift or tectonic areas by repeated gravimetric measurements. During the last years a possible new application has emerged: the deployment of field gravimeters for the observation of hydrology-related mass shifts. Such repeated measurements are of interest because they allow the realisation of areally distributed observations. The questions which need to be addressed are whether results of repeated gravity measurements can be of sufficiently high resolution and accuracy and how much and how unique information can be gained by these observations. Regarding these questions a local gravity network was established in a small-scale hilly area around the Geodynamic Observatory Moxa. Using 3 to 5 LCR gravimeters repeated measurements were carried out related to seasons as well as to particular events like snowmelts or longer drynesses in 15 campaigns so far. The standard deviations obtained by least squares adjustment are fairly small: They range between 8 and 14 nm/s for one gravity difference. Between the points of the network areal gravity changes of up to 139 nm/s between two successive campaigns with standard deviations between 11 and 20 nm/s could be proved significantly which correlate well with changes in the hydrological situation. Particularly hydrological variations in a hill flank next to the observatory have a crucial influence on gravity. The results obtained contribute to an improved reduction of the local hydrological signal in continuous gravity recordings and to the validation of hydrological models. Additionally, the results clearly show that for high accuracy measurements as i.e. required for the calibration of field gravimeters on outdoor calibration lines effects due to hydrology need to be considered. Because in a hilly area effects of several 10 nm/s could occur point locations with a minimum influence should be chosen.

Keywords: repeated gravity measurements, field gravimeters, hydrological variations



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2647****Estimation of a new high-accuracy marine geoid model offshore Argentina using CHAMP and GRACE-derived geopotential models*****Dr. Claudia Tocho****Department of Gravity Facultad de Ciencias Astronomicas y Geofisicas IAG****Michael G. Sideris***

The main objective of this paper is to investigate the possibility of improving the accuracy of the marine geoid models available offshore Argentina by employing the latest global gravity models from CHAMP and GRACE, and also by combining all the available gravity and altimetry data together. The existing geoid models were computed using shipborne gravity data and free-air gravity anomalies derived from satellite altimetry to fill in gaps. Additionally, an altimetric solution was computed based on ERS1 geodetic mission data alone. All previous solutions were computed using the EGM96 Global Gravity Model (GGM) as a reference field. During the last years, a new generation of GGMs were developed, some of them using only satellite tracking data from the CHAMP and/or GRACE gravity missions, and others combining the satellite data with gravity and altimetry. The latest GGMs employing CHAMP and GRACE data, i.e., EIGEN_GL04C, EIGEN-CG01C, EIGEN-CG03C and GGM02C are used in this study to compute new marine geoids. Combination methods such as least-squares collocation and Input Output System Theory (IOST) will be investigated. Purely altimetric, gravimetric and combined marine geoid models will be estimated for Argentina employing all available shipborne gravity data, satellite altimetry data (ERS1 geodetic mission as well as ERS1 and GEOSAT exact repeat mission data), and the new GGMs. To assess the quality of the estimated new marine geoid solutions, comparisons with old solutions, with stacked Topex/Poseidon (T/P) sea surface heights and with Jason-1 data were carried out.

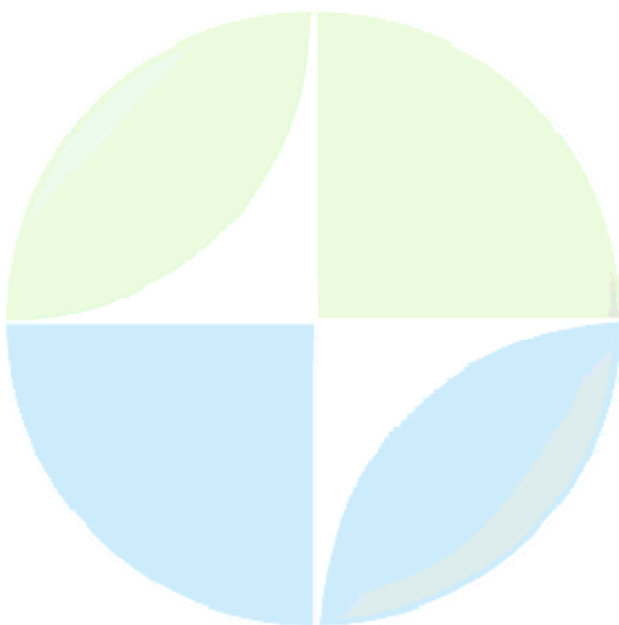
Keywords: geoid, argentina, ggms

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2648****Analysis of synthetic TFM patterns for salt domes****Mrs. Jaroslava Panisova***Geophysical Institute Slovak Academy of Sciences IAG***Peter Vajda**

The Truncation Filtering Methodology (TFM) can be classified as a gravity data interpretation method based on data enhancement and pattern recognition. This novice methodology makes use of specially designed filters, by which gravity data are transformed into new quantities. Animated sequences of filtered data are produced in which dynamic patterns are observed. These patterns are signatures of the anomalous masses generating the gravity data. From the onsets of a patterns the depth of some elements of certain geological formations are expected to be estimated. The TFM is still under development. Work is in progress to interpret the gravity data by means of TFM in terms of realistic mass sources. This may be established by synthetic simulations and case studies. Here we present results of computer simulations, in which we focused on synthetic modelling of salt domes embedded in sedimentary layers. Salt domes, which are known in every ocean and continent, supply industrial commodities, including fuel, minerals and storage caverns and therefore have large economic significance. We studied behavior of dynamic patterns in animated sequences of post-filter data generated by salt domes and sought a relation between the onset of the dynamic patterns and the depth of the head of the salt dome.

Keywords: gravity inversion, pattern recognition, tfm

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2649****Gravity field parameter estimation using QR factorization****Dr. Sean Bruinsma***Terrestrial and Planetary Geodesy CNES IAG***J.C. Marty, M. Baboulin, S. Gratton, G. Balmino**

This study compares the accuracy of the estimated geopotential coefficients when QR factorization is used instead of the classical method applied at our institute, namely the generation of normal equations that are solved by means of Cholesky decomposition. The objective is to evaluate the gain in numerical precision, which is obtained at considerable extra cost in terms of computer resources. Therefore, a significant increase in precision must be realized in order to justify the additional cost. Numerical simulations were done in order to examine the performance of both solution methods. Reference gravity gradients were simulated, using the EIGEN-GL04C gravity field model to degree and order 300, every 3 seconds along a near-circular, polar orbit at 250 km altitude. The simulation spanned a total of 60 days. A polar orbit was selected in this simulation in order to avoid the polar gap problem, which causes inaccurate estimation of the low-order spherical harmonic coefficients. Regularization is required in that case (e.g., the GOCE mission), which is not the subject of the present study. The simulated gravity gradients, to which white noise was added, were then processed with the GINS software package, applying EIGEN-CG03 as the background gravity field model, followed either by the usual normal equation computation or using the QR approach for incremental linear least squares. The accuracy assessment of the gravity field recovery consists in computing the median error degree-variance spectra, accumulated geoid errors, geoid errors due to individual coefficients, and geoid errors calculated on a global grid. The performance, in terms of memory usage, required disk space, and CPU time, of the QR versus the normal equation approach is also evaluated.

Keywords: gravity, field, qr factorization

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2650****The inversion of the Poisson integral in the wavelet domain****Dr. Mohamed Elhabiby***Department of Geomatics Engineering University of Calgary***Michael G. Sideris**

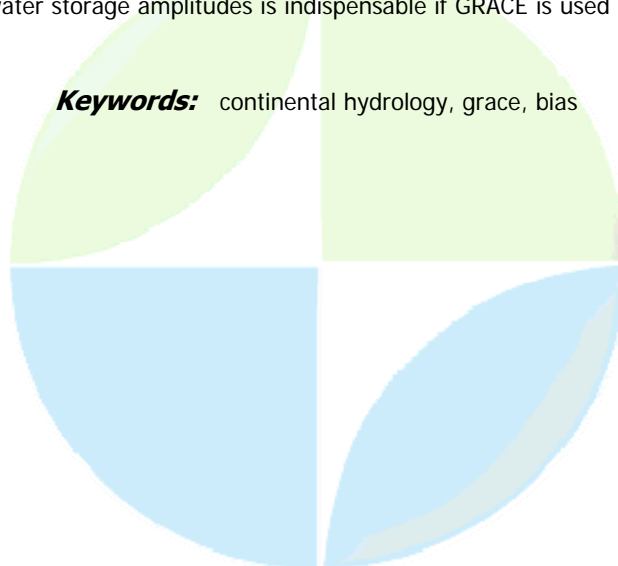
A new wavelet transform algorithm combined with a conjugate gradient method is used for the inversion of the Poisson integral (downward continuation) used in airborne gravimetry applications. The new combined algorithm is named the wavelet-optimization algorithm. The wavelet approximation is dependent on orthogonal wavelet base functions. The integrals are approximated in finite multiresolution analysis subspaces. Mallats algorithm is used in the multiresolution analysis of the kernel and the data. The characteristics of the base functions and their effects on the results are investigated. The full solution with all equations requires large computer memory, therefore, the multiresolution properties of the wavelet transform are used to divide the full solution into parts at different levels of wavelet multiresolution decomposition. Global wavelet thresholding is used for the compression of the kernel and, because of the fast decrease of the kernel towards zero, high compression levels are reached without significant loss of accuracy. Hard thresholding is used in the compression of the wavelet coefficients kernel matrices. A new thresholding technique is introduced. A first-order Tikhonov regularization method combined with the L-curve is used for the regularization of this problem. First, the Poisson integral is inverted numerically with the full matrix without any thresholding. The solution is obtained using the conjugate gradient method after 28 iteration steps with an root mean square error equal to 5.58 mGal in comparison to the reference data. Second, the global hard thresholding solution achieved a 94.5% compression level with less than 0.1 mGal loss in accuracy. These compression levels lead to large savings in the computer memory, and the ability to work with sparse matrices, which increases the computational speed. Conclusions and recommendations are given with respect to the suitability, accuracy and efficiency of this method.

Keywords: downward continuation, wavelet thresholding, regularization



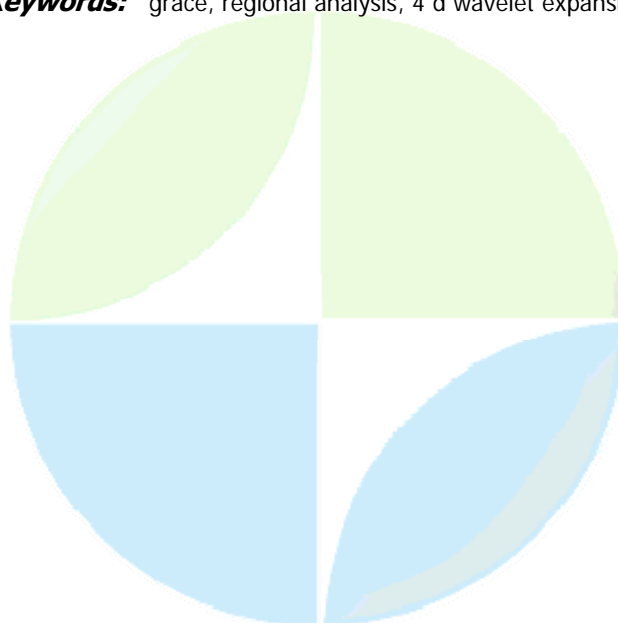
(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2651****The BIas in GRACE estimates of continental water storage variations****Dr. Elena Zapreeva***DEOS Delft University of Technology****Roland Klees, Hessel C. Winsemius, Hubert H.G. Savenije***

GRACE (Gravity and Climate Experiment) satellite gravity models are widely used to close the water balance at river basin scale. When computing monthly mean storage variations from GRACE gravity field models, spatial filtering is mandatory to reduce GRACE errors, but at the same time yields biased amplitude estimates. For a given filter function and target area, the bias can be estimated using a priori information about the mass variation, which is usually provided by a hydrological model. We computed and analyzed amplitude and time behaviour of the bias in GRACE estimates of monthly mean water storage variations for several target areas in Southern Africa. In particular, the relations between bias and the choice of the filter correlation length, the size of the target area, and the amplitude of mass variations inside and outside the target area have been investigated. Secondly, we investigated to what extent the bias can be corrected for using a priori information about mass variations provided by several hydrological models. Thirdly, we have quantified the errors in the estimated bias due to uncertainties in the hydrological model output. The target areas are located in Southern Africa around the Zambezi river basin. The release RLO3 (GFZ) of monthly GRACE gravity field models have been used (January 2003 - March 2006). An accurate and properly calibrated LEW regional hydrological model for the target area and its surroundings has been used for the bias assessment. It has been compared with the global CPC-LDAS hydrological model. The main conclusion of the study is that spatial smoothing significantly biases GRACE estimates of the amplitude of annual and monthly mean water storage variations. For most of the practical applications, the bias will be positive, which implies that GRACE underestimates the amplitudes. The bias is mainly determined by the filter correlation length; in the case of 1000 km Gaussian smoothing, which is shown to be an appropriate choice for the target areas, the annual bias attains values up to 50% of the annual storage; the monthly bias is even larger with a maximum value of 75% of the monthly storage. A priori information about mass variations can provide reasonably accurate estimates of the bias, which significantly improves the quality of GRACE water storage amplitudes. For the target areas in Southern Africa, we show that after bias correction, GRACE annual amplitudes differ between 0 and 30 mm from the output of a regional hydrological model, which is between 0% and 25% of the storage. Annual phase shifts are small. Our analysis suggests that bias correction of GRACE water storage amplitudes is indispensable if GRACE is used to calibrate hydrological models.

Keywords: continental hydrology, grace, bias

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2652****Signals of extreme weather conditions in central Europe from GRACE 4-D wavelet expansions****Dr. Florian Seitz***DGFI Deutsches Geodtisches Forschungsinstitut IAG***Michael Schmidt, C.K. Shum, Lei Wang**

During the last four years weather conditions in central Europe featured strong fluctuations from year to year. A glaring example is the cold winter season 2005/2006 which was accompanied by a huge amount of snow. In contrast, the winter season 2006/2007 featured spring-like temperatures with hardly any snow northerly of the Alps. Since GRACE is sensitive to hydrological mass redistributions such as extreme weather conditions including severe or minimal snow accumulations over multiple seasonal scales, we conducted a regional analysis of GRACE data over Europe to study this phenomena. Global spatio-temporal gravity fields from GRACE are usually modeled as spherical harmonic expansions and routinely computed for fixed time intervals like one month. Since the Earth's gravity field shows heterogeneous structures over the globe, a multi-resolution representation (MRR) means an appropriate alternative modeling candidate. The basic idea of the MRR is to split a given input signal, here thought as the geopotential of the Earth, into a smoother version and a number of (resolution) level-dependent detail signals by successive low-pass filtering. Here we determine a spatio-temporal gravity model from GRACE using the spherical wavelet technique for the spatial part. In contrast to the global spherical harmonics the spherical scaling functions and wavelets are quasi-compactly supported (highly localizing) on the sphere and therefore, well suited for regional applications. We model the time-dependency of the geopotential by one-dimensional B-spline based MRRs introduced separately for each spatial detail signal. Hence, we end up with a four-dimensional geopotential model of tensor product type. Resulting mass variations are expressed in terms of equivalent water heights which are subsequently balanced with the net effect of precipitation and evaporation (inflow) reduced by runoff from river gauge data (outflow) for central European river basins. The inflow is computed from horizontal fluxes of specific humidity as provided by atmospheric reanalysis data. Furthermore our results are compared with the monthly mass grids from GRACE spherical harmonic solution data products.

Keywords: grace, regional analysis, 4 d wavelet expansion

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GS002

Poster presentation

2653

Construction of the Absolute Gravity Network in Taiwan

Mr. Yi-Da Chung

Department of Civil Engineering in National Chiao IAG

Chun-Sung Chen

Due to the development of gravity control system is not complete, its difficult to have a accurate surveying of geodynamic and relative gravity in Taiwan. We need to expedite the construction of gravity control system that can be applied to gravity research. Therefore, we selected 15 positions that surround Taiwan uniformly for gravity surveying and to construct the absolute gravity network. In this research, its the first time to use Absolute Gravity Instrument FG5-224 in non-constant temperature and humidity environment. During surveying process, the problem issues are the accuracy not enough or equipment shut down. However, these are caused by over heat of controller and laser beam non-steady (that are because of the high temperature and humidity of environment). After resolved the over heat issue of controller and stabilize the laser beam, we finally implement all the measurement of research and measurement precision average 0.67 uGal.

Keywords: fg5, gravity, network

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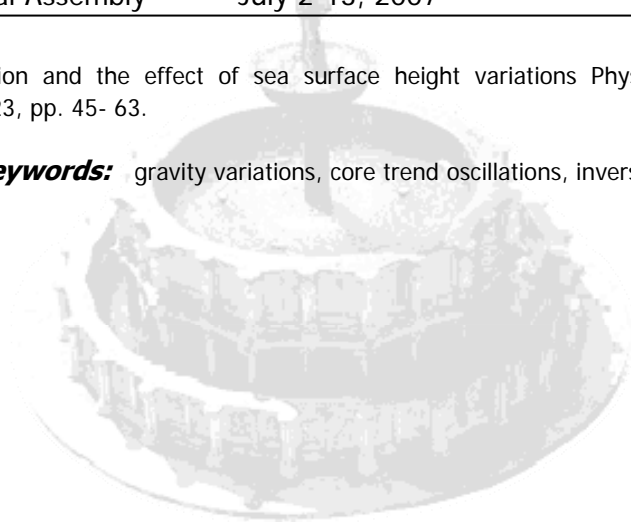


(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2654****The core drift and oscillations as the main mechanism of non-tidal variations of gravity****Prof. Yury Barkin***Laboratory of Gravimetry Sternberg Astronomical Institute IAG*

The mechanism of polar drift and periodic oscillations of superfluous mass of the Earth outer core relatively to the centre of mass of the mantle is one of the basic mechanism of not tidal variations of a gravity. Its nature is connected to external differential gravitational influences on not spherical shells of a planet (Barkin, 2002). Moreover, this mechanism plays the important dynamic role in redistribution of air and oceanic masses of the Earth. It determines and directs the redistribution of planet masses from one hemisphere in opposite. In the given work on the basis of geodynamic model about polar displacements of the core (Barkin, 2005) and known results about an annual mode of inversion deformations of the Earth (Blewitt et al., 2001) the analytical formula for variations of a gravity has been obtained: $dg = [(2.72t + 4.52\cos(V) + 1.02\cos(W))] \sin Q$. Here the time t is measured in years (from the beginning of year), and arguments are measured in degrees and calculated under formulas $V = 360t - 56$ and $W = 720t - 207$; amplitudes are given in microgals (MGal), and velocity of drift in MGal/yr. Q is the latitude of station of the observations. The formula takes into account direct effect of gravitational influence of displaced superfluous mass of the core, an additional attraction of the mantle deformed by displaced core. The annual deformation of a surface is described by the solution of Blewitt et al. (2001) on which it is estimated also secular inversion component of deformation of the Earth. The core actively participates in a redistribution of masses between northern and southern hemispheres with various cyclicities. Therefore the discussed mechanism is predominating in researched problem. Circulating between hemispheres atmospheric and oceanic masses bring the certain contribution to not tidal variations of a gravity, but they are small for considered stations. They were evaluated on the basis of the elementary model of polar points with variable masses. We plan to investigate these effects, and also spatial character of relative displacements of the centre of mass of the core and mantle in other works. The given theoretical formula for dg rather precisely explains main effects in the variations of a gravity observable at station Syowa, in Potsdam and some others. The secular gravity variation at Potsdam is evaluated in 2.1 MGal/yr. During 1976-1986 the similar tendency - gravity trend with velocity 2.6 MGal/yr (absolute measurements) here have been observed. The similar tendency has been determined on measurements on superconducting gravimeters during 1993-1997: 2.3-2.5 MGal/yr (Neumeyer and Dittfeled, 1997). For more extensive period of observation (Neumeyer, 2002) the similar result for gravity trend has been obtained. Observable annual variations of a gravity are characterized by amplitude about 3 MGal (on our model it is 3.5 MGal). Observations at Syowa station have been confirmed the developed model. Here it was expected negative gravity trend - decreasing of gravity with velocity -2.54 MGal/yr, that have actually confirmed SG observations during 1995-1998: -2.4 MGal (Sato et al., 2001). Amplitudes of an annual and semi-annual variations approximately make 4.8 MGal and 0.8 MGal (theoretical values: 4.2 and 0.95). Another's confirmations of the developed theory and geodynamic model are given by the data of SG observations at Medicina, Isashi and Canberra stations. References Barkin Yu.V. (2002) Explanation of endogenous activity of planets and satellites and its cyclicity. *Izvestia cekzii nauk o Zemle. Rus. Acad. of Nat. Sciences*, Issue 9, December 2002, M.: VINITI, pp. 45-97. In Russian. Blewitt G., Lavallee D., Clarke P., Nurutdinov K. (2001) New global mode of Earth deformation: seasonal cycle detected. *Science*, V. 294. pp. 2342-2345. Neumeyer J., H.-D. Dittfeled (1997) Results of three year observation with superconducting gravimeter at the GeoForschungsZentrum Potsdam. *Journal of Geodesy*, 71, pp. 97-102. Neumeyer J. (2002) Curve of the gravity variations at Potsdam. Private communication. Sato T., Fukuda Y. et al. (2001) On the observed

annual gravity variation and the effect of sea surface height variations *Physics of the Earth and Planetary Interiors*, 123, pp. 45- 63.

Keywords: gravity variations, core trend oscillations, inversion



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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2655****The detailed model of Antarctic gravity field*****Dr. Andrey Grushinskiy****Russian Academy of Science Institute of physics of Earth IAG****Andrey Aleksandrovich Buluchev***

The gravity field of Antarctica is of great interest of many researchers. For its study, land and marine observation was carried out on the continent as well as on the adjusted offshore water. But a number of the available points prohibit making a common map of the gravity field of Antarctica or its parts, excluding the territory, where by geophysicists from USA was made air gravity survey. So, we can only produce its models on the base of spherical expansions. At the same time, there are the gravity field models calculated by altimetry data. Such models are not covered regions further south to 83oS. Its comparison with the results of on-board survey shown that there are systematic discrepancy in some regions. This discrepancy may achieve 20mGal. At present there are a number of Earths gravity field models, such as EGM-96, JGM-3, GRIM5-S1, GRIM5-S1CH1, PGM2000A. We calculated Antarctic gravity field by these models and compare the results with the available measured points by statistical methods. Furthermore, we estimate discrepancy between different models. This comparison shown following: 1) mean discrepancies between calculated models are within 0.044 s +0.019mGal; 2) mean discrepancy between final calculated model and land measured points is 3.23 mGal and RMS equal 15.31mGal; 3) mean discrepancy between final calculated model and the results of airgravity square survey is nearly 25mGal and RMS equal 13.34mGal. Such results allow to assume that the comprehensive gravity field model (step 15 arc minutes) obtained by us is perfectly adequate and good for use for solving regional geophysical problems.

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2656****Research on the calibration of onboard accelerometer by dynamic method****Mr. Xiancai Zou***School of geodesy and geomatics, wuhan university geodesy IAG***J.Li, Luo Jia**

The strategies of calibrating onboard accelerometer using dynamic method have been studied in detail in this paper based on the simulated satellite orbit. Calibrating the onboard accelerometer with the background earth gravity model fixed, the satellite orbit can be integrated again with the calibrated accelerometer observations and compared with the simulated orbit data. Results show that the choice of the reference earth gravity model has a significant effect on the accelerometer calibration, and the standard deviation between the re-integrated orbit and simulated orbit can be up to the order of meter. Therefore, the reference gravity models error on the calibration of accelerometer cannot be negligible and the selection of the background earth gravity model is very important. Further investigation demonstrates that the calibration of onboard accelerometer will be more stable and reliable if the earth gravity model parameters are estimated simultaneously.

Keywords: dynamic method, accelerometer calibration, satellite gravity

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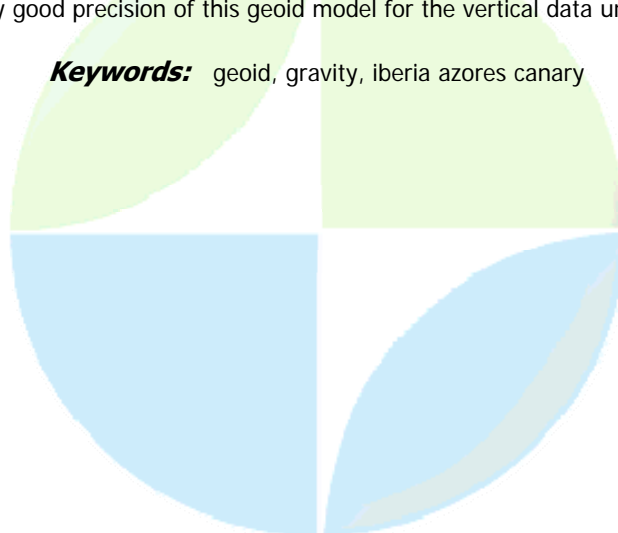
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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2657****The ICAGM07 geoid model for the North-East Atlantic (Iberia Canaria - Azores)****Prof. Joao Catalao***Geographic Engineering, Geophysics and Energy University of Lisbon, Faculty of Sciences,
LATTEX IAG***Miguel J. Sevilla, Helena Koll**

The Iberia-Canarias-Azores gravity and geoid model (ICAGM) is a project within the Iberian countries aimed at the determination of a high precision geoid model. This geoid intends to be a geographic extension of EGG97 to the west limit of European plate tectonics (Azores archipelago) and to the south of Canary islands. The main purpose of this geoid surface is to establish the connection between the existing vertical reference systems in Iberia and Azores and Canary islands and also to be the reference surface for real time kinematics positioning within this geographic area. A gravity database with all available gravity data sources were included for the gravity field determination, including 113382 terrestrial free-air gravity anomalies, 533918 shipborne anomalies and 653395 altimeter derived gravity anomalies from KMS02 model. Shipborne marine gravity data was carefully edited, validated and adjusted. The adjusted marine data was combined with satellite altimeter derived gravity by least squares optimal interpolation, improving the spectral and spatial resolution of the derived gravity field. Land gravity data from Azores, Canary and Madeira islands and Iberian peninsula were merged with the marine data and a gravity grid with a resolution of about 0.025 degrees was determined by least squares collocation. On land, a new digital terrain model with a resolution of 100m was constructed from the compilation of altimetric data from cartographic charts and from SRTM mission and on sea the 500m Gebco grid was used. The recent released GGM02C geopotential model extended to degree and order 360, using EGM96 coefficients above order 200, was used. The geoid model was computed from these data using the Helmerts second condensation method and the Stokes' integral with a spherical cap radius of 0.8 degree. The geoid surface was fitted, by a 4-parameter affine transformation, to the mean sea surface height derived from 10 year of TOPEX altimeter data, in order to remove long wavelength errors from datum inconsistencies. The geoid model was compared with GPS-leveling data on Iberia (Portugal and Spain), and on 7 different vertical data used on Azores, Madeira and Canary archipelagos. The comparisons indicates an overall precision of 15.7 cm for Portugal and 14.9 cm for Spain and offsets ranging from 87 cm in Canary to -19 cm in S. Miguel island on Azores, with an offset of 16 cm between Portugal and Spain mainland. The later offset is close to the 18 cm obtained from the EUVN, revealing a very good precision of this geoid model for the vertical data unification.

Keywords: geoid, gravity, iberia azores canary

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2658****Gravity field determination at the AIUB - the celestial mechanics approach.****Mr. Lars Prange**
IAG**Gerhard Beutler, Leos Mervart, Rolf Dach, Adrian Jggi**

The launch of the CHAMP and GRACE missions led to an enhancement of the gravity field estimation based on GPS and accelerometer observations of LEO satellites. We discuss a new approach based on GPS-derived satellite positions. We use kinematic satellite positions as pseudo-observations in order to solve for the spherical harmonic coefficients of the Earth's gravity field in a generalized orbit determination problem. Apart from the spherical harmonic coefficients, each of the daily arcs is characterized by a set of initial conditions, additional orbit parameters such as accelerometer calibration parameters and pseudo-stochastic parameters (pulses or piecewise constant accelerations) compensating for modelling deficiencies. In this context we try to find a balance between a sufficient compensation of non-gravitational effects and a possible absorption of gravitational forces. The daily solutions are combined on the normal equation level. This allows a flexible modification of the pseudo-stochastic part of the orbit model without a new time-consuming assembly of the normal equations each time. First results based on one year of CHAMP data demonstrate that the new method is comparable in quality with alternative approaches. Particular emphasis is put on the investigation of the contribution of the accelerometer data on the solution.

Keywords: gravity field, pseudo stochastic parameters, kinematic positions



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2659****Accuracy analysis of external reference data for GOCE evaluation in space and frequency domain****Mrs. Karen Insa Wolf**

With the upcoming ESA satellite mission GOCE, all components of the gravitational tensor (2nd derivatives of the Earth's gravitational potential) will be measured globally. An accuracy level of about 7 to 11 mE / sqrt(Hz) is required within the measurement bandwidth (5 to 100 mHz) for the main diagonal components of the tensor. To meet these requirements, the gradiometer will be calibrated and evaluated internally as well as externally. One strategy of an external evaluation includes the use of gravity data on ground upward continued to satellite altitude. The evaluation can only be applied regionally because sufficiently accurate ground data are only available for selected areas. In the upward continuation procedure, the combination with a geopotential model is included. In this study an error estimation for the external reference data is carried out in a synthetic environment, which comprises a geopotential model and regional terrestrial gravity data over central Europe, both including (white and coloured) noise. The use of synthetic data permits a closed-loop validation in all points using different computation methods. Both data sets are combined applying the spectral combination based on integral formulas with a modified kernel function. The requirements concerning the characteristics of the input data (noise level, area size and resolution) are discussed in view of the accuracy level of GOCE's gradiometer. All components of the tensor are computed in order to rotate the tensor in the actual (simulated) gradiometer orientation. The closed-loop differences are analysed in space and frequency domain. Evaluation in the frequency domain is important for GOCE as the gradiometer reaches the exceptional high accuracy only in a limited frequency band, the measurement bandwidth. Frequency dependent quality analysis is therefore of special interest. Numerical results show that the required accuracy can be reached for reference data based on gravity anomalies with a noise level of 1 mgal combined with current global geopotential models.

Keywords: satellite gradiometry, spectral combination, synthetic earth model



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2660****Calibration in the MBW of simulated GOCE gradients aided by ground data.****Mr. Martin Veicherts***Department of Geodesy University of Copenhagen***J. Boumann, C. C. Tscherning**

The GOCE gravity gradients will be calibrated using external gravity field data. While the GOCE gradients will have the minimal noise level within the Measurement Band-Width (MBW) from 5 to 100 mHz, they suffer from a $1/f$ error below the MBW. It is therefore required to band-pass filter the gradients to suppress the $1/f$ error on the one hand, while keeping the signal in and possibly below the MBW. Two data sets for the external calibration of the GOCE gravity gradients are explored. First the gradients are calibrated using a global gravity field model (GGM). Both time series of GOCE gradients and GGM derived gradients are identically filtered and scale factors for each component are determined. In order to verify this calibration result, the GGM has been enhanced using gradients computed by combining the model with ground gravity in four regions with good quality gravity data. Scale factors were determined for the gradients on each track passing through the area, and it could be concluded that the scale factors could be determined track-wise with results not significantly different from those obtained using the GGM only. Using 1 month of 1 s simulated data we have tested different procedures for extracting data in the MBW. The tested procedures included Butterworth filtering, long wavelength filtering with splines, zero padding and cosine tapering. The effect of varying the filter window and the data period was also investigated.

Keywords: gradient calibration, filtering, mbw**PERUGIA**
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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2661****An error model for the GOCE space-wise solution by Monte Carlo methods****Prof. Federica Migliaccio**
*DIAR Politecnico di Milano IAG***Mirko Reguzzoni, Fernando Sans, Nikolaos Tselfes**

The aim of the data analysis of the GOCE gravity satellite mission is to estimate spherical harmonic coefficients of the gravitational potential and their error covariance matrix. However the propagation of the noise from observations to harmonic coefficients is very complicated and numerical demanding. In particular this is true for the space-wise approach where the solution is obtained by several steps like Wiener orbital filter, gridding and global harmonic analysis. Up to now the noise propagation for this method has been implemented under simplifying hypotheses. In order to get a more realistic assessment of the true estimation error, Monte Carlo methods can be applied. This requires to generate several stochastic simulations and to compute the corresponding solutions. This procedure is made numerically feasible by storing and not recomputing every time the operators that comprise the space-wise approach. Tests on realistic scenarios have been performed and the expected results have been achieved.

Keywords: goce, space wise approach, monte carlo methods

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2662****Downward continuation of airborne gravity by Poisson integral, least-squares collocation and Fourier transform: a case study over the Kuroshio east of Taiwan*****Prof. Cheinway Hwang****Civil Engineering Dept of Civil Engineering, National Chiao Tung Uni IAG****Artu Ellmann, Hsuan-Chang Shih, Yu-Shen Hsiao***

Several methods exist to solve the downward continuation problem of physical geodesy. In this contribution the least squares collocation (LSC) method, the inverse of the Poissons integral formula, and Fourier transform are investigated. The three methods all employ a remove-restore procedure in which effects due to a long wavelength gravity field are first removed and then restored. The LSC uses the anomaly degree variances, error degree variances of the gravity model and data error variances to establish the covariance functions at desired altitudes. The Fourier transform in this study is actually a planar approximation of the Poisson integral. The kernels of the Poisson integral and Fourier transform are modified to accommodate the fact that (1) airborne gravity is band-limited because of use of long wavelength gravity model and filtering, and (2) data contain noises. The numerical comparisons utilize band-limited airborne gravity data collected over the Kuroshio east of Taiwan. Two airborne gravity surveys were carried out in the periods 2004-2005 and 2006-2007 here. The average flight altitudes are 5156 m and 1500 m. The overall airborne gravity accuracy is 2 mGal at a spatial (half wavelength) resolution of 6 km. The two surveys share a common area of ~30,000 km². This allows a more consistent validation of different approaches for the downward continuation. Possible reasons for the detected discrepancies between the results of the tested downward continuation methods are discussed.

Keywords: airborne gravity, downward continuation, taiwan

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2663****Inversion of gravity data N wavelet domain using normalized forward models****Mr. Arash Motasharrei***Geology Azad university of Now Shahr&Chalus-Iran IAG***Hossein Zomorrodian**

Because of mathematical advantages of wavelets, representing and inverting the gravity data in wavelet domain is now very common in the literature. In this research a modification has been applied on Multi Scale Edge (MSE) inversion method. Normalized Forward models of simple shapes (useful for salt domes and similar structures) are extended in MSE domain. The inverse process is used for the depth parameter. Some tests have been performed both on noise free and noisy synthesized data. The result shows that in specific range of scale factors appropriate result can be obtained. The method is also applied to real data consisted of two salt domes in central (Qom salt dome) and south part of Iran (Surveyed by national Iranian oil company in recent petroleum investigations). For each case appropriate depth has been estimated. Discrete wavelet analysis has been performed in separation processing.

Keywords: wavelet, multi scale edge

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2664****Estimation of the time-variable part of the geoid from monthly GRACE solutions*****Dr. Jianliang Huang****Natural Resources Canada Geodetic Survey Division, CCRS IAG*

The geoid, an equipotential surface of the Earth's gravity field that closely represents the global mean sea level, varies with time in response to mass redistributions caused by various processes in the Earth system. These processes, which include atmospheric, oceanic and hydrological circulations, solid earth and ocean tides, crustal motions, various geodynamic events, and mass variations inside the Earth, can be detected by the GRACE satellites. GRACE is a twin-satellite gravity mission launched in 2002 for mapping the Earth's gravity field and its time-variable component with unprecedented accuracy at a spatial resolution of about 450 km. In this contribution, we present results on the time-variable part of the geoid over from the available monthly GRACE gravity models, and oceanic and atmospheric models. Our results indicate that the seasonal geoid variability is about 5 mm in RMS for wavelengths longer than 450 km. This variation is mainly due to the hydrological cycle. On the other hand, the inter-annual trend reaches an approximate maximum of 1.5 mm per year and is closely correlated with post-glacial rebound in .

Keywords: geoid, grace, variation

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Poster presentation

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Status Report of Commission 2 - Gravity Field

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Earth Sciences Ohio State University IAG

Commission 2 is one of several principal components of the new structure of the IAG, inaugurated at the previous IUGG Assembly in Sapporo, Japan. It essentially continues the work of the former Section III of the IAG (Determination of the Gravity Field), but includes some aspects of satellite geodesy (former Section II), and is designed to have stronger links to other components of the IAG, specifically the Inter-Commission Committee on Theory (ICCT) and Commission 1 (Reference Frames). In this report, marking its first quadrennium, the activities of the Commission are summarized with particular emphasis on its participation in international gravity field symposia, beginning with the GGSM2004 (Gravity, Geoid, and Space Missions 2004) meeting in Porto and concluding with the upcoming Terrestrial Gravimetry, Static and Mobile Measurements 2007 Symposium in St. Petersburg. Also, many significant accomplishments can be reported in the area of geoid modeling and determination, as well as in activities by several collaborating entities. Perhaps the most famous achievements in global gravity field studies are in the area of space gravimetry, where the successes of the GRACE mission in identifying temporal gravity signals associated with regional hydrology, with tide signals under Antarctic ice shelves, and with major seismic events have demonstrated the utility of space gravimetry beyond merely obtaining better (static) global field models.

Keywords: gravity field, commission report, space gravimetry

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Poster presentation

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**Ocean tide loading correction for GPS static positioning in Taiwan:
comparison of GPS and SG loading effects**

Mr. Chun-Huan Wang

Department of Civil engineering NCTU IAG

Chun-Sung Chen, Ta-Kang Yeh, Cheinway Hwang

Ocean tidal loading (OTL) correction is important for GPS positioning, especially in the height direction. In general, the OTL-induced error increases with the baseline length. The OTL effect varies with time and space, and its magnitude ranges from few cm to tens of cm around . In this study, more than ten OTL models were collected and used in the GPS static relative positioning to see which model provides the best OTL correction around . The Bernese GPS software was used to process GPS observations in August 2006 at about 20 stations in a minimum constraint solution. The GPS time series at the 18 Peak Mt., where s superconducting gravimeter (SG) station is located, will be compared to the gravity time series from SG. Implications of the comparison will be presented.

Keywords: otl, gps, sg



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2667****Non-stationary covariance function modelling for least-squares collocation****Mrs. Neda Darbeheshti**
*spatial sciences IAG IAG***Will Featherstone**

Least-squares collocation (LSC) assumes stationarity and relies on a covariance function to account for the spatial dependence in the observed data. Standard LSC implicitly uses a stationary covariance, in which the covariance between any two points is some [decreasing] function of distance. This stationarity assumption is often justifiable and leads to a reasonable results based on observational data (e.g., in regional geoid modelling and derivation of marine gravity anomalies from satellite radar altimeter data). In some instances, however, the assumption that the spatial dependence structure is constant throughout the region is violated. Therefore, assuming a stationary covariance structure will result in over-smoothing of the gravity field in the mountains and under-smoothing in the great plains. Some progress has been made in defining non-stationary covariance structures for Kriging in geostatistics (a more general form of LSC for Gaussian-process regression). In these studies, spatial covariance models that allow the spatial dependence structure of the data to vary as a function of location are presented. We review wavelet basis-function model, process-convolution model, and spatial deformation model in Kriging, and demonstrate their advantages for providing insight into the extent and nature of the non-stationarity that may exist in geodetic data. The 100-km-long north-south-trending Darling Fault in Western Australia causes a major inhomogeneity in gravity anomalies, which provides a nice illustration of non-stationarity. We applied stationary and non-stationary covariance functions to an example of gravity anomaly interpolation using LSC in this area. The results with non-stationary covariance functions are very promising, but some computational difficulties - notably ill-conditioning are noted. Finally, possible extensions for non-stationary covariance function modelling on the sphere are reviewed. We believe that using non-stationary covariance functions can improve LSC results for approximation procedures in physical geodesy.

Keywords: least squares collocation, covariance function, non stationary

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Recovery and analysis of earth's gravity field using FORMOSAT-3/COSMIC GPS data

Mr. Tingjung Lin

Gravity Field Ph. D candidate IAG

Chienway Hwang, Tzu-Pang Tseng

The joint Taiwan-US FORMOSAT-3/COSMIC (FC) mission (Constellation Observing System for Meteorology, Ionosphere and Climate) was launched on April 17, 2006, and contains a geodetic element in the mission. Each of the six FC satellites is equipped with two POD GPS antennas, which yield data for precise orbit and gravity determinations. With 6 satellites in the constellation, FORMOSAT-3/COSMIC configuration will provide a strong geometry in determining earth's gravity fields. FORMOSAT-3/COSMIC GPS data can be used to compute orbit perturbations and/or accelerations which can then be used to recover the earth's temporal gravity fields and finally derive the spatial and time variations of the earth's mass. In this research, we will use Bernese 5.0 software to compute the precise kinematic orbits from FORMOSAT-3/COSMIC GPS data and use NASA/GFSC software GEODYN II (Pavlis, 1996) to determine the reference orbits for deriving temporal gravity fields. The perturbation forces caused by the earth's non-sphericity, N-body, solid earth tide, ocean tide, air drag, solar radiation pressure, earth radiation and relativity will be modeled. We will present experimental determinations of gravity harmonic coefficients using kinematic orbits of COSMIC in different scenarios. Data from the satellite missions GRACE will be combined with COSMIC data to enhance the accuracies of the estimated gravity fields.

Keywords: formosat 3, gravity, gps

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Poster presentation

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**Gravity field modeling using spherical radial basis functions A case study
for the territory of the Netherlands**

Dr. Robert Tenzer

Institute of Earth Observation and Space Systems Delft University of Technology IAG

Roland Klees, Ilya Prutkin, Tobias Wittwer, Erna Oudman

A new methodology for local gravity field modeling from terrestrial gravity anomalies and GPS/leveling data using the Spherical Radial Basis Functions (SRBFs) is used to compute a new improved quasi-geoid for the territory of the Netherlands. A sketch of the overall methodology is given, and the results of individual computational steps are analyzed. The new height-reference surface is compared with the current official height reference surface (quasi-geoid) NLGEO2004 for the Netherlands. The latter has been computed using Stokes integral with Wong-Gore-Meissl kernel modification and a parametric surface to model differences between GPS/leveling data and gravimetric height anomalies. The main conclusion is that the new methodology outperforms the traditional approach used so far for the computation of the Dutch geoid in terms of accuracy and numerical efficiency.

Keywords: gps leveling, gravity, heightreferencesurface



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2670****What type of spherical radial basis functions are best suited for local gravity field modeling?*****Dr. Robert Tenzer****Institute of Earth Observation and Space Systems Delft University of Technology IAG****Roland Klees***

The choice of the optimal Spherical Radial Basis Functions (SRBF) in local gravity field modeling from terrestrial gravity data is investigated. Various types of SRBFs are investigated, among others point masses, radial multipoles of different orders, Poisson wavelets of different orders, and the Poisson kernel. The analytical expressions for the Poisson kernel and the point mass kernel are well known, while for the Poisson wavelet and the radial multipole, new closed analytical expressions are derived for arbitrary orders using recursions. The performance of each SRBF is analyzed using real data of varying quality on the territory of the Netherlands. A penalized least-squares technique is applied to estimate the gravity field parameters. As follows from the analysis, the same accuracy of gravity field modeling can be achieved for different types of SRBFs if the bandwidth of SRBFs is chosen optimally. Excellent results are obtained with Generalized Cross Validation (GCV). As alternative to GCV, RMS residual minimization at a set of control points is analyzed. The optimal regularization parameter is determined using Variance Component Estimation techniques. We also show that when the bandwidth for each type of SRBF is chosen optimally, the correlation lengths of the SRBFs are the same or very similar. This is in agreement with results obtained with Least Squares Collocation.

Keywords: gravity, quasi geoid, spherical basis functions**PERUGIA**
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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2671****Comparison of techniques for the computation of a height reference surface from gravity anomalies and GPS/levelling data a case study at the territory of Germany*****Dr. Robert Tenzer****Institute of Earth Observation and Space Systems Delft University of Technology IAG****Uwe Schirmer, Roland Klees, Johannes Ihde, Ilya Prutkin, Gunter Liebsch, Tobias Wittwer, Uwe Schaefer, Bas Alberts***

Different techniques for the computation of a height reference surface from terrestrial gravity anomalies and GPS/levelling data are compared: (i) a penalized least-squares technique using spherical radial basis functions (SRBFs), (ii) a least-squares technique using point masses on different layers, and (iii) a least-squares collocation solution. Method (i) uses a data-driven strategy to select automatically position and depth of the SRBFs using Generalized Cross Validation and Variance Component Estimation techniques. The combination with GPS/levelling data is formulated in terms of a Cauchy boundary-value problem, which is solved numerically using Finite Element Methods. Method (ii) uses three layers of point masses at predefined locations and estimates the gravity field parameters by least-squares using gravity anomalies and GPS/levelling data directly. Method (iii) uses a least-squares collocation approach with parameters and measurement noise. A parametric model is used to count for systematic inconsistencies between GPS/levelling data and gravimetric quasi-geoid heights. Subject of the study is a 5x5 degree area in Germany. Gravity anomaly data and GPS/levelling data are reduced for the contribution of the EIGEN-CG03C global geopotential model and a digital terrain model. The quality of the individual solutions is assessed using ground control points.

Keywords: gravity, quasi geoid, gps leveling

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2672****Analysis of the possibility of predicting sea floor from vertical gravity gradient****Mr. Taoyong Jin***School of Geodesy and Geomatics Wuhan University IAG***Jiancheng Li, Zhengtao Wang, Yunsun Wu**

The techniques of satellite altimetry and satellite gravity have provided the adequate data of ocean, which establish the basis of the development of oceanography. Historically, prediction of ocean floor depth, or bathymetry, has been based on the isostatic modeling and linearized relationships between gravity anomalies and bathymetry. The need for isostatic modeling limits the application of the resulting bathymetry predictions as constraints in geophysical models. The original observation of the new mission of satellite gravity (GOCE) is gravitation gradient. Therefore, on the basis of the theory of sea floor predicted from vertical gravity gradient (Wang YM, 2000), this article predicts sea floor of the South China Sea from multi-satellite altimeter derived vertical gravity gradient. Compared with the result predicted from satellite altimeter derived gravity anomalies, the possibility of the method is discussed, which ensures the application of data of GOCE.

Keywords: satellite altimetry, vertical gravity gradient, sea floor



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2673****Error-covariances of the estimates of spherical harmonic coefficients computed by LSC, using simulated GOCE gradiometer data*****Prof. Dimitrios Arabelos****Department of Geodesy and Surveying Aristotle University of Thessaloniki IAG****Carl Christian Tscherning***

In an earlier paper a strategy was discussed for the collection of point data on real GOCE orbits, leading to optimal LSC determination of spherical harmonic coefficients, with the minimum number of data points. For this purpose experiments for the determination of harmonic coefficients were carried out, using noise-free or noisy simulated data with different distributions. The suggested strategy was based on the comparison between computed and true coefficients, the collocation error estimates and the comparison of the original data with data generated by the computed coefficients. For the experiments carried out in this earlier paper error-covariances of the estimates of the predicted spherical harmonic coefficients are computed in the present paper and the results are given in terms of the square root of the error-covariances between coefficients of the same degree and order and as error correlation of coefficients of a certain degree and order with all other coefficients. These error correlations are characteristic of the data distribution and of the features of the data noise. Generally, the error-correlations are very small, except when data are gridded equidistantly in longitude, where the correlation between coefficients of the same order is significantly different from zero.

Keywords: harmonic coefficients, least squares collocation, error correlations

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2674****Scientific report of subcommission 2.1 for the period 2003-2007*****Prof. Shuhei Okubo****Earthquake Research Institute University of Tokyo IAG*

Absolute gravity measurements provide nationwide fundamental basis for local and regional gravity surveys and consequently a reference for the height system of the nation as well. Moreover the absolute gravity measurements contribute to the studies of crustal movements, sea level changes as well as secular gravity changes due to various phenomena in and on the Earth. Thanks to the great effort of Kyoto University and others (Takemoto et al, 2006), remarkable progress was achieved in the establishment and enhancement of the Absolute Gravity Standard Station Network in East Asia and South-East Asia (AGSSN-ESEA). The network comprises 10 stations in China, 4 in Indonesia, 2 in Malaysia, 1 in Taiwan, 2 in Australia, 1 in Antarctica, 2 in Thailand, 1 in Philippines, and 8 in Japan. Significant progress in South America was also reported by the Commission Project 2.7. Gravity networks were established in Ecuador with new data becoming available in Colombia, Chile and Brazil (the latter with two new absolute gravimeters obtained by the National Observatory of Brazil). The two networks in Asia and in South America will serve as reference frames when discussing the long term deformation in the regions. The other point to be remembered is evaluation of accuracy of the absolute gravity measurements. For that purpose, the Seventh International Comparison of Absolute Gravimeters ICAG-2005 was organized in September 2005 at the BIPM by our Study Group 2.1 and other groups. 19 gravimeters from 16 countries participated in the ICAG-2005. A preliminary evaluation of the results was performed and final reports will become available.

Keywords: gravity network, intercomparisonPERUGIA
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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2675****Overview of GOCE Level 2 Gravity Field Products*****Dr. Thomas Gruber****Inst. für Astronomische und Physikalische Geodäsie Technische Universität München IAG****Reiner Rummel, Radboud Koop***

The GOCE High-level Processing Facility (HPF) is in charge of the production of the following final level 2 products: Calibrated and corrected gravity gradients, precise science orbits and global gravity field models. These products represent the main input to all further applications of GOCE. In order to correctly apply these products the user has to know the definitions, conventions and standards adopted for their generation. The underlying assumptions are described in detail in two documents, which will be released together with the data products. These are the GOCE Standards and the GOCE Product Data Handbook. The standards provide detailed information about the reference systems, the transformations between the reference systems and the adopted geometrical and the dynamical models. The data handbook is intended to provide to the users all required information for the correct use of the products. It includes an overview of the mission and products, general definitions, mathematical and geophysical conventions as well as a description of formats. The paper summarizes the applied standards and conventions and introduces in detail the content of the global gravity field product.

Keywords: goce, products

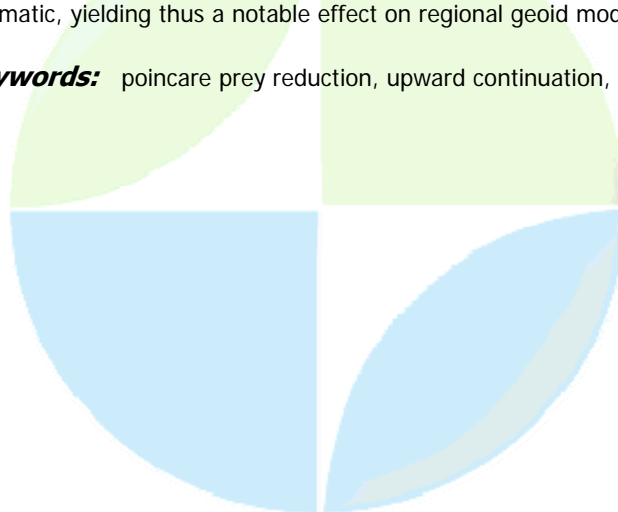
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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2676****Upward continuation of seafloor gravity data over inland seas****Dr. Artu Ellmann***Civil Engineering Tallinn University of Technology IAG***Harli Jrgenson**

Solving the geodetic boundary value problem by Stokes method requires gravity observations that refer to the geoid. Generally, the gravity observations are taken at the topographic surface. This contribution, however, deals with the seafloor gravity measurements. To satisfy the boundary condition the gravity quantities in question need to be continued upwards to the geoid level. An approximate vertical gravity gradient can be deduced from the Poincare-Prey gravity reduction. This method had been originally designed for the reverse task - predicting the gravity inside of the earth from the surface data. For the seafloor data this method is conventionally split into the following steps. First, the unwanted gravitational effect of water masses between the measurement point and the sea level is removed. For this the effect of the above masses on gravity is calculated by approximating the masses by an infinite plate of width equal to the depth of the measurement point. Thereafter, the free-air reduction is applied to move the gravity station upwards to the sea level. Finally, the slab of the water masses is restored back to the former position and its attraction at the station (now at the sea level) is accounted for. Apparently, such an approximate method could only be acceptable over the flat-bottomed areas of the open ocean. Conversely, in the case of inland seas or semi-enclosed gulfs the method suffers due to adopted approximations. First we note the density contrast between the dry and liquid masses. Second, the variations of the sea bottom and topographic surface (relative to the slabs boundaries) need also be considered. Consequently, this contribution aims at formulating the upward continuation of the sea-bottom measurements more rigorously. In particular, we take the full volume integral over the above masses, whereas the upper integration limits are the sea level and topographic surface. The lower integration limit is a constant equal to the depth of the observation point. After this step the gravity quantities become harmonic, which allows their upward continuation to the sea level. Thus there are two principal elevations for the computations points. At the remove stage the volume integral is taken with respect to the computation point on the seafloor, whereas at the final (restore) stage the computation point will be referred to the sea level. Strictly speaking, the volume integrals need to be computed over the whole globe, which is rather impractical. Therefore this contribution presents a new algorithm, which provides an alternative to the global integration without significant loss of accuracy. The new method is verified by numerical investigations over a part of the Baltic Sea. The gravity anomalies predicted by the new method were compared against the traditional approach. The resulting discrepancies are systematic, yielding thus a notable effect on regional geoid model as well.

Keywords: poincare prey reduction, upward continuation, geoid



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2677****Off-line validation tools for GOCE gradiometer data****Mr. Gernot Plank**
EPO-SME ESA ESTEC**Michael Kern, Roger Haagmans, Rune Floberghagen**

The European Space Agency's Gravity field and steady-state Ocean Circulation Explorer (GOCE) Mission, to be launched 2007 will deliver a new kind of space borne observables gradiometric measurements. To meet the mission goals accuracy of the derived geoid of 1-2 cm and of the gravity field of 1 mGal at a spatial resolution of 100 km a throughout calibration and validation of these measurements is of outmost importance for the success of the mission. After the launch during the commissioning phase the gradiometer will undergo a series of (internal) calibration procedures to derive calibration parameters, which will be used during the science phase of the mission. In the proposed paper a system will be presented which is composed of a validation of the internal calibration performed by ESA / industry, and several tools to monitor the quality of the observations. All presented tools will work during the commissioning phase of the mission as well as during the science phase. The major goal is to provide rapid feedback of the system performance to support the activities of the calibration /validation team of the mission.

Keywords: goce, validationXXIV 2007
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Poster presentation

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Mean vertical gravity gradient within the topography

Dr. Robert Tenzer

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Artu Ellmann

The mean gravity gradient along the plumbline within the topography is investigated in this study. Obviously, the precise determination of the actual gravity gradient inside topographical masses is restricted mainly by knowledge of the actual topographical mass density distribution. The computations are conducted at the area of study in the Canadian Rocky Mountains. The results are presented and the accuracy discussed.

Keywords: mean gravity gradient, boundary value problems



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2679****In-flight validation methods for the GOCE gradiometer****Mr. Michael Kern***Science, Applications and Future Technologies European Space Agency IAG***Roger Haagmans, Gernot Plank, Rune Floberghagen**

One of the key observables of the European Space Agency's Gravity field and steady-state Ocean Circulation Explorer (GOCE) Mission will be the gradiometer measurements. The GOCE gradiometer consists of three pairs of identical ultra-sensitive accelerometers, mounted on three mutually orthogonal arms. To meet the mission goals - to determine the Earth's gravity field and its anomalies with an accuracy better than 1 mGal, and the global geoid with an accuracy better than 1-2 cm at a spatial resolution of 100 km or better - the calibration and validation of the gradiometer is of utmost importance. The instrument will undergo a series of calibration procedures before launch and in flight. In flight, the gradiometer will be calibrated prior to the measurement phases by the so-called in-flight calibration, which makes use of a unique satellite and proof mass shaking set-up and calibration techniques. Ultimately, the gradiometric measurements are externally calibrated using external gravity information over well-surveyed areas and global gravity field models. In this paper, two methods to monitor and validate the gradiometer are suggested. One is based on accelerometer data themselves and checks whether the estimated validation parameters do not vary drastically from validation period to period. The other method checks the gradiometer by checking the collinearity, the magnitude of the estimated residual non-gravitational accelerations and conditions between the accelerometers. The theoretical developments and numerical results will be presented and discussed.

Keywords: goce, validation

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Poster presentation

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**Physical interpretation of the differences between the gravity anomalies
and the gravity disturbances A case study for the Canadian Rocky
Mountains**

Dr. Robert Tenzer

Institute of Earth Observation and Space Systems Delft University of Technology IAG

Artu Ellmann, Philip Moore, Petr Vanček, Pavel Novk, Peter Vajda

In the geoid modeling from gravity data, the Earth's gravity field is commonly treated separately for the components of gravity generated by the atmosphere, topography and the mass irregularities below the geoidal surface. In this study we utilize the decomposition of the Earth's gravity field in computing the differences between the gravity anomalies and the gravity disturbances. The individual contributions of atmosphere, topography and mass irregularities below the geoidal surface are analyzed and results demonstrated. The computations are conducted at the area of study in the Canadian Rocky Mountains.

Keywords: gravity disturbance, gravity anomaly

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2681****Numerical Comparison of Two Strategies for Geoid and Quasigeoid Determination over Sweden****Dr. Jonas Agren***Geodetic Research Division Lantmateriet IAG***Ramin Kiamehr, Lars E Sjberg**

Several quasigeoid models have been computed by the Nordic Geodetic Commission (NKG), the latest one being NKG2004. The latter was derived using a remove-compute-restore method involving topographic corrections by the Residual Terrain Model (RTM) technique and a Wong and Gore type of kernel modification. An alternative strategy lately adopted over Sweden is the so-called KTH method, developed at the Royal Institute of Technology (KTH) in Stockholm. It includes least squares (stochastic) kernel modification with additive corrections for the topography, downward continuation, the atmosphere and the ellipsoidal shape of the Earth. One problem with previous comparisons of NKG2004 and the quasigeoid as computed by the KTH method is that not the same data have been utilised in all steps. It is the purpose of this paper to remedy this defect and compare the NKG2004 and KTH methods numerically over Sweden using exactly the same data. This work is part of the Swedish geoid project, which is an on-going joint project between KTH and Lantmateriet (National Land Survey of Sweden), whose ultimate aim is to evaluate the KTH approach numerically and to compute both a geoid and a quasigeoid model over Sweden.

Keywords: geoid determination, kernel modification, topographic corrections



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2682****Image superresolution via filtered scales integral reconstruction applied to GOCE Geoid Data*****Dr. Guido Vingione****Department of Aerospace Engineering , SUN Aversa, Second University of Naples****Ciro Caramiello, Alessandra Tassa, Eric Monjoux, Rune Floberghagen, Alessandra Buongiorno***

The need for new and reliable n-dimensional interpolation techniques has recently gained a paramount importance in several areas of scientific research both from a theoretical and a computational point of view. In this work, a new approach is presented for enhancing image super-resolution via filtered scale integral reconstruction. Based on the concept that any sensed (from an instrumental point of view) specie must be necessarily considered as an averaged value in a suitable time and space continuum, the local reconstruction approach expects to map a space of average values onto another one (filtered scales) with smaller extension and possibly, in an asymptotic limit, onto the space of points. The only assumption is that the measurements are given in the integral average sense i.e. that, for some reason, they have to be considered as integral average values for given computational domains or cells. The proposed algorithm can be used to correlate averaged values to pointlike values; yet the most reliable results, in a probabilistic sense, can be obtained if the ratio between input and output scales is not too high. The essential concept of this working methodology is the possibility to correlate averaged measurements to averaged measurements upon suitably weighting the contribution of the molecules (or cells) surrounding the inspected one. The method based on analytical frame, is fairly general and can be applied to any kind of data. GOCE Geoid data could be particularly interesting in this regard, since the geoid data will be provided with minimum spatial resolution about 100 Km. By applying the proposed approach, new interpolated geoid grid can be obtained ensuring the minimization of estimation integral error in a best fit sense.

Keywords: geoid superresolution, integral filtering, best fitting

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2683****Geoid-type surface computation for the improved determination of heights from global positioning systems*****Dr. Ali Soltanpour****Geodetic Division Norwegian Mapping Authority IAG****Hossein Nahavandchi***

The wide spread use of the Global Positioning System (GPS) for precise height determination has established (quasi)geoid computation as a practically relevant product of physical geodesy. The geoid is the equipotential surface of the Earth's gravity field, which corresponds most closely with mean sea level, and is commonly used as the height datum for topographic elevations. A gravimetric (quasi)geoid, however, does not exactly coincide with the vertical datums. This is due to a combination of the approximations required in gravimetric (quasi)geoid computation, systematic errors in height and gravity data, and the exact definition of the height system. The practical problem that this presents is that the gravimetric (quasi)geoid is not suited to the direct determination of heights from GPS. At present, a surveyor using GPS and a gravimetric (quasi)geoid model must apply further data reductions in order to make their heights compatible with the height datum. This is particularly problematic for real-time GPS positioning because the surveyor must post-process the height data with an associated increase in survey cost. Therefore, it is logical to provide a (geoid-type) surface that specifically defines the separation of the height datum from the reference ellipsoid used by GPS. This procedure replaces costly conventional levelling operations with quicker and cheaper GPS surveys. This study focuses on combination of quasigeoid and GPS-levelling data over Norway to obtain a geoid-type surface which enhances the accuracy of levelling by GPS. The combination of the gravimetric quasigeoid model with GPS-levelling data using the Least-Squares Collocation (LSC) and Second-Generation Wavelets (SGW) is considered. Since results from LSC are sensitive to the selection of the trend and covariance model, different models are employed and results are evaluated. Results show that using the 3rd order or trigonometric trend model and exponential covariance model provide better agreement with GPS-levelling data (standard deviations of 2.9 cm and 0.15 ppm achieved in absolute and relative sense, respectively). Second-generation wavelets and their associated lifting scheme, which do not require regularly spaced data, are also used to combine gravimetric quasigeoid model and GPS-levelling data over Norway. The wavelet-based results are also evaluated with GPS-levelling data and standard deviations of 3.3 cm and 0.12 ppm achieved in absolute and relative sense, respectively. Comparison with the solutions from LSC merging shows that using LSC provides smaller standard deviation in absolute sense. But, in relative sense, the SGW solution with smaller standard deviation is preferred. Employing the SGW solution as a trend model in LSC is led to a combined method called SGW-LSC here. The solution using this combined method provides better results both in the absolute (2.8 cm) and relative (0.11 ppm) sense.

Keywords: geoid, gps, wavelet

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2684****GRACE and the geoid in South America****Dr. Denizar Blitzkow***Transport Engineering University of So Paulo IAG***Ana Cristina O. Cancoro De Matos, Ilce De Oliveira Campos, Flvio Guilherme Vaz De Almeida, Maria Cristina B. Lobianco**

The geopotential models derived from GRACE represent an important contribution to the medium wavelength component knowledge of the gravitational field. This fact has consequences for the computation of the respective wavelength component of the geoid. An analysis has been carried out on the quality of the GRACE models using geoid heights derived from GPS observations on the leveling network in South America. A total of 549 points has been used for comparison. The analysis has shown that the GRACE mission provides an important improvement on the knowledge of the gravitational field. The 'only' satellite model (eigen-g104s1) and the combined model, eigen-g104c1, have been compared with 549 GPS geoidal heights on the leveling network. The terrestrial gravity data in South America have been updated with the most recent measurements in and. A new geoid model was then derived using GRACE model up to degree and order 150 as a reference field. The short wavelength component was estimated via FFT with Featherstone modified kernel. Helmert anomalies were computed using SRTM model for terrain correction.

Keywords: geoid, gravity

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2685****Improving the precision of GPS acceleration for moving base gravimetry*****Mr. Xiaopeng Li****School of Earth Sciences The Ohio State University IAG****Christopher Jekeli***

We investigate methods to improve the precision of computing the kinematic acceleration using GPS data in an INS/GPS moving-base gravimetric system. Both position solutions and phase data are employed to compute the GPS acceleration. The kinematic acceleration of the system is determined through a wave-number correlation filter that combines the position-derived acceleration and the phase-derived acceleration in the frequency domain. The data gaps in the DGPS positioning solution are fixed by a two-stage adaptive Kalman filter. Based on the Doppler measurements, a novel method is developed to efficiently fix the cycle slips in the phase observables. All these techniques are applied to both static data and kinematic data collected by a terrestrial INS/GPS system. The results show that both the data gaps and cycle slips can be properly fixed. Moreover, the filtered kinematic acceleration improves both the precision and the robustness of the moving base gravimetric system.

Keywords: ins, gps, gravimetry

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I T A L Y

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2686****On Some Aspects of GLS06 Data Quality assessment and downward continuation****Mr. Jarir Saleh**
NGS NOAA IAG**Dan R. Roman, Yan Ming Wang**

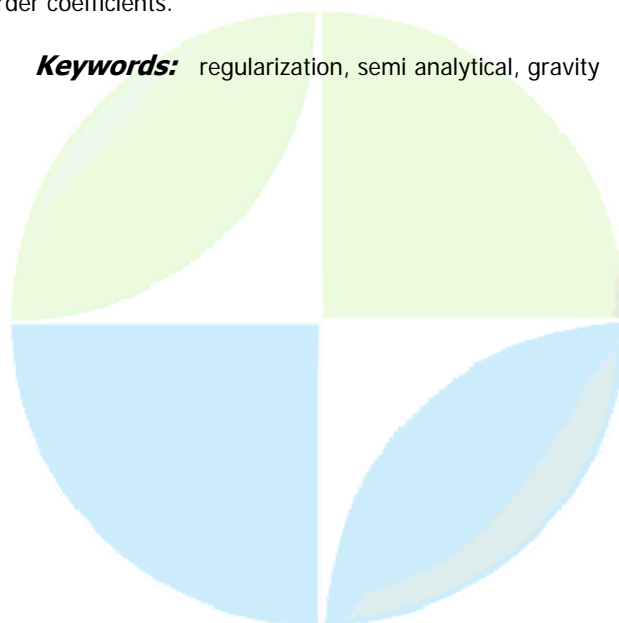
GLS06 is a gravity/Lidar survey conducted in 2006 by an NRL/NASA/NGS team in the Gulf of Mexico in an area of about 400x500 km on and off the coasts of Mississippi, Alabama and Florida. NRL collected and processed the gravity data and crossover adjusted them. Quality assessment tests at NGS revealed an RMS-crossovers of 0.86 mGal, based on 343 crossover errors, with a maximum and minimum of 2.8 and -3.1 mGals, respectively. The RMS differences between the crossover-adjusted and the upward-continued surface gravity along the 51 tracks range from 1.0 to 2.3 mGals. This data were downward continued to the surface using a 3D Fourier series fit with low-pass filtering, compared and merged with NGS surface gravity data. This paper describes the work done to quality-check, downward continue and merge the GLS06 data.

Keywords: airborne gravity, downward continuation, quality assessment



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2687****Evaluation of the Regularization Methods Used in the Torus-Based Semi-Analytical Approach for Gravity Field Recovery****Mr. Chen Xu***Department of Geomatics Engineering University of Calgary***Michael G. Sideris**

Global gravity field recovery from satellite observations by least-squares adjustment is an inverse problem. Due to various reasons, e.g., the polar gap problem and non-continuous data distribution, the normal matrix in the least-squares adjustment is typically ill-posed. Thus, the traditional gravity field recovery approaches have difficulty inverting the unstable normal matrix to estimate the unknown coefficients. The torus-based semi-analytical approach is an alternative tool due to its efficiency and flexibility to handle any kind of geopotential functionals. In the torus approach, the normal matrix in the least-squares adjustment is stable, because the polar gaps are filled by interpolation, and the irregular data are gridded regularly on the torus surface. However, the observable itself, e.g., a certain single component from the gravity gradient tensor, may contain insufficient information about the gravity field. In addition, the downward continuation from satellite altitude to the surface of the Earth always causes instabilities. Therefore, it is still important to evaluate the regularization methods in the torus approach of gravity field recovery from satellite observations. In the torus approach, since the spherical harmonic coefficients are estimated by a blockdiagonal order-wise least-squares inversion, the regularization methods are implemented blockwise by different order m , as well. There are two aspects involved in the Tikhonov regularization evaluation. One is the choice of an appropriate regularization matrix. For instance, Kaulas rule of thumb, the first and second order Tikhonov matrices provide different weights on the data. In addition, knowledge of gravity field errors may be incorporated into the least-squares inversion. The other issue is the optimal determination of the regularization parameter, which is the trade-off between propagated data and the regularization constraint. The optimal factor is investigated by the L-curve criterion, the generalized cross-validation (GCV), and the mean square error (MSE) method, respectively. Our preliminary results show that regularization methods have slight influence on the results in the CHAMP data processing. However, for the processing of the GOCE gravity gradient tensors, the optimal regularized results are two orders of magnitude better than the original solution, especially in the low order coefficients.

Keywords: regularization, semi analytical, gravity

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2688****Ellipsoidal corrections for geoid computations with modified kernels*****Dr. Sten Claessens****Western Australian Centre for Geodesy Curtin University of Technology IAG****Will Featherstone***

Ellipsoidal corrections to quasi/geoid heights computed via the spherical Stokes integral have been derived by many authors, but only a few have studied the behaviour of ellipsoidal corrections for the case of various modified Stokes kernels. Here, new, simple formulas to compute ellipsoidal corrections to spherically approximated geoid heights are derived for any arbitrary type of kernel modification, and for any arbitrary radius of the reference sphere used in the spherical Stokes integral. In this paper, the magnitude and global distribution of ellipsoidal corrections for different types of deterministic kernel modifications is investigated numerically. It is shown that use of the so-called spheroidal (or Wong-Gore) Stokes kernel in geoid computation leads to the smallest ellipsoidal corrections, and any kernel modification aimed at reducing only the truncation error will always amplify the ellipsoidal corrections. However, for any type of kernel modification, the ellipsoidal corrections can be accurately modelled by a series of low-degree and -order spherical harmonic coefficients if the reference sphere radius is set equal to the ellipsoidal radius of the computation point (i.e., the distance between the computation point on the ellipsoid and the ellipsoids centre). The influence of different choices of the integration cap size and the maximum degree of the spherical harmonic model used to model the low degrees are illustrated. This shows that the ellipsoidal corrections reach magnitudes of several centimetres for common parameter settings, which remains significant in the quest for a cm-geoid.

Keywords: geoid, ellipsoidal**PERUGIA**
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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2689****A unified definition and formulation of analytical approximations in gravity field modelling*****Dr. Sten Claessens****Western Australian Centre for Geodesy Curtin University of Technology IAG****Will Featherstone***

All existing techniques for the computation of the Earth's gravity field and the quasi/geoid from gravity-related observations rely on analytical approximations of non-linear relations, such as the relation between the gravity anomaly and the disturbing potential given by the fundamental equation of physical geodesy. The oldest and simplest solutions, such as Stokes integral for geoid computation, are based on a number of approximations, altogether often referred to as the spherical approximation. However, in the last few decades, the spherical approximation has become insufficient, and improvements to the theory in the form of various corrections, such as ellipsoidal corrections and linearisation corrections, have been derived by many authors. Unfortunately, arguably poor coordination of contributions has led to a plethora of definitions and symbology, many of which are inconsistent with one another. This causes or has caused confusion, and hinders the practical implementation of these more rigorous derivations. In this contribution, the various conflicting definitions and formulations in literature are analysed, and a universal unambiguous set of definitions, symbology and notation is proposed. This proposed new system removes all current inconsistencies, and is also consistent with - yet clearly distinguished from - the well-known and often-applied spherical formulation. As far as possible, the existing notation and definitions are retained so as not to generate any further confusion, thus making the ellipsoidal approach more accessible and applicable. We hope that this new system can serve as the framework for a universal theory of the relatively new field of ellipsoidal physical geodesy, which will facilitate its wider adoption in practice.

Keywords: physical geodesy, ellipsoidal, approximations

(G) - IAGA - International Association of Geomagnetism and Aeronomy

GS002

Poster presentation

2690

Determination of Earth Gravity Field Model WHU-GM-05 Using GRACE Gravity Data

Dr. Zhengtao Wang

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Jiancheng Li, Dingbo Chao, Weiping Jiang

Based on the energy integral equation of satellite orbit-motion, some applied computation formulas for Earth gravity field recovery from satellite to satellite tracking data are presented, in which a strict expression of the difference of kinetic energy between two satellites on the same orbit in terms of KBR range-rate observation value is given. Using GRACE data from the both satellite and energy integral method, a gravity model with max. degree 120 is derived, which named WHU-GM-05. The tests of WHU-GM-05 series are performed by multi-comparisons, which include the comparisons between the model series and several analogous international geopotential models include EIGEN-GRACE series and GGM02S with respect to the corresponding degree variances and geoidal heights, and comparisons of the model geoidal heights with GPS leveling in the area of U.S. and China (some regions). The results show that the total accuracy of WHU-GM-05 is near to that of the models used in the comparisons.

Keywords: grace, gravity filed model, energy conservation



(G) - IAGA - International Association of Geomagnetism and Aeronomy

GS002

Poster presentation

2691

Modelling range rates for recovering the Earth's gravity field by fully taking the errors of acceleration measurements into account

Prof. Yunzhong Shen

Department of Surveying and Geomatics Tongji University, P.R. China IAG

Peiliang Xu, Houze Hsu

The intersatellite range rate observations and non-conservative acceleration observations of twin Low-Earth-Orbit satellites play a key role in recovering high precision, low-to-medium frequency gravitational models. Undoubtedly, all observables will be contaminated by random errors, even after all possible systematic biases/errors may be corrected and the scale/bias is calibrated for acceleration observations of, e.g., CHAMP (CHALLENGING Minisatellite Payload) and GRACE (GRAVITY and CLIMATE Experiment). As a result, an algorithm for modeling both range rate and non-conservative acceleration observation errors is proposed in this paper. The corresponding observational equations have been derived and solved, based on the least squares criterion. Simulated examples are studied based on the GRACE orbit elements. If the accuracies of the range rate and non-conservative observation are assumed to be 10-12m/s².

Keywords: satellite gravimetry, low low satellite tracking, modeling acceleration error



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2692****Combined vertical motion model- a case study for the Great Lakes*****Mrs. Elena Rangelova****Department of Geomatics Engineering University of Calgary IAG****Michael G. Sideris***

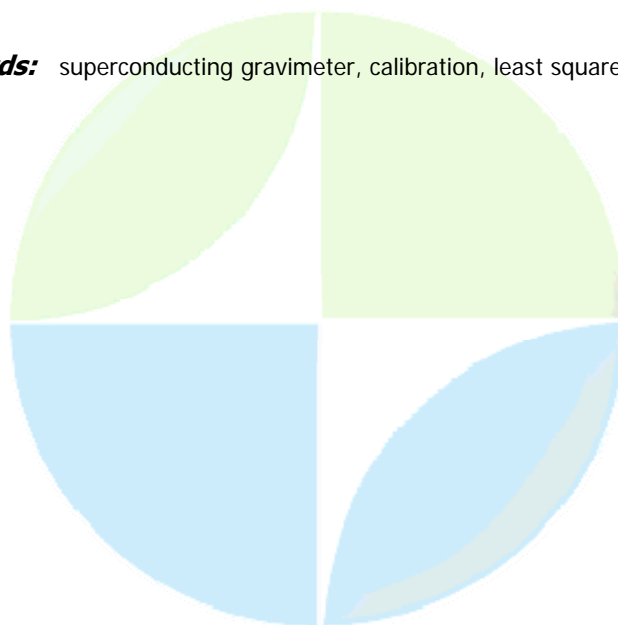
In this study, a map of vertical crustal motion is produced via a combination of different data sources. The region of interest is the Great Lakes, which allows for modelling the line of zero postglacial uplift which is an important constraint for postglacial rebound models. In particular, the most recent GRACE-observed rates of gravity change converted to vertical crustal motion are combined with joint tide gauge/satellite altimetry data and GPS velocity data. While the different data sets exhibit a consistent gradient for the velocity surface, the line of zero motion deviates from one data set to the other due to various factors including biases, different time spans of measurements and data accuracy, to name a few. The combined velocity model is realized via a least-squares adjustment procedure with variance-component estimation for the optimal weighting of the data sets and extensive data screening procedures. The latter is necessary to ensure reliable estimates of relative errors in the combined least-squares adjustment (via re-scaling of covariance matrices) and to ensure that the final vertical motion model is not corrupted and/or distorted by erroneous data. The computed vertical rates vary between -2mm/yr (subsidence) along the southern shores and 3 - 4mm/yr (uplift) along the northern shores. The results of this study show agreement with the most recent \dot{g} map for Canada in the Great Lakes region and can be further utilized as constraints for postglacial rebound modelling.

Keywords: grace, pgrPERUGIA
ITALY

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2693****On the potential of least squares product spectra for calibration of Superconducting Gravimeter and atmospheric reduction****Mr. Mahmoud Abd El-Gelil***Department of Earth & Space Science & Engineering York University IAG***Spiros Pagiatakis, Ahmed El-Rabbany**

Recent improvements in technology have created extremely precise and accurate measuring systems that are sensitive to minute physical phenomena that were once much too small to be detected. The superconducting gravimeter (SG) is no exception; it is sensitive to changes in gravity that reach the nanogal level. This instrument is used to study the earth tide, ocean loading, Chandler wobble, core nutation and even to search for the Slichter triplets and core modes. The above-mentioned phenomena are spread over a very wide spectral band from hours to years. In this presentation, we propose a new procedure based on the least squares spectrum and its product spectra to calibrate the SG in the frequency domain and to estimate a frequency-dependent admittance to reduce the atmospheric pressure effect. Absolute Gravimeter (AG) measurements from 1997 to 2007 are used to calibrate the SG at Cantley station, Canada. Both data sets are filtered using a Parzen window to produce unequally spaced AG and SG time series. The common peaks in SG and AG spectra, once identified in the product spectrum, they are suppressed to estimate their amplitudes and phases. Then, the ratio of the AG to SG amplitudes (scale factor for SG) and their corresponding difference in phases for every statistically significant common constituent are estimated. A smooth function is subsequently fitted (weighted least-squares) to the estimates to calculate the scale factor of the SG. The atmospheric mass variation is the second most significant phenomenon affecting gravity after the Earth tide. The atmospheric effect, usually removed by using a physical model (loading) and/or an empirical transfer function (admittance). In this contribution we adopt a new approach to estimate the atmospheric pressure admittance. This approach is also based on the product spectrum of the SG and pressure time series. Here we use the product spectrum of one year long data set from Canadian Superconducting Gravimeter Installation CSGI (Cantley, Canada). A smoothed frequency-dependent admittance is estimated and used to correct the gravity data series (residual series). The results show improvements in the gravity residuals and spectrum compared to the ones from other models currently in use and particularly from the physical models.

Keywords: superconducting gravimeter, calibration, least squares spectrum



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2694****Insights into the Mexican Gravimetric Geoid (GGM05)****Dr. Marcelo Santos***Geodesy and Geomatics Engineering University of New Brunswick IAG***David Avalos, Petr Vanicek**

The Mexican Gravimetric Geoid (GGM) is an ongoing effort from INEGI, the federal institution in responsible for its computation. The latest version is GGM05. The technique implemented and used for the compilation of GGM05 follows the UNB Stokes-Helmert scheme, dealing with the solution of the geodetic boundary value problem. As many as 1.4 million gravity data measurements were used to generate the GGM05. The resulting geoid provides many useful and interesting insights. The estimated accuracy of GGM05s geoidal heights is 45cm rms. This value comes from comparison against GPS/Benchmark references. Regional and systematic biases, some very high, have been detected on the central part of the country. This fact has lead to an analysis of the computation process and also the reference data. There is an attempt to guarantee the use of a reliable dataset of gravity values to calculate the GGM05, and, on the other hand, to certify the correctness of the benchmark data, some coming from observations 30 years older than the combined GPS data. Recent leveling lines suggest that some of the benchmarks are not in their original place. Vertical crustal movements can explain that. But this new information cannot be used as reference because is not yet attached to the same vertical reference. It has been recently realized that the standard deviations of geodetic heights obtained from GPS are optimistic. So, a question remains in the air: are there gravimetric data pushing the geoid model or are the vertical reference points no longer accurate enough to evaluate a geoid model? This is the fundamental question that this investigation is devoted to.

Keywords: geoid, stokes helmert, boundary value

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2695****Approach of regional gravity field modeling from GRACE data for geoid model improvement for Japan****Dr. Yuki Kuroishi***Space Geodesy Laboratory Geographical Survey Institute IAG***Frank G. R. Lemoine, David D. Rowlands**

The Japanese islands and their vicinity are located in a region of plate convergence boundaries, producing substantial gravity and geoid undulations in a wide range of wavelengths. Because of the geometry of the islands and trenches, precise information on gravity in the surrounding oceans should be incorporated in detail, even if the geoid model is required to be accurate only over land. The Kuroshio Current, which runs south of Japan, causes high sea surface variability, making altimetric gravity field determination complicated. The objective of this study is to determine the gravity field at long wavelengths precisely in the vicinity of from GRACE data and to use the resulting model for reducing the systematic errors at such wavelengths in the latest gravimetric geoid model for , JGEOID2004. The geoid model, developed by combining surface gravity data with a global marine altimetric gravity model under EGM96 as a foundation, suffers from errors at wavelength around 1000 km in a range of +/- 20 cm, which are presumably attributed to EGM96 errors. Our approach is based on exclusive use of inter-satellite range-rate data with calibrated accelerometer data and attitude data, for regional or global gravity field recovery. In the first step, we calibrate accelerometer data in terms of scales and biases by fitting dynamically calculated orbits to GPS-determined precise orbits. The calibration parameters of accelerometer data thus obtained are used in the second step to recover a global/regional gravity anomaly field. We analyze one year of GRACE data for 2005 and discuss the improvement effects of the resulting gravity models on JGEOID2004.

Keywords: grace, gravity recovery, geoid for japan

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2696****Towards the optimum strategy of determination of terrain corrections in Poland****Prof. Jan Krynski***Geodesy and Geodynamics Institute of Geodesy&Cartography, Warsaw, Poland IAG*

Modelling of precise regional quasigeoid in Poland conducted in last few years clearly indicated the principal directions of further research required for developing the quasigeoid model of a centimetre accuracy. It has been shown that the quality of elevation data considerably affect calculated terrain corrections, and as a further consequence the quality of the quasigeoid model developed. Each of the existing sources of elevation data in Poland, i.e. heights of gravity stations, digital terrain models, data on gravitational attraction of terrain in the close vicinity of some gravity stations, etc. carries a unique and valuable information on the terrain. Elevation data from different sources available in Poland are complimentary and they should be combined for generating the most reliable terrain corrections. The strategy of determination of terrain corrections based on the optimum use of elevation data in Poland was developed. The improvement in the quality of new regional quasigeoid model has been shown.

Keywords: terrain corrections, quasigeoid modelling, elevation data



(G) - IAGA - International Association of Geomagnetism and Aeronomy

GS002

Poster presentation

2697

**Forward gravity modelling of global databases - report of IAG study group
2.2 for the period 2003 – 2007**

Dr. Michael Kuhn

Western Australian Centre for Geodesy Curtin University of Technology IAG

Dimitrios Tsoulis

Today an increasing number of databases with ever increasing resolution are available that describe the Earth's shape and internal structure. These databases include high resolution digital elevation models (DEM) such as the latest release of SRTM-derived DEMs, bathymetric models of the world's oceans and models describing the geological and geophysical structure (e.g. density distribution) of the Earth's crust and mantle. The increasing number of these data allows for the use of forward gravity field model techniques (direct application of Newton's integral) being of great significance to gravity field modeling and interpretation. Furthermore, the comparison of the forward modeling results with existing gravity field models reveals useful information on the Earth's interior as well as the validity of the forward gravity modeling techniques. The International Association of Geodesy (IAG) Study Group 2.2 is concerned with the employment of forward gravity modelling techniques to recently released global digital databases for gravity field recovery and interpretation. The key points the study group were focusing at are (i) the construction of forward gravity field models, (ii) the interpretation and application of forward modelling results, and (iii) the studying of forward modelling techniques. This contribution summarizes the activities of the study group over the last four years since its creation at the IUGG General Assembly at Sapporo in 2003.

Keywords: gravity, forward modelling



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2698****Shallow-water gravity anomalies over China Seas from retracked Geosat/GM and ERS-1/GM altimetry*****Prof. Cheinway Hwang****Civil Engineering Dept of Civil Engineering, National Chiao Tung Uni IAG****Haihong Wang, Yuande Yang***

Satellite altimeter data over shallow waters are prone to errors caused by corrupted waveforms and inferior geophysical corrections, yet much more important than open-ocean altimeter data for such purposes as coastal geoid modeling, determination of coastal current and sea level, and offshore geophysical explorations. The continental shelf of China Seas, including Bohai, Yellow, East China and South China Seas and Taiwan Strait, is a vast area where altimetry can contribute significantly to geodetic, geophysical and oceanographic studies. In this paper, attempt was made to retrack Geosat/GM and ERS-1/GM by an optimal retracker to correct for range measurements of Geosat and ERS-1 altimeters. The performances of some candidate retrackers such as threshold, modified threshold and beta-5 are also evaluated. Over most coastal zones, spurious altimeter data are still present despite retracking, and they are removed by filtering and outlier detection. Global tide models perform poorly at certain coastal zones of China Seas. A careful use of tide model will be discussed. The prediction of gravity anomalies is carried out using both least-squares collocation and inverse Vening Meinesz formula. Shipborne marine gravity anomalies over the East China and South China Seas were compared with altimetry gravity, and a detailed analysis of the location-dependent discrepancies between the two will be reported.

Keywords: altimetry, gravity, china sea

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2699****Qu-AUSSIE-Geoid: The anticipated new Australian geoid-type model****Prof. Will Featherstone***Western Australian Centre for Geodesy Curtin University of Technology IAG****S.J. Claessens, M. Kuhn, J.F. Kirby, N. Darbeheshti, M. Filmer***

We are nearing the final stages of producing a new geoid-type model for that will replace our current gravimetric-only national quasigeoid, AUSGeoid98. The exact date of release depends on the release of EGM07 and multi-mission satellite altimeter-derived gravity anomalies. The terminology geoid-type reflects that our new regional gravimetric quasigeoid model will have to be fitted to GPS-levelling data because of government decree to retain the Australian Height Datum (AHD) for the moment. Nevertheless, this fitting approach will provide a user-friendly product for the more direct transformation of GPS ellipsoidal heights to normal-orthometric heights on the AHD, thus better supporting the majority of geoid users in Australia. The AHD contains about 1-2m north-south-oriented distortions due to the fixing of 32 tide gauges in its practical realisation. Some users of AUSGeoid98 now find up to 1-2m discrepancies with existing AHD benchmarks. We will use improved quasigeoid modelling techniques and the most recent datasets available, such as GRACE (Gravity Field and Climate Experiment) global gravity field models, satellite-altimeter-derived gravity anomalies in marine areas that have been re-tracked to improve them in the coastal zone, the latest cleaned release of the Australian land gravity database, the v-2 Australian digital elevation model, which now allows the computation of nine-arc-second resolution topographical effects. Emphasis will be placed on the use of modified kernels as high-pass filters to manage long-wavelength errors in the Australian terrestrial gravity and terrain data, so that they do not contaminate the high-quality GRACE data.

Keywords: geodesy, geoid, australia

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2700****Analysis and Comparison of multi-year GRACE Gravity Field Time Series by means of spectral and spatial Techniques*****Mrs. Lieselotte Zenner****Institute of Astronomical and Physical Geodesy Technical University Munich IAG****Thomas Peters***

The main objective of the GRACE dual-satellite mission, apart from atmospheric sounding, is the determination of the Earth's gravity field and its temporal variation. Since March 2002 the satellites continuously and globally provide observations of the gravity field, which are the basis for the definition of the most important physical reference surface of geodesy and oceanography the geoid. Various research centers like the GeoForschungsZentrum (GFZ, Potsdam), the Center of Space Research (CSR, Austin), the Centre National d'Etudes Spatiales (CNES, Toulouse) and the Jet Propulsion Laboratory (JPL, Pasadena) provide continuous time series of GRACE gravity solutions with different temporal resolutions. Each time series has specific characteristics, which reflect differences in the processing strategies. The main focus of this study will be a comparison between the latest revisions of GRACE gravity field solutions. Spectral and spatial characteristics in the fields as well as differences in modelling and conspicuous irregularities will be discussed. Finally, the GRACE gravity fields will be compared with a hydrological model (LaD). This example shall demonstrate the suitability of GRACE for global detection of mass variations with satellite gravity observations either as alternative or extension to existing (hydrological) models.

Keywords: grace, gravity field**PERUGIA**
I T A L Y

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2701****Analysis of the Gradiometer Equations of the GOCE Satellite Mission*****Mrs. Claudia Stummer****Institute for Astronomical and Physical Geodesy Technical University of Munich IAG****Bjrn Frommknecht***

The satellite mission GOCE shall measure the gradients of the Earth gravity field with an accuracy of a few mE ($E = \text{Etv/s}$; $1\text{E} = 10^{-9}/\text{s}^2$). The GOCE gravity gradiometer consists of six three-axes accelerometers. Each of them has two high sensitive axes and one less sensitive axis. The mathematical relationship between the gravity gradients and the accelerometer measurements is described by the gradiometer equations. The equations are set up for each axis with respect to the different measurement accuracies of the accelerometer-axes. Furthermore, several systematic instrumental errors can affect the GOCE measurement system, such as bias, scale factor, misalignment and non-orthogonality of the accelerometer-axes. Therefore, the gradiometer equations are extended to take into account these additional errors. Using realistic assumptions about the measurement errors the accuracy of the gravity gradients can be calculated by means of error propagation. Contrariwise it can be found out to which extent the instrumental errors are tolerable if the gravity gradients shall be determined with an accuracy of a few mE. The paper specifies the extended gradiometer equations and provides numerical results for the gradiometer error budget and for the impact of the instrumental errors.

Keywords: goce, gradiometry

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2702****Regional astrogeodetic validation of GPS/levelling data and quasigeoid models****Mr. Christian Voigt***Institut für Erdmessung Leibniz Universität Hannover IAG***Heiner Denker**

In the context of a regional validation and combination experiment in Germany, a work package within the framework of the GOCE-GRAND II project, gravity observations, vertical deflections and GPS/levelling data are collected as independent data sets. The observation of absolute gravity values is carried out by the Bundesamt für Kartographie und Geodäsie (BKG), while the deflections of the vertical are observed by IfE using the Hannover digital transportable zenith camera system TZK2-D. The vertical deflections have an accuracy of approx. 0.1 arc seconds and are arranged along a north-south and east-west-profile. The two profiles have a length of about 500 km and spacing between adjacent stations of 2.5 - 5 km. Furthermore, a national GPS and levelling data set of about 900 stations with an accuracy of approx. 1 cm is available for Germany. The analysis of the vertical deflections is carried out by the astronomical levelling method, resulting in two (quasi)geoid profiles. The accuracy of the profiles is expected to be at the cm level. The cross-validation of both the vertical deflection and GPS/levelling data is realised by traversing the profiles through all nearby GPS/levelling stations (about 50 in total). In addition, comparisons are performed with existing (quasi)geoid and global geopotential models from the GRACE mission (as GOCE models are not available yet) associated with appropriate filtering techniques.

Keywords: astrogeodetic validation, deflections of the vertical, gps levelling data

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GS002

Poster presentation

2703

Activities of IAG Subcommittee 2.2: Spatial and Temporal Gravity Field and Geoid Modelling

Prof. Martin Vermeer

Surveying TKK Helsinki University of Technology IAG

The Subcommittee's work over the last four years is summarized. The subjects of study are global and regional gravity modelling including topographic/isostatic modelling and the problems of upward and downward continuation, BVP and spectral approaches; tides, geodynamics, gravity changes due to air and water movement, and related subjects. Highlights of the reporting period were the symposia in Porto, Cairns and Istanbul. Technology wise, the most reportable developments are undoubtedly 1. the GRACE mission results, which are still being added to, giving an unprecedented picture of the static global Earth gravity field as well as seasonal and other temporal variations; and 2. the extensive use of airborne gravimetry, facilitated by real-time GPS positioning, for regional and national gravimetric survey especially in heretofore unsurveyed areas. The report refers to the Subcommittee web site for a compilation of relevant publications by Subcommittee members and others over the reporting period.

Keywords: spatial temporal, gravity, modelling



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2704****Postseismic deformation and gravity changes around Marmara Sea*****Mrs. Sabine Roedelsperger****Institute of Physical Geodesy Darmstadt Technical University of Technology****Ugur Dogan, Semih Ergintav, Carl Gerstenecker***

In 1999, Turkey was hit by two destructive earthquakes, near Izmit on August 17 and near Dzce on November 12. Since then, much effort has been undertaken to monitor postseismic deformation along the western North Anatolian Fault Zone, particularly with GPS. In 2003, also a gravity network (MAGRANET) has been established. Between Oct. 2003 and Oct. 2006 six gravity campaigns with relative gravimeters were carried out. It is investigated, whether the observed gravity changes and deformations can be explained by postseismic relaxation processes. Co- and postseismic displacements, observed shortly after the Izmit and Dzce event, are inverted to model the geometric and elastic parameters of the relevant faults in a viscoelastic half-space. Postseismic displacements and gravity changes are then computed with the adjusted model for comparison with the gravimetric observations between 2003 and 2006.

Keywords: north anatolian fault zone, gravity changes, postseismic

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2705****An auto-adaptive method for numerical integration over the Earth's surface in gravity field studies****Mr. Otakar Nesvadba***Department of Gravimetry Land Survey Office IAG*

The integration over a boundary of a three-dimensional domain is a problem, which, as a rule, is a key step in the solution of boundary-value problems of potential theory in physical geodesy. The aim of this paper is to discuss improvements in the numerical treatment of this problem. Two-dimensional manifolds (star-shaped in the origin in our case), which under some degree of idealization represent the Earth's topography, are uniquely projected onto a sphere. A hierarchical division of the sphere may then be used to generate the corresponding patching of the manifolds. Subsequently, the established hierarchical grids are efficiently exploited for the recursive enumeration. Moreover, an auto-adaptive approach, which follows criteria of Richardson's extrapolation, is applied to refine the patch hierarchy. In parallel the approach offers also an estimate of the integration error. Several numerical experiments, in dependence of the input data as well as the quality and regularity of the boundary, have been done. The results show a good numerical efficiency and reliability of the method. Therefore, the numerical treatment applied may be successfully used in the majority of practical cases.

Keywords: gravity field, numerical methods, surface integration

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2706****Determination of precise kinematic orbits of CHAMP and GRACE satellites for gravity field modeling****Dr. Qile Zhao***geodesy and geodynamics gravity field modelling IAG*

Q. Zhao (1,2) , P. Ditmar (1), X. Liu (1), R. Klees (1), C. Shi (2), J. Liu (2) (1)Delft institute of Earth Observation and Space Systems (DEOS), Faculty of Aerospace Engineering, Delft University of Technology, Kluyverweg 1, 2629 HS Delft, The Netherland (q.zhao@tudelft.nl), (2)GNSS Research and Engineering Center, Wuhan University, 129# Luoyu road, 430079, Wuhan, China Precise orbits determination (POD) for low Earth orbiting (LEO) satellites with onboard GPS receivers is a rapidly developing research area. The POD procedure plays a very important role in the satellite missions such as CHAMP, GRACE and GOCE. When a kinematic orbit is used as the input for gravity field modeling, the quality of the result is mostly determined by the accuracy of this orbit. The kinematic orbit determination for CHAMP and GRACE satellites was performed on the basis of 101 days of onboard GPS data. Zero-differenced measurements were processed. The GPS satellites ephemeride products of IGS and high-rate clock products of CODE were used. Prior to the kinematic orbit determination, reduced-dynamic orbit determination was applied to edit the data. In order to obtain better baseline estimations for two GRACE satellites, an effective ambiguity resolution method deliberately developed for zero-differenced data was applied. The accuracy of the kinematic orbits was assessed by comparing them with JPL and TUM reduced dynamic orbits as well as with SLR data and KBR data. Furthermore, gravity models recovered from the computed kinematic orbits were compared with those derived from TUM kinematic orbits; the state-of-the-art gravity field model EIGEN-CG03C was used as the ground truth. The results of comparison confirm a high quality of the computed kinematic orbits.

Keywords: champ, grace, kinematic orbit determination

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GS002

Poster presentation

2707

On the rigorous determination of orthometric heights in regional areas

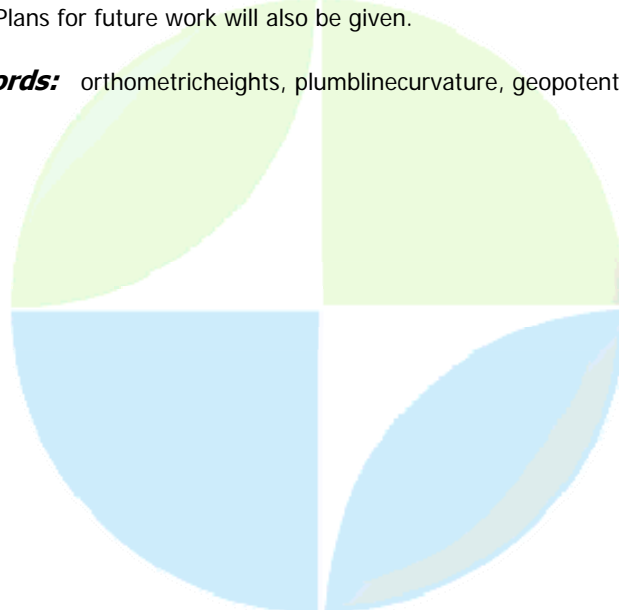
Dr. Gerassimos Manoussakis

Surveying Engineering National Technical University of Athens, Greece IAG

Demitris Delikaraoglou, George Ferentinos

The orthometric height is the distance, measured positive outwards along the plumbline, from the geoid to a point of interest, usually on the Earth's topographic surface. According to its classical definition, it can be computed from the geopotential number of a point, using the mean value of the Earth's gravity acceleration along the plumbline within the topography (i.e. between the geoid and the Earth's surface). Hence, the main problem in the rigorous definition of orthometric height reduces to the accurate evaluation of the mean value of the Earth's gravity acceleration along the plumbline. Alternatively, recent efforts concentrate on the determination of orthometric heights from GPS derived geometric heights (above the ellipsoid) and geoid undulations derived from detailed local geoid models using the familiar Stokes integration or FFT techniques. In this paper, we show that a rigorous and yet practical and accurate determination of the orthometric height of points on the Earth's surface can be made by a methodology which relates the orthometric height with the geopotential number C , the magnitude of the gravity vector g and the curvature k of the plumb line, all determined at the point of interest on the physical surface. The required geopotential number C is computed through the evaluation of the Earth's gravity potential W from one of the available Global Geopotential Models in spherical harmonics, while g and k are computed by suitable formulae which use the first and second partial derivatives of the disturbing potential T (Etvos components) and the normal potential U accordingly. An overview is given on our project structure, the computation strategy, the test data sets we used, the expected accuracies, and the work done so far. This approach was tested using different Global Geopotential Models (e.g. EGM96, GPM98CR, and recent models from the CHAMP and GRACE missions) and extensive leveling benchmark datasets from USA and Europe. Initial results from these comparisons will be presented for various areas and for various classes of orthometric heights (i.e. 0-250 m, 250-500 m, 500-1000 m, 1000-1500 m, and >1500 m), demonstrating that generally the differences between these rigorously determined orthometric heights and actual orthometric heights typically range from a few centimeters and up to 4 decimeters, thus showing the future promise of this methodology as new and continually improving geopotential models from the CHAMP and GRACE missions become available to be used for this purpose. Plans for future work will also be given.

Keywords: orthometric heights, plumbline curvature, geopotential models



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2708****Gravity field modeling on the basis of satellite accelerations directly derived from onboard GPS measurements****Dr. Qile Zhao***geodesy and geodynamics gravity field modelling IAG*

Q. Zhao (1,2) , P. Ditmar (1), X. Liu (1), R. Kless (1) (1)Delft institute of Earth Observation and Space Systems (DEOS), Faculty of Aerospace Engineering, Delft University of Technology, Kluyverweg 1, 2629 HS Delft, The Netherland (q.zhao@lr.tudelft.nl), (2)GNSS Research and Engineering Center, Wuhan University, 129# Luoyu road, 430079, Wuhan, China A new gravity field modeling approach is presented. It is based on average satellite accelerations directly derived from onboard GPS phase measurements, i.e. without computing the kinematic orbit as an intermediate product. An advantage of this approach is that no ambiguity resolution is needed, and most of systematic errors that exist at neighboring epochs can be eliminated. In order to validate the new approach, GPS data from CHAMP and GRACE satellites covering 101-day interval were processed to recover a model of Earth's gravity field model. The results were compared with the models derived from the kinematic orbits computed on the basis of the same GPS data; the EIGEN-CG03C model was used as the ground truth. The comparison showed that calculating accelerations directly from GPS measurements improves the quality of the gravity field model by approximately 20%.

Keywords: champ, grace, gravity field modeling

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2709****The Realization of Three-Dimensional Inversion of Non-tidal Gravity Changes by Wavelet Decomposition****Mr. Shaoming Liu***Institute of Seismology, CEA CEA (China Earthquake Administration) IAG***Minyu Jia, Shaoan Sun, Chongyang Shen**

The gravity non-tidal gravity changes results from the redistribution of substance in earths interior, surface and outside and the displacement of observation station. To decompose the gravity field changes into different component we can see the relations between seismic activities and gravity changes more clearly. To inverse the different component of gravity changes, we can get the three-dimensional density changes image and explore the relations between the density changes image and the process of earthquake gestation and occurrence will help to understand the physical cause of earthquake occurrence and carry out physical prediction. The Wavelet transformation is a new mathematical branch which is developed recent years. It has good locality in time and frequency. Its decomposition results are better than conventional method such as Fourier transformation and filtering. By combination of wavelet transformation and matrix least square method we realize a new three-dimensional gravity inversion. As application, we decompose the gravity changes in Western-Yunnan by wavelet method developed by Hou Zunze(1997). The decomposition results are inverted by matrix least square method and the three-dimension density changes maps in west Yunnan are obtained.

Keywords: gravity changes, wavelet transformation, three dimensional inversion

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2710****The analysis of models of the Earth's gravity field derived from GRACE
using empirical orthogonal functions*****Dr. Hanjiang Wen****Chinese Academy of surveying and mapping geodesy IAG*

The models of the Earth's gravity field are provided every month in terms of spherical harmonic coefficients by the NASA/CSR/GFZ Gravity Recovery and Climate Experiment (GRACE) satellite mission. The spatial resolutions (half-wavelength) of these models are limited to about 1000 km. Monthly geoid anomalies are derived from these models by subtracting mean geoid. The Empirical orthogonal functions are used to analyze the series of the geoid anomalies to see the characteristics of the geoid variations from these models.

Keywords: grace, eof, geoid anomalies

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I T A L Y

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2711****Preparing the next generation EGM; Satellite altimetry for gravity and Mean sea surface determination****Dr. Ole Andersen***Danish National Space Center Scientist IAG***Per Knudsen**

Satellite altimetry is one of the key elements of the global high resolution gravitational models. In this presentation we will focus on the latest development in the accuracy and processing of satellite altimetry. The DNSC07GRAV global marine gravity fields and mean sea surfaces (DNSC07MSS) will be presented. Both the gravity field and the associated mean sea surface have been derived with a spatial resolution of 1 minute by 1 minute and cover all marine regions of the world including the Arctic Ocean up to the North Pole. Amongst the improvement in satellite altimetry are retracking the entire ERS-1 GM mission using a highly advanced expert based system of multiple retrackers the return time from both the open sea surface and from all ice-covered regions within the coverage of the ERS-1 can be derived with higher accuracy that presently available. Also the GEOSAT GM data which have been reprocessed and retracked by NOAA, are included in these new global fields. This presentation describes the combined effort in improving the altimetric data sets in various regions. Among these are Polar and near coastal regions. Extensive comparisons and validations carried out at the DNSC and at the National Geospatial-Intelligence Agency is also presented

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Poster presentation

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A preliminary three-dimensional density model of the Western Carpathians based on the CELEBRATION 2000 seismic experiment.

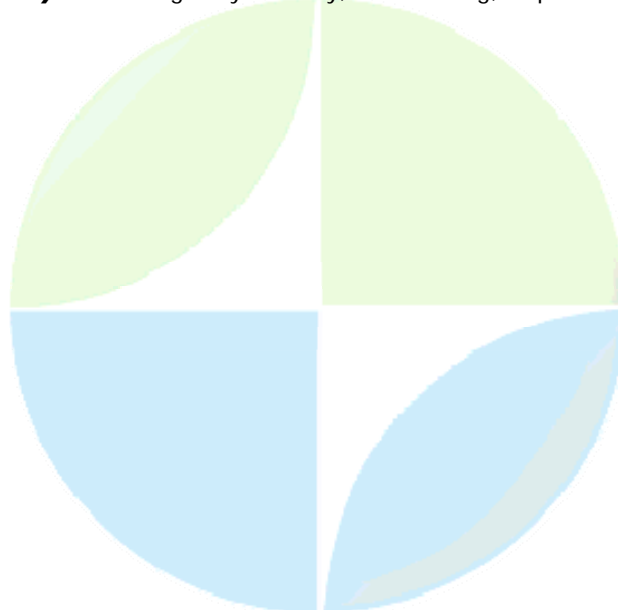
Dr. Zuzana Alasonati Tasarova

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Miroslav Bielik, Hans-Jrgen Gtze

The arcuate Carpathian Mountains, extending over a distance of 1300 km, are typically divided into several distinctive segments: the Western, Eastern and Southern Carpathians (clockwise from left). Together with the Pannonian Basin they belong to the youngest features in Central and Eastern Europe. Both the Carpathians and Pannonian Basin are the result of Mesozoic/Cenozoic plate interactions during the convergence of the European and African Plates (e.g. Kovč 2000, Guterch et al., 2003, and references therein). Due to a complicated tectonic evolution and a complex lithospheric structure, the Carpatho-Pannonian area as well as its surrounding regions, the Eastern Alps, Bohemian Massif and European Platform, were subjects to numerous geological and geophysical experiments already in the past. Recently, many refraction seismic experiments, such as POLONAISE 97, CELEBRATION 2000 followed by the ALP 2002, SUDETES 2003 and BOHEMIA teleseismic experiment, were conducted here. These data provide an excellent foundation for combined geophysical interpretation of gravity, magnetic, seismic and geological data. Hence, in the framework of this study, a three-dimensional (3-D) density model focused on the Western Carpathians is constructed, using simultaneous forward modelling of the Bouguer gravity and magnetic anomalies. The model is constrained by a relatively large amount of geophysical and geological data, most notably the results from the CELEBRATION 2000 seismic experiment that are merged with other information available from this region into a 3-D structural image. The preliminary results show significant differences between the lithosphere of the Pannonian basin and Western Carpathians (Alcapa block) and the European Platform. While the crust of the Alacapa block is thin and less dense (2335 km, average density of 2.77 Mg/m³), the European Platform is characterized by a thick and dense crust (3550 km, average density of 2.93 Mg/m³). This supports the well known interpretation of a southward subduction of the dense European Platform underneath a less dense Alcapa block.

Keywords: gravity anomaly, 3d modelling, carpathians



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2713****Influence of hydrology-related temporal aliasing on the quality of monthly models derived from GRACE satellite gravimetric data****Mr. Joao Encarnacao***DEOS Delft University of Technology IAG***R.Klees, E.Zapreeva, P.Ditmar, J.Kusche**

Satellite gravimetric data acquired by the GRACE mission are extensively used to retrieve temporal variations of the Earth's gravity field. A traditional way to represent these variations is a set of spherical harmonic coefficients derived once per month. In practice, however, the gravity field changes continuously (e.g. because of on-going hydrological processes). This discrepancy causes temporal aliasing which manifests itself as errors in the obtained gravity field models. Additional factors that amplify these errors are (i) the fact the GRACE re-visits each particularly area only once in while, so that the collected "snapshots" may not be representative for a given month, and (ii) the GRACE mission is relatively insensitive to nearly-sectorial spherical harmonics, so that even a minor imperfectness of the functional model may cause large errors in the corresponding spherical harmonic coefficients. The goal of the study is to quantify the influence of temporal aliasing caused by hydrological processes onto the quality of computed monthly gravity field models; the Zambezi river basin is used as the test area. Unlike in the traditional representation based on spherical harmonics, the water mass variations are parameterized as point-masses (one per catchments), which are to be estimated. A number of scenarios of a steadily increasing complexity are considered, in which the water mass per grid-cell is either constant or varying (in space or/and in time). All these scenarios are based on the water mass variation derived from the LEW (The Lumped Elementary Watershed) regional hydrological model over Southern Africa (Winsemius et al, 2006). The GRACE observations are simulated along the actual GRACE orbits as gravitational potential differences. The mass variations per cell obtained by the Least Square adjustment are compared with the "true" values (as assumed in each scenario) used for data simulations. This allows conclusions to be drawn on how the quality of recovered models depends on the number of cells (i.e. the grid resolution), the ground track distribution, and the rate of temporal water mass changes.

Keywords: gravity, aliasing, grace

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2714****Terrain correction of gravity gradients by different approaches****Dr. Gyula Tth***Dept. of Geod. and Surveying BUTE, Budapest, Hungary IAG*

Several approaches are discussed for estimating terrain corrections (TC) on gravity gradients measured in the vicinity of the terrain. First method is prism integration with spline densification near the computation point, the second one is an approximation of the terrain by polyhedra using Hansens formulas, and the third one is numerical quadrature. Heights of the topographic surface at quadrature points were estimated from bilinear and trigonometric interpolations, respectively. TCs were determined at 25118 benchmarks using numerical quadrature, prism and polyhedron methods using a 3x3 elevation grid for the inner zone and a 30x30 elevation grid for the outer zone. The dependency of TCs on the station height is investigated. The results were compared with TCs from a conventional integration method due to Schweydar, supplied with the measurements. Since gravity gradients are very sensitive to features of the nearby terrain the most precise method should be carefully selected for TC computations.

Keywords: terrain correction, gravity gradients, numerical integration



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2715****New combined geoid solution by gravity space approach applied in the South of Portugal mainland*****Dr. Carlos Antunes****Matematica LATTEX, IDL, Universidade de Lisboa IAG****Joo Catalo***

In the last few years different strategies have been implemented in the linear formulation of the gravity space approach for local geoid computation. The initial vector solution has been modified into a combined solution resulting from a combination of two boundary-value equations, the vector and the scalar equation. The main reason for this new strategy is the reduced availability of astronomical observations when compared with the large number of gravity data. Another reason is the possibility to obtain the exact boundary value of the anomalous adjoint potential with the scalar form of the boundary-value equation, on the data points where there is no information on the true values of the gravitation vector direction by astronomical data. Therefore, the two boundary-value equation forms, the vector equation form on the data points with the complete gravitation vector observations (gravity and astronomy) and the scalar equation form on the gravimetric data points, can be combined in the same region and with the same accuracy. Consequently, the boundary values of the anomalous adjoint potential are obtained for the entire data area, and the geoid model returns by differentiation of this spatial function in the gravity space. The combined geoid solution by gravity space approach is applied in the south of mainland using both gravimetric and astronomical data. Different solutions, using conventional methods and the same data, were performed to be compared and analyzed. The results and the conclusions are presented in the communication.

Keywords: gravity space approach, adjoint potential, combined geoid solution



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Poster presentation

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GOCE: System and Mission Performance, Data Processing and Mission Products

Dr. Rune Floberghagen

Ground Segment Department Directorate of Earth Observation Programmes IAG

Danilo Muzi

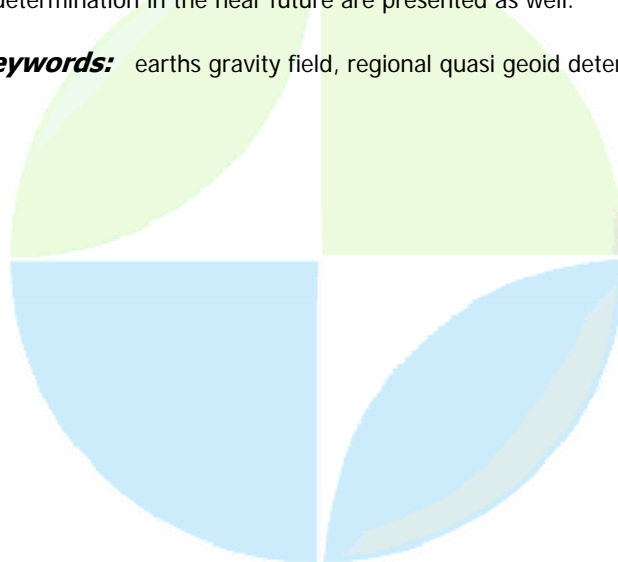
This paper presents the processing and predicted performance of the GOCE Level 1b and Level 2 mission products. Level 1b products include calibrated and corrected time series of measurements from the Gradiometer instrument as well as from the Satellite-to-Satellite Tracking instrument, while Level 2 products include all precise orbit and gravity field information. In addition, the overall lay-out of the ground segment and the role of the ground segment elements in the quality assurance of the products to be delivered to end users will be discussed.

Keywords: goce, products, performance



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2717****Progress in Regional Quasi-geoid Determination of China****Prof. Jiancheng Li***School of Geodesy and Geomatics Wuhan University IAG***Jinsheng Ning, Weiping Jiang, Dingbo Chao, Yibin Yao**

The geoid with an accuracy of centimeter level will become a new milestone in the progress of geodesy. As a basic reference surface in geodesy, geoid is the height datum for measuring orthometric height. If the geoid with an accuracy of centimeter level is realized, then the GPS ellipsoidal height could directly be converted into orthometric height with the same accuracy level. Therefore, the effective-economical GPS altimetric technique will replace the conventional burdensome spirits leveling. This would be a great progress in measuring orthometric and/or normal height. It is possible to determine local or regional geoid with an accuracy of centimeter level or even better when the new satellite gravimetry technique can provide the global geoid with the same accuracy in the medium wave and long wave band, and the global geoid is combined with precise GPS leveling networks, terrestrial gravity data and high resolution DTM. Since the 55 China quasi-geoid (CQG2000) was completed in 2000, we have mainly focused on the refinement of the local geoids in some regions such as provinces and cities in order to meet the emergent demands upon the information of ground elevations in these regions and cities, the economic constructions of which are in the rapid development. This presentation will introduce the studies of related theories and methods to local geoid refinement, as well as the progress and results of the local quasi-geoid refinement in several typical regions among some provinces and cities where the refined geoids have been accomplished. In the studies of theory and method, we laid special stress on the investigation of the problem about the determination of a unified quasi-geoid across land and sea. A topographicisostatic correction model is presented which is suitable for computing the correction in land-sea edge area; a strict algorithm for the determination of land-sea unified quasi-geoid is also given; as well as a more reasonable method for fitting gravimetric quasi-geoid to GPS-leveling is put forward and tested using spherical cap harmonic analysis. In addition, the Molodenskys method and Helmerts second condensation method for the gravimetric quasi-geoid determination are checked and compared with their respective computing results. The new methods used in the refinement of local quasi-geoid and corresponding results with the accuracies of better than 5cm and 1cm are described in detail. Finally, we propose that some problems on the realization of local geoid with the accuracy of one centimeter level should further be investigated, and some comments on the prospect for development of precise local geoid determination in the near future are presented as well.

Keywords: earths gravity field, regional quasi geoid determin

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2718****The effect of topographic and isostatic masses on the EtvS-tensor****Dr. Szabolcs Rozsa***Department of Geodesy and Surveying Budapest University of Technology and Economics IAG***Gyula Tth**

For the validation and downward continuation of the space gradiometric observations it is important to know the effect of topographic and isostatic masses on the elements of the EtvS-tensor. In this paper spherical approximation and mass prism topographic models are used to compute the effect of topographic and isostatic masses. Various isostatic compensation theories are also investigated. The investigations are based on the ETOPO5 and the SRTM topographic data sets. Computations are carried out over Europe as well as over the whole globe. The results show that the effect of the full topography without isostatic compensation is significant in the altitude of the LEOs and reaches the level of 10 EtvS for all of the gradients, while they are smaller when the isostatic compensations are also taken into account.

Keywords: gradiometry, topography, eotvos tensor

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Poster presentation

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Report on the Activities of SC 2.4 "Regional Geoid Determination"

Dr. Urs Marti

Geodesy Department Federal Office of Topography IAG

This presentation gives a summary of the final report of the activities of the IAG Sub-Commission 2.4 "Regional geoid determination" of the last four years. It focuses mainly on the activities of the Commission 2 projects which aim at the determination of continental geoid models. For most of these projects, a detailed presentation is given separately in this session. These projects are the following: CP2.1 (European Gravity and Geoid); CP2.2 (North American Geoid); CP 2.3 (African Geoid); CP 2.4 (Antarctic Geoid); CP2.5 (South American Geoid); CP 2.6 (Southeast Asian Geoid). Many other activities related to SC 2.4 were presented in the corresponding sessions of the symposia in Porto (2004) and in Istanbul (2006), as well as at the IAG Scientific Assembly in Cairns (2005). This includes the determination of national and local geoid models, their comparison with global models or with GPS/leveling data and the introduction of new methodologies in various domains of gravity field determination. A short summary of these activities will be presented on the poster.

Keywords: status report sc24, regional geoid projects, commission2 projects



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Poster presentation

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The National Gravity Network of Switzerland

Dr. Urs Marti

Geodesy Department Federal Office of Topography IAG

In 2003, a project LSN2004 was started by swisstopo to modernize the national gravity network of Switzerland. This new network is based on the existing gravity network of 1995 and is connected to several stations of the European gravity network UEGN. In this project, it is foreseen to establish some new absolute stations and to re-measure the existing ones with an FG5. Additional high precision relative measurements are performed with SCINTREX-CG5 gravity meters in order to improve the accuracy and stability of the network. With repeated observations, the accuracy of LSN2004 should also allow the first determination of gravity changes and derived vertical movements in Switzerland. The poster shows the concepts of LSN2004 and presents the observations performed so far. The first results of a preliminary total adjustment of all gravity observations since 1992 are presented and compared to the results of the adjustment of 1995.

Keywords: national gravity network, absolute gravity measurements, gravity change

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Poster presentation

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Report of Working Group on Satellite Gravity Theory

Dr. Nico Sneeuw

Institute of Geodesy Universitaet Stuttgart IAG

The current and future satellite gravity missions CHAMP, GRACE and GOCE have given rise to a wealth of data, exciting results, interdisciplinary research, new science, but also to many new problems. The task of IAG Working Group 2.1 on "Satellite Gravity Theory", an Inter-Commission Working Group between Commission 2 (Gravity Field) and the InterCommission Committee on Theory, has been to monitor the ongoing activities and to actively contribute to such activities in this exciting area of research. Here we report on the working group's activities by highlighting some key research areas (novel processing approaches, time-variable gravity field modeling, future mission concepts) and by explaining the group's role at main events (conferences, special issue of Journal of Geodesy).

Keywords: report, working group



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2722****The analysis of models of the Earth's gravity field derived from GRACE
using empirical orthogonal functions*****Dr. Hanjiang Wen****Chinese Academy of surveying and mapping geodesy IAG****Zhu Guangbin, Xu Kehong***

The models of the Earth's gravity field are provided every month in terms of spherical harmonic coefficients by the NASA/CSR/GFZ Gravity Recovery and Climate Experiment (GRACE) satellite mission. The spatial resolutions (half-wavelength) of these models are limited to about 1000 km. Monthly geoid anomalies are derived from these models by subtracting mean geoid. The Empirical orthogonal functions are used to analyze the series of the geoid anomalies to see the characteristics of the geoid variations from these models.

Keywords: grace, eof, geoid anomaliesIUGG
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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2723****New combined geoid solution HGTUB2007 for Hungary****Dr. Gyula Tth***Dept. of Geod. and Surveying BUTE, Budapest, Hungary IAG*

A new geoid solution HGTUB2007 was computed for Hungary using least-squares collocation technique for the first time by combining different gravity datasets. More than 300000 point gravity data were interpolated onto a 1.5" x 1" geographical grid consisting of 26 478 values in the IGSN71 gravity system. These gravimetric data were combined with 137 astrogeodetic deflections and gravity gradients available at more than 25000 points in the least-squares collocation procedure. Topographic information was provided by the SRTM data at 3x3 resolution. We have used the high resolution GPM98CR model and the GRACE-based GGM02 models as a global geopotential reference to our new solution. As a quick evaluation of the solution with GPS/Leveling data shows, the obtained accuracy is about 3 cm in terms of standard deviation of geoid height residuals.

Keywords: geoid, least squares collocation, combination solution



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Poster presentation

2724

Report of the Internal Working Group of the ICCT on Inverse Problems and Global Optimization

Dr. Juergen Kusche

Geodesy and Remote Sensing GeoForschungsZentrum Potsdam IAG

At the Sapporo General Assembly of the IUGG, 2003, the International Association of Geodesy (IAG) has approved the Intercommission Committee on Theory (ICCT) as part of its new structure. In order to support its work, the ICCT has established working groups, among them one (WG-ICCT1) which is directed towards the study of Inverse Problems and Global Optimization in geodesy. According to its terms of reference, the objectives of this working group can be identified as (1) the identification and theoretical understanding of inverse and /or ill-posed problems in geodesy, (2) the development and comparison of mathematical and statistical methods for the proper treatment of inverse problems, and (3) the development of recommendations and communication of new inversion strategies. After the working group being four years in existence, this report will describe their main activities. These activities found a recent culmination with the finalization of a special issue on Satellite Gravimetry and Inverse Problems in the Journal of Geodesy (January 2007), jointly with the joint ICCT-commission 1-2 working group on satellite gravity theory (IC-WG3).



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2725****Time variable gravity field recovery in local areas by means of Slepian functions****Dr. Matthias Weigelt***Geodaetisches Institut Universitaet Stuttgart IAG****Oliver Bauer, Nico Sneeuw, Wolfgang Keller***

Time variable changes in the gravity field are in many cases derived by a spherical harmonic analysis of GRACE data. Changes in subsets of the global monthly coefficients are analyzed and interpreted for local areas. However, geophysical phenomena, e.g., hydrological changes in river catchments, have a very local behaviour and differ strongly from region to region. Obviously, the analysis using a set of global base functions is suboptimal. Slepian functions on the other hand form an orthogonal set of base function which are bandlimited and optimally concentrated within any arbitrarily shaped area of interest. Thus, it is an alternative but powerful tool for local gravity field recovery. Based on the work of Simons et al. (2006) the Slepian functions are found by solving an algebraic eigenvalue problem in the spectral domain which ensures the orthogonality of the base functions. The eigenvalues itself are a measure for the spatio-spectral concentration. The eigenvectors can be used to map the spherical harmonic coefficients directly into Slepian coefficients and their time variations can be analyzed. If the spherical harmonic coefficients are not available, a spatial analysis using least-squares and the Slepian functions as base functions yields the same set of coefficients. Vice versa this also means that the global spherical harmonic analysis can be avoided and the gravity field can be recovered directly by analyzing in-situ measurements. In this case study Slepian coefficients are derived from monthly GRACE solutions and their time variation is analyzed and compared with results from spherical approaches thus showing the suitability of the Slepian functions for time variable gravity field recovery in local areas.

Keywords: slepian functions, grace, local gravity field recovery



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2726****Computing Lateral Topographical Density Variations and Terrain Roughness Effects on the Orthometric Heights in Iran****Mr. Seyed Abdoreza Saadat***Physical Geodesy Department Field Surveying Management IAG*

The system of orthometric heights is fundamental to absolute height positioning in Geodesy. Its primary manifestation is the evaluation and use of the geoid as a vertical datum. The main problem of the rigorous definition of the orthometric height is the evaluation of the mean value of the Earth's gravity acceleration along the plumbline within the topography. Traditionally, the Helmert method of calculating mean gravity has been used in orthometric height calculations. Helmert (1890) used Poincar-Preys gravity gradient for the definition of the orthometric height. According to this approach the gravity value needed for the evaluation of the height is obtained from the observed gravity at the earth surface reduced to the mid-point between the earth surface and the geoid, considering that the gravity gradient is constant along the plumbline. However, the mean topographical density is assumed to approximate the actual distribution of topographical density. Recent efforts have shown that it is unable to meet modern heighting requirements. While the Helmert approach approximates topographical effects on gravity by representing topography as a Bouguer plate, more modern efforts instead evaluate the effect of a Bouguer shell, plus the effect of variations in topography above and below that shell. This allows rigorous calculation of all but one topographical effect on gravity. The main barrier to evaluating the effect of these density variations is our limited knowledge of the three-dimensional density distribution within the topography. In lieu of a three-dimensional density model, two-dimensional models have been used. This contribution, however, presents results for simulated but realistic models of density distributions in topography show that the error resulting from using simplistic two-dimensional models can reach several centimeters.

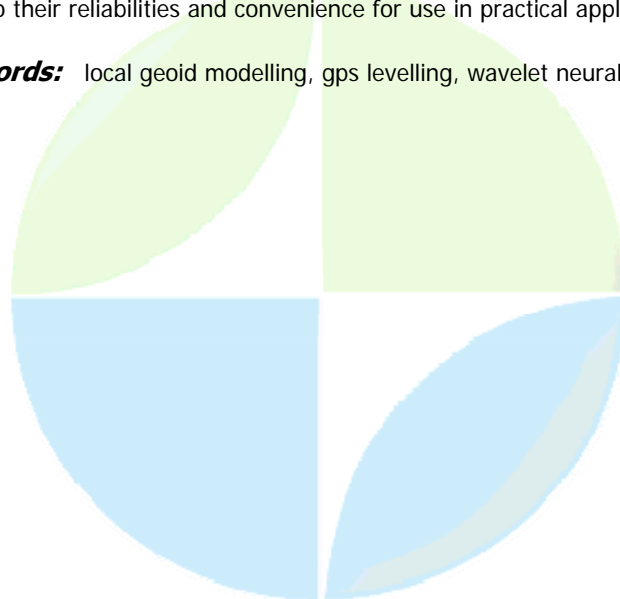
Keywords: mean gravity, orthometric height, plumbline



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2727****Determination of Local GPS/Levelling Geoid using New Computing Approaches*****Mrs. Bihter Erol****Geodesy Istanbul Technical University IAG****Rahmi Nurhan Elik***

The use of Global Positioning System (GPS) to establish vertical control in an area, where levelling data is available, can involve the so-called GPS/levelling technique. While evaluating the performance of GPS/levelling geoid solution, besides the distribution, density and quality of the data, the used modeling algorithm has role on the final accuracy. Modelling the GPS/levelling geoid heights (at co-located benchmarks) is usually carried out using polynomial surface fitting, least-squares collocation, finite-element method etc. The soft computation algorithms, which have been proven to be effective in solving complex problems-represented by noisy and missing data-in many applications so far, are quite new in solving geodetic problems. The inspiration of this study is based on analysing and investigating the improvements in the accuracy of local GPS/levelling geoids by using these soft computing algorithms. With this objective; multi-layer feed-forward back-propagation Artificial Neural Network (MLFFBP-ANN), Adaptive Network Fuzzy Inference System (ANFIS) and Wavelet Neural Network (WNN) (as the combination of Wavelet Transform with Artificial Neural Network) are applied in the local test area (Istanbul) in the North-West Turkey. The Istanbul geodetic network consists of 1204 GPS/levelling benchmarks distributed throughout the region between 40N-42N latitudes and 28E- 30E longitudes (a benchmark per 25 km²). The data comes from GPS and geometric levelling measurements, having 3.5 cm accuracy of GPS-ellipsoidal heights (h) and 2.51 cm accuracy of levelling heights (after adjustment). Nearly 8% of the benchmarks are removed at the beginning of determinations. The results are compared with the model by multivariate regression equation in the form of the 5th order polynomial, which provides 4 cm absolute accuracy. In order to statistics, it is seen that soft computing algorithms can produce the result that are comparable to polynomial surface model with the low deviations from the GPS/levelling data, however the results will be discussed considering the advantages/disadvantages of each approach in the conclusion. The computation parameters used in the processes, such as iteration numbers, numbers of the neurons, subsets and/or wavelet neurons (wavelons), respectively, corresponding to the approach are investigated considering the basic statistics. The approaches are compared according to their reliabilities and convenience for use in practical applications.

Keywords: local geoid modelling, gps levelling, wavelet neural network



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2728****The gravity signature of the Sumatra-Andaman 2004 earthquake:
comparison between GRACE observations and modeling.*****Mrs. Caroline De Linage****Laboratoire de Dynamique Globale de la Terre EOST-IPGS****Luis Rivera, Sophie Lambotte, Jean-Paul Boy, Jacques Hinderer, Richard Biancale***

We extract the gravity coseismic signature of the Sumatra-Andaman earthquake in the GRACE temporal gravity solutions provided by the Toulouse "Team of Space Geodesy" (CNES/GRGS) in 10 day periods in a spherical harmonic decomposition (up to degree 50). We discuss about the role played by various geophysical sources such as hydrology and ocean circulation in the determination of the coseismic signature all over the Earth surface. A modal summation technique for an elasto-gravitational spherical stratified Earth model is used to compute the static coseismic deformation and the resulting permanent change in the regional gravity field and geoid. We investigate the possible impact of the elastic parameters of the regional lithosphere. We also discuss the drastic low-pass spatial filtering in the GRACE solutions with respect to the full modeled field. We simultaneously extract the postseismic gravity effect in GRACE and show evidence for a viscous relaxation still occurring more than one year after the seismic event.

Keywords: grace, sumatra

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2729****Reduced-dynamic Precise Orbit Determination Based on Helmert Transformation*****Mr. Junping Chen******Jiexian Wang, Jrgen Klotz, Marcos Moreno, Volker Grund, Jan Bolte***

A method based on Helmert transformation is presented in reduced-dynamic Precise Orbit Determination (POD). Unlike the traditional dynamic POD approach, which uses code and phase observations directly, the model takes kinematic orbits as pseudo-measurement and sets up the Helmert transformation between kinematic and dynamic-integrated orbits. One advantage of this approach is the reduction of parameters. A set of programs was developed. Based on the programs, kinematic and reduced-dynamic POD were performed for the CHAMP and GRACE satellite over a period of 2 weeks. Intermediate results show that reduced-dynamic orbits of CHAMP have a 3D RMS of 25cm comparing with PSO orbits of GFZ, and 3D RMS has the same magnitude for the reduced-dynamic orbits of GRACE comparing with GNV1B orbits of JPL. However, these results are severely impacted by the kinematic trajectories. Another factor can be improved in our model is the calibration of bias and scales parameter. With these improvements, best performance of the model may be expected.

Keywords: precise orbit determination, helmert transformation, low earth orbiter

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2730****Space localizing gravity field determination for airborne gravimetry in consideration of topographical aspects****Mr. Felix Mueller***Institute of Geodesy and Geoinformation University Bonn IAG***A.A. Makhloof**

Airborne gravimetry and gradiometry are capable of filling the gap between the long wavelength parts of the gravity field provided by the satellite missions such as GRACE or GOCE and the short wavelength parts derived from terrestrial data. Furthermore, airborne gravity measurement techniques are not restricted to continental areas and are not subjected to certain limitations in contrast to terrestrial data. Under optimal conditions the measurement accuracy varies around 1 to 2 mGal for a spatial resolution of approximately 2 km. In order to achieve this accuracy the downward continuation process in connection with the representation of the gravity field functionals becomes of special importance. In this paper we present the use of space localizing spline functions and their advantage in comparison to common integral methods. In this matter we also investigate the benefit of topographic-isostatic gravity field information for the downward continuation process. This procedure is also able to improve the high frequency part of the gravity field. The use of the approaches is demonstrated on simulated airborne gravimetry and as well as on gradiometry data.

Keywords: airborne gravimetry, topography, downward continuation

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GS002

Poster presentation

2731

Combining GPS, Levelling and Geoid Data using Estimated Stochastic Parameters for Vertical Control in North-West of Turkey

Mrs. Bihter Erol

Geodesy Istanbul Technical University IAG

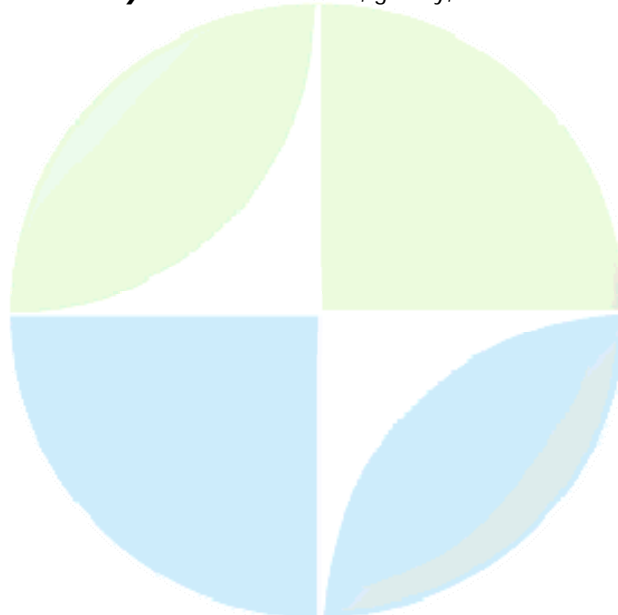
Roland Klees, Michael G. Sideris, Rahmi N. Elik

This study aims to investigate the role of the data qualities on the combination of GPS-ellipsoidal (h), levelling (H) and geoid (N) heights to establish vertical control in a local test area using dense GPS/levelling data. In the numerical tests, the geodetic network of Istanbul, consisting of 1204 GPS/levelling benchmarks distributed throughout the region between 40N-42N latitudes and 28E-30E longitudes (a benchmark per 25 km²), is used. The root mean square errors are 3.5 cm and 2.51 cm for the GPS-ellipsoidal and levelling heights, respectively. Nearly 8% of the benchmarks are detected as blunders and removed at the beginning of determinations. The gravimetric geoid is computed by Remove-Compute-Restore (RCR) method using EIGEN-CG03C as reference global potential model, free-air gravity anomalies on land (5 x 5 resolution) and at sea (2 x 2 resolution) and topographic data from Shuttle Radar Topography Mission (SRTM) (2 x 2 resolution). In the variance component estimation process, the fully populated initial covariance matrices (CV) are used for h , H and N . The cofactor matrix for GPS-heights (Q_h) is extracted from the adjustment of GPS baselines, which are obtained from the results of commercial post-processing software. Q_h is obtained from the adjustment of first, second and third order levelling measurements in the area. Also, Q_N at the GPS benchmarks is obtained by straightforward application of error propagation to the RCR solution. GPS, levelling and the gravimetric geoid heights are combined using multivariate regression equation in the form of low-order polynomial. Combining the height data using the method of Least Squares, weights of the each height type (observations) are essential to correctly estimate the unknown parameters. Improper stochastic modelling can lead to systematic deviations in the results. Hence, the aim of variance component estimation (VCE) is to estimate realistic and reliable variances of the data types for constructing the appropriate a-priori covariance matrix of the observations. When the variance component estimation is concerned, numerous solution algorithms to the problem are suggested. In this study, Rao Minimum Norm Quadratic Unbiased Estimation (MINQUE) is used to combine the heights. In conclusion, the parametric model is determined using estimated a-priori variances; the significance of the parametric model coefficients is tested using F-test. After removing non-significant parameters, the final parametric model is evaluated using new GPS/levelling benchmarks, which are not contributed to the computation of the model. The found results are also compared with national Turkey Geoid TG03, which is hybrid model having absolute accuracy in decimeter, in the test area.

Keywords: local geoid modelling, variance component estimation, gps levelling

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2732****Unveiling a glaciated Antarctic Volcano with airborne gravity data****Mr. Tom Jordan****Fausto Ferraccioli, Jones Phil, John Smellie, Marta Ghidella**

Understanding Antarctic volcanoes is important as they may record a detailed, datable, paleo-environmental and paleo-climatic record of highly contentious changes that affected Antarctic ice sheets during warm Neogene periods and a window on associated crustal and magmatic processes. This study presents 3,500 line km of airborne gravity data collected during the 1998/99 field season as part of a collaborative survey supported by the British Antarctic Survey and the Instituto Antartico Argentino across the ~10 Ma to 80 ka James Ross Island volcanic complex, which lies close to the eastern tip of the Antarctic Peninsula. The new Bouguer gravity anomaly map shows a discrete negative anomaly of 45 to 25 mGal, depending on the correction density used, which is associated with Mt Haddington, in the centre of James Ross Island. This anomaly cannot be accounted for by an isostatic model, and therefore a low-density intra-crustal body must be present to explain the observed anomaly. A 3D inversion technique was applied to recover the location of density variations within the crust. The results of this inversion suggest a low-density body at 3-5 km depth. However the magnitude of the observed anomaly is underestimated, if the anomaly source is placed at these depths, for reasonable density contrasts compared to the background. Two alternative scenarios are envisaged from 3D modelling; one with a deep-seated (>5 km) low-density body, related to a hot magma chamber. The second with a shallow caldera-like body up to ~5 km deep, filled with low-density material. Lower residual errors for the latter models suggest that the shallow low-density body is the preferable candidate model for the crustal structure in this region. Overall this study shows that modelling of airborne gravity data can provide new insight on the interior of glaciated volcanic complexes in the Antarctic. This implies that airborne gravity techniques have the potential to augment more widespread aeromagnetic anomaly investigations in analysing glaciated volcanic terranes over Antarctica. Application of similar airborne gravity data modelling could for example target the largely unexposed volcanoes buried beneath the West Antarctic Ice Sheet and further assess the impact of volcanism on the stability of the ice sheet.

Keywords: antarctica, gravity, volcano

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2733****Numerical approximation of trajectory disturbing gravity*****Dr. Zhao Dongming****Gravity Field IAG****Wu Xiaoping, Zhang Chuanding***

Aiming at the shortcomings on workload and time consumption in the computation of disturbing gravity of the ballistic trajectory points using gravity potential model, this study puts forward an alternative method to approximate the disturbing gravity of the active phase of trajectory numerically, which is called the finite space partitioning method. Based on the principles of finite element partition and interpolation, firstly the finite space around the trajectory is partitioned into proper-sized spatial cubic blocks, and the disturbing gravity of each vertex of every cubic block could be computed using geopotential model, and then the disturbing gravity of any trajectory point could be interpolated from those gravity values of the block vertices immediately. Numerical experiments indicate that the disturbing gravity of trajectory can be computed fast and accurately using this method. This method not only overcomes the shortcomings of workload in method based on gravity potential model, but also shortens the time consumption greatly.

Keywords: disturbing gravity, approximation, finite space partitioning



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2734****Use of a Fine Scale Hydrologic Model to Validate GRACE Measurements in the Amazon Basin****Mr. Yiqun Chen***school of earth sciences the ohio state university IAG***Jeong Woo Kim¹²³, Doug Alsdorf, R.E. Beighley, Yiping He, C.K. Shum, Kenneth Eggert, Burkhard Schaffrin**

Accurate measurement of continental water storage changes for both the surface and subsurface water over basin scale improves our understanding of hydrologic fluxes and their ecological and environmental impact as a result of climate change. Recent fine-scale advances in Amazon Basin hydrologic modeling and availability of space-based measurements (e.g., TRMM), allow quantification of the total water storage (soils, channel and floodplains) and floodplain inundation characteristics (extent, duration and frequency). Preliminary model results have been produced for the entire Amazon Basin over the 2001-2005 time period, and compared to the results of monthly continental water storage change derived from GRACE, a dedicated satellite mission for observing Earth's temporal gravity field. Specifically, GRACE observed Amazon hydrologic fluxes will be computed in terms of temporal gravity field changes in the form of spherical harmonic representation, and regional inversion using in situ geopotential difference and gravity difference measurements directly inferred from GRACE's intersatellite K-band range difference measurements. By applying various forward and inverse modeling approaches, we intend to assess whether model predicted precipitation timing and amount agree with GRACE derived values, which of the various components of the Amazon Basin water masses is the major mass contributor, and the similarities or differences between the preliminary hydrologic model and GRACE derived values. Finally, various GRACE measurement products are assessed in terms of their spectral contents using the hydrologic model outputs, at orbital altitude and at the Earth surface.

Keywords: grace, continental water storage, hydrologic modeling



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Poster presentation

2735

Study of the orbit accuracy improvement for the Single and Multi-satellite SAR Mission using the currently released Geopotential Models

Dr. Mohammadali Sharifi

Surveying and Geomatics Engineering University of Tehran

Marzieh Jafari

The Earth's gravity acceleration is the dominant force which governs the satellites orbital motion. The better the knowledge on the geopotential the more accurate the orbit is. Launching the gravity field dedicated missions, i.e., CHAMP and GRACE, has improved our knowledge and led to better dynamic orbits. In this article, we investigate the CHAMP and GRACE models contribution to Envisat satellite orbit and consequently on the accuracy of the products. Moreover, we analyze the effect of this improvement on the relative accuracy of the multi-satellite SAR mission from orbital geometry point of view.

Keywords: sar, geopotential, dynamic orbit

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Poster presentation

2736

Prediction of the gravity field in shallow waters from the bathymetry data

Mr. Michel Sarrailh
BGI CNES IAG

Briaïs Anne, Lequentrec-Lalancette Marie-Franoise, Rouxel Didier

For the determination of an accurate geoid to be used as a reference surface for current studies, we need a dense gravity coverage. Such data are not always available, the bathymetry information can be used to predict the free air anomaly. Two techniques are compared in the northern part of the mediterranean sea : the first one is based on a neural network, with learning rule using the existing gravity profiles ; the second one is based on the determination of the local transfer function between the bathymetry and the gravity data, resulting from the compensation effect in the medium spectrum. These techniques can also be used to analyze the continental margin structure.

Keywords: gravityfield, bathymetry, prediction

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2737****Report CP2.1: The European Gravity and Geoid Project (EGGP)****Dr. Heiner Denker***Institut fuer Erdmessung Leibniz Universitaet Hannover IAG****J.-P. Barriot, R. Barzaghi, D. Fairhead, R. Forsberg, J. Ihde, A. Kenyeres, U. Marti,
M. Sarrailh, I.N. Tziavos***

The European Gravity and Geoid Project (EGGP) is a project within IAG Commission 2, reporting to Sub-commission 2.4. The EGGP started shortly after the last IUGG General Assembly in Sapporo 2003. The main goal of the project was to compute an improved European geoid and quasigeoid model based on new and improved data sets and computation techniques which have become available since the last published model in 1997 (EGG97). The improvements include better global geopotential models from the GRACE mission, better digital elevation models (DEMs) in some regions (e.g., new national DEMs, SRTM3), updated gravity data sets for selected regions, updated ship and altimetric gravity data, improved merging procedures for the ship and altimetric data, and the availability of extended GPS/levelling data sets. The present report describes the progress made during the last four years. A major step forward was the creation of a unified European terrain data base with a resolution of 3 x 3, based on existing national digital terrain models (DTMs) and the SRTM data (3 x 3) supplemented by the GTOPO30 and other 30 x 30 data. In addition, significant new or updated gravity data sets were included in the project data base. All available terrestrial terrain and gravity data were combined with a global geopotential model based on the GRACE mission, leading to the new completely revised European geoid and quasigeoid model EGG07. The computations were based on the spectral combination approach with integral formulas evaluated by 1DFFT. The EGG07 model was validated by independent data sets from GPS and levelling, indicating an accuracy potential of 3.5 cm at continental scales in well-surveyed regions.

Keywords: geoid, quasigeoid, egg07

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2738****Alternative Mission Architectures for Future Satellite Gravity Missions****Mr. David Wiese***Aerospace Engineering Sciences University of Colorado at Boulder****R. S. Nerem, P. L. Bender, M. Watkins, W. M. Folkner***

The Gravity Recovery and Climate Experiment (GRACE) mission has been providing unprecedented levels of accuracy in measuring the Earth's gravity field since its launch in 2002. GRACE employs a mission architecture consisting of a collinear satellite pair, constraining the observable to intersatellite range measurements in the along-track direction. It is thought that this is a contributing factor to the longitudinal striping seen in the monthly gravity solutions. This paper focuses on the use of alternative mission architectures using multiple pairs of GRACE-like satellites to achieve better performance in measuring the time varying gravity field. One implementation involves the use of cartwheel orbits as a means to add radial information to the observable. Cartwheel orbits consist of a satellite formation performing 2:1 relative elliptical motion about their center of mass as the formation orbits the Earth, thus providing radial and along-track information. A 60x60 gravity field was estimated using 30-day mission simulations for both two-satellite and four-satellite cartwheel formations, and a collinear satellite pair at 250 km and 400 km altitudes. Additionally, a four-satellite mission consisting of two collinear pairs of satellites separated in the node with 15-day repeat orbits was examined. Satellite range rate measurements were perturbed by adding data noise comparable to the nm/sec level in range-rate. Additionally, aliasing due to atmospheric modeling errors and ocean tide errors were examined. Results showed the errors in geoid height for the cartwheel formations were approximately one order of magnitude lower than the collinear satellite pair. Additionally, the cartwheel formation eliminated most of the vertical striping seen in the geoid height solutions. Finally, a covariance analysis showed the error spectrum of the cartwheel formation to be more isotropic than that of the collinear satellite pair. We will also discuss the advantages/disadvantages of other mission configurations, such as varying the orbit repeat periods to achieve better mission performance.

Keywords: gravity, grace, cartwheel



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2739****Using airborne gravity to image sedimentary basins beneath the Thwaites glacier Catchment, West Antarctica*****Mrs. Theresa Diehl****Institute for Geophysics University of Texas at Austin****John W. Holt, Donald D. Blankenship, Duncan A. Young, Fausto Ferraccioli***

Growing concern about the impact of global warming on Antarctica has led the international science community to evaluate the mechanisms governing ice flow. In West Antarctica, we know that fast flow of the Ross Sea Embayment (RSE) ice streams can be attributed, in part, to the presence of subglacial sediments. However, the RSE ice streams do not seem to pose as serious a threat to near-term sea level change as do the Amundsen Sea Embayment (ASE) glaciers. Recent hypotheses suggest that warm ocean currents invading the ASE could be a significant driver of present and future glacier retreat. We cannot predict how the ASE glaciers will respond to ocean (and other) warming until we understand the subglacial conditions that control their fast flow. However, until recently very little has been known about the subglacial conditions of the two sizable ASE glaciers: Pine Island and Thwaites. The first large-scale geophysical surveys of the area were completed in the 2004-2005 austral summer. The British Antarctic Survey carried out an airborne survey of the Pine Island Glacier catchment while the University of Texas at Austin completed an adjacent airborne survey over the Thwaites Glacier catchment. Both groups flew Twin Otter airborne platforms that included ice-penetrating radars, gravimeters, magnetometers, carrier-phase GPS, and precision altimeters. Here we concentrate on gravity results over the Thwaites Glacier catchment. The most likely locations to find subglacial sediments are in narrow, rift-related valleys and in broader, low-lying basins also related to the West Antarctic Rift System, which underlies a large portion of the Thwaites Glacier catchment. Airborne gravity and magnetic data allow us to test our hypotheses for the distribution of subglacial sediments. Free-air gravity anomalies show a high degree of correlation with the bedrock topography, as determined from airborne radar. In order to identify sediments, we must first remove the effect of known bedrock topography and ice cover; therefore, we applied a complete 3D Bouguer anomaly correction to the data. However, the signature of sedimentary basins in the Bouguer anomalies is often obscured by large changes in the depth of the Moho, which are largely due to isostatic compensation of topography. We utilize a simple Airy isostatic model to account for these Moho variations. Isostatic residual gravity lows are then more easily identified and, in combination with magnetics and bedrock roughness, interpreted as sedimentary basins. We use inverse models of the isostatically-corrected Bouguer anomalies to determine the distribution and thickness of subglacial sediments. Aeromagnetic anomaly lows and regionally smooth bed topography correlate well with areas we have modeled as sedimentary basins. Depth to magnetic source calculations can be used to help constrain gravity inversions. Finally, by superimposing the potential fields anomalies with ice velocities, we expand upon the sedimentary basins potential for control on the glaciers fast ice flow.

Keywords: gravity, sediments, antarctica

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GS002

Poster presentation

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Strengthening the vertical reference in the southern Baltic Sea by airborne gravimetry

Mrs. Henriette Skourup

Geodynamics Danish National Space Center

Rene Forsberg, Sofie Louise Sandberg Srensen, Christian Jermin Andersen, Uwe Schfer, Gnter Liebsch, Johannes Ihde

In order to improve the gravity field and geoid modeling in the border area between Germany and Denmark, and over the Baltic Sea, an airborne gravity campaign (BalGRACE2006) with an overall mileage of about 10,000 km was carried out in the area bounded approx. by 53.5 - 55.5 N, 8 - 15 E in October 2006. A main purpose of this endeavor was to give a substantial contribution towards comparison, verification and improvement of the vertical reference in this area. Before the campaign the area was characterized by a quite inhomogeneous spatial distribution of gravity points and of their measurement epochs. Especially in the sea areas there were significant less observations with poorer data quality, and in some areas there were no observations at all. Using the newly obtained airborne data in connection with existing terrestrial / satellite observations that contain information about the regional gravity field it allows to perform various methodological investigations into gravity field modeling. First numerical results of modeling the geoid are presented applying different techniques.

Keywords: gravimetry, airborne, geoid

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2741****Detecting the Baltic Sea Level Surface with GPS-measurements and Comparing it with the Local Geoid Model*****Mrs. Aive Liibusk******Harli Jrgenson***

GPS-measurements detect the gravimetric geoid's relative change on the Baltic Sea water surface. These gravimetric data are necessary to compute the local geoid. They allow comparison of the gravimetric geoid with GPS-leveling on earth surface. On the sea this is possible, as well, but means eliminating the seasurface topography effect and the current water tilt corrections. On shipboard, the GPS device stores data every second and determines the heights with an accuracy of a few centimeters (using the kinematic method with post-processing at several base stations close to the ferryboat line). At the moment of measurement, it takes into account the sea level topography, allowing us to observe the relative change in the geoid and comparison with the gravimetric geoid. To explore this method on the Baltic Sea, we chose the sites where the geoid changes rapidly and ferryboats operate regularly (Estonia-Sweden). One such area lies about 30 km north of the island of Hiiumaa (in Estonia), where the geoid has a lump (geoid separation from the ellipsoid changes 1 meter over a 70-km distance starting from Paldiski). We also performed the same kind of measurement on regular ferry lines running between Estonia-Finland. The last such measurements were interesting, because there are no gravimetric data for the eastern part of the Gulf of Finland. The eastern part of the gravimetric geoid is the result of interpolation. The GPS-measurement results indicated that the existent gravimetric geoid is precise and GPS-measurements give good results: the data difference was 10 cm.

Keywords: sea level, geoid, gps measurements

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2742****On a feasibility of high-precision gravity field modeling based on data from non-dedicated satellite missions****Dr. Pavel Ditmar***DEOS Delft University of Technology IAG***Ales Bezdek, Xianglin Liu, Qile Zhao**

Currently, studying the Earth gravity from space is almost exclusively attributed to dedicated low-orbiting satellite missions like CHAMP, GRACE, and GOCE. This vision seems to be justified by the past experience: the data from the new dedicated missions strongly outperformed practically all the data collected earlier. Nevertheless, we found it not unreasonable to turn to non-dedicated missions as the source of information about the Earth's gravity field for the years and decades to come. Our motivation is as follows: (i) The number of low-orbiting non-dedicated satellite missions steadily increases; (ii) the presence of an on-board GPS receiver is likely to become soon a common practice for all the Earth observation satellites; (iii) accuracy of the orbit determination from GPS data keeps improving; the full deployment of GLONASS and GALILEO systems will definitely stimulate a further progress in this direction; (iv) data from numerous non-dedicated satellites are likely to result in a homogeneous errors pattern in a gravity field model (both in space in time), unlike data from one or two dedicated satellite missions; (v) thank to an increasing amount of non-dedicated satellites, the data from them can be available continuously, whereas the availability of data from dedicated missions can be interrupted due to technical or logistical reasons. We have executed a numerical study to investigate the proposed option quantitatively. In doing so, we assumed that the satellite under consideration is equipped with a high-quality GPS receiver and the attitude control system (but not with an accelerometer). The results extrapolated to a multitude of satellites confirm that future non-dedicated satellite missions will likely be capable not only to measure the static gravity field, but even to monitor temporal gravity field variations.

Keywords: non dedicated, satellites, gravity

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GS002

Poster presentation

2743

Gravity and Geoid Projects in South America

Dr. Denizar Blitzkow

Transport Engineering University of So Paulo IAG

Maria Cristina Pacino

The projects on Gravity and on the Geoid in South America, coordinated by Maria Cristina Pacino and Denizar Blitzkow respectively, have strong links and join activities since their establishment. Efforts have been oriented in order to improve the quality of the gravity data in different countries, to carry out surveys in order to fill the gaps, to establish absolute measurements as reference gravity for densification surveys and to derive versions for the geoid model in a constant improvement. The efforts are supported by many different organizations in the various countries with emphasis to universities, military institutes and geographic and geophysics institutes.

Keywords: projects, gravity, geoid



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2744****Updated OCTAS geoid in the northern North Atlantic - OCTAS07*****Dr. Ove Omang****Geodetic Institute NMA IAG****Dag Solheim, Addisu Hunegnaw, Dagny I. Lysaker, Kourosh Ghazavi, Hossein Nahavandchi***

A new gravimetric geoid (OCTAS07) is generated using Stokes' formula with gravity data as input. As local gravity data a combination of land gravity data, new and old airborne gravity data, and adjusted marine gravity data has been used. All marine gravity data has been error screened and quality assured by removing dubious data and adjusting the data when necessary. Voids in the gravity data distribution were patched with satellite altimetry gravity data. The geoid is estimated using the remove-compute-restore technique. The long-wavelength part of the gravity signal due to the local gravity data was reduced using an Wong-Gore modified Stokes' function. The long-wavelength part is represented by a global gravity field model based on GRACE data. A high accuracy gravimetric geoid model is one of the main objectives of the the Ocean Circulation and Transport between north Atlantic and the arctic Sea (OCTAS) project. An improved MDT, based on a this geoid in combination with mean sea surface heights (MSSH), will serve as input to ocean circulation and transport studies in the polar region.

Keywords: geoid, octas

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2745****Accurate Account of the Topographic Effect on the Geoid Computations*****Dr. Yan Ming Wang****NOAANGSNGS6 geodesist IAG****J Saleh, D Roman***

The topographic and gravity reductions are one of the critical steps for precise geoid computations. In this paper, we propose a procedure of remove-restore of the topography in combination of the downward continuation of gravity anomalies. Since the effect of the topography can be put in a closed form and evaluated accurately, we set the computation error under 0.1 mGal. The same standard is applied to the downward continuation of the gravity anomalies. Stabilization is assured by a regularization factor that based on the magnitude of signal at the surface and the geoid. The results will be compared with the classical Faye anomaly geoid and be judged by comparison with the GPS/leveling data implied geoid heights in the .

Keywords: geoid**XXIV2007****PERUGIA
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Poster presentation

2746

Time series of absolute gravity in finland 1976-2006

Dr. Jaakko Makinen
IAG

Mirjam Bilker-Koivula, Fred Klopping, Reinhard Falk, Olga Gitlein, Ludger Timmen

The Finnish Geodetic Institute has repeated absolute gravity measurements in Finland at three sites since 1988, and shorter time series are available at additional stations. Initially the JILAg-5 instrument was used. Since 2003 the work is continued with the FG5-221 within the Nordic Absolute Gravity Project. In addition, we use results by IMGC (1976), ANSSSR (1980), NOAA (1993, 1995), BKG (2000, 2004), and IfE (2003-). Most stations are co-located with continuous GPS and vertical velocities are up to 1 cm/yr. Gravity results are consistent with a ratio of approximately -2 microgal in gravity per 1 cm uplift..

Keywords: absolute gravity, postglacial rebound, fennoscandia



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GS002

Poster presentation

2747

Gravity field determination based on relativity

Mr. Drazen Svehla

Institute of Astronomical and Physical Geodesy Technical University of Munich IAG

Christophe Salomon

Accuracy, the geopotential determination at cm level appears feasible in the next decade. Finally, we analyzed frequency transfer using the GPS satellites by estimating the so-called phase clocks. We show that for the best performing GPS satellite clocks we can clearly identify periodic relativity effects down to 70 ps with periods of 6 hours. Using these results we discuss estimation of the parameters such as Earth's semi-major axis and geocentric constant based on space-borne atomic clocks. Performance of the GPS satellite clocks are compared to the performance of the clocks in several timing labs with ACES clocks and first results in the relativistic gravimetry are presented. We show that relativistic gravitational potential differences can already now be determined with an accuracy of 1 m.

Keywords: acs, gravity, relativity

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2748****Refinements of a numerical approach to direct methods in the determination of gravity potential from terrestrial data with iterations representing some small effects*****Dr. Petr Holota****Geodesy and Geodynamics Research Inst. of Geodesy, Topogr. and Cartogr. IAG*

In the paper the numerical solution of the linear gravimetric boundary value problem is discussed. The problem is formulated in terms of the so-called weak solution and the approach follows principles of variational methods. It leads to Galerkins approximations of the solution. Linear combinations of radial basis functions were used for this purpose. In particular the reproducing kernel proved to be very suitable for constructing systems of these functions. The boundary of the solution domain is the surface of the Earth. Galerkins system was constructed rigorously for the boundary-value problem considered. Thus the accuracy of gravimetric data, data coverage and the capability of computer hardware are the only factors that affect the accuracy of the solution sought, i.e. the disturbing potential. Nevertheless, in order to reduce the demands associated with the computation of the elements in the matrix of Galerkins system an approximation matrix was used instead. The simplification is then compensated by means of successive approximations leading to the solution of the original system. In order to clarify their convergence the ellipticity of the defining bilinear form was investigated. The successive approximations express the topography effects as well as effects caused by the obliqueness of the derivative in the boundary condition. The discussion is added extensive numerical simulations using gravity data derived from the EGM96. The computed solutions were compared with the EGM96 input data in terms of potential values and gravity disturbances at points on the boundary of the solution domain.

Keywords: gravity field modelling, boundary value problems, galerkin approximations



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GS002

Poster presentation

2749

Designing and Implementation of the Multi-purpose Physical Geodesy and Geodynamics Network of Iran (MPGGNI2005)

Mr. Yaghoub Hatam

Gravity Field Geoid computation IAG

Y. Djamour, P. Vanicek, R. Bayer, M. Mohammad Karim, A. M. Abolghasem, M. Najafi Alamdari, R. Saadat, H. Cheraghi, S. Rafiey, S. Arabi, H. Nankali, S. Hoseini

For the purpose of modeling earth gravity field and its changes with time in the nationwide of Iran, we designed the multi-purpose physical geodesy and geodynamics network of Iran (MPGGNI2005). We considered to measure different kinds of observations at each built bedrock station in a collocated manner. These different kinds of observations are (absolute and relative) gravity, GPS, precise levelling, and precise astronomy. Since the main objective of the mentioned network is in vertical (both geometrical and physical) direction, we defined to obtain the different kinds of measurements with an accuracy of the order of 1cm (both GPS heights and orthometric heights) or its equivalent, i.e. 3 microgals for the gravities. The distribution of the MPGGNI2005 is 55km by 55km and it contains 700 multi-purpose bedrock stations for whole of Iran. Two main special objectives are followed the above network, i.e., Computing a geoid with a reasonable (from 1cm to 25cm) accuracy for different practical uses, and to compute the effect of the earth gravity field on the precise levelling observations to obtain their respected orthometric heights. It is defined to gather GPS measurements at each station for 24 hours continuously, with using 6 double-frequency GPS receivers at the same time to obtain 1cm accuracy for GPS heights. It is also defined to observe precise levelling measurement for the all multipurpose stations and connecting them to the existed 1-st order national precise levelling network of to reach the mentioned 1cm accuracy for the orthometric heights in 55 km distance, i.e., between each 2 neighbor stations. For gravity measurements, using 6 precise microgravimeters, it is defined to measure 2300 gravity lines between each 2 neighbor stations and also connecting the MPGGNI2005 to the stations of Gravity Base Network of Iran to strengthen the gravity part of the MPGGNI2005. Each gravity line is measured at one day and it contains 3 sets of 0.5 hour observations, which are necessary to obtain the mentioned accuracy of the order of 3 microgals. The MPGGNI2005 has still mainly implemented at the field and will be finished as soon. It is considered to repeat the measurements of the MPGGNI2005 for about each 10 years to model the changes of the earth gravity field. The data of MPGGNI2005 are also very useful for the calibration/validation purposes of the existed Grace gravity data and also for the future Goce gravity information. It is also very useful for our near future national airborne gravimetry job in Iran.

Keywords: mpggni2005, earth gravity field

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GS002

Poster presentation

2750

FINN2007: The New Geoid Model for Finland

Mr. Gunter Finn

Department of Geodesy Stuttgart University IAG

Erik W. Grafarend

Due to new observations and refined modelling, the geoid model FINN2004 could be significantly improved. The determination of the new FINN2007 astro-gravimetric geoid is based on the remove-restore-technique. The paper focuses on the modelling of the reductions as well as the fusion of the different types of observations. A comparison with existing models will be made.

Keywords: geoid, vertical deflections, data fusion

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2751****Efficient gravity field solution from GOCE mission by DFT integral*****Dr. Ramon Garcia****EARTH SCIENCE SCHOOL RESEARCHER****Moraila Carlos, Guzman Tiojari***

An analysis is presented on the regularization of the downward continuation of disturbing potential values as produced by GOCE mission by using the second-order radial derivative of the disturbing potential in the space domain. The downward continuation to the Earth surface is performed by integral inversion. The inversion is implemented with the 1D and 2D FFT deconvolution processes. The last one is applied in a multi band fashion in order to reduce the meridians convergence error. On both methods, the Tikhonov regularization parameter values are modeled with lineal and second order polynomial variations to account for the condition number variation of the sub-systems involved with respect to latitude. Some tests made show improvements of solution with respect to using only one regularization parameter. The solutions are made on a 30-days data basis and data for one year is used. For a global 1x1 degrees grid solution, tests made also indicate a better performance when comparing to global solutions based on spherical harmonic expansion.

Keywords: regularization, integral, inversion



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2752****Monte Carlo Gibbs sampler methods for variance covariance estimations in gravity network adjustment****Dr. Addisu Hunegnaw***Geology and Geophysics Geodesy IAG***Roger Hipkin**

In many Earth Science applications the quality description of the estimated quantities are as important as the estimated parameters themselves: it controls weighting procedures when the estimates are combined with other data or it can be propagated into quality descriptions for functions or quantities which are derived after processing steps. We adjust marine gravity observations to minimize the discrepancies at cross over points. For our work with North Atlantic data, there are about 49000 unknown parameters. The parameters were estimated using the Conjugate Gradient iterative techniques. However, in least squares estimations, we deduce the quality of the estimates from the inverse of the normal equation matrix. Direct inverse of the full normal matrix is often prohibitive. This paper presents algorithms based on Markov Chain Monte Carlo integration and sampling methods for the estimations of variance covariance matrix of the network adjustment. One particular method, Gibbs sampler is used which samples a sequence of error vector from a given probability distributions. A blocking scheme was used in order to ameliorate the de-correlation between subsequent samples in the network adjustment. An algebraic measure of the Frobenius norm is used to test the number of significant digits not distorted by errors. We have successfully inverted the normal equation matrix of the size 49000 in our cross-over network adjustment.

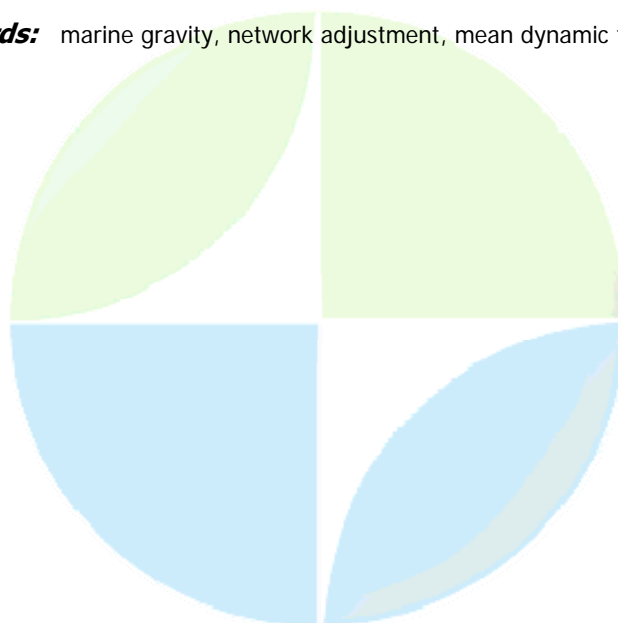
Keywords: gibbs sampler, variance covariance matrix, network adjustment



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2753****A method of error adjustment in marine gravity with application to sea surface topography in Northern North Atlantic****Dr. Addisu Hunegnaw***Geology and Geophysics Geodesy IAG***John Edwards, Roger Hipkin**

International compilations of marine gravity, such as those by the International Gravity Bureau (BGI) and the National Geophysical Data Centre (NGDC) contain some tens of millions of point data. Lemoine et al. (1998) chose not to include any marine gravity when forming the 30' mean gravity anomalies used in the construction of the global gravity model EGM96. They used synthetic anomalies derived from altimetry instead so that no independent information about dynamic ocean topography can be deduced. Software has been developed not only to identify and correct those aspects of marine gravity data that are unreliable, but to do so in a way that can be applied to very large, ocean-wide data sets without excessive manual intervention. First, we select only straight-line parts of ship-tracks and fit each one with a high-degree series of Chebyshev polynomials, whose misfit standard deviation is and measures the random error associated with point gravity data. Then, network adjustment determines how the gravity datum is offset for each survey. A free least squares adjustment minimises the gravity anomaly mismatch at line-crossing points, using to weight the estimate for each line. For a long, well crossed survey, the instrumental drift rate is also adjusted. For some 42000 cross-over points in the northern Atlantic Ocean, network adjustment reduces the weighted standard deviation of the cross-over errors from 1.32mGal to 0.39 mGal. The adjustment reduces the unweighted standard deviation from 4.03 mGal to 1.58 mGal. Similarly the difference between KMS04 altimetric anomalies and shipborne and airborne data improved, with the adjustment reducing the standard deviation of the differences from 7.17 to 4.53 mGal. This paper also reports a high accuracy image of ocean circulation in the northern North Atlantic with a resolution of a few km based on a consistent high quality marine and airborne gravity data. It is a first demonstration that geodetic oceanography can characterise the details of basin wide ocean circulation with a resolution better than global ocean circulation models. The result matches with regional models of ocean circulation based on hydrography measurements and Lagrangian drifters data (cf Orvik and Niiler, 2002, Pickart, 2000, Jakobsen 2003).

Keywords: marine gravity, network adjustment, mean dynamic topography



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2754****The first airborne gravity survey in ethiopia for the purpose of geoid determinations and the establishment of vertical height systems.****Dr. Addisu Hunegnaw***Geology and Geophysics Geodesy IAG***Roger Hipkin, Arne Olesen, Rene Forsberg**

Due to the relatively high speed and low costs at which measurements can be made, an airborne gravimetry provides an attractive alternative to the mapping of the gravity field of the earth compared to conventional terrestrial and space based methods. The techniques specially suited for geoid mapping in mountainous and jungle regions due to the random and alias free sampling of the terrain. The advantage of the airborne gravimetry is more evident in than most part of the world due to the mountainous nature of its land mass. We have carried out the first airborne gravity survey over in autumn 2006 to collect high-quality airborne gravity data, as a part of the establishment of vertical height systems and the determinations of high quality geoid over . The airborne survey was carried out with a local Cessna Caravan aircraft equipped with a number of GPS receivers in the aircraft and at reference stations in airports to provide kinematic positioning of the aircraft for the estimations of non-gravity induced vertical accelerations, and a modern LaCoste and Romberg marine gravimeter (S-99) mounted on a gyro stabilized platform. The actual airborne gravity surveys were measured in cooperation with Danish National Space Center . The Danish National Space Center hardware setup has a proven accuracy of 2mgal rms or better with practically bias free gravity data. The processing of the airborne gravity data has shown a very good result. In this paper we presented our experience of airborne gravity data acquisitions as well processing to get high quality gravity data over mountainous regions. The airborne gravity data in conjunction with the high quality SRTM topography will be used to produce high quality high resolution geoid model for .

Keywords: airborne gravity, gps, geoid

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2755****Determination of tensor gravity at GOCE height****Dr. Addisu Hunegnaw***Geology and Geophysics Geodesy IAG***Roger Hipkin**

In this paper we describe a set of gravity gradient tensor values for comparison with future GOCE measurements. They are evaluated at satellite altitude over the northern Atlantic Ocean between Europe and Greenland from about 53°N to 72°N. We have combined real ship-borne and air-borne gravimetry with synthetic but theoretically rigorous gravity anomalies derived from satellite altimetry and oceanography. This combination of different disciplines has resulted in gravity coverage over the North Northern Atlantic ocean that is complete and has an accuracy of locally representative free-air anomalies that has hitherto not been matched on adjacent land. Our computation is based on a residual free air anomaly given on the ellipsoid surface. The resulting ellipsoidal coefficients of the residual gravity are then converted to spherical harmonics coefficients using Jekeli's 1988 transformations techniques. The GOCE orbit is nearly circular so computing the tensor components at satellite altitude involves evaluating them over the surface of a sphere. To simulate GOCE, we have used a sphere with a radius R equal to the semi-major axis of the Reference Ellipsoid plus 250 km. We have computed the components of the gravity gradient tensor G with respect to a rectangular Cartesian coordinate system, centre on the satellite and moving with it. The z-direction is radial outwards from the Earth, while the x- and y-directions are tangential to the sphere, in the easterly and northerly directions respectively. Our computation involves two parts: the first is due to a pre-existing global gravity field, the GRACE field ggm01c; the second is derived from residual gravity anomalies.

Keywords: goce, tensor, gravityPERUGIA
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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS002****Poster presentation****2756****Representation of regional gravity field by radial base function****Mr. Markus Antoni***Geodaetisches Institut Universitt Stuttgart IAG***Wolfgang Keller, Matthias Weigelt**

The research aims at an investigation of the optimal local base functions to derive a regional solution of the gravity field. Usually the global gravity field is represented in a series of spherical harmonics up to a certain degree, which omits smaller variations. On the other hand, spherical harmonics always cause a smoothing of the local details. In order to avoid this, the gravity field can be separated into a global representation and a residual signal, which represents the local details. To detect these details, a localizing radial base function with a few parameters is developed, that can easily be rotated on the sphere. To test this approach a CHAMP-like scenario was chosen. The global field was represented by EGM96 and the residual field was generated by a small number of buried masses in the region of interest. Using the energy-balance technique synthetic potential observations were created along CHAMP-arcs across the region. From this synthetic data the regional field was recovered by using a searching grid of few base functions. The following effects were observed: 1) The energy-balance data contain long periodic systematic errors. 2) The direct use of the energy-balance data results in a contorted regional solution, even if the coordinates of the buried masses are used in the estimation. 3) Taking the systematic errors into account, by estimating a data offset per arc, leads to improved results. Satisfying solutions are obtained, if the coordinates of the buried masses are part of the searching grid.

Keywords: regional gravity field, radial base function**PERUGIA**
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GS003

2757 - 2843

**Symposium
Earth Rotation and Geodynamics**

Convener : Prof. Veronique Dehant

Co-Convener : Dr. Cheng-Li Huang

The symposium will deal with the subjects covered by IAG Commission 3 and the related services. Earth Orientation (Earth rotation, polar motion, nutation and precession). Earth tides. Tectonics and Crustal Deformation. Sea surface topography and sea level changes. Planetary and lunar dynamics. Effects of the Earth's fluid layers (e.g., post glacial rebound, loading). All aspects of theory are also included. (See also Symposium JGA3).

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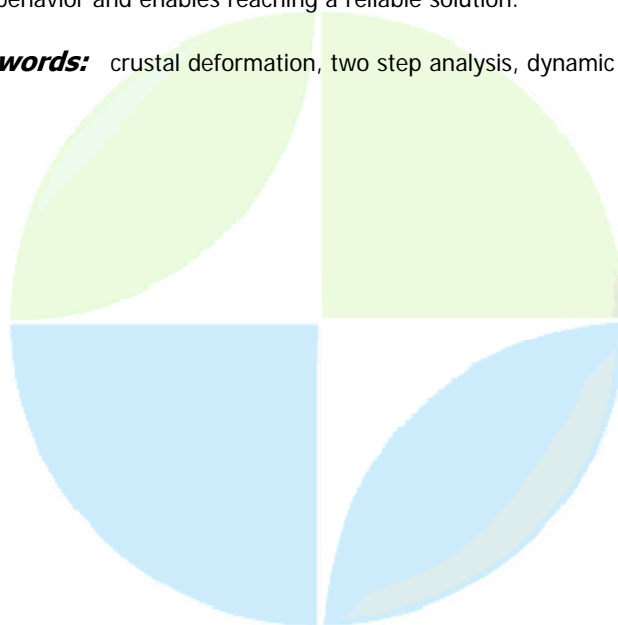
I T A L Y



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Oral Presentation****2757****Dynamic analysis of crustal movements along the Dead Sea Rift****Mr. Lior Shahar***Mapping and Geo-Information Technion-Israel Institute of Technology IAG***Even-Tzur Gilad**

The GPS geodetic-geodynamic network (G1) was constructed in the 1990s, with the aim of understanding recent tectonics and deformation in Israel. The network contains approximately 150 points which were built according to high-standard technical specifications to ensure their high geotechnical stability. In this research we use measurements of 60 points, from the northern part of G1 together with five permanent GPS stations to monitor current crustal movements across the Dead Sea Rift (DSR) in the north of Israel. The DSR is the northern part of the Syrian-African Fault. It extends from southern Turkey to the Eilat Gulf and separates the Arabian plate from the Sinai sub-plate. Recent researches show that the DSR behaves as a locked strike-slip fault. The research makes use of the Two-Step analysis of dynamical networks. This method is based on a first step of independent adjustment of every measurement campaign to a set of network points coordinates, followed by a second step in which we use the coordinates as pseudo-observations for adjusting a set of kinematical or dynamic parameters. The least squares estimation of the second step assumes an ideal mathematical model of the tectonics. While the correlation between the mathematical model and the physical phenomenon is not absolute, the solution is biased due to the correlation. That is the main reason for using prior information for matching of the model to the phenomenon. We use the locked fault model to describe the dynamic behavior of points in the north of Israel. It relies on an arctangent function and depends on four independent parameters. The locked fault model suffers from an instability relationship between its parameters since it deals with extremely different scales of its parameters. By using prior knowledge we evaluate the model parameters by enforcing constraints on the adjusted parameters. A second solution of the model parameters is presented by extended free dynamic network. In this method we adjust the kinematical parameters simultaneously with the dynamical softened parameters. A third solution is achieved by regulation of the normal matrix in certain ways. The paper presents the three solutions based on two GPS measurement campaigns undertaken in 1996 and 2002. Applying different solutions strengthens the possibility of correct use of the mathematical model to achieve results in close proximity to the actual physical behavior and enables reaching a reliable solution.

Keywords: crustal deformation, two step analysis, dynamic model



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GS003

Oral Presentation

2758

VLBI analysis strategy and geophysical parameters

Prof. Veronique Dehant

Time, Earth Rotation, and Space Geodesy Royal Observatory of Belgium IAG

Sebastien B. Lambert, Veronique Dehant, Anne-Marie Gontier

We derive several nutation time series from VLBI observations using different analysis strategies, especially concerning the constraint applied to the radio sources coordinates in order to free the Earth orientation parameters from reference frame effects. Geophysical parameters are then derived from these data sets and their interpretation is performed. In particular we examine the stability of the RFCN resonant period and damping factor determinations and the implication in terms of physics of the Earth's core. We also look at the inner core parameters and determine the impact of VLBI uncertainties on the physics of the inner core.

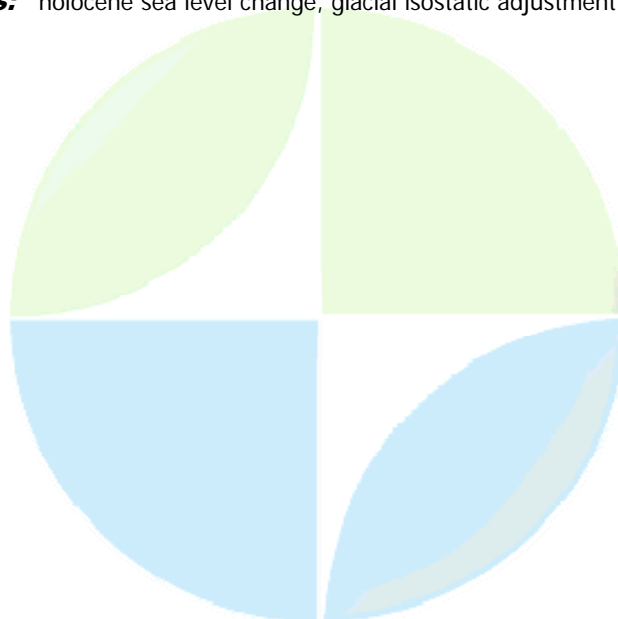
Keywords: earth rotation, outer core, inner core



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Oral Presentation****2759****Holocene relative sea-level change, isostatic subsidence and the radial viscosity structure of the mantle of north-western Europe (Belgium, the Netherlands, Germany, southern North Sea)****Dr. Holger Steffen***Institute of Geodesy Leibniz University Hannover***Annemiek Vink, Georg Kaufmann, Lutz Reinhardt**

A comprehensive observational database of Holocene relative sea-level index points from the NW European coast (Belgium, the Netherlands, northwest Germany, southern North Sea) has been compiled in order to compare and reassess the data collected from the different countries/regions and by different workers on a common timedepth scale. Relative sea-level rise (RSL) varies in magnitude and form between these regions, revealing a complex pattern of differential crustal movement which cannot be solely attributed to tectonic activity. It clearly contains a non-linear, glacio- and/or hydro-isostatic subsidence component, which is only small on the Belgian coastal plain but increases significantly to a value of ca. 7.5 m (since 8 cal. kyr BP) along the northwest German coast. The subsidence is at least in part related to the post-glacial collapse of the so-called peripheral forebulge which developed around the Fennoscandian centre of ice loading during the Last Glacial Maximum. The RSL data have been compared with geodynamic Earth models in order to infer the radial viscosity structure of the Earth's mantle underneath NW Europe (lithosphere thickness, upper and lower mantle viscosity), and conversely to predict RSL in regions where we have only few observational data (e.g. in the southern North Sea). A broad range of Earth parameters fit the Belgian RSL data, suggesting that glacial isostatic adjustment (GIA) only had a minor effect on Belgian crustal dynamics during and after the last ice age. In contrast, a narrow range of Earth parameters define the southern North Sea region, reflecting the greater influence of GIA on these deeper/older samples. Identification of the effects of local-scale factors such as compaction or past changes in tidal range on the spatial and temporal variations of sea-level index points based on modeldata comparisons is possible but is still complicated by the relatively large range of Earth model parameters fitting each RSL curve, emphasising the need for more observational data.

Keywords: holocene sea level change, glacial isostatic adjustment, earth model



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Oral Presentation****2760****Contribution of non-tidal oceanic mass variations to Earth rotation determined from space geodesy and ocean data*****Mrs. Franziska Goettl******Michael Schmidt, Florian Seitz, Wolfgang Bosch***

On time scales from a few days to decades mass variations within the atmosphere and the oceans are the dominant forcing mechanisms of Earth rotation variations. Atmospheric and tidal induced oceanic contributions can be assessed comparatively well from reanalysis data and theoretical models, respectively. However, non-tidal oceanic influences are less well known which manifests itself when the results of different ocean model simulations are compared to each other. In this paper we discuss the suitability of satellite altimetry for an independent assessment of oceanic mass effects on Earth rotation. For more than a decade satellite altimetry observes variations of the sea level with an accuracy of a few centimeters. Since a large part of the geometrically observed sea level fluctuations is caused by the steric effect, i.e. the volume change due to thermohaline expansion, the observations have to be reduced accordingly. In our study we determine steric sea level anomalies from temperature and salinity changes as described by (1) the WOA05 climatology, (2) the objective analysis data from Ishii and (3) the ARMOR-3D thermohaline fields. Residual non-steric sea level variations are transformed into time series of equatorial and axial components of Earth rotation excitation functions which are related to the Earth's tensor of inertia. The excitation functions are subsequently compared with time series from different ocean models. Furthermore the results are validated by excitation functions derived from observations of Earth rotation. In order to provide a comparable reference, these geodetic excitations are reduced by atmospheric effects, oceanic influences from tides and currents as well as hydrologic effects. For comparison we apply various analysis methods, e.g., wavelet- and Fourier-analyses as well as the computation of correlation coefficients and RMS differences.

Keywords: oceanic mass variations, altimetry, earth rotation

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GS003

Oral Presentation

2761

European tidal gravity observations: Comparison with Earth Tides models and estimation of the Free Core Nutation (FCN) period

Prof. Bernard Ducarme

Reference Systems and Geodynamics Royal Observatory of Belgium IAG

Jian-Qiao Xu, Leslie Vandercoilden, He-Ping Sun

There is a cluster of stations equipped with Superconducting Gravimeters (SG) in Europe. These Global Geodynamics Project (GGP) stations are surrounded by many independently calibrated tidal gravity stations. Moreover the ocean tides loading effect is negligible in the diurnal (D) band and smoothly changing in the semi-diurnal (SD) band. It is thus a natural laboratory for a large scale comparison of tidal gravity results. We correct the tidal gravity factors for ocean loading effect for 7 GGP stations equipped with recent CT or CD superconducting gravimeters. For comparison we use also 9 other stations equipped with spring gravimeters or older superconducting instruments. For tidal loading computations we use the mean 9 different ocean tides models with different grid size (0.5, 0.25 and 0.125). For the principal waves O1 and M2 the standard deviation of the mean corrected amplitude factor DELTA is lower than 0.1% for both data sets and the mean values agree to better than 0.05%. We still detect inconsistencies at the level of a few tenth of a per cent in some stations. For O1 the value $\text{DELTA}=1.15340+-0.00023$ falls between the elastic and inelastic DDW99 models. For M2 the value $\text{DELTA}=1.16211+-0.00020$ fits perfectly the DDW99 inelastic model. Due to the FCN, a resonance occurs in the diurnal frequency band. The precise determination of the FCN parameters (period, damping, resonance strength) is important as they strongly depend on the coupling mechanism at the core-mantle boundary (flattening, topography, electro-magnetic coupling). The main source of errors in the estimation of the FCN parameters is the oceanic loading effect which is imperfectly modelled. It is a reason why the European stations are very suitable for that purpose. We determine the FCN period using the 7 best GGP stations and find values between 430 and 432 days.

Keywords: tidal gravity, ocean loading, earth tide models



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Oral Presentation****2762****Loading effects on the Earth's crust from GPS and gravity observations compared to models****Prof. Susanna Zerbini**
*Fisica Universit di Bologna IAG***Francesco Matonti, Bernd Richter, Tonie Van Dam, Erika De Simone, Herbert Wilmes**

Time series of GPS height and gravity data at co-located stations have been analyzed. The network of stations is located in the North-eastern part of Italy. At the Medicina station, located in the South-eastern part of the Po valley, decadal GPS height and absolute gravity measurements as well as superconducting gravimeter time series are available. At the other stations of the network, GPS height and absolute gravity measurements are regularly acquired. After estimating long-term linear trends, we compare the seasonal oscillations present both in the GPS height and gravity data series. The amplitude of these oscillations is in the order of 1 to 2 cm peak-to-peak for the GPS heights and 4-to-6 Gal for the gravity observations. We built models representing the atmospheric, hydrologic and non-tidal ocean loading. These models are compared to the observed oscillations.

Keywords: loadings, gps, gravity

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I T A L Y



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Oral Presentation****2763****Rotational feedback in global glacial isostatic adjustment*****Prof. Richard Peltier****Physics University of Toronto IAMAS*

Two anomalies in Earth's rotational state have previously been identified as being due to the ongoing global process of glacial isostatic adjustment, namely the so-called non-tidal acceleration of planetary rotation and the true polar wander that is presently occurring at a rate of approximately 1 degree per million years towards the Hudson Bay region of . Although the connection of these anomalies to the GIA process has been uncontested for some time, it has recently been suggested that the latter may not be exclusively due to this ice-age related influence. This has been suggested to be associated with the influence of Earth's observed oblateness upon the speed of polar wander induced by glaciation and deglaciation. In the theory for the response of the rotating Earth to such surface forcing, the strength of this inhibiting influence upon polar wander speed is connected to the difference between the so-called fluid Love number and the infinite time asymptotic value of the tidal Love number of degree 2, as this is determined in the theory of Peltier (1982) and Wu and Peltier (1984). Although this difference appears to have a relatively minor influence upon the important contribution that rotational feedback makes to relative sea level history, it does influence the strength of the time dependence of the degree 2 and order 1 component of Earth's gravitational field. I will discuss the implications of new results obtained with the revised form of the theory required to fully incorporate the influence of rotational bulge derived inhibition of the TPW. The observation of this signal by the GRACE satellite may provide a means of directly assessing the fraction of the observed speed of TPW that we may be obliged to explain by appeal to other processes such as mantle convection. In exploiting the GRACE data set in this way, however, we will be obliged to simultaneously understand the secular variation in the strength of the pole tide that may be also occurring in the current greenhouse warming climate.

Keywords: polar wander, sea level history, isostasy



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Oral Presentation****2764****On the Earth's global dynamical flattening****Dr. Cheng-Li Huang***Astro-geodynamics Shanghai Astronomical Observatory IAG***Yu Liu**

From modern astrometric observation (mostly by precession observation), The global dynamic flattening (H_{obs}) is about $1/305.5$, while its calculated value from hydrostatic equilibrium (HSE) earth model PREM (H_{PREM}) is approximately $1/308.5$ which is about 1% smaller than H_{obs} . This difference stimulated lots of study. First, we will briefly review the observation and related studies. Second, we calculate the ellipticity profile of the Earth interior from both Clairaut equation + Darwin equation to second order accuracy and another independent potential theory in hydrostatic equilibrium (HSE) to third order accuracy. Comparison with the results of Denis(1989) is also made. The approximate 1% discrepancy still exists. Next, the homogenous upper crust and oceanic layers in PREM are replaced by some more realistic models. All the results are deviated from the observed value more than H_{PREM} . These results verify the isostasy theory indirectly and may imply that the positive effects from such as mantle circulation associated with the density anomalies maybe larger than what was discussed before. Finally, a deeper mantle model up to 2000km depth from seismic tomography is also used to evaluate the contribution of the inhomogenous and deviation from HSE in whole mantle to the H. A short discussion is also presented.

Keywords: global dynamical flattening, topography, non hydrostatic equilibrium



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Oral Presentation****2765****Analysis of GPS data from an Antarctic Glacier****Dr. Rolf Dach***University of Bern Astronomical Institute IAG***Hilmar Gudmundsson, Gerhard Beutler**

Data from five GPS receivers on a glacier in Antarctica were collected during two months. The extension of the network is about 60 km. The glacier is moving with a velocity of about one meter per day. For the glaciological interpretation a kinematic processing of the data with a resolution in time of 30 seconds is required. The kinematic data are processed using different strategies: (1) zero-difference network solution (2) Precise Point Positioning (3) double-difference network solution with resolved carrier phase ambiguities. The different solutions are compared with respect to the quality of the obtained time series of coordinates. Special attention is paid to the advantages and disadvantages of the analysis methods for different frequency ranges because the spectral analysis of the resulting time series is one of the glaciological aims of this measurements.

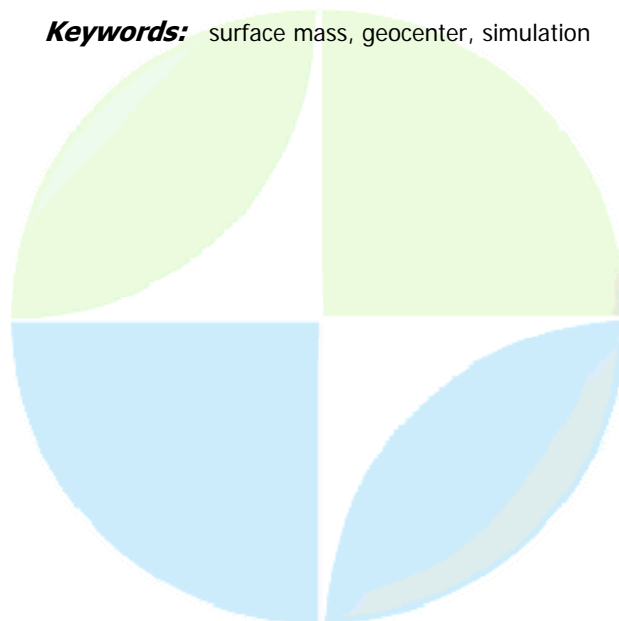
Keywords: gnss analysis, kinematic positioning

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Oral Presentation****2766****Mass distribution sensitivity study concerning GRACE, GPS and Ocean Bottom Pressures****Mr. Mark-Willem Jansen***DEOS Delft University of Technology IAG***Jrgen Kusche, Brian C. Gunter**

In an effort to improve the estimates of global surface mass variations, an approach has been developed in which GRACE monthly fields are combined with GPS site displacements and ocean bottom pressure (OBP) data. The motivation for the study is that while GRACE monthly fields provide excellent results for the mid to high degree spherical harmonics, they do not deliver degree-1 coefficients. This means however, when GRACE-derived grids are interpreted in an Earth-fixed reference frame one disregards exactly that part of the mass change that causes a significant (on the order of one centimetre) geocenter shift. Using degree-1 coefficients is particularly important when considering the polar regions because of the large seasonal motion of the z-geocenter. Recent studies have indicated that, through loading theory, large-scale mass variations can be derived from a time-series of globally distributed GPS site displacement vectors. Unfortunately, the current IGS network does not provide homogeneous coverage of the Earth. It contains very few stations in the oceans, and has sizable gaps in regions such as Africa and Antarctica. Not much can be done regarding the continental data gaps, but one method of treating the absence of GPS stations over the oceans is to take surface loading from OBP models. To explore the impact that the distribution of GPS stations, as well as errors in the OBP models, might have on the final combined GRACE-GPS-OBP inversion, a sensitivity study has been conducted. The results of a range of simulations will be presented in which the distribution of a hypothetical global GPS station network is varied and compared to a "best-case" scenario. The characteristics of the OBP models will serve as another variable in the simulations. To make the simulations as realistic as possible, error characteristics from the real IGS network and ECCO ocean circulation models will be employed. The ultimate goal of the simulations is twofold: first, to quantify the errors in the combined inversion as a result of the GPS and OBP data, and their impact on surface mass estimates (including degree-1 coefficients); secondly, to find the optimal combination of the three data types for the final solution using real data.

Keywords: surface mass, geocenter, simulation

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Oral Presentation****2767****Present-day arabian plate motion from campaign GPS measurements:
preliminary results*****Mr. Bandar Almuslmani****The University of Nottingham (IESSG) Student****Richard Bingley, Terry Moore***

Current investigations of the motions of the Arabian and its neighboring plates are primarily based on GPS measurements obtained in the surrounding areas of the Arabian plate, with few stations actually located on the Arabian plate itself in the Kingdom of Saudi Arabia. In order to advance the knowledge of the dynamics of the Arabian plate and its intra-plate deformations, the General Directorate of Military Survey (GDMS), through collaboration with the Institute of Engineering Surveying and Space Geodesy (IESSG), densified the GPS network in Saudi Arabia, covering nearly two thirds of the tectonic plate. Since July 2002, a network of 32 GPS stations has been established at locations of the geodetic network. At all of these GPS stations a concrete pillar has been used as the monument and the locations have been selected in order to give the broadest distribution of observing sites. During 2005, 27 additional GPS stations in the Hejaz and Asser Mountains in the south-western part of Saudi Arabia, have been established, with the GDMS GPS network now comprising a total of 59 stations. In this presentation we will introduce the new GPS network established by GDMS and present results from several GPS campaigns to date. These results use the new absolute satellite and receiver antenna phase center models together with newly available GPS products from a recent global re-processing effort, and are referenced to ITRF2005.

Keywords: arabian plate motion, campaign gps measurements

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Oral Presentation****2768****Comparison of regional polar motion excitations derived from hydrological signals****Dr. Jolanta Nastula***Earth Rotation Space Research Center of the PAS***David A. Salstein, Rui M. Ponte, Barbara Kolaczek**

The excitation of polar motion is related in large measure to changes in the global balance of angular momentum due to the mass redistribution of geophysical fluids. The importance of atmospheric and oceanic angular momentum (AAM and OAM) signals for polar motion excitation at monthly and longer periods is well established. The role of the continental hydrologic signals on polar motion excitation (hydrological angular momentum-HAM) resulting from the changes in mass distribution associated with land water and snow/ice, however, is less well known, especially in oscillations with periods shorter than annual. Recently, though, estimates of HAM have been made from several models of global hydrology that are based upon the observed distribution of surface water, snow, and soil moisture. Although combining HAM with AAM and OAM should account for nearly all the geophysical signals needed to explain the observed polar motion, the relatively sparse observation network and the presence of errors in the data and the geophysical fluid models preclude a full explanation at present. Here we investigate regional sources of polar motion excitation from the distribution of HAM, and we intercompare such regional patterns derived from different models. Regional excitations are also compared with those from GRACE gravity field observations, which provide a uniform new source of information for all mass redistributions within the Earth. Lastly, we examine a relationship between regional and global hydrological excitation functions of polar motion to determine the relative contributions of different areas to the global total.

Keywords: hydrological, excitation

(G) - IAGA - International Association of Geomagnetism and Aeronomy

GS003

Oral Presentation

2769

Analysis of the FCN resonance in Superconducting Gravimeters data of the European GGP sub-network using a Bayesian approach

Dr. Severine Rosat

Reference system and geodynamics Royal Observatory of Belgium IAG

Nicolas Florsch, Bernard Ducarme, Jacques Hinderer, Muriel Llubes

Because of the fluidity of the core, the Earth possesses a rotational mode, the Free Core Nutation (FCN) with a period almost diurnal in the solid Earth reference frame. The FCN parameters (period and damping) strongly depend on the coupling mechanism at the core-mantle boundary. As the period of the FCN is quasi-diurnal, a resonance with the tidal waves occurs in the diurnal frequency band. This resonance effect can be detected and analyzed with time-varying gravity data recorded on the Earth's surface by Superconducting Gravimeters (SGs) of the Global Geodynamics Project (GGP) network. The FCN resonance effect is commonly modelled by a damped harmonic oscillator that we inverse to retrieve the frequency, the quality factor Q and the resonance strength of the FCN. As the quality factor of the FCN is not Gaussian, the usual least-squares inversion is inappropriate. Therefore we consider a Bayesian inversion approach as proposed by Florsch and Hinderer (2000). The result of the Bayesian inversion is the probability law for each parameter (Tarantola and Valette, 1982). The main error in the estimation of the FCN parameters is the oceanic loading effect which is imperfectly modelled. In order to obtain precise FCN parameters, we focus the inversion on a subset of European SG sites, where the ocean loading effect is weak and stable. In order to have realistic observational errors, the differences between different ocean tide models at the SG sites are added to the tidal analysis uncertainties. Quoted references Florsch, N. and Hinderer, J., 2000. Bayesian estimation of the free core nutation parameters from the analysis of precise tidal gravity data, *Phys. Earth Planet Int.*, 117, 21-35. Tarantola, A. and Valette, B., 1982. Inverse problems quest for information, *J. Geophys.*, 50, 159-170.

Keywords: fcn, gravimetry, bayesian



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Oral Presentation****2770****Axial Atmospheric Angular Momentum Budget at Diurnal and Sub-Diurnal Periodicities****Dr. Francois Lott***Institut Paul Simon Laplace Centre National de la Recherche Scientifique IAMAS***Olivier De Viron, Pedro Viterbo, Francois Vial**

The diurnal and sub-diurnal variations of the mass and wind terms of the axial Atmospheric Angular Momentum (AAM) are explored using a 1-year integration of the LMDz-GCM, twelve 10-day ECMWF forecasts and some ECMWF Analysis products. In these datasets, the wind and mass AAMs present diurnal and semi-diurnal oscillations which tendencies far exceed the total torque. In the LMDz-GCM, these diurnal and semi-diurnal oscillations are associated with axisymmetric ($s=0$) and barotropic circulation modes that resemble to the second gravest ($n=2$) Eigensolution of the Laplace's tidal equations. This mode induces a Coriolis conversion from the wind AAM toward the mass AAM that far exceeds the total torque. At the semi-diurnal period, this mode dominates the axisymmetric and barotropic circulation. At the diurnal period, this circulation also presents a mode resembling to the first gravest ($n=1$) Eigensolution of the Laplace's tidal equations. This last mode does not produce anomalies in the mass and wind AAMs. A shallow water axisymmetric model driven by the surface stresses issued from the GCM is then used to interpret the dynamical origin of these modes of motion. In geodesy, the large but opposite signals in the mass and wind AAMs due to the $n=2$ modes can explain the large errors done in the evaluation of the AAM budget at the diurnal periodicities, and when reanalysis datasets are used. The $n=2$ responses in surface pressure can affect the Earth Ellipcity, and the $n=1$ diurnal response can affect the geocenter position.

Keywords: aam budget, diurnal periods

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Oral Presentation****2771****Using GRACE derived gravity rates to constrain postglacial rebound in North-America****Mr. Wouter van der Wal***Dept. of Geomatics Engineering University of Calgary IAG***P. Wu, H. Wang, M.G. Sideris, H.H.A. Schotman**

The largest secular signal that is present in the GRACE fields over North-America is postglacial rebound. Our goal is to use GRACE-derived gravity rates to infer a viscosity profile for postglacial rebound. However, gravity rates can be influenced by secular mass changes due to ice sheet melting in Greenland and Alaska, and interannual variations in continental water storage. Therefore, we will investigate here the influence of these mass changes on the gravity rates derived from GRACE. We simulated the leakage from the Alaska glacier melting by using previous non-GRACE estimates for the volume of ice melting in Alaska. We found that removing the Alaska glacier melt from GRACE shifts the maximum gravity rate to the west of Hudson Bay. In addition, we compared the effect of removing two different global hydrology models and found that the difference can amount up to 1 microGal/year. Furthermore, defining the GRACE errors as the residual coefficients after a trend and annual and semi-annual terms are removed, we found that the standard deviation of the secular gravity rate is less than a few tenths of microGal/year. Postglacial rebound simulations are performed using two methods. For the laterally homogeneous earth, the normal mode method is used for a Maxwell viscoelastic radially symmetric Earth. The second method uses the finite element method to study the effects of lateral heterogeneity in the mantle. We will compare the simulated gravity rates for these two methods with the GRACE-derived gravity rates.

Keywords: postglacial rebound, grace

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Oral Presentation****2772****Plate motion and deformation derived from 10 year GPS observations in Australia and South Pacific region****Dr. Minghai Jia***Earth Monitoring Group Geoscience Australia IAG****Phil Cummins, John Beavan, Michael Bevis, Gary Johnston, Bary Drummond***

Up to 10 years (1997-2006) GPS data over 70 sites from Australia, South Pacific and Antarctica has been reprocessed recently at Geoscience Australia using the Bernese GPS software Version 5.0. The GPS coordinate time series and velocity field in the IGS05 reference frame (the IGS realisation of the ITRF2005 reference frame) have been obtained using the CATREF combination software from GPS weekly solutions. Plate motion models determined from the velocity field using the DEFNODE software show that Fiji does not exactly belong to the Australia plate or some intraplate deformation occurs in Fiji area. GPS site Lautoka (Fiji) moves 6.5 1.5 mm/yr at an azimuth 243.2° 8.4° in an Australia fixed reference frame and GPS site Suva (Fiji) moves 10.0 0.9 mm/yr at an azimuth 230.5° 5.6°. The Tonga block rotates 7.9° 1.5° /Myr clockwise at latitude 25.9° S and longitude 178.1° W relative to the Australia plate. GPS sites Tongatapu, Lifuka and Vavau move 83.8 1.0 mm/yr, 106.9 4.3 mm/yr and 125.3 7.7 mm/yr at azimuths 118.7° 0.9°, 118.7° 1.6° and 116.9° 2.0° respectively, relative to the Australia plate. The movement is gradually fast from south to north along Tonga arc. The movement pattern is inconsistent with sea-floor spreading in the Lau basin determined from geophysics research. These three sites move 155.0 1.0 mm/yr, 179.9 4.2 mm/yr and 200.5 7.7 mm/yr at azimuths 105.4° 0.5°, 107.1° 0.9° and 107.1° 1.1° respectively, relative to the Pacific plate. These motion patterns show that the convergence between the Pacific plate and the Tonga block at the Tonga subduction zone is gradually fast from south to north. In addition, significant co-seismic deformation caused by May 3, 2006 Tonga Mw 8.0 earthquake has been detected at GPS sites Tongatapu, Lifuka and Vavau. Post-seismic deformation also is recorded at the continuous GPS site Tongatapu.

Keywords: south pacific, plate motion, deformation

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Oral Presentation****2773****The impact of atmospheric pressure tides on global GPS analysis*****Dr. Christopher Watson****Centre for Spatial Information Science University of Tasmania IAG****Paul Tregoning, Laurent Millet***

The modelling of the non-tidal component of atmospheric pressure loading has been clearly shown to improve the repeatability of global geodetic GPS time series. Further improvement is possible considering that the modelling of the tidal components of atmospheric pressure are yet to be routinely included in pressure loading models. This is of particular importance given a number of studies have shown that unmodelled sub-daily periodic signals have the potential to propagate into GPS time series at low frequencies, and potentially bias the geophysical interpretation. This study investigates the impact of accounting for the tidal components of atmospheric pressure loading deformation in the analysis of data from a global GPS network. The tidal contribution (at S1, S2 and S3) is modelled from ~4 years of globally distributed raw pressure observations using a time variable amplitude and phase approach (varying annually, semi annually and three monthly). The modelled tidal pressures are convolved to compute solid Earth deformation and applied at the observation level in the GPS analysis. We also consider the application of the annual and monthly mean pressure tides of Ray and Ponte (2003). The addition of the tidal deformation modelling is tested by generating several solutions using the GAMIT / GLOBK software, with the solutions differing only by the use of the atmospheric tidal deformation model.

Keywords: pressure loading, pressure tides, tidal deformation

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Oral Presentation****2774****Refined prediction of earth rotation parameters with Neuro-Fuzzy techniques****Mrs. Stephanie Martin***Geodisches Institut, Hannover PHD Student IAG*

The knowledge about the Earth Rotation Parameters (ERP) (polar motion and length-of-day) is important for many tasks in geodesy and astronomy. These parameters can be obtained from space-geodetic techniques. The C04 time series of the International Earth Rotation Service (IRS) provide daily data of the ERP. This data is of high accuracy but it is not available in real-time what is essential for a lot of applications. Therefore a prediction of the ERP is necessary. In this study, a procedure to describe and predict the variability of the ERP is presented and discussed which is based on Neuro-Fuzzy modeling. Neuro-Fuzzy techniques are data driven, that means they deduce the model directly from the data. Hence, they are mostly convenient if there is no (or only partial) knowledge about the physical relations. In particular, the Adaptive Network based Fuzzy Inference System (ANFIS) technique is used here. It represents a fuzzy inference system which is implemented in the framework of adaptive networks. It is based on a supervised learning algorithm to optimize the parameters of a fuzzy inference system. The daily values of the ERP C04 time series from the IERS serve as the data base. One part of the time series is used for training and the other part for validating the network. This study focuses on the prediction of the polar motion (x- and y-component) and the length-of-day on different temporal scales. In comparison with previous studies two significant extensions are provided which are presented for the first time. First, the variation of one particular ERP is predicted either from the variation of the two other parameters or from the two other parameters and the parameter itself. Second, different (atmospheric and oceanic) excitation functions of different origin are used to set up a causal model for predicting all three ERP. These data are used to derive different ANFIS models which are estimated in order to exemplarily show and discuss the respective performance.

Keywords: fuzzy inference system, earth rotation parameters, prediction



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Oral Presentation****2775****Physical modelling to remove hydrological effects at local and regional scale: application the 100-m hydrostatic inclinometer in Sainte-Croix-aux-Mines (Vosges Mountains, France)**

Mr. Laurent Longuevergne
UMR Sisyphé Universit Paris 6 IAG

Frederic Boudin, Jean-Paul Boy, Nicolas Florsch

Hydrological phenomena are pointed out to possibly hide geodynamical processes (e.g. Evans and Wyatt 1984, Crossley et al., 1999). Some authors (e.g. Dal Moro and Zadro, 1998) concluded that hydrological effects should be removed before any other study regarding the monitoring and the identification of tectonic deformational signals intended to be extracted. In this work, we investigate the hydrological processes inducing geodynamical effects in order to correct time series. Two orthogonal 100-meter base hydrostatic inclinometers were set up in an old mine in the Vosges mountains (France) in Decembre 2004. They record tilt variations with a temporal sampling of 30 seconds and a resolution better than 10-10 radians. In the same time, an hydrometeorological monitoring system of the 100-km hydrological unit around the inclinometer has been installed. Hydrological models forced with observed meteorological and hydrological data are used to model both amount and distribution of water masses. Loading may then be calculated to estimate geodynamical effects. Finally, we emphasize the necessity to physically model each hydrological process separately in order to correctly remove hydrological effects, since all environmental signals are correlated.

Keywords: hydrology, physical modelling, loading

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Oral Presentation****2776****Observation of the low-frequency Earth free oscillations with the Kamioka laser strainmeters****Mr. Hideaki Hayakawa***Graduate School of Science Kyoto University***Akito Araya, Akiteru Takamori, Wataru Morii, Masatake Ohashi, Shuzo Takemoto, Yoichi Fukuda**

The studies of low-frequency Earth free oscillations including those related to Earth core motion are important to improve the density structure model inside the Earth. The Earth has two classes of free oscillations, toroidal and spheroidal modes. Observed splitting and coupling of these normal modes give us useful information on the Q structure and the heterogeneity inside the Earth. Spheroidal modes have been investigated well by various observation equipments, superconducting gravimeter, broadband seismometer and so on. In contrast, toroidal modes are more difficult to observe than spheroidal modes. Because the high sensitivity of a superconducting gravimeter is only for the vertical-component and the sensitivity of the horizontal components of a seismometer are worse to be affected by tilts induced by atmospheric disturbances. Continuous observations using 100m laser strainmeters have been carried out in the deep tunnel underground about 1,000m of the Kamioka mine, Japan. Kamioka laser strainmeters have high sensitivity of order of 10^{-13} and wide dynamic range of 10^{-13} - 10^{-6} for strain changes in the horizontal-component. The resolving power corresponds to that of a superconducting gravimeter. A strainmeter is directly sensitive to toroidal modes. So we can expect to determine parameters related to toroidal modes as well as spheroidal modes. Here we show observations of the low-frequency free oscillations using Kamioka laser strainmeters. The significant signals of toroidal modes and spheroidal modes are found from the obtained data including the 2004 Sumatra earthquake event in which the low frequency modes were strongly excited. We estimate the frequencies and the Q-value for the fundamental modes and the overtones up to a few mHz. In our analysis, we found the parameters for low-frequency toroidal modes below 1mHz.

Keywords: free oscillation, laser strainmeter, kamioka

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Oral Presentation****2777****Analysis of mass variations in northern glacial rebound areas from recently processed GRACE data****Prof. Juergen Mueller***Institute of Geodesy, University of Hannover Professor IAG***Holger Steffen, Heiner Denker**

Since 2002 the GRACE satellite mission is mapping the Earth's gravity field by making accurate measurements of the distance between the two satellites orbiting the Earth in decaying altitude. The integral effect of mass variations in the atmosphere, hydrosphere and geosphere results in observed variations in the gravity field. After reduction of oceanic and atmospheric contributions as well as tidal effects during the GRACE standard processing, monthly solutions of the gravity field are provided by the three GRACE analysis centers. Up to now, the solutions of these analysis centers differ slightly, which is due a coverage of different time spans and the application of different reduction models and center-specific processing schemes. In addition, residual signals from insufficient pre-processing of the transmitted satellite data may be present. We present our investigation of mass variations in the glacial rebound areas of North America and Northern Europe from GRACE data, especially from the new Release 4 (RL04) of the GFZ Potsdam. One key issue is the separation of the various signal parts and the reduction of the observed (or derived) quantities by applying dedicated filters (e.g. Gaussian with different radii) and models of the non-GIA induced contributions such as hydrological variations. In a further step, we analyse the results of both regions on their reliability and finally compare them with results from GPS campaigns (e.g. BIFROST) and geodynamic modelling results. Our results clearly show that the quality of the GRACE-derived gravity change signal benefits from the new RL04 and improved reduction models together with dedicated analysis techniques. Nevertheless, the comparison with results of terrestrial observation methods and geodynamic models still reveals differences, and thus further studies are in progress.

Keywords: grace, glacial isostatic adjustment, mass variations

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Oral Presentation****2778****Experimental Earth Tidal Models Based on Global Observations of the Superconducting Gravimeters in Considering Earth's Nearly Diurnal Free Wobble of the Liquid Core****Prof. Sun Heping***Key Laboratory of Dynamic Geodesy Institute of Geodesy and Geophysics, CAS***Xu Jianqiao, Ducarme Bernard**

Based on the 28 series of the high precision and high minute sampling tidal gravity observations at 20 stations in Global Geodynamics Project (GGP) network, the resonant parameters of the Earth's nearly diurnal free wobble (including the eigenperiod, resonant strengths and quality factors) are determined precisely. The discrepancy of the eigenperiod between observed and theoretical values is studied, the important conclusion that the real dynamic ellipticity of the liquid core is about 5% larger than the one under the static equilibrium assumption is approved by using gravity technique. The experimental Earth's gravity tidal models with considering Earth's nearly diurnal free wobble of the liquid core are constructed in this paper. The numerical results show that the difference among three experimental models is less 0.1%, and the largest discrepancy comparing to those widely used nowadays given by Dehant (1999) and Mathews (2001) is only about 0.4%. It can provide with the most recent real experimental gravity tidal models for the global study of the Earth's tides, ground and space based geodesy techniques and so on.

Keywords: ndfw, tidal gravity, experimental model

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Oral Presentation****2779****Accuracy in the Earth Orientation Monitoring****Dr. Daniel Gambis***SYRTE Observatoire de Paris IAG***C. Bizouard, L. Seoane**

Earth Orientation variations have been monitored over more than one century using different astro-geodetic techniques (optical astrometry, VLBI, SLR, LLR, GPS and DORIS). The technical evolution and improvements of these techniques as well as their processing and models developments allows now to compute combined solutions with precisions at the sub-centimeter level. For many applications, in particular in orbitography, the consistency of Earth Orientation Parameters with both terrestrial and celestial reference frame is becoming a strong requirement. We present the latest improvements in the combination procedure and the state-of-the-art concerning the earth rotation metrology, long term as well as near real time determination.

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Oral Presentation****2780****Simulation of Earth rotation parameters with GCMs Simulation of Earth rotation parameters with GCMs****Mr. Timo Winkelkemper***Meteorological Institute University of Bonn IAMAS****Xueen Chen, Florian Seitz, Claudia Walter, Andreas Hense***

Global circulation models are able to simulate mass movements and mass concentration on a global scale in a realistic way. Due to enormous mass displacements and relative movements (to the rotating Earth) the atmosphere and oceanic hydrosphere have an important impact on Earth rotation parameters. On a subdaily to decadal scale the atmosphere and the oceanic hydrosphere explain nearly all variance of Earth rotation parameters. The focus of this talk will be on atmospheric effects. An Earth system model has been developed by our interdisciplinary project group which has realized an entire coupling of the subsystems atmosphere, ocean and continental hydrosphere with respect to conservation of mass, energy and momentum. Tides are implemented as well. The coupled model consists of the ECHAM 5.3 GCM, OMCT 3.0 ocean model and HDM hydrospheric dispersion model. To distinguish between oceanic, hydrospheric and atmospheric impacts an atmospheric standalone run has been carried out additionally. One detailed structure analysis of observed (reconstructed) and simulated Earth rotation parameters and atmospheric forcing factors like solar variability, ENSO or greenhouse gas will be presented. A cross spectral analysis of simulated Earth rotation parameters with time series of ENSO and solar variability has already been performed and shows interesting results. To examine a possible future increase in the length of day associated with a decrease in Earth angular velocity, future trends have been calculated under a climate change scenario.

Keywords: earth rotation parameters, earth system model, spectral analysis



(G) - IAGA - International Association of Geomagnetism and Aeronomy

GS003

Oral Presentation

2781

Geodetic modeling and geophysical interpretation of recent vertical crustal movements and gravity changes over Canada

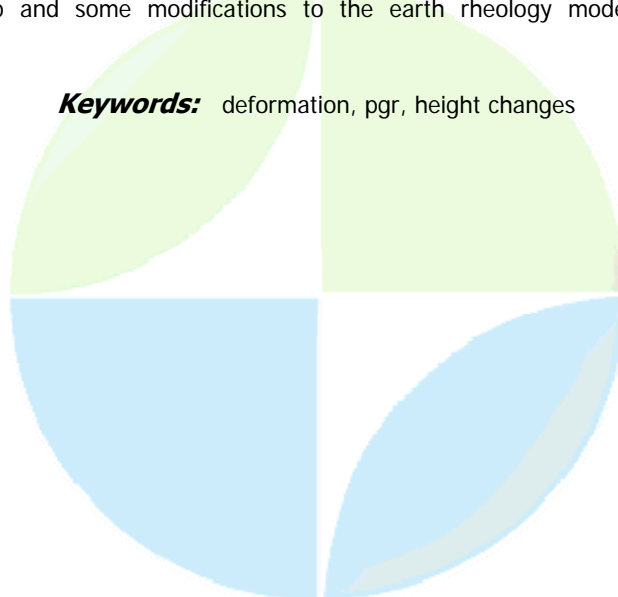
Dr. Azadeh Koohzare

Geodesy and Geomatics Engineering University of New Brunswick IAG

Petr Vanicek, Marcelo Santos

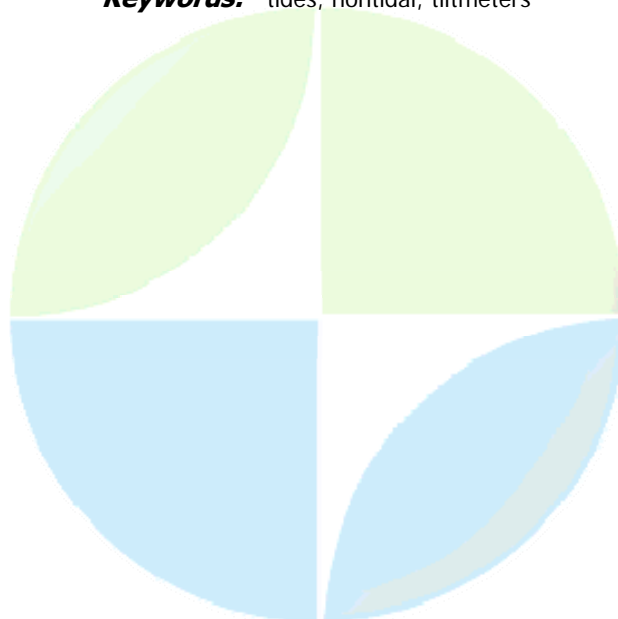
We developed a method to compute a smooth approximation of large scale scattered re-levelling data and historical tide gauge records given over and northern U.S., and ultimately compiled a map of Vertical Crustal Movements (VCM) in Canada. The VCM map was then compared with the maps of rate of gravity changes (\dot{g}), and geodetic height changes (\dot{h}) being the later based on GPS solution over the Canadian Base Network (CBN) stations. The Post Glacial Rebound (PGR) hinge line follows the same pattern in all the maps and the close correlation between the map of VCM and \dot{g} map is easily traceable and is in a fairly good agreement with theoretical model of Jachens (1978) in different areas, where different geophysical phenomenon are responsible for the movements. The values of ratio between gravity and orthometric height changes (\dot{g}/\dot{H}) in the once ice covered areas, such as southern Hudson Bay, are very close to -0.2mGal/m (Jachen, 1978). It suggests that the mass redistribution in this area is mainly due to the ice removal. However, the rate of crustal motion from the VCM indicates disagreement with the GPS solution in the Canadian prairies. The standard deviation of the GPS solutions are generally larger than the standard deviation of the VCM in the area where there are data for the computation of VCM, which draws special attention for the comparisons of VCM and GPS solutions. In this study, some of the probable causes of such inconsistencies are discussed. This investigation showed also that throughout, the difference between two values of \dot{H} and \dot{h} is within the range of 10 to 15% of the total crustal movements which is reasonable and theoretically related to the geoidal height changes mostly due to PGR. The spatial variation of these ratios and differences can be shown on maps of ratio between gravity changes to height changes and geoidal height changes. The VCM is also compared to Glacial Isostatic Adjustment (GIA) models based on the published ICE-3G and ICE-4G loading history and on a model of Earth rheology characterized by stratified viscosity variations. The VCM constraints on GIA model parameters are investigated by varying, one at a time, two key parameters: 1) viscosity in different layers, and 2) the thickness of Laurentide ice over individual ice disks in Eastern Canada, and the Prairies, to obtain better fits to the VCM. Clear patterns of viscosity distributions show up and some modifications to the earth rheology model and ICE model are suggested.

Keywords: deformation, pgr, height changes



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Oral Presentation****2782****Investigations of a nontidal plumb line variations observed by the long water-tube tiltmeter*****Dr. Marek Kaczorowski****Planetary Geodesy Space Research Centre of PAS*

The long water-tube tiltmeter installed in Ksiaz Geodynamic Laboratory, consists of two perpendicular tubes 65 and 83 meters-long, partially filled with water. The idea of measurements is based on phenomenon of hydrostatic equilibrium. Inside the hydrodynamic system of the instrument, the lunisolar tidal forces as well as other large-scale geodynamic phenomena generate variations of water level which are measured with the help of a interference technique. This technique allowed us to achieve internal sensitivity of tiltmeter close to 1 microarcsecond. Furthermore, stability of the He-Ne lasers light length and application of differential method for data elaboration caused elimination of the instrumental drift. Suggestion of existence of a nontidal plumb line variations of seasonal character comes from measurements carried on with help of quartz horizontal pendulums. During thirty years of performance of the pendulums we observed seasonal phenomenon of instability of their equilibrium position. Almost every year during the transition periods autumn-winter and winter-spring, the azimuth of equilibrium of the pendulums has been changing. By taking into account the construction of pendulums and possible influence of temperature fluctuations on instrument we tried to explain variations of azimuths by instrumental reasons. The installation in 2002 of a new long water-tube tiltmeter opened possibility of investigating the long period or systematic plumb line variations. In the beginning of 2004, we started to measure water level variations with the help of four sensors. This modification allowed us to apply differential method to eliminate instrumental drift and to investigate non-tidal plumb line variations. The tidal signal was subtracted from observations with the help of program ETERNA 3.4. During two years 2004-2005 we observed substantial plumb line variations which took place in the autumn-winter and winter-spring transition periods. During this period the plumb line completed two cycles of rotation in a clockwise direction which suggests an existence of the annual effect. The trajectory of the plumb line does not show any characteristic direction which could indicate a relationship between the observed tilts and the local tectonics structure.

Keywords: tides, nontidal, tiltmeters

(G) - IAGA - International Association of Geomagnetism and Aeronomy

GS003

Oral Presentation

2783

Report of GGP Activities to Commission 3, Completing 10 years for the Worldwide Network of Superconducting Gravimeters.

Prof. David Crossley

Earth and Atmospheric Sciences Saint Louis University IAG

Jacques Hinderer

The Global Geodynamics Project (GGP2) is due to end in 2007 at the IUGG in Perugia. This second cycle of operations started in 2003, and followed the initial years of GGP1 (1997-2003). Thus, by the time of the IUGG, GGP will have completed 10 years of collecting data from all the currently operating superconducting gravimeters (SGs). During the last cycle, GGP operations have gone smoothly for most stations, but with the inevitable instrumental problems. We have lost stations Boulder and Bandung, but gained an instrument in MunGyung (S. Korea) and two instruments in Hsinchu (Taiwan). New installations were recently done in Pecny (Czech Republic) and Dehradun (India), and several other locations in the US and Asia are being contemplated in the next cycle of GGP3 (2007-2011). Over the past two years, the major advance within GGP has been to prepare raw GGP data (at sampling times of 1-5 s) for inclusion into the IRIS data set for the seismologists to include in normal mode studies of the Earth. A very successful GGP Workshop was held in Jena, in March 2006, and the first ever Asian SG Workshop took place in March 2007 in Taiwan, hosted by our colleagues in Hsinchu. Of continuing interest within GGP is the issue of combining measurements from absolute gravimeters at the SG stations for a variety of long-term studies of the gravity field such as tectonic uplift, subduction zone slip, and determination of the Earth's centre of mass with respect to the terrestrial reference field. GGP has now become involved with the development of GGOS, a group that intends to coordinate the use of many different geodetic data sets for future ease of access.

Keywords: superconducting gravimeters, commission report, gravimetry



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Oral Presentation****2784****Laurentia glacial isostatic adjustment: constraints from satellite data and modeling****Mr. Hyongki Lee**
IAG**C.K. Shum, Jun-Yi Guo, Yuchan Yi, Alexander Braun, Patrick Wu, Chung-Yen Kuo,
Michael Schmidt, Hansheng Wang**

Satellite radar altimetry has been designed for synoptic mapping of ocean topography, and has been used to study challenging problems such as sea level, ice sheet mass balance and inland hydrology. This study demonstrates for the first time the potential use of satellite altimetry to detect solid Earth deformation signals including the Glacial Isostatic Adjustment (GIA). Our study region covers the seasonally-covered land area near Hudson Bay, where the maximum solid Earth uplift of ~1 cm/yr is due primarily to the viscoelastic rebound of the mantle as a result of the melt of the former Pleistocene Laurentide Ice Sheet. In this study we used primarily decadal (1992-2002) measurements from TOPEX (equipped with a circularly polarized radar altimeter antenna) retracked to produce time series of height changes over the study areas. ENVISAT, ICESat laser altimetry, in situ measurements, GPS vertical velocities and GRACE solutions (harmonic and regional solutions including wavelets) will be used to validate the TOPEX generated time series over selected areas. The observed crustal deformation is also compared with various GIA models, including the radial symmetric models, ICE4G (VM2), BIFROST, and ICE5G, and 3-D laterally heterogeneous model, including the Wu model. TOPEX-driven deformation rate can be used to enhance the density of GPS sites in GIA-deforming regions. It is anticipated that the new altimetric and other observations provide constraints on rheology of the Earth and the corresponding GIA models.

Keywords: glacialisostaticadjustment, satellitealtimetry

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Oral Presentation****2785****New results based on reprocessing of 13 years continuous GPS observations of the Fennoscandia GIA process from BIFROST****Mr. Martin Lidberg***Geodetic Research Division National Land Survey of Sweden IAG***Glenn A. Milne, Jim L. Davis, Jan M. Johansson, Hans-Georg Scherneck**

We present a new improved 3D velocity field of the Fennoscandian Glacial Isostatic Adjustment (GIA) process derived from more than 4800 days (13 years) of data at more than 80 permanent GPS sites. We use the GAMIT/GLOBK and the GIPSY/OASIS II software packages for GPS analysis. We compare the results obtained from GAMIT/GLOBK, GIPSY in PPP mode (Precise Point Positioning), and GIPSY with ambiguity fixing. The solution has an internal accuracy at the level of 0.2 mm/yr (1 sigma) for horizontal velocities at the best sites. We present our results both in the ITRF2000 and in the new ITRF2005 reference frames, and discuss the difference in vertical rates associated with the choice of reference frame. Our vertical velocities agree with results derived from classic geodetic methods (tide-gauge, repeated levelling, and repeated gravity observations) at the 0.5 mm/yr level (1 sigma). We also compare the observations to predictions derived from a GIA model tuned to fit the new data and get agreement on the sub-millimeter level. In the presentation, we will address the problem of stability of the geodetic reference frame. This is crucial in a number of key applications, such as when comparing results from space geodetic methods and tide gauges to study sea level change.

Keywords: glacial isostatic adjustment, reference frames, gps

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Oral Presentation****2786****An estimation of the contribution of the S1 thermal tide to Earth rotation****Prof. Aleksander Brzezinski***Dept. of Planetary Geodesy Space Research Centre, Polish Academy of Sciences***Rui M. Ponte, Sergei Bolotin**

The atmospheric thermal tide S1 occurring at exactly the frequency of 1 cycle per solar day causes diurnal variation of the global atmospheric angular momentum (AAM). The corresponding surface atmospheric pressure variation induces mass redistribution in the oceans, the S1 ocean tide, which is also manifested by the diurnal component of the ocean angular momentum (OAM). The S1 signals in AAM and OAM contribute at measurable level to all components of Earth rotation: to nutation - contribution to prograde annual term, with amplitude of about 100 microarcseconds, to polar motion - prograde harmonic with period of 24 hours and amplitude of the order of 10 microarcseconds, and to UT1 - 24-hours harmonic with amplitude of the order of 1 microsecond. Brzezinski et al. (2004, JGR, Vol.109, No.B11, doi: 10.1029/2004JB003054) estimated the S1 contributions to nutation and polar motion using a consistent pair of the subdaily estimates of AAM and OAM. Here we extend this estimation using the available alternative solutions of AAM and OAM with subdiurnal resolution. We also compute the excitation of Earth rotation using the hydrodynamic model of the S1 ocean tide developed by Ray and Egbert (2004, J. Phys. Oceanogr., Vol.34, 1922-1935). The estimated geophysical contributions are compared to the S1 parameters derived from the geodetic observations of Earth rotation. We take into account results following from the continuous observation campaigns - CONT94, CONT02, CONT05, but also our own recent estimates based on the entire set of available VLBI observations (Bolotin and Brzezinski, 2006, Geophys. Res. Abstracts, Vol.8, abstr. EGU06-A-01665).

Keywords: earth rotation, excitation, thermal tide

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Oral Presentation****2787****Gravity change and crustal motion in Dronning Maud Land, Antarctica****Dr. Jaakko Makinen**
IAG**Hannu Koivula, Joel Ahola, Mirjam Bilker-Koivula, Markku Poutanen**

The Finnish Geodetic Institute has made four absolute gravity measurements (1994, 2000, 2004, 2006) at the Finnish Antarctic Research Station Aboa (73 deg 03 min S, 13 deg 24 min W). Two measurements (2004, 2006) have been performed at the South African station Sanae IV and at the Russian station Novolazarevskaya. The work is performed under the auspices of the Finnish Antarctic Research Program FINNARP. In 2003 a continuous GPS receiver was installed at Aboa. It has so far successfully collected three years of uninterrupted data at this summer-only base. Sanae IV has the International GNSS Service site VESL, while at Novolazarevskaya we rely on the SCAR epoch campaigns. In addition, RTK-GPS techniques are used to monitor the close range snow and ice masses that exercise a strong influence on the absolute gravity measurements. The purpose of the work is to detect the gravity change and vertical motion caused by both past and present changes in the ice mass of the Antarctic. We describe the results obtained so far, and discuss the relationship of the point gravity measurements with GRACE observations.

Keywords: antarctica, postglacial rebound, mass balance

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(G) - IAGA - International Association of Geomagnetism and Aeronomy

GS003

Oral Presentation

2788

High-frequent EOP variations from continuous VLBI campaigns

Dr. Rudiger Haas

Department of Radio and Space Science Chalmers University of Technology IAG

The analysis of geodetic VLBI data allows to investigate high-frequency variations in earth orientation and rotation. Results from the three continuous VLBI campaigns CONT94, CONT02 and CONT05 are presented and compared to corresponding model predictions. A model for ocean tidal influences on polar motion and UT1 in the diurnal and semi-diurnal frequency bands explains the observed variations to a large extend. The remaining residuals still show significant signal strength in the diurnal and semi-diurnal frequency bands. However, these residual signals are not identical for the different CONT campaigns.

Keywords: vlbi, high frequency, eop

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Oral Presentation****2789****Initiation of a project in the International Lithosphere Program (ILP):
Upper mantle dynamics and quaternary climate in cratonic areas*****Prof. Markku Poutanen****Department of Geodesy and Geodynamics Finnish Geodetic Institute IAG****Soren Gregersen, Ilmo Kukkonen, Hans-Georg Scherneck***

Preparations are underway for a new ILP project to improve understanding of solid Earth structure and dynamics as well as long-term climatic variations in previously glaciated cratonic areas. We believe that important new insights can be obtained by integrating data and modelling constraints related to a variety of processes and topics. These include glacial isostatic adjustment, heat flow, rheology and composition of crust and mantle, data and models of ice sheet extent and thickness, and field evidence and modelling constraints of palaeoclimate variations. Long and accurate time series and extensive data sets are available. For instance, in the Fennoscandian area there are systematic geodetic observations extending more than 100 years based on repeated precise levelling, as well as more recent observations of surface motion and gravity change during the past few decades. In addition, the longer time series of the dynamic history of this region are available via reconstructions of sea-level changes from the geological record. Recent geological studies have much improved the data base on duration of ice cover during the Weichselian glaciation, also supported by ice sheet modelling. Deep borehole temperatures allow inversion for past ground temperature histories at a variety of times, including the LGM and the Holocene. There are a number of outstanding questions and problems relating to the dynamics, chemical and physical structure and climate history of cratonic areas. We will review some of these and outline a plan for a future multi-disciplinary research program to address them.

Keywords: lithosphere, glacia

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Oral Presentation****2790****Understanding the Azores Triple Junction using Space-Geodetic Observations*****Prof. Rui Fernandes****Computer Sciences UBI, CGUL, IDL IAG****J.M. Miranda, L. Bastos, J. Catalo***

The Azores Archipelago, a group of nine islands in the North Atlantic, was formed due to the temporal evolution of the Triple Junction between three major tectonic plates: Eurasia, Nubia and North America. The divergent boundary between the North American plate and the Eurasian and Nubian plates is well defined by the Mid Atlantic Ridge. However, the boundary between the Eurasian and Nubian plates, which is characterized by a transtensive regime along the Azores region, has been much more difficult to describe. Despite the large number of studies carried out up to the present using single and multidisciplinary approaches, the ambiguity on the present-day location and tectonic regime of the Azores Triple Junction region still exists. In this work, we explore GPS observation campaigns carried out between 1993 and 2006. Since 1999 that a total of 62 sites were added to the initial network (installed in 1988) of nine stations (one per island). This densification was concentrated in the Central Group of the Azores Archipelago. In addition, data from three continuously-operating stations are also available since 2001. Recent observations expanded the time-span and number of data points for a significant subset of our network. This allows us to better constrain the present-day velocity field of Azores and to infer robust estimations of the relative intra- (between the different islands) and inter- (relative to the stable part of the bordering plates) displacements. We investigate the location of the Triple Junction in the Azores using this derived regional GPS velocity field. Geometries based on different segmentations (using geophysical and geological data) of the EurasiaNubia plate boundary were evaluated in order to determine the most reliable configuration. The results favor the present-day location of the Azores Triple Point at the latitude of the Faial Island, which implies a wide band of deformation connecting the Faial and Terceira major fault system alignments.

Keywords: plate boundary, space geodesy, azores

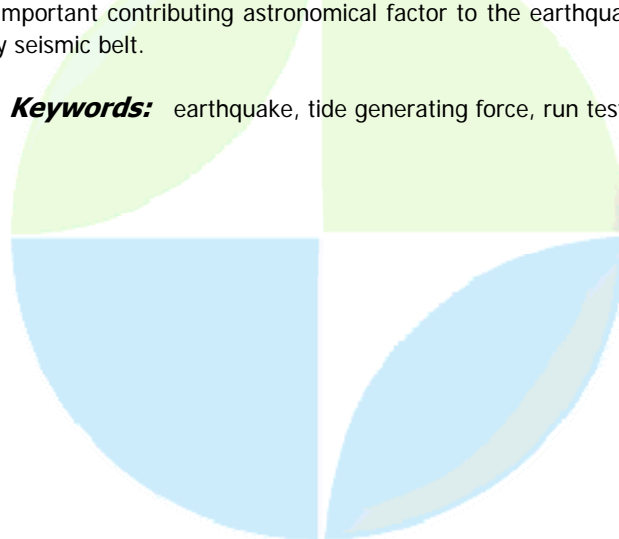
(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2791****Seismicity and monitoring crustal movements in and around Egypt*****Dr. Salah Mahmoud****Department of Geodynamics Prof, President NRIAG IAG*

Studies of crustal movements in Egypt started as early as 1983 following the occurrence of Aswan earthquake in 1981. Several publications were published and presented in local and international meetings. The first program for monitoring the crustal deformation has been started in Kalabsha area (Aswan) during the winter of 1983 with the cooperation between NRIAG, and the Aswan & High Dam Authority. The initial measurements were carried out in December 1984 and repeated twice a year till August 1992. Since the year of 1994 till now, the geodetic observations by means of Global Positioning System (GPS) were applied instead of the terrestrial ones to cover some other regions of the country. These regions include Sinai, Gulf of Suez, Greater Cairo, Aswan and the Middle part on the River Nile. Data adjustment and analysis of the repeated GPS campaigns from the different networks prevailed significant movements which may help in more understanding the geodynamics of these regions. In the meantime, GPS measurements of crustal motions for 189 sites extending east-west from the Caucasus Mountains to the Adriatic Sea and north-south from the southern edge of the Eurasian plate to the northern edge of the African plate were carried out for the period from 1988 till 2003. Estimate of plate motions at stations located at different plates were determined. Besides, earthquake activities and seismo-tectonics of Egypt were discussed based on data from 1900 to 2003. From the previous results, we could find there are some correlations between the computed surface deformation and the earthquake occurrences in Local and regional scales. In the regional scales, the Hellenic arc is the region which shows very well this correlation. While in the Local scales, there are some regions in Egypt such as Sinai, Aswan, Greater Cairo and Middle part of the Egypt around the River Nile. We also use the results of computing crustal deformation by means of GPS in studying the stabilities of any area for the purpose of establishing new strategic project and in planning for the constructions of new cities.

Keywords: gps

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2792****Research on correlation between tide generating forces and global great earthquakes****Prof. Hu Hui***Yunnan Observatory Yunnan Observatory, Academia Sinica IASPEI***Han Yanben, J.Vondrak**

The relation between the tide generating force and all the earthquakes of magnitudes larger than or equal to 7.0 which occurred in the world in 20th century is analyzed by means of the calculation of the tide generating force and the run test in the present article. So called run test is a nonparametric method. A sequence is considered which consists of N observed values of the stochastic variable x . The variable x is divided into two kinds which repel each other, and can simply be expressed with the positive sign (+) and negative sign (-). A run is defined as a sequence of observations of the same kind, before and after which there are the sequences of the distinct kind or no sequence. Let the assumption be that there is no clear tendency in the sequence which consist of N independent observations of the same stochastic variable. By means of the comparison of the observed run number with the region $(r_{n,1-1/2}, r_{n,1/2})$, the assumption can be tested under any required level of significance α , where $n=N/2$. If the run number obtained lies inside this region the assumption is accepted. Otherwise, the assumption is rejected. There were 1940 earthquakes of magnitudes larger than or equal to 7.0 in the whole world in the time interval from 1900.0 to 2000.0. Therefore, for the level of significance $\alpha=0.05$, the acceptance region of the assumption $n=N/2=970$ should lie in the interval (820, 1110). Based on the time of occurrence of the earthquakes and the longitude and latitude of their epicenters, the tide generating force exerted on the epicenters when the earthquakes occur is calculated. It is found from the results of the resultant, vertical component and horizontal component of the tide generating force, the runs at which the earthquakes occur near the extreme and non-extreme values are respectively 1244, 1206 and 702. Evidently, all the runs of the above mentioned three sequences lie outside this region (820, 1110), and therefore the assumption is rejected. In other words, there is an internal link between the occurrence of the earthquakes and the tide force, i.e. the earthquake events relate to the tide generating force. The celestial tide generating force is mainly Lunisolar one and the tide generating force of the Moon is 2.25 times as much as that of the Sun. There exists the period of 18.6 years in the seismic activities in all principal seismic belts and regions of the world, only the phases of the belts and regions are different one from another. The period of 18.6 years is the period of the motion of the lunar node tide. Analyzing the relationship between the two above-mentioned points, we conclude that the lunar node tide is an important contributing astronomical factor to the earthquake-pregnant process of an earthquake in every seismic belt.

Keywords: earthquake, tide generating force, run test

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2793****Research on crustal movement of Tibetan Plateau using repeated GPS measurement****Mrs. Zhou Xiaohui***School of Geodesy and Geomatics Wuhan University IAG***Weiping Jiang**

GPS has been widely applied to monitor crustal motion, and could provide high precision, wide range and quasi-real-time measurement, which makes it possible to obtain crustal velocity field in a relative short time. Since 1993, GPS was used to monitor the movement in Northern Tibet Plateau. We have analyzed all campaign and continuous GPS data collected in Northern Tibet Plateau from 1993 to 2002, using GAMIT/GLOBK software. The approach we applied determines the stations position and velocity vectors in a single, self-consistent reference frame, whereas previous studies used different frames for different surveys and used different fiducial stations for different period surveys. This helps mitigate the effects of changes in the network geometry as a function of time. In the paper we give GPS velocity field and stress field. The conclusions show the Himalayan block is mainly compressing strain, and the maximum compressing rate is $-98.54.24 \times 10^{-9}/a$ and with the extension rate of $26.72.8 \times 10^{-9}/a$ in the direction of N37.10.73E. Its maximum shearing strain reaches up to $62.62.55 \times 10^{-9}/a$, and plane strain up to $-71.85.1 \times 10^{-9}/a$. The middle part of the Tibet block is mainly compressing strain, and the maximum compressing rate is $-20.31.17 \times 10^{-9}/a$ in the direction of N39.031.99E and with the extension rate of $10.81.64 \times 10^{-9}/a$ in the direction of N1291.99E. Its maximum shearing strain reaches up to $15.551.00 \times 10^{-9}/a$, and plane strain up to $-9.52.15 \times 10^{-9}/a$. Both principal compressing strain rate and extension rate trails off from the Himalayan block to the middle part of the Tibet block. GPS height shows that Tibet Plateau ascend rapidly.

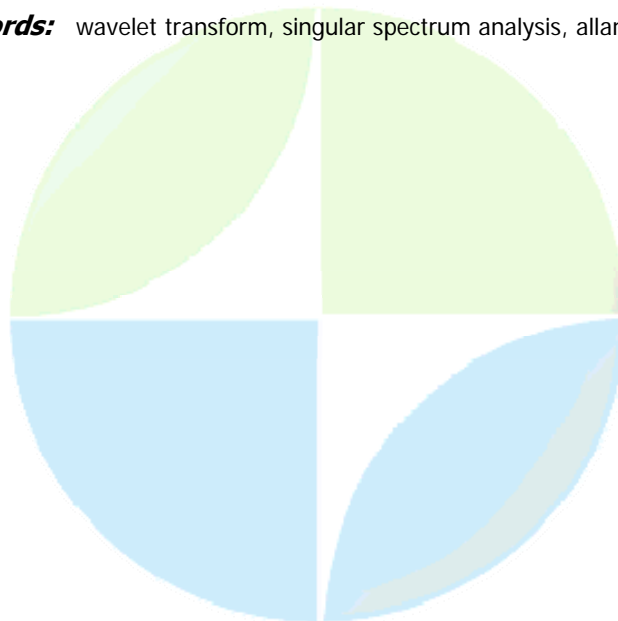
Keywords: gps data processing, gamit globk, crustal deformation



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2794****Analysis methodology of Doris stations coordinates time series****Mr. Sofiane Khelifa***Division of Geodesy National Centre of Spatial Techniques***Boualem Ghezali, Bachir Gourine**

For geodynamic studies, the goal of the analysis of the positions time series of terrestrial stations is to highlight the physical phenomena related to the response of the earth's crust to the various excitations which it undergoes. It is in this context that the topic of this present work is subscribed which aims to elaborate an analysis and diagnosis methodology of stations coordinates time series in order to evaluate the quality of these series (signals and noises). The data used during the processing are the weekly series residual coordinates (dN: Northern component, dE: East component and dH: Vertical component) of DORIS stations in the local reference frame, after removal of ITRF2000 model of positions and velocities. The methodology of adopted analysis includes seven (07) steps: 1. Graphical representation of the original (initial) time series. 2. Data pre-processing: elimination of the aberrant values and regularization of the series (time sampling constant) by a linear interpolation. 3. Identification of the series periodicity (if they are periodic) by the Power Spectral Density. 4. Decomposition of the series in principal components (tendency, periodic component and noise) by Spectral Singular Analysis (SSA). 5. Identification of stationary or non stationary series by tracing their autocorrelation function (correlogram). 6. Determination of noise types of the series by Allan variance. 7. De-noising of the series by wavelet transform. The application of this methodology to the data mentioned previously has permitted to conclude the followings: - A strong correlation between (dN) and (dH) time series relatively to the others combinations (dN, dE) and (dE, dH). This correlation became more significant after the de-noising of the series. - The existence of more or less significant systematic peak at one year in the power spectral density of all series (dN, dE and dH) for the majority of the stations. - The (dN) series for the majority of the stations are periodic, of one year period or less. - The partial variance of the reconstructed principal components of the series (dN, dE and dH) grows after the de-noising, while the eigenvalues corresponding to the noise became nulls. - The majority of the (dN, dE and dH) series are affected by a white noise which means that the data of each series are independents. - The optimal method of de-noising is the soft thresholding.

Keywords: wavelet transform, singular spectrum analysis, allan variance



(G) - IAGA - International Association of Geomagnetism and Aeronomy

GS003

Poster presentation

2795

Normal Modes for Kinematics of A Triaxial Earth

Prof. Wen-Jun Wang

Dept of Geodynamics, School of Surveying and Land Chinese Academy of Sciences

Wenbin Shen, Han-Wei Zhang

The Earth orientation is determined according to Euler dynamical equations as well as Euler kinematical equations. Solving Euler kinematical equations on behalf of multiple solutions of free wobbles and secular wander, three groups of solutions from Euler kinematical equations index that Earth possesses no regular precession but free precessions. The first group of free precessions has 46.46 days periodic precession for Eulers precession angle, 36.44 days periodic nutation for Eulers nutation angle and 30.01 days periodic free spinning oscillation for the rigid Earth case. By this discovery, the 40-50 day oscillations or so-called MJO (Madden-Julian Oscillations) can be clearly claimed possessing free precession background of Earth rotation. Other two groups of free precession solutions also provide detectable variations for the Earth orientation.

Keywords: earth orientation, euler kinematical equations, eulers angles free precession

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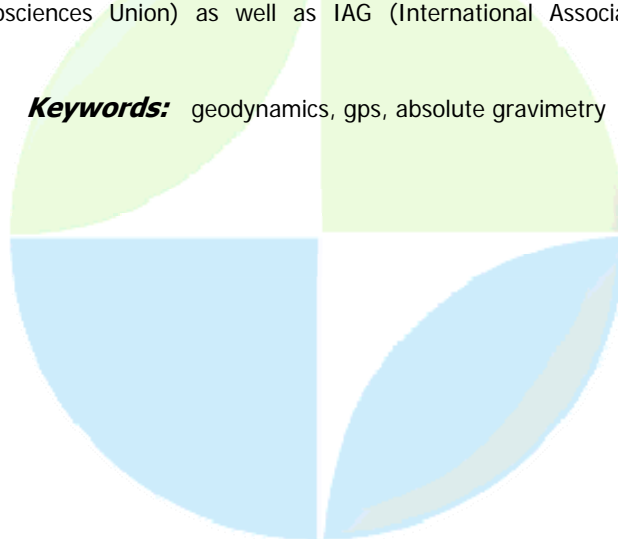
(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2796****Structural-geological and lithospheric factors affecting deformations of the upper crust****Mr. André Gebauer***Applied Geophysics, Institute of Geosciences Friedrich-Schiller-University Jena, Germany IAG***Corinna Kroner, Thomas Jahr**

In the past a number of studies have been carried out in order to determine the magnitude of effects originating from the surroundings of an observation site and influencing seismometer or deformation observations with tilt- or strainmeters. The focus was mostly on thermal, atmospheric, topographic, and cavity effects as well as on ocean loading. Recently, these studies have been continued and extended. On the one hand the topographic influence is systematically investigated with regard to e.g. rock coverage on an observation site, changes in the sloping of a hill flank or width of a valley. On the other hand interest focuses on the effect of local geological heterogeneities such as the occurrence of different lithological units, faults and anisotropic media. Elastic models were developed using the finite element software ABAQUS. The dimension of the models is 5 km x 5 km x 1.6 km. For loading different barometric pressure scenarios are used: a uniform load and a pressure front realised by a step function which moves over the model in different directions. The models base on the broadband stations Moxa, Wettzell, BFO, and Sopron with their different topographies: wide and narrow valley, hill flank, and flat area. At the foot of the hill flank galleries are integrated into the models. For studies of topographic effects on deformation the models are homogeneously parameterised according to PREM. Keeping heights constant an increasing slope angle yields a nonlinear increase in the strain component with a magnitude ranging from -0.03 to 0.90 nstrain and tilt changes between -2.0 and 0.5 nrad for an air pressure load of 1 hPa. For a constant slope angle and increasing height the deformation changes are in the same order of magnitude, but the trends differ for the components. In a next step lithological units (e.g. granite and sandstones) are included in the models. In varying distance of the border between the lithological units and the observation site the largest tilt signal occurs when this distance is small. As expected, with increasing distance the tilt effect decreases exponentially in orthogonal direction to the border. If the observation site is located in sandstone and distance from the border increases the tilt decreases compared to the instruments' locations situated in granite. The signal reduces from 10 msec to 1 msec at a border distance of 750 m for a load of 1 hPa. In a further step the model results will be compared with models for the above-mentioned stations considering their "real" geology and complex topography and with deformations observed at the sites. The results obtained will help selecting future observation sites and will contribute to an improved interpretation of observed deformations with regard to fundamental geodynamic processes.

Keywords: deformation observations, finite element modeling, structural geology

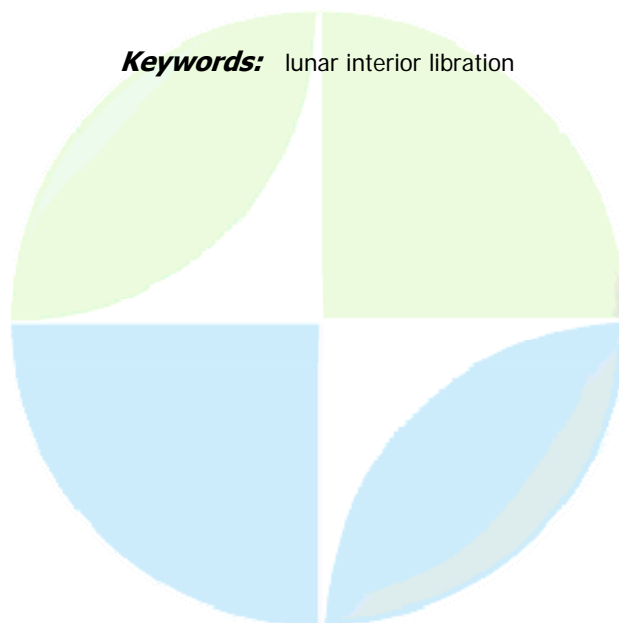
(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2797****Activities of the IAG permanent study group geodynamics of central europe*****Prof. Janusz Sledzinski****Warsaw University of Technology Institute of Geodesy and Geodetic Astronomy IAG*

The presentation includes concise information on recent geodetic and geodynamic projects that are realised by the Permanent Study Group Geodynamics of Central Europe working in the frame of the IAG Subcommission 3.2 Crustal Deformation of the Commission 3 Earth Rotations and Geodynamics. The projects were launched by the CEI (Central European Initiative) WG Science and Technology Section C "Geodesy" and are performed by the teams from 17 European countries assembled in the Section Geodesy. Some projects were financially supported by the European Commission. The wide programme of activities of the WG includes: Regional European programmes: CERGOP (Central Europe Regional Geodynamics Project), CEGRN (Central European GPS Reference Network) Consortium, Post-UNIGRACE action (Unification of gravity system in Central and Eastern Europe); Local geodynamic projects: Eastern Alps and the North and Eastern Adriatic Sea, Romania Plate, Pannonian Basin; Plitvice Lakes, Croatia; Tatra Mountains; Northern Carpathians; Balkan Peninsula; Working Group on University Education Standards; Working Group on Satellite Navigation Systems; Cooperation CEI Section C - European Geophysical Society (EGS)/European Geosciences Union (EGU); The main achievements of the international geodynamic project CERGOP (Central Europe Regional Geodynamics Project) are outlined. First phase of the Project CERGOP was concluded in June 1998 and the second phase CERGOP-2/Environment was realised in 2003-2006 The establishment and maintenance of the Central European GPS Reference Network (CEGRN) consisting of about 85 sites on the territory of 14 countries was performed with an accuracy of 2-4 mm in horizontal coordinates and 4-8 mm in vertical coordinates. Since 1994 eight epoch five-day monitoring satellite GPS CEGRN campaigns were carried out in 1994, 1995, 1996, 1997 (CERGOP-1) and 1999, 2001, 2003 and 2005 (CERGOP-2). Another CEI project UNIGRACE (Unification of gravity systems in Central and Eastern Europe) consisted in establishing seventeen absolute gravity stations covering the area from the Baltic Sea to Adriatic and the Black Sea forming the excellent frame for connection of all national gravimetric networks and providing the unified precise gravity frame in Central and Eastern Europe. Programme was concluded in 2001. The programme of activities of the Section C Working Group on Satellite Navigation Systems and actions realised by the Working Group on University Education Standards are summarised. The close cooperation links between CEI WGST Section C "Geodesy" and EGS/EGU (European Geophysical Society/European Geosciences Union) as well as IAG (International Association of Geodesy) are outlined.

Keywords: geodynamics, gps, absolute gravimetry

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2798****Free libration of the earth-like multi-layer planets****Dr. Alexander Gusev***Geophysics Kazan University, Russia IASPEI*

In many theoretical investigations normal modes of the linearized equations of rotation are computed, yielding both the periods and the eigenvalues of three librations. Libration in longitude decouples from the other two, vertical modes. There is a fast vertical mode (polar motion) with a period very close to the average rotational period. It corresponds to tilting the body around a horizontal axis while retaining nearly principal-axis rotation. In the inertial frame, this mode appears as nutation and free precession. The other vertical mode, a slow one, is the free wobble. The modern view of internal structure of the planet takes into account a complex two- or three-layer model. The three-layer model of a planet is considered: a solid inner core, a fluid outer core and elastic mantle. There are four rotational normal modes in its rotation. This number is reduced to two for a planet without inner core, and to one for a planet without liquid core (Getino, Ferrandiz, 1999; Defraigne et al., 2003). The Hamiltonian analytical method for the calculation of the rotation variations elaborated by Getino (1995) gives frequency magnitudes of these normal modes. They may be derived from governing equations and depend on a presence and on dimension of the inner core within the outer core, of their dynamical ellipticities. All types of modes are result of non-coincidence of inertia axes of mantle, outer and inner core. Calculation of free rotation of the earth-like planet was carried out in the frame of a two-layer model - fluid core and elastic mantle. Periods of Chandler Wobble (CW), Free Core Nutation (FCN) were estimated for the Moon, Mercury, Venus, Earth and Mars. Dependence of the core's parameters - density, radius and ellipticity was modeled using VBA-applications. We have estimated not only parameters of the three-layer Moon (Petrova, Gusev, 2005) but the FCN-period for the two-layer model of the Mercury and the Venus too, taking into account the resonance 3:2 for the Mercury. For instance, for the Mercury the $P_{CW} = 501 - 571$ yr, $P_{FCN} = 472-538$ yr. For the Venus $P_{CW} = 45638-47245$ yr, $P_{FCN} = 1503 - 1596$ yr. Such great value of the CW- and FCN- periods for the planets in comparison with the Earth ($P_{CW} = 433$ d, Lambert, 2006; $P_{FCN} = 430$ d, Herring, 2002) is explained by their slow rotation ($P_{Mercury} = 58$ days, $P_{Venus} = 243$ days) and by the smallness of their ellipticities. Obtained values of periods of CW and of FCN are in accordance with the results of other authors (Peale, 1966, 2002; Rambaux, Bois, 2004; Barkin, 2004).

Keywords: lunar interior libration

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2799****High resolution verification of ocean tide models using kinematic GPS: A case study across the British Isles*****Dr. Nigel Penna****Civil Engineering and Geosciences University of Newcastle upon Tyne IAG****Matt A King, Peter J Clarke, Machiel S Bos, Trevor F Baker***

Geodetic measurements are sensitive to the periodic deformation of the Earth due to ocean tide loading (OTL). Reliable site OTL displacement corrections must therefore be applied in geodetic analysis if the highest precisions and accuracies are to be achieved. The quality of such corrections is largely dependent on the ocean tide model used. Here, we use GPS data from over 15 sites across the British Isles to verify and test different ocean tide models, and to determine the variation in model quality at spatial scales finer than 100 km. This is achieved by processing several years of GPS data from each site in the kinematic precise point positioning mode of the GIPSY/OASIS software. Thus, we obtain coordinate estimates at the GPS data sampling rate, using several different modern ocean tide models in turn. At tidal frequencies, the power spectra of the resulting set of coordinate time series are sensitive to 1-2 mm variations in the OTL displacement corrections applied. These are smaller than the differences between the predicted OTL displacement values from different ocean tide models and therefore provide an indication of the quality of each ocean tide model. The kinematic GPS coordinate sensitivity, coupled with the excellent spatial coverage of continuous GPS sites both regionally and globally, provides encouragement for the continued use of GPS to test ocean tide models at ever finer precisions and spatial resolutions.

Keywords: gps, ocean tide loading, ocean tide models



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2800****Geodetic inversion of fault geometry and slip distribution: A case of co-
/post-seismic study****Dr. Shuanggen Jin***Astro-Geodynamics Center Shanghai Astronomical Observatory, Chinese Aca.Sci IAG***Pil-Ho Park**

The earthquake cycle is poorly understood. Earthquakes continue to occur on previously unrecognized faults. Earthquake prediction seems impossible. Nowadays, space geodetic techniques, especially CGPS, provide crucial data on earthquakes and the seismic cycle. Measuring the response of the Earth to the known shock of an earthquake can provide vital clues to the properties of the Earth's crust. In this paper, we take the MW 6.5 Chengkung earthquake occurred in Taiwan on 10 December 2003 as a case study. The GPS data collected from 18 continuously recording stations and 86 campaign stations are used to model the coseismic and postseismic deformation with the fault model in the elastic dislocation theory. The inferred slip distribution indicates high slip patches near the epicenter. In addition, six months of postseismic time-series are better fit with a logarithmic instead of exponential function, suggesting that the postseismic deformation is possibly controlled by afterslip. The modeled afterslip distribution on the coseismic rupture plane is strongly dominated by reverse slip of the main center of coseismic reverse slip.

Keywords: gps, fault geometry, slip distribution

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2801****Comparison of some datum transformation procedures*****Prof. Christian Ezeigbo****Dept of Surveying And Geoinformatic University of Lagos, Akoka, Lagos IAG****Oyewusi Abimbola M.***

The relationship between two geodetic datums is usually established by determining the set of transformation parameters needed to transform the coordinates of points from one datum to the other. In this study, three transformation models, relating the Nigerian geodetic datum (Minna datum) and the global datum (WGS84) were investigated, using the coordinates of fourteen common points on both datums. The three models, which involve the variations in semi-major axis, the flattening, the shift in the origin of the coordinate system or the variation in the coordinates of the initial point, the rotation about the coordinate axes, and the scale are defined as follows: Model 1: estimates the variations in semi-major axis, the flattening, and the coordinates of the origin of the coordinate axes Model 2: estimates the variations in semi-major axis, the flattening, and the coordinates of the initial point of the geodetic network Model 3: estimates the variations in the coordinate of the origin of coordinate axes, the rotations about the coordinate axes and the scale (k) The set of parameters derived from each model was used to transform the coordinates referred to WGS84 datum to the coordinates referred to Minna datum. The effect of the variations in the number and configuration of the given data set on the estimated parameters was investigated. The stability of each transformation model was also investigated by analyzing the effects of introducing small errors into the observed coordinates used in the estimation of the transformation parameters. The transformation model that gave optimum result based on our investigations was adopted as the optimum transformation model.

Keywords: datum, transformation, coordinates

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GS003

Poster presentation

2802

Present day crustal deformation and plate kinematics in the north-eastern region of India from repeated GPS measurements

Mr. Sunil Sukumaran

GPS Division Indian Institute of Geomagnetism

C.D. Reddy, S.K. Prajapati, M.Ponraj, S. Amirtharaj

The north-eastern region of India is one of the most seismically active collisional plate boundaries in the world, jawed between east-west trending Eastern Himalayan Arc and north-south trending Indo-Burmese Arc. The eastern Himalayan Syntaxis which lies at the junction of above two, where the rotational deformation is accommodated. The adjacent Shillong Plateau, which was the source area of 1897 great earthquake (M 8.7) and east-west trending Dauki fault, which separates the Shillong Plateau to the north and Bengal basin to the south, also contribute towards the seismic complexity of the region. In view of this tectonic importance, to elucidate the characteristic of interplate and intraplate deformations, strain accumulation and rotation rates in the continental plate boundaries as well as the surrounding region, total 5 Global Positioning System (GPS) campaigns were made during the months of November-December from 2002 to 2006. The data were processed using the GAMIT/GLOBK software by constraining the nearby IGS stations and expressed the velocity field in ITRF2000. To obtain better perspective and portraying the localized tectonic activity, the relative velocity in Eurasian, Sunda and Indian reference frames respectively is estimated. To compute the principal strain rate from the horizontal velocity field, we have made the estimates of the velocity gradient tensor from the Delaunay triangular mesh and computed the principal strain tensor at each grid point, using a common least square procedure. Taking into account the direction of principal strain axes, we derived the corresponding rates of shortening and elongation. Since rotation reveals the contribution of plate boundaries and fault zones activeness, rigid body rotation rates also estimated from the velocity gradient tensor. These results are discussed in conjunction with the stress pattern from the earthquakes focal solutions and other geophysical studies.

Keywords: gps, deformation, strain



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2803****Precession and nutation based on LLR observations from 1969 to 2006****Mrs. Wassila Zerhouni**
SYRTE Observatoire de Paris IAG

Lunar laser ranging has many applications in various domains including astronomy, lunar science, geodynamics, and gravitational physics. In the field of geodynamics, this technique provides accurate position angles between various celestial reference systems (ICRS, J2000.0 ecliptic, CIP equator ...) and corrections to the precession nutation model (Chapront et al.2002). In this paper, we present preliminary results on the determination of the precession of the ecliptic and the equator and of the principal terms of nutation, based on LLR observations from 1969 to 2006. This work is based on the principles and methods described in (Chapront et al.2002) which take into account the correlation between the parameters of the lunar orbit and those related to the reference systems and precession nutation.

Keywords: reference systems, earth rotation, lunar laser ranging



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2804****Ocean tide loading effects on GPS positioning around Taiwan*****Prof. Ta-Kang Yeh****Institute of Geomatics and Disaster Prevention Ching Yun University IAG****Ming-Han Chang, Cheinway Hwang, Yuei-An Liou***

Ocean tide loading (OTL) correction can be significant for sites near the oceans, especially in the height direction. The correction increases with decreasing distance to the coasts. The OTL effect varies from one site to another, and magnitude ranges from several to ten centimeters. In this study, six kinds of the OTL models were collected and applied to static relative GPS positioning. GPS observations at more than twenty stations during August 2006 were processed by the Bernese GPS. The average amplitudes of OTL effect are found to be 0.6 cm, 0.9 and 2.0 cm in the north, east and height directions, respectively. For a high-accuracy GPS positioning, the OTL correction must be applied. With OTL, it is expected improve the accuracy and reliability of GPS relative positioning. Moreover, we also analyze the advantage and disadvantage of these OTL models in different environments to provide GPS users in Taiwan with some needed information of OTL for enhancing the precision of the GPS positioning around Taiwan.

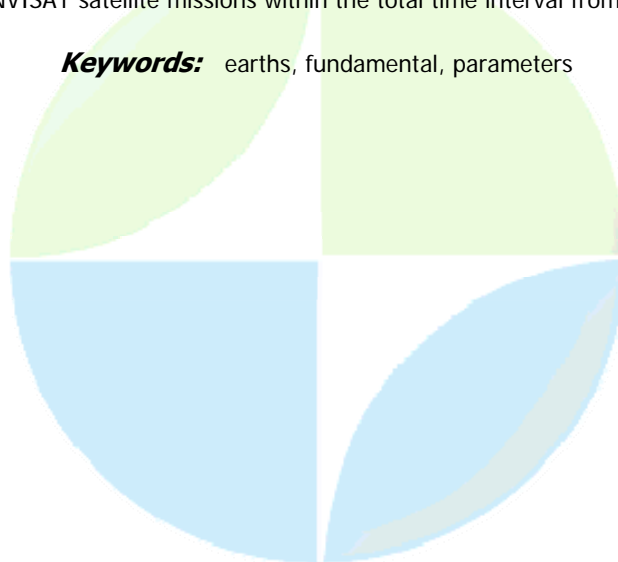
Keywords: gps, ocean tide loading, positioning

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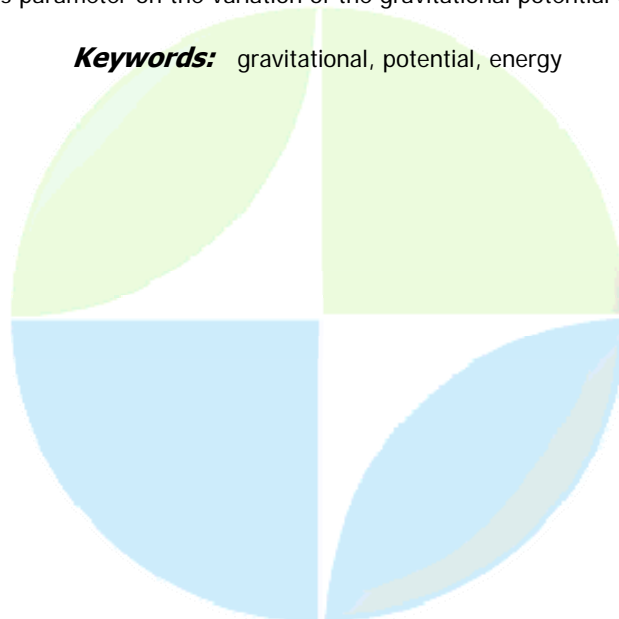
(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2805****Current estimation of the earths mechanical and geometrical parameters****Prof. Alexander Marchenko***Institute of Geodesy National University "Lviv Polytechnic" IAG*

System of the Earths mechanical and geometrical parameters was estimated from the simultaneous adjustment of the 2nd-degree harmonic coefficients of six gravity field models (EGM96, GGM01S, GGM02C, EIGEN-CHAMP03S, EIGEN-GRACE02S, EIGEN-GLO4C) and seven values H_d of the dynamical ellipticity (Williams, 1994; Souchay and Kinoshita, 1996; Hartmann et al., 1997; Bretagnon et al., 1998; Roosbeek and Dehant, 1998; Mathews et al., 2002; Fukushima, 2003) all transformed to common value of precession constant at epoch J2000. In the development of the previous paper (Marchenko and Schwintzer, 2003) the transformation of 2nd-degree coefficients in the case of a finite commutative rotation was derived to avoid uncertainty in the deviatoric part of inertia tensor and used for two adjustments: (1) six sets of geodetic parameters only, and (2) all sets of geodetic and astronomical constants. Thus, these formulae together with exact solution of the eigenvalue-eigenvector problem including a rigorous error propagation are applied to determine (a) static components and accuracy of the Earths tensor of inertia at epoch and (b) secular constituents to provide the time-dependence in the components of inertia tensor. Solution for static components consists of the adjusted five 2nd-degree harmonic coefficients related to the mean figure axis at epoch 2000, the Earths principal moments (A, B, C) of inertia, H_d , the orientation of principal axes, coefficients in the Eulerian dynamical equations, geometrical polar and equatorial flattenings. On the first step the evolution with time in components of the Earths inertia tensor was found from the secular variation in the 2nd-degree zonal coefficient using the condition to conserve changes in the trace of inertia tensor. Hence, the secular change of the above-mentioned static parameters including the dynamical ellipticity and precession constant was estimated. On the other hand, CHAMP and GRACE time series of the 2nd-degree coefficients with a step size of one to three months were applied for the direct computation of temporally evolving components of the Earths inertia tensor. As a result, a remarkable stability in time of the position of the inertia axis A (observed from CHAMP and GRACE) as the parameter of the Earths triaxiality was detected and its numerical value together with secular variation of precession constant can be recommended for the precession-nutation theory, in particular. This consistent set of geodetic and astronomical parameters was supplemented by the mean value of the potential W_0 related to the average world ocean surface and derived from the special processing of SSH altimetry data of the ERS-1, ERS-2, TOPEX/POSEIDON, GFO, JASON-1, and ENVISAT satellite missions within the total time interval from 1992 to 2005.

Keywords: earths, fundamental, parameters

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2806****Earths global density distribution and gravitational potential energy*****Prof. Alexander Marchenko****Institute of Geodesy National University "Lviv Polytechnic" IAG*

The Earths 3D global density model given by the solution of 3D Cartesian moments problem for the ellipsoid of revolution was adopted to preserve in this way the external gravitational potential from zero to second degree/order, the dynamical ellipticity, and the planets flattening f . A rigorous error propagation of this density parameterization was derived. 3D density distribution and accuracy at different depths were found from the Earths fundamental parameters under the conditions to conserve the Earths mass, f , all principal moments of inertia, and radial jumps of density taken from the PREM-model. Comparison of lateral density anomalies with obtained accuracy leads generally to values of the same order in uncertainties and density heterogeneities. Hence, several radial-only 1D density models (continuous and piecewise) were chosen for further determination of the gravitational potential energy E of the Earth: Legendre-Laplace law, Darwins model, Roches law (as solutions of Clairauts equation), Bullards model, and Gaussian (normal) distribution. Relationships for the potential energy E including error propagation were derived from the corresponding expressions for density and internal potential. Further numerical estimations of E according to different density radial profiles lead to the following result: there are two limits for all computed E and given by Rubincam E -values (1979). First one is the homogeneous distribution. Second one is the Gauss radial density law, which in continuous and piecewise cases gives a best agreement with the piecewise PREM-model. Because the solution of 3D Cartesian moments problem was applied to an ellipsoidal planet the corresponding 1D Roches radial density is also treated within the ellipsoid under the conditions to preserve the Earths mass, the mean moment of inertia, and the flattening f . Secular variation in the 2nd-degree zonal coefficient produces certain changes in the dynamical ellipticity and other parameters of this radial law of density of the ellipsoidal Earth. Spherically symmetric distribution is not sufficient: usual Roches law and other above-mentioned models are not responsible for this variation. Therefore, the ellipsoidal Roches model provides the time-dependence in the density distribution and can be used for the estimation of the dynamics of the Earths interior. As a result, the contribution of temporal change in the Earths 3D and 1D density coming from temporal variation in the 2nd-degree zonal coefficient is considered for different layers. Influence of this parameter on the variation of the gravitational potential energy was estimated.

Keywords: gravitational, potential, energy

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2807****Contribution of the GPS networks as the new infrastructure for investigations of Dinarides*****Mrs. Medzida Mulic****Geodesy Civil Engineering Faculty -University of Sarajevo IAG****Spec. Sc. Eldin Donlagic, Prof. Dr. Sc. Asim Bilajbegovic***

As in all European countries, the several GPS campaign carried out for the realization of the new reference frame. Since 1998, when 13 points were observed during EUREF Balkan GPS campaign for the widening of EUREF, several GPS campaign carried out. So, in the frame of BIHREF 2000 GPS campaign, about 30 stations were observed. During CEGRN 05 GPS campaign 15 stations were re-observed. Permanent station in Sarajevo established in 1999, and is a member of CEGRN and EPN networks. Valuable geodetic data for geodynamical investigation of the very interesting area of Dinarides and Adriatic micro-plate are available. Several new geological maps (with additional seismological, geomorphologic and geo-tectonics data) of area published, enabling new investigation of this very active geotectonic region. The local project: "Investigations on the terrain deformations caused by exploitation of the mine of salt in town Tuzla "will be discussed. However, the exploitation of the salt water from the ground, during the several last centuries, caused so strong terrene deformations, that the center of old town Tuzla destroyed. Even today, new parts of town are still experiencing deformations. The deformations were observed by geodetic precise observations since 1950. The deformations will be observed by precise GPS observations in combinations with precise leveling and other classical measurements from this year. Bosnian and Herzegovina Positioning System BIHPOS is in the process of establishing. Data from this active network BIHPOS together with the passive networks will present the valuable data set for the investigations of the Dinarides area, as well as for the Adriatic micro-plate and Mediterranean area. It represents good geodetic infrastructure for the multinational and multidiscipline projects requiring precise geo-referencing e.g. three-dimensional and time dependent positioning, geodynamics, precise navigation, geo-information data. Some results and applications of GPS networks will be discussed in this paper.

Keywords: gps, deformation

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2808****Active fault segments and block movement in Sichuan-Yunnan Region
from joint inversion of GPS and gravity data*****Prof. Caijun Xu****School of Geodesy and Geomatics Wuhan University IAG****Yuning Fu, Hui Li***

Sichuan-Yunnan region (China) or the study area lies in the southeastern part of the Qinghai-Tibet Plateau. Tectonically the study area falls in one of the most seismically active regions of the China mainland, which is well known globally for its high proneness to frequent high magnitude (M) earthquakes. Historically the area has suffered more than ten strong earthquakes ($M > 7.0$), with some being of even greater magnitude ($M > 8.0$). Based on four factors, namely: i) the concept of active crustal blocks (Zhang 1999); ii) spatial distribution of historical earthquakes; iii) surface ruptures; and, iv) major and subordinate active faults, Sichuan-Yunnan region had been divided into four 1st-order blocks. These blocks are namely, the Markang block (I); the Sichuan-Yunnan rhombic block (II); Baoshan-Puer block (III); and Mizhina-Ximeng block. The Sichuan-Yunnan rhombic block bounded by the Xianshuihe-Xiaojiang, Red River, and Jinshajiang fault systems is usually considered as a tectonic terrane, called the Sichuan-Yunnan fragment (Li and Wang 1997; Wang et al. 1998). Cut by sub-ordinate NE-trending active faults, the Sichuan-Yunnan rhombic block (II) can be further divided into two sub-blocks: the northwestern Sichuan sub-block (II1) and the middle Yunnan sub-block (II2), while the Baoshan-Puer block (III) can be further divided into three sub-blocks: Baoshan sub-block (III1), Jinggu subblock (III2), and Mengla sub-block (III3). The northwestern of Sichuan sub-block is mainly enclosed by Ganzi-Yushu-Xianshuihe Fault system (which forms the northern boundary), Li Jiang-Xiaojinhe Fault system (the southern boundary), and Jinshajiang Fault (which forms the western boundary). The middle of Yunnan sub-block is mainly a triangular area, which is enclosed by Li Jiang-Xiaojinhe Fault system, Annihe-Xiaojiang Fault and Red River Fault. It must be noted that these fault systems which are seismically active at present, play a crucial role in the kinematic and geodynamic models of the Sichuan-Yunnan region. There are more than 200 GPS observation stations in Sichuan-Yunnan region. We use the high precision GPS observation result from 1991 to 2004, and jointly use the gravity data (from 1985 to 2004) to invert and analyze the tectonic deformation in Sichuan-Yunnan rhombus block in this paper. In the inversion, the rational matching between GPS and gravity data is discussed, and the relative weight ratio is determined by variance component estimation method; besides, the current kinetic parameters of active Xianshuihe Fault, Honghe Fault, Jianchuan Fault and other faults, the northwestern Sichuan sub-block, The middle of Yunnan sub-block and other blocks are joint inverted by GPS velocity data and gravity segment difference data concerning the movement of both fault and block; in addition, the movement status of current active faults and blocks in Sichuan-Yunnan region the relationship between the faults and active blocks interaction and earthquake are also discussed

Keywords: active fault, block movement, sichuan yunnan region

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2809****Comparison between Bernese 5.0 and Gipsy/Oasis II PPP solutions: Case study on ocean loading in Brittany, Northwest France****Mr. Stphane Durand**

IAG

Laurent Morel, Jolle Nicolas-Duroy

Brittany, in the North-West part of Europe, is particularly suited for studying ocean loading effects. Indeed, in this region, ocean tides can reach up to 10 m and induce crustal displacements up to 12 cm peak-to-peak on the vertical component and cm-level displacements on the horizontal components. In order to study ocean loading in Brittany, GPS data were acquired in 2004, in the framework of a French national multi-techniques campaign. In order to study ocean loading with GPS data, one needs to process the GPS data using short time sessions (1hr or 2hr sessions). Such processing strategy can be achieved using double difference scheme and using several scientific software, namely the Gamit/Globk package, the GINS software (French scientific software), the Gipsy/Oasis II package or the Bernese software. In this contribution, we compare and analyse the GPS results obtained from two GPS processing software with Precise Point Positioning capabilities: Gipsy/Oasis II and Bernese 5.0. In the first part of this contribution, we present the processing strategy used in both software and the results, in term of GPS time series, obtained from each software. In the second part, we compare these GPS time series, in term of ability to observe the main tides of the ocean loading signal, and try to explain the discrepancies between the software in the processing scheme.

Keywords: ppp, gps, ocean loadingPERUGIA
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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2810****Second order Poisson terms in the non-rigid Earth nutation theory*****Prof. Veronique Dehant****Time, Earth Rotation, and Space Geodesy Royal Observatory of Belgium IAG****Marta Folgueira, Nicolas Rambaux, Sebastien B. Lambert, Veronique Dehant***

The tidal potential generated by bodies in the solar system contains Poisson terms, i.e., periodic terms with linearly time-dependent amplitudes. The influence of these terms in the Earth's rotation, although expected to be small, could be of interest in the present context of high accuracy modeling. We have studied their contribution in the rotation of a non rigid Earth with elastic mantle and liquid core. Starting from the Liouville equations, we computed analytically the contribution in the wobble and showed that the presently-used transfer function must be supplemented by additional terms proportional to the amplitude of the Poisson terms of the potential and inversely proportional to $(\sigma - \sigma_n)^2$ where σ is the forcing frequency and σ_n are the eigenfrequencies associated with the retrograde free core nutation and the Chandler wobble. In addition to the analytical computation, we used a time-domain approach through a numerical model to examine the core and mantle motions and compared to the analytical results.

Keywords: earth rotation, nutation, poisson term

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2811****Electromagnetic core-mantle coupling torques for different magnetic field models and core velocity fields****Dr. Jan M. Hagedoorn***Department 1: Geodesy and Remote Sensing GFZ Potsdam***H. Greiner-Mai, L. Ballani, I. Wardinski**

The electromagnetic (EM) core-mantle coupling torque is commonly split into a poloidal and toroidal part for its determination. The main reason for this splitting is the related splitting of the magnetic field, where the poloidal part only is observable outside the Earth. We use in this study two different magnetic field models, based on satellite and observatory measurements. For the toroidal part of the magnetic field and also for the toroidal part of the EM coupling torque it is necessary to use additional constraint, which is in our case a core velocity field at the core-mantle boundary (CMB). This is a result from fluid-flow inversion and is used here as an input data. In the first part we derive the poloidal and toroidal EM coupling torques for any divergence free velocity field at CMB. For the determination of the toroidal part of the magnetic field we consider the same conductivity model for the mantle as it is used in the non-harmonic field continuation of the poloidal part of the magnetic field. In the second part we compare all three components of the EM coupling torque for different magnetic field models and velocity fields. The poloidal magnetic field is determined at CMB by a non-harmonic field continuation through conducting mantle shells (Ballani et al., 2002). The velocity field at CMB is either given by a simple core drift (only u_ϕ component differs from zero) or by the velocity field, which was obtained from fluid flow inversion (Wardinski, 2004; Wardinski & Holme, 2006). References Ballani L., Greiner-Mai H. and Stromeyer D., 2002. Determining the magnetic field in the core-mantle-boundary zone by non-harmonic downward continuation. *Geophys. J. Int.*, 149, 374-389. Wardinski I., 2004. Core Surface Flow Models from Decadal and Subdecadal Secular Variation of the Main Geomagnetic Field. *Sci. Techn. Report. GFZ Potsdam, STR 05/07.* Wardinski I. and Holme R., 2006. A time-dependent model of the earth's magnetic field and its secular variation for the period 1980 to 2000. *J. Geophys. Res.*, 111, doi:10.1029/2006JB004401.

Keywords: core mantle coupling, electromagnetic torques

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2812****Mantle dynamics and Length of Day variations****Prof. Marianne Greff***Institut de Physique du Globe de Paris Institut de Physique du Globe de Paris IAG***Helene Rouby**

The geological evolution of the Length of Day (LOD) variations is mainly controlled by the frictional tidal torque responsible for the secular deceleration of the Earth rotation velocity and for the removal of the Moon. Superimposed to this variation existing from the early history of the planet, there are, at shorter time-scale (less than one Myr), LOD perturbations induced by the glaciation-deglaciation cycles. Here we investigate the influence of the mantle dynamics on the LOD at the geological time-scale. In particular we compute the effects induced by upwelling domes and subducted plates sinking into the mantle. We have already shown, using the equations governing the rotational dynamics of a viscous planet, that these internal mass redistributions involve geological variation in the orientation of the rotational axis with respect to a fixed terrestrial frame (the so-called True Polar Wander). Here, we use the same non-linear equations to compute the influence of these mantle density heterogeneities on the velocity of the rotation, that is to say on the LOD.

Keywords: rotation, mantle dynamics, length of day

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2813****The influence of earth tides on the intermediate depth seismic activity in the Vrancea zone, reflected through the periodicity of earthquake parameters: implications to seismic hazard estimation****Mrs. Nicoleta Cadicheanu***Natural Hazards Institute of Geodynamics of the Romanian Academy IASPEI***Michel Van Ruymbeke**

We examined the influence of earth tides on the intermediate depth seismicity in the Vrancea zone (Romania), by observing specific tidal & climatic periodicities in the modulation tendencies of earthquake parameters. We used the ROMPLUS catalogue of the National Institute of Earth Physics, Bucharest, which contains nearly 3250 events, between 1976-2005, with a magnitude larger than 2.5 on the Richter scale. Gravitational variations induced by motions in the gravity gradients of the Moon and the Sun, which induced earth-tide can be developed from the astronomical orbital parameters, in a series of components defined by their periods with a very high degree of accuracy. So it becomes possible to apply principle of stacking method analysis. We select for this work, the HiCum approach developed at Royal Observatory of Belgium and included in the MGR software. It is a useful tool for determining whether earth-tides are related with any geophysical parameters like occurrence, latitude, longitude, depth and magnitude. ROMPLUS catalog provides a long series of timed events and is therefore suitable for analysis using HiCum method. We were able to compare, for selected earth-tides component, the influence they may have. We statistically tested the level of confidence of the results by different methods adapted to each case. We used permutation and bootstrap tests with random sampling of the data, as well as the Schuster and chi-square tests, which are based on theoretical models of the distribution of parameter values. We found several intervals in which certain earth tide components correlated with seismic events at the 95% confidence level. Relative strong earthquakes ($M_w > 5.0$), August 30, 1986 ($h=131$ Km, $M_w=7.1$), and May 30, 1990 ($h=91$ Km, $M_w=6.9$), occurred during these intervals. This result suggests that the mechanism of coupling between a certain earth tide component and the earthquake, acts as a critical condition for the focal area. We assume that every seismic region is characterized by an energetic model with a stable component E0 and a variable part dE as the result of the action of different geophysical fields, which consist principally in climatic & gravitational variations. Among these at the hypocentre levels, the role of the gravitational field variations is predominant. Its systematic variations are controlled by the lunar-solar attraction forces on every terrestrial point through the precisely defined periods of the earth-tides. Local and regional heterogeneities lead to a different response from a zone to another in accordance with the geological and tectonic characteristics of each zone. This response is also influenced by the regional characteristics of the mantle-crust interface, probably associated with a viscous coupling mechanism. All these aspects are important in the seismic hazard evaluation. Our results are interpreted on these assumptions.

Keywords: earth tides, hicum method, vrancea zone

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2814****Geocenter motion and its geodynamical contents****Dr. Zotov Leonid***Laboratory of Gravimetry Sternberg Astronomical Institute IAG*

The comparative spectral analysis of the geocenter coordinates series was performed. Data sets from JPL GPS (3000 points 1993-2007 yrs.), JPL DORIS (727 points 1993-2006 yrs.), and ILRS LAGEOS (~100 points 1992-2000 yrs) were used. Singular spectral analysis was applied to extract main components and to remove the noise. Spectral components were detected in the low-frequency, Chandler, annual, semiannual, 4-months, 1-months and high-frequency bands at the millimeter and submillimeter levels. Amplitudes of the components in the DORIS and ILRS series were found much bigger than in the GPS data. Parameters of the linear trend of the geocenter motion were derived, they differ sufficiently depending on the data sets. Investigation was also performed in the spherical coordinates. The changes of the radius-vector (R), latitude (Q) and longitude (L) projections were studied and their Fourier analysis performed. With use of the new Fourier-aggregation technique 17 most reliable harmonics of the geocenter variations were detected for all the three components. For Z-component they have periods in days: 2389 (2403; 9.92 mm), 551 (515, 592; 6.99), 358 (365; 25.04), 175 (172; 5.38), 119 (122; 13.60), 107 (100, 113; 3.36), 88 (90.7; 6.18), 70 (69.8; 9.80), 59 (60.1; 6.65), 50 (50.4; 5.60), 39 (40.4; 5.61), 38 (38.1; 0.84), 32 (30.5; 1.44), 26 (27.4; 0.80), 21(-;0.37), 20 (19.4; 0.16). In the brackets the periods predicted by the geodynamical Earth layers excitation theory (Barkin, 2002) and amplitudes are given. According to the theory, detected periods of variations are observed in many processes in the nature. Investigation of the geocenter epicenter on the Earth surface was performed. The regions of avoidance, for which the amplitudes are small, and the regions with sufficient amplitudes of the geocenter oscillation were found. Particularly, for JPL GPS data these are 90 and 270 longitude zones of the preferable motion. The concentrations of the displacements are observed close to the Gudzone pole (and the opposite pole) of the lithosphere reference system (LRS), which was derived during the investigation of the plates motion (Barkin, 2002). The concentrations of the epicenters according JPL DORIS were found at the equator of the LRS in two opposite points (Brazil and Eastern China). This direction is well-known in geophysics and characterizes the constant displacement of the Earth core in the direction of Brazil and its swinging under the influence of the Solar and Lunar gravitational forces (Barkin, 2002). References Barkin Yu.V. (2002) Explanation of endogenous activity of planets and satellites and its cyclicity. *Izvestia cekzii nauk o Zemle. Rus. Acad. of Nat. Sciences*, Issue 9, M.: VINITI, pp. 45-97. In Russian.

Keywords: geocenter motion, geodynamics, singular spectral analysis



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2815****To an explanation of secular changes of ocean surface****Prof. Yury Barkin***Laboratory of Gravimetry Sternberg Astronomical Institute IAG*

Velocity of secular change of ocean level is the certain function of a latitude and a longitude of a point of observation. As a result of data processing about linear trends of ocean level, obtained at 655 gauge stations distributed worldwide (the data of measurements basically for 20 century) on a method of the least squares, this velocity has been presented as standard series on spherical functions of latitude and longitude. Coefficients A_{nm} , B_{nm} ($n=1, 2$) of these series have been determined only for first and second harmonics (Nakiboglu, Lambeck, 1991). On the other hand the surface of ocean coincides with a surface of geoids and, changes of this surface are determined by the corresponding variations of geopotential. On a basis of specially developed point model of the slow and directed redistribution of masses of the Earth (Barkin, 2001), secular variations of all coefficients of the first, second, third and fourth harmonics of geopotential C_{nm} , S_{nm} ($n=1,2,3,4$) for the first time have been evaluated. The model represents the system of two material points with masses m_2 and m_1 , located on the Earth surface at the poles of geocentric axis OP (its pole P in northern hemisphere has coordinates 70.0 N, 104.3 E). Masses of both points increase linearly with velocities 0.179×10^{15} kg/yr and 0.043×10^{15} kg/yr. On our geodynamic model an identical drift of the outer core of the Earth relatively to elastic mantle in same northern direction (Barkin, 1995, 2001) corresponds to the secular drift of geocenter. It leads to slow redistribution of atmospheric and oceanic masses from the southern hemisphere in northern hemisphere. Variations of coefficients J_2 , J_3 and J_4 of the second, third and fourth zonal harmonics will well be coordinated to their values obtained by methods of a satellite geodesy on laser observations in last approximately of 25 years (Cheng et al., 1997). Coefficients of tesseral harmonics have been evaluated for the first time (Barkin, 2001). The offered model will precisely be coordinated with data of the space geodesy about secular drift of a geocenter in the direction of mentioned pole P (Gayazov, 2003), and also completely explains not tidal acceleration of rotation of the Earth and secular drift of its pole. It has formed the basis for determination of coefficients A_{nm} , B_{nm} ($n=1, 2$) actually on the basis of the space data and the offered model of redistribution of masses of the Earth and their comparison with the "sea" data. Under the static theory of tides between the mentioned above factors simple relations take place: $A_{nm} = RC_{nm}$ and $B_{nm} = RS_{nm}$. Therefore the important possibility for comparison of the results obtained by both especially "sea" methods, and space geodesy methods here is opened. We can make similar comparison only with one model of variations of ocean surface (Nakiboglu, Lambeck, 1991). The certain conformity between theories takes place, that it is well visible in values of Nakiboglu and Lambeck coefficients (with errors) and in model coefficients (they are in brackets): $A_{10} = -0.24 \pm 0.52$ (-1.36); $A_{11} = 0.12 \pm 0.47$ (0.12); $B_{11} = -0.42 \pm 0.45$ (-0.48); $A_{20} = -1.92 \pm 0.56$ (-1.95); $A_{21} = -0.01 \pm 0.30$ (0.19); $B_{21} = -0.70 \pm 0.30$ (-0.74); $A_{22} = 0.08 \pm 0.13$ (0.08); $B_{22} = 0.17 \pm 0.14$ (0.07). Coefficients in brackets have been determined on the base of secular variations of coefficients of geopotential under formulas: $-10C_{nm}$ and $-10S_{nm}$ ($n=1,2$). It means that the gravitational method based on our model, gives in 10 times smaller values for velocities of variations of the ocean surface (moreover with the opposite tendency of changes), than by calculations on the data of gauge stations. The origin of appeared factor -10, and also some difference in numerical values of factor A_{10} will need the additional analysis. Values of coefficients are given per one mm/yr. Secular variations of coefficients of the third and fourth harmonics of a geopotential on the basis of presented here point model of redistribution of masses of the Earth have been evaluated (Barkin, 2001). Referenses Nakiboglu S.M. and Lambeck K. (1991) Secular sea-level change. In: Glacial Isostasy, Sea-Level and Mantle Rheology (Eds. R. Sabadini et al.) Kluwer Academic Publishers. p. 237-258. Barkin,

Yu.V. (2001) Explanation and prediction of the secular variations of the Earth rotation, geopotential, force of gravity and geocenter drift. Proceedings of International Conference "AstroKazan-2001". Astronomy and geodesy in new millennium (24-29 September 2001), Kazan State University: Publisher "DAS", pp. 73-79. Cheng M.R., Shum C.K. and Tapley B.D. (1997) Determination of long-periodic changes in the Earth's gravity field from satellite laser ranging observations. Journal of Geophysical research, V. 102, No. B10. pp. 22377-22390.

Keywords: secular surface variations, level sea trend, core drift



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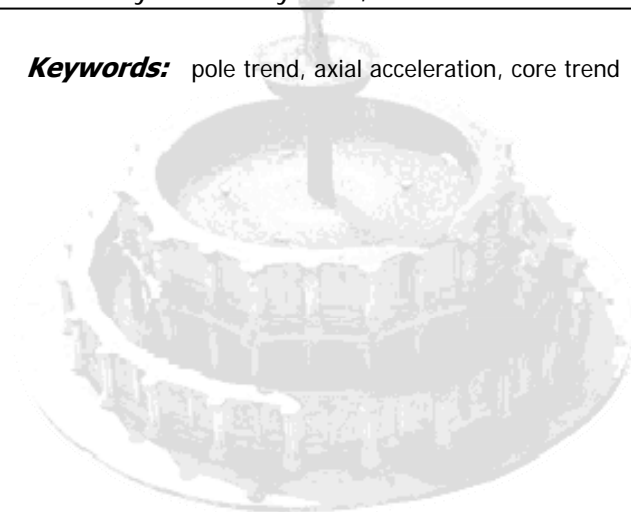
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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2816****To an explanation of non-tidal acceleration of the Earth diurnal rotation and secular trend of its pole****Prof. Yury Barkin***Laboratory of Gravimetry Sternberg Astronomical Institute IAG*

The problem of non-tidal acceleration of axial rotation of the Earth is discussed more than 100 years. The most exact determinations of this acceleration were made in work of Stephenson and Morrison (1995) on the basis of the data on observations of antique eclipses of the Sun for 2700 (700 BC-AD 1978). The ratio of positive acceleration of the Earth rotation $\dot{\omega}$ to its angular velocity ω makes $\dot{\omega}/\omega = (6.9 \pm 1.7) \times 10^{-11}$ (1/yr) (Stephenson, Morrison, 1995). The explanation of secular drift of a pole also represents rather old both not solved and actual problem. On the modern data the pole of an axis of rotation of the Earth is displaced along a meridian 72.9 W with angular velocity of 0.331 ± 0.003 seconds of an arch for hundred years (Gross, Vondrak, 1999). Ratios of variations of the equatorial components of angular velocity of the Earth thus make: $\dot{p}/\omega = 395 \times 10^{-11}$ 1/yr, $\dot{q}/\omega = -1548 \times 10^{-11}$ 1/yr. A secular variation of coefficients of the second zonal harmonic of a geopotential: $\dot{d}J_2 = -3.07 \times 10^{-11}$ 1/yr it has appreciated on the basis of laser observations of satellites (Cheng, Tapley, 1997). For an explanation of the specified secular variations in our work it is used the point asymmetric inversion model of secular redistribution of masses of the Earth, which is characterized by a general direction along the geocentric axis OP directed to the pole P with geography coordinates 70 N, 104.3 E (Barkin, 2001). The model represents the system of two material points with masses m_2 and m_1 , located on surfaces of the Earth at poles of geocentric axes OP. Masses are changed linearly in the time with velocities: 0.179×10^{15} kg/yr and 0.043×10^{15} kg/yr. On our geodynamic model the secular drift of a geocenter is a simple reflection of identical drift of the Earth core relatively to elastic mantle in same northern direction (Barkin, 1995, 2001). That results to slow secular redistribution of oceanic and atmospheric masses from a southern hemisphere to northern hemisphere. The space geodesy data confirm the predicted direction of secular displacement of the centre of mass of the Earth to a point with geographical coordinates 72.7 N, 115.4 E with velocity about 6 mm/yr (Gayazov, 2003). On the basis of the given model we have obtained analytical formulas for secular variations of coefficients of the second harmonic of a geopotential on which the following values of velocities of secular changes of the mentioned parameters have been obtained (1 unit = 10^{-11} 1/yr): $\dot{d}J_2 = -3.06$, $\dot{d}C_{21} = -0.294$, $\dot{d}S_{21} = 1.155$, $\dot{d}C_{22} = -0.095$, $\dot{d}S_{22} = -0.052$. For the acceleration of axial rotation of the Earth we have $\dot{\omega}/\omega = 6.19$ and for the components of secular drift of the Earth pole we have obtained values: $\dot{p}/\omega = 388$, $\dot{q}/\omega = -1505$. References Stephenson, F.R. and Morrison, L.V. (1995) Long term fluctuations in the Earth's rotation: 700 BC to AD 1990, Phil. Trans. R. Soc. Lond., A, 351, p. 165-202. Gross R.S., Vondrak J. (1999) Astrometric and space-geodetic observations of polar wander. Geophysical res. Ltrs/ 1999GL900422, Vol. 26, No. 14, p. 2085. Barkin, Yu.V. (2001) Explanation and prediction of the secular variations of the Earth rotation, geopotential, force of gravity and geocenter drift. Proceedings of International Conference "AstroKazan-2001". Astronomy and geodesy in new millennium (24-29 September 2001), Kazan State University: Publisher "DAS", pp. 73-79. Cheng M., Tapley B.D. (2004) Variations in the Earth oblateness during the past 28 years. Journal of geophysical Research, V. 109, B09402, pp. 1-9. Cheng M.R., Shum C.K. and Tapley B.D. (1997) Determination of long-periodic changes in the Earth gravity field from satellite laser ranging observations. Journal of Geophysical research, V. 102, No. B10, pp. 22377-22390. Gayazov I.S. (2003) Variations of C_{21} , S_{21} geopotential coefficients from SLR data of Lageos satellites. Proceedings of International conference "Astrometry, Geodynamics and Solar System Dynamics: from milliarseconds to microarcseconds". Journees 2003 (September 22-25, 2003, St. Petersburg, Russia). St. - Petersburg. pp. 193-202.

Keywords: pole trend, axial acceleration, core trend



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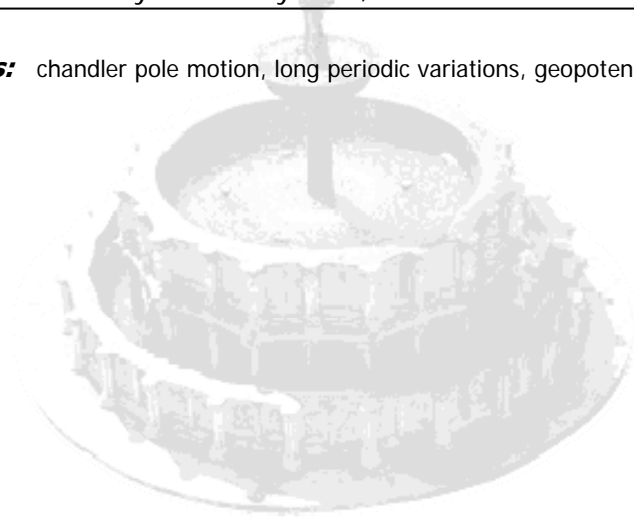
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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2817****Chandler amplitude and phase decade oscillations of the Earth pole and corresponding variations of geopotential coefficients C21 and S21****Prof. Yury Barkin***Laboratory of Gravimetry Sternberg Astronomical Institute IAG*

A dynamic explanation and an analytical description of observable decade variations of amplitude, period and phase of Chandler perturbed motion of the Earth pole (Ach, Tch and Fch) is given. It has been shown, that observable Chandler motion of the pole has the forced character (Barkin, 2000). The basic role in excitation of pole motion and in maintenance of the basic oscillation with the periods about 430 days play variations of products of inertia of the Earth with the periods close to unperturbed Chandler pole motion. According to developed geodynamic model (Barkin, 2002) the forced oscillations of system of outer core and elastic mantle (and, accordingly, the displacements of the centre of mass of the Earth) under gravitational attraction of the Moon and the Sun are characterized by known frequencies of orbital motions of system the Earth - the Moon - the Sun (or by some combinations of these frequencies). The same frequencies characterize variations of the tension of the mantle layers, cyclic redistributions of masses of atmosphere, oceanic masses, subsoil waters and other fluids. These processes determine corresponding variations of the moments of inertia and geopotential coefficients which obtain dynamic reflection in axial rotation of the Earth and in its pole motion. The specified positions have obtained a set of confirmations according to astronomical, geodetic and geophysical observations. In the given work it is shown, that perturbations of the Earth system on the part of the Moon and the Sun with frequencies from a vicinity of Chandler unperturbed frequency and its double value lead to decade perturbations of parameters Ach, Tch and Fch. The analytical description is given to the specified perturbations on the basis of the special form of the equations of rotary motion in Andoyer variables for weakly deformable bodies (Barkin, 2000). Let's result the periods of orbital perturbations of the Moon to which there correspond translational oscillations of the core and elastic mantle (the last determine decade changes of amplitude and phase of perturbed pole motion): 411.8 d [40.7 yr], 409.2 [33.06 yr], 205.9 d [20.3 yr], 388.3 d [12.78 yr], 386.0 d [11.92 yr], 199.8 d [9.67 yr], 365.3 d [7.27 yr], 346.6 d [5.22 yr], 329.8 d [4.08 yr], 182.6 d [3.63 yr], 177.8 d [3.04 yr], 173.3 d [2.61 yr]. In square brackets theoretical values of the decade and interannual periods of perturbations in amplitude and a phase are given. Close values of the periods of perturbations in envelopes of pole coordinates are revealed on the basis of the data of observations (Kolaczek, Kosek, 1998; Nastula et al., 1993; Lapaeva, 2000; Vondrak, 1999 etc.). The predicted variations in position of a geocenter with the mentioned above periods (in days) have obtained confirmation as a result of the spectral analysis of coordinates of a geocenter, and also in variations of coordinates of the Earth pole. In particular the perturbations with periods (in days) were revealed: 217.11.1, 196.1 1.1, 367.60.8, 344.22.0, 317.02.2, 183.60.6, 175.22.0, 173.50.4 and others (Kaftan et al., 2003; Gayazov, 2003). On the basis of analytical formulas for amplitudes of variables: Ach, Tch and Fch on the data on observable decade variations of amplitude and phase Chandler amplitudes and phases of the appropriate variations of products of inertia of the Earth and factors of geopotential C21, S21 have been determined. Amplitudes have values about $0.2-0.5 \times 10^{-10}$, that proves to be true the data of satellite laser observations (Gayazov, 2003). References Barkin, Yu.V. (2000a) Perturbated rotational motion of weakly deformable celestial bodies. *Astronomical and Astrophysical Transactions*, Vol.19, Issue 1, pp. 19-65. Barkin, Yu.V. (2000b) A mechanism of variations of the Earth rotation at different timescales. In: *Polar Motion: Historical and Scientific Problems* (Eds. Steven Dick, Dennis McCarthy, and Brian Luzum)/ *Proceedings of IAU Colloquium 178* (Cagliari, Sardinia, Italy, 27-30 September 1999). *Astronomical Society of the Pacific conference series*, V. 208. Sheridan Books, Chelsea, Michigan. pp. 373-379.

Keywords: chandler pole motion, long periodic variations, geopotential variations



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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2818****To model explanation of annual variation of oblateness and annual pole oscillations of the Earth****Prof. Yury Barkin***Laboratory of Gravimetry Sternberg Astronomical Institute IAG*

The model of the directed annual redistribution of masses of the Earth as a material point on its surface with harmoniously varied mass is used for dynamic interpretation and an explanation of observably annual oscillation of the Earth pole and annual variation of coefficient J_2 of second zonal harmonic. Let us dp/w , dq/w and dr/w are the ratios of the annual variations of the equatorial (p , q) and polar (r) components of the angular velocity of the Earth to its unperturbed value (w). The point models process of redistribution of atmospheric and oceanic masses and located at the pole P of geocentric axis OP with geographic coordinates 70.0 N, 104.3 E (Barkin, 2001). The mass of a point changes harmoniously under the law $2.10\cos(V+b) \times 10^{15}$ kg, where $V=360t$ it is measured in degrees, time t is counted in years (from the beginning of year). A phase $b=10$ degrees. At a choice of model the particularities of trajectory of the pole of load moment (Blewitt et al., 2001) for which the original phenomenon of standing near to poles of axis OP is observed were taken into account. The base idea of our geodynamical model (Barkin, 2002) is the existence of the relative translational displacements of the core relatively to elastic mantle under gravitational attraction of external celestial bodies. Observed variations of geocenter in first are determined by the core displacements and are identical. We suppose that annual oscillation of geocenter corresponds to the radial annual oscillation of the center mass of the core along geocentric axis OP . This model, as well as similar model of secular mass redistribution of masses of the Earth from southern hemisphere to northern, has obtained set effective confirmations in the parallel researches (Barkin, 2001). On the base of this model coefficients of the second harmonic of geopotential J_2 , C_{21} and S_{21} have been determined as periodic functions of time: $dJ_2 = -2.90 \times 10^{-10} \cos V$, $dC_{21} = -0.28 \times 10^{-10} \cos V$, $dS_{21} = 1.09 \times 10^{-10} \cos V$. The variation dJ_2 will well be coordinated to its value obtained by methods of geodetic satellite laser ranging: $dJ_2 = -(2.80 \pm 0.22) \times 10^{-10} \cos(V-30 \pm 19)$ (Cheng and Tapley, 1999). On the obtained values of annual variations of products of inertia of the Earth the variations of coordinates of the pole of axis of rotation of the Earth have been determined. Basing on N.S. Sidorenkov monograph (2002), we present here the ratios of these variations to the angular velocity in comparison with their determinations on the observational data (Yazkiv et al., 1976) and under the analysis of variations of atmospheric masses (Jeffreys, 1916; Sidorenkov, 1973): $dp/w = 45.5 \cos(V-250)$, $dp/w = 41.1 \cos(V-333)$ (Yazkiv et al., 1976), $dp/w = 50.1 \cos(V-264)$, $dp/w = 43.5 \cos(V-356)$ (Jeffreys, 1916). $dp/w = 50.4 \cos(V-280)$, $dp/w = 42.6 \cos(V-14)$ (Sidorenkov, 1973). $dp/w = 44.1 \cos(V-246)$, $dp/w = 44.2 \cos(V-336)$ (given paper). One unit here consists 10^{-8} . Calculated axial acceleration of the Earth is $dw/w = 5.85 \times 10^{-10} \cos(360t+10)$. It makes only certain contribution to the observable annual variation of angular velocity. For its full explanation it needs the detailed analysis of the angular moment of the redistribution of atmospheric and oceanic masses. Referenses Barkin, Yu.V. (2001) Explanation and prediction of the secular variations of the Earth rotation, geopotential, force of gravity and geocenter drift. Proceedings of International Conference "AstroKazan-2001". Astronomy and geodesy in new millennium (24-29 September 2001), Kazan State University: Publisher "DAS", pp. 73-79. Cheng M., Tapley B. (1999) Seasonal variations in low degree zonal harmonics of the Earth gravity field from satellite laser ranging observations. Journal of Geophysical Research, V. 104, Issue B2, p. 2667-2682. Sidorenkov N.S. (2002) Physics of non-stabilities of Earth rotation. - Moscow: Nauka. Fismatlit. 384 pp. In Russian.

Keywords: pole motion, annual oscillation, core motion

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2819****Tidal excitation of Earth rotation observed by GPS and VLBI*****Mrs. Sigrid English****Geodesy and Geophysics Vienna University of Technology****Paulo Mendes Cerveira, Robert Weber, Harald Schuh***

Oceanic and solid Earth tides induce periodic signals in the Earth Rotation Parameters (ERP), i.e. the pole coordinates and universal time (UT1) or length of day (LOD), respectively. The oceanic tides cause variations with diurnal and semidiurnal periods in all parameters, whereas the zonal Earth tides mainly influence the rotational speed of the Earth, and thus UT1 and LOD. These signals show periods from ~5 days to 18.6 years. For the investigation of short and long period tidal effects ERP series of several years are computed from VLBI and GPS observational data with hourly resolution. The technique specific series are compared in time domain and a combined ERP series of one year is generated by solving the combined inter-technique normal equation system. The variations in the combined series as well as in the individual VLBI- and GPS-based ERP series are examined for periods from a few hours up to one year. The observed periods and corresponding amplitudes are compared to the theory of tidal excitation in order to detect and if possible interpret remaining fluctuations in the ERP series.

Keywords: earth rotation, tides, space geodetic techniques

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2820****Digital Elevation Model; a tool in detail study of deformed landforms of Earth's crust****Mr. Alireza Babaie Mahani***institute of geophysics MS.c student of seismology IASPEI***Shayesteh Mehrabian, Majid Bagheri**

GPS has become one of the most efficient tools for measuring the deformations of the Earth's crust. In order to study the deformed landforms in detail, DEM (Digital Elevation Model) of the target area is needed. Obtaining this kind of information with sufficient precision, could be not easy in some cases. By means of one set of GPS devices, one is as the Base (stationary device) and the other as the Rover device we can make a DEM of a region, good for mapping the landforms such as Inflected streams, fault scarps and other features in order to active tectonic studies. The aim of this study is to present a case study that has been done in Iran for making the DEM of small regions (~ 1 1 km) in the NE of the country. In making these maps we used GNSS solution to convert the points surveyed by the Rover and Base, to the format appropriate to use in graphic softwares like ERMapper or Surfer. The obtained results are precise maps of the ground which show the details of what that can not be recognized in satellite images.

Keywords: dem, gps, iran

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2821****TIDAL variations of the gravitational potentials of the Moon, Mercury and Titan****Prof. Yury Barkin***Laboratory of Gravimetry Sternberg Astronomical Institute IAG*

In this communication, we describe the secular and periodic variations in the gravitational coefficients of the second degree harmonics of the gravitational potential of the Moon, Mercury and Titan caused by the attraction of their external bodies. The first evaluations of the amplitudes of these variations have been obtained assuming a plane model of translation-rotary motion of the above-mentioned elastic bodies on elliptical orbits. The main variations of the coefficients C_{20} , C_{22} , S_{22} , with periods multiple of the orbital period have been obtained and evaluated. The variations of the coefficients of the second degree harmonics of the selenopotential and the mercurypotential caused by the terrestrial and solar tides have been also studied considering their perturbed orbits, described by the precision analytical theories. In the paper, we use analytical expressions for the tidal variations of the Stokes coefficients obtained for a model of an elastic celestial body with concentric mass distribution, elastic parameters (Love numbers), and their reduced form using fundamental elastic parameter k_2 (for the Moon $k_2=0.025$, and for Mercury $k_2=0.0644$). The Moon is considered as an elastic deformable body by the dynamical structure close to Takeuchi's model: in the non-deformed state, densities and elastic parameters of the Moon are characterized by concentric distribution; variations of densities are linear with respect to radial displacement and volume divergence. The lunar core is small and we do not take it into account. Taking into account the resonant properties of the Moon motion, the variations of the selenopotential coefficients we have been presented in the form of Fourier series in the four classical lunar orbital arguments: l_m , l_s , F and D . Values of the amplitudes and periods of variations of selenopotential have been tabulated for an elastic model of the Moon characterized by elastic parameter $k_2=0.025$. Variations of polar moment of inertia of the Moon due to terrestrial tides lead to remarkable variations of the Moon axial rotation which also have been determined and tabulated. From our results it follows that the tide periodic variations of gravitational coefficients of the Moon in an order bigger than corresponding tide variations of Earth's geopotential coefficients (Ferrandiz, Getino, 1993). Variations of coefficients of the second degree harmonics of the potential of Mercury caused by the solar tides have been studied using analytical expressions for the tidal variations of Stokes coefficients, also obtained for a model of the elastic celestial body with concentric distributions of masses and elastic parameters and their reduced form using fundamental elastic parameter k_2 of Mercury. Taking into account the resonant properties of the Mercury motion, variations of the Mercury potential coefficients are given as Fourier series on the multiple of corresponding arguments of the Mercury orbital theory. Evaluations of the amplitudes and periods of observed variations of Mercury potential have been tabulated for an elastic model of Mercury, characterized by the elastic parameter $k_2=0.0644$ (Zhang, 1992) and $k_2=0.184$ (Bodri, 1987), $k_2=0.0965$ (Kelvin's formula). Tidal variations of the Mercury axial rotation have been also determined and tabulated. We have also obtained similar results for Titan, and they describe remarkable changes in its dynamical structure due to gravitational influence of Saturn.

Keywords: moon mercury titan, gravitational potentials, rotation

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2822****Constraints on Glacial Isostatic Adjustment (GIA) Motion in North American Using GPS*****Dr. Giovanni Sella******S. Stein, T. H. Dixon, M. Craymer, T. James And S. Mazzotti, R. K. Dokka***

We use continuous and episodic Global Positioning System (GPS) data to measure the motion caused by glacial isostatic adjustment (GIA) due to glacial unloading in eastern North America. The large vertical signal due to GIA ($>10\text{mm/yr}$) in the area of maximum uplift, near Hudson Bay, permits this motion to be resolved with both continuous GPS (CGPS) data and even with episodic GPS (EGPS) data. We present data from 239 CGPS sites throughout North America and 123 EGPS sites of the Canadian Base Network (CBN). The CBN sites are located across central and southern Canada and have been episodically occupied between 1994 and 2002. We detect a coherent pattern of vertical motions around the area of maximum glacial loading, Hudson Bay. The observed velocities are initially large and upward, and decrease southward from Hudson Bay to zero, delineating the hinge line near the Great Lakes. The position of the hinge line is in agreement with some numerical GIA predictions. The horizontal residual velocities after removing the motion of the rigid North American plate also show a consistent, but more complex pattern than the vertical velocities. In particular we observe larger than expected motions on the east side of the Canadian Rocky Mountains, possibly reflecting larger ice loads and/or changes in mantle viscosity. We believe that this velocity field provides a comprehensive direct description of GIA motion and can be used to constrain GIA model predictions.

Keywords: gps, gia, northamerica

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GS003

Poster presentation

2823

The spatiotemporal distribution of the earth tide responses estimated from GPS network in Japan

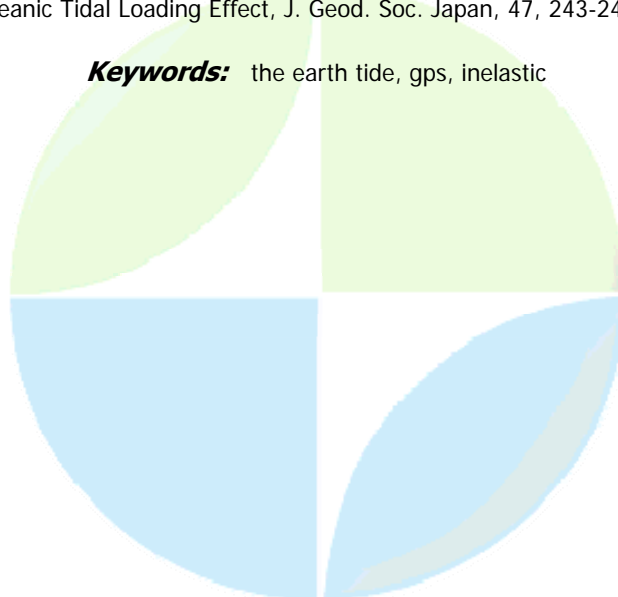
Dr. Takeo Ito

RCSV, Graduate School of Environmental Studies Nagoya University

Makoto Okubo, Takeshi Sagiya

Introduction The lunisolar attraction is acting on the Earth and is producing the so-called Earth tides. The Earth tides are producing surface deformations of the Earth. This displacement field is response to the power source, which is controlled accurately. The observed the Earth tide, which is producing the accuracy controlled power source, may be called the kind of "Active Monitoring". A great deal of effort has been made on the observed the Earth tides. What seems to be lacking, however, is spatial distribution of observation points. The gravity or strain observation can observe the Earth tides. However, they are very expensive and need the limited environment of observation places, where is low noise. It follows from what has been said that hard to observe the spatial heterogeneous of the Earth tides. On the other hands, if we can observed the migrating crustal deformation due to earth tide by GEONET (GPS Earth Observation Network System) which GPS observation network consist of 1200 observation sites, operated by GSI (Geographical Survey Institute) in Japan, we can know the spatial heterogeneous response of the Earth tide field. Analysis In this study, PPP (Precise Point Positioning) was analyzed for 30 seconds sampling of RINEX file of about 1200 GPS continuousness observation points in the Japanese Islands by GpsTools ver.0.6.3 software. We use the orbit information, which from IGS and the absolute and relative satellite clocks using IGS and COD, respectively. Our strategy of GPS analysis is the two days as a unit, and smoothly combines with unit and unit, which is overlap four hours. We estimate the spatial distribution of lag between observation data and the time series are calculated by GOTIC2, which is modern ocean models. Result We observed the spatial distribution of phase delay and amplitude of the earth tides from about 1200 GPS stations in Japan. The component of best S/N ratio is UP-DOWN. We find the phase delay area due to underground structure. We can derive inelastic response of the earth tides from this information. The temporal change of response is very useful for the active monitoring. Reference: Takasu, T., and S. Kasai, Development of precise orbit/clock determination software for GPS/GNSS, the 49th Space Sciences and Technology Conference, Hiroshima, Japan (in Japanese), 2005. Matsumoto, K., T. Sato, T. Takanezawa, and M. Ooe, GOTIC2: A Program for Computation of Oceanic Tidal Loading Effect, J. Geod. Soc. Japan, 47, 243-248, 2001.

Keywords: the earth tide, gps, inelastic



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2824****Modeling and Observation of Time-Variable GPS Site Positions****Dr. Pascal Gegout***Dynamique Globale CNRS IAG****Gilbert Ferhat (1,2), J.-P. Boy (1), J. Hinderer (1)***

Our aim is to investigate loading consequences on the time-variable GPS site positions of hundred stations around the world during the time span 2001-2005. We model the three dimensional site displacements using a Love number formalism to describe the elastic deformation of a spherical Earth's model submitted to atmospheric, oceanic and hydrological loadings. We produce site positions time series using the GPS analysis software GAMIT/GLOBK with/without inserting a combination of loading models and study their impact on 3D site positions. We first of all compare the variability of modelled and observed sites positions (without loading in the GAMIT Software). We secondly study the variance reduction in the GPS sites positions provided by the loading process. We conclude that the seasonal variability of sites displacements is quite well explained by our model in several geographic regions, e.g. at mid-latitudes in the northern hemisphere, while it is much less understood at other locations, e. g. near coastal areas.

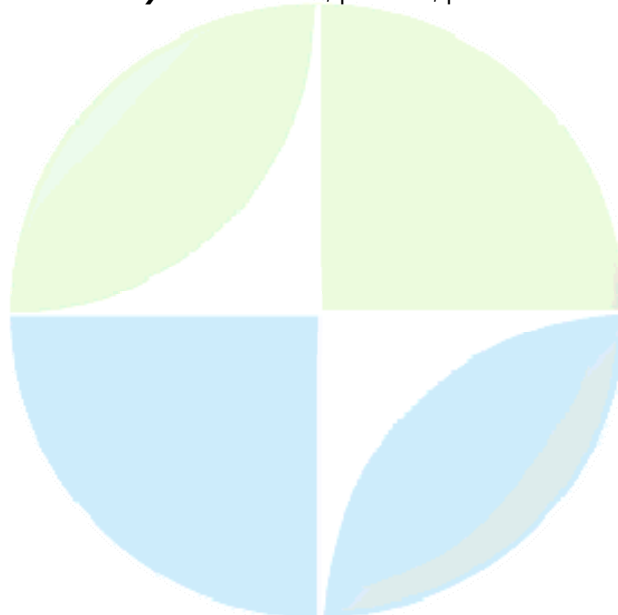
Keywords: loading, deformation, gps

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PERUGIA
I T A L Y

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2825****Analytical Development of Tide-Generating Potential of Terrestrial Planets*****Dr. Sergey Kudryavtsev****Celestial Mechanics Sternberg Astronomical Institute IAG*

A high-accurate analytical development of the tide-generating potential (TGP) of Mercury, Venus and Mars is presented. To make the development we used a modified method of spectral analysis of TGP values pre-calculated over a long period of time (Kudryavtsev 2004). A feature of the method is the development is directly made to Poisson series where both amplitudes and frequencies of the series terms are high-degree polynomials of time as opposed to the classical Fourier analysis where the terms amplitudes and frequencies are constants. The long-term lunar/planetary ephemerides DE/LE-405/406 (Standish 1998) and Martian moons motion theory MARTSAT (Kudryavtsev, Kolyuka, Tikhonov 1997) are used as sources of the attracting bodies positions. The TGP development for Mercury and Venus is done over 2,000 years (1000-3000) and includes 2,345 second-order Poisson series terms of amplitude exceeding 10^{-8} m²/s² for Mercury and 1,725 analogous terms - for Venus. The TGP development for Mars is performed over 200 years (1900-2100) and includes 278 second-order Poisson series terms of amplitude exceeding 10^{-6} m²/s². [The reduced time interval and relatively high cut-off limit of the TGP terms for Mars is caused by known uncertainties in the mass and orbital parameters of the Martian moon Phobos.] A modification of the standard format HW95 (Hartmann, Wenzel 1995) for representation of a terrestrial planet TGP is proposed. The number of terms of the TGP development given in the modified HW95 format is 1519 for Mercury, 1120 for Venus, and 162 for Mars. All coefficients of the TGP development for Mercury, Venus and Mars given in both the original and modified HW95 format are available at SAI ftp-server. The work is supported in part by grant 05-02-16436 from the Russian Foundation for Basic Research. References: Hartmann T., Wenzel H.-G. (1995) The HW95 tidal potential catalogue. *Geophys. Res. Lett.*, 22, 3553-3556 Kudryavtsev S.M. (2004) Improved harmonic development of the Earth tide generating potential. *J. Geodesy*, 77(12), 829-838 Kudryavtsev S.M., Kolyka Yu.F., Tikhonov V.F. (1997) New analytical theory of motion of Phobos and Deimos for navigation support of mission to Mars. *ESA SP-403*, 377-382 Standish E.M. (1998) JPL planetary and lunar ephemerides DE405/LE405. JPL IOM 312.F-98-048, Pasadena

Keywords: tides, potential, planets

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2826****Semi-hourly polar motion and universal time series from the VLBI CONT02 data set****Dr. Paulo Jorge Mendes Cerveira***Advanced Geodesy IGG, Vienna University of Technology IAG****Wresnik Jrg, Bhm Johannes, Weber Robert, Hobiger Thomas, Tetsuro Kondo, Salstein David, Schuh Harald***

Recent studies claim having detected significant ter-diurnal variations in the order of 40 as in polar motion during the Very Long Baseline Interferometry (VLBI) campaign CONT02, from October 16 to 31, 2002. However, up to now no geophysical model is able to confirm or validate the amplitudes of the 8-hours period. Atmospheric series reveal ter-diurnal signals, however of much smaller amplitudes; these are predominantly caused by the periodic signal lacking a harmonic feature (due to periodic jumps in a current atmospheric model/data assimilation series) and thus introducing overtones. The same reasoning is valid for polar motion residuals, due to obvious jumps in polar motion whenever a new 24-hours session starts. In order to confirm this conjecture, we applied a single continuous least squares adjustment to the CONT02 data set, seeking for high-frequency residuals in polar motion and universal time. In a first step, a reduced observation vector was produced using the VLBI software package OCCAM61E, applying the most recent reduction models mostly following the IERS Conventions 2003. Then, the most critical part tackled the detection of baseline-common jumps in the reduced observation vector. And finally, local (e.g., one clock trend, hourly wet zenith delays) and global (weekly station coordinates, fortnightly source positions, semi-hourly polar motion and universal time offsets) parameters were estimated in a mutually consistent and continuous approach.

Keywords: vlbi, polar motion, universal time

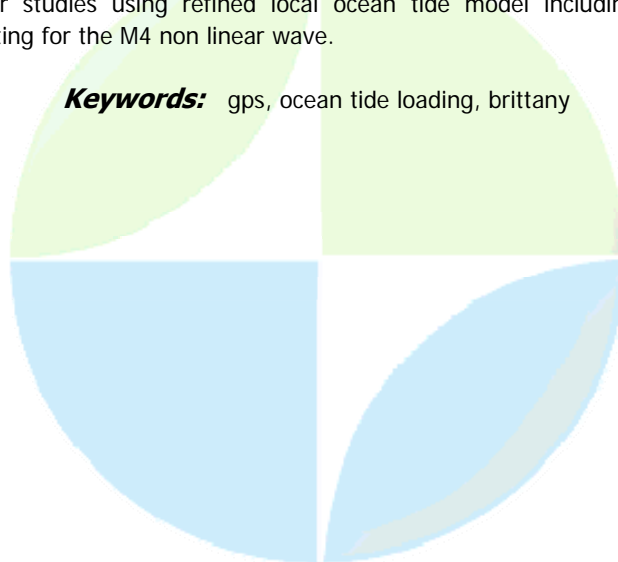
(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2827****GPS estimates of ocean tide loading in NW-France and comparison with a recent ocean tide model.**

Dr. Mathilde Vergnolle
LGIT CNRS UMR 5559 IAG

Marie-Noelle Bouin, Joelle Nicolas, Laurent Morel, Frdric Masson, Stphane Durand, Stavros Melachroinos

Oceanic loading effects cause 3D displacements large enough to affect space geodesy measurements either at the sub-diurnal period or at longer time scales by the way of spurious signals. GPS measurements, in turn, could provide local improvement of the models at coastal areas if their ability to precisely monitor such rapid displacements is assessed. In this presentation, we use 105 days of continuous GPS measurements collected in 2004 in the French Brittany and Cotentin region to investigate: 1- the precision achieved by GPS analysis on measuring 3D sub-diurnal displacements and amplitude and phase of the tidal constituents, 2- the quality of the most recent ocean tide model FES2004 in such a complex coastal context. Indeed, in this area, tide amplitudes are among the highest in the world (up to 12cm of loading displacements on the vertical component) and are believed to show strong non linear terms at the 3rd, 4th and 6th diurnal periods. From a state of the art GPS analysis using the scientific GAMIT software at 2h sessions, we test two independent strategies for the realization of the reference frame. The position time series are then compared with the displacements predicted by FES2004 model applied on an elastic Earth model. The two sets of results we obtained are consistent with each other at the same level of agreement than with the predicted displacements, namely 3 to 5mm on the horizontal components and 10mm on the vertical. We therefore assess the capability of this technique for measuring 3D ocean tide loading deformation. We validate the FES2004 model in the Brittany area, even if it slightly (2-3mm) underestimates the 3 components amplitudes. With a harmonic analysis of the observed position time series, we obtain nevertheless an overall agreement of the tidal constituents at a sub-millimeter level. Moreover, the GPS time series show non linear components significant at the 95% confidence level on the 3rd, 4th and 5th diurnal waves. These non linear terms could partly fill the amplitude gap between the FES2004 predicted and GPS observed displacements and therefore explain the observed discrepancy. Finally, we sharpen our local analysis by sorting the stations into four geographical groups (Brittany coastal area, Cotentin except Bayeux, Bayeux and inland) according to the response to the ocean tide loading effects. Some improvement is expected from further studies using refined local ocean tide model including fitted hydrodynamic processes and accounting for the M4 non linear wave.

Keywords: gps, ocean tide loading, brittany



(G) - IAGA - International Association of Geomagnetism and Aeronomy

GS003

Poster presentation

2828

Surface-Load Induced Deformation of Lake Nasser, Egypt

Dr. Khaled Zahran

Geodetic department National Research Institute of Astronomy and geoph IAG

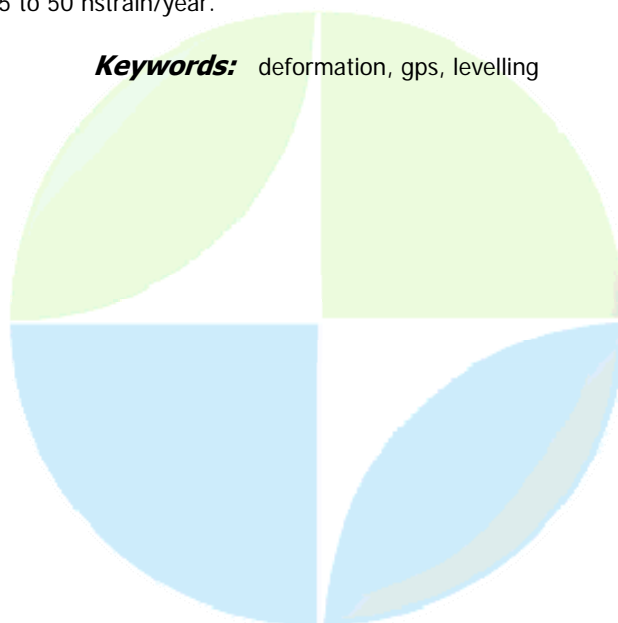
Lake Nasser , which impounds by Aswan High Dam extends 500 km in southern Egypt and Northern Sudan and has a capacity of about 133.8 km³. The water level of the Lake fluctuates four times a year according to a cycle of inflow and discharge. Variable loading of the water mass of the reservoir changes the geodynamical regimes around it and causes the equilibrium state to be broken. Thus, variable induced load of the Lake affect almost all geodetic quantities. A numerical model of the induced load deformation of the Lake based on the elastic parameters is introduced in the current study. Evaluation of the modeled deformation has been carried out by comparison of repeated gravity and GPS observations in a network pound the northern part of the Lake . Discrepancies between modeled and observed gravity field variation and crustal deformation have been discussed in term of elasticity and viscosity of the crust around the Lake .

Keywords: surface load, gravity variation, crustal deformation



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2829****SWISS4D: modelling the kinematics of the deformation of the Swiss Geodetic Reference Network****Mr. Adrian A. Wiget***Geodesy Federal Office of Topography, swisstopo IAG***Urs Marti, Ramon Egli, Alain Geiger, Oliver Heller**

The study of recent crustal movements in and the development of a kinematic 3D model for the Swiss Terrestrial Reference System CHTRS were the main goals of the swisstopo project Swiss4D. The model should be suitable for monitoring the geodetic reference frames as well as for scientific studies. Between 1988 and 1995, the Federal Office of Topography (swisstopo) installed the Swiss GPS Reference Network LV95 (Landesvermessung 95) as the national first order GPS network and made the first GPS observations on its geodetic control points. As a quality check and for the study of tectonic movements, swisstopo reobserved the whole network in 1998 and 2004. The direct comparison of the new horizontal coordinates with their earlier determinations proved the stability of the reference frame on the cm level. Together with the 30 permanent GPS stations of the automatic GPS network Switzerland (AGNES), the 200 LV95 stations represent the backbone of the Swiss Terrestrial Reference Frame (CHTRF). The vertical velocities were taken from the kinematic adjustment of all national levelling data from 1903 to 2004 used for the definition of the new national height system LHN95 (Landeshennetz 95). The horizontal velocity vectors (~1mm/ year) derived from the combined adjustment of the high-precision GPS measurements in AGNES and LV95, introduced as SINEX files, were combined with the vertical velocities from LHN95. These values define a set of constraints for a kinematic model of crustal deformation in and were used to calculate a three-dimensional discrete velocity field on the surface of the Earth's crust. The strain rate field and the main components of the deformation tensor were then obtained from the interpolated velocity field using an adaptive least-squares collocation (ALSC) method developed at the Geodesy and Geodynamics Laboratory (ETH Zurich). The interpolated 3D vector field and the strain rate field are presented as results. The vertical velocities relative to an arbitrarily chosen reference point varying from -0.4 mm/year to +1.4 mm/year have been well known before. New was the conclusion that the horizontal velocities are also on the millimeter level. But since the uncertainty in GPS measurements is of the same order of magnitude, the horizontal results are not yet significant. The strain rates vary from 5 to 50 nstrain/year.

Keywords: deformation, gps, levelling

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2830****Determination of invariant deformation parameters from GPS permanent stations using stochastic spatial interpolation*****Dr. Ludovico Biagi****DIAR Politecnico di Milano IAG****Athanasios Dermanis***

The calculation of invariant deformation parameters requires continuous spatial positional variations, while networks of permanent GPS stations provide data which are virtually continuous in time but discrete in space: therefore, to investigate deformations from permanent network data a time modelling and a spatial interpolation are needed. Moreover, typically the time series of planimetric estimates are more accurate than the height estimates: so, in order to investigate geodynamics deformations, it seems justified to adopt a two dimensional approach. In the proposed approach the regional deformation is modelled as a process which is linear-deterministic in time and stochastic with respect to space; we use spatial covariance functions in some simple prior family, like gaussian, where the amplitude and the correlation length of deformation patterns are estimated from data. Deformation parameters are then derived from interpolated displacements in latitude and longitude, where the interpolation performed through minimum mean square error prediction. Prior trend removal is based on the transformation to a new reference system satisfying a discrete Tisserand principle. Special emphasis is given to the problem of quality assessment independently of the unrealistic statistics accompanying GPS coordinates, as well as to the propagation of realistic accuracy measures to the invariant deformation parameters calculated using new rigorous formulas. A numerical example demonstrates the performance of the developed software package; a test on a one year period of data stemming from the national Japanese permanent network provides the first results on real data.

Keywords: deformations, collocation, covariance propagation



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2831****Report of Activities (2003-2007) of Commission 3: Earth Rotation and Geodynamics*****Prof. Veronique Dehant****Time, Earth Rotation, and Space Geodesy Royal Observatory of Belgium IAG*

This presentation will report on the activities of Commission 3 and its sub-commissions and inter-commission projects. The objectives of Commission 3 are: (1) To develop cooperation and collaboration in computation, in theory, and in observation of Earth rotation and geodynamics, and to ensure development of research in geodynamics and Earth rotation by organizing meetings, symposia, and general assemblies, by creating working groups on specific topics, and by encouraging exchange of ideas and data, comparisons of methods and results improving the accuracies, content, methods, theories, and understanding of Earth rotation and geodynamics; (2) To serve the geophysical community by linking them to the official organization providing the International Reference Systems/Frames and Earth orientation parameters (IERS and related bodies), and organizations providing all the other data on which geodynamics and Earth rotation studies can be performed. The Advisory Board consists of the following members (their responsibilities is also given below): President: Vronique Dehant; Vice-President: Mike Bevis; Past Presidents: Clark R. Wilson and Martine Feissel-Vernier; Head of Sub-commission 3.1 Earth Tides: G. Jentzsch (Germany); Head of Sub-commission 3.2 Crustal Deformations: M. Poutanen (Finland); Head of Sub-commission 3.3 Geophysical Fluids: R. Gross (USA); Head of Inter-commission project 3.1 GGP: D. Crossley (USA); Head of Inter-commission project 3.2 WEGENER: S. Zerbini (Italy); Commission 3 representatives to inter-commission committee on Theory: T. Van Hoolst (Belgium); Commission 3 representatives to inter-commission committee on Planetary Geodesy: O. Karatekin (Belgium); Commission 3 representatives to inter-commission project 3.1 GGP: D. Crossley (USA); Commission 3 representatives to inter-commission project 3.2 WEGENER: T. Van Dam (Luxembourg); Commission 3 representatives to IERS: C. Wilson (USA); Commission 3 representatives to IAU commission 19: M. Rothacher (Germany); Member at large: Kosuke Heki (Japan). Reports from these sub-bodies will be presented.

Keywords: earth rotation, geodynamics, commission 3

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2832****Vertical deformation in the southern Tibetan plateau derived from GPS data*****Prof. Min Wang****Institute of Earthquake Science China Earthquake Administration****Zheng-Kang Shen, Qi Wang, Peng Li***

As the most prominent example of large-scale continental deformation, Tibetan Plateau offers an ideal natural laboratory for quantifying such deformation and understanding the relevant dynamic process. Up to now, the horizontal deformation derived from global positioning system (GPS) data has been used to interpret and verify the deformation models of Tibetan Plateau. Because the vertical deformation is significantly less than the horizontal deformation, the vertical component accuracy of GPS positioning is not enough, and the non-tectonic deformation caused by geophysical effects is included in GPS data, we have less the understanding of Tibetan Plateaus vertical deformation from GPS data. Along with the accumulation of GPS data for a longer time and the development of GPS data analysis, the above situation has been improved. We collected the GPS data from multiple survey epochs conducted between 1991 and 2006 in the southern Tibetan Plateau and Himalayas, and try to obtain the vertical deformation. Uniform data processing strategy, the most recent geophysical models and appropriate error correction models will be adopted. IGS05 station positions and velocities of the IGS sites will be used to define the reference frame. Our result will help us understand better of Tibetan Plateaus deformation and provide the more complete and reasonable constraints for continental geodynamic model.

Keywords: tibetan plateau, vertical deformation, gps

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2833****Seasonal Signals in Gravimetric Data, Polar Motion and the Gravitational Constant*****Dr. Alexander Unzicker***

We analyze time series of local gravity from superconducting gravimeters of the Global Geodynamics Project (GGP) network. Tidal reduction is done by direct computation of forces using NASA's DE405 ephemeris data. Deformation tides are estimated by an elastic earth model. We also take into account the influence of air pressure and of temperature using a 3-D atmospheric model based on NCEP climate data. The inferred polar motion signal is compared to data from IERS. The results indicate a dependence of the tidal gravimetric factor δ on location. Finally, after reducing the signal, we discuss the possibility of detecting a minute spatial variation of the gravitational constant G which, due to the elliptic earth orbit, should be visible as a slight annual signal in the residuals (Unzicker and Fabian, arxiv.org/abs/gr-qc/0610028).

Keywords: gravimetry, polar motion, gravitational constant



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2834****GPS height time series: amplification of spurious long period signals in float solutions****Dr. Mike Stewart***Spatial Sciences Curtin University of Technology IAG***Nigel Penna**

That short period (eg < 24 hour) systematic errors in tidal models used in GPS geodetic processing can manifest themselves in GPS height time series as spurious long wavelength signals has recently been demonstrated both theoretically and empirically using real data. In this paper, it is demonstrated that the magnitude of the amplitude of such errors is dependent on the status of the solution bias parameters ie whether or not a solution is a fixed or float solution. It is shown, both theoretically using a simplified model, and empirically using real GPS data processed in BERNESE software, that the amplitude of spurious long wavelength signals is amplified in float solutions in comparison with fixed solutions. This result suggests that successful ambiguity resolution has an important role to play in the mitigation of periodic systemic errors in GPS height time series.

Keywords: gps, time series, errors

(G) - IAGA - International Association of Geomagnetism and Aeronomy

GS003

Poster presentation

2835

The Crustal Strain Rate in Baikal-Mongolia Area From GPS Measurement

Mr. Faqi Diao

Institute of Geodesy and Geophysics, CAS Key Laboratory of Dynamic Geodesy IAG

Xiong Xiong

The Baikal-Monglia area, located at the central of the Eurasia continent, is one of the largest active tectonic zone in the world. GPS measurements have shown us the initial state of crustal deformation in past few years. In order to learn more tectonic information from the observed GPS results, we derive the crustal strain rate in this area. At present, the calculation of the strain field require spatially dense GPS observations covering the whole area. However, due to the uneven distribution of the GPS sites, the crucial for determining strain field is the velocity field that is usually derived from interpolation by functional or stochastic models. Functional models are applicable for the interpolation with clear trend and systematic variations, and stochastic methods for interpolation with random characteristics. We propose a new interpolation approach integrating two classes of models, for minimizing the residual misfit. It is shown, by comparison between results derived by various models, that the integrated approach is better than the methods based on individual model, either functional or stochastic, for interpolation of velocity field. On the basis of reliable velocity field, the strain rate field were computed using least square method. The results reveal that the Baikal rift zone has distinct extent strain rate at a rate of 2.510-8/yr in NW-SE direction which have a well consistency with focal mechanisms. We also find compressed strain rate in NE-SW direction of most Monglia area and large shear strain rate in Baikal rift zone in response to the India-Eurasia collision. The comparison between our result and seismic activity in the area display that the earthquake occurred in past decade years are located in areas with high shear strain rate.

Keywords: crustal strain, baikal monglia, gps



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2836****3D models of basement evolution and salt structures activity in Firouzabad area, Zagros, from Permian to Miocene****Dr. Mortaza Pirouz**
*geology Tehran University***Mohammad Reza Ghassemi, Abbas Bahroudi, Neda Ghazipour**

The study area is located in Zagros simply fold belt, south of Firouzabad, Fars . We have considered sedimentary basin floor deformation, initial time of folding and salt plug upwelling, by using of isopac data. Also, these data can used for indicated of expanding development. We have used National Iranian Oil Company isopac data from Permian to Miocene age. If isopac data value be reversed and the 3D patterns calculated, it can show sedimentary basin floor shape. According to 3D patterns, sedimentary basin evolution pattern, primary time of salt plugs movements and basement faults movement in firouzabad area has been obtained. Mengharak basement fault with N-S trend activated with vertical displacement in the Permian and its movement have changed left lateral strike slip after Triassic. Also, extensional structures formed in the east of Mengharak fault zone and continue to middle cretaceous. At the same time, Neothetys closed and the extension structures be converted to compression structures and also Mengharak fault overment have changed to right lateral strike slip. 3D models are showed that salt plugs activity (Jahani and Firouzabad) began in Permian and its activation have increased cretaceous in the Mengharak fault zone.

Keywords: zagros, 3dmodel, basement

(G) - IAGA - International Association of Geomagnetism and Aeronomy

GS003

Poster presentation

2837

Velocity field in Southern Spain- Northern Morocco Area

Dr. Jorge Garate

Geophysical Department San Fernando Naval Observatory IAG

San Fernando Naval Observatory installed a permanent GPS network in the surrounding of the Alboran Sea and the Gulf of Cadiz in 1998. A further densification was made, starting in 2001 with the installation of a new station in Granada, and ending in 2007 when a new station has been located in the Chafarinas Island Lighthouse, close to the border between Morocco and Algeria. This observational effort is producing a set of coordinate time series for each site. The most of them are already long enough to give good velocity approaches. But there are still a couple of them which are shorter than needed to take conclusion from their behaviour yet. Furthermore, there are other permanent station located in Southern Spain, Southern Portugal, and Northern Morocco, included in the EUREF and IGS networks. We have used at least three years of data files of all available GPS station in the area in order to derive a complete velocity field for the Eurasian and Nubian Plates boundary zone. This work is showing the horizontal velocities we have got in relation to the Eurasian Plate Stable Area: while a broad plate boundary zone accomodating the relative motion between the two big plates seems to be clearly established to the west, some different behaviours have been gotten for different areas to the east, where the new station time series will be added in the near future.

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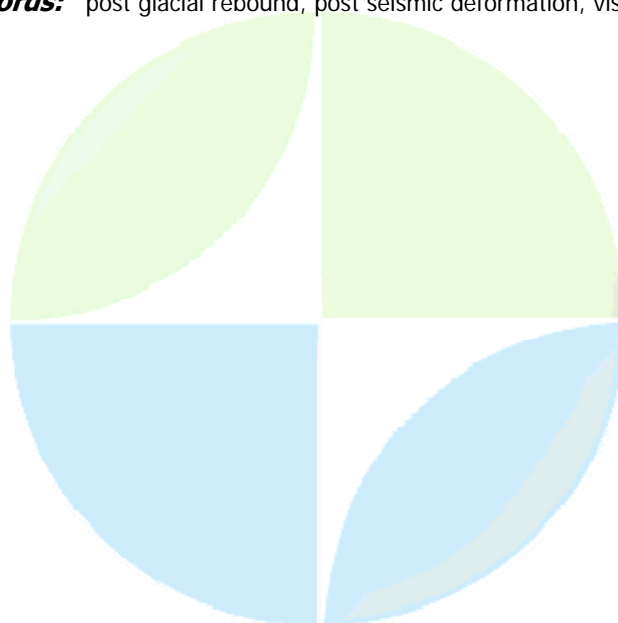
I T A L Y



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2838****Numerical modelling of the crustal deformation due to post glacial rebound and post seismic deformation in southern Alaska*****Dr. Junichi Okuno****Earthquake Research Institute Univ. Tokyo IAG*

Postglacial rebound is the response of the Earth to the decay of ice sheets. The recent studies have measured the rapid present-day glacio-isostatic uplift derived from GPS geodetic observations combined with studies of raised shorelines (e.g. Larsen et al., 2005). In these studies, the results of post glacial rebound modelling explained the rapid crustal deformation in southern Alaska that occurred during retreat of the Cordilleran ice sheet in Little Ice Age (about 2000 ~ 100 yrBP), and required the presence of a low viscosity asthenosphere about 3.7×10^{18} Pa s. Other studies related to post glacial rebound around the Vancouver Island suggested that the predictions of relative sea-level change using the mantle viscosities less than about 10^{20} Pa s fitted the observations well (James et al., 2000). These viscosity values are smaller than most upper mantle viscosity estimates derived from post glacial rebound studies of tectonically less active regions those are about 10^{20} 10^{21} Pa s. They may result from hydration of the mantle wedge between the subducting oceanic plate and continental lithosphere. On the other hand, the 1964 Alaska earthquake was the second largest seismic events in the 20th century. During the 1964 $M_w=9.2$ earthquake, coastal sediments around upper Cook Inlet in south-central Alaska experienced up to 2 m of subsidence suggested by Shennan and Hamilton (2006) using the analysis of the sediment cores and micro fossils. The aim of this work is the use of surface deformation data derived from geographical evidences, tide-gauge and GPS to determine the viscoelastic deformation due to post glacial rebound and the Alaska earthquakes. The crustal deformations revealed by these data in this region include the two components of post glacial rebound and co-, post-seismic deformation. In this study, we use the numerical modelling of the viscoelastic Earth deformation, and reconstruct land uplift and subsidence by the post glacial rebound and the 1964 and five earlier great earthquakes during the past 3300 years. And we estimate the contributions of isostatic and tectonic effects for Holocene and recent crustal deformations and infer the appropriate viscosity structure of the crust and mantle in this region.

Keywords: post glacial rebound, post seismic deformation, viscoelastic



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2839****Low degree variation in the surface mass load from GPS and SLR*****Dr. David Lavallee****Civil Engineering and Geosciences University of Newcastle IAG****Philip Moore, Peter John Clarke, Qiang Zhang, Craig Hancock***

Variations in the Earth's surface mass load (atmosphere, oceans and continental hydrology) cause detectable changes in both the Earth's shape and its gravity field. Changes in the degree-1 and degree-2 spherical harmonics of the geopotential can be inferred from Satellite Laser Ranging (SLR) tracking and dynamic modelling of satellite orbits, and corresponding changes in the Earth's shape with Global Positioning System (GPS) and SLR station coordinate solutions. Measurements of these two lowest degrees of the surface mass load are important, since degree-1 relates to geocenter motions and the origin of the Terrestrial Reference Frame, while degree-2 relates to Earth rotation. The Gravity Recovery and Climate Experiment (GRACE) satellites cannot measure degree-1 variation, and there have been difficulties obtaining precise degree-2 results. SLR and GPS are therefore highly complementary to GRACE measurements. We present results for degrees 1 and 2 of the surface mass load from inversions of GPS and SLR displacement and gravity field data with the application of elastic load Love-number constraints and self-consistent mass conserving basis functions. Due to the complexity of interpreting secular changes we focus on non-secular variation. We compare the results of GPS-only, SLR-only, and joint inversions at degrees 1 and 2. We find very good agreement between SLR and GPS estimates of the degree-2 spherical harmonics which has improved with the evolution of the two techniques. The degree 2 results are also compared to those from GRACE.

Keywords: surface mass loading, geopotential, gps

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Poster presentation

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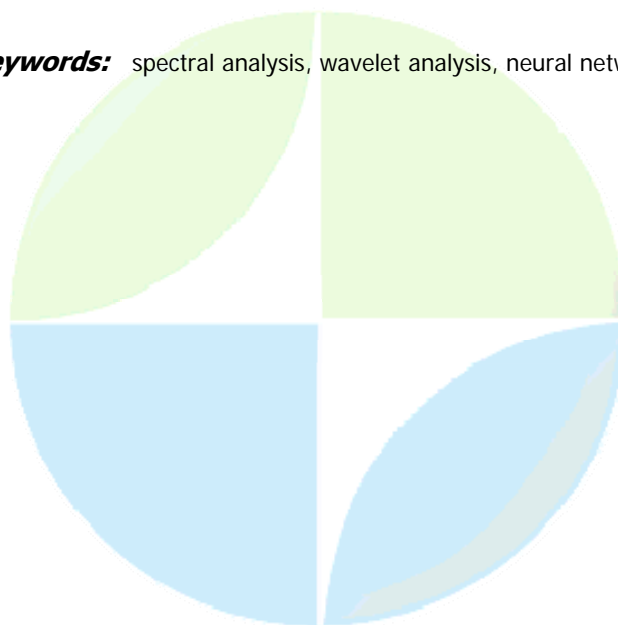
Spectral Analysis of Global and Local Sea Level Changes

Mr. Serdar Erol

Geodesy and Photogrammetry Istanbul Technical University IAG

The knowledge of sea-level variations is crucial for ocean-sciences and geo-sciences. It also has an essential role in the practical realization of the height reference surface in geodesy. Sea level varies spatially due to sea surface topography, tides and changing of local and global meteorological conditions. The temporal variation known by sea level change should be taken into consideration in terms of science and daily life. The proper determination of sea level changes can be done using sea level observations in globally distributed tide gauges. Tide gauges are directed and controlled by the Global Sea Level Observing System (GLOSS) program which is an Intergovernmental Oceanographic Commission (IOC) project, one of the aims of the program is to improve the quality and quantity of data supplied to the Permanent Service for Mean Sea Level (PSMSL) organization, which has been responsible with collecting, archiving, analyzing, interpreting and distributing hourly, monthly and annual sea level observations from the global network of tide gauges all over the world. In this study, four selected PSMSL - GLOSS tide gauge stations (Oaqortoq, Atlantic Ocean, Greenland, Lat: 60 43N, Lon: 46 02W Antalya II, Mediterranean Sea, Turkey, Lat: 36 50N, Lon: 30 37E Dakar, Atlantic Ocean, Senegal, Lat: 14 40N, Lon: 17 26W Mawson, Indian Ocean, Australia, Lat: 67 36S, Lon: 62 53E which are in different latitudes between 60.70N 67.60S degrees) hourly and monthly sea level observations were used as time series data between the years of 1986 and 2005. 19-year monthly time series data of Antalya-II station and 6-year hourly time series data of the other stations were analyzed and hidden periodicities in the spectrum were determined using Least Squares Spectral Analysis (LSSA) technique, which has high performance in evaluating the data include gaps, trend, datum shift (off-set) and unequal sampling rate. Continues Wavelet Analysis and Cross Wavelet Analysis techniques were also applied to the time series to determine the similarities in the each tide gauge spectrum and the pair of the tide gauges. In the conclusion, the frequencies, amplitudes and trends for tide gauge stations (in different latitudes) found in the result of LSSA were compared, and their differences were interpreted. In addition to these spectral analysis techniques, Multi Layer Feed-forward Back-propagation (MLFB) Neural Network (NN) was used to create a model for prediction of sea level data and filling the gaps in the time series.

Keywords: spectral analysis, wavelet analysis, neural network



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2841****Analysis of geophysical variations of the Earths dynamical flattening*****Dr. Laura Isabel Fernandez****GESA, Geodesia Espacial y Aeronomia Fac. Cs. Astron. y Geof. Univ. Nac. de La Plata IAG*

The luni-solar precession and nutation of the Earth depend on the dynamical flattening (H), which is related to the principal moments of inertia of the whole planet. Therefore H is linked to the C_{20} coefficient of the Earths potential, which is regularly determined by space geodetic techniques. In this work, the temporal variations of the C_{20} spherical harmonic coefficient time series are analyzed. The contribution of atmospheric mass redistributions, along with the oceanic mass terms and solid Earth tides were removed from the geodetic C_{20} time series as a difference. Afterward the hydrological influence from different models was investigated for the residual time series.

Keywords: dynamical, flattening, geopotential

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2842****Modelling the glacial isostatic adjustment of the British Isles: constraints from continuous GPS measurements of 3-D crustal motion*****Dr. Norman Teferle****Inst. of Eng. Surv. and Space Geodesy Univ. of Nottingham IAG****Sarah Bradley, Glenn Milne, Richard Bingley, Etienne Orliac***

Large scale present-day deformation within the British Isles is dominated by the glacial isostatic adjustment (GIA) process. Model predictions demonstrate that the GIA-induced deformation includes a significant component from both the local British-Irish ice sheets as well as the more distant Fennoscandian and Laurentide ice sheets. For example, the associated tangential component of the GIA signal is predicted to be a uniform motion in a northwesterly direction which is mainly attributed to the Laurentide ice sheet. All previous studies, which used the high quality relative sea level (RSL) data set for the British Isles to constrain GIA models for this region, have been unsuccessful in obtaining high-quality fits to the entirety of these data due to the large spatial variations of the GIA signal itself and the highly non-monotonic nature of the RSL data. Furthermore, the model predictions display a strong sensitivity to local ice and Earth model parameters as well as the melt history of the remaining (globally distributed) ice sheets, resulting in a high degree of non-uniqueness. This is a major obstacle in arriving at a robust model solution for this region. In this study, we consider a data set of present-day, 3-D crustal motion at about 40 continuous GPS stations across the UK mainland to provide new constraints on GIA models of the British Isles that complement those imposed by the RSL observations.

Keywords: glacial isostatic adjustment, continuous gps, british isles

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS003****Poster presentation****2843****Impact of regional GNSS permanent networks in the study of local geodynamics*****Prof. Aurelio Stoppini****Dipartimento di Ingegneria Civile e Ambientale Universit degli Studi di Perugia IAG****Radicioni Fabio, Fastellini Guido***

DICA is currently operating two regional GNSS permanent stations networks: GPSUMBRIA (GNSS official network of the Region Umbria, offering services in post-processing and real time) and LABTOPO (University network covering a wider area, only for post-processing services). The stations of these networks, specially the first one, are quite dense, with an average interdistance of about 30-40 km. Until now, such networks have been mostly used by technicians for applications like mapping, engineering surveys and cadastre, but they also have a big potential for the monitoring of local crustal deformations. The monumentation of the sites is very stable, matching the EUREF-IGS specifics (two stations are part of EUREF EPN network and EUREF-IP project). All data are submitted to a daily quality control. Through the real time software, performing a continuous computation of the network, coordinates series of all sites at a very high sampling rate (e.g. 1 second) are available. Therefore, the networks are well suited for local geodynamic studies. In the specific case, such applications are particularly interesting because Region Umbria is characterized by a strong sismicity. In the present paper, both networks are described, as for stations location, data availability, and their performances in terms of positioning services at different accuracy levels. The possibilities for applications on local geodynamics are then discussed.

Keywords: gnss, local, deformations

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****2844 - 2966****Symposium
Positioning and Applications****Convener :** Dr. Sandra Verhagen, Prof. Chris Rizos

The symposium will deal with the subjects covered by IAG Commission 4 and the related services. Terrestrial and satellite-based positioning systems development, including sensor and information fusion. Navigation and guidance of platforms. Interferometric laser and radar applications (e.g., Synthetic Aperture Radar). Applications of geodetic positioning using three dimensional geodetic networks (passive and active networks), including monitoring of deformations. Applications of geodesy to engineering. Atmospheric investigations using space geodetic techniques. All aspects of theory are also included.

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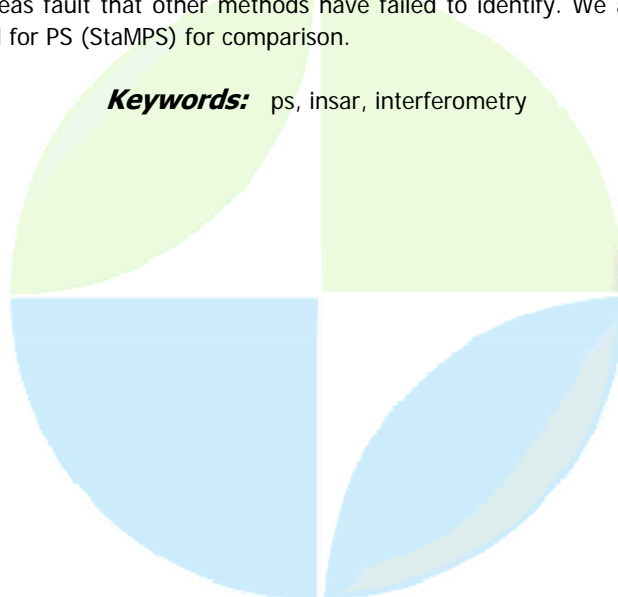
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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Oral Presentation****2844****Signal models with application to selection of persistent scatterers****Mr. Piyush Agram***Electrical Engineering Stanford University***Howard Zebker**

Persistent Scatterers method involves identifying a network of pixels in a series of interferograms whose scattering properties vary little with time and geometry. Pixels that are dominated by a single scatterer best meet this requirement. Most popular PS methods select this network of pixels based on observed amplitude scintillations. We have developed a new PS selection method that uses a probabilistic approach to identify a denser network of stable, coherent scatterers in a series of interferograms. We describe the mathematical framework for the PS selection process. This framework can be used for the common master scene approach, as well as the small baseline approach. We exploit the correlation in interferometric phase to correct for all known sources of error in every interferogram using an adaptive filter. We construct a time-series of phase residuals for every pixel in the interferograms and compare it with a phase distribution corresponding to a pre-selected signal model. These signal models enable us to compute the distribution function of the interferometric phase as a function of the pixel Signal-to-Noise ratio (SNR). In effect, we compute the most likely SNR, using simple Bayesian rules and maximum likelihood principle that would have generated the observed phase residuals. We compare these estimated SNRs against a reasonable minimum SNR threshold to identify the PS pixels. We present three different signal models with applications to this selection procedure. The first signal model, called the SAR model, is applicable to the common master scene PS selection problem and assumes that a strong scatterer with a constant return, dominates over the complex Gaussian random contribution from the other scatterers. By estimating the SNR, we determine the strength of the strongest scatterer as compared to its surrounding scatterers. The second model called the Constant plus Gaussian (CpG) model is applicable when all the interferometric phase measurements are made with independent pairs. The third model called the Gaussian plus Gaussian (GpG) model is also applicable to a similar scenario. This is well known as a second-order speckle model in the optics community. We discuss different methods of determining the right threshold SNR for our selection methods. We present results obtained using this method in the Bay Area (California). We identify 50% more PS pixels using our method as compared to other methods, including stable isolated pixels to the West of the San Andreas fault that other methods have failed to identify. We also present the results using Stanford Method for PS (StaMPS) for comparison.

Keywords: ps, insar, interferometry

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Oral Presentation****2845****Carrier phase ambiguity resolution using multiple GNSS signals: geometric approaches and performance analysis*****Prof. Yanming Feng****School of Software Engineering&Data Communications Queensland University of Technology
IAG****Chris Rizos***

Many techniques have been developed for reliable and rapid determination of the cycle ambiguity in carrier phase signals observed by two or more GPS receivers. Ambiguity resolution techniques normally involve the use of unambiguous code observations and ambiguous phase observations on multiple satellites together to provide enough measurements for an estimation of all the states (unknown parameters), preferably with measurements from a single epoch. Successful ambiguity resolution, regardless of whether it is based on single, dual or multiple carrier signals, depends on two major processes: modelling of phase measurements and biases, and estimation of the mixed integer problem. Some software systems implement more efficient integer search algorithms in the estimation process, whilst others deal with deterministic and/or stochastic modelling better. The most reliable ambiguity resolution system addresses both of these aspects, this being especially true in the current GPS case where only L1 and L2 carriers are available for making measurements and resolving carrier phase ambiguities. The paper describes a generic form for geometric models in ambiguity resolution, which combine geometry-free and geometry-dependent measurements and geometric constraints. First of all, the geometry-free, distance-independent approaches are outlined, which perform ambiguity resolution with three GNSS signals, comprising the three major processes: (a) estimation of the first and second wide-lane integers, (b) estimation of the first-order double-differenced ionospheric delay of any ray path from the two integer-fixed wide-lane signals; and (c) geometry-free estimation of the third independent integer. It is difficult to achieve desired success rates and reliability of fixing the second (wide-lane) and the third integers (medium-lane) if strong multipath effects are present in the code and phase measurements. Secondly, the authors review a novel geometry-dependent approach for improved ambiguity resolution and positioning performed with three or more ranging signals. For a given GNSS service based on three frequencies, the proposed method selects two extra-wide-lane (wavelength of above 2.90 m) and one narrow-lane (wavelength of about 11 cm) virtual signals that have the minimal ionosphere scale factors with respect to their wavelengths. As a result, these signals can tolerate much larger ionospheric delays than any other virtual signals, thus allowing for much more reliable and rapid ambiguity resolution over much longer base-to-rover distances. The method performs ambiguity resolution and position estimation using double-differenced phase and code measurements, comprising four procedures: (a) resolving two selected extra-wide-lane ambiguities using measurements from a single or multiple epochs; (b) estimating the first-order ionospheric delay using the two ambiguity-fixed extra-wide-lane signals and applying the correction to refine the wide-lane signal; (c) resolving the selected narrow-lane ambiguity; and (d) using the ambiguity-fixed virtual signals to perform positioning. The latter at regional to global scales for decimetre accuracy, and at local to regional scales for centimetre-level accuracy. The method provides the key technical basis for future generation local, regional and global GNSS services using three and more carrier signals. Thirdly, we examine the general formulation of the equation system for an ambiguity resolution problem. This general formulation enables the combination of geometry-free measurements, geometry-dependent measurements, and geometric constraints for known parameters, to achieve more reliable integer solutions or higher availability of RTK solutions. Theoretically, this generalizing procedure improves ambiguity resolution reliability on an epoch-by-epoch basis, instead of based on a combination of measurements from

previous epochs. In the fourth place, we have performed numerical experiments using six sets of 24-hour dual-frequency GPS data to demonstrate the performance benefits of some of the proposed key algorithms over baseline lengths of between 38 and 90 km. We obtained preliminary results from these data sets, and can conclude: (a) the ambiguity resolution reliability (success rate) is over 85% with measurements from single epochs; (b) introducing a few geometric constraints, such as for integers reliably obtained from previous epochs, the ambiguity resolution reliability can be improved to over 97%; (c) the phase noises and troposphere errors appear more dominating compared to the effect of ionosphere errors. In general, the experimental results support the new concepts for future regional and local GNSS centimetre-level positioning services using three frequency GNSS signals.

Keywords: gnss, tcar, positioning



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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Oral Presentation****2846****Improving the stochastic model of GNSS observations****Mr. Xiaoguang Luo***Geodetic Institute University of Karlsruhe (TH) IAG***Michael Mayer, Bernhard Heck**

Nowadays, Global Navigation Satellite Systems (GNSS) have become efficient and essential for a wide range of applications. However, the least squares algorithm used in GNSS data processing delivers reliable estimates of unknown parameters and associated accuracy measures only if both the functional and the stochastic models are appropriate. While in the past years the functional model of GNSS carrier-phase observations has been continuously improved and widely accepted, the stochastic model is still under development. Usually a simple stochastic model of GNSS carrier-phase observations with a scaled identity variance matrix is applied and the physical correlations, for instance the temporal and spatial components, are neglected. Obviously this simplified stochastic model is not suitable for applications with high accuracy requirements using high frequency GNSS observation data. In this paper a further step to improve the stochastic model of GNSS observations by using a more realistic weighting model based on signal-to-noise ratio (SNR) measurements is presented. This weighting model allows a frequency-related weighting of each phase observation and is more reliable for handling low elevation data in comparison with the common weighting model, which is merely dependent on satellite elevation angle and requires the assumption of azimuthal symmetry. This approach has been implemented in the Bernese GPS software version 5.0. Using this weight model in regional networks results in an enhancement of the accuracy of station specific neutrospheric parameters and an improvement in ambiguity resolution ability. Additionally, the repeatability of the estimated station coordinates is affected. As study case the permanent SAPOS (Satellite Positioning Service of the German State Survey) network is chosen.

Keywords: gnss, snr, weighting model

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Oral Presentation****2847****Use of Global and Regional Ionosphere Maps for Single-Frequency Precise Point Positioning****Mr. Quan Le***DEOS Delft University of Technology***Christian Tiberius**

Precise Point Positioning is a positioning technique in which only a standalone receiver is used to achieve high accuracy. Augmentation corrections or products are needed to account for major error sources, including satellite orbits and clocks, ionosphere, troposphere, and site displacement effects. The corrections/products are mainly obtained from publicly available sources, e.g. the International GNSS Service (IGS). Position parameters are estimated recursively together with the ambiguities of the precise carrier phase measurements in a filter known as the phase-adjusted pseudorange algorithm. This is a purely kinematic approach and suited for cheap single-frequency receivers with relatively fast convergence and easy implementation. For single-frequency PPP, the ionospheric delay is the most critical source of error. Global Ionosphere Maps (GIM) from the IGS a popular product to compensate for the ionospheric effect. With the GIMs, Vertical Total Electron Content (VTEC) values are provided with an accuracy of about 5 TECU (on average) at a 5x2.5 longitude and latitude grid. The remaining ionospheric error mainly affects the vertical positioning component. Using a (more detailed) regional ionosphere map would help to improve the positioning accuracy. Since mid 2004, regional ionosphere maps have been made available for Europe under the Space Weather Application Center - Ionosphere (SWACI) project. It is a joint project of the DLR Institute of Communications and Navigation (IKN) and the German Remote Sensing Data Center (DFD). With similar techniques to generate the GIM, the SWACI ionosphere maps are produced from a GPS tracking network. The ionosphere observations are used to determine the slant TEC from receiver to satellite. The slant TEC data are then mapped onto the vertical axis by applying a mapping function which is based on the single layer approximation at 400 km height. Finally, to produce regional TEC maps over Europe, the measured and calibrated TEC data are assimilated into the regional Neustrelitz TEC Model. In this paper, the impact of global and regional ionosphere maps on single frequency PPP performance will be analysed by processing data from static GPS stations in Europe as well as from kinematic flight experiments. The comparison between different ionosphere maps is made in both range and position domain. Less than half a metre position accuracy has been demonstrated using the IGS Global Ionosphere Maps (at the 95% level). Exploitation of the SWACI maps will show an improvement of 2-3 decimetres in the vertical component, bringing the vertical accuracy to the same level as the horizontal one (2 decimetres - 95%). Moreover, the very small latency of the maps allows application in real-time kinematic positioning.

Keywords: precise point positioning, ionosphere, single frequency

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GS004

Oral Presentation

2848

Precise Real-Time Point Positioning of Airplanes with Decimeter Accuracy

Dr. Yoaz Bar-Sever
Tracking Systems JPL IAG

Robert Meyer

We will demonstrate and discuss techniques for decimeter-level point positioning of airplanes, anywhere in the world, without the use of near-by ground reference sites. Our ppp approach uses real-time differential corrections from the NASA Global Differential GPS (GDGPS) System, relayed to the airplane in a variety of means, as well as onboard pressure measurements. Such a system was implemented for the NASA UAV-SAR mission, and we will describe the implementation, demonstration, and validation of this new capability. Indeed, validation of decimeter-level positioning for a maneuvering airplane is perhaps the most challenging task, and we will discuss our robust validation approach, which includes post processing, conventional differential techniques over short baselines, as well as mapping and satellite imagery. We will describe some of the scientific and civil applications that benefits from this new capability.

Keywords: gps, point positioning, uav

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GS004

Oral Presentation

2849

Static Stress Change from the 8 November, 1997 Ms 7.9 Manyi, Tibet Earthquake as Inferred from InSAR Observation

Mr. Yangmao Wen

School of Geodesy and Geomatics Wuhan university, Wuhan, Hubei, China IAG

Xu Caijun

On 8 November, 1997, an Ms 7.9 earthquake occurred in Manyi, Tibet plateau. The earthquake occurred on Maergaichaer-Ruolacuo fault at the northern edge of Qiangtang Basin. The region is flat with an elevation of 5000m, where rarefied atmosphere, cold climate, sparse vegetation coverage and lack of human habitation provide excellent conditions for Interferometric Synthetic Aperture Radar (InSAR) studies. We use co-seismic pairs (Frame 2889/2907, Track 033/076/355) of radar images acquired by the ESA ERS-2 satellite to construct interferograms of the surface displacement field due to the earthquake. The location and extent of the co-seismic fault rupture are mapped using interferograms fringes, interferometric correlation and azimuth offset measurements. Employing 3-D semi-analytical visco-elastic body force model and Genetic Algorithm (GA), we invert the location of the co-seismic fault and slip distributions, and compare the result with the studies of elastic dislocation model with variable and non-vertical dips. Our result is best fitted the InSAR displacement. Basing on the Coulomb failure criterion, we farther calculate static stress changes on target received fault planes and optimal failure planes by assuming a regional compressional stress with different friction and depth. The relationship between Manyi earthquake and aftershock is also presented in the paper. It shows that the 14 November, 2001 Ms 8.1 Kunlun mountain earthquake may be triggered by this earthquake.

Keywords: manyi earthquake, insar, static stress change



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Oral Presentation****2850****Current state of Precise Point Positioning, and future prospects and limitations*****Prof. Sunil Bisnath****Earth and Space Science and Engineering York University IAG*

The Precise Point Positioning Working Group within the Next Generation RTK Sub-Commission of IAG Commission 4 has been involved with Precise Point Positioning (PPP) developments for the past few years. The information presented here summarizes the Working Groups findings concerning the state of PPP technology, and discusses the probable near-term future potential and limitations of the technique. The broad question of the place of PPP within the future spectrum of space geodetic measurement techniques is addressed by investigating specific aspects of the method. The current state of PPP discussion includes delineation of performance specifications such as precision, accuracy, convergence period, reliability and integrity; usage and application issues such as areas of conventional usage and areas of growth; and the technical limitations of convergence period, ambiguity resolution and solution integrity. The potential for improvement is significant. Topics of most interest are ambiguity resolution, integration with RTK, integration with INS, ingestion of precision atmospheric models and improvements due to augmented observables from GPS Modernization, Galileo, GLONASS, etc. Infrastructure challenges are also addressed, including the availability of precise orbits and clock offsets, precise orbit and clock prediction, and real-time dissemination of predicted orbits and clocks.

Keywords: precise point positioning, gnss, positioning navigation



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Oral Presentation****2851****Integer ambiguity fixing for GPS precise point positioning****Dr. Maorong Ge***Department of Geodesy and Remote Sensing GFZ Postdam IAG****Gerd Gendt, Markus Rothacher, Chuang Shi, Jianghui Geng, Jingnan Liu***

Precise Point Positioning (PPP) has been demonstrated being a powerful tool widely used for very precise deformation monitoring, as well as for precise positioning of moving platforms. However, their results are still suggested to be improved by integer ambiguity fixing, which is, up to now, prevented by the presence of the uncalibrated phase delays (UPD) originating at receivers and satellites. In the network mode, ambiguity fixing dramatically improves especially results for kinematic applications or static positioning with short observation time. In expecting a similar improvement for PPP, its ambiguity fixing is considered as one of the innovative issues for GNSS research and applications in the next ten years. In this paper, it is shown that UPDs are rather stable in time and space, and can be estimated with high accuracy and reliability through a statistical analysis of the estimated ambiguities from a reference network. An approach is implemented to estimate the fractional parts of the single-difference (SD) UPDs between satellites in wide- and narrow-lane from a global reference network. By applying the obtained SD-UPDs as corrections to the SD-ambiguities at a single station, the corrected SD-ambiguities have naturally integer feature and can therefore be fixed to integer as usually done for the double-difference ones in the network mode. With data collected at 450 IGS stations, the efficiency of the presented ambiguity-fixing strategy is demonstrated by an 30% improvement in repeatability and consistency with IGS weekly solutions. Significant improved results for short observing time as well as for kinematic positioning will presented in details too.

Keywords: precise point positioning, gps, ambiguity fixing



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Oral Presentation****2852****Real-time kinematic OTF positioning using a single GPS receiver: test results and challenges****Prof. Yang Gao***Geomatics Engineering The University of Calgary IAG***Min Wang, Yufeng Zhang**

With the continuous improvements in accuracy/availability of precise orbit and clock products and the development of new error mitigation and data processing methodologies, precise point positioning (PPP) is going to become an efficient alternative to current differential positioning techniques for many applications. The application of PPP to real-time applications, however, is still limited by its long convergence time, typically 30 minutes, necessary for the float carrier phase ambiguity parameters to converge. To reduce this long convergence time, ambiguity resolution methods should be developed for PPP. In doing that, first we need to investigate if the integer property of the phase ambiguities in PPP can be recovered due to the existence of initial phase biases. Some recent research results have demonstrated that this is feasible based on the analysis of data from GPS reference networks. Next we need to answer the question if the integer ambiguities can be fixed to their integer values to dramatically reduce the convergence time in real-time kinematic positioning. This paper will investigate the potential to conduct real-time kinematic on-the-fly (OTF) positioning using a single GPS receiver. OTF refers to fast ambiguity resolution methodology to resolve the carrier phase ambiguities to their integer values. The paper will first discuss how to recover the integer property of the carrier phase ambiguities in PPP and then investigate the feasibility of OTF ambiguity resolution in PPP. Test results including static and kinematic data will be presented to demonstrate the performance of real-time kinematic OTF positioning using a single GPS receiver. The challenges encountered during the tests will also be addressed.

Keywords: ambiguity resolution, on the fly, ppp

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Oral Presentation****2853****Stochastic Modelling for Network-Based GPS Positioning****Dr. Samsung Lim***School of Surveying & Spatial Information Systems UNSW IAG***Tajul A. Musa, Chris Rizos**

Even if significant systematic errors can be modelled in network-based positioning, residual biases may still be present. In this case, not only the station-dependent terms but also the distance-dependent terms may affect the positioning process. It is difficult to define a functional model that can adequately deal with these residual biases, but their influence must be accounted for. The stochastic model, e.g. the variance-covariance (VCV) matrix, has been used to define the observation noise characteristics for this purpose. This paper investigates a realistic stochastic model for the network-based positioning technique. The least squares residuals can be used to define a heteroskedastic model of the double-differenced measurements, i.e. their a priori variances are changing over time. Test results using this stochastic model suggest that the performance of the ambiguity validation tests is improved, which can therefore provide better confidence in the ambiguity resolution process. Based on autocorrelation plots and the estimated correlation coefficients, it is suggested that strong temporal correlations exist in the homoskedastic model (i.e. their a priori variances are all the same). Residual analysis of the heteroskedastic model indicates that this temporal correlation can be effectively modelled using transformed measurements. Therefore the estimated VCV matrix can be represented as a block-diagonal matrix. Nevertheless, the estimated baseline components do not change very much regardless of the stochastic model that is used.

Keywords: gps, stochastic modelling, variance covariance



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Oral Presentation****2854****Permanent Scatterer Interferometry: State of the Art and New Trends****Prof. Fabio Rocca**

IAG

A. Ferretti, Claudio Prati

In the last eight years, extensive processing of thousands of SAR scenes acquired by ERS-1/2, ENVISAT and RADARSAT has demonstrated how multi-temporal data-sets can be successfully exploited for surface deformation monitoring, by identifying objects on the terrain that have a stable, point-like behaviour. These objects, referred to as Permanent Scatterers (PS), can be geo-coded and monitored for movement very accurately, acting as an opportunistic natural geodetic network, integrating successfully continuous GPS data. The paper presents examples of applications of monitoring landslides, seismic faults and subsidence areas, using experience in Europe, US and Canada, and concludes with a discussion on future directions for PSInSAR analysis. This second part will briefly discuss the technical features of the new radar sensors to be launched in the near future (namely: TerraSAR-X, RADARSAT-2, CosmoSkyMed and the new C-band ESA mission SENTINEL) and their impact on PSInSAR analyses, highlighting the importance of data continuity and standardized acquisition policies for almost all DInSAR and PSInSAR applications. Finally, recent advances in the algorithms applied in PS analysis, such as detection of temporary PS, new phase unwrapping strategies, PS characterization and exploitation of distributed scatterers, will be briefly discussed based on the processing of real SAR data.

Keywords: dinsar, permanent scatterers, sar sensors

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(G) - IAGA - International Association of Geomagnetism and Aeronomy

GS004

Oral Presentation

2855

The IAG Commission 4 Positioning & Applications

Prof. Chris Rizos

School of Surveying & Spatial Information Systems University of New South Wales IAG

The terms of reference of IAG Commission 4 Positioning & Applications give some hint as to the range of technologies and applications with which its entities are concerned. The TOR are conveniently summarised in the statement: To promote research into the development of a number of geodetic tools that have practical applications to engineering and mapping. Recognising the central role that Global Navigation Satellite Systems (GNSS) plays in many of these applications, the Commissions work focuses on several Global Positioning System (GPS)-based techniques. These include precise positioning, but extending beyond the applications of reference frame densification and geodynamics, to address the demands of precise, real-time positioning of moving platforms. Several sub-commissions deal with precise kinematic GPS positioning technology itself (alone or in combination with other positioning technologies such as inertial navigation sensors), as well as its applications in surveying and engineering. For example, there are sub-commissions that interest themselves in the R&D of the technology to address ground or structural deformation, mobile mapping or imaging (from land or airborne platforms). Recognising the role of continuously operating GPS reference station network, research into non-positioning applications of such geodetic infrastructure is also being pursued, such as atmospheric sounding. Finally, geodetic applications of interferometric synthetic aperture radar (InSAR) are also a topic of study for one sub-commission.

Keywords: iag, commission 4

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Oral Presentation****2856****Least Squares-Based Filtering of SAR Interferograms*****Dr. Xiaoli Ding****Land Surveying and Geo-Informatics Hong Kong Polytechnic University IAG****Xiaoli Ding***

Synthetic Aperture Radar (SAR) interferograms are usually contaminated by various noise, including the geometrical, temporal, thermal and Doppler centroid decorrelation effects. The noise not only introduces directly errors into Interferometric SAR (InSAR) measurements (typically DEM and deformation measurement products), but also causes pseudo phase residues that hinder the process of phase unwrapping. It is therefore important to develop strategies to reduce the effects of the noise. We present a novel least squares-based filter for reducing the noise in SAR interferograms. The basic concept of the filter is to find a balance between noise reduction and preservation of image details. The development of the filter, the determination of the parameters for the filter, and its practical implementations are discussed in detail. Both simulated and real data sets are used to test the filter against existing SAR ones including the widely used Goldstein filter. The results show that the new filter has its distinctive advantages.

Keywords: leastsquares, sarinterferogram, filter

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GS004

Oral Presentation

2857

State-of-the-Art RTK and DGNSS in comparison with Precise Point Positioning

Dr. Herbert Landau

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Differential GNSS (DGNSS) and Real-Time-Kinematic (RTK) solutions are widely accepted methods for accurate positioning and navigation. Initially these methods were based on single reference stations. A big breakthrough in performance and accuracy was achieved by the introduction of network solutions. Today, the use of the Virtual Reference Station (VRS) method is a standard technology applied in a large number of regional RTK networks all over the world to provide a positioning service with centimeter accuracy. DGNSS techniques are used for marine, airborne and land applications and provide accuracies in the several decimeters range. The DGNSS and RTK methods are based on regional reference station networks or nearby single stations. In contrast, the Precise Point Positioning (PPP) method is providing position accuracy of several centimeters to decimeters based on a globally distributed tracking network. The network processing derives precise satellite orbit and clock information. The achievable accuracy with PPP is impressive, but this method suffers from long convergence times of the order of more than 20-30 minutes and therefore might not be the method of choice for all applications. While these methods co-exist and have their relevance for different markets nowadays, we observe a tendency for larger networks and large reference station spacing in regional networks on the one hand side and densification of the global PPP networks to provide improved accuracy and faster convergence. This paper describes the current state-of-the-art in RTK and DGNSS technology and compares it with the performance of PPP applications today. Performance numbers are presented for various baseline lengths and networks including accuracy, convergence, and reliability.

Keywords: rtk, ppp, dgnss



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Oral Presentation****2858****Carrier phase ambiguity resolution: challenges and open problems****Prof. Peter J.G. Teunissen***DEOS, Delft University of Technology Professor IAG***Sandra Verhagen**

Next generation Global Navigation Satellite Systems will open the door to a whole new field of applications, for example in Earth observation, construction, and safety-of-life navigation. This implies very high requirements not only on precision and availability, but also on reliability. In order to properly address these requirements, rigorous diagnostic tools with a sound probabilistic basis will be needed for the field of carrier phase ambiguity resolution. This contribution addresses the theoretical challenges and open problems with respect to carrier phase ambiguity resolution. One of the issues is quality control in the case of mixed integer models. A related problem is the probabilistic evaluation of the fixed baseline solution. Furthermore, it is important to assess the bias robustness of integer ambiguity resolution, in order to guarantee that common biases do not corrupt the final solution if these biases are not detected or corrected. These and other issues will be addressed in the context of the current and future GNSSs.

Keywords: ambiguity resolution, theoretical challenges

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Oral Presentation****2859****Integration of InSAR time series analysis and water vapour correction for mapping postseismic deformation after the 2003 Bam, Iran Earthquake****Dr. Zhenhong Li***COMET, Department of Geomatic Engineering University College London IAG***Eric J. Fielding, Paul Cross**

A major source of error for repeat-pass InSAR is the phase delay in radio signal propagation through the atmosphere (especially the part due to tropospheric water vapour), which could cause errors as large as 10-20 cm in deformation retrievals. Reduction of the spatial variation of InSAR path delays using space-based water vapour measurements (e.g. the NASA Moderate Resolution Imaging Spectroradiometer (MODIS) and the ESA Medium Resolution Imaging Spectrometer (MERIS)) have been successfully demonstrated [Li et al., 2005; 2006]. Although MERIS and MODIS near IR water vapour products are sensitive to the presence of clouds, we found that the Middle East, North Africa, South Africa, Australia, Chile, Antarctica, Southern California and North Mexico show cloud-free frequencies as high as 60% or even more. The small baseline subset algorithm (SBAS) is a robust time series analysis approach, which mainly uses interferograms with small baselines to minimise the effects of baseline decorrelation and inaccuracies in topographic data used. Unlike persistent scatterer InSAR, phase is unwrapped in 2D image space first for SBAS (instead of in time first or in 3D), making it easy not only to implement in standard interferometric processing, but also to integrate with existing water vapour correction models. The SBAS algorithm is perfect for processing data over arid and urban regions where the coherence is generally high even for long periods with the existing C-band radar archives of ERS, Envisat and Radarsat 1. Therefore, it is clear that the integration of SBAS and MERIS/MODIS water vapour correction models shows promise to map small deformation signals over certain regions (such as the aforementioned desert areas): (1) it has the ability to map surface deformation as it evolves in time; and (2) it is able to better separate deformation signals from water vapour effects. We examine with Envisat ASAR data the postseismic surface deformation after the 2003 Bam, earthquake, which is one order of magnitude smaller than the coseismic deformation, so the signal in individual interferograms is affected strongly by atmospheric variations. For the first time, we are exploring the use of integration of SBAS and water vapour correction models to investigate the postseismic time history in the three years since the earthquake. Preliminary InSAR time series analysis (without water vapour correction) shows small spatial-scale ground deformation that decayed with a time constant of about 1/2 year after the earthquake but any larger spatial-scale deformation was masked by the water vapour variations [Fielding et al., 2006]. A better time series of surface deformation is expected when reduction of water vapour effects by c. 50% is achieved (as we did in the Los Angeles region [Li et al., 2005; 2006]) using MERIS and MODIS data. References: Fielding, E. J., P. Lundgren, Z. Li, G. Funning, and R. Brummann (2006), Post-seismic deformation after the 2003 Bam, earthquake from time series analysis of Envisat InSAR, presented at the 2006 SSA Annual Meeting, 18-22 April 2006, San Francisco, California, 18 - 22 April 2006. Li, Z., E. J. Fielding, P. Cross, and J.-P. Muller (2006), Interferometric synthetic aperture radar atmospheric correction: MEdium Resolution Imaging Spectrometer and Advanced Synthetic Aperture Radar integration, Geophysical Research Letters, 33, L06816, doi:06810.01029/02005GL025299. Li, Z., J.-P. Muller, P. Cross, and E. J. Fielding (2005), Interferometric synthetic aperture radar (InSAR) atmospheric correction: GPS, Moderate Resolution Imaging Spectroradiometer (MODIS), and InSAR integration, Journal of Geophysical Research, 110, B03410, doi:03410.01029/02004JB003446.

Keywords: insar, meris, postseismic

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Oral Presentation****2860****Combination of multiple repeat orbits of Envisat for mining deformation monitoring****Mr. Hsing-Chung Chang***School of Surveying and Spatial Information System The University of New South Wales IAG***Linlin Ge, Hua Wang, Chris Rizos**

Radar interferometry techniques, including interferometric synthetic aperture radar (InSAR), differential InSAR (DInSAR) and permanent scatter InSAR (PSInSAR), have demonstrated their capabilities to extract geodetic information of the earth surface. They are considered to be more cost-effective and complementary to conventional ground-based surveying methods. The authors have been studying the dynamics of mine subsidence using DInSAR in the state of New South Wales, . A mine subsidence profile extracted from a JERS-1 DInSAR result illustrated a root mean square error (RMSE) of 1.4cm against the ground levelling data. Also, we demonstrated that sub-centimetre accuracy of DInSAR result can be achieved when ERS-1/2 tandem pairs are used. As in many other DInSAR studies for land deformation monitoring, the deformation is measured along the line-of-sight between the radar antenna and the ground object. Then the subsidence (vertical surface deformation) is measured with the assumption of negligible horizontal deformation. However, the in-situ ground surveying data shows that the underground mining activity may cause horizontal surface displacement. In addition, this assumption is more applicable to the ERS-1/2 data rather than the JERS-1 data as the look angle of ERS-1/2 (23o) is smaller than the angle of JERS-1 (35o). With the steep look angle, the DInSAR results are more sensitive to the vertical deformation than the horizontal. In order to study the vertical and horizontal displacement of mine subsidence, multiple repeating orbits in both ascending and descending modes of ENVISAT/ASAR data are used. Recently, PS-InSAR has been proved its ability to measure the slow deformation of the persistent ground objects (or the permanent scatterers) at the accuracy of a few millimetres. However, PS-InSAR is not suitable for the case of monitoring land deformation caused by underground mining, as the imaged pixels near the centre of the subsidence basin have a large deformation so that they loss their stability to be considered as permanent scatterers. Some previous research used DInSAR with both ascending and descending orbits of ERS-1/2 SAR imagery. Due to the fixed small look angle (23 degree) of ERS-1/2 satellites it makes the DInSAR results more sensitive to the vertical displacement of the land surface but less sensitive to its horizontal vector. The variation of the swath mode of ENVISAT/ASAR provides the opportunity to investigate the 3-D surface deformation vectors due to underground mining with a range of satellite look angles ranging from 15o to 45.2o. This study combines the DInSAR results generated from three different look angles. This means 3 deformation vectors along three independent line-of-sight of the same site over similar period can be obtained. Therefore, the deformation vectors of Up, Easting and Northing can be resolved. The quantitative results are assessed against other spatial data with the aid of GIS.

Keywords: dinsar, subsidence, mine

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Oral Presentation****2861****Land subsidence monitoring in Australia using satellite interferometry****Mr. Alex Hay-Man Ng***School of Surveying and Spatial Information System University of New South Wales IAG****Hsing-Chung Chang, Kui Zhang, Linlin Ge, Chris Rizos***

Groundwater is one of the most important natural resources in Australia. It provides water to Australian population by supporting agriculture, households, electricity and gas generation, manufacturing industry, mining industry etc. The amount of groundwater usage has increased dramatically in Australia in recent years due to the limit amount of surface water supplies available. The groundwater resources have been over-extracted in many areas of Australia. In addition, the future sustainability of groundwater resources is at risk from overuse in many capital cities in Australia. The continued over-extraction of groundwater may lead to large land subsidence which causes economic loss and threaten humans life. The aim of this research is to investigate the effect of groundwater extraction using Permanent Scatters approach. One of the aims of this project is to use PS-InSAR approach to investigate the effect of groundwater extraction. The result can be used for monitoring land subsidence which can help to improve understanding on terrain and built structures movements. Permanent Scatters Radar Interferometry (PS-InSAR) approach is an alternative technique for land subsidence monitoring to conventional surveying methods. The advantage of PS-InSAR technique over the conventional surveying methods such as levelling is its ability to identify the whole subsidence basin. In conventional surveying methods, it is very difficult to set up bench marks for the ground survey over a large area because it is time consuming and it also requires large labour intensity for dense survey marks over a huge area. Therefore, Permanent Scatters Radar Interferometry technique is used here as a complementary technique to conventional surveying methods. Spaceborne radar interferometry has already been used in many ground deformation monitoring application due to its high precision and spatial resolution. Some studies in Europe have demonstrated the capability of PS-InSAR for land subsidence monitoring. This research uses C-band ERS-1/2 and ENVISAT radar images to investigate the land subsidence due to groundwater extraction in both Australia and China. The PS-InSAR technique first identifies all the stable point scatterers and a 2D deformation analysis is then applied to these points. PSInSAR techniques can generate deformation time-series with accuracy up to millimeter depending on the number and quality of SAR images. The PS-InSAR results are validated with other spatial data such as groundwater extraction bore sites and road structure maps. A total of 10 and 18 ERS-1/2 images acquired from 06/1992~12/1996 and 04/1992~04/1997 for Perth and Sydney respectively are chosen to be investigated with PS-InSAR. 9 ENVISAT images from 12/2003~06/2006 acquired over Northern China are chosen to be investigated by PS-InSAR. In Sydney area, highest deformation rate is observed in Eastern Suburb especially along the Botany Sands Aquifer which is the biggest aquifer in Sydney. This is possibly due to the groundwater extraction. The groundwater resources in both Perth and Northern China have already been overused. Much higher subsidence rates have been recorded in these locations compare to Sydney. Up to 7 centimetres deformation per year have been observed in both test sites.

Keywords: subsidence, groundwater, interferometry

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Oral Presentation****2862****Kinematic precise point positioning during marginal satellite availability*****Dr. Jon Glenn Gjevestad****Dept. of Mathematical Sciences and Technology University of Life Sciences, N-1432 Aas,
Norway IAG****Dr. Narve Kjorsvik, Dr. Ola Ovstedal, Ovstedal Ola***

Using Precise Point Positioning (PPP) techniques, kinematic positioning at sub-decimeter accuracy is currently available. The simplified logistics make PPP a highly competitive alternative for many large scale surveys. Due to the presence of biases in both satellite and receiver hardware, the integer carrier phase ambiguities may currently not be reliably identified, hence ambiguities must be estimated as real numbers, a so-called float solution. A float solution will be highly accurate, provided sufficient convergence of the ambiguity parameters. In PPP convergence times is usually 20-60 minutes, provided continuous carrier phase observations from a sufficiently number of well-distributed satellites. In many applications, these requirements can not be fully met all the time, e.g. due to topographic constraints. This exposes the need to treat the periods with marginal satellite availability separately. The current investigation focuses on marine surveying in narrow and steep Norwegian fjords. A typical survey pattern will consist of a number of parallel fjord crossings. Hence, a sufficient number and distribution of satellites will only be available in the middle of the fjord. The situation is further complicated by the fact that different satellites will be available at each side of the fjord. Almost 40 days of 1 Hz GNSS observations were collected at a shuttle ferry under good conditions. A reference trajectory was computed using a local (<2 km) reference station and fixed double-differenced ambiguities. Using a Digital Elevation Model (DEM) the topography of a nearby fjord was simulated, and the artificial horizon was applied to the actual data to limit the satellite availability. We investigate several approaches on how to improve PPP accuracy during constrained and changing satellite availability, without access to external information. A first step is to investigate the contribution of GLONASS. The International GNSS Service (IGS) provides precise orbit and clock corrections for both GPS and GLONASS. The GLONASS products are currently not on par with the GPS products. The GLONASS constellation has also suffered from poor maintenance. Hence, under normal conditions GLONASS gives a very small contribution. The orbital inclination is however favorable at high latitudes, and even a few extra satellites may be highly beneficial during marginal conditions. As a second step we investigate the effect of height constraints during periods of marginal satellite availability. It is shown that PPP may be a competitive alternative even during marginal satellite availability, provided all available information is considered in the processing.

Keywords: gnss, ppp

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Oral Presentation****2863****The total optimal criterion in solving the mixed integer linear model with GNSS carrier phase observations*****Dr. Jianqing Cai****Institute of Geodesy Universitt Stuttgart IAG****Erik W. Grafarend, Congwei Hu***

High precision relative global positioning system (GPS) positioning is usually based on the double-differenced (DD) carrier phase observables, where the resolution of the phase ambiguity is a crucial problem. When the integer ambiguity is rightly determined the positioning results with millimeter accuracy can be achieved. Until now there are many algorithms on the GPS ambiguity determination, which can be classified as three categories, i.e., ambiguity resolution in measurement domain, the ambiguity search technique within coordinate domain and in ambiguity domain. There are so many search technique developed in ambiguity domain, such as FARA (Frei and Beutler 1990), LSAST (Hatch 1990), the modified Cholesky decomposition method (Euler and Landau 1992), LAMBDA (Teunissen 1993), FASF (Chen and Lachapelle 1995) and modified LLL Algorithm (Grafarend 2000, Lou and Grafarend 2003), in which the widely applied LAMBDA method is based on the Least Squares Ambiguity Search (LSAS) criterion. G. Xu (2002) proposed also a new general criterion for ambiguity searching that can be carried out in coordinate domain or in ambiguity domain or in both domains. Therefore, a discussion about the priority of both criterions in the sense of optimality und unbiasedness arises. Based on the mixed Integer Linear Model with constraints in both coordinate and ambiguity parameters we have studied this kind of problem and developed a total optimal criterion for resolving the integer ambiguity in both coordinate and ambiguity domain. This criterion is implemented in our GPS data proceeding software and tested with real GPS phase data. The theoretical and numerical results show that (1) the LSAS criterion is just the special case of the total optimal criterion with the constraint only in ambiguity parameters, and (2) the criterion from G. Xu is incomplete without considering the correlation of the integer and coordinate parameters correctly. The effects of the total optimal criterion on GPS carrier phase data processing are discussed and its practical implementation is also proposed.



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Oral Presentation****2864****NTRIP based Real-Time Estimation and Broadcast of GNSS Clock Corrections from EUREF and IGS Sources****Dr. Georg Weber***Geodesy Federal Agency for Cartography and Geodesy (BKG) IAG***Prof. Dr. Leos Mervart, Dr. Christian Rocken**

In November 2004 the Radio Technical Commission for Maritime Services (RTCM) adopted a new standard for Networked Transport of RTCM via Internet Protocol (NTRIP). The NTRIP is a non-proprietary HTTP-based open transport protocol that was initiated by the German Federal Agency for Cartography and Geodesy (BKG) within the framework of EUREF. It allows a remote GNSS receiver to connect to NTRIP broadcasters to upload data in real-time. The broadcasters in turn redistribute the incoming data as NTRIP streams. BKG provides access to open source software clients that can be used to finally obtain the data with very small latencies. The growing popularity of RTK together with the availability of networked GNSS hardware from major vendors resulted in a considerable number of streaming reference stations. Some of them are meanwhile accessible through NTRIP broadcasters operating for the EUREF-IP Pilot Project (EUREF-IP) and the Real-Time IGS Working Group (RTIGS). Thanks to highly appreciated contributions from more than 80 stream providers worldwide, a global real-time GNSS network of about 150 stations emerged. It can serve as a basis for many applications that need online access to open wide-spread GNSS resources. In this paper we report on the current status of NTRIP based GNSS stream collection and dissemination. We then describe the utilization of such data streams in the real-time estimation of accurate GPS and GLONASS satellite clock corrections. The GNSS network processing software RTNET is used to estimate the clocks with predicted IGS orbits. As a part of upcoming EUREF-IP and the RTIGS test and evaluation efforts, the clock corrections are distributed via NTRIP to stationary or mobile users for improved Point Positioning performance. The paper describes the software, shows Point Positioning results, and discusses format issues for orbit and clock correction distribution via NTRIP.

Keywords: satellite clocks, real time, ntrip

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Oral Presentation

2865

The International GNSS Service Real-time Pilot Project, Preparing for the Delivery of Real-time IGS Products

Mr. Mark Caissy

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Paul Collins, Robert Weber

The International GNSS Service (IGS) has been preparing for the introduction of real-time processes that will enhance the service it currently offers the international community. Through the efforts of the IGS Real-time Working Group, real-time infrastructure and processes have been developed that will deliver real-time data to IGS global data centers and analysis centers, and will in the future facilitate the delivery of real-time products to users. The IGS is planning for a real-time pilot project that will commence in mid-2007. The pilot project will further refine and enhance the existing real-time infrastructure and processes with the goal of readying the IGS to make available real-time products. One emphasis of the pilot project will be the delivery of classical IGS products in real-time including raw data and precise satellite clocks and orbits. The vision is that these real-time products will facilitate real-time access to the global reference frame when used with precise point positioning (PPP) techniques. This presentation is intended to explore key activities for the pilot project including the management of global real-time infrastructure and data. On the practical side, examples will be given relating to the processing of real-time data, both for the purposes of validating the current IGS Ultra-Rapid predicted orbits and for the computation of precise satellite clock information in support of real-time PPP users.

Keywords: igs, real time, pilot project

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Oral Presentation****2866****Rigorous analysis of GPS time series with respect to operator-software noise*****Prof. Hansjoerg Kutterer****Geodaetisches Institut, Leibniz Universitaet Hann. University professor IAG****Xing Fang***

GPS observation data are typically processed in a sequence of individual steps. Despite the fact that well-elaborated conventions on models, constants, etc. are used today there are a lot of degrees of freedom in the respective software products and in the processing strategy of the individual operator. On the one hand, various corrections and reductions are applied which improve the quality of the data. On the other hand, additional noise is superposed to the data. Therefore, it is in general impossible to obtain identical results from different operators using different software packages. In this study a rigorous mathematical estimation procedure is presented which takes both the identity of the original data and the differences due to influences of operator and software into account. Here, GPS coordinate time series are used as input data which are derived using different software packages. The average solution is estimated based on a Gauss-Helmert model (condition equations with unknowns), the individual noise is obtained using variance component estimation. Thus, the operator-software noise can be assessed and quantified in order to obtain a more refined GPS uncertainty budget. Both theory and numerical examples are presented.

Keywords: operator software noise, gps time series**PERUGIA**
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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Oral Presentation****2867****InSAR Results from ALOS PALSAR: Southern San Andreas Fault and Hawaii*****Prof. David Sandwell****Scripps Institution of Oceanography Univ. of California at San Diego IAG****Benjamin Brooks, Masanobu Shimada***

PALSAR is the first L-band synthetic aperture radar having the duration and orbital accuracy needed to monitor slow crustal deformation globally. The main advantage of the L-band (23 cm wavelength) PALSAR over C-band (5.8 cm wavelength) is that deeper penetration of vegetated areas results in less temporal decorrelation enabling interferograms having longer time separation. This will facilitate the study of slow crustal deformations in vegetated areas. We report on our experiences making interferograms using PALSAR data and provide preliminary results showing crustal deformation in California and Hawaii. As part of our calibration and validation effort, we have begun interferometric processing of repeat passes over radar corner reflectors at Pinon Flat Observatory near the San Andreas Fault. The longer wavelength, combined with a 2 times increase in range resolution, requires some modifications to standard InSAR processing algorithms. Improvements are needed in three areas: 1) Proper focus of the SAR image is very sensitive to the accuracy of the Doppler rate parameter. The precise orbital information provided with the level 1.0 product, along with a simple polynomial-fitting algorithm, is used to estimate this parameter. 2) The pulse repetition frequency (PRF) of the radar changes incrementally along the track to accommodate variations in spacecraft height and velocity. A PRF interpolator could be needed although we have not yet encountered an image with a PRF change. 3) The longer wavelength, combined with the higher bandwidth, permits the use of long baseline pairs (1-2 km). In areas of significant overall topography (> 2 km), the range change between the top and base of a mountain can exceed a range resolution cell (4.6 m). We have implemented a topographic, image-shift algorithm that significantly improves coherence at extreme elevations. Initial results show that flattened interferograms have less than 1 fringe (12 cm) of residual phase suggesting that ALOS orbits are quite accurate. Phase coherence is excellent in areas of rugged terrain but is somewhat lower in flat areas. Understanding the ALOS orbital errors as well as the ionospheric effects at L-band will require processing many more interferograms. We have analyzed PALSAR data over two tectonically active areas (fine beam, single polarization mode). Interferograms over the creeping section of the Southern San Andreas Fault system do not yet have sufficient time separation to monitor shallow fault creep (~5 mm/yr). However, improved temporal correlation in the agricultural areas of the Coachella valley already reveal subsidence due to groundwater withdrawal. Interferograms over the island of Hawaii reveal two tectonic events - deformation from the October 15, 2006, magnitude 6.7 Kiholo Bay earthquake on the northwest side of the island and a 10-cm volcanic inflation event near Kilauea caldera. Deformation of the Kilauea area is well resolved by PALSAR in three independent interferograms and coherence is good in heavily vegetated areas. These interferograms reveal 10 cm of domal uplift located 7 km southwest of the main caldera. Determining if this feature is associated with actual renewed southwest rift zone activity is important as the region has not been the locus of activity in the most recent phase (post-1983) of Kilauea eruptive activity. Additional PALSAR observations will be used to monitor the rift zone and to compare with continuous GPS measurements in the region.

Keywords: insar, volcano, earthquake

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Oral Presentation****2868****Challenges In Stochastic Modelling, Quality Control And Design In Geodetic Positioning*****Dr. Marcelo Santos****Geodesy and Geomatics Engineering University of New Brunswick IAG****Richard Langley, Don Kim, Rodrigo Leandro***

The search for the ultimate accuracy in a plethora of applications always poses demands and challenges, some new, others with new outfit. At any new frontier, though, new challenges appear. Errors which belong to the domain of either functional or stochastic models must be conveniently addressed, either detected or removed, or properly modeled at the processing phase. Depending on the type of geodetic positioning methods these errors are associated with the observables being used, with atmospheric effects of various sources and variability, with errors which take place at the measurement site, due to the electronic environment of data collection, etc. A search for a reliable modeling in the sense of having the capability of detecting those errors and mitigating them or even estimating their effects resides in the domain of quality control. The application of statistical testing and reliability analysis will eventually reach a degree of efficiency provided stochastic quantities are being dealt with, i.e., on how much the stochastic models are appropriately formulated. If the stochastic model is incorrect, it affects negatively the process of statistical testing and quality control. A problem arises when dealing with errors which are quasi-random in nature. In such a situation, processes such as Baarda's data snooping can play an important role. This presentation will provide a broad overview on the state-of-the-art and showcase the problems that present it as challenges and on the opportunities that these challenges present for the development of novel solutions or optimal combinations of existing solutions.

Keywords: gnss, stochastic modeling, quality control

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2869****Use of GPS survey methods for estimating****Dr. Hasanuddin Abidin***Geodesy Institute of Technology Bandung IAG****V. Sadarviana, J. Santoso, J. Kahar, H. Andreas, M. Gamal***

Landslide is one of a number of prominent geohazards that continuously affect Indonesia, especially in the rainy season. Landslide monitoring and mitigation is therefore very crucial and should be done continuously. One of the methods that can make a contribution in studying landslide displacement is repeated GPS survey. This paper present and discuss the performance and results of GPS surveys conducted in a well known landslide prone area in West Java (Indonesia), namely Ciloto, the hilly region along the Bandung-Jakarta highway. The paper concentrates on the estimation of characteristic, type and slip surface location using GPS-derived vector displacements. Six GPS surveys involving 17 GPS points have been conducted during the period 2002-2006. The results of GPS surveys show that the horizontal displacements in the study area vary from the centimetre to decimetre level with various direction, depending on the location and the observation period in relation to the rainy and dry seasons. The vertical displacements have relatively similar magnitudes, with mixing of subsidence and uplift (bulging) phenomena. Testing and analysis on the GPS derived displacements show that the landslide phenomena in Ciloto area can be classified as a multiple compound (rotational and translational) type of landslide. The existence of several minor scarps has also been identified using GPS-derived results. By utilizing a vertical profile function of surface and GPS-derived velocity trend function, a few locations of slip surfaces including their depths have also been estimated. In general, the GPS-derived information is consistent with the results obtained by previous geological investigation.

Keywords: gps, landslide, monitoringPERUGIA
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Poster presentation

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Monitoring distortion of THAI Geodetic Network due to the BANDA-ACEH and NIAS earthquakes using GPS observations

Dr. Chalermchon Satirapod

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Wim Simons, Chaiwat Promthong

The Thai geodetic network has been regularly observed with GPS since 1994. The continuous tectonic motions in Thailand located on the Sundaland block are well determined. However, the occurrence of the mega thrust earthquake occurred at Banda-Aceh on the 26th December 2004 with Mw 9.3 magnitude has caused significant surface displacements in many surrounding countries. The geodetic network within Thailand was also deformed during the earthquake at the centimetre to decimetre level and the geodetic network will continue to deform for many months and possibly even years to come. The magnitude of displacements certainly has a direct impact on the Thai geodetic control network. Royal Thai Survey Department (RTSD) has been carrying out GPS field campaigns in an attempt to monitor the post-seismic displacement. However, the situation became more complicated when the second major earthquake occurred at Nias, Sumatra on the 28th March 2005 with Mw 8.7 magnitude. This paper will analyse the GPS data obtained from RTSD GPS campaigns and existing permanent GPS stations in Thailand using the Precise Point Positioning (PPP) strategy of the GIPSY-OASIS II software. An impact of both earthquakes on a deformation of the Thai geodetic network will be illustrated. In addition, a strategy for updating the Thai geodetic network will be proposed.

Keywords: gps precise point positioning, thai geodetic network, network deformation

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2871****Contemporary High-Resolution LiDAR Derived DEMs Could Inspire Developments in the Study of Impact Structures****Mr. Michael Finn***U. S. Geological Survey National Geospatial Technical Operations Center IAG***Gary W. Krizanich, E. Lynn Usery**

In the mid-continent of the United States there are eight peculiar geological structural features whose geneses have been variously accounted for yet most likely appear to be crater impacts (Snyder, 1964; Snyder and Gerdeman 1965; Unkelsday and Vineyard, 1992; Kenkmann, 2001; Plymate, 2004; Evans et al., 2005a, 2005b; Planetary and Space Science Center, 2005). The primary alternative interpretation is of cryptovolcanic origin. We have used a primary Geographic Information Science (GIScience) technique of creating a digital elevation model (DEM) of two of these eight features that both occur in Missouri: the Crooked Creek Structure and the Weaubleau Disturbance (also known as the Weaubleau-Osceola Impact Structure Chamot, 2003; Plymate, 2004; Evans et al., 2005a, 2005b). Crooked Creek is a ring like structure in formations of Cambrian and Ordovician age and is located in Crawford County, approximately 5 kilometers miles northeast of Cook Station on Highway VV. Weaubleau is a larger structure in beds from the Mississippian Period and is located in St. Clair County, approximately centered on the villages of Vista and Gerster (Beveridge, 1978, 1990; Unklesbay and Vineyard, 1992; Evans et al., 2005a). For the US, the nominal, publicly available DEM is based on 1 arc second posting of latitude and longitude with varying higher resolution DEMs available at 1/3 arc second and even a few at 1/9 arc second available. These DEMs have nominal postings of 30-meter, 10-meter, and 3-meter, respectively (Gesch et al., 2002; USGS, 2005). We hypothesized that a very high resolution DEM derived from airborne light detection and ranging, or LiDAR, would allow GIScience to contribute in some manner to the study of these structures and also be of benefit to scientists in other disciplines studying them as well. Through contract mechanisms, we have acquired airborne LiDAR data at nominal 1.4 m pulses (ground sample distance) and have processed these data to a DEM at 1.6 m posting, representing a statistically rigid solution based on samples collected at 90 percent, in two directions, of the final post spacing. These new high resolution DEMs are accurate enough to allow for precise measurements of geological structures, particularly jointing in the carbonate rocks and ultimately stimulating advancements in knowledge of these meteorite impact structures. REFERENCES: Beveridge, Thomas R. (1978) [Vineyard, Jerry D., revised edition, 1990] *Geologic Wonders and Curiosities of Missouri*. Missouri Department of Natural Resources, Division of Geology and Land Survey, Education Series Number 4. Chamot, Josh (2003) *Jumbled Missouri geology linked to impact*. *Geotimes*, July. American Geological Institute. Evans, Kevin R., Patrick S. Mulvany, James F. Miller, Kevin L. Mickus, and George H. Davis (2005a) *SEPM Research Conference: The Sedimentary Record of Meteorite Impacts*, May 21-23, 2005, Springfield, Missouri, *Field Trips Guide Book*. Evans, Kevin R., J. Wright Horton, Jr., Mark F. Thompson, and John E. Warne (2005b) *The Sedimentary Record of Meteorite Impacts: An SEPM Research Conference. The Sedimentary Record*, Volume 3, Number 1 (March). SEPM Society for Sedimentary Geology. Gesch D., m. Oimoen, S. Greenlee, C. Nelson, M. Steuck, and D. Tyler (2002) *The National Elevation Dataset. Photogrammetric Engineering and Remote Sensing*, Volume 68, Number 1, pp. Kenkmann, T. (2001) *Deformation mechanisms during impact crater modification inferred from the Crooked Creek Impact Structure, Missouri, USA*. In *Lunar and Planetary Science XXXII*, Abstract #1560, Lunar and Planetary Institute, Houston (CD-ROM). Planetary and Space Science Center, UNB (2005) *Earth Impact Database*. Internet at: <http://www.unb.ca/passc/ImpactDatabase/index.html>. Last accessed 21 November 2005. Plymate, Thomas G. (editor) (2004) *Field Trip Guidebook of the Association of Missouri Geologists 50th Annual Meeting*, Springfield, Missouri, September 26-27, 2003.

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Keywords: impactstructure, crater, dem



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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2872****Monitoring Deformation using Robust and Conventional Kalman Filters****Prof. Stelios Mertikas***Mineral Resources Engineering Crete Technical University IAG*

This work presents an algorithm for examining the quality of measurements of the Global Navigation Satellite Systems. The algorithm has been constructed for real-time and automatic deformation monitoring to issue warnings in case of, for example, a seismic risk or volcano eruption, a land slide, and when certain pre-programmed tolerances have been exceeded. The proposed algorithms have been applied to Real-Time-Kinematic GPS coordinates for an antenna. Two filters have been running simultaneously. The proposed methods have been implemented using intentional deformation for the antenna of the order of 1-, 2-, and 3-sigma. By examining the performance of the differences between conventional (non-robust) and robust Kalman filter state estimates, we are able to reliably detect deformation of the order of one-sigma. At first, a comparison is made in terms of the confidence regions created by the conventional (non-robust) and the robust Kalman filter estimates. When no changes are present in the observations, then the corresponding conventional and robust confidence intervals will overlap. However, if observations contain changes, then the conventional Kalman filter state estimates will deteriorate and no overlapping with the corresponding robust estimates will exist. The developed monitoring tools do an excellent job and provide powerful and efficient diagnostics for detecting small changes in the GNSS observations automatically and in real-time. Change detection can be achieved even at the level of a standard deviation of the process.

Keywords: gnss, quality control, robust conventional filtering



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2873****GPS Precise Point Positioning Accuracy Test: Regional Egyptian Case*****Dr. Ashraf Mousa****Geodynamic Associate Prof. IAG*

The real-time availability of precise GPS satellite orbit and clock products has enabled the development of a novel positioning methodology known as precise point positioning (PPP). Based on the processing of un-differenced pseudo range and carrier phase observations from a single GPS receiver, positioning solutions with centimeter accuracy can be attained globally. Such accuracy can currently be achieved only through differential processing of observations acquired simultaneously from at least two receiver stations. The potential impact of PPP on the positioning community is expected to be significant. It brings not only great flexibility to field operations but also reduces labor and equipment cost and simplifies operational logistics by eliminating the need for base stations. This paper will address issues related to PPP to assess the performance of its solution on a regional scale. The PPP solution accuracy of three Egyptian stations: Helwan, Aswan and Abu simple and precision is compared with the points network solution. Numerical results will be presented to show the positioning accuracy attained with datasets acquired using precise orbit/clock products currently available. Possibility for RTK solution using real time IGS products is also studied.

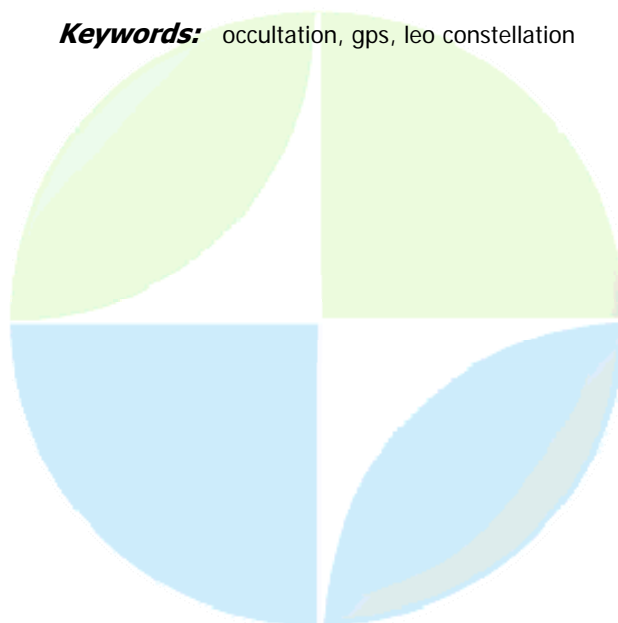
Keywords: gps, ppp, igs

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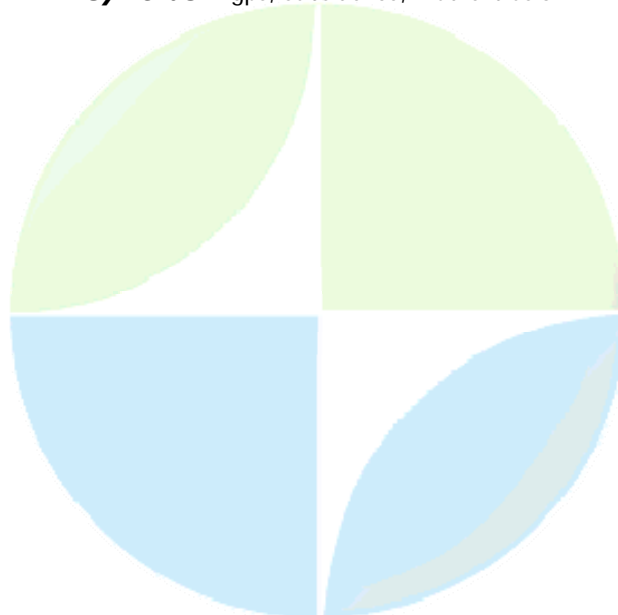
(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2874****The Impact of rose-type LEO constellations Parameters on the Number and Distribution of GPS Occultation Events****Dr. Xiaohua Xu***GS004 GPS Meteorology IAG***Li Zhenghang**

Global Positioning System (GPS) occultation events will be observed with receivers installed on Low Earth Orbit (LEO) satellites, from which the properties of terrestrial atmosphere can be retrieved. Occultation events are the basic observations in a GPS occultation mission. An occultation event happens when the signals of a GPS satellite pass through the Earth's atmosphere and are received by the receiver on a LEO satellite. The number and distribution of occultation events, which are mainly determined by the orbital status of GPS and LEO satellites, are crucial for the potential of this technology in climate and atmospheric research. A LEO constellation can improve the time and space resolution and the number of occultation events greatly compared with a single LEO satellite. In this paper, the impacts of different satellite numbers and different k parameters of rose-type LEO constellations on the number and space-time distribution of occultation events occurred over certain area in one day are studied with numeric simulation method. The simulation is based on the force model for generating LEO satellite orbits and the models of occultation antenna. When judging whether an occultation event will be observed or not, there are 2 steps: (1) to judge whether the line connecting the two satellites can pass through certain layer of the Earth's atmosphere; (2) If the occultation event can be observed based on the geometric relationship as shown in (1), the field of view of the antenna is taken into consideration further more, which means to judge whether the direction of the line connecting the two satellites is in the view field of the antenna. Follow this approach, it is found that a constellation composed of at least of 4 satellites can improve the time and space resolution of occultation observation over certain region obviously. If the constellation parameter k is zero or the greatest value, the time distribution of occultation events is not even. With other permitted k value, the time distribution is better and when k equals to the number of LEO satellites minus 3, the number of occultation events is preferable. The research achievements can be referenced when determining the orbit parameters of the LEO constellation in practice.

Keywords: occultation, gps, leo constellation

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2875****GPS-Based monitoring of subsidence phenomenon****Dr. Hasanuddin Abidin***Geodesy Institute of Technology Bandung IAG***M.A. Kusuma, B. Istadi, A.B. Darmoyo, P. Sumintadireja, I. Purwaman, H. Andreas,
M. Gamal**

Since Ma 29th 2006, gas and hot mud has been gushing out from the ground in Sidoarjo, East Java, 35 kilometers south of Indonesia's second largest city, Surabaya. Some 50,000 cubic meters of hot mud were erupting every day as of August; in September, the extrusion rate escalated to some 125,000 cubic meters daily. On September 26 barriers built to contain the mud failed, resulted in the flooding of more villages. On November 24th, a gas pipeline exploded near the mud extrusion center and killed several people. Scientists are convinced that the eruption is a mud volcano in the process of forming, and may be impossible to stop. The mud is thought to have been sourced from thick layers of overpressured shale and fueled by a geothermal process due to its excessive water content. Subsidence of the area is imminent due to this massive mud extrusion. GPS observations, both in campaign and continuous modes, were conducted to study this subsidence phenomenon. This paper present and discuss the subsidence characteristics as obtained by these GPS measurements. GPS surveys were performed on 18 stations using dual-frequency geodetic type receivers, with observation session length of about 5-7 hours. Five GPS campaigns have been conducted in 2006, namely on 29 June-2 July, 23-25 July, 26-29 August, 17-20 September and 12-15 October. GPS continuous subsidence monitoring was conducted on five stations, and started since 22 September 2006. Field survey to check the surface representation of subsidence phenomenon was also conducted. Based on GPS data, combined with other geophysical survey results it is interpreted that the area about 1.5 km around the extrusion center experience subsidence with the rates of about 1 to 4 cm/day with the increasing rate toward the extrusion center. This observed subsidence might consist of ground relaxation due to mudflows, loading due to weight of mud causing the area to compact, land settlement and/or geological structure/ tectonic activities. Geological interpretation of the observed subsidence will also be presented and discussed in this paper

Keywords: gps, subsidence, mud extrusion

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2876****Monitoring land subsidence using GPS and INSAR****Mrs. Parul Patel***Civil Engineering Department Indian Institute of Technology, Mumbai, India*

Land subsidence is one of the most varied forms of ground failure with devastating effects, ranging from broad regional lowering of the land surface to local collapse. Geological reasons like tectonic and volcanic activities affect at regional scale while localized phenomena can be mainly attributed to either human activities or natural activities like sink holes, fissures etc. With the increase in population, demand of natural resources like water, oil and gas has also increased, resulting in the extraction of these important natural resources in a haphazard manner. Such unplanned extraction of natural resources is one of the major reasons for land subsidence. Uniform settlement of ground does not create any major problem; however, uneven settlement causes lots of damage to infrastructure built over the affected area. There is a significant financial loss in repair of such the infrastructure. Hence attention should be paid to this man-made hazard. To monitor and measure land subsidence, many techniques are available, like conventional leveling, Global Positioning System (GPS), Synthetic Aperture Radar Interferometer (InSAR), in situ techniques like Bore hole extensometer and Radio Active Marker method, etc. With the advancement of space technology, land subsidence is increasingly being measured and monitored with GPS. GPS has proven to be a reliable technique for monitoring the land subsidence with the precision of few mm levels, using geodetic dual frequency receivers, precise ephemeris and processing the data in post processing mode with scientific software. To measure subsidence near Surat in Gujarat state, India, GPS survey has been carried out by the Indian Institute of Technology Bombay (IITB) GPS team. The Study area is a shallow gas reservoir, probably the first shallow gas reservoir in India. A total of 10 GPS field campaigns have been carried out during the period: February 2004 to October 2006, at an interval of 3-4 months. A GPS monitoring network was established in February 2004 with four reference stations and 27 deformation stations. Geodetic dual-frequency GPS receivers have been used for these observations. The reference station GPS receivers were continuously observing during the entire field campaign, and at each deformation station, minimum five hours of continuous GPS data was collected. The collected data and base lines were processed with scientific GPS data processing software: Bernese v 4.2. IGS data files as well as precise ephemeris were downloaded from IGS data bank, which were used for post processing the data. The data was processed considering saastamoinen troposphere model and ionosphere free solution combining L1 and L2 frequencies. The processing was done in two stages. In first stage, precise coordinates were obtained from IGS website for three nearby IGS stations, namely LHAS, BAHR and IISC. By tightly constraining these three stations, the precise coordinates of all the four reference stations along with IIT Bombay permanent reference station were calculated. In second stage, all 27-deformation stations were processed with two reference stations and IITB permanent reference station. Here the coordinates of IITB and two reference stations were tightly constrained to their estimated values in stage 1. In this paper, the results of ten campaigns are compared to understand land subsidence phenomena in the area of study. During a period of two years, 67 mm subsidence has been measured within the gas reservoir area. It has been confirmed that the rate of subsidence is more within reservoir boundary compared to that out side the reservoir boundary. Estimated subsidence is also correlated with the parameters responsible for land subsidence like gas extraction rate, pressure depletion, water level. It is established that, gas extraction is one of the main causes of subsidence over the study area. The GPS derived results are compared with the results of the InSAR method. ENVISAT data are used to generate interferograms. Probably this is the first attempt in India to measure land subsidence over the gas reservoir, using GPS and InSAR techniques.

Keywords: landsubsidencegpsinsar



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So Paulo State - BRA - Active GPS Network: status and services

Prof. Joo F Galera Monico
Cartography UNESP IAG

Daniele Barroca Marra Alves, Luiz Fernando Antonio Dalbello

The services and preliminary results provided by the So Paulo State active GPS network being set up by FCT/UNESP will be the main topic of this paper. At this moment, January of 2007, six active stations are providing data. Two of these stations belong to the L2C test network (JPL/NASA) and three stations to the NTRIP (BKG) real time network. The DGPS and RTK network concepts are being implemented and tested. The preliminary results will be presented. Additionally, the results concerning the L2C code analysed so far will also make part of this presentation. It concerns to the MP and SNR parameters analyses.

Keywords: dgps network, ntrip, rtk network



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New solutions to classical geodetic problems on the ellipsoid

Prof. Lars Sjöberg
Geodesy IAG IAG

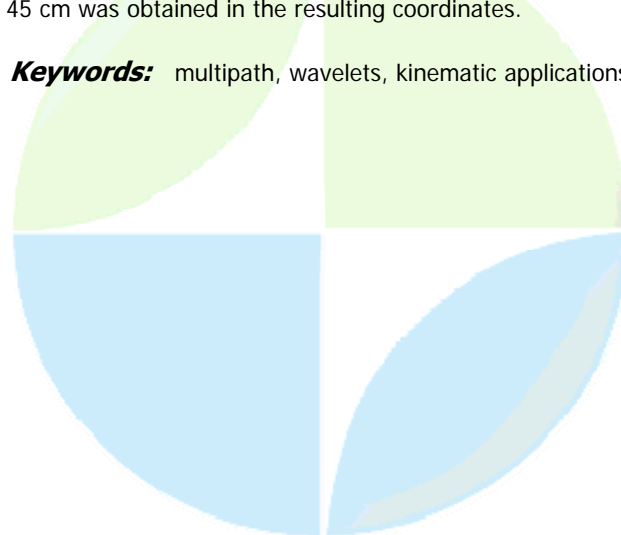
New solutions are provided to the direct and indirect geodetic problems on the ellipsoid. In addition, the area under the geodesic and the problem of intersection of geodesics are treated. Each solution is composed of a strict solution for the sphere plus a small correction of the order of the eccentricity of the ellipsoid. The correction is conveniently determined by numerical integration.

Keywords: area, geodesic, intersection



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2879****Low-Frequency multipath mitigation in kinematic positionings using the wavelet method: preliminary results****Mrs. Eniuce Menezes De Souza***Cartography PhD Student of Cartographic Science IAG***Joo Francisco Galera Monico, Wesley G. Canducci Polezel, Aylton Pagamisse**

Multipath reduction has become essential for any high precise GPS application. Unlike the other errors, multipath is not attenuated when the double differences (DD) are formed involving data of short baselines, because of the highly dependency of the survey environment. On the contrary, multipath errors can even increase in the double-differentiation process. Although the use of especial antennas and receivers can minimize multipath, it cannot always be eliminated and frequently the residual multipath disturbance remains as the major error in GPS results. The high-frequency multipath from large delays is of easier mitigation. But the low-frequency multipath from short delays is very difficult to be reduced or modeled, mainly in kinematic applications. The wavelet methods have showed promising performance to detect and reduce the low-frequency multipath in static applications. In these applications, there are some possibilities to apply wavelets in order to reduce multipath effects. One of them is to reduce the multipath directly from the DD. But in this case just the high-frequency multipath is mitigated. One way to reduce effectively the low-frequency multipath is to apply the wavelet method to the DD residuals. In this process, DD residuals are decomposed into low-frequency bias and high-frequency noise components. The bias components extracted by wavelet method are then directly applied to the DD observations to correct them from the multipath trend. The remaining terms, largely characterized by the high-frequency measurement noise, are expected to give the best linear unbiased solutions in the least-squares (LS) adjustment. This method has presented very promising results in static processing. Thus, the aim of this paper is to investigate the possibility of extending this wavelet method to reduce multipath effects for kinematic applications. An experiment was carried out using objects placed close to the receiver antenna to cause, mainly, low-frequency multipath. The receiver antenna remained static, but the processing was performed as it was in a kinematic mode, in order to analyze the wavelet performance. The ground truth coordinates were computed with data collected in the absence of the reflector objects. The coordinates and ambiguity solution were compared with and without the multipath mitigation using the wavelet method. The multipath effects impeded the reliable ambiguity resolution during the processed data period. With the multipath mitigation, ambiguity could be reliable fixed in the beginning of the processing and the obtained coordinates were of better quality. Improvement of up to 45 cm was obtained in the resulting coordinates.

Keywords: multipath, wavelets, kinematic applications

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2880****Analysis of Temporal Non-stationary Tropospheric Processes Using Geodetic PWV Time Series****Mr. Botai Joel***Space Geodesy Hartebeesthoek Radio Astronomy Observatory***Dr. Combrinck, W. L., Prof. C. J. Dew (Hannes) Rautenbach**

Statistical properties of Precipitable Water Vapour time series acquired using space geodetic techniques such as the GPS (Global Positioning System) or VLBI (Very Long Baseline Interferometry) exhibit temporal variations that could be interpreted as an indicator of variability of atmospheric structure. These tropospheric structures carry long-range spatial information which can be utilised for both geodetic applications and meteorology. The time series can be segmented into small windows from which window-dependent statistical parameters are derived. These second order quantities of non-stationary stochastic processes can be used to describe local stationary processes in the troposphere with lower biases albeit larger variances that depend on the width of the window. In this presentation, each segment is modelled using Principal Component Analysis to extract salient features that describe processes that are locally stationary. A non-decimated discrete wavelet is used to compute wavelet evolution spectrums of PWV time series which reveal trends, jumps, excursions and flickers in the time series; all are manifestations of tropospheric structure.

Keywords: non stationary, geodesy, wavelets

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A 3D Measurement and Analysis System for Quality Control Supported by AI-Techniques

Dr. Alexander Reiterer

Institute of Geodesy and Geophysics Research and Teaching Assistant IAG

Martin Lehmann, Johannes Fabiankowitsch

In the FWF project P18286 Multi-Sensor Deformation Measurement System Supported by Knowledge Based and Cognitive Vision Techniques a new kind of image-based measurement system will be developed. This system is able to detect un-signalised object points by means of appropriate algorithms the procedure is divided into three main steps: image pre-processing, automated point detection and interactive point filtering. This system is based on new techniques (originally developed in the area of Artificial Intelligence) which shall be used for the task of deformation measurement, analysis and interpretation. Examples for such techniques are knowledge-based systems, cognitive vision and image understanding methods and case-based reasoning. We report on the state-of-the-art of such new measurement systems, their functionality and development stage.

Keywords: multi sensor systems, knowledge based systems, quality control



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2882****AutoGNSS: A new GPS Vector Processing Software.****Mr. Joaquin Zurutuza**
*Geodesy Geodesy***Miguel J. Sevilla De Lerma, Miguel Elorza**

Several Automated Online GPS Vector Processing Services have been already created by many Geodetic Agencies: OPUS, AutoGIPSY, AUSPOS, SAPOS,... In this Poster, a new service, to be used only in the Iberian Peninsula, but valid wherever an IGS Station is surround, based in the PAGES Software (National Geodetic Survey) is presented. The new Internet Service is called AutoGNSS and it is planned to compute all kinds of GNSS signals in the future. AutoGNSS searches the nearby IGS Stations of the Centroid of the Stations to be processed and computes a solution, following the minimum spanning tree. In case a set of non-IGS Permanent GPS Stations has been defined, these can be easily added to processing engine so that a solution is computed with respect this Stations. This way, better results can be achieved with less observation interval, as the distances will be less and the sampling rate can be higher. Actually, The Active GPS Network of Gipuzkoa has been added to the AutoGNSS Service. Several Vectors have been processed with this new Service inside the Province of Gipuzkoa and this paper shows the quality of the results. Also, this poster shows the Geodetic Tasks accomplished in Gipuzkoa (Spain), where accurate GPS processing is not always easy due to the bad horizon in almost all the Province. Nevertheless, GPS is the main positioning Technique as visibility is often very poor, chiefly, because of vegetation or orography.

Keywords: gps computations, autognss, time spanPERUGIA
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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2883****An Forecasting Model for Combined Bias in Network RTK Based on Nu-SVR*****Prof. Xinzhou Wang****Association Positioning and Applications IAG****Shu Haichi***

The high positioning precision of rover station is depended on the bias that get from the system in the network RTK. There are many kinds of bias in the observing data due to the effect of ionosphere , troposphere and orbital bias , and so on. It is hard to distinguish and calculate individually. On the contrary , we can combine the effect and calculate it in a model. To date , there are combined interpolation bias method and modified combined interpolated bias method we know , but this two methods have used only a few information of base station whichs distance to rover station is relative short. This article firstly put forward a united combined bias model based on Nu-SVR which have used the information of all base station in the network RTK , and then use this model to train and predict by using the data from a network RTK which have six base station , The result proved that this model is useful and efficient.

Keywords: networkrtk, combinedbias, supportvectormachine

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2884****Geodetic Height Determination of the Qomolangma Mountain*****Prof. Yamin Dang****The Institute of Geodesy and Geodynamics Chinese Academy of Surveying and Mapping IAG****Chuanlu Cheng, Xiaorui Wang, Chunxi Guo***

There were many GPS measurements on geodetic height determination of the Qomolangma Mountain during last two decades. The most recent GPS surveying over this area was conducted in May 2005 by Chinese scientists. There were three GPS networks in the 2005 Qomolangma height surveying, regional GPS crustal deformation network, geodetic GPS control network, and GPS measurement on the summit of the Qomolangma Mountain. The GPS data collection and data processing were introduced in the paper. The data processing strategy and reasonable geodetic height were fairly determined based on the careful data analysis. Besides, we collected 4 epochs of GPS measurements on the geodetic height determination of the Qomolangma Mountain from 1992 to 2005. The data processing were conducted carefully and some comparison results were analyzed.

Keywords: qomolangma, geodetic height, gps

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2885****Precise point positioning: an attractive alternative to kinematic relative positioning****Dr. Xiaohong Zhang***School Geodesy and Geomatics, Wuhan University No. 129, Luoyu Road, Wuhan, P.R.China
IAG*

Recently the GPS Precise Point Positioning (PPP) mode has become an attractive alternative to the relative GPS positioning mode. For many years users have had to implement techniques in order to overcome the accuracy degradation as the distance from rover to base increases in kinematic relative positioning. Interest in single receiver positioning has been rekindled by the recent availability of post-mission satellite clock and ephemeris information generated by various data analysis centers, as byproducts of the data processing carried out under the auspices of the International GNSS Service (IGS). For example, the Jet Propulsion Laboratory (JPL) etc has established a service to provide precise satellite clock corrections, and IGS analysis centers (JPL, CODE, GFZ etc) provide precise orbit information and precise satellite clock corrections with different interval via the Internet. The use of post-mission precise orbit information and satellite clock corrections overcomes the effects of orbit and clock error. Using ion-free carrier phase observations and pseudoranges, a stand alone geodetic dual-frequency receiver can fulfill the same level accuracy as relative positioning with PPP technique. So the PPP attracts much attention and opens a new alternative to precise kinematic positioning. In this paper, the components and functions of software, named TriP, based on PPP mode, developed by the author are described briefly. Several innovations, for example, carrier phase ambiguities resolution, atmospheric correction models, etc., are being investigated for improving the positioning accuracy. And then in-situ ground GPS data and airborne surveying GPS data was analyzed. The results from data analyses are presented, and applications for the technique are discussed. Finally, some comments on PPP technique are given.

Keywords: ppp, accuracy, reliability

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2886****MyRTKnet: The accuracy and coverage of real-time positioning services for Survey and Mapping community in Malaysia****Mr. Soeb Nordin**

Global Positioning System (GPS) technology was introduced in Malaysia in early 90s has changed the scenario of survey profession rapidly. The current GPS infrastructure in Malaysia is mainly served as a ground control station for mapping and cadastral survey purposes. A nation wide project that has been initiated by Department of Survey and Mapping Malaysia (DSMM) in 2004 is the Virtual Reference Station (VRS) that can provide users with cm accuracy positioning in a minute, and by 2008, 78 stations will be in operational. This study mainly focuses on the achievable accuracy of the network base and single base RTK on various condition and location as well as location at the VRS network boundaries. The study also looks into the possibility of using Malaysian precise geoid model WMGeoid04 and Virtual Reference Stations (VRS) for Rapid Height Determination and Monitoring System. Analyses of the results have shown that the VRS can achieve or even better results when compare with conventional static GPS surveying. The results also shown that GPS Levelling with can be used as a tool to determine and monitor the current status of Bench Mark and establishing new levelling routes.

Keywords: gps, myrtknet, vrs

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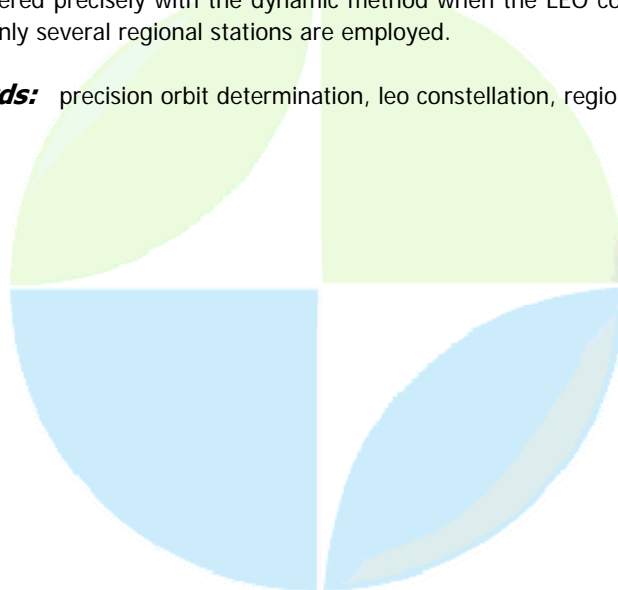
GNSS Precision Orbit Determination Based on Regional Stations and LEO Constellation

Mr. Jianghui Geng

Jingnan Liu, Cheinway Hwang

During the past two decades, Global Positioning System (GPS) has been made an essential tool for its high-performance standards in the very demanding professional, commercial and scientific applications. In the near future, Galileo of Europe will be launched and become the first commercial Global Navigation Satellite System in the world. GPS and GLONASS (GLObal NAVigation Satellite System) will be modernized and adapted to the increasing market demand. China, Japan and India will also develop their own global or regional satellite navigation systems that are named as Compass, QZSS (Quasi-Zenith Satellite System) and IRNSS (India Regional Navigation Satellite System), respectively. Precise orbit determination (POD) for GNSS satellites is the base for all the applications above. The key problems underlying GNSS POD are the orbit dynamics and tracking geometry. At present, globally distributed stations are necessary for the POD of GNSS satellites. This prerequisite needs international cooperation and is not always permitted for various reasons. However, regional stations are not able to track the GNSS satellites continuously and the observation geometry is also limited. Consequently, the characteristics of satellite dynamics can not be recovered accurately. The precision of satellite orbits is also degraded to a great extent. The paper, therefore, investigates the contribution of Low Earth Orbiters (LEO) in the POD of GNSS satellites with regional tracking stations. The authors use the GPS data from several IGS stations in China and from CHAMP (CHALLENGING Minisatellite Payload), twin GRACE (GRAVITY Climate Experiment) and six COSMIC (Constellation Observing System for Meteorology, Ionosphere and Climate) satellites to determine the orbits of GPS satellites with dynamic approach. In the processing, the orbits of all the LEOs are also restituted. The ambiguity fixing between the LEOs will be employed to enhance the solution. The positions of the regional ground stations are constrained tightly to maintain the datum of the orbits. Obviously, the tracking geometry for GPS satellites will be improved considerably after including the LEOs in the regional network. Meanwhile, the GPS satellites can also be observed continuously by the LEO constellation. Both of these will compensate the limitation of regional network to a great extent. It is expected that the orbits of GPS satellites will be recovered precisely with the dynamic method when the LEO constellation is taken into account despite that only several regional stations are employed.

Keywords: precision orbit determination, leo constellation, regional stations



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GS004

Poster presentation

2888

Effect Analysis of Different Observations and Satellite Clock Bias Sampling Intervals on Ambiguity Convergence in PPP

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Chen Yongqi, Lu Xiushan

In GPS kinematic precise point positioning (PPP), the ambiguity convergence (AC) time and stability is one of important items, there are many factors affect on it, the effect of different sampling intervals of observations and satellites clock bias (SCB) on AC time and stability of kinematic PPP is discussed deeply in this paper, taking GPS observations from twelve GPS static stations in Shanghai GPS network of China for example, we analyzed the relationship of sampling intervals and convergence time, and statistic analyzed the convergence time of different sampling intervals. Finally, some helpful conclusions are put forward in this paper.

Keywords: precise point positioning, ambiguity convergence, sampling intervals



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GS004

Poster presentation

2889

Research on 3-Dimensional laser scanner system monitoring the land sliding of the strip mine

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Hu Zeng-Qi, Qian Jian-Guo, Li Hui

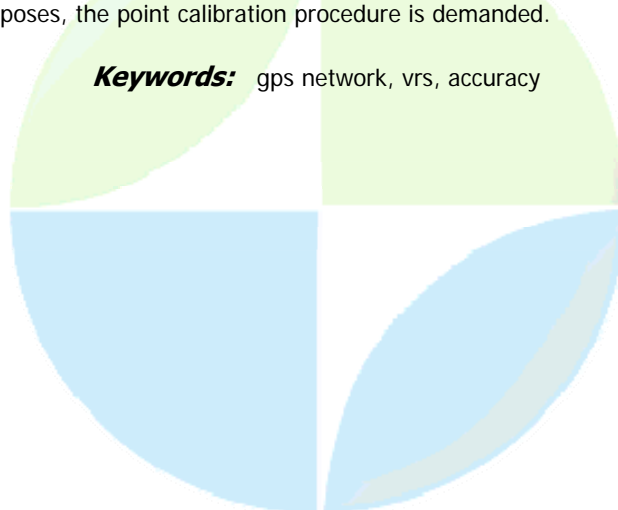
The 3-dimensional laser scanner system has several advantages, including a change of single point data acquisition to automatically continuous and untouched data acquisition, the capability of capturing abundant spatial information, as well as improvement of efficiency and accuracy in measurement. The technology applied the 3-dimensional laser scanner system monitoring land sliding to realize new progress in large area land sliding deformation measurement of the strip mine. The 3-dimensional laser scanner system of CyraX2500 was applied to observe the land sliding deformation of the west region in Fuxin open cast mine. With the Cyclone software, the dot cloud data of observation was dealt with. The data processing included the noise data weeding, many sceneries data positing and joining, the joint points error precision evaluating and the DEM model establishing. With the DEM model, the parameters of land sliding profile can obtain accurately. Based on the profile parameters and the rock mechanics parameters, the stability of land sliding was researched by the ANSYS software of finite element method. The monitoring and computing method can forecast the stability of land sliding precisely. The research shows that 3-dimensional laser scanner system can capture high accuracy 3-dimensional data of the land sliding, observe entire model geometric deformation by the untouched method, establish the DEM model of the land sliding, and realize the comparable analysis of land sliding dynamic deformation data in different period of time. The method provides a new technology means for land sliding deformation measurement and analysis.

Keywords: 3 dimensional laser scanner, land sliding monitoring, the finite element method



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2890****The Accuracy and Reliability of Shanghai VRS Network****Dr. Lizhi Lou***GS004 Positioning and Applications IAG***Yi Chen**

The Shanghai Virtual Reference Stations (VRS) network is operated by the Shanghai Surveying and Mapping Institute and will serve as the infrastructure for the "Digital Shanghai" information system. Integrated with the city's intelligent transportation system, network and communication system, the VRS network will provide a highly accurate and fast positioning service as well as a GPS mobile positioning service. The network currently includes Trimble GPS reference stations operating with Trimble software. In addition, there are many different kinds of GPS rovers (Trimble, Leica, Topcon, Thales etc.) to use with the system. Concerning different applications, we would like to test the precision and reliability of Shanghai VRS system. The VRS test measurements were made during June 2006 and include 22 points. In every test point, 5 independent VRS fixed solutions were measured for investigating the repeatability of VRS. In order to improve the reliability of the test, we selected 11 locations, which are well-distributed in Shanghai; there are two points at every location, which are visible from each other for checking by total station. In the centre there are the base stations of Tongji University (TJBS and TJBA), which have fixed WGS84 and local coordinates. To avoid any errors due to the deformation of the GPS-Network, we only fixed TJBS as known point and TJBS-TJBA as known direction, and we considered all the other points as unknown points and observed all baselines minimum for 2 hours in static mode. Furthermore, all the points were surveyed by forced centering. Thus we can use GPS software to obtain the adjusted results 3D geodetic coordinates, and the local coordinates by using the Shanghai projection parameters can also be calculated. At the same time, the VRS results are directly obtained using the VRS system from a GPS rover. The repeatabilities of VRS are 2.2mm, 2.4 mm and 3.8mm in N- and E-direction and height, separately. Simultaneously, the differences between VRS and total station results are also less than 2 mm. Comparing the VRS results with those obtained from GPS network, some useful results are obtained: geodetic coordinates have an average bias of 0.0194 in latitude with rms of 0.0003, 0.0121 in longitude with rms of 0.0004 and -0.534m in geodetic height with rms of 3.0cm. In contrast, local coordinates have an average bias of 60cm. When we used another set of 3 known points to calculate the transformation parameters, and then measured the test points again, the accuracies of VRS local coordinates were 11.2 mm, 13.2 mm and 34.4 mm in N- direction, E-direction and height. Thus, Shanghai VRS Network has a good inner accuracy but a larger bias with respect to the correct value; when the local coordinate system shall be used for surveying purposes, the point calibration procedure is demanded.

Keywords: gps network, vrs, accuracy

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GS004

Poster presentation

2891

Establishing a GNSS receiver antenna calibration field in the framework of PROBRAL

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Jaime Freiburger Junior, Michael Mayer, Andreas Knpfler

PROBRAL is the name of a joint venture between the Department of Geomatics (DGEOM), Federal University of Paran (UFPR), Curitiba (Brazil) and the Geodetic Institute (GIK), University Karlsruhe (TH), Karlsruhe (Germany). The aim of the research project, which started in 2006 and is founded by Brazilian academic exchange service CAPES and German academic exchange service DAAD (PROBRAL: Precise positioning and height determination by means of GPS: Modeling of errors and transformation into physical heights), is to validate and improve the quality of GNSS-based positioning, especially of the height component. Therefore, the close co-operation between the DGEOM and the GIK was intensified. One main goal of this fruitful co-operation was to establish a receiver antenna calibration field for GNSS instrumentations on the roof top of the so-called LAGE (<http://www.lage.ufpr.br/>). In the framework of PROBRAL several studies were carried out in close collaboration at the DGEOM as well as at the GIK concerning site-specific effects (e.g. multipath, antenna modelling), especially. The status of the establishment of a GNSS receiver antenna calibration field is going to be presented.

Keywords: precise positioning, probral, antenna calibration

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2892****Performance improvement of network-based RTK-GPS positioning in North Taiwan****Prof. Ta-Kang Yeh***Institute of Geomatics and Disaster Prevention Ching Yun University IAG***Zu-Yu Lee, Chun-Sung Chen**

The conventional single-reference station positioning is affected by systematic errors such as ionospheric and tropospheric delay, so that the rover must be located within 10 km from the reference station in order to acquire centimeter-level accuracy. The medium-range real-time kinematic has been proven feasible and can be used for high precision applications. However, the longer of the baseline, the more of the time for resolving the integral ambiguity. This is due to the fact that systematic errors cant be eliminated effectively by double-differencing. Recently, network approaches have been proposed to overcome the limitation of the single-reference station positioning. The real-time systematic error modeling can be achieved with the use of GPS network. For expanding the effective range and decreasing the density of the reference stations, Land Survey Bureau, Ministry of the Interior in Taiwan have set up a national GPS network. In order to obtain the high precision positioning and provide the multi-goals services, a GPS network including 27 stations already been constructed in North Taiwan. The users can download the corrections from the data center via the wireless internet and obtain the centimeter-level accuracy positioning. The service is very useful for surveyors and the high precision coordinates can be obtained real time.

Keywords: gps, rtk, network basedPERUGIA
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GS004

Poster presentation

2893

Analysis of multi scale monitoring data for landslide disaster mitigation

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Dr. Andreas Eichhorn, Prof. Heribert Kahmen

In 2006, OASYS, an EU funded project on a multi scale monitoring concept for landslides as a basis for an alert system, was completed. 12 institutes from 6 countries tried to merge their multidisciplinary knowledge in the field of landslides and disaster management. As members of the research group Engineering Geodesy of the Vienna University of Technology were the initiators of this project, they feel responsible to report about the innovative steps and some highlights of the research. The main emphasis of this report lies on three different tasks: GIS integrated geological evaluations of remote-sensing data geometrical analysis of the monitoring data by fuzzy techniques as a basis for the design of the sensor network and geomechanical modelling of the landslide by FE-methods as a basic information for an alarm system.

Keywords: landslides, monitoring, alarm system

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2894****Model correction and analysis of the influence on high accuracy Baseline processing****Mr. Xuan Zou***GNSS Research Center, Wuhan University, China Doctor's Degree Candidate***Jingnan Liu, Weiping Jiang**

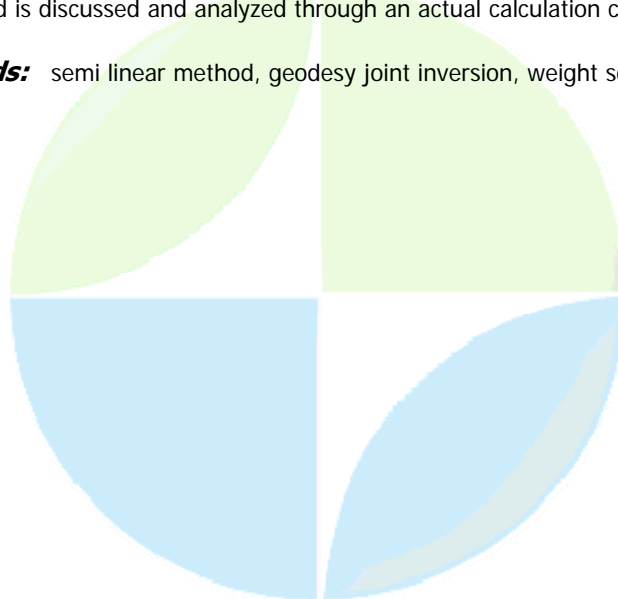
In the past two decades, Global Positioning System (GPS) has been made an essential tool for its high-performance standards in the very demanding professional, commercial and scientific applications. In the near future, Galileo of Europe will be launched and become the first commercial Global Navigation Satellite System in the world. GPS and GLONASS (GLObal Navigation Satellite System) will be modernized and adapted to the increasing market demand. The launch of more and more satellites will ensure GNSS navigation reliability. However the geodesic errors can not be eliminated by the difference and combination of signals completely; besides, they will be often enlarged due to the increasing of distance, the high accuracy of baseline processing can not be realized only by increasing new satellites. In order to reflect and give a quantitative evaluation of the environmental changing influence on the signal and position of GNSS, lots of correction models are set up by the ways of Astronomy, Geography and so on. This paper analyzes the influence on the processing results of different length and latitude baseline when the models of solid tides, ocean tides, earth pole tides and atmospheric tides were corrected. The systemic statistics of these model correction applicabilities are made as well. It has huge reference value to the study of high accuracy baseline processing of GNSS data which has been widely used in the study of deep geophysical features and engineering practice in the future.

Keywords: gps, baseline processing, model correction

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2895****Semi-linear method in nonlinear geodesy joint inversion with weight scaling factor****Prof. Caijun Xu***School of Geodesy and Geomatics Wuhan University IAG***Kaihua Ding**

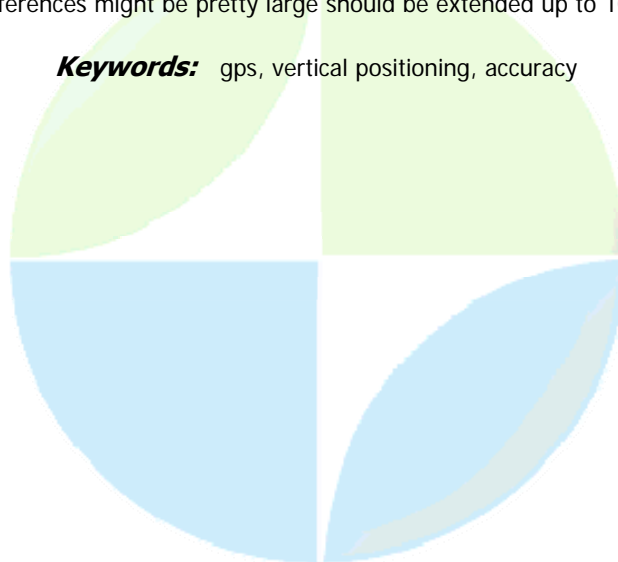
Geodesy and geophysics joint inversion, short for geodesy joint inversion, is based on observed geodetic signals, combined with geologic, seismic and geophysical signals, to inverse the parameters of geodynamical model, amend and advance the new geodynamical model. It also can be used to inverse the motion of active faults and blocks according to measurements on the ground, research the relationship between the earthquakes and crust motion, and forecast seismic or geological disasters. Recently, for most geodesy joint inversion, its forward modeling has highly nonlinear feature, and the forward modeling is difficult to be expressed by analytic forms of linearization, which is inevitable to resolve the nonlinear problem with the linear method. Meanwhile, the linear inversion method greatly depends on the initial model, or the initial value of the inversion parameter, X_0 . These two problems restrict the wide use of linear method in nonlinear inversion badly. Although some recent nonlinear inversion methods can obtain the optimal value in its domain, they can hardly estimate the accuracy of the inversion result. The semi-linear inversion method, which fully integrates the advantages of the linear inversion theory and the nonlinear inversion algorithm, is discussed in the paper. Its concrete procedures are followed by the initial value of the model, numerical linearization, solution of linear model, and theory of linear evaluation. Here, the initial value of the model can be solved by general nonlinear inversion algorithms, then the Jacobi matrix B , the quasi-kernel matrix, can be obtained at X_0 by numerical differentials, and further the error equation of the linear model can be got. Xu C.J. et al. discuss the methods on fixing the weight scaling factor in geodesy joint inversion (2005, 2006), and consider that it is the most appropriate to fix the weight scaling factor by Helmert method of variance components estimation. But generally speaking, Helmert method is compatible with the linear problem, and needs linearization and iterative computation for the nonlinear problem, so it is very improper to solve the complex nonlinear problem. For this reason, this paper deduces the semi-linear method in nonlinear geodesy joint inversion with weight scaling factor, and the corresponding formulas to apply in the actual inversion, with fixing the weight scaling factors by Helmert method. At last, the feasibility of the semi-linear method is discussed and analyzed through an actual calculation case.

Keywords: semi linear method, geodesy joint inversion, weight scaling factor



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2896****Effect of Inter-Station Height Difference on GPS Vertical Positioning Accuracy*****Dr. D. Ugur Sanli****Geodesy Department Kandilli Observatory and Earthquake Research****Fatih Kurumahmut***

Recently it has been shown that the GPS positioning accuracy depends on the observing session duration rather than the inter-station distance, provided that atmospheric biases between stations are estimated, ambiguities are fixed and IGS precise ephemeris is used. These ideas were tested for observing session durations of 4 to 24 h and for baselines of 20 to 300 km. It has also been studied that GPS accuracies derived from < 4 h sessions show larger scatter and different behavior due usually to bad satellite-receiver geometry and atmospheric anomalies. This study further investigates the effect of inter-station height difference on campaign GPS solutions (i.e. solutions derived from short observing session durations). The effect of inter-station height difference on GPS vertical positioning component was previously studied, and it was stated that unless a tropospheric bias is estimated between baseline points, GPS solutions, especially the vertical component could seriously be biased. The experiments presented here indicate that large inter-station height difference still could be a problem even-though a relative tropospheric bias is taken into consideration between sites. In order to reveal this, an experiment has been designed using the data of GPS stations from SOPAC archives. About 25 baselines were formed, and for each baseline 10 days of GPS data were selected observed in the year 2003. GPS data were processed from subdivided sessions of 1 through 24 h using NASA's GIPSY OASIS II research software. Inter-station height difference was incremented 50 m at each step starting from 50 up to 1600 m and baselines were kept in a range of 10-15 km (where distance dependent atmospheric effects are smaller) just to purely reveal the effect of growing height difference on the solutions. Differential PPP results indicate that RMS values derived from short spanned GPS campaign solutions are highly correlated with inter-station height difference values. In other words, there is strong (i.e. statistically significant) linear association between the RMS values and the height difference estimates. All three GPS baseline components are affected however the effect is a factor of 2-3 is smaller on horizontal components. Across flat surfaces, typical 10 h GPS campaigns can be shortened down to 3 h since tropospheric decorrelation between sites hence the effect on vertical estimates is smaller. On the other hand, observing session durations for studies of volcano monitoring or land slide monitoring where inter-station height differences might be pretty large should be extended up to 10-12 h periods.

Keywords: gps, vertical positioning, accuracy

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2897****Impact of a GPS network location on tropospheric and positioning estimates****Mr. Fund Francois**
ESGT ESGT IAG**Morel Laurent, Mocquet Antoine, Duroy-Nicolas Jolle, Durand Stphane**

Global positioning system is well-suited for monitoring geophysical deformations of solid earth. This work is part of a PhD work which intends to take benefits of a local GPS network in order to quantify some geophysical deformations in the West of France. Numerous GPS stations are present because of the installation of real time GPS networks. Geodynamical effects such as oceanic loading and its reversibility can be monitored due to this particular density. In this area, GPS satellites can be located as above Atlantic Ocean as above European continent. Meteorological conditions affecting this two areas are not similar, which implies spatial refractivity differences in the neutral atmosphere. Consequently, tropospheric delays on GPS observations are different and have to be taken into account. Here, the impact of each refractive media in which GPS propagation signals occurs is studied with respect of zenith tropospheric delays (ZTD) estimates. The final objective of this study is to correct these two medias effects on the network treatment located in this area. GAMIT software is used to process a coastal baseline and satellites located above ocean or continent are filtered in order to quantify differences in the ZTD estimations for each case (apart from a geometrical error due to a partial and non homogeneous satellite coverage). Then, usual tropospheric models and mapping functions and their ability to model signal propagation are assessed by comparing with ZTD radiosondes results.

Keywords: troposphere, gps network, mapping functions

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2898****Application of CAS to geodesy: a 'live' approach*****Mrs. Piroška Zaletnyik****Department of Geodesy and Surveying Budapest University of Technology and Economics IAG****Bla Palncz, Joseph L. Awange, Erik W. Grafarend***

Nowadays, computer algebra systems (CAS) integrate modern numeric and symbolic algorithms and offer the possibility of 'live' interaction to users. This is in contrast to the widely held belief by most scientists, even today, that CAS language is a programming language. CAS can be used like 'live' mathematics for creating, proving as well as evaluating algorithms and expressions in numeric or symbolic form. Most nonlinear geodetic computational problems, e.g., finding initial values for iterative algorithms, avoiding ill-conditioned numerical problems, or finding effective global or local minimums are immaterial when CAS is properly employed. CAS systems are equipped with many in-built professionally implemented algorithms representing the state of art of mathematical methods. They provide flexibility of computing with any working precision, mixing numeric and symbolic algorithms and enabling formation of personalized algorithms. This contribution extends, based on CAS, the previous work of Awange and Grafarend (*Solving Algebraic Computational Problems in Geodesy and Geoinformatics*, Springer, Berlin, 2005). Using Groebner basis and Dixon's resultant as the engine behind CAS, we demonstrate how 3D GPS positioning, 3D intersection, as well as 3D Helmert and 3D Affine datum transformation problems are solved 'live' in Mathematica, thanks to modernization in CAS. Mathematica notebooks containing these 'live' computational models and examples are available on Web, in the MathSource of Wolfram Research (<http://library.wolfram.com/infocenter/MathSource/6654>).

Keywords: cas, positioning, transformation

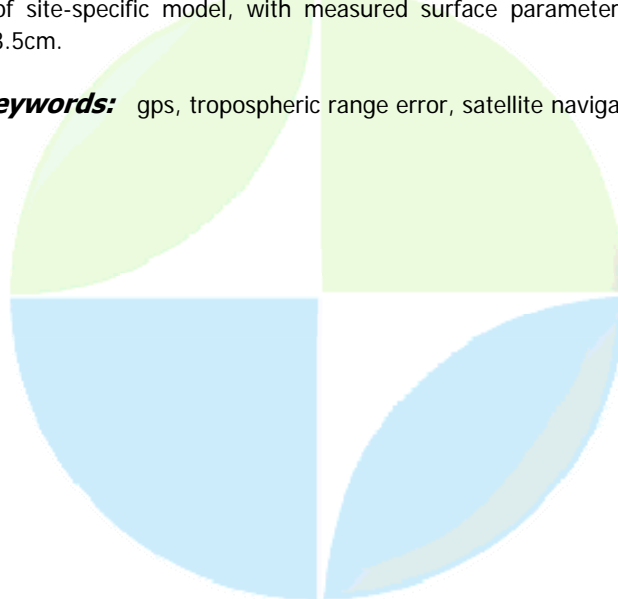
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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2899****Region specific model for tropospheric delay correction for GPS ranging over Indian Subcontinent****Dr. Suresh Raju***Space Physics Lab., Vikram Sarabhai Space Centre Indian Space Research Organisation IAG***Korak Saha, K. Parameswaran**

Application of Global Positioning System (GPS) in satellite-based navigation essentially requires a priori knowledge of the tropospheric refraction effect of GPS signal. The tropospheric delay estimated by ray tracing through the earth's atmosphere employing appropriate altitude profile of refractivity, is modeled in terms of measurable surface atmospheric parameters such as pressure, temperature, humidity as well as columnar water vapor for different locations over the Indian subcontinent using the upper air data (Radiosonde measurements). Different analytical forms are examined for this purpose. These site-specific surface models for zenith hydrostatic delay (ZHD) and wet (non-hydrostatic) delay are first generated for eighteen different selected locations over the continent. These stations are located at different climatic regions covering a geographical extent 8°N to 33°N in latitude and 60°E to 90°E in Longitude. Taking all these models into account a unified model that in principle is applicable for the entire subcontinent is derived. This unified model though is slightly inferior to site-specific surface model, the deviations are within the allowable limits for this specific application (~ 5 mm). Even though the wet delay contributes about 10% of the total delay, the uncertainty associated with its prediction is very large. In a limiting case when the surface measurements are not available they are to be modeled based on the geographical coordinate and time (day of the year). For this the UNB model employed in WAAS, developed based on U.S standard supplements, is found to be inadequate for the Indian tropical region as far as the required accuracies are concerned. So a Region-specific model is developed using five years daily atmospheric data over Indian subcontinent which coupled to the unified model provides a Region-specific Tropospheric Delay (RTD) model for the prediction purpose. This model is found to be superior to UNB model. Since RTD does not involve any real time measured atmospheric parameters and relies only on mean model values, the prediction using this model is inferior to that derived from the other two. The maximum uncertainty of RTD model is ~8.2cm and the minimum uncertainties is ~0.86cm (at one sigma level) depending on the location, while the unified model with real-time measured inputs provides the same with an uncertainty between 5.2cm (maximum) and 0.65cm (minimum). In case of site-specific model, with measured surface parameters inputs the maximum deviation is less than 3.5cm.

Keywords: gps, tropospheric range error, satellite navigation



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GS004

Poster presentation

2900

GPS Based Water Vapor Estimation Using Models Developed Based On Atmospheric Data Over The Indian Sub-Continent

Dr. Suresh Raju

Space Physics Lab., Vikram Sarabhai Space Centre Indian Space Research Organisation IAG

Korak Saha, K. Parameswaran

The tropospheric delay estimated from the GPS signals received at the ground using a GPS receiver could be used efficiently for deriving the information on atmospheric precipitable water vapor (PW) continuously. This mainly involves modeling of weighted mean temperature (T_m) to account for altitude distribution of atmospheric temperature in the presence of water vapor. A detailed analysis of T_m , is carried out in the context of GPS based PW estimation over Indian region by analyzing three years (1995-1997) daily upper air data from different meteorological stations well distributed over the continent. An empirical relation was established for T_m in terms of surface temperature. Two years daily GPS data from Bangalore and Hyderabad, are used to derive the PW. For this as a first step, station-specific models for the hydrostatic component of the tropospheric delay established in terms of surface pressure are used to separate the non-hydrostatic component from the zenith tropospheric delay derived from GPS data. Secondly, empirical relations between PW and the non-hydrostatic tropospheric delay are established for these stations using the radiosonde measured humidity profiles. This relationship was used to derive PW from the non-hydrostatic tropospheric delay estimated from GPS data. The values of PW thus estimated from GPS data using the station-specific models, regional model and other existing global model (Bevis model) are compared with those derived from radiosonde measurements on a day-to-day basis.

Keywords: precipitable water vapor, weighted mean temperature, gps tropospheric zenith delay



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2901****A Study of Best-Fit Plane Accuracy of 3D Laser Scanner Point Cloud****Mr. Chien-Ting Wu**
IAG**Chun-Sung Chen, Mei-Li Liu**

The 3D Laser Scanner is a kind of instruments that can be used to obtain a large number of high-accuracy three-dimensional relative coordinates in a short time. The original point cloud data of observing objects are implicit but not explicit. As to using for surveying, the point cloud data is necessary to be modeling to get the explicit description of objects. The geometry information of an object in the space is generally composed of points, lines, and surfaces. The information can not be directly obtained from point clouds, though some instrument manufactures offered targets for catching the perfect three-dimensional coordinates. However, it is quite difficult to execute this work. The data applied in this study is surveyed by Trimble GS200 3D Scanner. Least-Squares method is applied to calculate the best-fit planes in this study. Besides, different resampling method is used to reduce the original point cloud data. In this study, the calculating time is shortened and the accuracy is kept by reducing point clouds data.

Keywords: lidar, pointcloud, datadensity

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2902****Towards the development of next generation RTK technologies*****Prof. Yang Gao****Geomatics Engineering The University of Calgary IAG****Lambert Wanninger, Sunil Bisnath, Wu Chen, Yanming Feng***

This paper is to report the research and development progress related to SC4.5 Next Generation RTK towards the development of next generation RTK technologies. The paper will focus on the description of the research progress reported by SC4.5s four working groups which has covered the major research topics for the development of next generation RTK systems and their applications. The report from WG4.5.1 Network RTK will describe the rapid development of GNSS reference network infrastructures and the wide adoption of network RTK technologies into applications in the past four years as well as future directions. The report from WG4.5.2 Carrier Phase based Precise Point Positioning will address issues and challenges related to precise point positioning and report some latest progress in the field. WG4.5.3 High Precision Positioning on Buoys and Moving Platforms will report the progress in the application of RTK methodologies and the data fusion of GNSS and other ocean environment sensors in the marine environment. The report from WG4.5.4 Multiple Carrier Ambiguity Resolution (MCAR) Methods and Applications will describe the improvement of RTK positioning accuracy and reliability by additional carrier frequencies from multiple navigation systems including GPS, GLONASS and Galileo systems and their impact on future applications.

Keywords: next generation rtk, wc45, gnss

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2903****Testing DGNS and NRTK positioning accuracy and repeatability on long sessions****Prof. Aurelio Stoppini***Dipartimento di Ingegneria Civile e Ambientale Universit degli Studi di Perugia IAG***Radicioni Fabio, Fastellini Guido**

The performance of a DGNS or NRTK positioning system, in terms of accuracy and repeatability, is normally evaluated for very short sessions (a few epochs at a fast sampling rate, e.g. 1 second), following the normal surveying praxis adopted with such methods. The accuracy of the position is estimated by comparison with known coordinates and heights obtained by means of more accurate methodologies such as post-processed static GPS followed by network adjustment. Every DGNS or NRTK position is an instantaneous solution, therefore it depends on factors varying in time, the most important of which is the satellite geometry (DOP parameters). To estimate the effect of such variable factors on accuracy and repeatability, a series of tests have been carried out for long sessions (1 to 24 hours) on fixed receivers, acquiring GNSS signals and network corrections with continuity, and processing them epoch by epoch in real time, obtaining long time series of three-dimensional instantaneous positions. Such time series have been analyzed in terms of intrinsic repeatability and accuracy, putting the results in relation with the number of visible satellites and the DOP parameters and comparing the NRTK positions with static GNSS solutions. The experimentation has been performed in the area of Umbria (Italy), utilizing the regional GNSS permanent stations network set up by the Region administration together with our Department. The network is composed by 10 permanent stations with geodetic GPS/GLONASS receivers, located at an average distance from each other of about 40 km and connected to the network control center at DICA in Perugia. The real time functionality of the network is obtained with the software GNSMART by Geo++ GmbH, Hannover, Germany. The real time corrections are transmitted to the users by direct connection through GSM modems or (preferred approach) through Internet connection by means of the Ntrip protocol. The tests have been performed in a number of different experimental conditions: locations at a variable distance from the nearest station, GPS only vs. GPS/GLONASS, different types of network real-time corrections (DGNS NRTK VRS NRTK FKP with or without NMEA). For the acquisition of corrections has been always used the Ntrip protocol with Internet connection (Ntripper client software installed on a mobile phone or GNSS Internet Radio by BKG on a portable PC). Network DGNS has generally given stable and reliable results, with a few decimeter accuracy that is suitable for a lot of applications. The analysis of the NRTK tests results shows that for the most part of a long session the expected accuracy is reached, but with some significant exceptions: a few epochs flagged as fixed having differences from the known position well over the normal accuracy levels, not always clearly referable to a bad satellite geometry.

Keywords: gnss, dgnss, nrtk

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2904****The impact of trivial baselines on GPS network solutions*****Dr. Christos Pikridas****Geodesy and Surveying Aristotle University of Thessaloniki IAG****A. Fotiou, C. Pikridas, D. Rossikopoulos, M. Chatzinikos***

Many software packages used for static GPS surveying are based on baseline processing, where correlation between simultaneously measured baselines is ignored. In addition a common processing scheme for a 3D network adjustment combines a number of baselines that are non-independent, usually called trivial. The objective of this study is a systematic and rigorous evaluation of various network solutions based on different observing and processing scenarios. For this reason a small and a medium scale GPS network are selected and properly analyzed. Interesting conclusions are drawn with respect to the variation of the estimated coordinates and measures of the stochastic behaviour.

Keywords: gps networks, trivial gps baselines, gps stochastic modelIUGG
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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2905****Crustal velocity field modelling with neural network and with polynomials*****Mrs. Piroška Zaletnyik****Department of Geodesy and Surveying Budapest University of Technology and Economics IAG*

In this paper artificial neural network and polynomial models describing horizontal crustal velocity distribution are compared. For both models, horizontal velocities are used in the area of western Canada and Northwest Pacific Coast on North America through permanent GPS solutions of PANGA network. One part of the data set is used to calculate the unknown parameters of the models, while the remaining part of the data is employed for testing the precision. The northing and easting velocities are determined as a function of geodetical latitude and longitude. In case of neural network model the so-called overfitting problem can be avoided by stopped search technique. Stopped search refers to obtaining the network's parameters at some intermediate iteration during the training process and not at the final iteration as it is normally done. This can be achieved by using a validation data set, which has not been applied to training. In this way one can obtain a smooth, but good fitting model, while in case of high order polynomial, it is hard to avoid the negative effect of overfitting, the oscillation of the model values between the training points. The calculations are computed with Mathematica software, and in both cases the results are given in a symbolic form, which can be used to calculate easily the partial derivatives of the velocity models to determine later the crustal strains.

Keywords: crustal deformation, neural network, polynomial

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GS004

Poster presentation

2906

Monitoring Crustal and Dam Deformation and the Dam Movement During the Occurrence of an Earthquake Using GPS, at the Koyna Dam in Western India

Prof. Madhav Kulkarni

Civil Engineering Department Indian Institute of Technology, Bombay IAG

GPS studies for monitoring of the crustal and dam deformations at the Koyna Dam in Western India are being carried out since December, 2000, for estimating the crustal deformations in this area, and the displacements of different parts of the Dam body. From previous studies, a structural fault was located in this area. For study of the deformation field in the fault area, a network of well-distributed geodetic points has been established, and GPS observations have been carried out during the period 2000 to 2006. The data from fourteen field campaigns were analyzed using Bernese v 4.2 software, and the deformations between each pair of epochs for all geodetic points were estimated. Also, the rate of deformations between the first and last epoch were determined. Based upon the results obtained, conclusions have been drawn regarding the geodynamics of the region, and the stability of the dam structure. On June 8th, 2005, the Koyna region in Western Maharashtra, India was affected with a felt earthquake of magnitude M 4.2. This earthquake was followed by an aftershock of M 3.6. For monitoring the deformation of the dam, a GPS receiver was set up on the top of the dam and was continuously operating, even during the time of the earthquake. This data was used to estimate the movement of the dam due to the earthquake. Analysis of the data just before and after the earthquake occurrence showed a displacement of 2.3 cm in the northwest direction. After this period, a displacement of 2.1 cm in the opposite direction (southeast) was observed i.e. the station attained its original position. These results reflect the movement and the response of the Dam body to the occurrence of the mainshock and its aftershocks, and indicate the high stability of the Koyna Dam.

Keywords: gps, deformation, dam



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2907****Intrinsic Deformation Analysis****Mr. Khosro Moghtased-Azar**
*Geodtisches Institut Stuttgart University IAG***Erik W. Grafarend**

This study presents an analytical formulation and implementation of a method of Earth's surface deformation analysis referring to the real surface of the Earth. We benefit from the mathematical models and tools of surface deformation analysis in shell theory, differential geometry of surfaces, in order to develop appropriate modelling of deformations on the Earth's surface. We described the Earth's surface as a 2-dimensional Riemann manifold, namely a curved surface, embedded in a 3-dimensional Euclidean space. Thus, deformation of the surface can be completely specified by the change of the first and second fundamental tensors, namely changing of metric tensor and changing of curvature tensor, of the surface, which changing of curvature tensor is responsible for detection of vertical displacements on the surface. Special emphasis is given to definition of proper invariants of the introduced surface deformation tensors with meaningful physical interpretations. Enhance to understanding of the capacities of the intrinsic method which is presented in here, we decided to give an example of simulated deformation field. The ability of the patterns to uncover the upward and downward motions of the deformed surface represented by the curvature tensor is able to provide significant information about the vertical motions. It seems to be just one of deformation tools, namely invariants of deformation tensor of first or second kind could not portray the real deformation surface and it must be consider both of them in deformation analysis.

Keywords: intrinsic approach, deformation analysis, surface deformation



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GS004

Poster presentation

2908

Research in the field of indoor and pedestrian navigation at the research group engineering geodesy at the Vienna University of Technology

Dr. Guenther Retscher

Institute of Geodesy and Geophysics Research Group Engineering Geodesy IAG

Within the last decade navigation systems have become popular in the Western World. Especially in outdoor environments location-based services (LBS) play an important role for supporting the wayfinding process. Vehicle drivers have started to trust in the information provided by car navigation systems and even pedestrians are gaining interest in reliable guiding instructions. Most of the available systems on the market, however, are limited to outdoor areas, whereas wayfinding within buildings has mostly been neglected so far. Merely some museums and exhibitions offer digital guiding services to their customers. Even though the range of some positioning sensors may be sufficient for navigation tasks, they are rarely available within buildings and hardly fulfil the minimum conditions concerning cost. In a first stage in our research available indoor location systems have been analyzed and their performance was investigated. Because of the expensive infrastructure for some of these systems, however, the user has to expect high costs when using the system. One approach to reduce costs is the use of already available wireless infrastructure such as Wireless Local Area Networks (WLAN). Such a positioning system has been installed in an office building of the Vienna University of Technology and can be employed for location determination of users which are equipped with a WLAN enabled mobile device. In a second step the use of Radio Frequency Identification (RFID) tags at selected known points, so-called active landmarks, is currently investigated. Then the user can be located using cell based positioning if he is in the read range of such a tag. Currently the deployment of such a concept in our office building and in the surrounding outdoor environment is investigated. In addition, a combination with WLAN and dead reckoning shall be performed in the near future.

Keywords: pedestriannavigation, indoorpositioning, location basedservices



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2909****Using GPS Scintillation Data and Receiver Tracking Models to Mitigate Positioning Errors**

Dr. Marcio Aquino
IESSG Nottingham University

Joao F G Monico, Alan Dodson, Haroldo Marques, Giorgiana Defranceschi, Lucilla Alfonsi, Vincenzo Romano

The satellite-receiver links from Global Navigation Satellite Systems - GNSS (such as GPS and Galileo) may be subject to ionospheric scintillation effects when they pass through the ionosphere. These rapid changes in the amplitude and phase of the signals can occur due to small-scale irregularities in the ionosphere, typical of certain regions of the Earth's ionosphere. Whereas at mid latitudes, scintillation effects are generally negligible, except for times of strong geomagnetic disturbance, significant problems may arise at equatorial and high latitudes, in particular during times of high solar activity that frequently occur during the maximum phase of the solar cycles. These effects can also affect users of GNSS at sub-auroral, and mid-latitude regions as some satellite-receiver links may pass through the irregularity region at a higher latitude than the receivers. The impact of scintillations on GPS positioning has been reported in the literature and indeed may be severe, including loss of signal tracking and positioning accuracy degradation. The latter clearly occurs mostly due to some, and not all, of the satellites used in the position computation being affected by scintillation as their links traverse the irregularities. Ideally the satellite-receiver links most affected could be isolated and left out, however constraints in the quality of the resulting geometry would not favour this method. Furthermore, the effect of scintillations on individual satellites can be completely different. However this effect can be assessed with the use of a suitable receiver tracking model. The variance of the output error of the receiver PLL (Phase Locked Loop) and DLL (Delay Locked Loop) expresses the quality of the range measurements that are used by a GNSS receiver to provide user position. The latter is calculated through a least squares process where the measurements from all satellites in view are normally considered of the same weight and as discussed above this is not true in the case of certain satellites being affected by scintillations. The capability of translating phase and amplitude scintillation effects into the variance of the tracking errors prompts the idea of applying relative weights to measurements from different satellites in the position computation, giving the least squares stochastic model a more realistic representation. This paper investigates the suitability of this approach and presents different approaches to tackle this problem. Scintillation parameters and high rate scintillation data collected by specialised GPS scintillation monitor receivers during periods of high geomagnetic activity were used to calculate the tracking jitter variance according to the tracking models introduced by Conker et al (2003). Relative weights were then computed, so that a scintillation-mitigated solution could be performed and compared to the conventional, equal weights solution. Results of this experiment are presented and discussed in the paper.

Keywords: ionosphere, scintillation, mitigation

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2910****Solar flare effect on the geomagnetic field and ionosphere****Dr. Amalia Meza***GESA Fac. de Cs. Astr. y Geof., UNLP, La Plata****Maria Andrea Van Zele, Marta Rovira***

A solar flare effect (sfe) over the ionosphere and the geomagnetic field during a very quiet geomagnetic period is studied. Then the variations of the geomagnetic field and ionosphere measurements are easily related with the solar flare radiation. On December 13, 2001, an X6.2 solar flare occurred near the solar centre (at solar coordinates N16 E09). This way, it is possible guarantee that the sfe arrive at the Earth. From GOES (Geosynchronous Operational Environmental Satellites) data every minute, the flare started at 14:23 UT and had its maximum at 14:30 UT. Considering that the subsolar point is at 23:18 S and 37.17 W (geographical latitude and longitude respectively), the geomagnetic and ionospheric variations are studied using the measurements of observatories located around the subsolar point at different solar zenith distance. The parameter used to study the ionospheric variability is the vertical electron content obtained from the GPS stations which belong to IGS (International GPS Service). The records of geomagnetic observatories available in WDC Kyoto are used to analyze the geomagnetic variability under SFE.. The time resolution is 0.5 and 1 minute respectively. The geomagnetic data record the solar effect 1 to 3 minutes after GOES reports and in most of the cases the amplitude is lower than 40 nT. Only in few cases the maximum variation reaches values larger than 60 nT and they can be related with the location of these observatories since they are placed near the equatorial electrojet. The VTEC measurements record a sudden variation related to the sfe 0.5 to 2.5 minutes after GOES reports and the maximum variation reaches 6 TECU. The aim of this work is to show the quantitative and qualitative relation between the sfe and the geomagnetic and ionosphere variation.

Keywords: flare, tec, sfe

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2911****Analysis of ionospheric range delay corrections for navigation in South America low latitude Region****Dr. Amalia Meza***GESA Fac. de Cs. Astr. y Geof., UNLP, La Plata***Laura Fernandez**

The ionosphere introduces large errors in GPS signals; these inaccuracies can be mitigated using a Satellite Based Augmentation System (SBAS) scheme. SBAS corrections are based on several approximations which are generally valid for mid latitudes and in Northern Hemisphere. In this work ionospheric conditions for a South American low and mid latitude scenario are simulated. The performance of a SBAS type algorithm is analyzed for this region. Since slant range delays came from a numerical simulation, they are perfectly known, and therefore the mismodeling produced by each SBAS approximation can be separately quantified. Our study has focused on the inaccuracy introduced by two components of the problem: 1) the single layer shell representation of the ionosphere and 2) the simple geometric mapping function that relates vertical and slant TEC. The effect of both components on positioning are evaluated and discussed. Tests were done in periods with different levels of ionospheric activity during solstices or equinoxes and La Plata Ionospheric Model (LPIM) algorithms were used for computing the results.

Keywords: tec, sbas, gps

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2912****Annual and semiannual VTEC variations in the South and North Atlantic region based on TOPEX*****Dr. Amalia Meza****GESA Fac. de Cs. Astr. y Geof., UNLP, La Plata****Mara Paula Natali***

The aim of this work is the analysis of the annual and semiannual variations in the total electron content of the terrestrial atmosphere. The region of study is the Atlantic Ocean at mid-low geomagnetic latitudes. Spatial and temporal ionospheric variability are investigated from Topex/Poseidon (T/P) altimetry data. The altimetry equipment is onboard of a satellite that operates in a 66 inclination circular orbit at about 1336 km. Its period is 1.87 hours and the ground track velocity is 5.8 km/s (an exact repeat orbit with a 9.91 day/cycle). In one cycle the satellite records the sea level at any geographical longitude and latitude between 66 and + 66 but at local hour it samples two bands separated by approximately 12 hours and the width of these bands of about 2 hours. T/P surveys sea-level heights by measuring the time required for pulses generated by the onboard radar altimeters to bounce vertically back to the satellite from the sea surface. To correct the Earth ionospheric delay on the radar pulse, the satellites altimeter makes measurements in two channels. The difference between both measurements yields the estimated values of the integrated total electron content (TEC) from lower part of the ionosphere up to the height of the satellite (1330 km). Time series of vertical TEC, provided by T/P on a regular 5 grid, are studied making use of Principal Component Analysis (PCA). Simulated data from IRI model are computed to improve our analysis, mainly regarding the data time coverage. The behavior of TEC variations at four different hours of the day (morning, midday, afternoon and night) are analyzed, highlighting particular characteristics associated with every period and with the geomagnetic region.

Keywords: topex poseidon, tec, pca

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2913****Inter comparison and validations of ionospheric VTEC maps for the South American Region*****Dr. Amalia Meza****GESA Fac. de Cs. Astr. y Geof., UNLP, La Plata****Mauricio Gende***

Since July 2005 Vertical Total Electron Content (VTEC) hourly maps have been generated for the South American region. These maps were modelled using a lineal combination of GPS carrier phase observables. Different research centers (JPL, CODE, UPC, ESA) also compute VTEC maps using GPS permanently tracking network but each of them obtain its results using different observables (undifferenced or double difference- carrier phase and code data), different ionospheric assumptions (single layer or tridimensional models), handling hardware-related biases in diverse ways and approaching the problem with different mathematical functions (spherical harmonics, local polynomials, kriging, global Gauss-Type Exponential) This work presents an inter comparison of our regional maps with respect to four Global Ionospheric Maps (GIM) for South America in the space-time domain and validates each model in the VTEC representation and in the position domain. Comparisons differentiate solstice and equinox sessions, low and middle latitudes and four different representative times of the day. Validation against ground true geodetic coordinates will be carry for GPS in middle and equatorial stations as well under the anomaly region.

Keywords: vtec, gps

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GS004

Poster presentation

2914

Multipath analysis on ROSA GPS receiver onboard of OCEANSAT_2 Indian space mission and its effects on the accuracy of atmospheric profiles retrieved by applying radio occultation technique

Dr. Francesco Vespe

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Alberto Zin, Vittorio De Cosmo

The Radio Occultation Sounder of the Atmosphere (ROSA) is a spaceboard GPS receiver tailored for sensing the atmosphere by applying the limb sounding technique. It was designed and developed by the Italian Space Agency (ASI) and Alenia Alcatel Space (AAS). In 2005 A Memorandum of Understanding was signed between ASI and the Indian Space Research Organization (ISRO) just to put ROSA onboard their next OCEANSAT_2 space mission devoted to Earth's remote sensing. A detailed analysis has been performed to arrange the antenna pointing toward the anti-velocity direction. In particular a simulation has been performed to understand what are the effects of multipath on the antenna. So in the first part of our presentation we will describe the results of the multipath analysis of ROSA antenna on OCEANSAT_2. Then we plan to investigate the sensitiveness of the atmosphere profiles, namely pressure, temperature and humidity, to the multipath disturbances suffered by ROSA.

Keywords: radiooccultation, atmosphere, gps

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2915****On the Determination of Systematic Errors Caused By Deformation in Geodetic Data, Case study: Kenai-peninsula area****Mr. Gholamreza Joodaki***surveying and geomatics engineering Tehran University***A.Safari, V.Nafisi, M.Jafari**

Regression models play an important role in many applied settings, providing prediction and classification rules, and data analytic tools for understanding the interactively behavior of different variables. Although attractively simple, the traditional linear model often fails in these situations: in real life effects are generally nonlinear with a non parametric model part. The statistic approach of non-parametric or semi-parametric regression is a valuable tool for detection and diagnosis of these effects. The approach concept is based on the theory of collocation and filtering method of geodesist H.Moritz. Of course, with several methods to determine the signal to noise ratio such as cross validation, this approach is more simply and precisely than the collocation method. Moreover, it may also be applied to the estimation of locally different motions of sliding slopes. In this paper, by applying these methods to the transformation of GPS-coordinates in two annual epochs (1996 and 1998), systematic distortions caused by deformation of the area can be estimated besides the estimation of Helmert-transformation parameters. Details of the computations are presented in the paper.

Keywords: deformation, non parametric model, collocation

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2916****Crustal Deformation following the impoundments of the Three Gorges Reservoir, China****Dr. You Xinzhao***National Earthquake Infrastructure Service China Earthquake Administration IAG*

Geodetic observations following the two-epoch impoundments of three gorges reservoir .in June 2003 and October 2006 have detected vertical displacement of 6-8 cm at maximum. and the horizontal displacement less than 5-10mm. The subsidence on the surface are concentrated on narrow zone outlined by the river-reservoir and the horizontal deformation induced by the water loading decays rapidly away from the central line of the reservoir, accompanied by slightly intensified shallower earthquakes $ML < 2$ following the filling the reservoir. The observed deformation is consistent with the prediction based on elastic half-space crust in response to surface loading. Compared to instantaneous displacement, the deformation due to aseismic fault slip as measured by creep meter, seismic activity in the upper crust recorded by local seismic network is apparent but less significant. The transient displacement due to viscous relaxation in deep lithosphere can not be resolved by the present data.

Keywords: deformation, gps, reservoir

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2917****Network Based DGNSS for Location Based Services Applications****Dr. Xiaolin Meng***IESSG The University of Nottingham IAG****Chun Liu, Alan Henry Dodson, Terry Moore, Pengfei Cheng, Quan Wang***

For Location Based Services (LBS) applications, the signal availability and the users mobility may be more important than the positioning accuracy. To improve GNSS positioning performance, notably GPS positioning, there are many regional or global based GNSS augmentation systems in operation or under development, with the attempt to increase the availability of signal in space (SIS) and positioning accuracy. However, in many countries such as in China, EGNOS signals are not available to assist GNSS for a variety of highly desired LBS applications in urban areas. Galileo will hopefully be operational in 2010 to double the number of positioning satellites. Many studies have been carried out to address the benefit Galileo system would bring to highly accurate positioning under a less obstructed observation environment. However, less effort has been made to investigate how network based differential GNSS (DGNSS) will improve the LBS services where the mass market exists with millions new LBS service subscribers of each year. Network based RTK GNSS facilities and telecommunications technologies have evolved rapidly in recent years and have already paved the way for achieving more flexible, timely and accurate DGNSS positioning solutions to support LBS activities. This research focuses on how to achieve network based DGNSS from an end user point of view and the analysis of potential positioning improvement through the introduction of simulated Galileo measurements into GPS measurement processing. The authors present a prototype demonstrator using a Bluetooth GPS receiver and the RTCM data streams from existing facilities such as the Nottingham Network RTK GPS testbed facility and Leica SmartNet service for LBS applications. The results collected from tests on several hundred miles of different grades of UK highway are compared with those from more sophisticated positioning devices such as a survey grade rover receiver and an integrated GPS and INS platform, to quantify the GPRS coverage, achievable positioning accuracy and continuity, and SIS availability as well as the users mobility.

I T A L Y

Keywords: lbs, galileo, simulation

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2918****Monitoring the Nanpu Bridge in Shanghai with GPS and Result Analysis****Prof. Lianbi Yao***Dept of Surveying and Geo-informatics Tongji University IAG***Ping Yao, Rengeng Wang**

With the development of GPS technique in recent years, it is possible to conduct kinematic positioning of centimeter even millimeter accuracy. The sampling rate of a dual frequency GPS receiver can reach 20 Hz and the maximum inter-station distances can be 20km with conventional real-time kinematic positioning. This makes GPS a very viable tool for monitoring large structures such as dam, bridge, high building, etc. This paper introduces the implementation scheme of a recent Nanpu Bridge monitoring trial in Shanghai. The NanPu Bridge is the first steel and concrete composite girder cable-stayed bridge built in Shanghai. The total length of the bridge is 8346 meters with its centre span of 423 meters long. When it was opened to traffic in 1991 it ranked third among cable-stayed bridges in the world. The supporting towers of the Nanpu Bridge are 150 meters high with two cables to suspend the bridge deck. A four-day data collection was carried out in October 2006 with 14 dual frequency GPS receivers of different makes. The collected data is post-processed in a kinematic manner to obtain each-epoch positioning solutions of 10 Hz. The detailed data processing and the result analysis for the aerostatic and dynamic characteristics of the bridge are introduced in the paper. The dynamics extracted from the field testing data match very well with the prediction of a finite element model and indicate good health condition after more than 15 year services. The trial demonstrates that the GPS positioning technique is completely capable of monitoring the dynamics of large or medium size bridges in a cost effective and reliable way.

Keywords: gps, bridge, monitoring

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2919****Quality Assurance of Network RTK GNSS Positioning: an end user perspectives****Dr. Xiaolin Meng***IESSG The University of Nottingham IAG****Alan Henry Dodson, Chun Liu, Terry Moore, Chris Hill***

In recent years, many network based real-time kinematic (NRTK) GNSS facilities, notably NRTK GPS facilities, have been developed to meet daily increasing demands for large, timely and accurate geo-spatial data to support a variety of engineering and environmental applications as well as scientific studies. These networks normally comprise three basic components, i.e. sparsely distributed reference stations, a data centre and end user groups. Dual-way communication either through wireless or landline connections is required to link both the reference stations and the user groups to the data centre. From an end users point of view he or she needs to subscribe to a NRTK GPS product provider and equip himself or herself with a GPRS/GSM enabled GPS receiver to receive real-time RTCM correction streams. He or she is more than less concerned about the GPRS connection and the completeness of the RTCM data streams. Of course from a NRTK facility developers or administrators point of view their emphasis might be more focused on the design of the overall network, the layout of the reference stations such as optimal inter-station distances under the consideration of local terrain, the security measures implemented for the field instruments, the selection of proper hardware, the system scalability and the software development, especially the advanced algorithm R&D for the integer ambiguity resolution and the mitigation approaches for addressing systematic and random errors. Since NRTK technology is still far from mature, many research efforts are needed for achieving more reliable, accurate and robust positioning solutions. In this paper, the authors will only address the quality assurance issues from an end users perspective. For carrying out the proposed research, RTCM data streams produced by a Nottingham network RTK GPS testbed facility and the Leica SmartNet service are utilised in the tests. In this paper the results from three types of tests are presented with different application scenarios in mind. The first test is carried out using a survey grade GPS rover and a GPRS data link to receive RTCM corrections. The output rate of a 24-hour test is set to 1 Hz and 10 Hz respectively. The software for processing NRTK GPS data is Leica Spider V2.2. A similar configuration is employed in the second test but commercial RTCM data streams from Leica SmartNet service are used in the test which also lasts for 24 hours, aiming at the impact analysis of different network configuration on the final positioning solutions. In the third test, two rover receivers share an antenna with a signal splitter. One receiver is configured as a standard NRTK rover by receiving RTCM data streams from the Nottingham testbed facility but the other one is connected to a reference receiver by a direct serial connection. After collecting the sampling data sets, the GPRS connection/strength, the completeness of RTCM corrections, the delay of signal transmission and its impact on the positioning accuracy are utilised as the major factors in the analysis of NRTK data quality. Relevant quality assurance measures are recommended in the paper for improvement of the overall quality of NRTK GPS positioning but more practical approaches need to be further investigated.

Keywords: network, quality, assurance

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2920****GNSS activities within the Automated GPS Network of Switzerland
(AGNES)****Dr. Elmar Brockmann***Swiss Federal Office of Topography swisstopo Federal Surveying IAG***D. Ineichen, S. Schaer, U. Wild**

The Automated GPS Network Switzerland (AGNES) has been established between 1998 and 2001 and consists nowadays of 31 permanent GPS stations. Since the beginning, the network has been designed as a multi-purpose reference network for national first order surveying, scientific research such as geodynamics and GPS meteorology, and as a base for the Swiss positioning service (swipos). It is planned to enhance AGNES to combined GPS/GLONASS stations mid of 2007. Different GNSS test analyses were performed in order to prove the ability to process GNSS data and to specify the gain due to GNSS for different applications. The paper gives an overview of results achieved with data of 4 different modern GNSS receivers collected at the geostation Zimmerwald using commercial and scientific analysis software. Furthermore results from swisstopo's contribution to the European Permanent GNSS Network (EPN) are presented. Real-time results, derived from several test measurements and comparisons of the performance of two in parallel operating real-time networks, show that due to the actual status of the GLONASS system as well as due to the current status of the GNSS software mainly the RTK availability is improved, whereas the coordinate accuracy may be degraded.

Keywords: gnss, glonass, multi purpose network agnes

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2921****A new GNSS software simulator****Dr. Hiroshi Munekane***Space Geodesy Research Division Geographical Survey Institute, Japan****Yuki Kuroishi, Shigeru Matsuzaka, Akira Akaishi***

We developed a new GNSS software simulator to evaluate the impact of introducing coming GNSS systems (Galileo, QZSS etc) on the precision of geodetic positioning. The simulator has the following new features: 1) the simulator can simulate arbitrary satellite trajectory under general perturbation forces such as atmospheric drag, gravitational drag, relativistic effect, etc. 2) the simulator generates simulated GNSS observation data in RINEX-2 format so that one may analyze the data with arbitrary software. 3) the simulator is capable of taking into account realistic masking effects from topology and buildings. 4) the simulator is capable of incorporating general error sources such as satellite/receiver clock error, multipath, ionospheric delays (including higher order terms), cycle slips, tropospheric delays, arbitrary white/random walk errors during propagation, etc. 5) the simulator is capable of taking into account realistic ionospheric/tropospheric delays from numerical models. In this presentation, we will describe the detailed functions of the GNSS simulator. We will also demonstrate the ability of the GNSS simulator to reproduce realistic observational errors by comparing the simulated/observed positioning errors in island GPS sites under meteorological disturbances.

Keywords: gnss, software simulator, positioning accuracy

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2922****Performance of New Rapid-Static Positioning Algorithms for Centimeter-Level Position within EUPOS Network****Dr. Pawel Wielgosz***Institute of Geodesy University of Warmia and Mazury in Olsztyn IAG*

EUPOS is a European project aiming at establishing a uniform, multifunctional DGNS (Differential Global Navigation Satellite System) infrastructure in 14 Central and Eastern European countries. EUPOS will provide DGNS correction data for real-time positioning and navigation as well as for the DGNS observation data for the post-processed positioning. The expected separation between the reference stations is about 50-70 km; therefore in the worst case scenario, the distance from the user site to the closest reference station should not exceed ~40 km. One of the most important services for geodesy will be rapid-static (fast-static) positioning, assuring reliable sub-centimeter accuracy of the horizontal position when using short spans of dual-frequency GPS data (e.g., 5-10 minutes). In the rapid-static applications over medium and long distances, fast and reliable ambiguity resolution (AR) is crucial in order to achieve a sub-centimeter position accuracy. The speed and the reliability of AR strongly depend on the observational session duration as well as on the quality of the atmospheric corrections (ionospheric in particular), which may be provided, e.g., by the reference network. In this paper, data collected at ASG-EUPOS (Polish part of EUPOS) with 5, 15 and 30-second sampling rates were processed using the newly proposed fast-static algorithms in order to determine the recommended sampling rate and observational session duration for the users. The data were processed in single- and multi-baseline modes to recommend the best solution geometry. The Multi Purpose GPS Processing Software (MPGPS) algorithms were used in all numerical tests. The fast-static (rapid-static) positioning module is the latest extension of the MPGPS software developed at the Ohio State University (OSU) in cooperation with the University of Warmia and Mazury in Olsztyn (Kashani et al., 2005, Wielgosz et al., 2005; Grejner-Brzezinska et al., 2005). Its algorithms are a basis for the Online Positioning User Service Rapid Static (OPUS-RS), an interactive web service provided by the US National Geodetic Survey (NOAA/NGS). The MPGPS software uses network-based algorithms to derive accurate ionospheric and tropospheric corrections from the data set collected by a permanent GNSS array (e.g., EUPOS). These corrections are used to support accurate and reliable rapid-static positioning of the user receiver. The data analyses and the positioning results provided in this paper are derived using the newest software extension. References: Grejner-Brzezinska, D.A., Wielgosz, P., Kashani, I., Mader, G.L., Smith, D.A., Spencer, P.S.J., Robertson, D.S., and Komjathy, A., (2005), Performance Assessment of the New Rapid-Static Module of the Online Positioning User Service OPUS-RS, Proceedings of the ION GNSS 2005, September 1316, Long Beach, California, pp. 25952605. Kashani, I., Wielgosz, P., Grejner-Brzezinska, D.A., and Mader, G.L., (2005), A New Network-Based Rapid-Static Module for the NGS Online Positioning User Service - OPUS-RS, Proceedings of the ION 61st Annual Meeting, June 2729, 2005, Cambridge, Mass., pp. 928936. Wielgosz, P., Kashani, I., and Grejner-Brzezinska, D.A., (2005), Analysis of Long-Range Network RTK during Severe Ionospheric Storm, Journal of Geodesy, Vol. 79, No. 9, pp. 524-531.

Keywords: gnss, eupos, rapid static

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GS004

Poster presentation

2923

Report of Sub-Commission 4.2 - Applications of Geodesy in Engineering

Prof. Heribert Kahmen

Geodesy and Geophysics Geodesy and Geophysics IAG

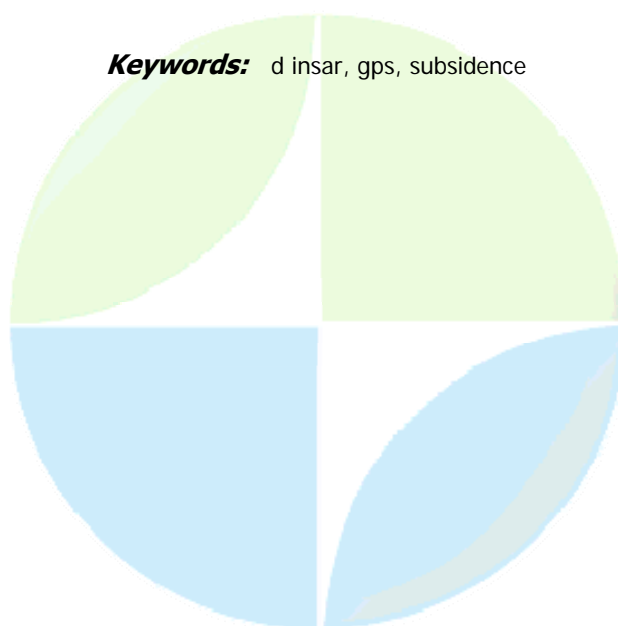
Sub-Commission 4.2 organized two International Conferences (in Vienna, Austria, 2005 and in Baden, Austria, 2006), where four Working Groups: WG 4.2.1 Measurement Systems for the Navigation of Construction Processes, WG 4.2.2 Dynamic Monitoring of Buildings, WG 4.2.3 Application of Knowledge-based Systems in Engineering Geodesy and WG 4.2.4 Monitoring of Landslides & System Analysis got a possibility to present the results of their research. Highlights of the research work will be reported. The currently used navigation systems and new techniques for controlling construction processes will be shown. Currently used building monitoring systems including techniques based on satellite and terrestrial measurements will be discussed. The newest developments concerning the application of Knowledge-Based Systems will be reported such as: control of measurement systems, deformation analysis control of alert systems and the evaluation of the complex data streams. As concerns landslides a multi-disciplinary integration of different methods for monitoring and analysis systems was promoted. Another goal was to establish an integrated workflow for landslide hazard management.

Keywords: monitoring, landslides, buildings



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2924****GPS, leveling and InSAR data fusing in City Subsidence monitoring****Dr. Li Tao***GNSS research center of Wuhan university Wuhan university, China IAG****Liu Jingnan, Zhang Shiyu, Jiang Yanxiang, Lu Xu, Xia Ye***

Many cities in faced the problem of land subsidence for over withdraw ground water. But free cities have enough money to monitor the subsidence and control its developing. The dilemma between economy developing and environment protecting becomes hard to solve. However, monitoring the present subsidence condition is important for the protecting actions in the future. According to the surveying techniques, leveling, GPS and InSAR are the main tools to monitor the city subsidence in . In fact, most of cities undertake more or less precise leveling surveying every year. Those data become a precious database for revealing the city subsidence upon the leveling benchmark. With more and more SAR satellites and accumulated thousands of SAR images, InSAR technique becomes an important role in land subsidence movement. In recently, there are many GPS continuous stations have been built and will be established. Those stations will also give great impact on the City subsidence monitoring. This paper studied Tianjin City, a city with smooth topography and severe subsidence, with GPS continuous stations, leveling data and InSAR results. In order to organize and co-register all these data into the same coordinate and do some analysis, a GIS platform is needed. Grass, an open source free GIS software, which is popular over the geodesy and geosciences field is introduced in this project. With open GIS software Grass, a city subsidence database was established in Tianjin area. Fusing continuous GPS station observation into interferogram, some primary results have been made to improve the deformation subtracting. The leveling data and InSAR results were co-registered into the same coordinate system. By comparing and fusing these two observations, more city subsidence information and better results have been made. The features of the subsidence in Tianjin area were analyzed. Primary results showed that InSAR technique can help the local controlling center to control the water pumping in time. Enough continuous GPS stations can help InSAR to calibrate the tropospheric delay and some time decrease the effect by data fusing. According to grass software, using open source and free software to solve geosciences problem will be more and more popular in the future. As more and more people come into using and developing grass software, it will become a key tools in geosciences field.

Keywords: d insar, gps, subsidence

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2925****An evaluation of geodetic positioning error simulated using the fast ray tracing algorithms through the JMA mesoscale numerical weather data****Dr. Ryuichi Ichikawa***Kashima Space Research Center NICT IAG***Thomas Hobiger, Koyama Yasuhiro, Kondo Tetsuro**

We evaluate atmospheric parameters (equivalent zenith total delay and linear horizontal delay gradients) derived from slant path delays obtained by new ray tracing technique [Hobiger et al., 2007] through the Japan Meteorological Agency (JMA) meso-scale numerical weather data with 10 km horizontal resolution. We numerically also estimate position changes caused by the horizontal variability of the atmosphere by means of simulation analysis using the ray-traced slant delays. Our ultimate purpose is to establish a new method for reducing atmospheric effects on geodetic positioning. We first seek to establish the level of positioning error due to intense mesoscale and local scale phenomena. The JMA data which we used in our study provides temperature, humidity and pressure values at the surface and at 21 height levels (which vary between several tens of meters and about 31 km), for each node in a 10 km by 10 km grid that covers Japan islands, the surrounding ocean and eastern Eurasia. We first reconstruct modified grid scheme based on the original JMA data for adapting the new ray tracing algorithms with analytic expressions. The topography used in the data is retrieved from SRTM30 digital elevation data set. For each grid point we invert the simulated slant delays using an isotropic and an anisotropic delay model. The isotropic model has only one parameter - the zenith total delay (ZTD). The anisotropic delay model [e.g. Chen and Herring, 1997] has two additional lateral gradient parameters. We compare the 'true' ZTD, computed by directly integrating the atmospheric refractivity field of the grid data, with the ZTD estimated by least squares inversion of the 'observed' slant delays obtained by ray tracing. We did this using the isotropic and the anisotropic delay model. In addition we also numerically estimate atmospheric parameters and site position changes simultaneously from the ray-traced slant delays, assuming single point positioning without coordinate constraints. We consider the vector between the true position and estimated position to be the positioning error. This estimation is performed to investigate the behavior of the positioning errors generated by local atmospheric disturbances, the relation between the slant delay errors and the vertical positioning errors and so on. At present the 3-hourly operational products are only available by JMA. Thus, we mine the data field at intermediate hours obtained by time interpolation in order to evaluate temporal change of estimates. We find that the large horizontal positioning errors through the modified JMA data set at a single epoch of 0000 UT 18 October 2004. The maximum of the errors up to 7 cm is represented in the south of Kyusyu island where a complex distribution of water vapor associated with an extremely large-scale and powerful Typhoon No. 23 and it is not reduced by isotropic mapping function.

Keywords: numerical weather model, gnss, vlib

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2926****Reliability of Helmert coordinate transformation for horizontal control networks in deformation analysis****Mr. Bahattin Erdogan***Geodesy and Photogrammetry Engineering Yildiz Technical University IAG***Serif Hekimoglu**

Deformation analysis is one of the most interest areas in the survey engineering. Deformation analysis contains the comparison of coordinate differences between different observation epochs. If the coordinates differences statistically are confirmed, the point coordinates changes are interpreted as the displacement. Several deformation models can be employed, one of this method is Helmert or Similarity Coordinate Transformation model. After coordinate transformation, we can investigate the displaced point by using residual of transformed coordinates as the outliers. We can apply conventional test for outliers and robust methods, but there is not any knowledge whether they give the correct results in all probable situations or which situations change their reliabilities. The reliabilities of the conventional test for outliers and robust methods are measured by Mean Success Rate (MSR). Different horizontal control networks are simulated to investigate how the reliability of the Helmert Transformation Method changes depending on the number of points and observations, the magnitude of the displacements and the number of the displaced points. In this study, first the weights of the coordinates are chosen the same and the MSRs are computed in a given displacement interval for a certain number of displaced points for conventional test for outliers and robust methods, then their variance covariances will be considered as their weights.

Keywords: deformation analysis, helmert transformation, reliability



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2927****An investigation into robust estimation applied to correlated GPS networks****Mr. Ramazan Cuneyt Erenoglu***Department of Geodesy and Photogrammetry Eng. Yildiz Technical University IAG***Serif Hekimoglu**

High precision positioning can be achieved by tracking GPS satellites. However, there exist lots of error sources. Especially point locations for GPS networks have to be chosen rather by task requirements than by optimality of the environment in respect of GPS signal propagation. So, the effect of unfavorable error source on precise GPS positioning is a usual problem. Least squares estimation (LSE) yields results of low accuracy in the presence of outliers in GPS baselines. Different weight models have been suggested to account when analyzing GPS networks. In this study, we use robust estimators which clearly identify outlying observations. It performs significantly better than the LSE. Furthermore, GPS observations are fundamentally correlated. So, herein the robust estimators are applied to heterogeneous and correlated observations. The mean success rate (MSR) is employed to be a practical tool for measuring abilities of the methods. Many different correlated GPS networks based on IGS sites are used and the robust methods are applied to this simulated corrupted samples and the degree of corruption is varied. Further performances of the estimators are demonstrated using real data from GPS networks.

Keywords: robust estimation, correlated gps network, reliability

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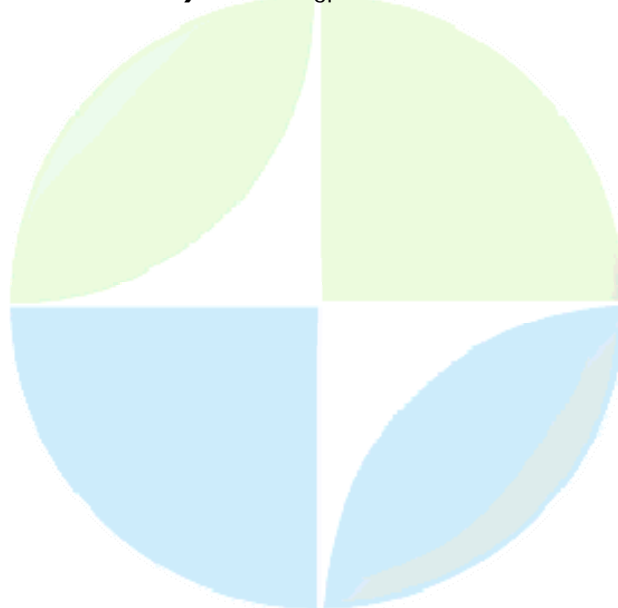
(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2928****A critical assessment on the current EGNOS performance****Mr. Michael Opitz***IGG Vienna University of Technology***Robert Weber, Wolfgang Winkler**

The main purpose of this paper is to evaluate the current performance of the European Geostationary Navigation Overlay Service (EGNOS) in comparison to commercial, local DGPS services. In full operational capability (FOC) EGNOS provides orbit and clock-corrections of all GPS satellites as well as the ionospheric delay for real-time users within the service area by means of three geostationary satellites. In addition EGNOS should disseminate integrity information in the near future. The analysis is mainly based on the comparison of the trajectories of a slowly moving vehicle obtained by two real-time correction techniques EGNOS and WEP (Wienstrom Positioning Service Provider). The tests are carried out in medium obstructed environment which slightly harms the visibility of the EGNOS satellites. In order to set up a comparable test environment, the GPS-signals were received by one single antenna, divided in two data streams by an antenna-splitter and subsequently forwarded to both a GPS/EGNOS receiver and a GPS-receiver with RTCM-input capability. During the trial session also raw data of the rover receivers as well as the reference station will be logged. This allows to verify a posteriori the calculated real-time positions and to test different positioning algorithms using EGNOS correction data by means of the program SISSIM (SISNet Simulation). Additionally an evaluation of the EGNOS ionospheric model will be presented.

Keywords: egnos, dgps services, urban navigation**PERUGIA
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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2929****The behavior of the horizontal gradients of TEC over Europe during different geomagnetic conditions and its impact on GPS positioning accuracy****Dr. Andrzej Krankowski***Institute of Geodesy University of Warmia and Mazury in Olsztyn IAG***Shagimuratov Irk, Baran Lubomir, Sieradzki Rafal, Krypiak-Gregorczyk Anna**

As known, the horizontal gradients of TEC influence the carrier phase ambiguity resolution as well as the accuracy and precision of GPS positioning. The TEC gradients essentially depend on geophysical conditions and particularly strong changes of gradients that take place during geomagnetic storms. In this paper, we present the spatial and temporal dynamics of latitudinal TEC gradients over the European region. For analysis of TEC gradients, the regional TEC maps were produced using GPS observations of the IGS/EPN networks. The dense network of GPS stations over Europe provides the detailed picture of the gradients in different geomagnetic conditions. The behavior of the latitudinal gradients depends on the solar and geomagnetic activity, season and time. During high solar activity, in quiet geomagnetic conditions, the latitudinal TEC gradients may reach the value of 1-2 TECU/degree. It is 10-times higher than in a low solar activity. The highest changes of latitudinal gradients are related to the occurrence of the main ionospheric trough. Maximal values of TEC gradients have been recognized at equatorial and polar walls of the trough. During quiet geomagnetic conditions, the trough is usually located over 60-70N. During severe geomagnetic storms the trough shifts equatorward and can reach latitudes lower than 55-50N. Therefore, even over middle latitude stations, the phase ambiguity resolution may be disrupted. At the sharp gradients near the occurrence of the trough a different scale inhomogeneities can be developed, which also can increase a number of the cycle slips over middle latitudes stations and, in consequence, to decrease an accuracy of GPS positioning. The analyses relied on studying the repeatability of vectors coordinates, connecting Lamkowko with other IGS/EPN stations: Matera, Graz, Wettzell, Borowiec, Borowa Gra, Onsala, Kiruna and Tromso. This impact, at the middle and high latitude ionosphere has been discussed in terms of the total number of double-differences (DD) and in the ratio of the unresolved ambiguities.

Keywords: gps, tec, storms

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2930****Verification of GPS derived ZTD and IWV potential for meteorology****Dr. Michał Kruczyk***Institute of Geodesy and Geodetic Astronomy Warsaw University of Technology IAG*

Paper describes a number of various analyses, experiments and overall author experience in the 'GPS meteorology' area. Main aim is to assess value of ZTD and IWV series of geodetic origin (GPS) in atmospheric research. Firstly I will show some indicators of standard ZTD products (Zenith Tropospheric Delay) quality. Special attention is paid to effects evoked by station location (e.g. height and, ZTD series correlation coefficient as a function of distance) and weather pattern. Direct values of ZTD and IWV were obtained from radiosoundings (RAOB). I use also input values (profiles) from Numerical Weather Prediction model COSMO-LM (version maintained by Polish Institute of Meteorology and Water Management). From NWP models treated as meteorological database we can obtain/calculate ZTD and IWV for all stations independently from sparse RAOB network. Extremely interesting to me is information exchange potential between Numerical Model and GPS network derived values - which need for future development of weather prediction I hope to prove. IGGA team with my participation have developed automatic system for GPS tropospheric delay estimation in the Near Real Time (NRT). Accurate comparisons of this project outcome with ZTD combined product (EPN and IGS) and radiosounding data has been made. Finally I will illustrate a few possible scientific applications of tropospheric delay products: IPW series analysis in search for geophysical interpretations - especially long (climatologic?) series, deficiency of surface humidity data to model IWV etc.

Keywords: ztd, iwv, meteorologyPERUGIA
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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2931****Ionospheric scintillation impact on precise positioning at European auroral latitudes****Dr. Biagio Forte***CENTRE FOR ATMOSPHERIC RESEARCH UNIVERSITY OF NOVA GORICA IAG*

Transionospheric radio signals may experience fluctuations in their amplitude and phase. The fluctuations characteristics depend on the radio frequency, magnetic and solar activity, time of day, season of the year and magnetic latitude of the observation point in the case of satellite to ground links. Nowadays, one of the most important topic is to estimate scintillation effects on Global Navigation Satellite Systems (GNSS). Ionospheric scintillation is responsible for transionospheric signal degradation that can affect the performance of navigation systems. An outline of an alternative detecting technique for measuring ionospheric scintillation activity based on a GPS single frequency receiver is presented, with particular reference to the calculation of scintillation indices. Moreover, precise positioning at European auroral latitudes during the October 2003 magnetic storm is analysed and compared with co-located ionospheric scintillation measurements. The impact of ionospheric scintillations on precise positioning is carried out and possible explanations are also provided.

Keywords: ionosphere, scintillation, gnss



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2932****Report on Activities 2003-2007 for IAG Sub-Commission 4.3: GNSS
Measurement of the Atmosphere*****Dr. Susan Skone****Geomatics Engineering University of Calgary IAG****Hans Van Der Marel***

Over the past decade, significant advances in Global Navigation Satellite Systems (GNSS) technology have enabled the use of GNSS as an atmospheric remote sensing tool. With the growing global infrastructure of GPS/GNSS reference stations, the capability exists to derive high-resolution estimates of total electron content and precipitable water vapour in near real-time. Additional observation capabilities are available through spaceborne GNSS receivers using radio occultation techniques. The focus of this Sub-Commission has been to facilitate collaboration and communication, and support joint research efforts, for GNSS measurement of the atmosphere with applications in geodesy, meteorology and atmospheric research. Specific objectives have been pursued through working groups on ionospheric scintillation, tomographic modeling of the ionosphere and the use of numerical weather products for geodetic positioning. This presentation will provide an overview of Sub-Commission 4.3 and associated working group activities over the past four years.

Keywords: gps, gnss, atmosphere

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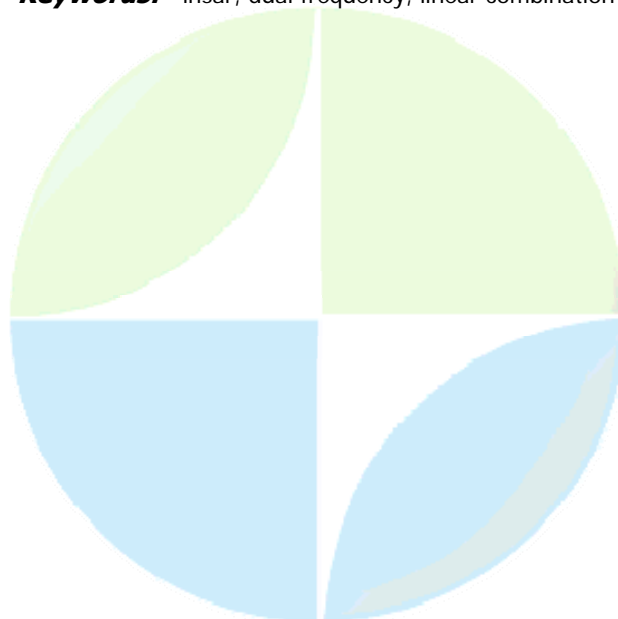
(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2933****Precise vertical velocities from continuous GPS*****Dr. Rick Bennett****Department of Geosciences University of Arizona****Rick Bennett, Sigrun Hreinsdottir***

We have analyzed data from long running continuous GPS (CGPS) stations in the Mediterranean region and the western United States to assess the precision of relative vertical rate estimates at regional-distance scales. We restricted our analyses of precision to subnetworks of aperture ~500 km and stations that have been in operation for at least 5 years. For all subnetworks that we have investigated, we determine vertical rate estimates with precision in the range 0.2 to 0.4 mm/yr, based on numerical experiments, comparisons with independent data sets, and simple models for deformation. Formal rate uncertainties are 2 to 4 times smaller than the actual empirically determined precision, consistent with the effects of colored data noise and/or unmodelled deformation processes. Nevertheless, the sub-millimeter per year level precision that we find is lower than might be expected based on the prevailing expectation that GPS determinations of vertical crustal motion are inherently imprecise. Our initial results were based on older relative antenna phase center models and satellite antenna phase center offsets. We are in the process of repeating our analyses using the new International GNSS Service absolute phase center models for both ground and satellite based antennas. These are expected to improve the global accuracy of vertical rates determined by GPS. We suggest that under suitable conditions CGPS geodesy provides a powerful tool for constraining the vertical motions of Earth's surface at the regional-scale, with direct application to models for lithospheric loads, convergent and divergent tectonics, and other geodynamic processes.

Keywords: gps, vertical, deformationPERUGIA
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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2934****Linear combination for differential radar interferometry****Dr. Linlin Ge**
Surveying UNSW IAG

LINLIN GE¹, Hua Wang^{1,2}, and Hsing-Chung Chang¹ 1. CRC for Spatial Information & School of Surveying and Spatial Information Systems, The University of New South Wales, Sydney NSW 2052, 2. School of Geodesy and Geomatics, Wuhan University, 129 Luoyu Road, Wuhan 430079, Synthetic aperture radar interferometry (InSAR) has been widely used over the past two decades for topography mapping and deformation monitoring. In particular, in contrast to other geodetic techniques differential InSAR has the capability to measure surface deformation with a measurement precision of a few millimetres and a spatial resolution of a few tens of metres over hundreds of kilometres. However, ground surface may deform by large amount within a small area because of a wide range of natural or man-made activities such as earthquakes, underground mining, and groundwater extraction, which causes severe damages to surface and underground infrastructures. Current satellite radar interferometry, because of its single-frequency signal structure, cannot measure large-gradient deformation producing too dense fringes. The upper limit of the deformation gradient is determined by wavelength and pixel spacing. Although the longer wavelength of the radar signal is less susceptible to the high deformation gradient, we still find that loss of correlation often occurs due to the high co-seismic strain near the epicentre and high subsidence gradient near the centre of the mine panel even when L-band imagery are used. In this paper, we propose a novel method to effectively monitor such large-gradient deformation: differential InSAR by linear combination of interferograms acquired from dual-frequency sensor. Some simulated interferograms are generated through the combination of the widely used radar wavelengths, for instance, C, L1, L2, S and even P band. Using well designed linear combination factors, the wavelength of the combined interferogram is flexible for different applications. From the simulated results, we find that linear combination is powerful to improve the correlation and make the phase unwrapping much easier. Once validated using the real imagery acquired by multi-frequency SIR-C/X-SAR sensor, our method should be useful for the design of the next generation satellite radar interferometry in the future.

Keywords: insar, dual frequency, linear combination

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2935****Modelling tropospheric delays without mapping functions****Mr. Peter Smythe***Research School of Earth Sciences The Australian National University IAG***Paul Tregoning**

Empirical functions are routinely used to map a priori zenith delays of GPS signals to arbitrary elevations angles. These mapping functions are increasingly derived by raytracing through numerical weather models or meteorological data to model the troposphere for GPS analyses. The concept of direct mapping makes use of site- and time- specific atmospheric meteorological data as opposed to parameterized mapping functions derived from seasonal trends in long term atmospheric data. We have extended this concept by making observation-specific estimates of Slant Hydrostatic and Wet Delays for each observation site, time, elevation and azimuth by direct ray tracing through an atmospheric model provided by the National Center for Environmental Prediction - National Center for Atmospheric Research reanalysis data. This method has been implemented in the GAMIT GPS analysis software and removes the need for mapping functions entirely. Further, the introduction of errors by over-simplified models involving tropospheric gradients is avoided. We will present the results of a comparison of this method and commonly used empirical mapping functions.

Keywords: mapping function, raytrace, slant delay

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2936****Effect of un-modeled errors on GNSS integer ambiguity resolution and validation****Dr. Jian Wang***School of Surveying & Spatial Information Systems The University of New South Wales
Sydney***Jinling Wang**

The LAMBDA (least-squares ambiguity decorrelation adjustment) method based on the integer least squares (ILS) procedure is currently one of the most applied methods for GNSS integer ambiguity resolution (AR), which aims at resolving unknown cycle ambiguities of double-differenced (DD) carrier phase data as integers. However, the Un-modeled errors, including system biases and gross errors, can cause the failures of ambiguity resolution. It is demonstrated that there are different means to improve success rate of AR and verify its validation. The F-ratio and the W-ratio are selected to assess the effect of the Un-modeled errors on AR in this paper. This paper can be separated into four parts. In order to evaluate the effects of gross errors on the AR and ambiguity validation, different gross error scenarios have been investigated using real-data set. It is noted that the ambiguity validation ratios change dramatically once a gross error occurs. Therefore, it is obvious that the quality control and the gross error handling process must be included before AR. As the systematic biases due to atmospheric delays and orbital errors after double differencing show a significant impact on the AR. This can be improved with a Wavelet systematic error extraction procedure. Finally, a procedure for the baseline solution including the gross error detection and exclusion, noise reduction and systematic error mitigation is proposed. The proposed baseline solution scheme tested by the Real GPS continuous monitoring data sets provides good results.

Keywords: un modeled error, ambiguity resolution, ambiguity validation



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2937****Analysis on temporal-spatial variation of Australian Tec****Dr. Jian Wang***School of Surveying & Spatial Information Systems The University of New South Wales
Sydney***Gary Ouyang, Jinling Wang, David Cole**

Characteristics of temporal variations of ionospheric TEC play an important role, in GPS static, kinematic and navigation application, especially in the derivation of high precision ionospheric corrections for position. There are many models advanced by researchers for modeling these characteristics.. In this paper, TEC temporal-spatial distribution characteristics in the Australian region are inverted using an improved Geogiadiou model based on real GPS continuous data. The main areas of research are as follows. (1) A five-year time series of TEC is analyzed to define the long term trends. A time-frequency analysis is used for detecting periodical variations. FFT is used for frequency distribution characteristics, Thereafter, a finite infinite response (FIR) filter is applied to extract the specific frequency span.information (2) The same period of a different year is analyzed and compared to show seasonal changes. (3) A relationship between solar cycle and TEC is developed. (4) A scheme for the generation of real-time spatial TEC distribution maps in the Australian region is proposed with time and spatial visualization model. This paper gives a scheme for regional TEC inversion and analysis of temporal-spatial TEC variability. Time and spatial modeling of TEC and its visualization has potential applications for single-frequency GPS navigation.

Keywords: tec, temporal spatial variation, visualization**PERUGIA
I T A L Y**

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2938****Towards Single Epoch Ambiguity Resolution with Multiple Frequency Galileo****Dr. Chen Wu***Department of Land Surveying and Geoinformatics Hong Kong Polytechnic University IAG****Ji Shenyue, Xiaoli Ding, Yongqi Chen***

The major differences between GNSS pseudorange and carrier phase measurements are measurement noise level and ambiguity associated with carrier phase. If carrier phase ambiguity can be resolved for within single epoch data, the carrier phase measurements represent pseudorange-type of measurements with much higher precision. The European Galileo system will provide signals in four frequency bands which provide more frequency combinations with longer equivalent wavelengths than that from GPS. This paper investigates single epoch ambiguity resolution performance using Galileo four frequency data. An improved Cascade Ambiguity Resolution (CAR) algorithm is proposed in this paper. The algorithm first utilizes the success rate analysis method to select optimal frequency combinations to achieve longer equivalent wavelengths. Then a new processing method is proposed to reduce the measurement noise level caused by conventional CAR method. The test results from simulated Galileo data show, in general, the improved CAR method proposed in this paper performs better than the conventional CAR method and LAMBDA method. The speed of ambiguity resolution is closely related to the carrier phase measurement precision. With carrier phase measurement precision of less than 6mm, single epoch ambiguity resolution can be achieved at every epoch with simulated 1 second-interval 24-hour Galileo data (total epochs: 86400). When the noise level is increased to 12mm, single epoch ambiguity resolution can only be achieved about 70% of epochs.

Keywords: ambiguity resolution, galileo

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2939****Network RTK with moving reference stations****Dr. Chen Wu***Department of Land Surveying and Geoinformatics Hong Kong Polytechnic University IAG***Congwei Hu, Xiaoli Ding, Yongqi Chen, Shan Gao**

In recent years, the GPS Precise Point Positioning (PPP) technique has attracted many interests in research as it does not require reference stations as conventional GPS relative positioning and can be used in anywhere on the earth's surface. However, one of the main problems of the PPP technique is the convergence time for ambiguity resolution. It is commonly require 10 to 30 minutes before ambiguity can be estimated precisely to achieve centimetre level positioning accuracy. On the other hand, network RTK is able to provide centimetre positioning accuracy in real-time, and covers a fairly large region (a few hundred kilometres). The working principle of network RTK, which is very similar to the WADGPS, separates GPS errors (i.e. satellite clock error, ionospheric and tropospheric delays) into different components. Then the measurement errors at a user site can be interpolated by the estimation of the errors at reference stations. But network RTK techniques require users are within the coverage of the reference network, and that restricts the application of real-time positioning in some area, i.e. in the sea. In this paper, we propose a new method that enables to use GPS receivers on moving platform as reference stations for network. With this approach, we can set up reference stations at any locations (i.e. to set up reference stations at sea on buoys) to provide a better coverage for different users (i.e. to set up reference stations at sea on buoys). The key question for this approach is if we can estimate the GPS measurement error components on a moving platform with the same accuracy as that obtained from a static reference station. In this paper, we will use kinematic PPP method to estimate the ionospheric and tropospheric delays on a GPS buoy. The results demonstrate that the estimation accuracy of ionospheric and tropospheric delays are compatible to those obtained from static GPS receivers.

Keywords: kinematic gps, network rtk, ppp

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2940****Continuous Orbit Polynomials Stream: the source, usage and evaluation*****Dr. Jan Dousa****Geodetic observatory Pecn Research Institute of Geodesy IAG****Leos Mervart***

Continuous Orbit Polynomials Stream (COP-S) for GNSS satellites has been developed as an alternative format to the Standard Product #3 (SP3) for streaming precise orbits in real-time. The COP is designed on a basis, that precise orbits could be well predicted for the real-time applications. Besides, the precise satellite clock corrections should be preferably estimated in real-time. Two streams could be thus provided separately - continuous precise orbits (COP) represented over the validity interval and the precise clocks (CLK) providing e.g. 1Hz product. The COP stream was designed as the efficient format for non-permanent stream. It uses polynomials hourly representing orbit components in ECEF system. These values are hourly calculated fitting the last available IGS ultra-rapid orbit predictions in SP3 format (currently from 6 hour update). The COP are completed for the GLONASS orbits from the other available sources (e.g. CODE ultra-rapids). The continuity of the precise orbits (polynomials connections) in the stream are provided up to the first derivatives (velocities). The clock corrections are also predicted here. The corrections missing in SP3 files are completed from the navigation message. The presentation shows the COP stream generation, the distribution (via NTRIP), the use and summarizes the orbit quality monitoring results. The aspect of the product stability and robustness will be discussed too. COP is now provided as a pilot NTRIP stream at ntrip.pecny.cz caster.

Keywords: gnss, orbits, real time**PERUGIA**
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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2941****GPS clock correction estimation for near real-time orbit determination applications*****Dr. Heike Bock****Astronomical Institute University of Bern****Yoke Yoon, Rolf Dach, Oliver Montenbruck***

Precise orbit determination for Low Earth Orbiting (LEO) satellites using GPS is usually done in a post-processing mode. However, the need for an availability of precise orbit information within hours or even minutes after the availability of the data is getting more and more important for LEO satellite missions. The accuracy requirements for such a near real-time orbit are depending on the mission applications being, e.g., generation of atmospheric sounding profiles (10 cm, 3-dimensional) or altimeter measurements for ocean monitoring (10 cm, radial). A study has been performed by AIUB and DLR to assess the achievable orbit accuracy using different types of near real-time GPS orbit and clock products. Besides using publicly and commercially ephemeris products, an effort has been made to generate near real-time clock solutions from the IGS high-rate data network based on IGS ultra-rapid-predicted orbit solutions. This approach ultimately enables an orbit determination accuracy of 10 cm and is thus compatible with stringent near real-time accuracy requirements for LEO satellites. A summary of currently available near real-time GPS orbit and clock products and a description of the generation of near real-time GPS clock corrections are given in details in this paper. In a first step, the clock corrections are validated with a kinematic (PPP) precise point positioning for static ground stations. Moreover, the use of the GPS clock corrections is being demonstrated for GRACE GPS data through a near real-time simulation using two software packages (DLR's GHOST and AIUB's Bernese GPS Software). The resulting orbits are compared with each other as well as validated with SLR measurements. The results from the near real-time simulation show promising aspect of such a concept to achieve unprecedented LEO orbit accuracy in near real-time.

Keywords: gps clock corrections, near real time, low earth orbiting satellites



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2942****Results obtained applying ionosphere maps for differential and precise point positioning in the South American region*****Mrs. Sonia Costa****Geodesy Instituto Brasileiro de Geografia e Estatística****Mauricio Alfredo Gende, Claudio Antonio Brunini, Alberto Luis Da Silva, Newton Jos De Moura Jnior***

This paper presents two strategies for improving GPS coordinates solutions using regional ionospheric maps in South America, a region that presents a strong ionospheric activity. Since 2005, La Plata Ionospheric Model (LPIM) is used to routinely generate Vertical Total Electron Content (VTEC) maps by CPLAT (La Plata Processing Center) using about 50 GPS stations in South America. VTEC is modeled in modip latitude using a lineal combination of GPS undifferenced carrier phase observables. A particular approach is used to solve the hardware-related biases. Since 2003, the Instituto Brasileiro de Geografia e Estatística (IBGE) collaborates to maintain SIRGAS Reference Frame in South America, delivering weekly coordinates solutions using the same set of permanent stations that the CPLAT uses for computing ionospheric maps. This work examines two possible benefits of VTEC maps in GPS processing namely, to solve ambiguities in differential solution and to mitigate ionospheric bias in single frequency undifferential solution. For differential processing, ionospheric maps are applied in the ambiguity resolution step when using Bernese GPS software. For undifferential processing, ionospheric maps are used to mitigate ionospheric errors when using GPS Precise Point Positioning (PPP) software, developed by the Geodetic Survey Division (GSD), Natural Resources Canada (NrCan). In order to validate our proposal a network of GPS stations near the anomaly ionospheric region in four different periods of 2006 were tested with and without VTEC regional ionosphere maps.

Keywords: gps processing, ionosphere maps, regional network

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2943****Geodetic Remote Sensing: Past and Future Work of the IAG SC 4.4*****Prof. Xiaoli Ding****Land Surveying and Geo-Informatics The Hong Kong Polytechnic University IAG****Xiaoli Ding, Linlin Ge, Makoto Omura***

Geodetic remote sensing technologies, especially the Interferometric Synthetic Aperture Radar (InSAR), have become increasingly important for geodetic science and applications. The main objectives of this Sub-Commission are to promote collaborative research in the development of such technologies, and to facilitate communications and exchange of data, information and research results through coordinated efforts. Four WGs have been set up within the Sub-Commission: n Permanent Scatterer / Corner Reflector / Transponder InSAR (Chair: Prof. F. Rocca) n Atmospheric Effects on Satellite and Airborne Imaging Systems (Chair: Dr. L. Ge) n Imaging Systems for Ground Subsidence Monitoring (Chair: Prof. A. Manu); and n InSAR for Polar Regions (Chair: Prof. M. Omura) Substantial progress has been made by the WGs in each of the research areas. The Sub-Commission has also sponsored a number of conferences/workshops in these areas. This paper summarizes the activities of the Sub-Commission over the past four years and discusses possible future work of the Sub-Commission.

Keywords: insar

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Poster presentation

2944

Water vapour estimations under heavy storm conditions in Hungary

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Ferenc Dombai, Dvid Ablonczy

On August 20, 2006 a heavy storm hit Budapest, with wind speed of more than 120 km/h. The weather front entered Hungary at 16.00 UTC and reached Budapest at 19.00 UTC. In the weather front a super cell was also formed slightly south from Budapest. The data of the continuously operating GPS network of Hungary is used to estimate integrated water vapour values during the study period. Since the evolution of the storm is well documented, meteorological observations are also used to validate the IWV values derived from the GPS observations.

Keywords: iwv, meteorology

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2945****An Optimality Property of GNSS Integer Ambiguity Bootstrapping****Prof. Peter J.G. Teunissen***DEOS, Delft University of Technology Professor IAG*

The integer least-squares (ILS) estimator is known to be an optimal ambiguity estimator in terms of its probability of correct integer estimation (success rate). Within the class of integer estimators, the ILS estimator has the largest success rate (Teunissen, 1999). Since the computation of the ILS solution requires a rather complicated integer search, a popular alternative for resolving the Global Navigation Satellite System (GNSS) carrier phase ambiguities is based on sequential integer rounding. This class of methods, of which integer bootstrapping is a member, does not require an integer search and they are very easily implemented. They are, however, known to be suboptimal since they do not take the full precision information of the float ambiguities into account. In this contribution it will be shown that if one opts for sequential integer rounding, then integer bootstrapping is the preferred integer estimator. It will be shown to have the largest success rate of all sequential integer estimators. With this result we are also able to rank the various GNSS sequential integer estimators with respect to their success rate performance. Teunissen, P.J.G. (1999): An optimality property of the integer least-squares estimator. *Journal of geodesy*, 73: 587-593

Keywords: ambiguity resolution, integer bootstrapping, success rate

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Poster presentation

2946

Post-processing of GPS data with one minute of observations using virtual reference stations

Mr. Mauricio Sejas

Department of Geomatic Federal University of Parana (UFPR) - Brazil IAG

Claudia Pereira Krueger

Many countries are using networks formed by permanent GNSS reference stations to provide users with a fast and precise positioning system. Employing the information from several GPS reference stations, it is possible to reduce and to model some errors, e.g.: ionosphere, troposphere, orbit and multipath. Nowadays there are two distinct concepts for differential positioning available that apply corrections from reference stations: the ACP concept (Area Corrections Parameters) and the VRS concept (Virtual Reference Station). Field measurements were made in Baden-Wrttemberg state, Germany, to study the quality of positioning system using VRS in post-processing mode. In this paper some results of base lines processed between the reference stations and the rover stations are described, applying the VRS concept to process base lines with 1 minute observations. The analysis of the results indicates that the achieved precision depends on the length of the baseline among other factors.

Keywords: gps, vrs, fkp

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2947****Total mapping function****Mr. Etienne Orliac***IESSG University of Nottingham****Norman Teferle, Alan Dodson, Richard Bingley***

The use of a total mapping function (TMF) in place of a usual pair of hydrostatic and wet mapping functions (HMF & WMF respectively hereafter) is investigated. Azimuthal symmetry is assumed. In terms of data modelling, it is effectively the same as applying the TMF twice to the a priori zenith hydrostatic delay and to the estimated 'wet' zenith delay. The TMF used is derived using ray tracing from a high resolution numerical weather model that covers the . The impact of using a TMF is assessed by comparing time series processed in the usual way, with a pair of HMF and WMF derived exactly the same way as the TMF. The impact of the a priori zenith hydrostatic delay can also be evaluated by using either a standard model or the ray traced one. In the case of linear modelling of the tropospheric delay variation over time, as is the case in the Bernese GPS software 5.0, the use of a TMF effectively removes the necessity for any a priori knowledge of the zenith hydrostatic delay and thus, avoids relying on a model to provide surface pressure at the site. Using three years of data, initial results show that, after applying atmospheric pressure loading corrections to daily estimates of the coordinates using precise point positioning, the vertical component WRMS repeatability can be reduced by up to 25 % for coastal sites compared to a usual processing using the Niell mapping functions. No results are yet available for inland sites but will be presented.

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Poster presentation

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PPP vs Double-Difference positioning: first results of the GINS CNES/GRGS software.

Dr. Felix Perosanz
Space Geodesy CNES IAG

Stavros Melachroinos, Sofiane Rekhis, Sylvain Loyer, Richard Biancale

CNES/GRGS has implemented the capability to process GPS data in the PPP mode in its GINS software which was already capable to estimate classical Double-Difference (DD) solutions. In addition, GPS satellite constellation clock products can now be generated at the ground station sampling (i.e. 30 seconds). The PPP and DD strategies are compared through two network adjustment results : Seasonal vertical displacements from daily solutions of GPS stations affected by strong hydrological signature. The sources of discrepancies between the different sets of solutions are discussed.

Keywords: ppp, loading



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2949****Uncertainty assessment in Kalman filter techniques with respect to non-stochastic measurement errors****Mr. Ingo Neumann***Geodetic Institute Leibniz University of Hannover IAG*

Positioning and navigation play a key role in geodetic applications. Therefore different techniques were developed to estimate positions, velocities and accelerations and their uncertainty budget in two or three dimensional geodetic networks. We focus on one of the most famous algorithms, the so called Kalman filter which combines given physical information for a linear system and external observations of its state in an optimal way. Conventionally, the uncertainty is assessed in a stochastic framework: measurement and system errors are modelled using random variables and probability distributions. However, the quantification of the uncertainty budget of empirical measurements is often too optimistic due to, e.g., the ignorance of non-stochastic errors in the analysis process. Here, the Kalman filter is extended with respect to non-stochastic data (imprecision) which is caused by hidden systematic errors. For the modelling of imprecision it is important that the original measurement results are typically preprocessed before they are introduced in the measurement equation of the Kalman filter. These preprocessing steps comprise several factors influencing the observations, like model constants, sensor parameters and additional measurements (temperature, pressure, etc.). The non-stochastic uncertainty (imprecision) of the reduced measurements is meaningful to many reasons, e.g. due to neglected correction and reduction steps and non describable effects in data preprocessing. Furthermore the influence factors for data preprocessing are only partially representative for the given situation (e.g., the model constants for the refraction index for distance measurements), they are uncertain realisations of random variables. The presented approach provides a general tool for handling and assessing of these non-stochastic errors in Kalman filtering and is directly transferable to adaptive filter techniques with applications in positioning, navigation and deformation analysis. The paper presents both the theoretical formulation and a numerical example.

Keywords: kalman filter, uncertainty, systematic

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2950****Combination of GPS and Levelling Data in terms of 1D, 2D and 3D Deformation Analysis****Mr. Serdar Erol***Geodesy and Photogrammetry Istanbul Technical University IAG***Tevfik Ayan**

GPS technique has benefits of high accuracy and simultaneous 3D positioning; however there are still problems in vertical positioning using this technique. In GPS, the variance of height is normally the highest component of the 3D solution due to receiver-satellite geometry and residual path-delay problems. This is important due to the reliance on estimated variance in the analysis of global and local deformation using Fisher difference testing. This paper discusses the augmentation of Carrier-Phase Differential GPS (CP-DGPS) with terrestrial levelling to assess the accuracy improvements possible in vertical, planimetric and 3D components when applied to deformation monitoring of a viaduct. The observations from two different techniques are combined using Variance Component Estimation (VCE) methods. In the method of Least Squares (LS), knowledge of the weights of the observations is an essential prerequisite in order to estimate correctly the unknown parameters. The purpose of variance component estimation is to find realistic and reliable variance components of the measurements to construct correctly the a priori covariance matrix of them. Improper stochastic modeling can lead to systematic deviations in the results, particularly significant in deformation control networks. In this case, Minimum Norm Quadratic Unbiased Estimation (MINQUE) technique was used to find the most appropriate individual weights for each observation group iteratively. This paper reports initial results of the combination of levelling data with CP-DGPS, and underlines the necessity of levelling data and VCE techniques in deformation analysis using CP-DGPS to get more reliable results in terms of vertical, planimetric and three-dimensional.

Keywords: gps levelling, minque, deformation analysis



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2951****Monitoring hydrologically induced deformations in Gothenburg with GPS*****Dr. Rudiger Haas****Department of Radio and Space Science Chalmers University of Technology IAG****Natthachet Tangdamrongsub, Hans-Georg Scherneck, Jan Johansson***

The city of Gothenburg is located at the Swedish west coast, a region of moderate to high risk for landslides. As late as in December 2006 a landslide destroyed about 500 m of the European motorway E6 at Munkedal, about 100 km north of Gothenburg. The city is build partly on bedrock and partly on sediment layers. In particular the city center is build on clay with high porosity that reacts to changes ground water level. In the last couple of years a number of GPS-antennas have been established on buildings in the city center, but also in the city surrounding. We analyzed data from these roof-top stations together with data of permanent GPS-stations of the Swedish reference network SWEPOS in the larger Gothenburg region. The derived station positions show periodic motions in the horizontal direction on a centimeter level. These motions have an annual period that can be related to corresponding variations in ground water level and river level. The results demonstrate that GPS can be used to monitor hydrologically induced deformations. These results could be used in forward modelling for hazard mitigation in urban areas.

Keywords: gps, deformation, groundwater

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Poster presentation

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Working Group on Numerical Prediction Model for Positioning: report on activities

Dr. Marcelo Santos

Geodesy and Geomatics Engineering University of New Brunswick IAG

Anna Jensen

The International Association of Geodesy Working Group 4.3.3 on Numerical Prediction Model for Positioning was established under the umbrella of Commission 4, Sub-Commission 4.3 GNSS Measurement of the Atmosphere and Sub-Commission 4.4 Next-Generation RTK. Its objectives are to study various technical aspects of using Numerical Weather Prediction (NWP) model data to map the effect of troposphere on space geodetic signals. To concatenate the terminology used by both meteorological and geodetic communities. To test and sediment procedures related to ray-tracing through NWP data layers. To suggest quality control criteria to be used for assessing the quality of tropospheric data and results obtained from them. To evaluate state of the art and to report on the progress achieved so far and for the next two years on the use of NWP for positioning. Working Group 4.3.3 has been in operation since January 2006. This presentation will highlight the activities of the Working Group in a manner complementary to the report from each one of the Sub-Committees it is affiliated with, providing more detailed information on its milestones and results.

Keywords: troposphere, meteorology, weather models

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2953****Accuracy in zenith tropospheric delay from the Canadian regional numerical weather model****Mr. Felipe Nievinski***Geodesy and Geomatics Engineering University of New Brunswick IAG*

We analyze the accuracy of zenith tropospheric delays (ZTD) from analysis and forecast fields of the regional, high-resolution version, of the Canadian GEM numerical weather model (NWM), as compared to radiosonde and surface stations. From the analysis fields we show the accuracy available for GPS post-processing, whereas the forecast fields are relevant for real-time uses, in which case we show the accuracy degradation as the time offset from initialization increases. We give statistics (bias, standard deviation, root-mean-square error) and scatterplots of error in total, hydrostatic and non-hydrostatic (or wet) delay over the model range in latitude, longitude, height, and time offset from initialization. We also compare the performance of slightly different methods to extract ZTD from a NWM.

Keywords: nwp, ztd

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2954****Impact of Galileo measurements on zero- and double-difference processing of GPS data for a global IGS network****Mr. Markus Heinze***Institut für Astronom. und Physik. Geodäsie***Drazen Svehla**

We study the impact of GALILEO measurements on the performance of zero- and double-difference approaches in the estimation of the global IGS parameters such as GNSS orbits and clocks, Earth rotation parameters, station coordinates and troposphere zenith delays. Using simulated GPS and GALILEO data, we compare two double-difference solutions with fixed and float ambiguities as well as with a zero-difference solution and show how GALILEO differently improves the estimation of global IGS parameters in all three cases. These three approaches are compared with real GPS data by estimating all relevant global IGS parameters such as GNSS orbits and clocks, Earth's rotation parameters, station coordinates and troposphere zenith delays. Although zero- and double-difference approaches should be very similar, we show that adding GALILEO measurements affects the efficiency of these three approaches in a different way. Advantage of the double-difference approach is the possibility to fix ambiguities to their integer values and therefore considerably gain in the accuracy and efficiency. However, float solutions with increased number of measurements approach accuracy of double-difference solution with fixed ambiguities. Although GALILEO data improves estimation of all global IGS parameters, it is interesting that GALILEO improves the orbit determination of the GPS satellites, since parameters like station coordinates and troposphere zenith delays are common parameters for both GNSS systems.

Keywords: galileo, gps

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2955****A new technique for topographic surveys****Mr. Rodrigo Leandro***Trimble Geomatics and Engineering Group IAG***Tule Barcelos Maia**

Topographic surveys are in general realized using equipment capable of measuring angles and distances. Equipment which are capable of measuring high precision angles are usually more expensive than others. Based on this economical drawback, a new technique of surveying was developed. The technique makes the survey possible by measuring distances only, what makes it still simple, but less expensive than other common techniques. The equipment used in this novel technique is composed by an EDM installed in the center of a cube which has 8 prisms installed in each of its corners. During the survey it is necessary to work with at least two equipments, which have to be installed on the markers linking the alignment which has to be determined. The technique is based on the principles of trilateration. Once the distances between the EDMs and prisms are determined, and with known dimensions of the cube, the angles for a tridimensional solution can be obtained. Since the observations are redundant, the angles can be determined. The positioning errors are impacted by errors in the distance measurements and in the determination of the geometry of the cube. Since the observations should be redundant, the angles needed for position determination can be computed by means of an adjustment considering all sources of errors related to them. The determination of the coordinates is somehow complex, however this problem is easily solved with the automation of the computations. Angles which are associated with at least one EDM are always very precisely determined; however angles formed by prisms only usually have poor precision, due to the small dimension of the cubes. Adopting an EDM with precision of 2 mm plus 2 ppm, and a distance between prisms of around 20 cm, the precision of angles formed by prisms only is around 1 degree of arc. This problem is being mitigated with the undergo enhancement of the technique.

Keywords: surveying, positioning, trilateration

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2956****An assessment of Bernese GPS software precise point positioning for geodetic monitoring applications****Dr. Norman Teferle***Inst. of Eng. Surv. and Space Geodesy Univ. of Nottingham IAG****Etienne Orliac, Richard Bingley, Alan Dodson***

In recent years, precise point positioning (PPP) has become a popular technique for many geodetic monitoring applications at the millimeter level. To date, PPP has mainly been associated with the GIPSYOASISII software developed at the Jet Propulsion Laboratory (JPL). However, other scientific GPS software packages, such as the Bernese GPS software (BSW) version 5.0 developed at the Astronomical Institute at the University of Berne (AIUB), are also capable of analyzing un-differenced GPS measurements. In this study we assess the use of PPP within the BSW over the period from 2000.0 to 2005.0. In our strategy we compute a set of daily PPP solutions for International GNSS Service (IGS) reference frame (IGb00) sites by fixing IGS final satellite orbits and clock products, followed by a Helmert transformation of these solutions into ITRF2000, forming a set of continuous position time series over the entire time span. We assess BSW PPP by comparing our set of transformation parameters to those produced by the IGS Analysis Center Coordinator (ACC) and our position time series to those of the JPL and the Scripps Orbit and Permanent Array Center at the Scripps Institute of Oceanography (SIO). We find daily position differences with mean values at the few millimetre level with standard deviations of nearly 2 cm. Similarly, we find sub-millimetre mean velocity differences with standard deviations at several mm/yr. These results clearly highlight the capability of BSW PPP to give position estimates for individual stations on a global scale at the mm to cm accuracy level.

Keywords: precise point positioning, bernese gps software, geodetic monitoring



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GS004

Poster presentation

2957

Humidity convergence zones influence in the seasonal variability of the tropospheric zenithal delay in the South America.

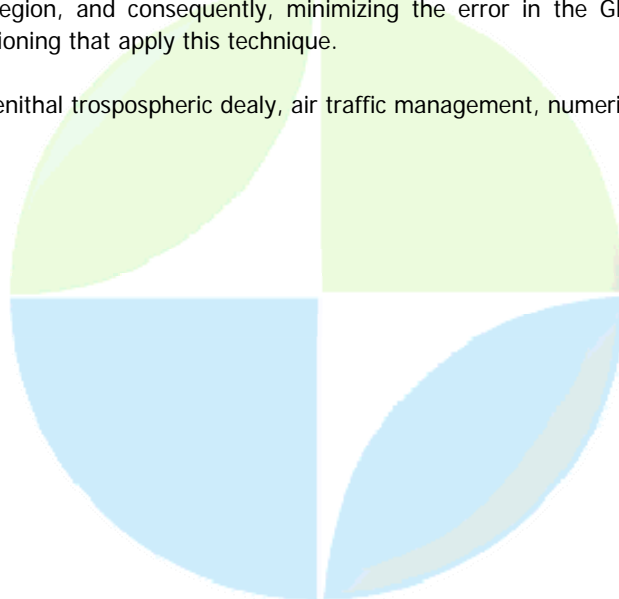
Dr. Luiz Fernando Sapucci

Diviso de Modelagem e desenvolvimento Instituto Nacional de Pesquisas Espaciais

Luiz Augusto Toledo Machado, Joo Francisco Galera Monico

The Zenithal Tropospheric Delay (ZTD) is an important error source in the observable involved in the positioning methods using artificial satellites. The humidity convergence zones are characterized by an extensive precipitation band and high nebulosity almost stationary. In South America there are two main convergence zones that has strong influence in the troposphere variability, the ITCZ (Inter Tropical Convergence Zone) and the SACZ (South Atlantic Convergence Zone) zones. While the first is located near the equator, over the Amazonian Region, the second occurs between -18 and -25 of latitude over Brazilian littoral. The physical processes associated with these convergence zones associated with the penetration the cold front from Antarctic pole into the continent present strong impacts in the seasonal variability of wet component (ZWD) of ZTD. In 2010 a new navigation and administration system of the air traffic, denominated CNS-ATM (Communication Navigation Surveillance - Air Traffic Management) should be running operationally in South America. This new system will basically employ the positioning techniques by satellites to the management and air traffic control. However, the efficiency of this new system demands the knowledge of the behavior of the atmosphere, more specifically the characteristic of main factors that influence the oscillation of ZTD components in regional scale. The predictions of ZTD values from Numeric Weather Prediction (NWP), denominated here dynamic modeling, permit assess the temporal and spatial variation of ZTD values. Brazilian Center for Weather Forecasting and Climate Studies (CPTEC) of the National Institute for Space Research (INPE), jointly with researchers from UNESP (So Paulo State University), has generated operationally prediction of ZTD values to South America Continent (available in the electronic address <http://satelite.cptec.inpe.br/htmldocs/ztd/zenithal.htm>). The available regional version is obtained using ETA model (NWP model with horizontal resolution of 20 km and 42 levels in the vertical). The aim of the present paper is to investigate the ZTD seasonal variability over South America continent using NWP and the humidity convergence zones influence in the ZWD values. This work contributes with ZTD modeling over South America continent using NWP identifying where and when the ZTD values present lower predictability in this region, and consequently, minimizing the error in the GNSS (Global Navigation Satellite System) positioning that apply this technique.

Keywords: zenithal tropospheric delay, air traffic management, numerical weather model



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2958****L2C signal assessment using IGS L2C network****Mrs. Liliana Sukeova**
GGE UNB**Richard B. Langley, Rodrigo F. Leandro, Okwuchi Nnani**

A new generation of Global Positioning System (GPS) satellites, called Block IIR-M, has been launched since December of 2005. These satellites are part of the modernization effort that the GPS is undergoing. The signals transmitted by these satellites contain a new civilian (C/A) code superimposed on the L2 carrier. This new, modernized observable has been referred to as the L2C, meaning, C/A code on L2 carrier. The first satellite to carry the L2C signal was PRN 17. Recently, two additional satellites have been launched with the capability to transmit the new L2C signal, satellites PRN 31 and PRN 12. Research into the characteristics of the actual L2C signal is based on an International GNSS Service (IGS) L2C dedicated network. This network is composed of both existing stations as well as newly established ones with receivers capable of tracking the L2C signal. L2C-capable receivers have been manufactured by several vendors, such as Trimble, NovAtel, Septentrio and Leica. The IGS L2C network is composed only of Trimble receivers. The University of New Brunswick (UNB), Fredericton Campus, Department of Geodesy and Geomatics Engineering (GGE), obtained a Trimble R7 receiver on loan from CANSEL, a Canadian distributor of Trimble products. The R7 receiver is a L2C-capable receiver. This receiver was collocated with IGS station UNB1 (now station UNBJ), sharing the same antenna, has become a part of the L2C signal tracking network. Recently, we have replaced the R7 receiver by another L2C-capable Trimble receiver, the NetR5. This paper presents results of our analysis on the L2C data was collected by the IGS network. Our analysis starts with an examination of the signal-to-noise ratio (SNR) on the L1 and L2 frequencies. The range of the SRN values on the L1 frequency is similar for all satellites, whilst the range of the SRN on the L2 frequency for PRN 17 is higher than those for all other satellites. This indicates an improvement in the SNR of the L2C signal over the P(Y) code. It follows with a study on the multipath and noise levels of C/A and L2C code pseudorange for PRN 17. These values were calculated and compared. A typical standard deviation of the C/A and L2C code noise and multipath is 0.27 m and 0.61 m, respectively. This fact contradicts the expectation of having similar noise and multipath levels for both L2C and C/A code. However this can be explained by issues in the firmware versions 2.26 and 2.28, which were used in the Trimble R7 receiver during the observation period. Those issues have been fixed in the new firmware release, version 2.30. We will compare this fact with results from other receiver manufacturers. To further research into the intricacies of the L2C code in the absence of a full L2C satellite constellation we used the Spirent hardware simulator which was purchased by UNB. The Spirent simulator is capable of simulating the L2C signal transmitted by a full constellation of satellites. The simulation allows an investigation on the effects of signal noise and multipath level on the new signal. Also, comparisons can be drawn about the precision and signal acquisition time at low elevation angles of the L2C signal as compared to existing signals. Analysis of the aforementioned experiments and simulated results are underway and will be included in the paper. We hope the results will ultimately lead to a greater understanding of the characteristics of the new L2C signal among the GPS community.

Keywords: l2c signal, modernized gnss, noise level

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2959****An adaptive knowledge-based system for indoor navigation*****Dr. Dorota Grejner-Brzezinska****Civil and Environmental Eng. and Geodetic Science The Ohio State Universtiy IAG****Charles Toth, Shahram Moafipoor, Jay Kwon***

The recent technological developments in positioning and tracking sensors, offer a potential to develop small and portable systems for in situ orientation and decision support for ground personnel. The basis for pedestrian navigation is multi-sensor integration (that may include the vision component), where GPS/IMU (inertial measurement unit) facilitates the basic navigation capabilities, recently combined with human locomotion modeling. The integration of these two techniques forms an intelligent navigation system, where the intelligent navigation represents the transition from the conventional GPS/IMU systems to multi-sensor systems that increasingly rely on knowledge-based methodology, including artificial neural networks (ANN), Fuzzy Logic, etc. It should be emphasized that the need for indoor/GPS denied environment navigation is growing (emergency response, personnel tracking, etc.), so ensuring a smooth transition from the open sky environment to a confined environment (such as buildings and underground structures) is a challenging area of algorithmic and technological research. In this evolution, a variety of new sensors, such as MEMS IMU (micro-electromechanical systems), electronic compasses, barometers, motion sensors, RF signals of opportunity, GIS/CAD map data, etc., as well new algorithmic approaches for integrated navigation are introduced. In order to support intelligent navigation, knowledge-based systems are necessary to handle the complexity of the wide range of data entities and their characteristics, as well as their rapidly changing availability in varying environments, which requires on-the-fly adaptive mechanisms. Since the conventional Extended Kalman Filter (EKF) model cannot effectively address these conditions, the knowledge-based systems are introduced that can work in a variety of ways, such as individual agents that monitor the input signal conditions and control EKF with the adaptive error models. This can be implemented, for example, using Fuzzy Logic, which de facto leads to what is now called Fuzzy Kalman filter, combined with ANN algorithms used to calibrate and predict (during GPS outages) certain components of the overall dynamic and parametric model. This paper presents the theoretical framework, architecture design, prototype implementation and the performance analysis of a personal navigator based on multi-sensor integration, augmented by human locomotion model, implemented as Fuzzy EKF combined with ANN. The emphasis is on the algorithmic implementation of the knowledge-based system and its training and performance using the actual test data collected by several operators (as human dynamics model varies from operator to operator). The system is trained during the GPS signal reception using ANN with 0input parameters defining human dynamics model, and is subsequently used to support navigation in dead reckoning mode when GPS signals are blocked. The calibrated, operator-dependant human dynamics model combined with heading information from compass/IMU offer dead reckoning navigation during GPS gaps.

Keywords: intelligent navigation, knowledge based system, integration algorithms

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2960****GPS Tropospheric delay estimation from different softwares - results and analyses****Prof. Joo F Galera Monico**
*Cartography UNESP IAG***Daniele Barroca Marra Alves, Guilherme Poleszuck Santos Rosa, Luiz Fernando Antonio Dalbello**

Scientific softwares are considered the most reliable to process GNSS observations. One of the most important characteristics of this kind of software is the ability to provide important information concerning the processing stage. This paper presents a comparative analysis obtained by two scientific softwares well known by the scientific community: Bernese 5.0 (relative mode) and GIPSY-OASIS II (absolute mode- PPP). Some researchers have been using the GIPSY software, as well as Bernese, to estimate the daily tropospheric delay. Using these softwares it is possible to compute high accurate tropospheric delays due to the water vapor existing in the atmosphere. This estimation may improve the Numerical Weather Prediction (NWP) models, which benefit from the assimilation data quality. It is important to emphasize that to determine the tropospheric delay with GPS observations, the other errors involved in GPS positioning must be eliminated/reduced or modelled. In fact, this may not be a problem for scientific softwares like GIPSY and Bernese. In order to verify the compatibility of these two softwares, data from the Brazilian Continuous GPS Network (RBMC - <http://www.ibge.gov.br/home/geociencias/geodesia/>) and GPS Active Network of West of São Paulo State (<http://gege.prudente.unesp.br/english/index.php?p=50>) were processed using these two systems. The main focus of this presentation is related with the tropospheric delays. The preliminary obtained discrepancies were on average 4 mm with a standard deviation of 18 mm. The significance of these and other results that will be obtained will be discussed in this paper.

Keywords: ztd precision, gps, gps scientific software

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2961****Next-generation algorithms for navigation, geodesy and earth sciences under modernized Global Navigation Satellite Systems (GNSS)*****Dr. Marcelo Santos****Geodesy and Geomatics Engineering University of New Brunswick IAG****Richard Langley, Spiros Pagiatakis, Sunil Bisnath, Rock Santerre, Marc Cocard, Ahmed El-Rabbany, Ren Landry, Herb Dragert, Pierre Hroux, John Paul Collins***

The project on Next-generation algorithms for navigation, geodesy and earth sciences under modernized Global Navigation Satellite Systems (GNSS) has been under development in the scope of the GEOIDE Network. The GEOIDE Network is part of the Networks of Centres of Excellence program (NCE). Networks of Centres of Excellence are unique partnerships among universities, industries, government and non-profit organizations aimed at turning Canadian research and entrepreneurial talent into economic and social benefits for all Canadians. Among its objectives, the GEOIDE Network intends to drive the research and development of new Geomatics technologies and methods via multidisciplinary collaboration in a fully networked environment; The GEOIDE Network is currently in its Phase III. In this presentation we will display an overview of the research which have been taken place under this project. They involve: (a) Processing and analysis of real modernized GNSS data (L2C) as well as simulated data; (b) Performing constellation, system performance and augmentation analyses of the modernized GNSS; (c) Designing algorithms for single-point and relative positioning using combined signals; and, (d) Integrating legacy and modernized GPS observations and GPS and Galileo observation.

Keywords: gps, galileo, algorithms**PERUGIA**
I T A L Y

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2962****A new GPS data analysis and positioning tool****Mr. Rodrigo Leandro***Trimble Geomatics and Engineering Group IAG***Richard B. Langley**

Precise Point Positioning (PPP) is one of the existing techniques to determine point coordinates using a GPS (Global Positioning System) receiver. In this technique observations realized by a single receiver are used in order to determine the three coordinate components, as well as other parameters, such as the receiver clock error and total neutral atmosphere delay. The technique is said to be "precise" because precise information, such as satellite orbits and clock errors, is used in the data processing. The idea behind our present work is that PPP can be used not only for positioning, but for a variety of tasks, such as signal analysis. The fact that the observation model used in this technique has to take into consideration the several effects present in GPS signals, and that observations are undifferenced (there are no differences between receivers or between satellites), makes PPP a powerful data analysis tool which is sensible to variety of parameters. The PPP application developed at UNB (University of New Brunswick), which is called GAPS (GPS Analysis and Positioning Software), was modified and enhanced in order to be used as a tool for determining other parameters than position, receiver clock error and neutral atmosphere delay. These estimated parameters include ionospheric delays, code biases, satellites clock errors, and code multipath among others. In all cases the procedures were developed in order to be suitable for real-time applications. GAPS is also an application available online via a web interface, which can be easily run from anywhere, producing all data analysis results discussed in this paper. In this paper GAPS is presented as a data analysis and positioning tool, all procedures used in it are described, and results obtained using it are analyzed.

Keywords: gaps, data analysis, positioning

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2963****Ionospheric modelling in the North of Algeria****Prof. Salem Kahlouche***Geodetic Division National Centre of Space Techniques IAG***Kadri C., Dekkiche H., Mir R.**

The precise positioning, in the north of Algeria, necessitates a very good knowledge of the variation of the ionospheric behaviour. The precise Algeonet (Algerian Geodynamical Network) is used as a tool, with the support of a hundred IGS stations distributed around the area of study, to establish an ionospheric mapping of the Total Electronic Content (TEC). The model used is based on the theory which considers that the electronic density has an orthogonal variation determined by empirical orthogonal functions based on spherical harmonics provided by the IRI (International Reference Ionosphere). The data processed using the Bernese software concerns six Algeonet stations distributed in the North of Algeria, and observed during a non permanent GPS campaign, and the results are obtained for several heights (350 Km, 400 Km, 450 Km) with an hourly determination. The maximal value of the TEC obtained in the north Algerian area is about 10 (midnight) to 60 (midday) TECU. The comparison between the different combinations shows that the ionospheric effects provide a network contraction; and the deformation is correlated with the range between the fixed reference station to the other GPS points of the network. The use of the ionospheric corrections deduced from the ionospheric map will allow us to reduce the deviation, with regard to the L3 solution, up to 10 cm (in planimetry) and 50 cm for the ellipsoidal heights.

Keywords: ionosphere, gps, algeonet**PERUGIA**
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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2964****Establishing corner reflector networks for PSINSAR analysis****Mr. Jon Leighton***Institute of Engineering Surveying and Space Geode Student***A. Sowter, R.M. Bingley, F.N. Teferle**

A remote sensing technique called Persistent Scatterer Interferometric SAR (PSInSAR) has produced measurements of land deformation to millimetric precision. However, it is usually difficult to tie-in such measurements to traditional ground surveying methods, such as GPS or levelling from the remote sensing data alone. If trihedral corner reflectors are used, these can be precisely surveyed. The optimisation of reflector networks will depend on a number of factors such as the relationship between the GPS antenna and reflector, the relative geometry of the reflector network, establishing reflector alignment in azimuth and elevation, site selection, site stability and how the reflectors are secured at the site. This paper discusses the various issues from a surveying perspective encountered during the planning and establishment of a real network around the Nottinghamshire area, optimised for ENVISAT acquisitions. Radar observations before and after reflector installation are compared.

Keywords: psinsar, reflector, envisat

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GS004

Poster presentation

2965

Correlation between codes for PPP

Mrs. Salua Daghay

Fundamental Electricity and Instrumentation Vrije Universiteit Brussel

In order to get optimal results, any observations variance-covariance matrix should reflect the noise characteristics of the GPS data being processed. So we need a more sophisticated stochastic model. Most observable noise seems more or less normally distributed. But concerning satellite elevation angle dependence and cross correlation between observation types, we should develop a new stochastic model. We will research this for precise point positioning technique. We have 2 reasons for this: 1) in case of single positioning, the observable errors propagate directly into the result 2) we don't need to priorly know the coordinates of a base station and need only one receiver

Keywords: precise point positioning, correlation between codes, covariance matrix

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS004****Poster presentation****2966****The Sigma-C model: a proposal for modelling physical correlations between GPS phase observations****Prof. Steffen Schön***Leibniz Universität Hannover Institut für Erdmessung (IfE) IAG***Fritz K. Brunner**

The dynamic processes in the atmosphere induce correlated wave propagation effects on GPS signals. These correlations are usually not modelled in the variance-covariance-matrix of the GPS observations. Hence, the estimated parameters can be biased and their associated variance-covariance-matrix is too optimistic. Based on turbulence theory, we have previously proposed a new variance-covariance-model for the description of the physical correlations induced by refractivity fluctuation in the troposphere. This model is now combined with the SIGMA-É model (Hartinger and Brunner, 1999) to obtain a variance-covariance model for GPS phase observations: the SIGMA-C model. In this paper, in a first part we will explain the physical and mathematical properties of the SIGMA-C model. Special emphasis will be drawn on the transformation between spatial and temporal separation of observations using Taylor's hypothesis of frozen turbulence. In a second part, using the double-differenced phase data from a specially designed test network with station separations between 1 km and 16 km, we compare the empirical auto-correlation functions with those predicted by the model. We will show that the geostrophic wind direction and velocity, which can be easily computed from isobaric maps, are appropriate to explain the correlation processes reflected in the empirical auto-correlation functions of the double-differenced phase data time series. Consequently, SIGMA-C model contributes to adequately consider the resulting physical correlations between GPS observations in the GPS data analysis.

Keywords: gnss, stochastic model, turbulence theory

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS005****2967 - 2993****Symposium****The Global Geodetic Observation System (GGOS)****Convener** : Prof. Markus Rothacher**Co-Convener** : Prof. Hans-Peter Plag, Mrs. Ruth Neilan

The helplessness felt in the wake of recent natural disasters (the tsunami in the Indian Ocean, flooding in New Orleans, etc.) has made it abundantly clear that our understanding of the complex Earth system and our tools for the timely detection of potentially disastrous events are rather limited. Therefore, gaining deeper insights into the processes and interactions of this system is one of the most urgent challenges facing society. Earth observation is fundamental for advancing our understanding, and a global Earth monitoring system is high on the agenda of a large number of countries. The Global Geodetic Observing System (GGOS) has been set up by the International Association of Geodesy (IAG) as the geodetic contribution to such a global Earth monitoring system providing, in particular, the metrological and reference system basis for all Earth observing systems. GGOS represents an umbrella for the products derived by the IAG Services using the space geodetic techniques (VLBI, SLR/LLR, GNSS, DORIS), altimetry, InSAR, gravity missions, and in-situ measurements etc. allowing for the monitoring of the Earth system with an unprecedented accuracy of less than one part in one billion. This session will focus on all major issues concerning GGOS: contributions are very welcome dealing with the design of a future GGOS (networks, communications, data portals, innovative observation technologies and analysis methods, new satellite missions, early warning systems,), the combination of different space- and ground-based geodetic observation techniques including common modeling and parameterization standards for all techniques, the integration of models for Earths deformation, variations in Earths rotation and temporal changes in the gravity field, the study of mass transport phenomena in the Earth system and their observation and modeling, and the progress being made by the IAG services towards GGOS.

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS005****Oral Presentation****2967****GPS Constraints on Continental Deformation in the Africa-Arabia-Eurasia Continental Collision Zone and Implications for the Dynamics of Plate Interactions*****Dr. Salah Mahmoud****Department of Geodynamics Prof, President NRIAG IAG****Robert Reilinger, Simon McClusky, Philip Vernant***

We Present a GPS-derived velocity field (1988-2005) for the zone of interaction of the Arabian, African (Nubian and Somalian) and Eurasian plates. The Velocity field indicates counterclockwise motion of a broad area of the Earth's surface that includes the Arabian plate, adjacent parts of the Zagros and Central Iran, Turkey and the Aegean at rates in the range of 20-30 mm/yr. This relatively rapid motion occurs within the framework of the slow-moving (<5 mm/yr relative motions) Eurasian, Nubian and Somalian plates. The circulatory pattern of motion increases in rate towards the Hellenic trench system, suggesting that subduction in the eastern Mediterranean is the dominant process responsible for regional deformation. Using seismic and other geophysical and geological information, we develop an elastic block model and use the GPS velocity field to estimate relative block motions. This model provides a reasonable fit to the observed motions with the principal block boundaries corresponding to known seismically active faults (e.g. Sinai and Marmara regions). The GPS observations for Sinai imply that the Sinai Peninsula and Levant region comprise a separate sub-plate sandwiched between the Arabian and Nubian plates.

Keywords: gps, deformationPERUGIA
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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS005****Oral Presentation****2968****Atmosphere angular momentum time series in the frame of GGOS****Dr. Johannes Boehm***Institute of Geodesy and Geophysics Vienna University of Technology IAG****Paulo Jorge Mendes Cerveira, Sigrid English, Robert Weber, Harald Schuh***

The atmosphere plays a key role for the Global Geodetic Observing System (GGOS): it delays signals from satellites and radio sources, deforms the Earth surface, changes the gravity field of the Earth, and excites Earth rotation. The determination of each of these quantities rests on a multitude of aspects and assumptions concerning, e.g., numerical weather models (NWM), geophysical hypotheses and models. We investigate the application of different classes of NWM data (from the European Centre for Medium-Range Weather Forecasts) and different geophysical models for the determination of atmospheric angular momentum (AAM) time series. In particular, we derive various sets of AAM time series for the CONT05 time span, a 15 days continuous Very Long Baseline Interferometry (VLBI) campaign in September 2005. These series are related and then compared to changes in polar motion and universal time, estimated from the VLBI observations. Additionally, we relate those effects shown for the AAM to the Earth's surface deformation and gravity field variations induced by the atmosphere.

Keywords: aam, cont05, vlbi

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS005****Oral Presentation****2969****Earth rotation parameters from combined VLBI, ring laser and gravity observations****Dr. Paulo Jorge Mendes Cerveira***Advanced Geodesy IGG, Vienna University of Technology IAG****Kluegel Thomas, Schreiber Ulrich, Velikoseltsev Alexander, Meurers Bruno, Schuh Harald***

One of the tasks of the Global Geodetic Observing System (GGOS) is dedicated to combine geodetic observables for retrieving technique independent parameters. In that perspective, Very Long Baseline Interferometry (VLBI) is exclusively sensitive to the complete rotation matrix from the terrestrial to the quasi-inertial frame, while ring lasers being sensitive to the instantaneous Earth rotation vector, i.e., to polar motion and length of day variations, in an Earth-fixed frame. Additionally, assuming a perfect knowledge of mass attraction variations, superconducting gravimeters (SG) permit to detect Earth rotation variations from the magnitude of the local gravity. The formula of the Sagnac frequency and gravity variation caused by the motion of the Earth's body w.r.t. the instantaneous Earth rotation vector will be presented and compared to VLBI parameterization. The potential of a combination at the observation level of the three independent types of observables will be examined for sub-diurnal polar motion and universal time variations.

Keywords: vlbi, ring lasers, superconducting gravimeter

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS005****Oral Presentation****2970****Simulations for VLBI2010 at the IGG Vienna****Mr. Joerg Wresnik***Institute of Geodesy and Geophysics Vienna University of Technology IAG***Johannes Bhm, Harald Schuh**

In October 2003 the International VLBI Service for Geodesy and Astrometry (IVS) installed Working Group 3 (WG3) VLBI 2010 to examine current and future requirements for geodetic VLBI systems. The question how VLBI could exploit its present resources more efficiently and how future VLBI networks could look like should be investigated. At the IGG, Vienna different kind of simulations are carried out to evaluate new observing strategies and schedules, to improve modeling of the troposphere and the clocks, to find the best antenna configuration and to optimize the network geometry. To allow reasonable geophysical conclusions out of the VLBI analysis, the designed networks contain 2 stations on each main tectonic plate. Networks with up to 40 stations are tested. Main part of the simulation studies is a so called Monte Carlo simulator that creates the artificial observations which are entered in the OCCAM VLBI software package. The criteria to evaluate the potential of the VLBI-system are: baseline length repeatabilities, formal errors of Earth orientation parameters and the agreement between the simulated stochastic processes (troposphere, clocks) and their estimates. First simulations show that the most limiting factor of the VLBI system is the influence of the wet zenith delay. Therefore, turbulence models using wind speed and wind direction information from numerical weather models are used in the Monte Carlo Simulator to create realistically simulated wet zenith delays. One of the main goals of VLBI 2010 is to design a new VLBI system to obtain baseline length repeatabilities of smaller than 1mm for the longest baselines in the network.

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS005****Oral Presentation****2971****Design of next generation global geodetic networks to support GGOS****Prof. Erricos C. Pavlis***JCETUMBC and NASA Goddard Univ. of Maryland, Baltimore County IAG****J. C. Ries, D. S. Macmillan, M. Kuzmicz-Cieslak, C. Ma, D. D. Rowlands***

The Global Geodetic Observing System--GGOS places the utmost importance on the development, maintenance and wide distribution of an International Terrestrial Reference Frame (ITRF) with very stringent attributes. At present, our goal is an origin definition at 1 mm or better at epoch and a temporal stability on the order of 0.1 mm/y, with similar numbers for the scale and orientation components. The stability, integrity and applicability of the ITRF are directly related to how accurately we can account for mass redistribution during the analysis and reduction process of the data used for its development. Long wavelength variations of the gravity field driven by these mass redistributions produce geometric effects that are manifested as changes in the origin and orientation between the instantaneous and the mean reference frame. An uneven distribution of the stations that realize the ITRF on the globe generates biases and distortions in the combined product due to the dissimilarity of the combined networks and the de facto lopsided overlap of the combined networks. The poor geometry of the constituent networks results in increased correlations between the similarity transformation parameters, and they thus lead to biased and unstable results. Using simulations of geodetic data that we expect to collect with the future geodetic networks, we provide some preliminary investigations of the design of the complementary networks that will ensure the desired accuracy in the origin, scale and orientation definition of the ITRF.

Keywords: ggos, geo networks, technique combinations



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS005****Oral Presentation****2972****Consistency of Earth Rotation, Gravity, and Shape Measurements*****Dr. Richard Gross****Geodynamics and Space Geodesy Group Jet Propulsion Laboratory IAG*

The rearrangement of mass within the surficial fluid layers of the Earth, including the atmosphere, oceans, and water, snow and ice stored on land, causes the Earth's gravitational field to change, causes the Earth's rotation to change by changing the Earth's inertia tensor, and causes the Earth's shape to change by changing the load acting on the solid, but not rigid, Earth. Large-scale changes in the Earth's gravitational field have been measured for more than two decades by satellite tracking and more recently by the CHAMP and GRACE satellite missions. Changes in the Earth's rotation have also been measured for more than two decades by the space-geodetic techniques of satellite and lunar laser ranging (SLR and LLR), very long baseline interferometry (VLBI), and the global positioning system (GPS). Recently, it has been shown that GPS can be used to measure large-scale changes in the Earth's shape by precisely positioning the sites of a global network of ground-based GPS receivers. On time scales of months to a decade, loading of the solid Earth by surface fluids dominates non-secular variations in each of these three fundamental areas of geodesy (gravity, rotation, and shape). Since the rotation, gravitational field, and shape of the Earth all change in response to changes in the surface mass load, measurements of these quantities must be consistent with each other. Here, the consistency of these measurements on monthly to interannual time scales is checked.

Keywords: rotation, gravity, shape

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS005****Oral Presentation****2973****The Contribution of GGP Superconducting Gravimeters to GGOS*****Prof. David Crossley****Earth and Atmospheric Sciences Saint Louis University IAG****Jacques Hinderer***

The network of more than 24 superconducting gravimeters (SGs) of the Global Geodynamics Project (GGP) is available as a set of reference stations for studies related to time-varying gravimetry. The inherent stability of the SG allows it to detect signals from a sampling time of 1 s up to periods of several years with a time-domain accuracy of 0.1 microgal or better. SGs within the GGP network comprise a valuable set of stations for geodetic and geophysical studies that involve the surface gravity field. Experience has shown that SGs can be calibrated to an accuracy of 0.01 0.1%, and that most instruments have a low, but well-modelled, drift of a few microgal /yr. For most purposes except the determination of an absolute gravity reference level, the SG is the best observation-style instrument we have today. SG data is now freely available, much of it going back to the early 1990s, from the GGP database at ICET (International Centre of Earth Tides, in Brussels,) and GFZ (Potsdam,). Frequently it is combined with other datasets such as atmospheric pressure and hydrology for studies of ground deformation and tectonics. One of the most interesting new ideas within GGOS is the determination of the geocenter using a combination of satellite and ground-based gravimetry. The GGP network can provide a unique contribution through continuous data at the stations where absolute gravimeters (AGs) will be deployed. The combination of the two instruments is necessary to ensure that AG measurements are referencing the mean station gravity and not short-term gravity perturbations due for example to hydrology or meteorology. Another promising application is the use of SG sub-networks in Europe and Asia to validate time-varying satellite gravity observations (GRACE, GOCE).

Keywords: superconducting gravimeter, time varying gravity, ggos

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS005****Oral Presentation****2974****Collocated GPS and absolute gravity measurements help to tie the geometric reference frame to the center of mass of the EARTH SYSTEM****Prof. Hans-Peter Plag***Nevada Bureau of Mines and Geology University of Nevada, Reno IAG***Corne Kreemer, William C. Hammond**

It has long been suspected that the reference frame origin (RFO) of the International Terrestrial Reference Frame (ITRF) exhibits a secular trend with respect to the Center of Mass of the whole Earth system (CM). Such a secular trend would cause a global bias of vertical rates with a spherical harmonic degree of two. Estimates for ITRF2000 indicate that locally the uncertainty due to this bias is of the order of 2 mm/yr. This bias hampers the interpretation of vertical rates in terms of geodynamics processes, sea level changes and other applications. Extending the theory of Wahr et al. (1995), we have used a global network of absolute gravity measurements collocated with GPS stations to determine the linear secular trend of the RFO with respect to CM that would minimize the discrepancy between absolute gravity and GPS-observed secular vertical trends. The geographical distribution of the available stations only provides adequate constraints on the Z-component of this translation of the geometric frame. The inverted parameters are consistent with theory and the secular trend is of the same order and direction as the difference between ITRF2005 and ITRF2000, potentially indicating that ITRF2005 is better connected to the CM than ITRF2000. Based on these results, we develop a proposal for an absolute gravity network to be integrated with the station network of the Global Geodetic Observing System (GGOS). We propose to collocate permanent absolute gravimeters with the fundamental geodetic sites of GGOS, in particular those that are not close to ongoing presentday mass changes. Reference: Wahr, J. M., Dazhong, H., Trupin, A., 1995. Prediction of vertical uplift caused by changing polar ice volumes on visco-elastic Earth, *Geophys. Res. Lett.*, 22, 977-980.

Keywords: reference frame, absolute gravimetry

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS005****Oral Presentation****2975****Combined analysis of earth orientation parameters and gravity field coefficients for mutual validation*****Mrs. Andrea Heiker****Geodetic Institute PHD-Student IAG****Kutterer Hansjrg, Mller Jrgen***

The temporal variations of the earth orientation parameters (EOP) and spherical harmonics coefficients of the gravity field of the earth are geodetic contributions to the analysis of global geodynamic processes. As the earth's inertial tensor is functionally related both to the EOP via the Euler-Liouville equations and directly to the gravity field coefficients of degree 2 it plays a decisive role. However, it is still common practice to derive these two sets of parameters separately without taking this natural link into account. In contrast, this study suggests a statistically founded method of combining the temporal variations of the EOP and of the gravity field coefficients of degree 2 by a least-squares estimation based on the Gauss-Helmert model (condition equations with unknowns). The EOP and the gravity field coefficients are introduced as observations together with excitation functions and the luni-solar torque. As there are typically no direct observations of the time derivatives in the Euler-Liouville equations, the respective values are approximated by numerical differentiation. The elements of the inertial tensor of each epoch are the unknown parameters which have to be estimated. By this means values of the elements of the inertial tensor are estimated as well as residuals of the EOP and gravity field coefficients and the other observations. In addition, variance components are estimated since a proper stochastic model is not known up to now. This approach allows to discuss various aspects of EOP and gravity field coefficient combination. First, the consistency of different datasets of EOP, gravity field coefficients and angular momentum functions with different temporal resolution can be studied. The effects of the different datasets and the different temporal resolution are analyzed and compared to the effects of a simulated dataset. Second, the variance relations between the different types of observations are derived. Third, the potential for mutual validation can be evaluated.

Keywords: earth orientation parameters, gravity field coefficients, temporal variations



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS005****Oral Presentation****2976****The capability of contribution to the GGOS through the domestic space geodesy techniques in Korea****Dr. Jong Uk Park***Space Geodesy Korea Astronomy & Space Science Institute IAG****Jung-Ho Cho, Hyung-Chul Lim, Young Hong Shin***

Since the first GPS reference station was established in 1992, KASI (Korea Astronomy and Space Science Institute) has been involved in GNSS research and its applications. Currently more than 80 GPS stations are in operation by several institutes and government agencies in since 2000. In addition, a new GDC of IGS, which can be used for GGOS Data Center, is operated by KASI from Jan. 2006. KASI is now constructing the Korean VLBI Network (KVN) which is composed of three new-generation 21m radio telescopes. KVN will be used for geodesy and mm-wave VLBI astronomy. National Geographic Information Institute (NGII) is also designing a dedicated geodetic VLBI antenna in order to establish a new national geodetic system consistent with the ITRF. A preliminary study for developing Satellite Laser Ranging (SLR) system was done at 2005 and SLR system in will be operated in next few years, consisting of one fixed and one mobile systems. The Ministry of Construction and Transportation (MOCT) of is planning to improve the accuracy of Geoid models up to few cm-level, since the current accuracy of about 13cm cannot meet the todays levelling requirement using GNSS. The up-to-date global geopotential models (e.g. GRACE, next GOCE) and dense surface gravity data will be used. The gravity references will be extended and reinstalled with precise absolute and relative gravimeters. A large amount of gravity data will be re-processed, and data sparsity will be improved by new gravity surveys. The KOMPSAT-5 (the 5th Korea Multi-Purpose Satellite) equipped with dual frequency GPS radio occultation (RO) receiver is planned to be launched in 2010. The vertical profiles for ionospheric electron density and tropospheric temperature and pressure can be derived from KOMPSAT-5 GPS RO soundings. Korea has a plan to establish a domestic GGOS Data Gathering System in parallel with extending Space Geodetic facilities. It will be very useful to fulfil the goal of GGOS to monitor the change of the Earth and to prevent natural hazards.

Keywords: ggos, gnss, vlbi

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS005****Oral Presentation****2977****Numerical models of transient atmospheric and hydrospheric dynamics:
Benefits for the interpretation of geodetic observations****Mr. Henryk Dobslaw***Institute for Planetary Geodesy Dresden University of Technology IAG***Maik Thomas, Andre Groetzsch**

Dynamical processes in the Earth's system caused by internal and external forces and accompanied by mass redistributions within and mass exchanges between the individual subsystems are well reflected in variations of the three fundamental observables of geodesy, i.e., the Earth's shape, its rotation and the gravity field. Since all these global parameters are precisely observed with various space- and ground-based geodetic techniques, mass transports in the Earth's system and corresponding dynamics are principally monitored. However, due to the integral character of geodetic observations and restrictions concerning resolution in time and space, the processing as well as the interpretation and utilization of the data requires independent, interdisciplinary and consistent methods, e.g., from theory and modelling. Here, a numerical model approach covering transient dynamical processes and corresponding mass redistributions in the atmosphere-hydrosphere system is applied in order to highlight the benefits of a combined interpretation of different geodetic observations. By means of numerical simulations, atmospheric and hydrospheric induced mass anomalies, vertical deformations, sea-surface height variations as well as the impact on Earth rotation are deduced and contrasted to corresponding observations in order to show how large-scale, near surface mass transports are represented in geodetic data. Considering the individually limited spatial and temporal resolution of the different observations it will be demonstrated how the various observing techniques and the complementary model approach may contribute to a comprehensive understanding of the processes considered.

Keywords: modeling, mass transports

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS005****Oral Presentation****2978****Homogeneous time-series of EOP derived from space-geodetic techniques and their combination****Mrs. Daniela Thaller**
Dept. 1 GFZ Potsdam IAG**Manuela Krgel, Barbara Meisel, Thomas Artz, Sarah Bckmann, Rolf Knig, Markus Rothacher, Peter Steigenberger, Volker Tesmer, Johann Wnsch**

In view of the goals of the Global Geodetic Observing System (GGOS) it is indispensable to dispose of high-quality geodetic solutions with all parameters relevant for geodetic and geophysical studies. The highest possible quality can be reached only if all single input solutions are homogeneously processed with the most recent analysis standards. Against this background, the institutions BKG (Bundesamt für Kartographie und Geodsie), DGFI (Deutsches Geodtisches Forschungsinstitut), GFZ (GeoForschungsZentrum Potsdam) and IGG (Institute for Geodesy and Geoinformation of the University of Bonn, formerly GIUB) joined forces and initiated a project called "GGOS-D". The broad expertise within this group allows for a detailed harmonization of the processing standards and parameterizations for all software packages used within this project, and, secondly, to fully reprocess the VLBI, GPS and SLR data. Thus, the resulting solutions reach a high level of homogeneity within each time-series as well as between the individual contributions. This allows a rigorous combination of the single-technique normal equation systems. For the purpose of an inter-technique combination it is important that all parameters common to more than one technique are included in the normal equation systems. Therefore, site-specific troposphere parameters (i.e., zenith delays and horizontal gradients) as well as low-degree spherical harmonics of the Earth's gravity field have been included besides the usual station positions and Earth orientation parameters (EOP). The presentation will focus mainly on the EOP, although all parameters are treated together within one solution. The analysis of the EOP time-series encloses all five Earth rotation angles and their time-derivatives, i.e., polar motion, universal time and nutation. Homogeneous EOP time-series of all techniques and a combined time-series from 1994 until 2006 have been generated. In addition, the VLBI time-series starts already in 1984. This is of special importance for studies devoted to nutation. The validation of the estimated parameters is realized by comparisons with other time-series of EOP officially available, by spectral analysis in view of tidal amplitudes, and by comparisons with atmospheric and oceanic angular momentum data. The dependence of the combined EOP time-series on the terrestrial reference frame (especially the selected local ties) and the correlation with the degree-two spherical harmonic coefficients of the gravity field can be studied in this context as well.

Keywords: space geodetic techniques, combination, earth orientation parameters

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS005****Oral Presentation****2979****The EarthScope Plate Boundary Observatory Unified Geodetic Network****Dr. Greg Anderson***Plate Boundary Observatory UNAVCO IAG****Michael Jackson, Karl Feaux, David Mencin, Brian Coyle, Barrett Friesen, Katrin Hafner, Mike Hasting, Wade Johnson, Ben Pauk, Chris Walls, Chuck Meertens***

The Plate Boundary Observatory (PBO), part of the NSF-funded EarthScope project, is designed to study the three-dimensional strain field resulting from deformation across the active boundary zone between the Pacific and North American plates in the western United States. To meet these goals, UNAVCO will install 880 continuous GPS stations, 103 borehole strainmeter stations, 28 tiltmeters, and five laser strainmeters by October 2008, as well as manage data for 209 previously existing continuous GPS stations through the PBO Nucleus project and 11 GPS stations installed by the USArray segment of EarthScope. As of February 2007, UNAVCO had completed 519 PBO GPS stations and had upgraded 73% of the planned PBO Nucleus stations. Highlights of the past years work include the expansion of the Alaska subnetwork to nearly 70 continuously-operating stations, including coverage of Akutan and Augustine volcanoes and reconnaissance for future installations on Unimak Island; the installation of nine new stations on Mt. St. Helens; and the arrival of 33 permits for station installations on BLM land in Nevada. The Augustine network provided critical data on magmatic and volcanic processes associated with the 2005-2006 volcanic crisis, and has expanded to a total of 11 stations. Please visit <http://pboweb.unavco.org/?pageid=3> for further information on PBO GPS network construction activities. UNAVCO is also installing and operating the largest borehole seismic/strainmeter network in North America, as well as tiltmeters and laser strainmeters. As of February 2007, 27 PBO borehole stations had been installed and three laser strainmeter stations were operating, with a total of 60 borehole stations and 4 laser strainmeters expected by October 2007. In response to direction from the EarthScope community, UNAVCO installed a dense network of six stations along the San Jacinto Fault near Anza, California, and has densified coverage of the Parkfield area. During Fall 2006, the first PBO borehole tiltmeters were installed on Mt. St. Helens, and in Spring 2007, they will be joined by the first PBO volcanic borehole strainmeter stations. Please visit <http://pboweb.unavco.org/?pageid=8> for more information on PBO strainmeter network construction progress. The combined PBO/Nucleus GPS network has now provided almost 220 GB of raw data, with special downloads of more than 130 GB of high-rate GPS data following large earthquakes in Russia and the Tonga Islands, as well as for community requests. The standard-rate GPS data are processed routinely to generate data products including station position time series, velocity vectors, and related information, and all data products are available from the UNAVCO Facility archive. The PBO seismic network seismic network has provided 105 GB of raw data, which are available from the IRIS Data Management Center (DMC). The PBO strainmeter network has provided 45 GB of raw data, available in both raw native format and SEED format from the Northern California Earthquake Data Center and the IRIS DMC, along with higher-level products such as cleaned strain time series and related information. Please visit http://pboweb.unavco.org/gps_data and http://pboweb.unavco.org/strain_data for more information on PBO GPS and strainmeter/seismic data products, respectively.

Keywords: earthscope pbo, network design, data management

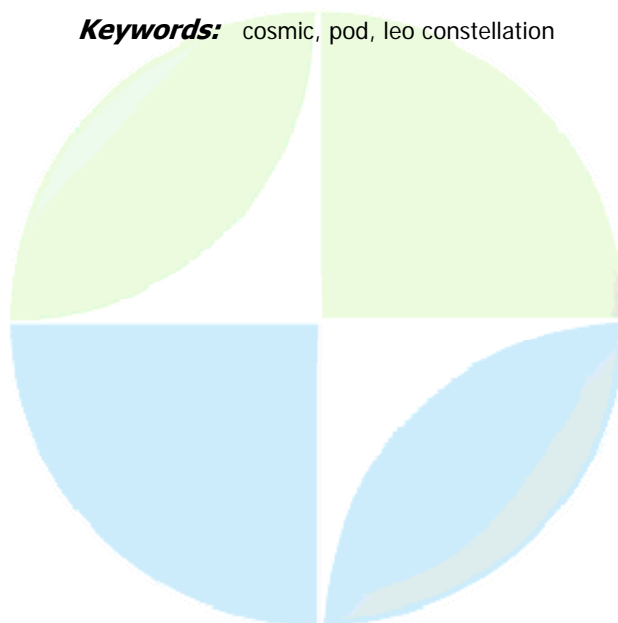
(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS005****Oral Presentation****2980****GGOS and the gravity field****Mr. Rene Forsberg***Geodynamics Department Danish National Space Center IAG***Steve Kenyon**

The gravity field of the earth is a central pillar of GGOS, and the International Gravity Field Service acts in coordination of the activities of the gravity-field related services of the IAG. Gravity field quantities are special in the way that measurements at the ppb-accuracies, matching the geometrical parameter determination, is either a function of wavelength (e.g., the long-wavelength mm-geoid from satellite gravity field missions), or based on point sampling (absolute or superconducting gravimetry). From a GGOS global perspective, one of the main challenges is to ensure the consistency of the global and regional geopotential and geoid models, with a global vertical datum a natural element of this. The current EGM07 geopotential model project, aimed at producing a global 10-cm geoid at very high spherical harmonic degree (2160), serves as a first example of a global static gravity field model serving GGOS needs. For temporal change of the global gravity field, IGFS could in a more distance future coordinate the unification of GRACE models from different processing centers; at present, however, processing of GRACE is still far from routine and not at all comparable to, e.g., reference system unification activities of the IERS. Other gravity activities a natural part of GGOS would be the coordination of repeated or continuous absolute gravity measurements worldwide at fundamental GGOS stations.

Keywords: ggos, gravity, grace

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS005****Poster presentation****2981****Precision Orbit Determination of COSMIC Constellation*****Prof. Jianghui Geng****GNSS Engineering Research Center Wuhan University****Cheinway Hwang***

The FORMOSAT-3/COSMIC mission is a microsatellite mission for weather forecast, climate monitoring, and atmospheric, ionospheric and geodesy research. This mission is a collaborative Taiwan-USA science experiment to deploy a constellation of six microsatellites in low Earth orbits. Each satellite consists of three science payloads: global positioning system (GPS) occultation experiment (GOX) payload, tiny ionospheric photometer (TIP) and tri-band beacon (TBB). The GOX in each microsatellite consists of one GPS receiver and four patch antennas (two high-gain antennas and two POD antennas). It supports the most important mission of FORMOSAT-3, contributing to near real-time weather forecasting. Two points should be noted. On the one hand, one of the particular characteristics of COSMIC satellites is that each of them has two POD antennas with a boresight of about 75 off the zenith in the spacecraft coordinate system. Thus the two antennas are able to track more GPS satellites if the receiver allows it than the past similar mission, such as CHAMP (CHALLENGING Minisatellite Payload). On the other hand, COSMIC constellation makes it possible that the ambiguities between the satellites can be fixed to enhance the solution. Thus more precise relative orbits can be determined for the gravity recovery that is demonstrated in the GRACE mission (GRAVITY Climate Experiment), which is also needed in COSMIC mission. The paper, therefore, aims at the precision orbit determination of the COSMIC constellation and the evaluation of the orbit quality of each microsatellite. One weeks space-borne GPS data from both POD antennas are used in the kinematic and dynamic POD. The GPS orbit and clocks are fixed to the CODE (Center for Orbit Determination in Europe) final products. Dynamic approach is implemented through the modeling of the solar radiation, the atmospheric drag and the empirical acceleration. The ambiguity fixing strategy will be carried out between the satellites. The orbit overlap comparison is employed to check the quality of the orbits. It is well-known that the kinematic orbit quality is sensitive to the GPS constellation that the LEO can track. Thus the authors believe that the kinematic approach will benefit from the two POD antennas to a great extent. The 3D RMS of orbit overlap difference is expected to be better than 10cm.

Keywords: cosmic, pod, leo constellation

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS005****Poster presentation****2982****Decade variations of position of the centre of mass of the Earth and their reflection in natural processes****Prof. Yury Barkin***Laboratory of Gravimetry Sternberg Astronomical Institute IAG*

According to geodynamic model developed by the author the uniform mechanism directs, makes active and coordinates all planetary processes - the mechanism of the forced swing and displacement of the core and the mantle of the Earth under action of a gravitational attraction of the Moon, the Sun and planets (Barkin, 2002). Thus complex character of small relative displacements of the centers of mass of the core and the mantle directly should be reflected not only in intensity of natural processes and their time arrangement, but also in their localization and migration on a surface of the Earth, in redistribution of oceanic, atmospheric and other fluid masses. Hence, any information about drift and cycles of displacement of the centre of mass gives the certain information on "a superficial trace" of activation of geodynamic and geophysical processes. On the other hand, the information on intensity and migration of the specified processes allows to determine a character of displacements of the centre of mass of the Earth and, accordingly, the core of the Earth. Basing on this hypothesis, in the given work we estimate the periods of possible long-periodic oscillations of a geocenter directly on character of interannual and decade processes on the Earth surface. So on the known data (Keilis-Borok, 1997) in the period since 1930 on 1965 the wave of migration of earthquakes with magnitude $m > 7.8$ from an arch Tonga up to Alaska with velocity 400 km/yr was revealed; a wave of earthquakes ($m > 7.9$) along a northwest part of the Pacific ring with velocity about 220 km/yr; a wave of earthquakes with $m > 5$ in Central America with velocity about 350 km/yr. On velocities of drift of seismicity around of the Pacific belt it is possible to estimate the periods of their full closed revolution on the Earth surface, which we compare to the appropriate long periods of oscillations of the centre of mass (and the core) of the Earth. So to velocity of drift of seismicity in 400 km/yr there corresponds the period of 100 years (99.6 yr), to velocity of drift of seismicity in 350 km/yr - the period of 114 years (116.4 yr), and to velocity 220 km/yr - the period 182 years (181.7 yr). Values of the periods of variations of natural processes of the Earth specified in brackets have been predicted earlier on the basis of developed geodynamic model (Barkin, 2002). The important information about displacements of a geocenter (and the Earth core) is given by the observed oceanic and atmospheric waves. In 1991 N.S.Sidorenkov has found out, that the centers of anomalies of temperature of a surface of ocean (ЦТ) are displaced from the west to the east with velocity about 0.25 m/s (Sidorenkov, 2002). Corresponding slow equatorial oceanic waves are running all over the Earth approximately in 4.8 years. The wave moved in 80th years more slowly, the period its full revolution around of the Earth made 4.8 years. In 1990 - 1993 the wave practically stood on a place, and in 1994 has run the Earth for 1.2 years. In 1996-1998 the period of a revolution of a wave has made 3.6 yr. It is important to emphasize, that the specified periods and a number of other interannual periods rather confidently are allocated, as at the spectral analysis of temporal series of coordinates of geocenter, and in variations of gravity (in measurements on the absolute gravimeters during 1980-2000), in variations of heights (Kaftan, Gusev, 2004; Barkin, Lyubushin, Zotov, 2007). Correlations of the described phenomena specify their deep dynamical relationship and confirm our hypothesis about the uniform mechanism of variations of natural processes (Barkin, 2002). The relative dynamical swing of system "the core - the mantle" of the Earth with the certain cyclicities and amplitudes raises the described interannual and decade waves in ocean and an atmosphere. The observable picture in redistribution of masses of the atmosphere and ocean reflects non-trivial superposition of oscillations of the Earth core. We shall specify some periods revealed on the GPS data of observations. The close polar oscillation of geocenter with period 2-2.2 years and amplitude about 5

mm takes place. It confidently proves to be true, for example, by gravimetry measurements in region of Moscow (a variation with the period 1.8-2.1 years with amplitude 1-1.5 microgall; Kaftan, Gusev, 2004). The big oscillations of a geocenter with the period of 8 years and 3.6 years are allocated (the appropriate amplitudes make about 1 cm and 7 mm; Tatevian et al., 2004). References Barkin Yu.V. (2002) An explanation of endogenous activity of planets and satellites and its cyclisity. *Izvestia sekcii nauk o Zemle Rossiiskoi akademii estestvennykh nauk*. Vyp. 9, M., VINITI, pp. 45-97. In Russian. Kuznetsov I.V., Kejlis-Borok V.I. (1997) Interrelation of earthquakes of Pacific seismic belt. *Reports of Academy of Sciences sciences*, volume 355, N 3, pp. 389-393. Sidorenkov N.S. (2002) Physics of non stabilities of rotation of the Earth. M.: "Nauka", Fizmatlit, 384 p. Tatevian, S.K., Kuzin, S.P., Kaftan, V.I. (2004) Comparison of geocenter variations derived from GPS and DORIS data. Report of EGU (25-30 April 2004, Nice, France). Kaftan V.I., Gusev N.A. (2004) Temporal changes of a gravity at Moscow station FAGS. The scientific and technical collection on a geodesy, aerospace photo cartography ("Physical geodesy"). M., ZNIIGAIK, v. 5, pp. 136-146. Barkin Yu.V., Lyubushin A.A., Zotov L.V. (2007) The geocenter motion and its geodynamical contents. Materials of Sagitov Conference (5-6 February 2007, Moscow). Sternberg Astronomical Institute, MSU: www.sai.msu.ru.

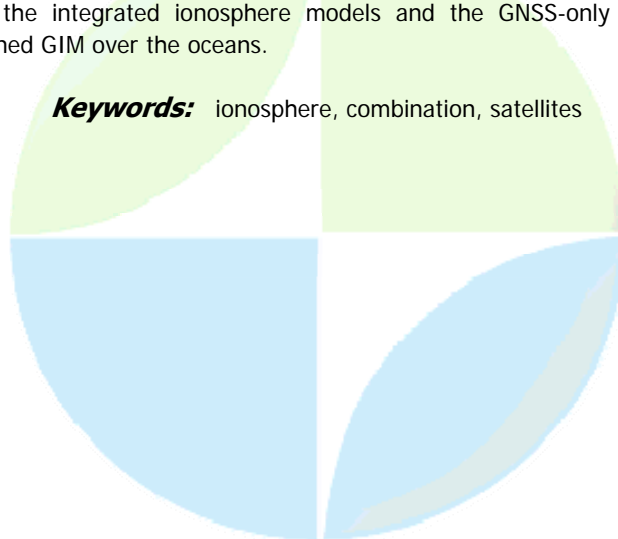
Keywords: geocenter variations, natural processes, correlations

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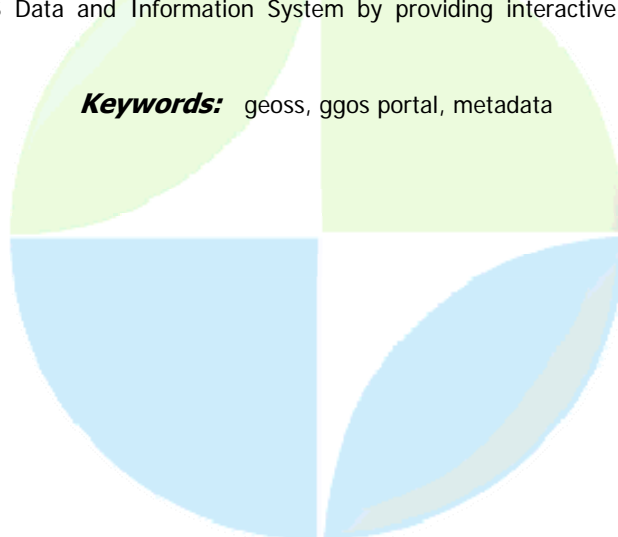
(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS005****Poster presentation****2983****Combination of different space geodetic techniques towards integrated global ionosphere maps*****Mrs. Sonya Todorova****Institute of Geodesy and Geophysics Vienna University of Technology, Austria****Harald Schuh, Thomas Hobiger, Manuel Hernandez-Pajares***

The ionosphere is a dispersive medium for the observables of all the space geodetic techniques operating in the microwave band. The high free-electron and ion density in the ionosphere influences the propagation of electromagnetic waves and disturbs both, their group and phase velocity. The effect is in first approximation proportional to the so-called Slant Total Electron Content (STEC) along the ray path and can be corrected if the measurements are carried out at two distinct frequencies. This approach, on the other hand, allows information about the parameters of the ionosphere in terms of TEC values to be obtained. Following space geodetic techniques can be utilized for observation and modelling of the ionosphere - the Global Navigation Satellite System (GNSS), including GPS, GLONASS, and with Europe's satellite system Galileo coming; satellite altimetry missions like Topex/Poseidon and Jason-1; the Very Long Baseline Interferometry (VLBI); Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS); the Low Earth Orbit Satellites (LEOs) like CHAMP, SAC-C, COSMIC. The different observation principles of these techniques result in specific features of the ionosphere parameters derived by each of them. The aim of our work is to develop a sound combination procedure for computation of integrated global maps using data from the various observation techniques. The combined model of the ionosphere should make best use of the advantages of each particular space geodetic technique, having a more homogeneous global coverage, and being more accurate and reliable than the single results. For deriving Global Ionosphere Maps (GIM) mainly GPS and GLONASS observations have been used so far. Their quality is generally very good; still the ground stations are inhomogeneously distributed, with large gaps particularly over the sea surface, which lowers the precision of the GIM over these areas. As a first step of this study we create Global Ionosphere Maps (GIM) from GNSS data and additionally introduce satellite altimetry observations, which help to compensate the insufficient GNSS coverage of the oceans. The obtained global maps are in two hours intervals and daily values of Differential Code Biases (DCB) for the GNSS satellites and receivers are estimated. The combination of the data from around 180 GNSS stations and the satellite altimetry mission Jason-1 is performed on the normal equation level. Using the features of the combination method, a test for estimating daily values of a constant Jason-1 bias was also carried out. The comparison between the integrated ionosphere models and the GNSS-only maps shows a higher accuracy of the combined GIM over the oceans.

Keywords: ionosphere, combination, satellites

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS005****Poster presentation****2984****IAG services GGOS GEOSS: Steps towards a system of systems****Dr. Bernd Richter***Division of Geodesy Federal Agency for Cartography and Geodesy IAG***Wolfgang Schwegmann, Alfred Kranstedt**

GEO will establish, within 10 years, its system of systems (Global Earth Observation System of Systems GEOSS) to provide timely data and products for local, national, regional, and international users. To enable implementation of the GEOSS architecture, GEOSS will draw on existing institutional and technical precedents in areas such as geodetic reference frames, common geographic data, and standard protocols. The Global Geodetic Observing System (GGOS) with its Data and Information System will be one of the important subscribers to GEOSS directly or by the contributions of the IAG services. The GGOS portal will be the major point of entry to the combined set of geodetic and gravimetric services. In order to provide such an ensemble information service several prerequisites have to be taken into account. As a first step towards a system of systems standardized interfaces have to be developed to allow the direct access to and the interrelation of datasets from the superior portal through the heterogeneous data and information systems. Moreover, a comprehensive metadata catalogue, based on international standards, e.g., ISO19115 or equivalent, has to be developed and applied to describe all available datasets. This is an indispensable prerequisite, e.g., to allow a search across all geodetic and gravimetric information systems as well as an interdisciplinary search across all geosciences as aimed for in GEOSS. Machine-readable metadata as well as standardized interfaces allow so called Web Services to automatically retrieve data for further processing. At the highest level of integration Web Services can be developed to automatically invoke individual applications, like e.g. plot or analytical tools available at different information systems, and to combine them to new applications. The IERS Data and Information System will be discussed as an example, how to realize a single point of entry to all products of the IERS generated by several Product Centres. Main characteristics of the system are the usage of a standardized metadata set based on the ISO19115 and the eXtensible Markup Language (XML) used as format for all data and products as well as for the exchange of data and applications. This allows a comfortable search finding specific datasets of interest or comparing available datasets by retrieving basic information describing the dataset. The system will be supplemented by an interactive plot-tool and a Web Map Server to visualize the data. The ERIS project (Earth Rotation Information System), developed as part of the research unit Earth Rotation and Global Dynamic Processes funded by the German Research Foundation, will complement the experiences gained with the IERS Data and Information System by providing interactive tools for analysis and simulation of data.

Keywords: geoss, ggos portal, metadata

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS005****Poster presentation****2985****VLBI Intra-technique Combination for Kalman Filter and Least-Squares Solutions*****Mrs. Emine Tanir****Institute of Geodesy and Geophysics Vienna University of Technology IAG****Vincenza Tornatore, Johannes Boehm, Klaus Felsenstein, Harald Schuh***

The VLBI software packages for the data analysis which are used by different IVS (International VLBI Service for Geodesy and Astrometry) Analysis Centers (BKG (Federal Agency for Cartography and Geodesy), NASA GSFC (Goddard Space Flight Center), DGFI (Deutsches Geodaetisches Forschungsinstitut), SHA (Shanghai Astronomical Observatory), USNO (U.S. Naval Observatory), MAO (Main Astronomical Observatory), AUS (Geoscience Australia)) use various statistical methods. These statistical methods are the Least-Squares (LSQ) method, the Kalman filter (KF) method, the Square-Root Information Filter (SRIF) and the Least-Squares Collocation (LSQC) method and consider the behaviour of stochastic parameters in different way. For the intra-technique combination of different VLBI Analysis Center solutions, the effect of using different stochastic models on the estimates of geodetic parameters should be taken into account. In this study, we start to consider the combination of Kalman filter and LSQ solutions in our VLBI intra-technique combination algorithm. With the Kalman filter method, the use of polynomials to model the effect of the clocks and atmospheric delays are replaced with stochastic models. The implementation of the Kalman filter estimator to account for stochastic behavior on those parameters which vary during a VLBI experiment will be discussed.

Keywords: vlbi, kalman filter, least squaresPERUGIA
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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS005****Poster presentation****2986****Towards an International Altimeter Service (IAS) a component of the
Global Earth Observing System****Dr. Wolfgang Bosch**
IAG**C.K. Shum, Phil Woodworth, Gary Mitchum**

According to the demonstrated multiple interdisciplinary research and applications of satellite altimetry there is a broad consensus that an International Altimetry Service (IAS) is a mandatory component of Global Earth Observing System of Systems as coordinated by GEOSS. IAS should act in a mission- and agency-independent capacity. In view of the many organisations already providing data and products for satellite altimetry, IAS can only be realised by an integrating effort, e.g., as collaboration between data providers, archive and product centres, research laboratories, space agencies and users. It is the purpose of the proposed IAS Integration Office to promote the necessary integration and, where possible, to gradually improve or extend existing services for the benefit of the broad altimeter user community. The paper provides a present status report on the development towards an IAS and describes our visions for its future integration into the Global Earth Observing System of Systems.

Keywords: ggos, altimetry service, ias

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS005****Poster presentation****2987****A global geodetic observation network for long-term Earth monitoring****Dr. Johannes Ihde***Geodesy Federal Agency for Cartography and Geodesy IAG****Hayo Hase, Bernd Richter, Wolfgang Schlter, Georg Weber, Herbert Wilmes***

A design of a global geodetic observation network (GGON) for Earth system monitoring is proposed which could play an important role as a component of the IAG Project GGOS. The GGON approach is proposed be a combination of different geodetic techniques (geometric and gravimetric) graded into sets of stations at different levels of instrumentations: Geodetic fundamental stations, geodetic collocation stations, and geodetic stations collocated with specific geodynamic instruments, like seismometers, tide gauges, and ring laser gyros. The benefit of the wider use of terrestrial gravimetric techniques is seen especially in the context of the validation for the satellite gravity field missions and the detection of regional and local changes due to varying mass distributions. A major element of the GGON will become the data exchange and accumulation of geodetic observations and products. A graded spectrum spread from off-line to on-line real-time data availability needs to be established. Aspects of e-VLBI and GNSS real-time data transfer are included into this consideration. Furthermore, the geodetic community is encouraged to provide a high precision positioning service to other geosciences and related disciplines for the spatial monitoring of their stationary instruments as well as for mobile field campaigns. In addition those disciplines should be invited to collocate their instrumentation with geodetic stations encouraged by use of common infrastructure. Organizational and legal aspects will be considered where relevant.

Keywords: geodetic network design, technique combination, real time positioning



(G) - IAGA - International Association of Geomagnetism and Aeronomy

GS005

Poster presentation

2988

GGOS Portal and Virtual Observatory, OV-GAFF team

Dr. Florent Deleflie

Space geodesy, celestial mechanics Astronomer IAG

Philippe Berio

One of the objectives of GGOS is to develop a web portal in order to promote very important and valuable products of the IAG services. All the relevant data and products for Earth sciences and applications have to be made accessible through a GGOS portal. The development of such a tool will certainly require to work on the notions of interoperability, standardization, data access protocol, data model, web services, The focus of this paper is to present the International Virtual Observatory Alliance (IVOA), which develops all these concepts in the field of astronomy/astrophysics since a few years. We also present the geodetic and fundamental astronomy component of the French part of IVOA, group called OV-GAFF, which have been created a few months ago. This group works on the definition of standards for the geodetic community (in terms of data model and Unified Content Deor for example) and on the development of webservices through two pilot projects. To conclude, and on the basis of the presented examples, we discuss the advantages for GGOS to develop its portal in the context of virtual observatory, and in particular thanks to metadata described with a specific format developed by IVOA: the user is allowed to search for data wrt time or space, and heterogeneous data can be compare and transformed in an easy way.

Keywords: virtual observatory, metadata webservices, space geodesy



(G) - IAGA - International Association of Geomagnetism and Aeronomy

GS005

Poster presentation

2989

NGOS, The Nordic Geodetic Observing System

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Per Knudsen, Mikael Lilje, Torbjørn Nrbach, Hans-Georg Scherneck

The Nordic Geodetic Observing System (NGOS) integrates fundamental geodetic techniques for the long term observation of Earth system parameters. The Nordic Geodetic Commission established a Task Force with the mission to prepare a document providing the definition and draft for the implementation of the NGOS. NGOS is planned to be a regional implementation and densification of the IAG Global Geodetic Observing System, GGOS. The NGOS is proposed as a system that will serve a wide range of scientific and practical applications. NGOS will contribute to the GGOS and other IAG Services; European activities such as EUREF, ECGN, EUVN, and ESEAS; provide the reference frames for the Nordic countries, as well as contribute to the global ones; support scientific projects related to the geodynamics of the Nordic area and provide ground-truth for satellite missions. For the Nordic countries, a main focus will be on crustal motion, dynamics of glaciated areas and sea level.

Keywords: ngos, observing systems

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(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS005****Poster presentation****2990****Digital elevations from SRTM and ICESat: Effects of terrain slope and dynamic terrain****Mr. Mohammed Dabboor***Geomatics Engineering University of Calgary***Dr. Alexander Braun**

The Ice, Cloud, and land Elevation Satellite (ICESat) provides an almost globally distributed data set of elevations well suited for evaluating the vertical accuracy of the Shuttle Radar Topography Mission (SRTM) digital elevation models (DEMs). The SRTM, using a C-band (5.6 cm wavelength) Interferometric Synthetic Aperture Radar (InSAR), has produced the most accurate near global DEM covering land areas between 56oS and 60oN. ICESat radar altimetry provides a footprint size of approximately 65 meters on the Earth's surface, which is comparable to the horizontal resolution of the SRTM 90-meter DEM. This study analyses the effect of the terrain slope and slope direction on the derived elevation differences between ICESat and SRTM data. ICESat is a vertical-looking laser altimeter while SRTM is a side looking radar: both measure terrain elevations. This study also investigates the spatio temporal changes in the elevations of a dynamic surface area using ICESat data acquired between 2003 and 2006. Thus, the objectives of this study are: 1) the investigation of the relationship between the elevation errors and the slope and slope direction in a high relief area; and, 2) the interpretation of the elevation changes over a desert area. In order to conduct a consistent comparison among the two height data sets, it is imperative that all the heights refer to the same vertical datum. For the purpose of this study, the data comparisons are performed in terms of ellipsoidal heights with respect to a TOPEX ellipsoid. The area of interest is the Kingdom of Saudi Arabia, where the western part exhibits mountain chains with high relief (static area) and the southeastern part comprises a desert with moving sand dunes (dynamic area).

Keywords: terrain slope, slope direction, dynamic area

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS005****Poster presentation****2991****Accessibility of Geodetic Data for Geodynamic Studies on NAFZ in Turkey*****Mrs. Asli Garagon Dogru****Geodesy Bogazici University Kandilli Observatory and ERI IAG*

In Turkey, geodetic observations have been performed for monitoring both local and regional crustal movements by establishing microgeodetic networks along plate boundaries on the western part of NAFZ in Marmara region over three decades. Geodesy Department of Kandilli Observatory and Earthquake Research Institute of Bogazici University has started the studies of monitoring horizontal crustal movements on the western part of NAFZ in 1990. Three geodetic control networks were established in the regions which have different seismotectonic features to monitor crustal displacements. There are also several on-going and completed projects which are being conducted by scientists from the universities and the other research institutes (e.g. General Command of Mapping, TUBITAK, MIT) for the region of interest. So geodetic and other types of data inferred from the studies of Earth crust (geophysical and geological) exist, however, users of these data do not have an open access to them. In order to develop successful science and engineering applications, we need to go through several stages. The first one is the reassessment of data dissemination policies, and the next step is getting the right information to the right user at the right time using Information Technologies (IT) for efficiency, and to avoid the repeated efforts. This study introduces the concepts of the present-day IT tools for geosciences and identifies the benefits and challenges associated with their implementation. This is not only limited to acquiring, storing and publishing data but also it adds value by integrating geospatial data and developing information services for geosciences.

Keywords: deformation monitoring, geosciences, information technologies



(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS005****Poster presentation****2992****The EarthScope Plate Boundary Observatory GPS Network: Contributor to, and user of, GGOS****Dr. Greg Anderson***Plate Boundary Observatory UNAVCO IAG****Thomas A. Herring, Robert W. King, Simon C. McClusky, Timothy I. Melbourne, V. Marcelo Santillan, Mark H. Murray***

The EarthScope project was funded by the United States National Science Foundation to explore the structure and dynamics of the North American continent using geodetic, seismic, and geologic techniques. The Plate Boundary Observatory (PBO) is the geodetic component of EarthScope, and is designed to study the four-dimensional strain field resulting from deformation across the active boundary zone in the western United States. One key element of the PBO network is a planned array of 880 new continuous GPS stations that will operate in conjunction with 209 existing GPS stations to provide a unified 1100-station GPS network covering Alaska and the continental United States; at present, 510 of these new stations have been installed. We will discuss the deployment of this array and its data management system, the data analysis methods used, and the contributions that the Global Geodetic Observing System will make in defining a stable reference frame for PBO and in providing high accuracy products that will be needed for PBO. Analysis of PBO data will also provide feedback to GGOS to ensure that its products are of the quality needed. The PBO aims to detect transient signals with amplitudes as small as a millimeter and on timescales that can as short as seismic surface wave periods and as long as a decade. Coordinated analysis of geodetic data, both local to PBO and global will be needed to achieve this goal.

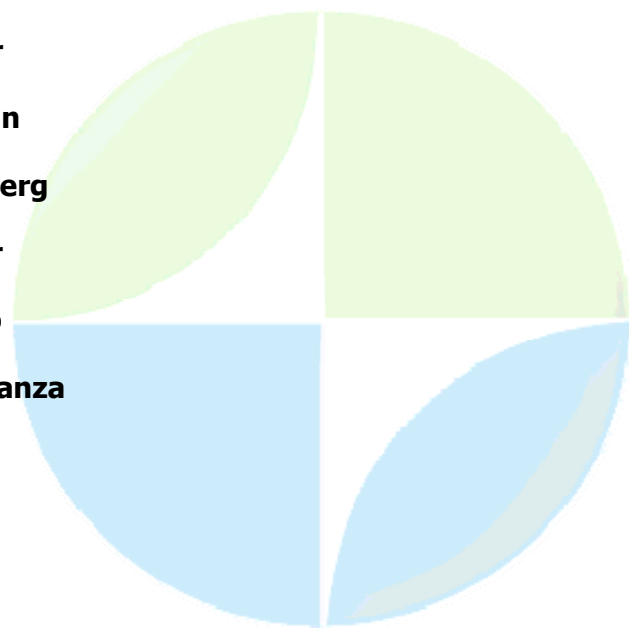
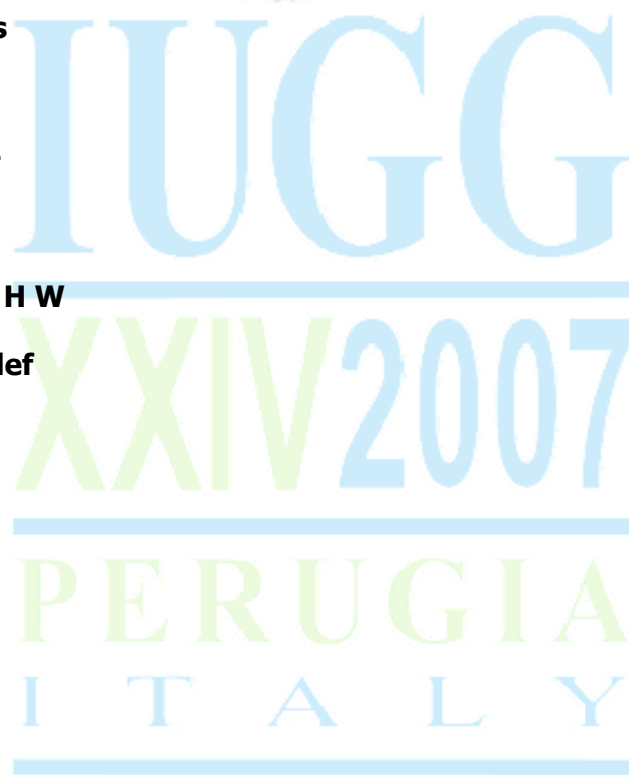
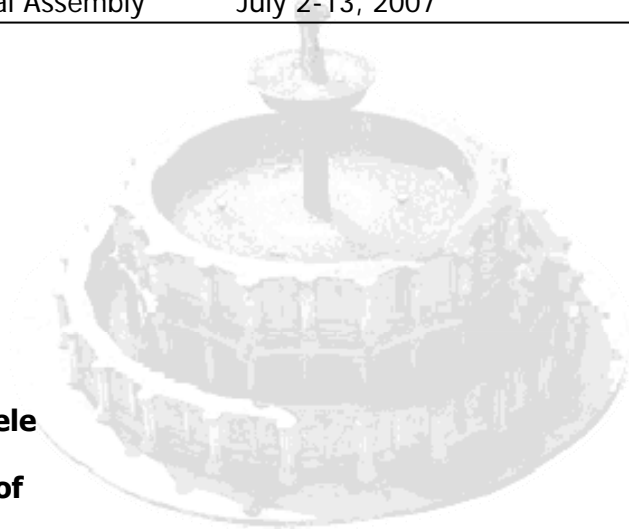
Keywords: earthscope pbo, network design, gps

(G) - IAGA - International Association of Geomagnetism and Aeronomy**GS005****Poster presentation****2993****VLBI 2010****Dr. Bill Petrachenko***Geodetic Survey Division Natural Resources Canada IAG****Dirk Behrend, Johannes Boehm, Brian Corey, Ruediger Haas, Yasuhiro Koyama,
Dan Macmillan, Zinovy Malkin, Arthur Niell, Gino Tuccari, Joerg Wresnik***

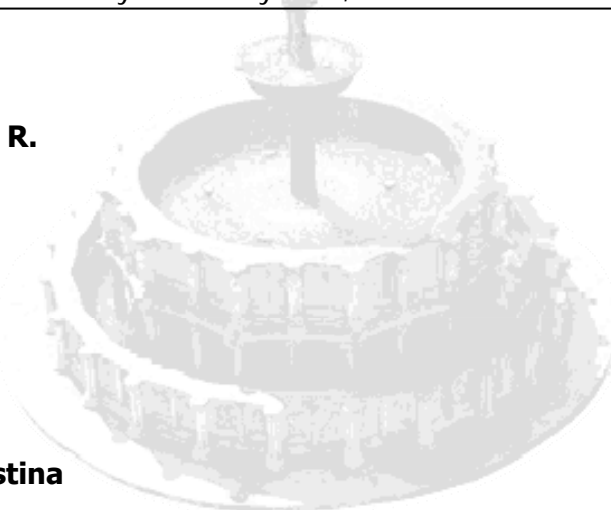
In October 2003, the International VLBI Service for Geodesy and Astrometry (IVS) installed Working Group 3 'VLBI 2010' to examine current and future requirements for geodetic VLBI including all components from antennas to analysis, and to create recommendations for a new generation of VLBI systems. To constrain these recommendations, a new set of criteria by which to measure the next generation geodetic VLBI system was established based on: - the recommendations for future IVS products detailed in the IVS Working Group 2 Report (WG2), - the requirements of the Global Geodetic Observing System project of the International Association of Geodesy (GGOS), - the science driven geodetic goals outlined in the NASA Solid Earth Science Working Group Report (SESWG). These goals are 1 mm measurement accuracy on global baselines, continuous measurements for time series of station positions and Earth orientation parameters, and turnaround time to initial geodetic results of less than 24 hours. To reach these goals, the following strategies are being investigated: - reduce the random component of the delay-observable error, e.g., the per-observation measurement error, the stochastic properties of the clocks, and the unmodeled variation in the atmosphere, - reduce systematic errors, e.g., the thermal and gravitational deflection of the antenna, drifts of the electronics, and source structure, - increase the number of antennas and improve their geographic distribution, - increase observation density, i.e. the number of observations per unit time. - reduce susceptibility to external radio-frequency interference, All of these considerations, along with the need for low cost of construction and operation, required a complete examination of all aspects of geodetic VLBI including equipment, processes, and observational strategies. A summary of the progress of the VLBI2010 project will be given.

Keywords: vlbi, vlbi2010, ivs

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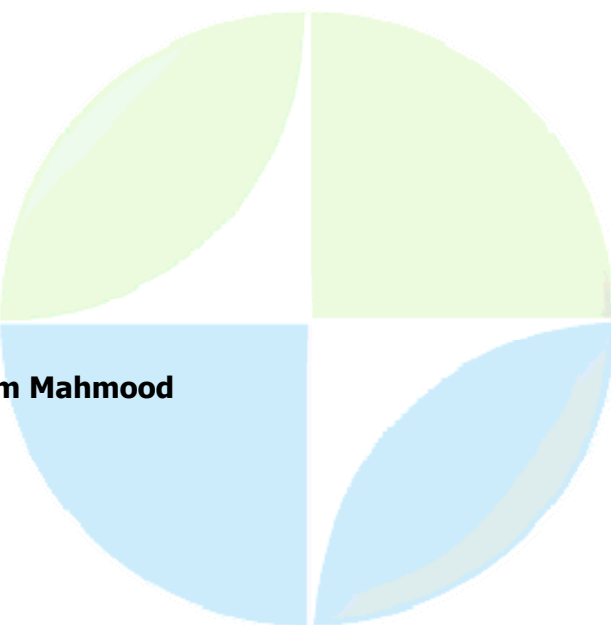


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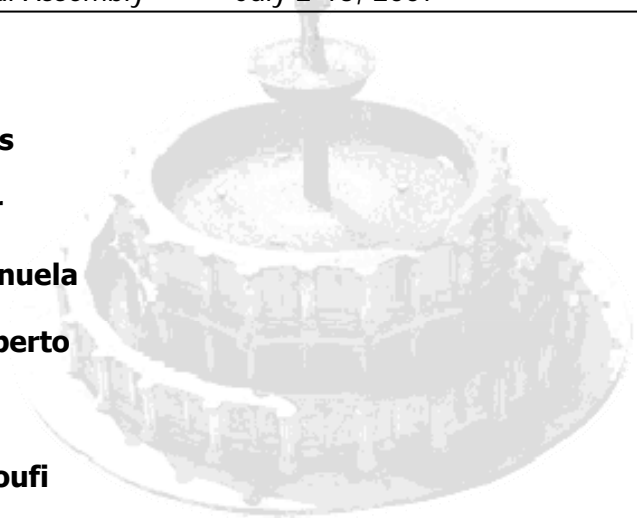
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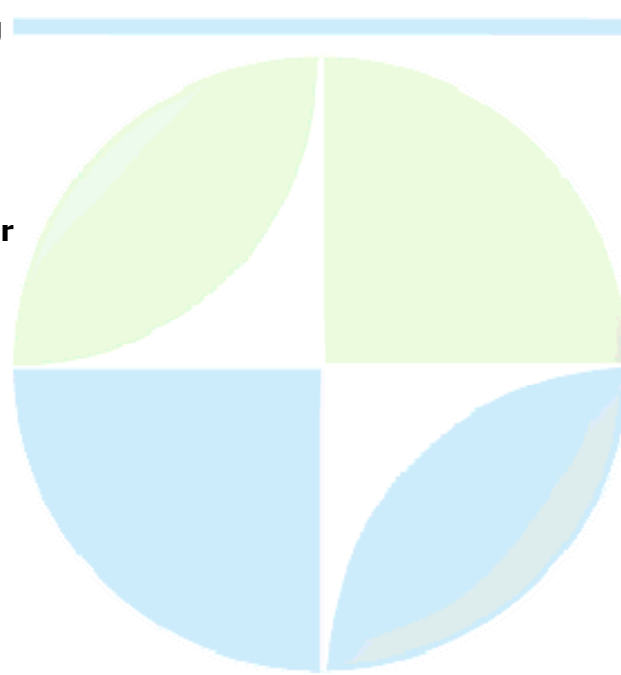
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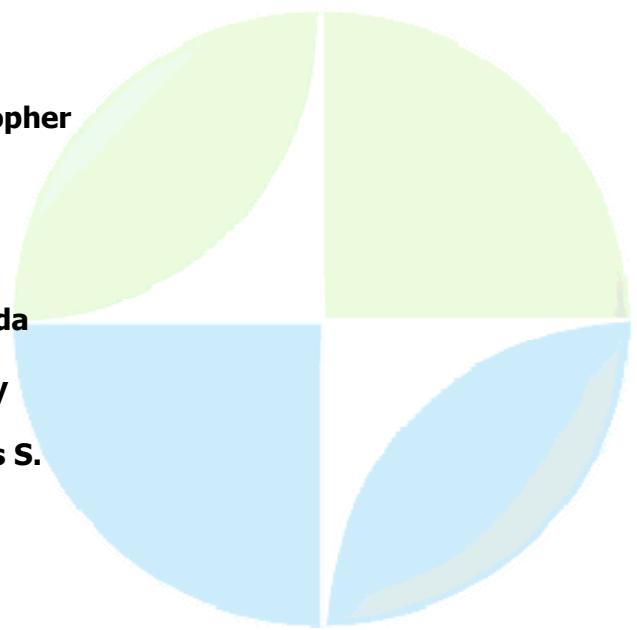
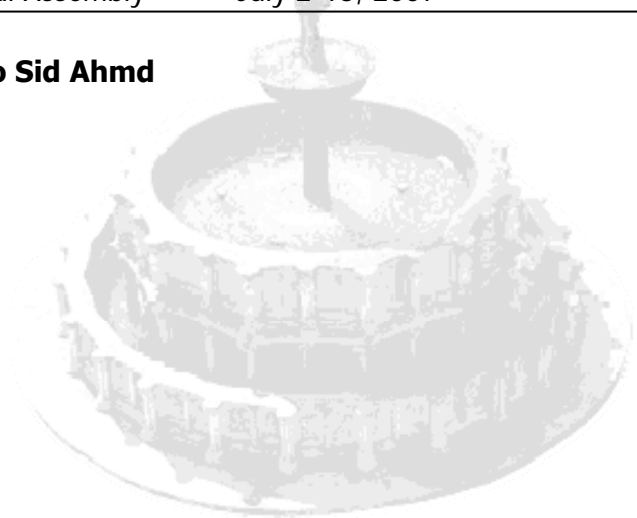
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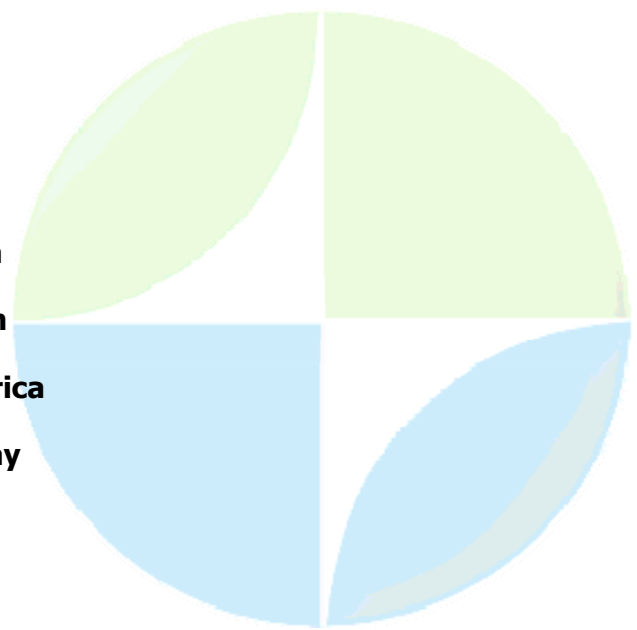
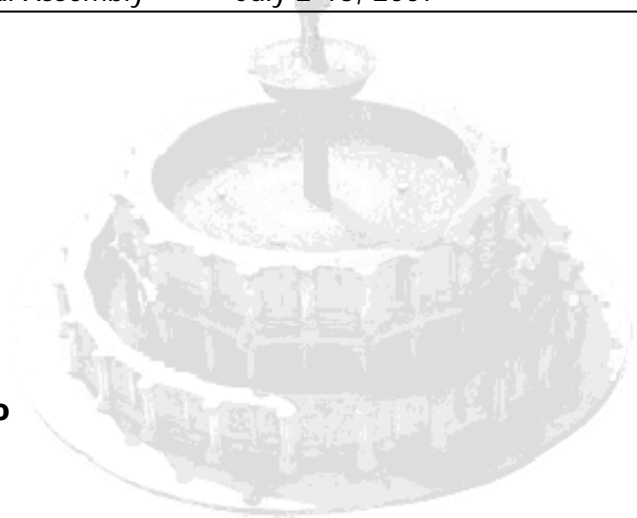
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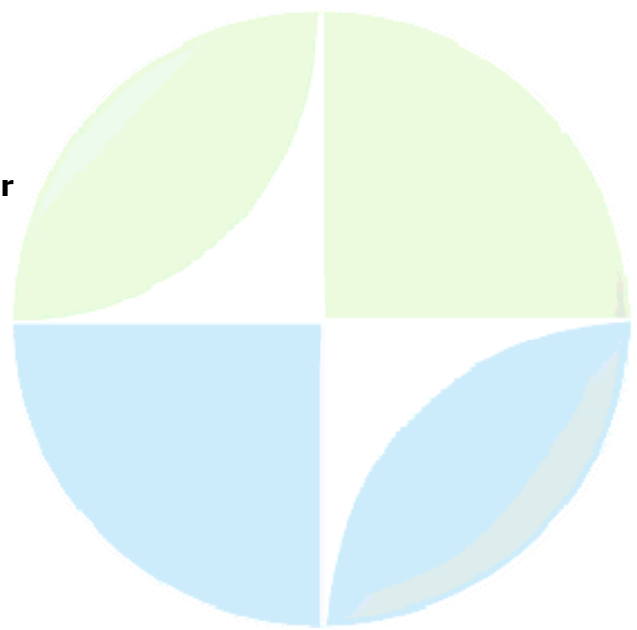
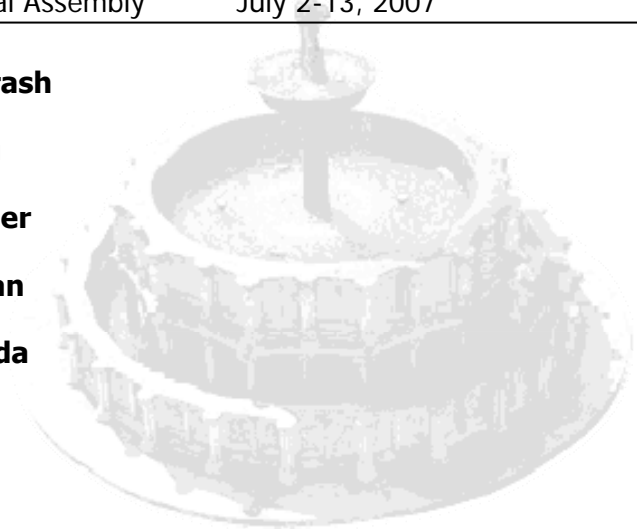
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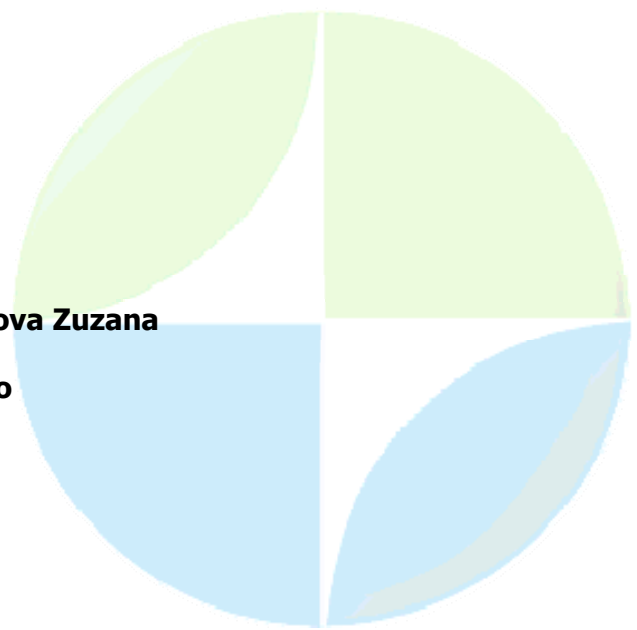
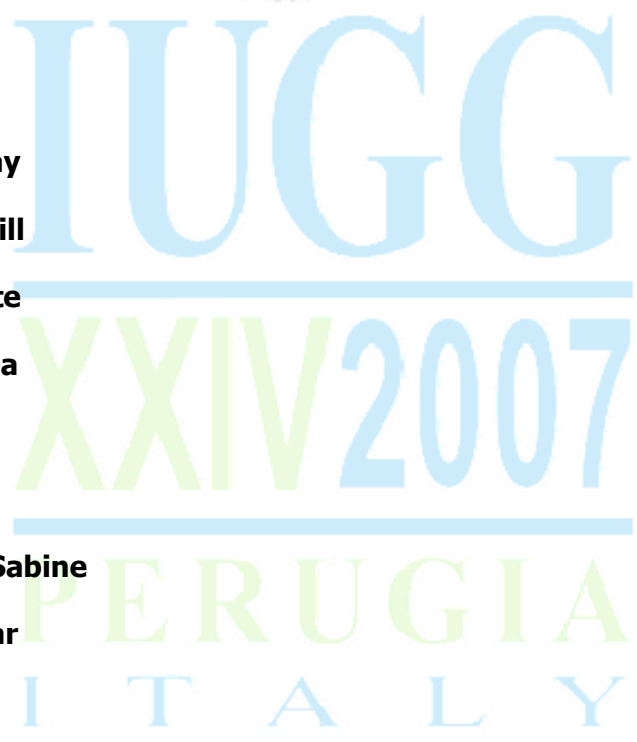
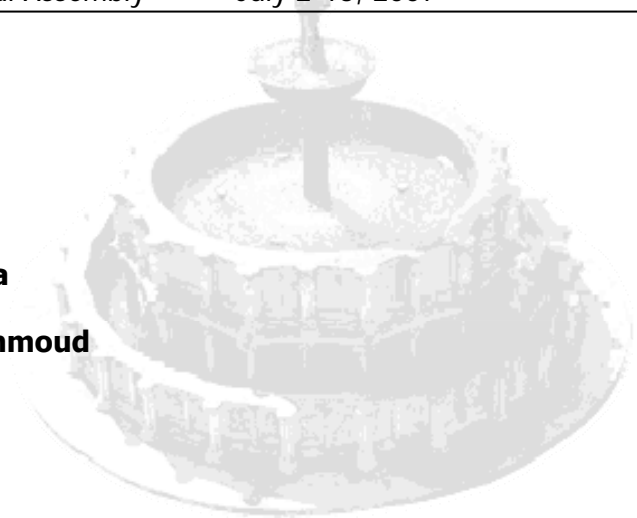
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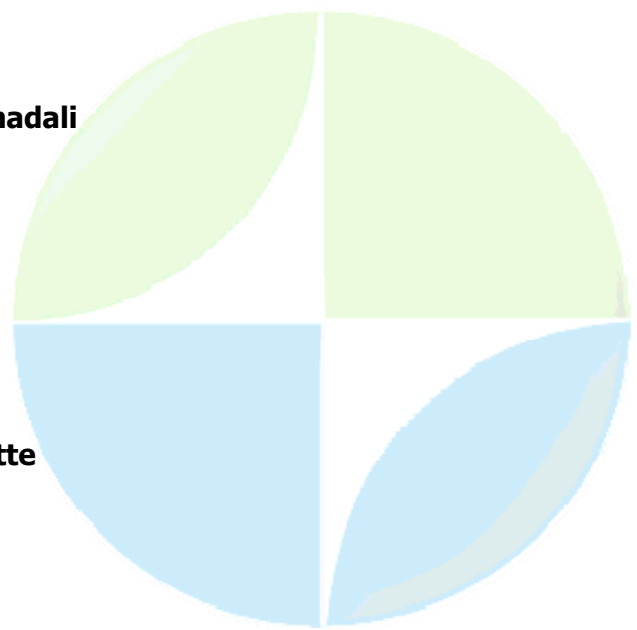
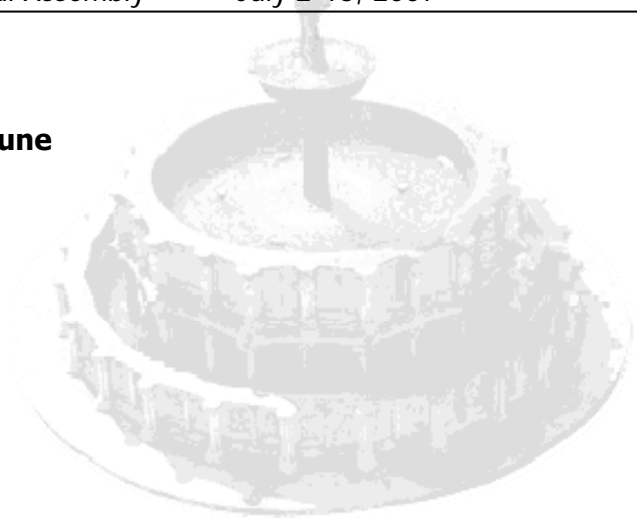
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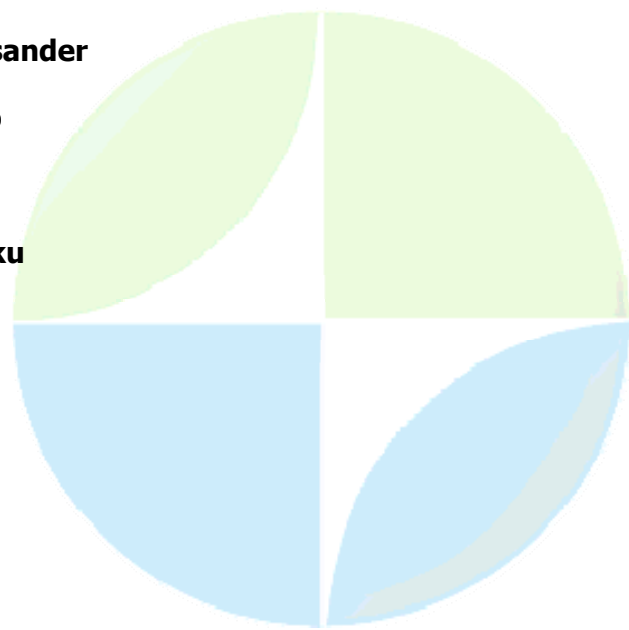
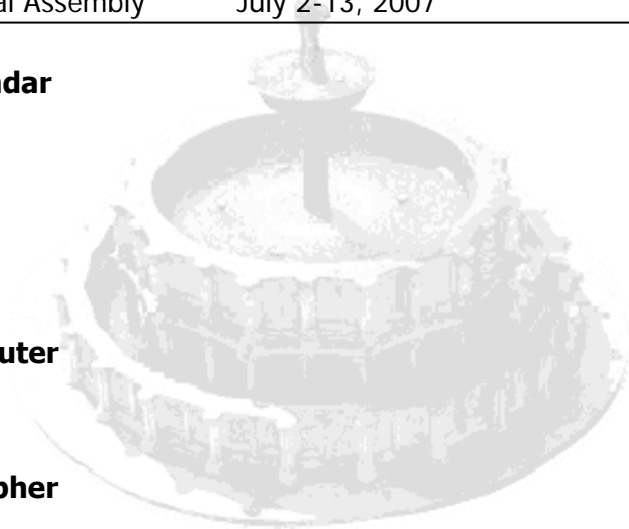
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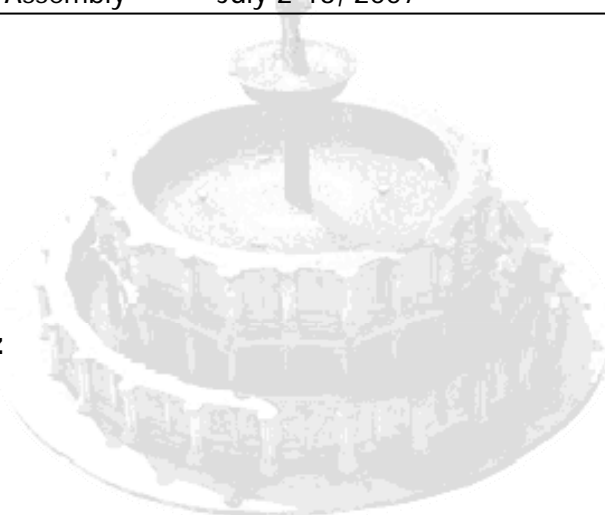
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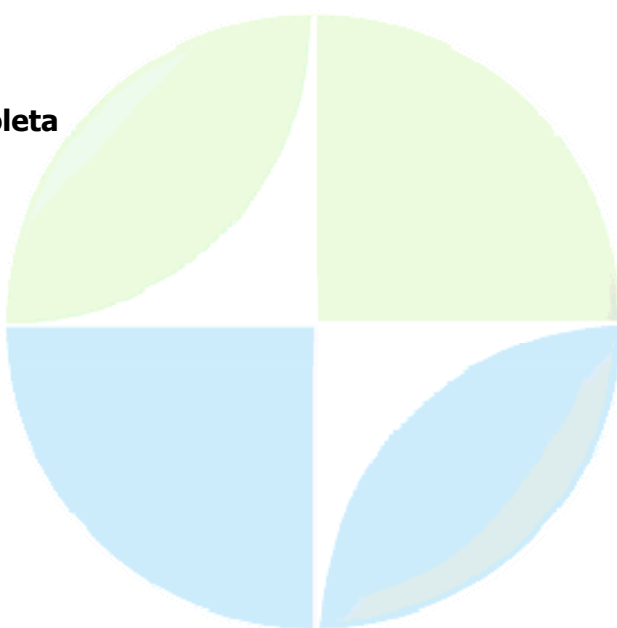


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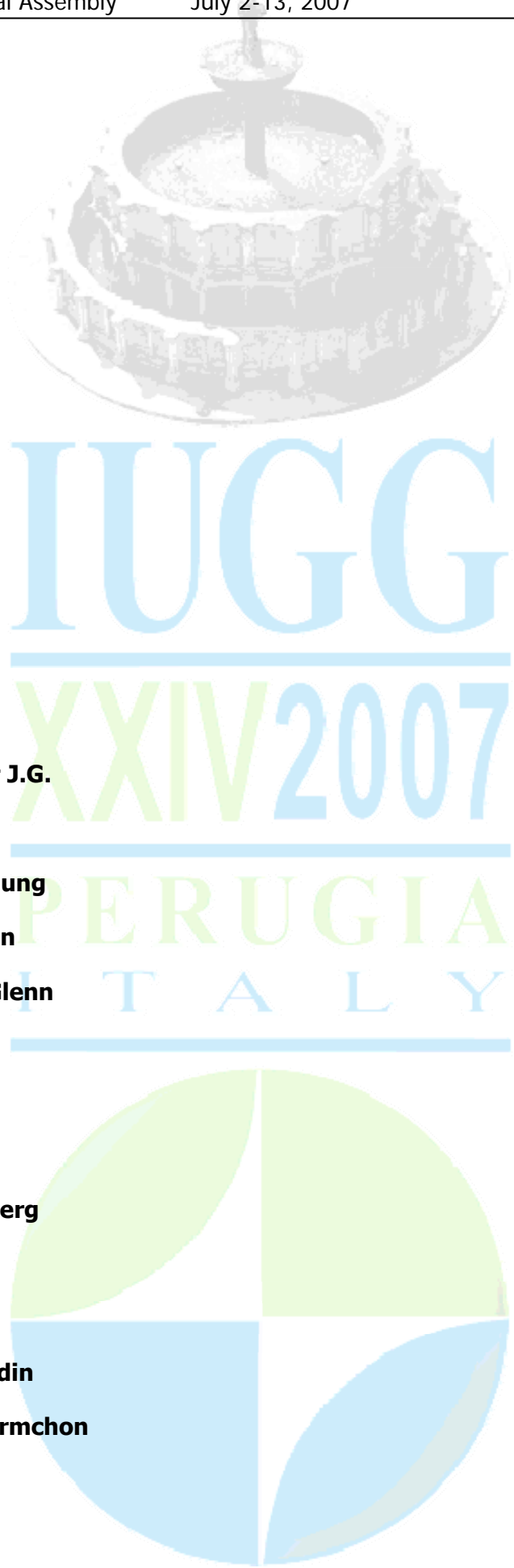
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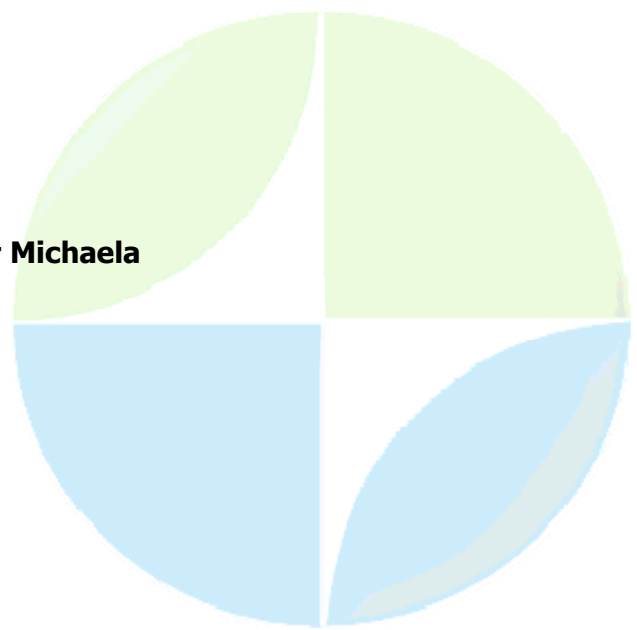
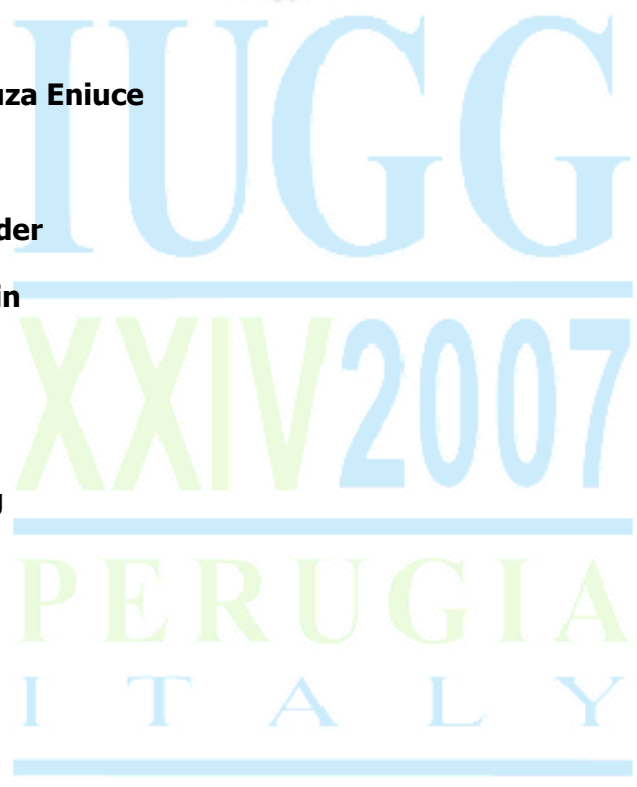
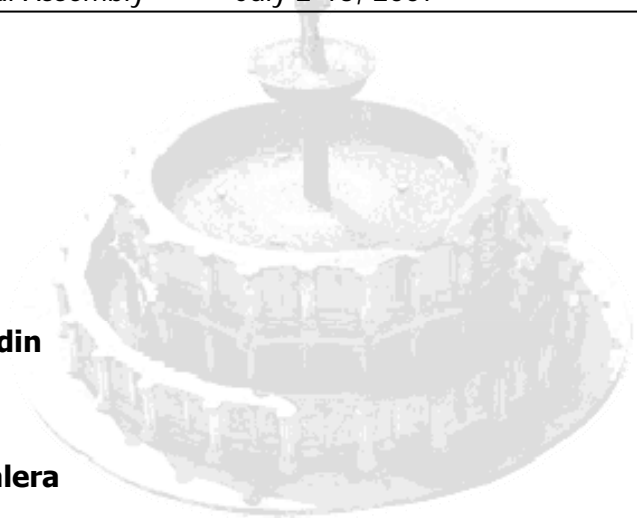
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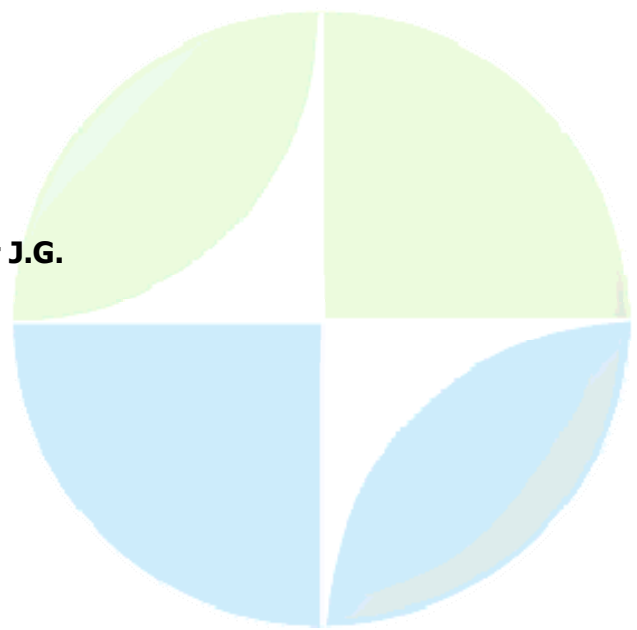
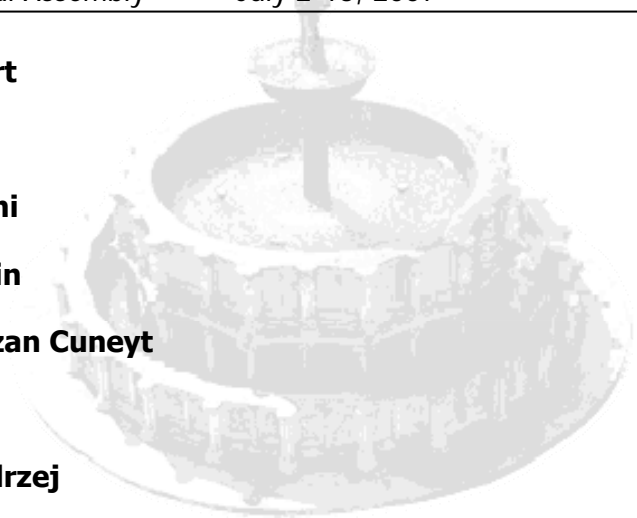
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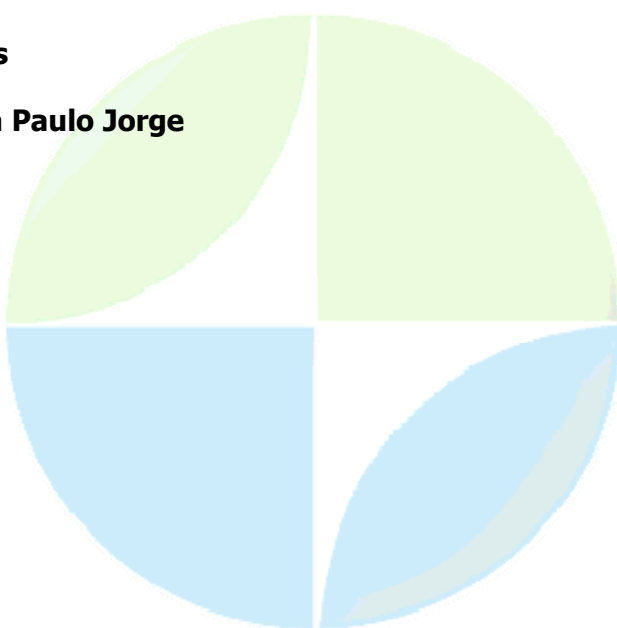


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