Perugia, Italy July 2-13, 2007

IUGG

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EARTH: OUR CHANGING PLANET

UNION SYMPOSIA

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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 Antartic 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, Scienti. c 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 codi. cation referring to a speci. c 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 **U**nion **S**ymposium; **JGW**001 is a **J**oint IA**G** **W**orkshop with IAG as the Lead Association;

MS003

is an Association (IA**M**AS) **S**ymposium. **AS III** 020 is an Association (IAG**A**) **S**ymposium sponsored by its **III** Division.

US001 Symposium (1 - 6)

Convener : Prof. Richard Peltier

Our Changing Planet (Part 1)

US002 Symposium (7 - 12)

Convener : Prof. Michael Kuhn

IGY+50 and I*Y: The International Geophysical Year 1957/58 and the international years of 2007/08

US003 Symposium (13 - 21)

Convener : Prof. Gerhard Beutler
Co-Convener : Dr. Keith Alverson

Global Earth Observing Systems

US004 Symposium (22 - 31)

Convener : Dr. Alan Thomson
Co-Convener : Dr. Vladimir Papitashvili, Mrs. Susan McLean

Digital geophysical data exchange: remote access, virtual observatories, GEOSS, and eGY

US005 Symposium (32 - 36)

Convener : Prof. Larry Esposito

Solar and planetary geophysics

US006 Symposium (37 - 44)

Convener : Prof. Daniel Schertzer

Challenges and Advances in Nonlinear Geophysics

US007 **Symposium** **(45 - 54)**

Convener : Dr. Alik Ismail-Zadeh

High-Performance Computations in Geosciences

US008 **Symposium** **(55 - 60)**

Convener : Prof. Richard Peltier

Our Changing Planet (Part 2)

US010 **Symposium** **(61 - 65)**

Convener : Prof. Guy Brasseur

Earth System Interactions

US011 **Symposium** **(66 - 80)**

Convener : Prof. Augusto Neri

Modelling and simulation of geophysical flows: present and future

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US012 **Symposium** **(81 - 95)**

Convener : Prof. Ramesh Singh

Early Warning of Natural Hazards

USSE013 **Symposium** **(96 - 96)**

Convener : Prof. Paola Malanotte-Rizzoli, Prof. Uri Shamir

Our Understanding of Climate Change

(U) - IUGG - *International Union of Geodesy and Geophysics*

US001 **1 - 6**

Symposium
Our Changing Planet (Part 1)

Convener : Prof. Richard Peltier

This Symposium is intended to initiate and provide an overview of the scientific program. The morning sessions will be devoted to invited papers and the afternoon session to contributed papers. This first part of the session (see US008) is devoted to the global change originating in the fluid envelopes of the Earth System involving the atmosphere (including the magnetosphere), the oceans, and the hydrosphere (including land ice). Topics will include trace gas induced global warming, the role of the oceans in climate variability and change, the stability of the cryospheric, etc.

(U) - IUGG - *International Union of Geodesy and Geophysics*

US001 **Oral Presentation** **1**

Solar Forcing Of Global Climate Over The Instrumental Era

Dr. Judith Lean
Space Science Division Naval Research Laboratory IAGA

The extent of industrial era surface warming attrib utable to the Sun remains co ntroversial. Similar trends of increasing solar activity and global surf ace tem peratures in t he first half of the twentieth century sugge st positive f orcing, of order 0.3 Wm-2 since 1750, according to IPC C (2001). Recent reconstructions of historical solar irradiance sugge st smaller forcing (~0.12 Wm- 2) as a result of ne w understanding of variations in Sun-like stars, cosmogenic isotopes and ge omagnetic activity, on which the earlier estimates were ba sed. Empirical studies of high fidelity global temperate da tasets provide increasingly pe rsuasive evide nce that temp eratures in the ocean, at the Earths sur face and in its atmosphere respond to s olar forcing durin g the 11- year solar act ivity cycle, even t hough general circulation models cannot simulate a climate respo nse to a cyclic decadal forcing. Parameterizations of solar irradiance and surface temperature have been derived during the past two deca des, taking into account concurrent ENSO, volcanic and anthropogenic influences. Extending the parameterizations over the instrumental era sugge sts solar-relat ed global warming of 0.1K compared with 0.7 K from anthropogenic influences. Regional effects m ay be larger, and possibly involve ENSO, the AO and other internal climate circulation modes. Solar- driven stratospheric variability is now w ell established. Subsequent strato spheric-tropospheric co upling via dynamical and radiative processes is considered a plausible mechanism for indirect so lar fo rcing of cl imate. Other pro posed indirect effects involve fluctuations in clo ud co ndensation nuclei by heliospheric nodulation of co smic rays. The relative strengths of the indirect and direct influences remain to be properly quantified.

Keywords: solar forcing, global climate

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US001 **Oral Presentation** **2**

Mass flux of high latitude land ice from GRACE lumped harmonic mascon solutions

Mr. Scott Luthcke
Planetary Geodynamics Laboratory NASA GSFC

H.J. Zwally, D.D. Rowlands, W. Abdalati, F. G. Lemoine, A.A. Arendt, S.M. Klosko

Mass changes of the Earths high latitude land based ice systems (ice sheets, caps and glaciers) are of considerable importance because of t heir sensitivity to climate change and thei r contribution to rising sea level. In recent years the ice sheets have experi enced significantly increased melt, thinning at the margins, and significantly increased discharge from many outlet glaciers. The fact that some regions are shedding mass dramatically while others are not indicates a clear need for direct measurements of mass flux with a spatial resolution that enables a ssessment of the beha vior of individual drai nage systems. Direct measurements of mass change have been made possible by the NASA/DLR Gravity Recovery and Climate Experiment (GRACE) mission. Since its la unch in March of 2002, GRACE has been producing ultra-precise i nter-satellite K -band range and rang e-rate (KBRR) me asurements enabling a direct mapping of static and time-variable gravity. Thes e data provide new opportunities t o observe and understand ice mass changes at unprecede nted tempor al and sp atial res olution. In order to improve upon the surfa ce mass flux observations derived from GRACE, we have employed unique data analysi s approaches to obtain lu mped h armonic local mass conc entration so lutions (mascon solutions) from GRACE inter-satellite range-rate measurements. We estimate the mass flux of land ice drainage systems at 10-day resolution. We have computed multi- year time series of surface mass flux for t he coastal and interior ice sheet drainage sys tems. These mascon solutions provide unprecedented observations of the seasonal and inter- annual e volution o f ice sheet mass. I n this present ation we discuss o ur analy sis techniques and the details of our lumped harmonic mascon solutions. Re sults from the application of our technique to monitoring variations in surface hydrology of the Mississippi basin and t he Indian sub-continent are also discussed as technique val idation. We present the results of our latest Greenland and Antarctica ice sheet mascon solutions fo cusing o n the seasonal and inter- annual variations as well as multi-year trends. In addition, we discuss the application o f our lumped harmonic mascon technique to studying mass flux of other land ice systems such as the Alaskan mountain glaciers. Finally, we discuss the important synergy between the high temporal reso lution direct mass flux observations made by GRACE and the high s patial resolution ice thickne ss obse rvations made by the Ice Cl oud and La nd Elevation Satellite (ICESat).

Keywords: mass flux, harmonic mascon solutions

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US001 **Oral Presentation** **3**

Arctic warmth, Greenland melting, and sea-level rise: a lesson from the past

Dr. Bette Otto-Bliesner
Climate and Global Dynamics Division National Center for Atmospheric Research

Jonathan Overpeck, Shawn Marshall, Gifford Miller

The Summary for Policymakers of the IPCC WG1 Fourth Assessment Report projects global average sea level rise at the end of the 21st century to range from 0.18 to 0.59 meters. This model-based range excludes possible future rapid dynamical changes in ice flow for Greenland and Antarctica. How much Greenland and Antarctica will add to future sea level rise has considerable uncertainty because of our limited understanding of these effects. Studying the past can provide a perspective on the sensitivity of polar ice caps to warmer temperatures. Globally, there was less glacial ice on Earth during the Last Interglacial (LIG), which lasted from about 130 to 116 kyrs ago (ka), with sea level 4 to 6 meters above present. Proxy data indicate a warmer LIG Arctic than today with greatly reduced sea ice in the coastal waters around Alaska and melting of almost all glaciers in the Northern Hemisphere. Boreal forest extended into areas now occupied by tundra in interior Alaska and Siberia. A new reconstruction from the IGBP CAPE project shows peak summer temperature anomalies 4-5C above present over much of the Arctic lands, notably in regions of the Atlantic sector. Several sites with sufficient resolution exhibit rapid warming to peak temperatures near the beginning of the LIG. The warm Arctic summers during the first half of the LIG were caused by changes in the Earths orbit and tilt, which intensified the amount of top of atmosphere solar radiation these latitudes received during the spring and summer months as compared to today. When forced with orbital forcing of 130 to 125 ka, climate model calculations show Arctic summers 3 to 5C warmer than today, especially over and near Greenland. Maximum daily surface temperatures during summer are above freezing over the entire Greenland Ice Sheet. Simulated LIG annual average global temperatures simulated by the climate models are not notably warmer than present, consistent with the orbital forcing. Ice core data indicate a large response over Greenland for the LIG with temperatures 3 to 5C warmer than today and a markedly reduced ice sheet size. Greenland ice sheet models forced with temperatures and precipitation produced by a climate model or temperature scenarios derived from data together suggest that the smaller Greenland Ice Sheet during the LIG was a steep-sided ice sheet in central and northern Greenland. Additionally, the nearby eastern Canadian icefields completely melted under LIG summer warmth. Calculations suggest that the Greenland Ice Sheet and Arctic icefields together contributed 2 to 4 meters of LIG sea level rise. Some sea level rise must also then have come from Antarctica.

Keywords: last interglacial, greenland, sea level

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US001 **Oral Presentation** **4**

Monitoring the Variability in the Atlantic Meridional Overturning Circulation at 25_N

Prof. Harry Bryden
School of Ocean and Earth Science University of Southampton IAPSO

Stuart Cunningham, Torsten Kanzow, Darren Rayner, Molly Baringer, William Johns, Jochem Marotzke, Hannah Longworth, Elizabeth Grant, Joel Hirschi, Lisa Beal, Christopher Meinen

Since March 2004 we hav e been monitoring the stre ngth of the A tlantic meridional overturnin g circulation at 2 5_N. For the fi rst time we c ombine co ntinuous measurements o f the ba sin-scale mid-ocean circulatio n using an array o f mo ored in struments deployed across the Atlantic with electromagnetic cable measur ements of Gulf Stream transport through Florida Straits and with surface Ekman transport derived fr om QuikScat satellite-based win d observ ations. M id-ocean geostroph ic transports are estimated from the first year's m oored time series using daily eastern and wester n boundary dy namic height p rofiles with th e referenc e le vel velocity chosen so that the mid-ocean transport balances the Florida Straits plus Ekman transports on a daily basis. The design of the array for monitoring basin- scale circula tion was o riginally te sted in numerical o cean circulatio n mo dels and a recent study d emonstrates that 4 indepen dently meas ured transpo rts (Gulf Stream, Ekman, intern al mode geostrophic and external mode geostr ophic time series transports) are in overall mass balance for time scales l onger than 10 days proving that the monitoring system works. Here t he moored arr ay measurements are used to describe the variabilit y in the strength and vertical structure of the southward mid-ocean return flow across 25_N that bala nces the northw ard Gulf Stream and Ekman transports. We define the variability in mid-oc ean layer transports: 0 to 800 m re presenting the southward thermocline recircu lation, 800 to 1100 m representing intermediate water, 1100 to 3000 m representing upper North Atlantic Deep Water (U NADW), and 3000 to 48 00 m representing lower North Atlantic Deep Water (LNADW). The year-long average thermocline recirculation has a tra nsport of -16.4 Sv with a standard deviation of 2.7 Sv; the intermed iate water a transport of 0.6 Sv 0.6 Sv, UNADW of -11.0 Sv 3.1 Sv, LNADW of -8.0 Sv 3.5 Sv. Such vari ability is a factor of 2 sm aller than previous estimates of the variability in basin-scale transports. The sum of Gulf Stream (mean, standard deviation of 31.7 Sv 3.3 Sv), Ekman (3.0 4.4 Sv) an d thermo cline recirculation tr ansports represents the net northward flow of warm upper layer waters; the sum of intermediate, UNADW and LNADW transports is the net southward flow of c old deep waters; togeth er the northward transport of warm upper water s and the southward transport of cold deep waters de fine the meridional overturning circulation. The mean overturning circulation defined in this way is 18.4 Sv for the period 28 March 2004 to 31 March 2005 and the s tandard deviation in this overturning is 5.6 Sv. Daily value s of thermocline recirculation, Gulf Stream and Ekman transports exhibit uncorrelated variability so they contribute about equally to the overall variability in overt urning. Notably, the basin-scale thermo cline recirculatio n has a tempo ral variability smaller than either the Gulf Stream or Ekman transports, suggesting that it should be possible to reliably observe interannual changes in the overturning with a resolution of 1.5 Sv.

Keywords: oceancir culation, climate change, monitoring system

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US001 **Oral Presentation** **5**

Global climate modeling activities in Japan

Prof. Masahide Kimoto
Center for Climate System Research University of Tokyo IAMAS

The Earth Simulator (ES), a large-scale vector-parallel supercomputer developed as a Japanese national project, has be en in operation since March 2002 and the maximum sustained speed of 35.9 teraflops did not yield the no.1 position in the TOP500 supercomputing web site for two and a half years. Than ks to this unprec edented facility together wi th research support fro m the Ministry of Educatio n, Culture, Sports, Science and Tech nology (MEXT), J apanese climate mo deling co mmunity has been able to advance their activities significantly. Some of the highlights of these advances and near-future plans will be reported in this talk. Several modeling g roups, supported by the Res earch Revolution 2002 proje ct (so-called Kyosei Project) of MEXT, have successfully finished their runs for the Four th Assessment Report (AR4) of IPCC: (1) A research consortium called K-1 project team, that consists of the Center for Climate System Research (CCSR) of the University of Tokyo, the National In stitute for Environmental Studies (NIES), and the Frontier Research Center fo r Global Change (FRCGC) of the Japan Age ncy for Marine-Earth S cience and Te chnology (JAMSTEC) has co nducted co upled atmo sphere-ocean general circulation model (AOGCM) experiments of global wa rming projection with 100 km atmosphere and 1/4 x 1/6 deg ocean, a model called MIROC (Model for Interdisciplinary Research on Climate). The high - resolution model enables more realis tic simulations, e.g., of East Asian monsoon rain band (Baiu front) and of Kuroshio and more re liable discussions on extremes and regional aspects of the global warming. The K-1 group has also used a large ensemble of medium resolution model (300 km atmosphere with 1 deg ocean) to quantify 20 th century climate change detection and attributions and adv ance understanding o n the clima te sensitivity pro blem. (2) A time-slice p rojection experiment has be en conducted by M eteorological Research In stitute (M RI) an d Japan M eteorological Agen cy (JM A) grou p using a 20 km atmospheric GCM, which can pro vide regionally detailed statistics of extreme events and high-impact weather. Future increase in str onger typhoons and elongate d hazards of p re-summer East Asian rain b and are predicted. The group a lso conducted a nested 5-km regional model experiment to discuss future changes in heavy rainfall e vents. (3) The FRCGC/CCS R/NIES group has also been developing an integrated ea rth system m odel. The MIR OC AOGCM is now coupled with terrestrial carbon cycle, stratospheric and tropospheric chemistry, and multitudes of aerosols with their direct and 1st and 2nd kinds of indirect climatic effects. A species-based ad vanced dynamic vege tation model is also being coupled with the model. An interactiv e carbon cycle experiment has i ndicated positi ve feedback of the climate-carb on cycle interaction as ha s been reported in other international efforts. (4) International c ollaborations thro ugh the ES have also be en initiated. T o name a fe w, the Central Research Insti tute for Electr ic Power Industry (C IERPI) group is colla borating with NCAR, USA to conduct an overshoot scenario experiment, and the K-1 group communicates with the UK Hadley Centre group on high-resolution modeling. (5) Another highlight of the ES climate studies is the realization of a global cloud s ystem resolving model called NICA M (N onhydrostatic IC osahedral Atmosph eric M odel), initiated by Professor Taroh Matsuno of FRCGC and le ad by Masaki Satoh of CCSR/FRCGC. The model is running at the highest reso lution of 3.5 km for studies, e.g., of multi-scale cloud organization, birth of typhoons, and climatic impact of resolved clouds etc. The second 5-yr plan of global warming projection research project has just be en initiated in 2007. Th e following subprojects will be highlighted: (i) an ensemble near-term (~30-year) prediction with a hi gh-resolution AOGCM with initializati on by the 20th century climate observations, (ii) a full-car bon cycl e scenario experiments with an integrated earth system model, and, (iii) a very high-resolution time slice experiment with a 20 km global AGCM and a nested 1 km regional model. I n all the above projec ts, quantification and r eduction of uncertainties are

emphasized and various impact assessment models are coupled with the climate models in order to provide more quantitative outlook to policy makers and to the public.

Keywords: earth simulator, es

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US001 **Oral Presentation** **6**

Observing and understanding present-day sea level rise : a review

Dr. Anny Cazenave
Earth sciences geodesy IAG

Measuring sea level change and understa nding its causes has impro ved co nsiderably in the recent years, essentia lly because ne w in situ and r emote se nsing data sets hav e become avai lable. Here we report on the current knowledge of present-day sea level change. Since early 1993, sea level variations are accurately measured by Topex/ Poseidon satellite altim etry, complem ented for the r ecent years by Envisat and Jason-1 data. This ~14 year-long data set indicates that, in terms of global mean, sea level is presently rising at a rate of ~ 3.3 +/- 0 .4 mm/yr, a value significantly higher than the mean rate recorded by tide gauges during the past 50 years (on the order of 1.8 +/- 0.3 mm /yr). This eventually suggests that sea level rise is currently accelerating due to enhanced land ice melting and/or increased ocean warming. Owing to its near global coverage, altimetry also reveals high regional variability in the rates of sea le vel change, with some regions exhi biting rates of 5-10 ti mes the global mean. Quasi-global ocean temperature data sets allow quantitative estimate of one of the two major contributions to present-day se a level rise : t hermal expans ion. Resu lts indicate that for the past 50 years, thermal expansion accounts for ~0.4 mm/yr sea level rise, i. e., 25% of the observed rise. For t he recent years (1993-2003), enhanced thermal expansion accounts for 50% of the obser ved sea level rise (1.5 mm/yr of 3 mm/yr). For both periods (last 50 years and last decade), there is ~1.5 mm/yr global mean residual not explained by thermal expansio n, and thus attrib uted to water mass exchange wit h the continents and land ice. Mountain glaciers mass balan ce studies report a ~1 mm /yr contribution to sea level r ise over the 1990s. Mass balance of Greenland and Antarctica ice sheets have been the obj ect of intensive studies in the recent years. Results indicate a net mass loss for Greenland corresponding to ~0.3 mm/yr sea level rise since 1992. In Antarctica, the eastern part is slightly gai ning mass while mass loss i s observed in the western part of the continent. As a result of this near balance state, Antarctica currently contributes negligible to present-day sea level ri se (by ~0.1 mm/yr). Preliminary r esults based o n GRACE indicate that the contribution of terrestrial waters to sea level rise is ~0.2 mm/yr for the recent years. Thus the sum of cli mate-related c ontributions a gree well (within the error bars) with the altimetry-based rate of sea level rise. We also discuss new perspectives offered by GRACE for measuring the ocean mas s component to sea level ris e as we ll as t hermal expansion by combining GRACE dat a over the oceans with satellite altimetry.

Keywords: sea level, altimetry, satellite

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US002 **7 - 12**

Symposium
IGY+50 and I*Y: The International Geophysical Year 1957/58 and the international years of 2007/08

Convener : Prof. Michael Kuhn

The International Geophysical Year has meant remarkable progress to the scientific disciplines represented in IUGG. The polar regions, the deep oceans, the earths interior, its atmosphere and the space beyond were explored at an unprecedented rate. New technologies like satellites and computers facilitated measurements, data collection and analysis and were applied in a global effort and with an extraordinary station density. The seven Associations and the Commission of Cryospheric Sciences of IUGG are invited to give an overview over the accomplishments in their fields during IGY and in the 50 years since. The anniversary of IGY is commemorated by four international years (I*Y): The International Polar Year, the Electronic Geophysical Year, the International Heliophysical Year and the International Year of the Planet Earth are invited to highlight their activities for 2007 and 2008. This symposium will consist of invited talks, which will be supplemented by extensive posters. It is closely related to U.03, U.04 and IDCH.01 of IAGA

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US002 **Oral Presentation** **7**

eGY - Towards an Earth and Space Science Information Commons

Dr. Barton Charles
IAGA

Daniel Baker

The Electronic Geophysical Year, 2007-2008 (eGY) provides a cooperative international framework for developing the sharing of data and information about our planet and geospace. eGY adopts and extends the ideals of IGY, when the foundations of a global geoscience information commons were created. Fifty years after IGY, the need for information and understanding about the Earth have become more acute, our ability to collect data has mushroomed, and we have the power of modern information and communications technologies at our disposal. Several Earth and space science informatics initiatives are already underway, such as GEOSS, AGUs Earth and Space science Informatics, GSAs Geoinformatics Division, CODATAS Global Information Commons for Science, and IUGSs Commission for Geoscience Information are responding to this opportunity. It is fitting that the 50-year anniversary of IGY be used to strengthen cooperation between such initiatives in a joint effort to address the issues of ready and open access to data, information, and services, including data discovery, data release, data preservation, data rescue, reducing the digital divide, and education and public outreach.

Keywords: electronic geophysical year

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US002 **Oral Presentation** **8**

The Earth's radiation belts: history and future prospects

Dr. Daniel Baker
IAGA

This lecture describes the structure and underlying physics of the Earth's radiation belts. The presentation will provide a brief history of the discovery of the Van Allen belts and will discuss the evolution of the theoretical understanding of the inner and outer radiation zones. Modern observations of trapped particle enhancement events and loss processes will be presented. Current issues in radiation belt physics such as acceleration mechanisms, wave-particle interactions, magnetosphere-atmosphere coupling, and ring current control of magnetic field properties will be addressed. The lecture will include a brief description of the Radiation Belt Storm Probe (RBSP) mission of NASA's Living With a Star (LWS) program and related international missions. We will describe outstanding key questions and methods proposed by current programs to obtain scientific closure on these persistent questions and issues.

Keywords: radiation belts, particle acceleration, space weather

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US002 **Oral Presentation** **9**

Is it still the same old Antarctic ice sheet? A look back at Antarctic glaciology since the IGY

Dr. Robert Bindschadler
Code 614 NASA GSFC

The earliest polar explorers collected scientific data despite the incredible hardships they had to endure. A notebook with a few drawings or a few rock specimens became rare and treasured archives of scientific information. The IGY opened up the modern era of Antarctic science with the first surface traverses expressly conducted for scientific data collection. Yet data were still hard won. Much of this tradition has continued with a sustained series of scientific studies supported by an increasing number of national polar programs. This is no more evident than in the field of glaciology. Despite five decades of work, the basic objectives of characterizing the shape and motion of the Earth's largest ice sheet remain unfinished. This fact reminds one of the harsh and unyielding environment with which Antarctica protects her secrets. The single most significant factor that has transformed the field of Antarctic glaciology is arguably the ability to launch satellites in orbit around the Earth. Satellites have carried a wide array of ever more sophisticated sensors that pass above the vast ice sheet every 90 minutes. The vast data sets collected from space have revolutionized Antarctic glaciology but have only expanded the wealth of discoveries made by glaciologists, many of whom now can make their discoveries in comfortable laboratories warmed by computers far from the biting winds that still howl across the Antarctic plateau. The newest revelations of the ice sheet highlight a dynamic character that was never dreamed of by its first explorers. The most recent changes add a new urgency to the task of Antarctic glaciologists to understand the workings of the ice sheet so that its role on our planet and its effect on everyone's life can be constructive.

Keywords: glaciology, ice sheet

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US002 **Oral Presentation** **10**

Data for the Ages--A look at datas role in science over the 125 year history of IPY

Mr. Mark Parsons
National Snow and Ice Data Center University of Colorado IAGA

Ruth Duerr, Ronald S. Weaver, Vladimir Papitashvili

2007 marks the beginning of the fourth International Polar Year--125 years after t he first IPY and 50 years after the third Polar Ye ar which grew to beco me the International Geophy sical Year. IGY. Du ring the 75 years of the first three Polar Years science evolved, but the means for recording, preserving, and distributing data remained lar gely unchanged. For centuries if not millen nia the means to record and store data was to write them down. To access the data one had to gain a physical copy, view it, and interpret it. Th e large scope and major advances of IGY hinted at the beginning o f a new paradigm. Some (but little) data were in digital form and a distributed data manag ement system--the World Data Center system--was established. Since IGY, science has se en many fundamental changes, but perhaps the most swee ping change is the growth of digital data and electronic n etworks such as the internet and world wid e web. The da ta collected du ring the cu rrent IPY will dwar f all the previous IPYs in both volume and complexity. This presents new chalIenges in data management and preserv ation that both IPY and eGY are seeking t o address. This presenta tion will review the current approach to IPY management in co ntrast to past IPY s, especially the IGY. We will discu ss how modern and rapidly evolving technologies are improving data access and integration; how data preservation may be a larger challenge than ever; and how politica l issues such as free and open a ccess to data continue to play a large role. The success of IPY will largely be measured by what data are available now and long into the future.

Keywords: igy, digita data

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US002 **Poster presentation** **11**

The russian WDCS for solar-terrestrial physics and solid earth physics today

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World Data Center for Solid Earth Physics Geophysical Center

Kharin Evgeny, Zabarinskaya Ludmila, Krylova Tamara

Already it is 50 years that the World Data Centers provide information on data set to the scientists and others with interest to geophysical science. The Centers fulfill the important functions such as geophysical data acquisition, storage and distribution on the underlying principles of long-term retention, assurance of the quality of scientific data, and provision of free and open access to data for scientific research. The rapid advances in digital technologies and networks involves the Russian WDCs for Solar-Terrestrial Physics and Solid Earth Physics in changes of their activity which was associated with the addition of new functions, change of technical equipment, use of new methods, techniques and approaches of data management and putting data into accordance with them. The Centers introduce the network technologies into their activity and realize the remote access to their information resource in the Internet. Since 1995 the Centers have own Web-site and provide the free access to digital data, metadata, thematic and problem oriented database on seismology, gravity, heat flow, geomagnetic field, Solar activity, ionosphere, cosmic rays and so on. Special user interface is developed to provide comfortable means for finding, reviewing, visualization, and selection data in net and assignment them to user. The Centers participate in International Polar Year 2007-2008 and accomplish the project of the Russian Academy of Sciences "The information support of geophysical researches at carrying out of The International Polar Year". The special web-site "IPY 2007-2008" is created on WDC server where geophysical data for polar areas of the Earth accumulated in the Center archives from IGY up till now are presented. A major portion of old data was converted from non-computer form into digital form or images. New data from the geophysical stations and results of specialized expeditions and experiments of IPY will be exposed on this web-site.

Keywords: world data center, geophysical data, international polar year

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US002 **Poster presentation** **12**

Activities at the world data center for geomagnetism, Mumbai

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Indian Institute of Geomagnetism IIG IAGA

Mahendra Doiphode, A. Bhattacharyya

The importance of the metho d of data archi val and its contributions in extrac ting valuable information was realized as far back as 17th century. Indias participation in the study of the earths magnetism dates back to the pe riod 1834-1841, when the cou ntry joined the Gottingen Ma gnetic Union which organize d simultaneous magnetic observations at 50 stations over the globe. WDC -C2, Bombay was established at the Indian Institute of Geomagnetism (IIG) in 197 1 follow ing the recommendation from the International Union of Geodesy and Geophysics and s ubsequently from Indian National Committee for Solar-Terrestrial Physics. Long term ground magnetic observations from the equatorial and low latitud e observatories have contributed extensively in studies of the secular variation of the main field produced by the geodynamo operating in the fluid outer core of the earth as well as in understanding the nea r and far space environment of the earth. Col aba - Al ibag magnetic records taken together form a long series of data consisting of p hotographic records from 1871 till date an d digital data f rom Alibag sin ce the inception of INTERMAGNET. Co laba - Alibag Ma gnetic Observator y data series consists of the observations at Alibag (Geog. Long. 7249E, Lat. 185 N) since 1905, in continuation of the earlier series of Observations at Colaba (Geog . Long. 7252E , Lat. 1838N) during 1841 to 190 4. Full-fledged functioning of the World Data center for Geomagnetism in India (WDC - Mumbai) started at IIG in early nineties under the reco mmendation of the Internatio nal Council of Scien tific Unions and the Panel o n World Data Centers. To start with, the acti vities at the Center were updated with the assistance of WDC-A for Solar-Terrestrial Physics, Environmental Data Service, NOAA, Boulder. In the recent past the center has made considerable progress by updating the technical and computational facilities to support the data archival and retrieval system by using modern co mputer techno logies. Procedural step s involved in modernizing the center to bring it at par with the WDC standards shall be discussed.

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US003 **13 - 21**

Symposium
Global Earth Observing Systems

Convener : Prof. Gerhard Beutler
Co-Convener : Dr. Keith Alverson

Global Earth Observation Systems and Strategies are of vital importance for virtually all associations working under the auspices of IUGG, which has adopted in the past several resolutions underlining the importance of Earth monitoring systems (IUGG Resolution No. 1, 1999, IUGG Resolution No. 3, 2003). The importance of developing global observing strategies is recognized, as well, by IGOS, the Integrated Global Observing Strategy working under the auspices of UNESCO, and GEO, the Group on Earth Observations designing its GEOSS (Global Earth Observation System of Systems), which is supported on the government level by about sixty countries. The symposium shall give an overview of all major international developments, as well as those within the IUGG associations. Follow-up symposia addressing specific issues associated with global observing systems will be organized by the IUGG Associations.

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US003 **Oral Presentation** **13**

The Earth Explorers of ESAs Living Planet Programme

Dr. Mark Drinkwater
Earth Observation Programmes Directorate European Space Agency IAG

Since the launch of ERS-1 some fifteen years ago, ESA has become a major provider of Earth-observation data to the Earth-science community. This has resulted in significant progress in a broad range of scientific areas, which also forms the basis for the development of new applications. This has been achieved mainly through exploitation of the ERS and Envisat satellites. When ESA established its Living Planet Programme in the mid-1990s, a new approach to satellite observations for Earth science was initiated, with focussed missions defined, developed and operated in close cooperation with the scientific community. A comprehensive strategy was formulated for the implementation of the Programme, which has resulted in the selection of six Earth Explorer satellite missions covering a broad range of science issues. At the Ministerial Council meeting in Berlin in December 2005, ESA Member States reconfirmed their commitment to the concept of the Living Planet Programme by funding the third phase covering the period 2008-2012. In addition to this, they approved the initiation of the Global Monitoring for Environment and Security (GMES) space component, in close cooperation with the European Commission. Although this programme is designed to provide data that underpin operational services, it will also contribute significantly to Earth science, in particular through the collection of long time series of observations. In turn, the Earth Explorers will provide new understanding that paves the way for new operational services: in this sense, the Living Planet Programme comprises complementary elements of research and operations. This synergy has long been demonstrated by the development and scientific exploitation of meteorological satellites, which continues to be an important part of the Living Planet Programme. This paper will describe the scientific context and primary objectives of ESAs approved Earth Explorer and GMES Earth Watch missions, and describe the present status of their development, and outline their scientific benefits.

Keywords: esa living planet, gmes

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US003 **Oral Presentation** **14**

Systematic ocean observations - revolutions past and yet to come

Dr. W John Gould
IAPSO

Since the mid-1980s there has been a revolution in our ability to observe the ocean s in a systematic fashion. Paradoxically the new generation of earth observing satellites (and particularly the satellite altimetry from Topex-Poseidon and ERS-1 in the early 1990s) provided the catalyst for new global-scale in-situ observations. The presentation will describe developments since that era, including:- the tropical moored arrays enabling ENSO predictions, the subsurface profiling using expendable probes and the from Argo's fleet of autonomous floats that are a key element in understanding the mechanisms and impacts of climate change, the fleet of surface drifters and their atmospheric pressure sensors. It is only when combined with earlier measurements such as those from the IGY, and from WOCE and with the records of sea level dating back to the 19th century that much of the value of the new generation of measurements is realised. The presentation will conclude with remarks on the challenges that remain and opportunities that are presented through sustained and systematic ocean observations..

Keywords: ocean observation

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US003 **Oral Presentation** **15**

An integrated, operational global ocean observing and hazard warning system

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The Global Ocean Observing System (GOOS) has been in existence for over a decade. During this first decade, GOOS has been primarily engaged in planning observational strategies and developing the international governance structures required to facilitate multi-national ownership and development of the system. The most important challenge now facing GOOS is to complete and sustain an integrated, global system with clear user benefits. Substantial progress has been made, with more than 50% of the in-situ open ocean observing system for climate already in the water, including buoys, moorings, floats, tide gauges and repeat hydrographic lines. Real time, operational warnings for tsunamis and other ocean hazards such as storm surges, based on this GOOS observational backbone, are now widely available as clear societal benefits. However, despite progress substantial challenges remain. Broadly speaking, the oceanographic research community is neither ensuring their observations fully contribute to, nor that their research fully benefits from the sustained, operational system. At the same time, current levels of national governmental contribution to the system, and existing mechanisms for coordinating these contributions, are insufficient. New modalities for both increasing research community participation and governmental commitments will be presented. The talk will begin with a brief overview of the status of the global ocean observing system, then highlight milestones achieved and conclude with an overview of key future challenges.

Keywords: observation systems

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US003 **Oral Presentation** **16**

Coordination between In-Situ Global Observing Systems in the Seismological Community

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IASPEI

T. Ahern, R. Butler, B. Dost, J. Lyons, S. Tsuboi

Earthquakes are the expression of the continuing evolution of the planet Earth and occur everywhere on the globe. Monitoring and understanding the earthq uake processes and mitigating their effects ar e global priorities. Seismological observations started 150 years ago, and today earthqu akes are recorded globally by over 20,000 short-period , b roadband and strong-motion permanent seismic stations operated by hu ndreds of n etworks an d observatorie s, pre senting a complex mosaic with a mlange of instrumental strategies and data distribution a pproaches. These observa tories analyse and exchang e data with the key objective of monitoring the seis mic activity and the earthquake hazard. The s ame data also provide the primary input for earthquake st udies and investigations of the Eart hs structure to the global seis mological and geop hysical community. Seismo logy pro vides a key in- situ co mponent of the Global Eart h Observing System of Systems (GEOSS). International seismology has a lo ng history of data sharing between various in-situ networks and it is a traditio n that continues to be strengthened as time advances . Since the mid-1990s much of the gl obal coordination has taken place within the International Federation of Seismographic Networks, the FDSN. The FDSN has commission status within the International Association of Seis mology and Physics of the Earths Interior (IASPEI). The FDSN plays a key role in the coordination of the installation of observatories as well as in coordinating the exchange of seismic data across the g lobe. The glob al coverage of seismic netw orks is organized in a multiple geographic level: local, regional and national. In addition, several programs in seismology deploy networks on a global scale or at least on a very large regional area extending well outside a single national boundary. Examples of these national efforts include: IRIS/USGS Global Seismographic Network or GS N (US), GEOSCOPE (Fr ance), GEOFO N (German y) and Pacific-21 (Japan). A key aspect of th e global seismological infrastructure is the availability of data, often in real-time. FDSN Data Centers work closely together to develop, maintain and operate distributed data s ystems that allow seamless acces s to the many terabytes of data collected by th e in-situ seismologi cal observing networks. This infrastructure for the collection, archive and distribution of information collected from this very extensive system of in-situ observing systems is a global GE OSS resource. The value of the open-data approach has bee n proven also in global and re gional tsunami warning sys tems. Future challenges i n seismological monitoring are to ˜Construct a true pan-global cyber-infrastructure to serve the needs of the scientific a nd mo nitoring communities ˜Netwo rk the main partners in seismo logy from the user s and infr astructures communi ties to facilitat e cross- disciplinary fertilizations and a wi der sharing of knowledge ˜Expand global seismologi cal coverage from land to the sea floor ˜Develop a unified portal system to provide remote access to all class es of seismological data ˜Foste r the development of the next generation of tools and sensors for future inst rumental observations ˜Invest in capacity building and technology transfer to ensure the acces s to mo dern technologies for infrastructures and the larger scientific com munity across the globe ˜Develop strate gies to ensure long-ter m sustainable monitorin g and access to seismological infrastructures and data.

Keywords: seismology, in situ observations

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US003 **Oral Presentation** **17**

The Global Geodetic Observing System (GGOS)

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Ruth Neilan, Hans-Peter Plag

The Global Geodetic Observing System (GGOS) has been established by the International Association of Geodesy (IAG) in July 2003. In April 2004 the IAG, represented by GGOS, has become a participating organization of the Group on Earth Observation (GEO) and in May 2006 GGOS was accepted as a member of the Integrated Global Observation Strategy Partnership (IGOS-P). GGOS is the contribution of geodesy to a global Earth monitoring system. In particular, it provides the metrological basis and the reference systems and frames, which are crucial nowadays for all Earth observing systems. GGOS is built on the IAG Services (IGS, IVS, ILRS, IDS, IERS, IGFS,) and the products they derive on an operational basis for Earth monitoring making use of a large variety of space- and ground-based geodetic techniques such as Very Long Baseline Interferometry (VLBI), Satellite and Lunar Laser Ranging (SLR/LLR), Global Navigation Satellite Systems (GNSS), Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS), altimetry, InSAR and gravity satellite missions, gravimetry, etc.. All these observation techniques are considered integral parts of GGOS, allowing the monitoring of the Earths shape and deformation (including water surface), the Earths orientation and rotation and the Earths gravity field and its temporal variations with an unprecedented accuracy. These quantities are direct evidence of many global processes that have a crucial impact on human society such as earthquakes, volcanism, floods, sea level change, climate change, ground water redistribution, mass balance of the polar ice sheets, etc. GGOS, alrready now, is more than just an observing system. Its future vision and goal is the development of a complete and consistent chain of innovative technologies, methods and models in order to understand global change processes and the dramatic effects they may have on the human habitat. This framework will range from the acquisition, transfer and processing of a tremendous amount of observational data to its consistent integration and assimilation into complex numerical models of the Earth system (including solid Earth, oceans, atmosphere, hydrosphere, cryosphere and the interactions thereof). This can only be achieved by an international effort and a close, multidisciplinary cooperation with groups working in related fields such as geodynamics, geophysics, oceanography, hydrology, glaciology, meteorology, and climatology. This presentation will introduce GGOS and its essential contributions to an integrated Earth monitoring, to the assessment of natural hazards and the development of early warning systems.

Keywords: geodesy, earth observation

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US003 **Oral Presentation** **18**

Platforms and data for a detailed mapping of the geomagnetic

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Systematic observations of the geomagnetic field exist for almost two hundred years, providing information about its morphology and time-evolution. Time variations are revealed by continuous magnetic records, monitored by geomagnetic observatories where the permanent installation of instruments ensures reliable measurements of the geomagnetic field. Additionally, so-called magnetic repeat-station measurements are regularly made at particular locations and distinct times to resolve the secular variation in specific areas. Aeromagnetic surveys provide the detailed pictures of magnetic anomalies, but generally confined to quite limited regions, thus lacking the large-scale parts of the lithospheric field. In addition, new satellite measurements, being made continuously since 1999 (Orsted, SAC-C, CHAMP), are greatly improving our knowledge of the geomagnetic field all over the globe. To map the geomagnetic field and both its spatial and temporal variations, it is essential to obtain high-accuracy, high-resolution data. Measurements from different platforms must be jointly used to achieve this. However, considerable difficulties exist in carrying out joint analyses of various platforms data due to their different spatial and temporal information content. In this contribution a few examples of different ways to take advantage of the combination of these measurements are given, with a special emphasis on a new World Digital Magnetic Anomaly Map, produced under the auspices of UNESCO.

Keywords: magnetic anomaly, observation

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US003 **Oral Presentation** **19**

Understanding sea level rise and variability

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Executive Committee IAG Member IAG

Thorkild Aarup, John Church, Stan Wilson, Phil Woodworth

The World Climate Research Program (WCRP) convened a workshop to identify the uncertainties associated with past and future sea level rise and variability, and to determine the research and observational activities needed for narrowing these uncertainties. The Workshop on Understanding Sea-level Rise and Variability was hosted by the Intergovernmental Oceanographic Commission (IOC) of UNESCO in Paris June 6-9, 2006 bringing 163 scientists from 29 countries together. This group encompassed all relevant scientific expertise with a view towards identifying the uncertainties associated with past and future sea-level change, as well as the research and observational activities needed for narrowing these uncertainties. The workshop helped develop international and interdisciplinary scientific consensus for the observational requirements needed to address these issues. Achieving this consensus was an objective of the workshop as a contribution to the Global Earth Observation System of Systems (GEOSS) 10-Year Implementation Plan. A workshop summary was recently printed in EOS, Vol. 88, No 4, 23 January 2007. An important workshop theme in the context of this IUGG session is the need for continuity and improvement of in situ and space-based observing systems, with an emphasis on open data policy and timely, unrestricted access to information. The importance of geodetic techniques to provide the reference frame for linking these collective observations was emphasized. This presentation will focus on the synthesis of the workshop, the resulting recommendations, and next steps. The complementary relationship of this workshop to the Intergovernmental Panel on Climate Change (IPCC) will also be addressed.

Keywords: sea level rise, earth observations

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US003 **Oral Presentation** **20**

GEOSS: The Global Earth Observation System of Systems

Prof. Jos Achache

GEO, the Group on Earth Observations is leading a worldwide effort to build a Global Earth Observation System of Systems, GEOSS, over the next 10 years. GEO involves 68 Member Countries, the European Commission, and 46 international Participating Organizations. The vision for GEOSS, articulated in the 10-Year Implementation Plan, stems from an emerging global scientific and political consensus: the assessment of the state of the Earth requires continuous and coordinated observation of our planet at all scales. Consistently, GEO has initiated a series of actions to improve monitoring of the state of the Earth, increase understanding of Earth processes, and enhance prediction of the behavior of the Earth system. GEOSS is designed to enhance delivery of benefits to society in nine areas: Disasters, Health, Energy, Climate, Water, Weather, Ecosystems, Agriculture, and Biodiversity. The rationale for taking a cross-cutting approach in building GEOSS is guided by the potential for synergies. Indeed, many observations are relevant to different societal benefit areas. For instance altimetry-derived observations have benefited geodesy, oceanography, hydrology, climatology, and ice-sheet monitoring and even tsunami detection. Maps of topography or land cover and land use, or even a geodetic reference frame for Earth observations represent products of common interest to most societal benefit areas. At the same time, most societal benefit areas are interdependent. Weather and climate changing patterns for instance have important implications for many areas, including human health, water availability, food security, and energy management. Building GEOSS will require the development of scientific research and will stimulate the development of operational products, services and tools. It will, in particular, facilitate the transition from research to operations of observing systems and techniques and enable partnerships between research and operational communities. GEO will also provide open and easy access to data anytime and anywhere. Indeed, the societal benefits of Earth observations cannot be achieved without data sharing. GEOSS will help ensure that the quality data required by users reaches them in a timely fashion and in an appropriate format. There will be full and open exchange of data, metadata, and products shared within GEOSS, recognizing relevant international instruments and national policies and legislation. Finally, GEO will have to facilitate substantial capacity-building efforts in human resources, institutions and observational infrastructures, particularly in developing countries.

Keywords: geo, geoss

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US003 **Oral Presentation** **21**

Global hydrological data - still a major challenge

Dr. Arthur Askew
President International Association of Hydrological Sciences IAHS

The study of hydrological processes has always been linked closely with the practice of water management, leading to a focus on the individual river basin or aquifer as the basic hydrological unit. The compilation of comprehensive data sets at this scale faces a major problem where, as is often the case, the water bodies concerned are under the control of a number of different national agencies and even several countries, each jealously guarding their right to monitor their own water resources. Any attempts to compile global sets of hydrological data face problems orders of magnitude greater. Nevertheless, from a slow start in the 1960s, considerable progress has been achieved, especially in the last 20 years, and a number of global data sets now exist. This has been spurred on by the need for international co-operation in the management of shared water resources, the need to reduce the ever-growing impact of large floods and, more recently, the realization that the hydrological cycle is a major component of important global processes which can only be fully understood when global sets of hydrological and related data are available for use in inter-disciplinary studies. The challenge remains, however, to convince the national agencies concerned that they have a global responsibility and real self-interest in collecting such data and making them available to the scientific community.

Keywords: hydrological data, global

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US004 **22 - 31**

Symposium
Digital geophysical data exchange: remote access, virtual observatories, GEOSS, and eGY

Convener : Dr. Alan Thomson
Co-Convener : Dr. Vladimir Papitashvili, Mrs. Susan McLean

There is a growing requirement for common data logging techniques, digital capture, exchange and integration of data sets across geophysical disciplines. The Electronic Geophysical Year (www.eGY.org) and the Global Earth Observation System of Systems initiatives offer modern approaches to remote data access, integration and management. This session focuses on the technology and tools, such as spatially enabled databases, Web-accessible open geographic information systems, common scientific lexicons and virtual data centers, which improve the discovery, browsing, visualization, and integration of geographically dispersed scientific data. The session will analyze trends towards the establishment of virtual observatories and networks and activities supporting the goals of the eGY and GEOSS.

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US004 **Oral Presentation** **22**

Integrating Ocean Observing Systems

Dr. Luis Bermudez
Research and Development Monterey Bay Aquarium Research Institute

The earth- and ocean-science comm unities are developing the concept of a "system of systems" for observing our planet. To achieve an integrated in teroperable Global Ea rth Ocean Observing System, standardization of s ome kind is needed. One challe nge is that we already have many standards that address data-encoding formats, content me tadata, transport prot ocols and controlled vocabularies. To help adv ance the orchestration of stan dards an d the creation of best practice, end-to-end interoperability test beds are essential. Two gra ss roots community initiatives, the Marine Metadata Interoperability (MMI) Project and OpenIO OS, have al igned their interoperability test beds to form OOSTethys. Within OOSTethys, system compo nents like 'data pro vider', 'data aggrega tor', 'mediato r' and 'registry' have been de fined. Standards that support interfacing between these components have been identified and tested for ocean observ atories and observing systems. In th is presentation we will provide an overview of OOSTethys and disc uss the va lue for ocean observations of n ear-real-time data exchange and presentation. I n particular, this talk w ill present our ex periences developing applications that support the Open Geo spatial Consortium (OGC) Sensor Observation Service, and using controlled vocabularies encoded with World Wide Web standards.

Keywords: oservation, near real time data exchange

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US004 **Oral Presentation** **23**

NASA'S VO program for integrating space and solar physics data

Dr. Charles Holmes

Joseph Bredekamp, Aaron Roberts

A modern data policy governing NASA's Heliophysics Data Environment has been developed. We are evolving today's environment of existing services in order to take advantage new computer technologies and at the same time respond to our evolving space mission set and community research needs. The environment will continue to be distributed and at the same time we are building data integration capabilities through the creation of discipline-based virtual observatories. Starting in 2001, NASA sponsored the development of the Virtual Solar Observatory (VSO) and the Virtual Space Physics Observatory (VSPO). Drawing upon the successes of these projects, NASA selected in 2006 five new 'VxOs' spanning the heliosphere, the Earth's magnetosphere and radiation belts, and ITM regions. These projects are now underway. This paper will introduce the family of NASA's VxOs, their attributes, data sources, and communities served. There are two overarching governing principles: the HP data environment requires data sources open to the broad research community and science participation is important in all levels of data management. NASA HQ is leading the implementation of the new features to the Heliophysics Data Environment which blends 'bottoms-up' implementation approaches with a 'top-down' vision for an integrated data environment. The roles of these principles, NASA's vision for building an integrated while distributed environment and the processes for capturing new technologies will be discussed.

Keywords: virtual observatories, solar and space physics data, space science data

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US004 **Oral Presentation** **24**

GEOSS: the global, virtual observatory

Prof. Jos Achache

GEO, the Group on Earth Observations is leading a wo rldwide effort to build a Global Ear th Observation System of Sys tems, GEOSS, over the next 10 year s. The vision for GEO SS stems from an emerging global scientific and political consensus: the assessm ent of the state of the Earth requi res continuous and coordin ated observation of ou r plan et at all scales. As a sustainable, com prehensive a nd coordinated observation "system of systems," GEOS S will work with an d build upon ex isting n ational, regional, and international sy stems to provide compre hensive, coordinated Earth o bservations – in situ, airborne & spa ce-based - from thousands o f instruments worldwide, transforming the data they collect into vital infor mation for soci ety. GEOSS is designed to enhance delivery of benefits to society in nine areas: Disasters: Reducing loss of life and property from natural and hum an-induced disasters, Health: Understanding enviro nmental facto rs affecting hum an health and well-being, Energ y: Improving management o f energy res ources, Climate: Unde rstanding, assessing, predicting, mitigating, and adapting to climate variability and change, Wate r: Improving water- resource manage ment thro ugh better underst anding o f th e water cycle, Weather: Impr oving weather info rmation, fo recasting, and warning, Ecos ystems: Improving the mana gement and protection of terrestrial, coastal, an d marin e ecosystems, Agriculture: Supporting sus tainable agriculture and c ombating desertification, a nd Biodiversity: Understanding, monitoring, and co nserving biodiversity. G EOSS expressl y intends to address the need for improving in situ observation ne tworks and facilitating their integration with other observation systems. This is reflected thro ughout the 10-Year Plan and in GEO annual work plans. For example, the 1 0-Year Plan m akes a strong commitment to improving in situ hydrological observations, as well as e cosystem and biodiversity ob servations: "In situ networks and the automation of dat a collection will be consolidated, and the capacity to collect and use hydrological observations will be built where it is lacking . . . Ecosystem observations wi ll be better harmonized and shared and in situ data will be better integrated with space-based observ ations . . . Implementing GEOSS will unify man y disparate biodiversity-observing systems . . . taxonomic and spatial gaps will be filled, and the pace of information co llection and dis semination will be in creased." The GEOSS architecture elements will be presented: registries, clearinghouse, Web Portal . These elements are designed to guarantee the interoperability of systems contributed to GEOSS, as well as the h armonization of the information the y will provide. They will be des igned to provide the ab ility for GEOSS to e volve with future technologies and new user requirements. Most critically, achieving the vision of GEOSS will require GEO to implement new concepts of observatories, such as Virt ual Constellations in space and intelligent networks in situ. These will also be discussed.

Keywords: virtual observatory, geoss, geo

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US004 **Oral Presentation** **25**

The earthscope plate boundary observatory distributed data management system

Dr. Greg Anderson
Plate Boundary Observatory UNAVCO IAG

Mike Jackson, Chuck Meertens

EarthScope is an ambitious, multidisciplinary project funded by the United States National Science Foundation to explore the structure and dynamics of the North American continent. The Plate Boundary Observatory (PBO) is EarthScope's geodetic component, and will measure the four-dimensional strain field resulting from active tectonic deformation in the western United States. UNAVCO is installing and will operate the PBO network of more than 1000 continuous GPS, borehole and laser strainmeters, seismometers, and tiltmeters. As of February 2007, 561 of these stations have been installed. The flow of data from these stations is managed from our Boulder Network Operations Center (NOC), located at UNAVCO Headquarters. Automated systems at the NOC retrieve data from our stations at least daily, monitor the status of the network and alert operators to problems, and pass data on for analysis, archiving, and distribution. Real-time network status can be found at http://pboweb.unavco.org/soh_map. PBO's analysis centers generate high-quality derived data products from PBO raw data. Central Washington University and the New Mexico Institute of Mining and Technology process raw GPS data to produce initial PBO GPS products including network solutions and station position time series; the Analysis Center Coordinator at MIT combines these products into the official PBO GPS products. Staff of UNAVCO and the University of California, San Diego process data from the PBO borehole and laser strainmeter networks and produce cleaned time series of shear, areal, and linear strain, Earth tides, pore fluid pressure, and other parameters. The UNAVCO Facility archives and distributes all PBO GPS data products and runs a secondary archive offsite; currently, these centers hold over 2.5 TB of PBO products. The IRIS Data Management Center and Northern California Earthquake Data Center archive and distribute all PBO strainmeter data products, and IRIS archives all PBO seismic data products; more than 160 GB of data products are available from these archives. These same centers also archive other EarthScope seismic and strain data. The PBO Web site provides centralized access to PBO products stored in our distributed archives. GPS products may be accessed from http://pboweb.unavco.org/gps_data and strain data products from http://pboweb.unavco.org/strain_data. In addition, the individual archives provide access to their holdings, both for PBO and other networks, through a variety of discipline-specific tools. The most exciting development still to come in providing access to EarthScope data products will be the creation of the EarthScope Portal. This system will be based on Web services, operated by the EarthScope components, that provide access to holdings at the EarthScope archives and are linked to a central Web portal. This system will provide a unified system for discovery and access to EarthScope digital data products, and is planned to be operational by October 2008.

Keywords: observatory, plate tectonic, cyberspace

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US004 **Oral Presentation** **26**

Virtual observatories in geosciences: finding and using data

Dr. Peter Fox
IAGA

Virtual Observatories can provide access to vast stores of scientific data: observations and models with the overall goal of making diverse and highly distributed holdings appear to be local and appear to be integrated. Consequently, there is potential to improve the efficiency, interoperability, collaborative potential, and impact of a wide range of interdisciplinary scientific research. In order to realize this potential, many technical challenges need to be addressed concerning (at least) representations and interoperability of data, access, and usability. This presentation will define the virtual observatory (VO) as it has now evolved in areas of geoscience, explain its general concepts and the paradigm it has introduced. We then survey some existing and planned virtual observatories, describe their goals, design, current implementations and technical infrastructure. We present what has been learned about building such VOs and what the future holds for the general paradigm and what potential technical challenges remain.

Keywords: virtual observatory, geo science, science data

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US004 **Oral Presentation** **27**

Advancing virtual observatories via knowledge management

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The Virtual Observatory (VO) architecture provides an effective mean for handling varied information contents derived from inhomogeneous data in geographically distributed repositories. Hence VOs fully achieve the goal of giving access to datasets relevant to one or more topical domains, and they represent ideal tools to overcome the "digital divide" in geosciences, the primary aim of the electronic Geophysical Year (eGY) initiative, as well as in most scientific disciplines. This technology is mature enough to be pushed further by embedding knowledge to allow for Knowledge Discovery in VO (KDVO). In this paper we consider the use of Concept Maps to codify knowledge in a VO-searchable mode to fully exploit the data information content via identification of data interrelationships, which enormously extends the capabilities of a basic VO.

Keywords: virtual observatory, knowledge discovery, concept map

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US004 **Oral Presentation** **28**

Virtual observatories, data fabric and cyberspace: scientific data collection, management, and dissemination in the era of internet and world wide web

Dr. Vladimir Papitashvili
Atmospheric, Oceanic and Space Sciences University of Michigan IAGA

Proliferation of global observing systems and distributed scientific/operational databases challenges human abilities to comprehend effectively ever-increasing volume of information about the Earth and Geospace. At the same time, better communication and advent of the Internet and World Wide Web provide effective means for the sophisticated search of various discipline-specific data posted on the Web; the identified data can then be retrieved for scientific analyses or practical applications. By analogy with physical observatories deployed over the Globe and in Geospace, a concept of "Virtual Observatory" transforms a personal computer to an instrument that "observes" specified data distributed through cyberspace: magnetic field measurements, atmospheric parameters, oceanographic profiles, environmental observations - you name it! Therefore, we postulate that a "Virtual Observatory" can only be deployed in cyberspace if a discipline-specific "data fabric" (primitive or sophisticated infrastructure) becomes available electronically. These data fabrics will intersperse through cyberspace, making itself open for search and retrieval by any software developed and installed either at single portals or at a number of nodes that have their FTP/HTTP (or SSL/S-HTTP) ports available for the open or secured access. This presentation will address the VxO deployment challenges in relation to data sources and management of the ongoing "International Year" initiatives (eGY, IHY, IPY, IYPE) and global observing systems (AON, GEOSS, PAntOS, and alike), suggesting some immediate and intervening options and solutions.

Keywords: virtual observatory, data fabric, cyberspace

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US004 **Oral Presentation** **29**

Geoscience information systems and interoperable catalog and data access services for global distributed gravity field data

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Hartmut Palm, Ronny Kopischke, Steffen Loos, Sebastian Freiberg, Lutz Gericke

Starting from the experiences of long lasting managing more than 250 very different geoscientific product types containing more than 10 million data sets and approximately 10 TByte of data volume, processed by different national and international scientific groups using the GFZ Information System and Data Center (ISDC) infrastructure, this presentation is focusing on the current status of the global gravity field information and data management as well as providing a concept and guidelines for realizing an information technology infrastructure consisting of data archives, information systems and related interoperable services in order to manage global distributed various gravity field products. Most of the content of this presentation is universally valid and can be adopted for diverse geoscience domains too. Most of the data which are managed by the ISDC are coming from the German CHAMP satellite as well as from the American-German GRACE satellite mission and appropriate projects. The scientific results are covering geodesy, geophysics and atmospheric research. More than 1300 registered users and user groups all over the world have access to the data using the project and product integrating ISDC portal which is providing different graphical user interfaces (GUI) and non-GUI batch processing interfaces. The ISDC geodetic products are low level processed time series from geoscientific instruments onboard of the satellites, ground-based GPS receiver and superconducting gravimeters but also earth rotation parameters or high level processed global gravity field models. Considering the current situation of existing national and international scientific gravity field information and data management infrastructure and services, the result is reflecting a very inhomogeneous picture. There is a big band with of individual and proprietaer solutions spanning still non-discovered (offline) archives on hard discs, CDs or tapes, websites with simple links to the data sets, accessible online using anonymous ftp and also metadata catalog-based information systems providing sophisticated product search features as well as authorized access to data and information. Based on user and system requirements in consideration of various constraints and derived main use cases the necessary steps for the development of global distributed interoperable gravity field products catalog and data access services on the basis of existing information and data management systems are presented in this talk. Some of the main topics are metadata and appropriate standards, OGC/ISO web-based catalog services, the lifecycle of products as well as ontologies and the semantic web.

Keywords: gravity field data, information systems, interoperable services

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US004 **Oral Presentation** **30**

Data access for space science through virtual observatories

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Jan Merka, Todd A. King, Steven P. Joy, Tom Narock

Geophysical data in general and space science data in particular are widely distributed. Successful management of distributed data repositories requires a combination of expertise in both science and information technology. The NASA Heliophysics Division has established a group of virtual observatories (VOs) to provide the scientific community with access to well-documented data and services. The VOs are organized by scientific discipline. In this talk, we will demonstrate the management of a distributed data system by using the example of the NASA Virtual Magnetospheric Observatory (VMO). The VMO creates robust links to the world's relevant data bases thus providing one-stop shopping for the magnetospheric researcher seeking data. The VMO is a joint effort of scientists at the Goddard Space Flight Center and UCLA. The VMO is being implemented by using existing and widely adopted technologies and provides well organized views of diverse science holdings. Since data are very dynamic especially during the early phases of a mission, the VMO portal design allows frequent and asynchronous updating. The VMO portal provides access to value-added services (e.g., to reformat, manipulate, analyze and display data) developed both locally and remotely. The registries for both data and services are designed to make it easy for suppliers to make their resources available and update information. The basis for resource deions is the SPASE data model. We have created tools to enable data repositories to populate the registries and communicate with the VMO even if they use other data models. Scientists trained in data management are available to work with data suppliers to prepare the metadata and to create archival quality data products.

Keywords: virtual observatory, portal, cyberspace

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US004 **Oral Presentation** **31**

Network geoinformation environment for the analysis of spatial and spatio-temporal data

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Yuri Arsky, Alexei Shogin, Arkady Weinstock

The Electronic Earth project is under development in the Russian Academy of Sciences. The project involves about 20 institutes of RAS. The main goal of the project is to provide the remote users with an integrated information environment for the decision support in the solution of tasks in Earth sciences. This environment comprises information resources (publications and geodata), analytical tools (program systems, specifically, GIS), computing tools (servers, supercomputers, front-end computers), and system tools for the search and integration of distributed resources and analytical tools. Searching, integration and analysis of the resources and tools are based on metadata and rubricators of resources. These operations support user personalization and profiling. The environment provides access to grid- and vector-based geodata, including the operative earthquake catalogue, NEIC USGS. The tools are composed of the analytical programs of the RAS supercomputer centre, Web and GRID technologies, analytical Web-GISs GeoProcessor 1.7, COMPASS V, GeoTime II, and web-map viewers. The analytical tools support the solution of the following analytical geoinformation problems: (1) estimation of relations between geological properties (e.g., cartography exploration of positional relationship of elements belonging to several information layers, estimation of parameters that refer to spatio-temporal geological properties, estimation of direct losses after an earthquake); (2) estimation of the relations between geographical objects (e.g., estimation of relations between natural processes, estimation of indirect losses after an earthquake). (3) forecasting, detection, and identification of geological properties and geographical objects (e.g., forecasting of maximal expected magnitudes of expected earthquakes using complex geological and geophysical data, detection of earthquake precursors);. (4) forecasting of spatio-temporal processes (e.g., modeling scenarios of a catastrophe that follows the earthquake). Interaction of the user with the environment includes a number of operations: registration, research of the problem under consideration, search and integration of the data into a project, analysis and solution of a task (statement of a casual model of the forecast, visual data exploration, transformation of the initial data into features, forecast rule inferences, construction of a logical rule for the explanation of the result), and saving the result, including the new metadata. The examples of the geoinformation analysis are presented. Three results of work are of major importance: (1) a step from analytical Web-GIS to the distributed analytical geoinformation environment has been made; (2) an integrated information environment for the solution of tasks in Earth sciences has been created; (3) the technology of the complex analysis of spatial and spatio-temporal data, suitable for a person without special IT training has been developed. This work was carried out under the Program of Presidium of RAS "Fundamentals of scientific distributed data-processing environment based on GRID technology", the section "Electronic Earth: scientific information resources and data processing and communication technologies". It was supported in part by the Russian Foundation for Basic Research, project No. 06-07-89139.

Keywords: analytical geo information

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US005 **32 - 36**

Symposium
Solar and planetary geophysics

Convener : Prof. Larry Esposito

The session will highlight frontiers in the geophysics of the Sun and planets. Invited speakers will address recent discoveries and open issues for the Sun, terrestrial, giant, and extra- solar planets. The presentations are intended to be accessible to a broad audience of geophysicists. Topics will include interdisciplinary and system-level investigations.

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US005 **Oral Presentation** **32**

Voyage through the solar system: latest images:

Prof. Larry Esposito
LASP University of Colorado IAGA

Solar system images are not only beautiful, but contain striking new information. What can we learn from true and false color images? From X-ray images of the Sun to radar images of Titan, to garish colors of Saturns rings in the UV, beauty combines with new discoveries. I will show a range of images as a preview to the invited talks that follow in the session Solar and Planetary Geophysics.

Keywords: sun x ray images, titan radar images, garish colors of saturns ring

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US005 **Oral Presentation** **33**

Venus atmosphere from Venus Express VIRTIS

Dr. Pierre Drossart
LESIA, Observatoire de Paris LESIA, Observatoire de Paris IAMAS

Giuseppe Piccioni

Observations by VIRTIS (Visible Infared Thermal Imaging Spectrometer) on board the ESA/ Venus Express mission have provided an unprecedented amount of atmospheric data on the Venus Atmosphere from a space mission. Observations by the VIRTIS instrument (Piccioni et al., ESA/SP 1291, 2007; Drossart et al. Planetary and Space Sci. 2007) provide measurements from virtually all the atmospheric levels from the surface to the mesosphere (0 to 150 km), at different wavelengths from 0.35 to 5 micron. Due to the orbit configuration of Venus Express, observations above the South Pole from apocenter between ~60,000 and 30,000 km allow VIRTIS to observe globally the Southern hemisphere of Venus. The thermal emission of the surface is observed on the night side, through the spectral windows from 1 to 1.3 micron. Variations of temperature, related to the altitude closely map topographic maps from Magellan, filling some gaps in radar observations. Results on the structure, composition and dynamics of the Polar Vortex have been obtained, with fine details on the thermal structure of this particularly rich dynamical feature. Composition variations from night side observations on CO and OCS are related to dynamical activity of the Venus atmosphere. At the highest altitudes, non-LTE emission from O2 are observed and mapped. Non-LTE emissions of CO2 and CO at the limb give a deep insights in the upper atmospheric layers. A panorama of present and future prospects of VIRTIS observations will be given for the mission.

Keywords: virtis, venus atmosphere, esa venus express mission

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US005 **Oral Presentation** **34**

Dunes and Lakes on Titan

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LPL The University of Arizona IAMAS

Cassini Radar Team

Thousands of longitudinal dunes and well over a hundred lakes have been discovered by the Titan Radar Mapper on the surface of Saturn's largest moon. The dunes are found within 30 degrees of the equator, with sparser coverage as high as 50 degrees in the northern latitudes. In total the dunes may cover 20% of Titan's surface, although this number is uncertain owing to the limited radar coverage. Based on radiometry the dunes are solid organic particles, or water ice coated with organics. At the northern, and possibly southern, high latitudes, very dark but radiometrically warm features ranging in size from ~ kilometer to 70 km are seen and interpreted to be lakes of liquid methane and ethane. Morphologies are diverse, and some of the smaller lakes may sit within small calderas. Darkness variation mayindicate partial fill or shallow lakes through which the radar penetrates. The dunes and lakes are part of a global cycle in which methane is converted in the high atmosphere, with nitrogen, to complex organics, and in the lower atmosphere cycles from pole to pole on seasonal timescales and from polar reservoirs to the equator on longer (millenial) timescales.

Keywords: titan, dunes, lakes

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US005 **Oral Presentation** **35**

Recent results on cometary water production

Dr. J. Teemu T. Mkinen

Water production rate is the best single indicator of the activity level of a comet. However, until recently it has bee n hard to obtain data series that are both sy stematic and dense enoug h to describe the behaviour of a co met throughout the perihelio n pa ssage. The full sky Ly man alpha ima ger instrument SWAN on board the SOHO spacecraft is capable of providing such data through observations of sola r Ly-a irradiation reso nantly scattered fro m the neutral hydro gen co ma, pro duced by th e photodissociation of cometary water. Since the launch of th e spacecraft in late 1995 the instrument has acquired data on about 100 comets. Because of the immense extent of a typical hydrogen coma a single observation represents the sum of activity over several days or even weeks. Therefore, a deconvolution method has been developed to reveal rapi d changes like ou tbursts. Examples of cometary behaviour that vary from regular to irregular, fragmenting or even a complete dissipation of the nucleus are shown

Keywords: cometary water production, lyman alpha imager, neutral hydrogen coma

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US005 **Oral Presentation** **36**

MRO-HiRISE Close-Up Views of Mars

Dr. Patrick Russell
Space Research and Planetary Science University of Bern, Switzerland

A. Mcewen, The Hirise Team

The High Resolution Imaging Science Experiment (HiRISE) on Mars Reconnaissance Orbiter has been returning images of Mars since late 2006, providing an exciting new perspective in which landscapes and processes revealed from orbit can begin to be related to the human scale. HiRISE consists of a 0.5 m-diameter primary mirror and a focal plane array containing 14 ~2000 pixel ccds in three colors. 10 adjacent red ccds produce typical images covering 6 x 12 km from a ~300 km orbit, achieving resolutions of 25-30 cm/pxl and signal-to-noise ratios of better than 200:1. Aligned with the center red ccds are 2 ccds each with blue-green and near infrared filters, allowing color imaging in unprecedented resolution over the central 1.2 km-wide image swath. Three-dimensional analysis of targets using stereo anaglyphs and DEMs is enabled by repeat imaging of a target from different viewing angles on different orbits. High-resolution, stereo, and color data are presented here in an overview of the major new insights into martian geology obtained from the mission to date. The evolution from target suggestions to science investigations is organized within high-level science themes. This presentation will highlight a select few topics within these themes. North polar geology took precedence early in the mission due to seasonal considerations. Cross-bedded sandy layers in terbedded with the ice-rich layers of the lower polar deposits suggest alternation of different climatic conditions, probably driven by orbital influences. In the north, and now in the south, the morphology, texture, and color of the residual cap surface seen in HiRISE can be incorporated into thermal models of surface evolution, and are being tracked for change detection over the mission duration. Seasonal frost retreat, dune avalanche and streak formation, sublimation deflation, and even carbon dioxide geyser eruptions, are among the processes potentially currently active and potentially observable by HiRISE. Among the most common surface features that can now be resolved with HiRISE are boulders and polygons. Boulders clustered around impact craters and at the base of mass-wasting slopes are easily explained, but their even prevalence over the northern lowlands and in some mantling materials is puzzling. Polygons attest to the activity of periglacial processes consistent with ice-rich ground at high latitudes, although a variety of polygonal fracturing is seen in layered rocks and polar ices. Sedimentological and stratigraphic evidence of fluvial activity recorded in basin and delta deposits can be used to describe the history of large fluvial systems. Alteration around tectonic faults and joints speaks to fluid circulation in the host strata. Several aspects of the cratering process and secondary cratering studies are also addressed by HiRISE data. HiRISE also performs detailed terrain characterization for the planning of future landing missions, such as Phoenix and MSL.

Keywords: mro hirise, mars, three dimensional analysis

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US006 **37 - 44**

Symposium
Challenges and Advances in Nonlinear Geophysics

Convener : Prof. Daniel Schertzer

Nonlineariities are ubiquito us in geo physics and geo desy, fro m Earth co re to outer space and they remain the main difficulty t o overcome fo r applicat ion sake, just like for theoretical adva nces. Thi s session will provide a forum to draw perspe ctives on the new challenges and opportunities due to the recent advanc es in no nlinear metho dologies (e;g. chaos, multifract als, wavelets, self-organized criticality) as applied to geophysics and geodesy.

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US006 **Oral Presentation** **37**

A dynamical systems view of the ocean circulation

Prof. Henk Dijkstra
Physics and Astronomy Utrecht University

The global ocean circulation is a complex three-dimensional flow generated by momentum fluxes (wind stress) and affected by buoyancy fluxes at the ocean-atmosphere interface. An understanding of the properties of the time-mean flow and the physics of the internal variability of the circulation can be accomplished by using a hierarchy of models. To systematically study the solutions of these models and the relations between these solutions over the model hierarchy, techniques of numerical bifurcation theory have shown to be very useful. To illustrate the approach and to provide a perspective on new challenges, focus will be on one important problem: the physics of the multidecadal variability in the North Atlantic sea-surface temperature.

Keywords: ocean circulation, multidecadal variability

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US006 **Oral Presentation** **38**

Scale, scaling and nonlinear variability in precipitation, landscape morphology and river flows

Prof. Shaun Lovejoy
Physics McGill Univeristy IAHS

D. Schertzer, Y. Tchiguirinskaya

The hydrologic cycle begins with precipitation input followed by topography modulated runoff producing streamflow distributed over river networks. Each of these parts of the cycle involve spatial structures varying over planetary down to millimetric scales ; the temporal variations of precipitation and streamflow vary from climatological scales down to scales of less than a second. In order to deal with these huge ranges, classical hydrology postulates a plethora of scaling laws, including the long range dependencies of the Hurst phenomenon and many river basin geomorphology scaling laws. In the last 25 years much progress has been made in understanding scaling processes which generically generate variability over such huge ranges of scale. Scaling processes have a nonlinear dynamical mechanism which repeats scale after scale form large to small scales leading to non-classical multifractal resolution dependencies. This means that the statistical properties vary systematically in strong, power law ways with the resolution, that classical geostatistics – which assume strong regularity and homogeneity assumptions – do not apply. We can now broadly understand these phenomena as consequences of scale invariant dynamics – although as we discuss - the notion of scale invariance must be suitably generalized to take into account the strong (spatial and spacetime) anisotropies of the processes. In this talk we review some of these scaling ideas focusing on their applications to precipitation, topography and streamflow processes. We review the recent HYDROP stereophotography experiment which directly determined the size and position of drops demonstrating that rain is strongly coupled with the wind field down to a "relaxation" scale of the order 30-50cm below which drop inertia makes them free. Above this scale, the liquid water density (ρ) follows a multifractal generalization of the classical Corrsin-Obukov passive scalar law; $\Delta\rho \approx l^{1/3}$. For larger but intermediate scales ($\approx$3m- 5km), we review lidar and radar data which also show multiscaling of the backscatter cross-section and radar reflectivity factors respectively. To extend this up to planetary scales (5 - 20,000km), we use 3 months (1166 orbits) of the TRMM (Tropical Rainfall Monitoring Mission) satellite radar data at heights 250m above the surface. This global data set (over the region $\pm$38o latitude) is remarkable for it's relatively complete and uniform coverage over a range of $\approx$4,000 in scale; it is also nearly free of the range dependent biases which plague ground based radar data. We find that over the observed range 5-20000km, the moments $\langle Z^q \rangle$ follow the theoretically predicted form $\langle Z^q \rangle \approx \lambda^{K(q)}$ to within a maximum deviation of $\pm$6% where λ=Leff/Lres Lres, is the resolution of the reflectivities and Leff is the effective outer scale of the cascade. We proceed to review recent large scale analyses of the topography showing that the multiscaling of the (isotropic) gradients holds to within $\pm$45% from planetary down to 40m scales. We the review recent river streamflow which confirms that the scaling of the input, the scaling of the geomorphology (and presumably runoff) leads to wide range temporal scaling of the flow statistics. Finally, we show how to model these processes with the help of causal, anisotropic, space- time multifractal simulations.

Keywords: nonlinear variability, river flows, hydrop

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US006 **Oral Presentation** **39**

Chaotic dynamics, fractional transport and non-adiabatic filamentary acceleration of plasma in the Earth's magnetotail

Prof. Lev Zelenyi
SPACE PLASMA PHYSICS SPACE RESEARCH INSTITUTE

Magnetic tail of the Earth is produced in the course of interaction of supersonic stream of solar wind plasma with the rather strong (on cosmi c scales) magnetic field of our planet . Energy which drives the magnetospheric dynamics is coming from the sola r wind and could be temporarily stored in th e magnetotail. From the pla sma physics point of view magnetotail could be conside red as a self-consistent high- beta co nfiguration where hot plasma is confined by the pressure of magnetic field generated by currents flowing within this plas ma. From thermodyna mic po int of view magnetotail could be considered as nonlinear open system wh ere t he incoming flux of solar wind energy is transformed into kinetic and thermal energies of magnetospheric and ionospheric plasmas. Region around magne tic separatrix between open and closed field lines in th e Earth's magnetotail (usually called PSBL=Plasma Sheet Boundary Layer) plays very important role in the overall magnetospheric energy circulatio n. Dynami cal plasma pr ocesses o ccurring in this region have ver y complicated spatial/temporal manifestations. The echoes of powerful acceleration processes operating in the distant regions of magnetotail could be seen in the high-latitude auroral region as VDIS (Velocity Dispersed Ion Structures) often fragmented at a sets of isolated sub-structures. Trajectories of solar wind ions interacting wit h magnetotail current sheet as a rule are n on-integrable and one may expect that non-adiabatic CS interactions should be accompanied by strong stochastic scattering and could produce only the energized quasi-isotropic thermal population of the plasma sheet. However detailed analysis reveals the existence of so called CS resonances producing islands of regular motion in otherwise chaotic phase space. Reso nant interactio ns pro duce fragmentat ion o f PSBL io n beams o n a finite number o f substructures Quantitatively the in tensity of PSBL ion fluxes is very high and their acceleratio n in the current sheet should be accompanied by strong nonlinear modifications of the cross-tail currents. Non-linearity competes with standard velocity filter and time of flight dispersion effects and produces well-defined features in VDIS p atterns which co uld be seen in a recent Cluster spacecraft data. Due to the weakness of magnetic field in a field reversal region near the tail midplane even electrons could become non-adiabatic and are no n-capable to pr ovide the "rig idity" to field lines which becomes stochasti c. Such sheets have more chances to be ob served far downstream of the tail at the open field lines. Complex topology of magnetotail fie ld in this region is se lf-consistently coupled to the distribution of plasma currents which particles should carry mo ving in such entangled magnetic geometr y .Assumption about self similarity of struct uring (confor ming with experimental data) allows to use methods of fractal geometry for descript ion of processes in magnetotail. We use fractional diffusion equation to describe permanent stochastic Fermi-type acceleration of particles in this multiscale structured magnetic field.

Keywords: magnetic tail, plasma

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US006 **Oral Presentation** **40**

Advances in characterizing spatio-temporal clustering and emergent applications in seismicity

Prof. Joern Davidsen
Department of Physics and Astronomy University of Calgary

In this talk, I will discuss new methods from nonlinear sciences and complex network theory to characterize spatio-temporal clustering of point processes with a particular focus on their application to seismicity. In particular, I will present a method to search for signs of causal structure in spatiotemporal data making minimal a priori assumptions about the underlying microscopic dynamics. To this end, the elementary concept of recurrence for a point process in time is generalized to recurrent events in space and time. This allows to generate a network of recurrent events and provides a strictly data driven technique to search for structure. Significant deviations in properties of that network compared to networks arising from random processes allows one to infer attributes of the causal dynamics that generate observable correlations in the patterns. I will show that for networks synthesized from time series of epicenter locations for earthquakes in Southern California, the following properties can be plausibly attributed to the causal structure of seismicity: (1) Invariance of network statistics with the time span of the events considered, (2) Appearance of a fundamental length scale for recurrences, independent of the time span of the catalog, which is consistent with observations of the "rupture length", (3) Hierarchy in the distances and times of subsequent recurrences.

Keywords: nonlinearity, complexity, seismicity

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US006 **Oral Presentation** **41**

Similarities and differences in sequences of starquakes, solar flares, and earthquakes

Prof. Vladimir Kossobokov
Intntl Institute of Earthquake Prediction Theory and Mathematical Geophysics IASPEI

Fabio Lepreti, Vincenzo Carbone

Impulsive energy release is observed in many natural systems. Starquakes (flashes of energy radiated by a neutron star), solar flares and earthquakes are among the most remarkable examples of these phenomena, which at the extreme may radiate about 1039 J, 1026 J, and 1018 J, respectively, in a single event. The statistical properties of starquakes, solar flares and earthquakes have a lot in common when the time series of energies and inter-event times and their distributions are considered. However, each of the two phenomena differ by overall scaling, and even the same phenomenon, when observed in different periods or at different locations, is characterized by different statistics that cannot be uniformly rescaled onto a single, universal curve. The apparent combination of similarity and differences of impulsive energy release processes evidences the complexity of the generating physical structures and forces in a self-organized hierarchical media like neutron star crust, solar atmosphere, and lithosphere of the Earth.

Keywords: scaling, complexity, extremes

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US006 **Poster presentation** **42**

Analysis of a stochastic mechanism in aerosol optical depth time series

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Physics Department-Salerno University Physics Department-Salerno University

A. Di Lisi, L. Mona, S. De Martino

The high complexity of the dynamical aspec ts characterizing the atmosphere and the c hallenging task embodied in t he construction of models d escribing their behaviour, requires new and more advanced techniques for the analysis and modelling of ge ophysical signals. Interplay between information theoretical methods and non conven tional signal analysis techniques were employed to extract quantitative information from time series data of Aerosol Index, retrieved from TOMS measurements, and used to modelling imp ortant features of ae rosol dynamics. In fact, a stocha stic resonance mechanism was recognized to play a funda mental role in the interpretation of the annual peak in the power spectrum of the Aerosol Index [1]. To gain a deeper insight of the aerosol dynamics by studying atmospheric parameters with a more trans parent ph ysical interpretation, we have analysed 144 tim e series of Aerosol Optical Depth (AOD), retrieved from daily satellite MODIS measurements, relative to a period of time going from February 2 000 to Ma rch 2006 , and to a sp atial extension corresponding, roughly, with the Italian peninsula (7°– 18°E and 36° – 47° N), with a r esolution of ab out 102 Km × 102 Km. Gaps in the regional coverage of MODIS retrievals have been filled by a stochastic extraction of missing data from a log-normal dist ribution parameterized by the statistical estimates of the real data. Power spectrum analysis of t he time series presents two recognizable peaks: one corresponding to a 3 days period, the other to an annual period. To get information about the dynamical system generating the signals, we performed an estimate of their ph ase space embedding dimension by ap plying the false nearest neighbors method to each reco rd: we have found that up to dimension 10 the algorithm does not co nverge, representing a clue to a p ossible sto chastic dynamics. Mo reover, we have applie d Independent Component Analysis (ICA), a technique borrowed from infor mation theory [2], t o extract independent d ynamical signa l comp onents, if there ar e, fr om the record ed series. In f act, as for the signals considered, ICA does not separate noise from any deterministic contribution, suggesting that the periodic part of these signals is intrinsically tied to the fluctuatio ns, i. e. generated by a genuine stochastic dynamics. Lo w-pass filtering the signal s to select the annual peak, and co njecturing a stochastic resonance mechanism for the dynamics, we have analyzed the distributions of time intervals between two consecutive switching events, singled ou t by setting suitable thresholds separating two different regim es in the d ynamics of the sy stem. Th e resi dence time distribution has a n exponential form, with a series of small peaks, the first of which is centred at about half a year. The an alysis of these distributions has enforced the hypothesis of a st ochastic resonance mechanism for the dynamics of the AOD, confirmed by numerical simulation s adjusted according the ph ysical atmospheric parameters of the system.

Keywords: stochastic resonance, aerosol, dynamics

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US006 **Poster presentation** **43**

Discrete Mathematical Analysis in nonlinear approach to geophysical data studies

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Geophysical Center RAS Russian Academy of Sciences IASPEI

S. Agayan, J. Zlotnicki, M.Diament

The presentation is devoted to a new approach to analysis of discrete geophysical data. This approach - Discrete Mathematical Analysis (DMA) - is an attempt of modelling of discrete analogues of such fundamental mathematical notions as limit and continuity. The goal of DMA is to model a human ability to analyze discrete complex data: indeed, expert can easily cope with such an analysis in case of small amount of data. The task of DMA is to realize this ability in the cases of large data volumes. Mathematical background of DMA is fuzzy logic and fuzzy mathematics. In the presented study DMA is realized in two series of algorithms. The first series of algorithms ("Monolith", "Crystal", "Roden", and "Tracing") are related to stationary multidimensional arrays, dealing with highlighting condensations, including clusters and linear structures. The second serie(algorithms "Equilibrium", "Forecasting", DRAS, and FLARS, search of fuzzy monotonies and extrema, morphological analysis) represent a functional approach to finite time series. The tasks decided by second series are similar to classical analysis of smooth functions. Thus, DMA is a set of algorithms of universal character bound by the common formal framework (discrete limit). DMA contains new fundamental solutions of classic tasks of data analysis: clusterization and search of linear structures in stationary multidimensional arrays; construction of smooth skeletons, search of signals and morphological analysis in time series. At present time DMA has numerous successful geological and geophysical applications. In the cases of study of magnetic and gravimetric anomalies this approach gives possibility to reveal the vague features in the Earth's crust structure. In result of analysis of relief data this approach gives possibility to reveal the areas of increased tectonic activity. In the case of analysis of data of volcanoes monitoring this approach gives possibility to distinguish in the time series between the anomalies concerned with different factors (storm rains, increase in hydrothermal activity, etc.). The DMA is one of approaches used now to deal with the problems in nonlinear geophysics.

Keywords: modelling, dma

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US006 **Poster presentation** **44**

Multiscale phenomena of the magnetosphere

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Thangamani Veeramani, Jian Chen

The magnetosphere is driven by the turbulent solar wind and exhibits multiscale features with global, regional and local components. The global features are in general captured by the geomagnetic indices and the regional and local features are measured by spacecraft- based imagers and ground- based instruments. The global features of the magnetosphere have been studied extensively using nonlinear dynamical techniques. The time series data of the distributed observations are used to develop spatio-temporal dynamics of the magnetosphere using state space reconstruction techniques. The global MHD simulations of the same epochs show similar global and multiscale characteristics. The studies of the magnetosphere using different approaches show many features of its multiscale phenomena and the global beahavior is obtained by following a the mean field approach. The multiscale phenomena are characterized by probability distribution functions which have the form of stretched exponentials. Such distributions are typical of systems with long term memory or long range correlations and are essential to the description of rare events, which are often hazardous. The extensive data of the solar wind and the magnetosphere is used to develop a predictive model based on statistical physics and Bayesian probabilities.

Keywords: multiscale dynamics, extreme events, geospace storms

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US007 **45 - 54**

Symposium
High-Performance Computations in Geosciences

Convener : Dr. Alik Ismail-Zadeh

Since recent years computation has been playing an increasingly important role in the understanding of the nature of the complex Earth system, especially catastrophic extreme events emerging from the system. Developments in computational science and technology has significantly accelerated the progress in data assimilation, modeling, and forecast/prediction oriented simulations associated with various branches of Earth sciences such as atmospheric, oceanic, space, and Solid Earth sciences. This development has a strong impact to the studies of geohazards and risks such as cyclones, earthquakes, landslides, storms, tsunamis, and volcanic eruptions and shows significant potentials to be applied to serve the sustainable development of society. To reflect up-to-date developments in this direction, to identify the new frontiers and important scientific/technique problems in this developing field, and to foster new opportunities for inter-disciplinary cooperation, this session aims to focus on (but not limited to) the following topics: 1) Computer simulation in geosciences, its physical significance, and observational constraints; 2) Web-based grid computation and parallel computation applied to geosciences; 3) Data assimilation, data analysis, and data mining in geosciences; visualization in geosciences and analysis of high-dimensional data; 4) Forecast/prediction of hazards and risks based on high performance computation and its engineering application; limitation on the predictability of hazards and risks, and related engineering countermeasures; 5) Physics of complex systems and its computational implementation; 6) Development and sharing of software for the simulation and visualization in geosciences: from traditional individual-based approach to modern networkbased approach. Invited and contributed papers will be presented in the session

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US007 **Oral Presentation** **45**

Towards seismic tomography based upon adjoint methods

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Qinya Liu, Carl Tape, Alessia Maggi

We outline the theory behind tomographic inversions based on 3D reference models, fully numerical 3D wave propagation, and adjoint methods. Our approach involves computing the Frechet derivatives for tomographic inversions via the interaction between a forward wavefield, propagating from the source to the receivers, and an 'adjoint' wavefield, propagating from the receivers back to the source. The forward wavefield is computed using a spectral-element method (SEM) and a heterogeneous wave-speed model, and stored as synthetic seismograms at particular receivers for which there is data. We specify an objective or misfit function that defines a measure of misfit between data and synthetics. For a given receiver, the differences between the data and the synthetics are time reversed and used as the source of the adjoint wavefield. For each earthquake, the interaction between the regular and adjoint wavefields is used to construct finite-frequency sensitivity kernels, which we call 'event' kernel. These kernels may be thought of as weighted sums of measurement-specific 'banana-doughnut' kernels, with weights determined by the measurements. The overall sensitivity is simply the sum of event kernels, which defines the 'misfit' kernel. The misfit kernel is multiplied by convenient orthonormal basis functions that are embedded in the SEM code, resulting in the gradient of the misfit function, i.e., the Frechet derivatives. The misfit kernel is multiplied by convenient orthonormal basis functions that are embedded in the SEM code, resulting in the gradient of the misfit function, i.e., the Frechet derivatives. A conjugate gradient algorithm is used to iteratively improve the model while reducing the misfit function. Using 2D examples for Rayleigh wave phase-speed maps of southern California, we illustrate the construction of the gradient and the minimization algorithm, and consider various tomographic experiments, including source inversions, structural inversions, and joint source-structure inversions. We also illustrate the characteristics of these 3D finite-frequency kernels based upon adjoint simulations for a variety of global arrivals, e.g., Pdiff, P'P', and SKS, and we illustrate how the approach may be used to investigate body- and surface-wave anisotropy. In adjoint tomography any time segment in which the data and synthetics match reasonably well is suitable for measurement, and this implies a much greater number of phases per seismogram can be used compared to classical tomography in which the sensitivity of the measurements is determined analytically for specific arrivals, e.g., P. We use an automated picking algorithm based upon short-term/long-term averages and strict phase and amplitude anomaly criteria to determine arrivals and time windows suitable for measurement. For shallow global events the algorithm typically identifies of the order of 1000 windows suitable for measurement, whereas for a deep event the number can reach 4000. For southern California earthquakes the number of phases is of the order of 100 for a magnitude 4.0 event and up to 450 for a magnitude 5.0 event. We will show examples of event kernels for both global and regional earthquakes. These event kernels form the basis of 'adjoint tomography'.

Keywords: adjoint method, computational seismology

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US007 **Oral Presentation** **46**

Challenges in computational geodynamics

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Geophysical Institute Karlsruhe University IASPEI

A new level of numerical modelling of geo dynamic processes must enc ompass the solution of multi-physics problems involving fluids (mantle and core) an d solids (lithosphere), their interaction, thermo-chemical and electro-magnetic effects; must invo lve multi-scale phenomena from the micro- t o the macroscopic scales; must include uncer tainties in the given data and so lution results. A real success in numerical modelling of Earth dynamics can be achieved only by a multidisciplinary and complementary approach (geoscience + applied and pur e mathem atics + computer science). Hig h-performance computing is an essential t ool t o solve c omplex model s of geodynamics. Ho w co mplex can be a numerical model? "A model which images any detail of the reality is as useful as a map of scale 1:1"- said Joan Robinson, a British economist. Keeping this in mind, geodynamical compute r models should try to approxi mate dynamics of the Earth such a way t o "simulate" it s basic proces ses and predict phenomena. A lthough the pr edictability of numerical models varies with their complex ity, numerical models predict dynamics of the Earth as well as the mathematical equations describe this dynamics. The model predicta bility depends also on init ial conditions. So far most numerical models in geodynamics have been carried out forward in time, i.e., from the onset of mantle structures to late stages of their maturity. The main drawback of thes e models is that the i nitial conditions (conditions in the geological past) for the models are unkno wn. However, mantle temperature and fl ow at the onset phase can b e inferred from t he present m antle temperature and flow using data assimilation techniques. Estimations of the initial co nditions from s eismically imaged structures provide an important way to test a range of geodynamics hypotheses.

Keywords: computational geodynamics, assimilation, modeling

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US007 **Oral Presentation** **47**

High-performance computations in mantle dynamics using finite volume

Prof. Paul Tackley
Department of Earth Sciences ETH Zurich IASPEI

Taras Gerya, Takashi Nakagawa

Modeling the dynamics of the solid Earth requires treating a huge range of lengthscales from global scale to the scale of compositional and mineralogical variations observed in rock outcrops (cm - m), the effects of phase transformations including melting, and a range of rheological behaviors including viscous, viscoelastic, plastic, and brittle. This multiscale, multirheological problem is thus computationally very challenging. Here we report simulation codes based on orthogonal finite volume discretizations for the velocity-pressure solution and a marker-in-cell technique for tracking composition and sometimes stress and/or temperature. In these codes, primitive variables (2 or 3 components of velocity plus pressure) are defined on a staggered grid so that derivatives involve adjacent points and the scheme is conservative with respect to stresses and fluxes. The code STAG3D, written in 1992 by P. Tackley and used for many studies, uses a multigrid solver for the velocity-pressure solution and the MPDATA technique for advection, and has from the start been run on up to 100s of CPUs on parallel computers by Intel and Cray, and Beowulf clusters. Originally treating Cartesian 3-D geometry, spherical 3-D geometry has recently been added using the "yin-yang" spherical grid, which combines two longitude-latitude patches to make a sphere similar to the construction of a tennis ball. STAG3D can handle large variations in viscosity (e.g., 6-7 orders of magnitude) with a visco-plastic rheology. Compositional variations are tracked using particles (aka. markers, tracers). It has been used for a variety of studies at different scales, including the thermo-chemical evolution of the Earth over billions of years; examples and performance tests will be presented. Elasticity can be handled with this approach, as demonstrated by the visco-elasto-plastic code I2ELVIS of T. Gerya, which uses the same discretization but with temperature advected on particles. Elasticity is treated by rewriting the momentum equation such that elasticity appears as an effective viscosity and additional force term on the right-hand side and advecting stress on particles; in this manner a viscous flow solver can be used. I2ELVIS uses a direct solver in 2-D geometry; a 3-D multigrid version is close to completion. The code has been used to model a variety of problems including crustal, lithospheric, subduction-zone and core differentiation, including results in which billions of particles are used to finely resolve chemical mixing features; examples will be presented. We also show how a self-consistent petrological/mineralogical treatment that minimises free energy for a given composition (J. Connolly) can be incorporated into such codes. In conclusion, the coupled finite-volume multigrid, particle-in-cell method is an effective and efficient approach for treating large-scale problems with complex rheologies and multiple scales, in global or regional models.

Keywords: mantle convection, visco elastic, plasticity

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US007 **Oral Presentation** **48**

Three-dimensional simulations of explosive volcanic eruptions

Prof. Gary Glatzmaier
Earth and Planetary Sciences University of California, Santa Cruz IAGA

Volcanism has played a major role in shaping the surfaces and atmospheres of many terrestrial planets and satellites in our solar system and explosive volcanic eruptions on Earth today present a major hazard. Although studied using a variety of techniques, it is not possible to directly observe the complex supersonic flows that feed the thermal plumes. Computer models of volcanic eruptions are used in many countries as part of civil defense programs for predicting their natural hazards. However, these models are often not three-dimensional and do not consider the supersonic turbulent multiphase aspects of the flow or the erosion and failure of the host rock during the eruption. Here we describe a study of the complex fluid dynamics within an explosive volcanic eruption using a computational fluid dynamics library (CFDLib) developed at Los Alamos National Laboratory. This study focuses on a compressible mixture of gases, liquids and solid particles flowing through a conduit within an incompressible but brittle host rock, leaving the vent at supersonic speed, forming a shock and then buoyantly rising into the atmosphere with entrainment and eventual deposition. Results from these simulations will improve understanding of the complex dynamics of explosive volcanic eruptions, therefore assisting in hazard mitigation and the interpretation of geophysical, remote sensing and field data.

Keywords: volcano, eruption, modeling

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US007 **Oral Presentation** **49**

Computational challenges in real-time tsunami forecasting

Dr. Vasily Titov
NCTR NOAAPMEL IASPEI

Tsunami Warning Centers (TWCs) of National Oceanic and Atmospheric Administration (NOAA) are tasked with issuing tsunami warnings for the U. S. and other nations around the Pacific. Tsunami warnings allow for immediate actions by local authorities to mitigate potentially deadly wave inundation at a coastal community. The more timely and precise the warnings are, the more effective actions can local emergency managers take and more lives and property can be saved. Advances in tsunami measurement and numerical modeling technologies can be integrated to create an effective tsunami forecasting system. The Deep-ocean Assessment and Reporting of Tsunamis (DART) technology can detect tsunami waves of less than 1 cm in the open ocean (at depths up to 6 km) and reliably provide data to NOAA's tsunami warning centers in real time. Tsunami modeling methods have matured into a robust technology that has proven to be capable of accurate simulations of past tsunamis. NOAA's Pacific Marine Environmental Laboratory has developed the methodology that combines real-time deep-ocean measurements with tested and verified model estimates to produce real-time tsunami forecast for coastal communities. This methodology (also known as Short-term Inundation Forecast - SIFT) is currently being implemented at NOAA's TWCs. Tsunami forecast should provide site- and event-specific information about tsunamis before the first wave arrives at threatened community. The next generation tsunami forecast provides estimates of all critical tsunami parameters (amplitudes, inundation distances, current velocities etc.) based on direct tsunami observation and model predictions. There are significant challenges in meeting TWS's operational requirements - speed, accuracy, and user interfaces that provide guidance that is easy to interpret. The methodology, tools, test results and operational implementation plans will be discussed.

Keywords: tsunami, warning, modeling

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US007 **Oral Presentation** **50**

Modeling and prediction-oriented simulations of hazards bridging to engineering application

Prof. Giuliano Panza
Earth Sciences University of Trieste IASPEI

The developments in computational scienc es and te chnologies have allowed significa nt progresses in data modeling and prediction oriented simulations in Solid Earth sc ience. Multiscale tomographi c images, obtained combining surface- and b ody-waves, often tested for their compatibility with gravity data, combine d with geoche mical analyses supply va luable information on the physical and chemical properties of the lithosphere-asth enosphere system (LAS). Integratio n of petrological a nd geoph ysical studies is par ticularly useful in geodynamica lly complex areas ch aracterised by abun dant and compositionally variable young magmatism, such as in the Tyrr henian Sea a nd surr oundings. Th e dominance of mafic subalkaline magmatism denotes larg e degrees of partial melting, well in agreement with the soft characteristic s of the uppermost mant le in this area. In contrast, striking isotop ic differences of Plio-Quaternary volcanic ro cks from so uthern to northern Sardinia does not find a match in the LAS geophysical characteristics. The combin ation of petrological and geophy sical constraints allows us to propose a 3D sc hematic geodynamic model of the Tyrrhenian basin and bordering volcanic areas, including the subduction of th e Ionian-Adria lithosp here in the southern Tyrrhenian Sea, and to place constraints on the geodynamic evolution of the whole region. This is of paramount importance for the assessment of Volcanic and Seismic hazard. The la tter is severely hampered by the inadequacy of the length of available relevant observations, even in a region like It aly where reliable earthquak e catalogues cover a time spa n of more tha n 1000 years. Lack of data makes realistic simulations of seismic gro und mo tion the o nly po ssible reliable co mplementary inf ormation; this is do ne taking advantage of t he reco gnition of earthqua ke pro ne areas techniques combined with intermediate-term middle-range earthquake pre dictions. With their use it is possible to obt ain seismic hazard scenarios, both at national and local scale, which can be used to support probabilistic estimations that have clearly shown their severe limits in the recent past.

Keywords: geohazards, modeling, prediction

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US007 **Oral Presentation** **51**

Fostering the simulation science

Prof. Tetsuya Sato
The Earth Simulator Center JAMSTEC

Computer simulation has a history of more than half a century. After the birth of the so-called vector computer, CRAY 1, in 1976, simulation has gained its scientific position as the third methodology of science. Until the end of the 20th century, however, its intrinsic advantage in promoting science had not been demonstrated because of the lack of capability and capacity. The intrinsic feature is that simulation can make a scientifically reliable prediction of the evolution of a system governed by natural laws or make a scientifically sound design of manufacturing goods. In 2002 the Earth Simulator appeared and demonstrated that a system of interest could be simulated rind and all. It becomes possible to deal with the climate change globally with a reasonable resolution such as 10 km. This indicates that simulation has finally passed through the gate of real simulation. In this invited talk I would like to present some, among many, typical simulation results that the Earth Simulator has produced in these five years, such as the five days advanced forecast of typhoon trajectory and five days advanced prediction of heat wave attack to Tokyo obtained by global climate variation simulations, and global mantle convection and geo-dynamo action. Finally, I discuss the limit of the Earth Simulator and propose an innovative simulation algorithm we call "holistic simulation" or "macro-micro interlocked simulation" which could be making a revolution in the 21st century simulation.

Keywords: high performance computing, earth simulator, japan

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US007 **Oral Presentation** **52**

Application of automatic finite element code generator to Earth science research

Prof. Yaolin Shi
Geophysics Graduate University of Chinese Academy of Sciences IASPEI

Huai Zhang, Zhongliang Wu

Abundant data fro m land and space- based o bservations enable earth scientists to explo re and understand be tter the planet Earth. Large- scale in formation techno logy, high- performance co mputing simulations and analysis via supercomputing and data cyber-infrastructure provide powerful tools for earth scientists to carry out collaborati on and in tegrated research. Parallel computi ng of coupled nonlinear partial differential equation s to simulate earth s cience problems is an ess ential element in t he study. However, advances in soft ware, especially writing th e codes for modeling, are not keeping pace with the dramatic improvem ents in the hardware. Pe rsonalized codes of researchers are difficult to maintain and improve by others . Our laboratory of Computatio nal Geodynamics has improved a modeling language based p rogramming software fr amework, which can be used to auto matically generate parallel finite eleme nt program source code for obtaining robust solu tions, simply from the user input info rmation of partial differential equati ons and corresponding algorithm expressions. This system will lib erate the geoscientist from monthly or ev en yearly time consuming and error pron e parallel coding. Codes for different physical problems com prise similar st ructures, therefore, easier for maintenance. We can easily program segments and scripts based programming methods to enhance the advanced features of portability, scalability and readability of comple x codes. Our laboratory has simulated a wide range of problems, such as elastic wave propagation for seismic hazard research, free oscillation excitation process o f two-tone Chime Bell of Marquis Yi of Zeng, vi sco-elastic deformation of continental geodynamics, probabilistic tsu nami risk map of Chinese coast, annual thermo-elastic deformation in observatories, genetic algorithm C fini te element gravity inversion, calculation of rock rheology from composing minerals, etc. We will conti nue to contribute to and develop this system to serve as a web-based grid computing environment fo r geodynamics everywhere in the world . This wi ll greatly allow geoscientists to focus only on the pure science.

Keywords: computational geodynamics, code development

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US007 **Oral Presentation** **53**

The essence of data assimilation or, why combine data with models?

Prof. Michael Ghil
Geosciences (TAO) Ecole Normale Suprieure, Paris

Data assimilation refers to the use of dat a that are irr egularly distributed in space and time in combination with a dynamical model. The m odel serves as a "smart interpolator" and smoother, since the data are not only irreg ularly distributed but al so contain instrume ntal and samp ling erro rs. The origins of dat a assimilation were in numerical weather predictio n, which was co nfronted since its beginnings in the early 1950s with having to solve an initial-value problem without the right initial data. The advent of satellite data in the late 1960s provided new opportunities and new challenges, leading to a method called "optimal interpolation." This me thod was generalized, using concepts from the engineering literature, to an approach called se quential estimation, which includes today various versions of the extended, reduced-rank and ensemble Kalman filter (EKF, EnKF, etc.). Data assimilation has become a major tool of research thro ughout the Geo sciences, extending to physical, chemical and biological oceanography, coupled ocean-atmosphere climate models, ge ophysical fluid dynamics in the laboratory, planetary atmospheres, geodynamics, space weather, and beyond. This lecture will present the basic principles of sequential estimation, th e connections with c ontrol-theoretical (also called variational) methods, and the asso ciated co mputational co nsiderations. New theo retical advances and applications to several fields of the geosciences will be given.

Keywords: data assimilation, kalman filter

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US007 **Poster presentation** **54**

Progress in earthquake forecasting research through advanced computing

Prof. John Rundle
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This talk is dedicated to the memory of Professor Keiiti Aki. Shortly before his death, our late colleague and friend, Kei Aki, was to give a talk at the 2005 European Geophysical Union meeting titled 'Opening of a New Era for Earthquake Prediction Research'. In the abstract describing his talk, he said: 'The Hagiwara symposium ... held at the Sapporo IUGG in 2003 ... opened a new era for the earthquake prediction research. Takahiro Hagiwara symbolizes an era of the earthquake prediction research since 1960's in which monitoring was emphasized and a variety of monitoring data have been accumulated throughout the world with the ever increasing quantity and improving quality. We now find, however, a growing recognition among earthquake scientists, especially in Japan, that modeling is as important as monitoring for a healthy development of earthquake prediction research as a branch of Physical Science'. This lecture will continue the theme advanced by K. Aki. At the 100th year anniversary of the Great 1906 San Francisco earthquake, progress in earthquake forecasting, prediction, and in understanding earthquake physics is made possible by the use of advanced computer models and simulations. Also of critical importance are new data sets and data mining techniques, together with ideas about the physics of complex nonlinear systems. Modern computational technology allows us to construct models such as Virtual California that include many of the physical processes known to be important in earthquake dynamics. Similarly, we can move towards simulations of other active fault systems in many other regions as well as around the Pacific Rim. The basic problems of model construction, data assimilation, ensemble forecasting and forecast verification can be addressed within a common computational framework. Progress will be dependent on continued international cooperation. This lecture will summarize the status of several earthquake modeling and forecasting approaches under development at the University of California, and their application to earthquake fault systems in California, Japan, Taiwan, and world-wide.

Keywords: earthquake prediction, computer, model

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US008 **55 - 60**

Symposium
Our Changing Planet (Part 2)

Convener : Prof. Richard Peltier

This Symposium is intended to initiate and provide an overview of the scientific program. The morning sessions will be devoted to invited papers and the afternoon session to contributed papers. In this second part of the session (see US001), the focus will shift to solid Earth processes and the Earths deep interior. Topics in this area may include the physics of the earthquake source mechanism, the geodetic monitoring of tectonic deformation, the style of the mantle convection process and the physics of the Earths core (dynamo process, mechanism(s) of field reversal, etc)

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US008 **Oral Presentation** **55**

Discovery of deep mantle phase transition and the new views of core-mantle boundary region

Prof. Kei Hirose
Department of Earth and Planetary Sciences Tokyo Institute of Technology

The boundary between the core and mantle has long been the most enigmatic region in side the Earth. Seismological observations identified large ano malies at the bo ttom several hundred kilometers of the mantle, called D layer, but the origins of these an omalies were difficult to exp lain with the known properties of MgSiO3 perov skite, a primary mine ral in the lower mantle. The existence of phase transition that could occur in this region has been a subject of debate. A phase transition of any specific mantle mineral, however, had not been identified until recently at high pressure and temperature (P-T) conditions exp ected for the D region. Rece nt develo pments in X-ray diffraction measurements at the synchrotron ra diation so urce, co mbined with laser- heated diamond- anvil cell (LH- DAC) techniques, enables the crystal structure determinations at deep Earth conditions. In 2004, a phas e transition from MgSiO3 perov skite to post-perovskite was discov ered through a significan t change in the X-ray diffraction pattern at high P- T conditions corresponding to the top of D layer around 2600-km depth, where seismic -wave veloci ty discontinuity is observ ed. T he calculated elasticity of this new phase suggests that many seismological ch aracteristics of the D" layer, su ch as D discontinuity, shear wave anisotropy, and anti-correlation between the anomalies in shear wave and bulk-sound velocities, may be explained by the presence of post-perovskite without chemical heteroge neities. In addition, the phase transition boundary has a large positive Clapeyron slop e, three to four ti mes larger than that for post-spinel phase transformation at 660-km depth, su ggesting that it p romotes upwe lling of high-temperature pl umes from the core-mantle boundary re gion. However, simply by its l ocation, the D" layer should have very complex thermal and chemical structures, and so me features remains unso lved. The temperature profile in D could be constrained by the locations of double discontinuities, but the P-T conditions o f phase transitio n still include so me uncertainty. Dense s ubducted MORB crust may have accumulated into chemically distinct piles underneath lower mantle upwellings, but t he seismologic al evidence for the presence of MORB crust in the deep mantle has not been presented. Partial melting at ultra-low velocity zone (ULVZ) and chemical reaction with the liquid outer core also could produce large chemical heterogeneities in D, but its nature remains to be examined.

Keywords: d layer, core mantle boundary, post perovskite

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US008 **Oral Presentation** **56**

Volcanism and Earth evolution

Prof. Stephen Sparks
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Volcanism is a fundamental manifestation of a dynamic planet. Volcanism has contributed to the formation of the oceans and the atmosphere through gas emissions, and has provided chemical conditions in which life could originate and thrive. Igneous processes have differentiated the crust and, via plate tectonics, have led to the main surface morphology of the Earth, namely continents and oceans. There is empirical evidence that periods of intense volcanism in the deep geological past caused environmental stresses that led to mass extinction, although the reasons are not yet well understood. Water, as the dominant volcanic gas species, has played a key role in evolution of the lithosphere, hydrosphere and atmosphere by volcanic processes, particularly in subduction zones. Water is highly soluble in silicate melts at moderate pressures and reduces the solidus temperatures of rocks and the liquidus temperature of magmas, thereby promoting melting. Conversely water becomes insoluble at low pressure and degassing of water induces solidification of rising magmas. The combination of these two properties explains the explosive character of many arc volcanoes. Eruptive and geophysical phenomena at volcanoes can also be related to non-linear flow in volcanic conduits caused by degassing of water and rheological stiffening in ascending magmas. Although there is no evidence that the rate of volcanism is changing from a statistical analysis of a global Holocene database, the hazardous and environmental consequences of volcanism are changing rapidly as a consequence of global change. In an increasingly inter-dependent, populated and ecologically stressed world vulnerability to effects of volcanic eruptions is increasing. Extreme volcanic events pose particular issues. Several megacities have developed close to dangerous volcanoes, which might cause immense lose of live and adversely affect the economy of a country or region. Very large magnitude caldera-forming super-eruptions are very rare, but are the only natural phenomena apart form Near Earth Objects that can cause a global catastrophe for humanity. Large explosive eruptions have major regional and global climatic and environmental impact, while many more frequent eruptions make important contributions to the atmosphere by emissions of gases and aerosols. Advances in modelling and monitoring of volcanic systems have led to significant improvements in ability to forecast volcanic eruptions. However, global knowledge of volcanism and capacity to monitor active volcanoes are very unevenly distributed between the developed and developing world.

Keywords: volcanism, modelling, monitoring

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US008 **Oral Presentation** **57**

Dynamical implications of the post-Perovskite phase transition

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Takashi Nakagawa

Since the discovery of the post-perovskite (PPV) phase transition, several researchers have investigated its possible implications for dynamics in the CMB region and its influence on the mantle above. The first thermal convection models to include it (Nakagawa and Tackley, GRL 2004; Matyska and Yuen, EPSL 2005) indicated a small dynamical effect in slightly destabilizing the lower thermal boundary layer, thereby increasing plume vigor and slightly increasing mantle temperature. As it has long been thought that seismic heterogeneities in the D" region might be caused partly by chemical variations, dynamical issues associated with a mixed thermal-chemical-phase boundary layer are reviewed here. If recent mineral physics data on the density of MORB are correct, a significant fraction of subducted MORB segregates into a layer above the CMB. A layer formed in this way is very heterogeneous and lacks a sharp, clean boundary, unlike layers inserted a priori into calculations. A layer may be global or in the form of intermittent 'piles' and has a large effect on both the mean value and the lateral variation of core heat flux. The post-perovskite transition has a destabilizing influence due to its positive Clapeyron slope, although this is partly offset by latent heat effects. Post-perovskite may occur in localized patches, or in a global, strongly undulating layer, depending on whether the CMB temperature is hot enough to be in the perovskite stability field. Post-perovskite regions may have near-vertical sharp edges, perhaps accounting for some seismic observations. Lateral variations in the occurrence of post-perovskite can cause seismic velocity variations larger than those caused by thermal or chemical variations. If the phase transition pressure is independent of composition, then regions containing a thick layer of post-perovskite are anticorrelated with regions containing thick accumulations of chemically-dense material, but if the PPV transition occurs at lower pressures in the dense material then it can also occur in piles. Heat flux across the CMB, as well as lateral variations in this heat flux, are strongly influenced by the presence of global or local chemical layering, but only mildly influenced by post-perovskite, and can be constrained by seismological observations of the post-perovskite boundary. Coupled models of core-mantle evolution taking into account these effects predict that radioactive potassium is needed in the core, in order to simultaneously allow the extraction of enough heat to drive the geodynamo while not growing the inner core to larger than its observed size.

Keywords: post perovskite, mantle convection

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US008 **Oral Presentation** **58**

Surface and Subsurface Hydrology in the Ice Age

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Over the past several years, increasing attention has been directed to wards understanding flow and solute transport processes occurring over the land surface and in the subsurface in a holistic, fully-integrated computational framework. Issues that have driven the development of such a modelling framework include forecasting the impacts of climate change, land use change, urban growth and increased water taking on the quantity and quality of surface water and groundwater resources. Climate change models, for example, typically ignore the dynamics of groundwater flow in subsurface aquifers although groundwater comprises the bulk of the Earths freshwater and it forms the base flow that maintains streams, lakes and wetlands and the ecosystems within them. This presentation will first briefly describe the underlying theoretical basis of the HydroGeoSphere model, a recently-developed surface/subsurface control-volume finite element model designed to simulate water flow and advective-dispersive solute transport on the 2D land surface and in the 3D subsurface under variably-saturated conditions. Full coupling of the surface and subsurface flow regimes is accomplished implicitly by simultaneously solving one system of non-linear discrete equations describing flow and transport processes in both flow regimes, as well as the water and solute fluxes between continua. The model capabilities and main features are then demonstrated with several 3D numerical simulations performed over various spatial and temporal scales. The examples range from the scale of a regional watershed of about 300 km2 in area and 200m depth to the continental scale that comprises a simulation of the impact of the Wisconsinian glaciation on groundwater flow system and groundwater age evolution (-120 k-year to present) over the entire Canadian land mass to a depth of 10km. For the latter example, a state-of-the-art glacial systems model is used to drive HydroGeoSphere, and includes the impact of ice sheet loading and unloading, isostasy, permafrost formation and thawing, and recharge from subglacial meltwater production. Future research directions include coupling of a climate model to HydroGeoSphere to examine the impact of climate change on surface and groundwater quantity and quality at both basin and continental scales. The simulations presented highlight the difficulties and challenges for representing water flow and solute fluxes in complex natural systems, and stress the advantage of using a process-based model such as HydroGeoSphere for prediction of current and future water management scenarios.

Keywords: hydrogeosphere, numerical simulations

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US008 **Oral Presentation** **59**

Global Earth Structure from Seismic Imaging

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The Earth is imaged by a variety of techniques, ranging from free oscillatons to short period body waves. The basic long wavelength features are well known and reproducible. The continents have deep (~250 km) keels which are particularly pronounced in the ancient cratonic regions, and have the largest anomalies at approximately 110km depth. The coolin g signature in the oceans is clearly mapped, although reconciling the seismic signature with the expected addition of heat as evidenced by seafloor topography poses questions, possibly associated with the contribution of anisotropy. At depths in excess of 250km the magnitude of lateral variations is much smaller, and the signature of subduction emerges as one of the clearest signals, persisting to great depth. The subduction signature persists through the 670 km discontinuity indicating that this boundary is not an impenetrable barrier to subduction, although in some regions there is evidence for the accumulation of seismically fast material near the boundary, suggesting that in these regions the boundary impedes the descent of material into the lower mantle. At the base of the mantle the amplitude of heterogeneity increase markedly, suggesting a high level of compositonal and/or phase heterogeneity. As data volumes have increased it has been possible also to map anisotropy, although the level of agreement between different groups is much less than is the case for the isotropic shear velocity. The need for anisotropy, however, is clear, and some of the features robust. Among such features is the approximate alignment of the fast directions for Rayleigh wave propagation with the directions of absolute plate motion. The determination of shear attenuation distribution is also difficult but some of the large scale features are clearly reproducible. Another way to probe the deep mantle is to investigate reflected and scattered body waves. Precursors to SS and PP have provided valuable information on the topography of discontinuities and also on their *complexity*. Both the 520km discontinuity and the 670km discontinuity have been found to consist of more than one discontinuity in some regions, placing constraints on possible composition. The geographical distribution of the Lehmann discontinuity and its depth variations have been mapped and the dependence of its depth on temperature has been inferred by comparison with tomographic models. Scatted shear waves from the lowermost mantle have identified high velocity features consitent with the laterally varying occurrence of post-perovskite. A general feature of these results is that the observations cannot be explained in terms of temperature variations alone; rather, the seismological results indicate a complex superposition of temperature, composition and/or other effects. Recent results will be summarized and discussed.

Keywords: wavelength features, anisotropy mapping

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US008 **Oral Presentation** **60**

Turbulent Liquid Metal Dynamo Experiments

Prof. Cary Forest
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The self-gener ation of magnetic fields in planet s a nd sta rs--the dy namo effect--is a lon g-standing problem of ma gnetohydrodynamics and plas ma physics. Until recently, r esearch on the self-excitat ion process has been primarily theoretical. Thi s talk will address how dynamo experimen ts, using high speed flows of liquid sodium, have been investig atingthe key processes of th e geodyn amo an d solar dynamo. I will begin with a brief tutorial on how ma gnetic fields are ge nerated in planets and stars, describing the "Standard Model" of self-e xciting dynamos known as the alpha- omega dynamo. In this model, axisymmetric differential rotation can produce the majority of the magnetic field, but some non-axisymmetric, turbulence driven currents are also necessary. Understanding the conversion of turbulent kinetic energy in the fluid motion into e lectrical currents and thus magnetic fields, is the biggest challenge for b oth experiments and t heory at this time. Experimental evidence for thes e currents has recently been discovered ina 1 meter dia meter, sp herical, liquid s odiumdynamo experiment at the University of Wisconsin. These experiments will be described and future directions will be discussed.

Keywords: magnetohydrodynamics, plasma physics

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US010 **61 - 65**

Symposium
Earth System Interactions

Convener : Prof. Guy Brasseur

This symposium invites papers on cutting edge simu lations and an alyses of observations of the Earth system and the interactions among its com ponents in the past, present, and pr ojected to occur in the future. Situati ons of particular interest include the factor s and processes affecting the interactions among the atmosphere, oce ans, ice and land. Also welcome are con tributions addressing human-induced changes that alter climate, contributed to the apparent stability of the pre-industrial climate and led to glacial cycling, and that prevailed during pa st climatic conditions that were warmer than at present

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US010 **Oral Presentation** **61**

Forcing and feedbacks: A continuing tale of a chicken and its egg.

Dr. Natalia Andronova
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Scientific forecasting of a path, which the Earth System follows in space and in time, depends on an ability to comprehend the complexity of interrelation of the systems components. So far, scientific comprehension of this path comes from an abstract vision of the reality, and applied mathematical methods allow freedom in choosing which of the systems variables are dependent and which are independent in fixed or flowing time-space domains. This allows for sorting the systems interactions in two classes- forcings and fedbacks. The perception on "what is what" is based mostly on limited observational constrains. However, where there is none a modeler relies upon his/her scientific intuition. In this paper, based on data available from observations and model simulations, we explore a Cause-and-Effect framework for climate system modeling and analyze the sensitivity of the constructed system to different combinations of the systems forcings and feedbacks.

Keywords: forecasting

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US010 **Oral Presentation** **62**

Large scale connectivities and transformation in the global water system.

Prof. Joseph Alcamo
Center for Environmental Systems Research University of Kassel, Germany

An important new insight of global environmental research has been the recognition of the existence of a global water system. Although the global cycling of water through the earths physical system (ocean, atmosphere, terrestrial freshwater bodies) has long been recognized, we now realize that water also cycles around the earth through its biogeochemical, ecological and socio-economic systems. We are only beginning to perceive the many long-distance connectivities that play an important role in water systems. These connectivities have a physical character (e.g upstream storages of water cause large-scale changes in residence time of surface water), economic character (water is embedded in food and other products and traded internationally), and institutional character (decisions about international trade in water technology have a global impact). While we are beginning to perceive the connectivities that make up the global water system, we are also starting to grasp the rapid changes transforming the system, and the vulnerabilities to society and nature that may come from these transformations. These changes come in many forms: physical alterations (e. g. persistent changes in precipitation and hydrologic patterns), chemical alterations (major changes in sediment and nutrient fluxes from the freshwater system to the ocean), and biological alterations (e.g . significant reduction in aquatic biodiversity). A main agent of change has been the anthropogenic abstraction of water which is leading to increased stress over much of the worlds freshwater system. Under a wide range of future socio-economic and climatic assumptions, water stress is projected to increase by 2050 in two-thirds to three-quarters of the area of the worlds river basins. The main cause of this increase is likely to be larger water withdrawals to satisfy the aspirations of developing countries for higher domestic water use. Associated with increasing water stress is an increase in contaminant loading to surface waters and direct threats to worldwide aquatic biodiversity (a range of scenarios point to a factor of four to eight increase in wastewater loadings within the next four decades over most of Africa). Water scarcity could also be a barrier to economic development in rapidly industrializing countries A recent scenario analysis showed that competition for water resources could pose a risk to the expansion of electricity capacity in India. How should we respond to this new awareness of the connectivities, changes and vulnerabilities in the global water system? One option would be to introduce or strengthen the global perspective in water research, for example, by expanding the scope of earth observations to support global water research, conducting large-scale field experiments and social science surveys to address global water research questions, developing models of the global water system, and/or by introducing the global perspective to the training of young water researchers.

Keywords: global water system, global change, water scarcity

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US010 **Oral Presentation** **63**

Earth system dynamics in the Anthropocene

Prof. Will Steffen
Office of the Vice-Chancellor The Australian National University

The concept of the Earth System implies that the components of the planet - land, ocean, atmosphere, lithosphere, cryosphere - are all connected, and that their interactions give rise to 'emergent behaviour' that cannot be understood or predicted by considering the components in isolation. The phenomenon of global change requires that another component of Earth - the anthroposphere - must now also be included to fully understand the planetary dynamics. This talk deals with the difficult task of incorporating the influences of humans and our societies into the dynamics of the Earth System. The perspective of the past provides important insights into the growth of the human enterprise and its influence on planetary functioning. Our impact on Earth has been discernible for a long time, but a crucial issue is the quantitative importance of the human imprint compared to the natural dynamics of the System. An analysis of the evolution of the human imprint reveals distinct stages, with the post-1950 period - the 'Great Acceleration' - standing out as an era of phenomenal growth in human activity and of unmistakable human influence on the global-scale dynamics of the Earth System. The future presents even bigger challenges in understanding the interaction of human activities with the rest of the Earth System. The talk will briefly explore some emerging approaches for putting homo sapiens interactively into the Earth System, not only conceptually but also in quantitative modelling framework.

Keywords: earth system dynamics, anthropocene

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US010 **Oral Presentation** **64**

Sun-Earth connections on time scales from hours to decades

Dr. Hauke Schmidt
IAGA

G. P. Brasseur,, M. A. Giorgetta, A. Gruzdev, J. Kieser

The variability of the solar particle and shortwave radiative output influences chemistry and dynamics of the Earth's atmosphere over a wide altitude range. While the response is in general stronger in higher atmospheric layers signals may propagate downward via the transport of chemical constituents or dynamical coupling. We are using the HAMMONIA chemistry climate model of the entire atmosphere to study the atmospheric response to a) solar and magnetospheric precipitating particles, and b) short wave solar irradiance variations on the 27-day and 11-year time scale. In this talk, results of our own numerical simulations will be compared to a variety of observational analyses to assess our current knowledge on the solar variability's effect from the lower thermosphere down to the troposphere.

Keywords: solar particle, shortwave radiative

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US010 **Oral Presentation** **65**

Chemistry-climate interactions

Dr. Drew Shindell
IAMAS

The composition of short-liv ed, reactive species in the atmosphere b oth affects a nd is affected by climate. Data on the historical evolution of reactive gases and aerosols is quite sparse, however, so that in co ntrast with well- mixed greenhouse ga ses (WMGHGs), estimati on of temporal c hanges typicall y requires models. These mo dels contain many uncertain processes, espec ially involving aerosol physics, and rely on uncertain emissions. Thus the linkages between reactive trac e species and climate changes are less well established than for WMGHGs. I will discuss model results demonstrating composition-climate interactions for ozone, methane and aerosols. Issues addressed include the climate impacts of : (1) interaction between sulfat e and oxidants, (2) aerosol mixin g, (3) alt ered stratosphere-troposph ere exchange in a warming climate and the res ulting effects on tropospheric ozone, (4) the interaction of solar variability and o zone, (5) the influence of stratospheric ozone depletion on Southern Hemisphere circulation, (6) and changes in natural emissions of methane, VOCs, dust and NOx (from lightning) in a warming climate. I will also discuss efforts to ca lculate net climate impacts of short-li ved precursor emissions, as well as modeling of the relative global and regional impacts of the s hort-lived chemically and radiatively active species as compared with the WMGHGs in the future.

Keywords: atmosphere, climate

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US011 **66 - 80**

Symposium
Modelling and simulation of geophysical flows: present and future

Convener : Prof. Augusto Neri

Understanding the dynamics of geological systems is the ultimate goal of any geophysical science. Such a goal is particularly difficult for geophysical flows since they occur on a wide range of temporal and spatial scales and, mostly, because they are often characterized by a multiphase nature of the mean and by a multidimensional and unsteady dynamics. In recent years, a major step forward in the exploration of these natural transport systems has been possible by the development and use of physical and mathematical models able to quantitatively describe, in a deterministic or probabilistic way, their behaviours. Complex non-linear relationships between system variables, occurrence of non- or counter-intuitive effects, ability to forecast specific system behaviours, are just a few examples of results that can be obtained by using these models. Such a progress has been made possible by the huge increase of computational power as well as by the availability of laboratory experiments able to provide constitutive equations of the fluids involved. Flows of volcanic origin, debris flows, landslides, atmospheric, surface and underwater flows as well as flows associated to the transfer of fluids in the crust and inner Earth are some of the systems commonly investigated by mathematical models. In this session we invite contributions on the latest advances in the modelling and simulation of geophysical flows of any kind. Presentations of state- of-the-art models, applications aimed at model validation through comparison with real observations and lab experiments, inter-comparison between models, and papers addressing future developments and needs in this field are particularly welcome.

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US011 **Oral Presentation** **66**

Numerical modeling and visualization of subduction processes

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Weronika Gorczyk, Manuele Faccenda, Ksenia Nikolaeva, James Connolly, David Yuen

Subduction represents one of the most prominent plate tectonics processes on the Earth and drives cold negatively buoyant lithospheric rocks into the mantle. We use coupled petrological-thermomechanical numerical models with finite-differences and marker-in-cell techniques to investigate the dynamics of this process in three major geodynamic settings: intraoceanic subduction, active continental margins and collisional orogens. We account for dynamical effects of metamorphic reactions and melting of shallow upper mantle and subducted oceanic crust on the melt/fluid pattern, dynamics of thermal-chemical plumes beneath above slabs and volcanic arc crust growth. Several important predictions are made on the basis of our numerical experiments: (1) Exhumation of high and ultra high-pressure rocks in subduction settings is controlled by several types of self-organizing return flows including (i) continuity driven flows in spontaneously forming "cold" and "hot" subduction/tectonic channels, (ii) buoyancy driven flows such as cold waves, cold plumes and buoyant extrusions from the channels. (2) Plume generation above slabs is driven by the subduction of buoyant crustal rocks and expulsion of low viscosity silica-rich aqueous fluids that trigger hydration and partial melting of the mantle wedge producing water-bearing magmas. The models demonstrates two chemically distinct types of plumes: (i) unmixed plumes initiate from the melting front within the mantle that arises as a consequence of the rapid upward infiltration of slab-derived fluids, (ii) mixed plumes initiate from the slab itself and entrain both slab and mantle derived magmas. Mixed plumes explain magmas such as adakites with crustal signatures, while primitive arc tholeiites are attributed to unmixed plumes. (3) Two fundamentally different regimes of melt productivity are predicted for active margins which are consistent with natural observations: (i) During continuous convergence with coupled plates melt production is a maximum at the onset of subduction and then decreases rapidly with time due to the steepening of the slab inclination angle, which precludes formation of partially molten mantle wedge plumes. (ii) During subduction associated with slab delamination and trench retreat resulting in the formation of a pronounced back arc basin with a spreading centre in the middle melt production increases with time due to shallowing/stabilization of slab inclination associated with upward asthenospheric mantle flow toward the extension facilitating propagation of hydrous partially molten plumes from the slab. (4) Most common one-sided pattern of subduction in intraoceanic settings is caused and sustained by upward fluid fluxes. These fluids (i) lower the yield strength of the mantle above the slab and (ii) cause mantle wedge melting and volcanic arc growth, thus creating an inherent subduction zone asymmetry. In contrast, numerical models which do not account for aqueous fluids have a strong tendency to form unrealistic double-sided subduction patterns. (5) One-sided and two-sided collision zones are identified differing in the pattern of lithospheric plate motion, crustal geometry, metamorphic zonning and topographic evolution. Strong recycling of the continental crust beneath collisional orogens toward transition zone and, possibly to the core-mantle boundary is predicted.

Keywords: subduction, numerical model, prediction

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US011 **Oral Presentation** **67**

Large-scale experiments on the mechanics of pyroclastic flows: first results and implication for density currents modelling

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A newly designed apparatus for experimental studies of pyroclastic flows consists of a cylindrical conduit that is filled with samples of natural volcanic products (tephra). Blowing nozzles in the base plate of the conduit are connected to a volume of highly pressurized gas. Opening of fast solenoid valves results in impulse like coupling of the released gas to the sample. The system was designed so that the range of mechanical energy transferred to the particle mass in the conduit reflects the mechanical energy observed and measured during fragmentation experiments with melts of similar composition. Depending on the specific mechanical energy (SME) of the system, which results from ˜P V/m, where ˜P is gas overpressure (i.e. pressure > atmospheric), V is gas volume and m is sample mass, different behaviours are observed. If SME > 2.6 kJ/kg, a dilute plume develops and particles are sedimented by fallout exclusively. If SME < 1.5 kJ/kg, the exiting column collapses and develops a shear current similar to a pyroclastic flow. The Reynolds number of the shear currents is > 106, implying that flows are fully turbulent, and that particle coupling to gas turbulence of natural pyroclastic flows is replicated by the experiments. The measured shear current velocities are proportional to the impact mass flow rate, i.e. the product of mixture density and impact velocity. Experimental data and grain-size analysis of the produced particle deposits suggest that the scale of the experiment is large enough to reproduce the transport dynamics of natural pyroclastic flows. Flow evolution after impact on the ground clearly resembles the formation of a turbulent boundary layer shear flow, as described in classic fluid-physics. Boundary layer theory is therefore a good foundation for modelling the transportation characteristics of pyroclastic density currents.

Keywords: pyroclatic flows, experiments, ash particles

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US011 **Oral Presentation** **68**

A minimal model of soil-vegetation-atmosphere interactions

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The interaction of soil moisture, atmospheric dynamics and vegetation controls the local hydrologic budget, and it can affect larger-scale climatic patterns. Here we discuss a simple box model of the interaction between vegetation dynamics, soil moisture and convection in the the planetary boundary layer. The model displays multiple stable statesand it can be used to rationalize the occurrence of dry and wet conditions under the same type of external forcing and the insurgence of summer droughts at continental midlatitudes.

Keywords: soil vegetation interactions, atmospheric convection, summer droughts

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US011 **Oral Presentation** **69**

Statistical parameterization of oceanic deep convection

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Tziperman Eli

Ocean deep convection occurs at spatial scales sm aller than the typi cal grid resolu tion of gen eral circulation models. Its effect is usually parameterized in terms o f enhan ced vertical dif fusivity or mo re refined vertical transport, that operate whenever the mean density vertical profile is statically unstable. Recent observational and mo deling studies have shown that convection is bo th affected by meso - and submeso- scale processes and also creates small sc ale anomalies. In presence of temperature and salinity variabi lity, convectiv e transport can resu lt in upgradient fluxes in grid-scale averaged temperature or salinity, which current parameterizations dont reproduce. Moreover, artificial spatial and temporal intermittency of convection has been observed in several commonly used parameterizations. A statitistical par ameterization that accounts for subgr id-scale variability in temperature and salinity and allows for parti al mixing between different l ayers in the w ater column has been shown to be able t o generate upgr adient fluxes and to reduce interm ittency by allowing f or smooth transitions betwee n states of convection on and off.

Keywords: convection, sub grid scale processes, countergradient fluxes

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US011 **Oral Presentation** **70**

Integrating multi-scale observations with macroscopic models of explosive volcanic eruptions: The role of subgrid models in coupling laboratory and numerical experiments with field observations

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Michael Manga

Explosive volcanic eruptions produce turbulent, multiphase flows that encompass a vast range of scales from micron-scale ash to eru ptive plumes t hat can extend 100s of kilometers. One of the fu ndamental challenges in understandi ng these events is reconcil ing t he role of mic rophysical proc ess (e.g. at th e scale of individual particles) with the macroscopic di spersal of particles in plumes and pyroclastic flows. Recent modeling efforts and long establish ed observ ations of deposits h ave demonstrated that quasi - persistent flow structures can develop in these eruptions and particles of different size and density can be concentrated as a resu lt of coupling with these structures. Yet due to limited resources, computational and conceptual models have focused on the large-scale structures of bulk material rather than local interactions that ma y ultimately pro duce emergent dyna mics that result fro m mass, momentum an d heat exchan ge at small scales. To a ccount for process es that occur at scales smaller than those resolved in simulati ons of large-scale dyna mics, we need to incorpor ate models fo r microphysical processes. We illustrate how laboratory characterization of particle-scale processes can be used to develo p such sub-grid scale models and then inte grated with numerical models of large-scale dynamics. While laboratory experiments are unable to si mulate the full range of scales in natural flows, it is possible to make measurements at conditions (e.g., temperature, velocity) that apply at the subgrid scale. We identify multiphase dimensionless groups th at are important for mass, momentum and heat transfer, and demonstrate how source terms from subgrid models ar e coupled in the governing conservation equations. After developing this ge neralized subgrid fra mework, we will discuss two examples of particle-scale pr ocesses that influence th e dynamics of pyroclastic flo ws. First we consider the role partic le-scale heat tr ansfer in generating steam when pyroclastic flows encou nter bodies of water. Seco nd we co nsider the generatio n o f ash du e to particle co llisions and frictio nal interaction within the flow. Both exa mples demons trate th e two-way cou pling of micro- an d macro-scale phenomena: b ody forces an d aerodynamic forces from l arge-scale turbulent structures sort part icles resulting in enhanced heat and mo mentum transf er leading to secondary gathering and dispersal events.

Keywords: modeling, volcanic eruptions

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US011 **Oral Presentation** **71**

Numerical Plume Modeling with ATHAM: Volcanic Eruptions Columns and beyond

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The dynamics of gas particle mixtures is affected by the exchange of momentum and heat between the components of this mixture. Volcanic eruption columns are an extreme example where the interaction between gas and particles is important for the plume development. Although ash particles occupy only a small fraction of the total volume they can by far dominate the mixture's mass. ATHAM simulates the dynamics of a gas particle mixture by assuming an instantaneous exchange of momentum and heat between between gas and particles. In the absence of particles ATHAM simplifies to a non-hydrostatic atmospheric circulation model. Because of this generality, we cannot only study particle laden plumes but also other atmospheric problems. This paper will discuss the model's concept, present available process modules and show results from several model applications while mainly focusing on the volcanic plume.

Keywords: gas particle mixtures, volcanic plume

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US011 **Oral Presentation** **72**

Modeling the fluid dynamics of multicomponent compressible magma in sub-surface volcanic environment

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Magmas are multiphase multicomponent fluids which undergo chemical evolution and phase changes during their sub-surface history, implying large variations in fluid flow properties and a richness and variety of fluid dynamic behaviours. The formation of gas bubbles upon exsolution from the liquid of magmatic volatiles, mainly water and carbon dioxide, represents the major factors inducing density differences and convection in magmatic bodies. This results in complex patterns of fluid flow which occasionally generate conditions for rock fracturing, magma ascent, and eruption. In order to simulate the fluid dynamics of magma in magma chambers and conduit/fissures, we have developed a C++ numerical code which solves the transient, 2D mass, momentum and energy transport equations for a homogeneous multiphase multicomponent magma with liquid-gas non-ideal equilibrium and locally defined P-T-composition-dependent physical/chemical properties. The numerical algorithm is based on a finite element formulation and space-time discretization with Galerkin least-squares and discontinuity capturing terms, which allow high numerical stability and robust and accurate solutions over a wide range of flow regimes from compressible to incompressible. The multicomponent formulation makes the code particularly suitable for the investigation of several relevant aspects of magma dynamics involving density changes, mixing, multiple volatile saturation and phase transitions. Applications of the code have been done to simulate the dynamics of free and forced convection in magmatic systems originating from gravitational instabilities, magma chamber replenishment, and conduit flow and magma ascent towards the Earth surface. The results highlight several aspects of the complex sub-surface magma dynamics, among which, the major role of carbon dioxide in inducing efficient magma convection and mixing dynamics, the possible occurrence of magma re-circulation from shallow reservoirs into deeper feeding conduits, the effect of convection of compressible magma in causing overpressure and enhancing stress on the confining rocks, and the generation of pressure fluctuations over a large range of frequencies encompassing those typical of quasi-static and dynamic rock deformation commonly registered in volcanic areas. The future research needs to improve the modelling and simulation of deep magmatic properties, specifically by coupling the dynamics of the fluid magma and the rock structure, are briefly outlined.

Keywords: magma dynamics, compressible flow, multicomponent fluids

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US011 **Oral Presentation** **73**

Bulk rheology of dense granular flows

Dr. Deniz Ertas

The rules that govern the flow of granular matter, i.e. their rheology, is still poorly understood relative to the well-es tablished field of Newtonian fluid mechanics, which describes flow rules for simple (Newtonian) fluids. My research focuses on the bulk rheology of steady dense granular flows, in orde r to fill the constitutive relations gap between critical state soil mechanics and kinetic theory descriptions. This is the regi me where the deformation rate is no longer independent o f applied stress, yet there is still a percolating contact network that transmits the vast majority of stress across the material. Most of our work to date involves using three-dimensiona l molecular dynamics simulations to study stead y gravity-driven flows of fricti onal inelastic spheres of diameter d and de nsity ˜g down an incline. Our more recent wo rk studies a plane Co uette geo metry with no gravity, which has the adva ntage o f creating spatially unifo rm flows (no gradients in the macrostate variab les). Dry fl ows are modeled through granular contact forces (both Hookean and Hertzian) with static friction. Interstitial fluid effects are then incor porated via two- body lubrication forc es only. Scaling arguments suggest that, in 3D, the lubrication forces constitute the dominant perturbation of an interstitial fluid for small Reynolds number Re and low fluid density ˜, when the dilatancy with re spect to the critical state is sm all. For both dry and submerged flows, the main parameter that determ ines the state of the flow is the dimensionless strain rate ˜, which controls the porosity, traction coefficient, and gr anular temperature, i.e., velocity fluctuations, of the flow. For dry incline flows, this parameter remains constant with depth and results in steady flows over a range o f inclination an gles and flo w depths. On the o ther hand, we o bserve th at incline flows with lubrication forces exhibit a porosity that increases with increasing distance from the surface. As the incline angle is incr eased, this results in a highly di lated basal layer that looks like "hydroplaning" similar to that observed in geological subaqueous de bris flows. The same phenomeno n is observed in the plane Couette geometry as a shar p transition beyond which the traction coeffic ient becomes independent of strai n rate. The ob servation of hydroplaning in this model is remarkable since the model explicitly disallows any b uildup of fluid pr essure in the base of the flow, and suggests t hat hydroplaning might have other contributing factors besides this traditional explanation.

Keywords: flow, granular matter

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US011 **Oral Presentation** **74**

Modeling the dynamics of turbulent multiphase gravity currents: the importance of geologically diverse boundary conditions

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G.W. Bergantz

Many processes in nature involve multiple, mechanically distinct phases: for instance, ash particles interacting with a turbulent gas phase in an explosive volcanic eruption. More generally, multiphase flows shape the landscape of all terrestrial planets and dictate interactions at the interface of the solid surface and the atmosphere. Although extremely common, the cumulative expression of numerous particle-particle and particle-fluid interactions can produce emergent meso-scale structure and self-organization that can be difficult to predict a priori. Yet many particle-laden and granular flows represent significant natural hazards. This presentation will focus on pyroclastic flows produced during explosive volcanic eruptions as they represent a high-energy end-member for granular flows, and permit exploration of a vast parameter space of particle-particle and particle-gas interactions. These flows contain a vast range of grain sizes (from microns to meters) and can transform from turbulent, particle-dilute flows to particle-dense flows. The inherent difficulty of observing volcanic events as well as the scarcity of on-going eruptions has resulted in a continuing debate about the internal particle concentration of pyroclastic flows from dilute to dense end-members. For instance, it remains unclear to what degree basally concentrated bed-load regions of the flow are responsible for mass and momentum transfer. In order to probe the internal structure of these flows an Eulerian-Eulerian-Lagrangian (EEL) computational approach coupled with an examination of the deposits of Kos Plateau Tuff (KPT) was used. In particular, the KPT eruption provides a unique opportunity to compare flows that may have traversed a body of water (and thereby filtering out their bed-load) versus flow that have traveled over-land. In the EEL computational approach, separate particle sizes are treated as distinct phases that can move relative to each other. This coupled deposit-driven and numerical investigation reveals that energy-dissipation at the basal boundary is one of the primary factors determining the run-out distance of pyroclastic flows. A significant portion of the momentum of over-land flows is transported in a bed-load region dominated by numerous particle-particle and particle-boundary interactions. Particle size sorting in the KPT deposits corresponds well to the simulated deposits and provides a mechanism to link the dynamics of a flow to its depositional record. Further, this investigation demonstrates that neglecting fluid entrainment and particle-bed interaction may underestimate run-out distance by over 100%.

Keywords: ash particles, volcanism

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US011 **Oral Presentation** **75**

Cyclic behaviour in lava dome building eruptions

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Lava dome eruptions are commonly characterized by large fluctuations in extrusion rate with cyclic behaviour on time- scales ranging from hours to decades. Such behaviour has been recognized worldwide, at Bezymianny and Shiveluch volcanos (Russia), Merapi (Java), Santiaguito (Guatemala), Mt St Helens (USA), Mt Unzen (Japan), and Soufrière Hills volcano (Montserrat), among others. Cyclicity provides an opportunity to test new models leading to improved understanding of the dynamics of complex magmatic systems. We will give a review of existing models that explain different timescales of cycles on lava dome building eruptions. It is clear that no single model can explain all ranges of observed timescales. Short-period pulsations (hours) are a consequence of shallow conduit processes, years to decades timescales are controlled by pressure evolution inside a magma chamber, even longer timescales reflect evolution of supply rate of fresh magmas from feeding systems. An intermediate timescale of an order of several weeks was observed on Mt St Helens (USA) and the Soufrière Hills volcano (Montserrat). We suggest that these pulsations can be a consequence of elastic response of a dyke shaped conduit with cross-section area that depends on magmatic overpressure. The dyke acts like a volumetric capacitor, storing magma as pressure increases and then releasing magma in a pulse of extrusion. For a well-documented case of the Soufrière Hills volcano, cyclic extrusions with time-scales of a 5 to 7 weeks are predicted for dykes 300 –500 m wide and 3-6 m thick. The model explains the sharp onset of tilt pulsations and seismic swarms as well as associated short- lived explosions. Common features of the models that predict cyclic variation in parameters of volcanic system are: first, there is a region of flow parameters where the conduit friction decreases with increase in the ascent velocity, and, second, there is some delay process in the system that controls periods of pulsations. Decrease in friction can be a consequence of volatile or crystal dependent viscosity or changes in wall boundary conditions from stick to slip. Delays are associated with crystal growth kinetics, volatile exsolution or heat exchange with wallrocks. The presence of these features, although, does not automatically mean that the system has periodic behaviour.

Keywords: volcaniceruption, lava dome, model

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US011 **Oral Presentation** **76**

Laboratory analogue investigation of the dynamics of vulcanian eruptions: insights into fundamental dynamics and constraints for numerical investigations

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Vulcanian eruptions are small explosive volcanic eruptions, which occur frequently at many volcanoes worldwide. This eruptive style presents a significant natural hazard in terms of ash deposition and pyroclastic flow development, and may form the initial and waning phases of larger more explosive eruptions. The eruption plumes generated by Vulcanian events are both unsteady and turbulent, and difficult to measure directly, due to their short duration and the low temporal resolution of field monitoring methods. An appropriate methodology for investigating the fundamental dynamics and testing the predictions of computational models is the use of laboratory analogue experiments. In this study we used appropriately-scaled laboratory experiments to investigate the dynamics of short duration, high pressure releases of buoyant and dense fluid. Pressurized mixtures of water, alcohol and solid particles were released into fresh water, producing short- lived jets, plumes, thermals and collapsing fountains. The experiments identified the total momentum, buoyancy and volume of the release as independent controlling parameters over a wide range of initial conditions, and this was confirmed by scaling analysis. In this presentation we focus on using the laboratory observations to constrain the development of predictive models for unsteady flows resulting from finite volume fluid releases. Experimental observations and dimensional scalings provide constraints on the flow velocity scales at short and long times, and provide fundamental insight into the mechanisms by which these flows incorporate, or entrain, fluid from their surroundings as they propagate. We emphasize observations and constraints that cannot be obtained from numerical models or field measurements, and highlight the role of laboratory experiments as part of the toolkit for investigating complex geophysical flows.

Keywords: vulcanian, laboratory experiment, theoretical model

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US011 **Oral Presentation** **77**

Long runout landslides: the role of frictional heating and hydraulic diffusivity

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Landslides are a significant worldwide natural hazard, also playing a leading role in the morphological evolution of the Earth and other planets. Natural landslides often exhibit surprisingly large travel distances and an unexplained decrease in apparent friction coefficient H/L (where H is the drop height and L the travel distance) with increasing slide volume, V. In this talk I will present a thermo-poro-elastic mechanism operating at the base of landslides that may explain this behavior. Numerical simulation results indicate that frictional heating at the base of landslides elevates fluid pore pressure and reduces friction, resulting in large sliding velocities and distances. Depth-dependent permeability controls pore pressure diffusion rates from the shear zone, allowing larger slides to maintain high pore pressure for longer times, thus resulting in lower H/L. The numerically obtained relation between V and H/L agrees with field data of subaerial landslides.

Keywords: friction, landslides, pore fluid

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US011 **Oral Presentation** **78**

Channelization driven by subsurface flow: models, observations, and experiments

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When groundwater emerges with sufficient flux on an inclined surface, material at the surface erodes. This process, known as seepage erosion, is thought to play a significant role in the formation of drainage channels, including beach rills, subaerial and submarine canyons, and Martian gullies. Because seepage flow into a channel depends mostly on the channel's shape, seepage-induced channelization provides a simple context for studying the relations between the small-scale dynamics of erosive processes and the largescale features of the resulting channels. Here we discuss quantitative models that address the growth of an individual channel and the formation of channel networks. Our models are motivated by table-top laboratory experiments and field observations. The experiments provide time-resolved topographic measurements of channel growth using a laser-aided imaging technique. We describe a model for the evolution of channel shape in which the erosion rate is composed of diffusive and advective components as well as a simple driving term due to seeping water. The time-dependent evolution of the model compares well to experimental data. Under steady driving conditions, the model predicts an asymptotically self-similar shape that depends on the erosion rate and granular transport coefficients. We compare this prediction to the transverse profile of a large-scale (100 m wide) seepage channel incised in unconsolidated sand in the Appalachicola River basin, Florida. A quantitative fit yields estimates of the granular transport coefficients. At the same Florida site, we have used ground penetrating radar to map the water table in the vicinity of channel heads. We have also measured the groundwater flux into channels. These observations motivate a numerical model of the channel network in which channels nucleate as side branches and grow at a rate proportional to the groundwater flux they attract. In general, the groundwater flux must be determined from a three-dimensional solution of the subsurface flow. We simplify the problem, however, by formulating an approximation of the groundwater flux that depends only on the planform geometry of the two-dimensional channel network. We use this approximation to construct a simple numerical model of a growing channel network. Results of the model are consistent with both qualitative and quantitative features of the Florida channels.

Keywords: erosion, groundwater flow, channelization

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US011 **Oral Presentation** **79**

Modeling of hydrothermal fluid circulation in active volcanic areas.

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Subsurface flow of heat and fluids govern many pr ocesses with a releva nt economic a nd social role. A special case is represented by non-isothermal and mu lti-phase fluids, such as those naturally occurring in geothermal areas. Modeling of heat and fluids transport through porous media has been developed through the ye ars, initially driven by the needs of geothermal industry. With time, the se models hav e been applied to a variety of problems inclu ding site testin g for nuclear waste disposal, environmental restoration, mining engineer ing, vado se z one hydro logy and, mo re r ecently, fo r carbo n dio xide sequestration. A particular field of application for models describing non-isothermal subsurface flows is the study of active but quies cent volcanoes. During quiescent times, the presence of a hydrothermal system controls the he at and mass tra nsfer from the m agma cham ber to the surf ace. Variable bu t significant am ounts of heat and fluids ar e daily re leased in active v olcanic areas through diffu se degassing, hot springs, and fumaroles. T he presen ce and circulatio n o f hydro thermal fluids may generate typical unrest phe nomena, including gro und deformation, s eismic activity , gravity and compositional changes. Physi cal modeling of hydrot hermal fluid circula tion allows to quantify thes e processes, and it therefore provides an imp ortant contribution to the interpreta tion of monitoring data and to volcanic hazard assessment. To this purpose, however, modeling results need to be comparable with different sets of monitor ing data. Physical models should therefore account for the non-isothermal, multi-phase and multi-comp onent na ture of hydrothermal fluids. Simulations should describe fluid properties, as they change with system con ditions, and ta ke into account the physical and chemical interactions between the fl uids and the porous rock. The mai n issues arising fro m modeling of hydrothermal f luid circulatio n in active volcanic areas will be disc ussed here, toget her with som e examples from recent applications and some comments on future prospects.

Keywords: subsurface flow, non isothermal, fluids

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US011 **Oral Presentation** **80**

On In Situ Dissolution of Evaporites

Prof. Andy Wooods
science member

We describe the processes controlling the in situ co nvective dissolution of evaporite deposits, using a heirarchical series of theoretic al models. We explore how the pattern of di ssolution is co ntrolled by the grade of the deposit and the supply rate of solute to the dissolution surface, leading to complex cavern morphologies. The presentation wll be supported with movies of analogue laboratory experiments which constrain and inform the modelling.

Keywords: evaporites, dissolution

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US012 **81 - 95**

Symposium
Early Warning of Natural Hazards

Convener : Prof. Ramesh Singh

Satellite remote sensing has proved to be a very important tool in mapping of the damages related to natural hazards in recent years. Numerous sensors onboard satellites have capability of providing information about land, ocean and atmosphere. Natural hazards (Earthquakes, Volcanoes, Tsunami , Landslides, Floods, Cyclones/hurricanes, Subsidence, Harmful algal blooms, Erosion, Cloud bursts, Snow avalanches, Oil spills, Dust storms, Coastal erosion, Droughts, Desertifications) occur on land or ocean; atmosphere provides linkage, it is now strongly believed that these natural hazards provide strong coupling between land- ocean-atmosphere-ionosphere. The session will discuss applications of Remote Sensing in mapping, monitoring and early warning of various Natural Hazards. Invited and contributed papers should be presented in the session

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US012 **Oral Presentation** **81**

Complementary behavior of Multi Sensor Data For Early Warning of Earthquakes

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Multi sensor satellite parameters are available glob ally during day and night that provide informatio n about land, o ceans and atm osphere. Recent studies of various related parameters in the epicentral regions of earthquakes have shown asso ciation with the actual occurrences. Deta iled analysis of such multi sensor data from numerous satellites have shown high sensit ivity prior to the occurrence of earthquakes of magnitude more than 5. 0. Some of the p arameters are found to be highly sensitive t o the location, geology, type of fault associated with the earthquake, while other parameters are found to be insensitive. In the present work, efforts have been made to analyze and compare numerous satellite and ground pa rameters showing their comp lementary anomalous behavi or few days prior to specific earthquake events. A series of earthquakes recent ly occurred on land, co astal and oceanic region s throughout th e glo be which sho w co mplementary a nomalous behavio r in several p arameters. We suggest these could be used in the future as early warning of impending earthquakes.

Keywords: natural hazards, remote sensing

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US012 **Oral Presentation** **82**

Early warnings of forest fires with MSG-SEVIRI data

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Francesco Marchese, Rossana Paciello, Nicola Pergola, Valerio Tramutoli

A Robust Satellite Technique (RST) permits us to automatically identify anomalous space-time signal transients related to actual hazardous events distinguishing them from signal occurrences of similar intensity but originated by the natural space-time variability of land coverage and/or atmospheric conditions. In this paper, the RST (Robust Satellite Technique) method has been successfully applied for the monitoring of major natural and environmental risks, exploiting MSG-SEVIRI potential for forest fire detection. The RST scheme is based on a multi-temporal analysis of co-located satellite records and on an automatic change detection scheme. The index of local (in space and time) change, which is at the basis of the classical RST approach, is here integrated with a differential index, computed by using RST prescription as well, which permits us to identify the very start of a forest fire event, exploiting the high temporal repetition of the sensor. A possible real-time implementation of such a scheme will be discussed, analysing its actual potential and its possible contribution to the development of a reliable and efficient early warning system. Moreover, the exportability of this approach (already applied both to polar e.g. NOAA/AVHRR- and geostationary data e.g. Meteosat 5, 7, GOES) guarantees its complete applicability to other present or future sensor data.

Keywords: rst, satellite, sensors

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US012 **Oral Presentation** **83**

Early warning in case of potential tsunami

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Gitews-Project Team

The mega-tsunami of Dec. 26th, 2004, in the Indian Ocean has made clear to the world that there is a need for reliable tsunami early warning not only in case of the Pacific where early warning is already in place since a few decades, but also in case of other major oceans, such as the Indic, the Atlantic, the Caribbean and the Mediterranean, where nothing comparable exists. Guided by the German-Indonesian activities towards an early warning system for the Indian Ocean, the presentation will attempt to answer the questions, - which technological components are essential and presently available for tsunami early warning, - which new scientific challenges can be identified in this field and - what are the technologies we should further develop for more effective systems in the future.The presentation will especially address new possibilities for tsunami early warning coming from satellite geodesy. In addition, it will point out that a scientific-technological system alone will not be sufficient for reliable early warning, but that bridging the 'last mile', i.e. bringing a warning message to the people and making them understand and react properly, is an absolutely necessary, though still the weakest link in the early warning chain.

Keywords: earlywarning, tsunami, satellite geodesy

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US012 **Oral Presentation** **84**

National assessment methodology for australian wind risk

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Mark Edwards, Krishna Nadimpalli

A review commissioned by the Council of Australian Governments (COAG) in June 2001 entitled 'Natural Disasters in A ustralia: reforming mitigation, relief and r ecovery arrang ements' co ncluded that a ne w approach to natural disasters in Australia was needed. The approach would aim to achie ve safer, more sustainable Australian comm unities in addition to a reduction in risk, da mage and losses from future natural disaster s. This new appro ach invo lves a fund amental shift in foc us beyond relief and recovery towards cost -effective, evidence-based disaster miti gation. Consequently, while disaster response and reaction plans remain important, the move is now towards anticipation and mi tigation against natur al hazards. Geoscience Australia is developing risk models and innovativ e approaches to assess the potential losses to Australian communities from a ra nge of sudden impact natural hazards. They aim to define the economic and social threat pose d by a ra nge of ra pid on set h azards th rough a combin ed study o f natural haz ard res earch metho ds and risk as sessment mod els. These hazards include earthquakes, cyclo nes, flo ods, landslides, severe winds a nd storm surge/tsunami. The aim of this presentation is to provide an overview of the risk that pea k wind gusts p ose to a numb er of Australian communities. The impact o f severe wind v aries co nsiderably between e quivalent structures lo cated at different sites due to local roughness of the upwind terrain, shielding provided by upwind structures and topographic factors. Terrain surface roughness informat ion is a critical spatial input used to generate wind multiplier s. It is gener ally the first spatial fiel d to be evaluated, as it is utilised in both the generation of the shielding and topographic wind multiplier. LANDSAT imagery was employed to generate terrain surface roug hness product for six ma jor metropolitan areas across Aus tralia in 2005/6. The digital ele vation model (DEM) was ass embled ut ilising locally derived 5 and 10- metre resolution DEM's and selected Shuttle Radar To mography Mission (SRTM) 3 arc-seco nd DEM tiles. To date, hazar d evaluation invo lves the spatia lly dependent estimated return period regional wind spee ds (for peak 3 second gusts) obtained from either the Au stralian/New Zealand wind loadi ng stan dard [AS/NZS 1170.2 (2002)], a reg ional assessment of the m eteorological observing st ation wind measurements, or a cyclone wind model or climate model. In the latter two models, an allowance is made for the gust factor based on empirical evidence. The local wind effects on these return period regional win d speeds were determined by assessing the local effect of terrain at the structure height of interest, the shielding effect of up-wind buil dings and the effect of topography. The estimation of the l ocal wind speeds that would be equalled or exceeded wit hin a given ti me period (commonly called return period wind speeds or return levels) was derived by combinin g the local wind multipliers (terrain/height, shielding a nd topographic) for 8 cardinal di rections with the retu rn period regio nal wind speeds on a 25 by 25 metre grid across each study region. The maximum gust wind speed for all directions over a ra nge of return periods was sampled at each grid location and used to assess the likelihood of residential damage. This assessment provides the first step towards a national scale peak gust wind risk assessment for Australia and represents the first iteration in what is pla nned to b e a co ntinuously impro ving pro duct. These assessments cover both urban development and adjacent rural regions of all Australian capital cities and some large rur al centres. It i s anticipated t hat th ese risk results will be refined and updated as the understanding of Australian peak wind g usts impr oves. The presenta tion explains the methodology employed by Geoscience Australia to evaluate the risk as sociated with peak wind gus ts in Australian cities, and provides results in the form of p ercentage losses for return p eriod gust winds ranging from 50 years to 20 00 years. Limitations with the present meth odology are al so ex amined. The discussion

provides an insight to the direction being adopted for a national scale assessment of severe wind gust risk.

Keywords: risk assessment, wind hazard, spatial enablement

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US012 **Oral Presentation** **85**

World Meteorological Organization Global Sand and Dust Storm Warning

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Leonard Barrie

During sand and desert storms, large amounts of du st are mobilized and transported away from desert sources. Suspended dust g enerates semi-permanent pa tterns of local to c ontinental scales that persist in the atmosp here for several weeks. Und er favour able conditions, dust plumes may be transported between continents. For count ries in and do wnwind of desert sources, sand and dust st orms represent serious natural hazards, causing numero us negative impacts. Impacts on health are among most serious, causing respiratory and ca rdio-vascular problems and eye infe ctions. In some regions such as North and South America, dust carries spores that cause diseases such as the valley fever. Through the intercontinental dust transpor t, dust plumes can al so efficiently transport nut rients to world oceans. Other impacts include negativ e effects o n the gro und transport, aviation, agriculture and visibility. The IPCC recognizes dust as a major component of the atmospheric aerosol that is considered by the Global Climate Observation System as an essent ial clim ate var iable. Advance d numerical aerosol models available today to the community provide r ather a ccurate dust concentr ation predictions for sever al days in advance. Dust models, by assimilating the satellite and ground-based observations are ca pable to simulate th e atmospheric dust cycle. D ust modules, driven by the numerical weather prediction systems, use complex parameterization and mathematical techniques to accurately represent the source fluxes, transport and dust removal. Sand and du st mo dels pro duce numero us pro ducts that ma y contribute to the mitigation and red uction of risks to human and a nimal health. In 2006, World Meteorological Organ ization (WMO) an d partn ers h ave initiated the implemen tation of the Sand and Dust Storm Warning System (SDS WS) in or der to improve the capabilities of countries affected by dust to reduce environmental risks caused by mineral ae rosol. Regional ce ntres will coor dinate access of users to a system of sand and dust storm operational research forecasts integrated with observations. A web portal will be established with links to regio nal contributing institutions, in order t o provide routine sand a nd dust storm forecasts, and to promote corre sponding research and ap plications. This article describes in detail components of the WMO SDS WS. It also reports s ome concrete examples of current applications that have been effectively implemented.

Keywords: dust, warning

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US012 **Oral Presentation** **86**

Responses of marine phytoplankton blooms to natural hadzards - tsunami, typhoons, and dust storms

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With global warming, typhoon activities have got strengthening in both intensity and spatial coverage in the past se veral decades in the South Chi na Sea; dust storm is becoming a serious problem in the northwestern China; o n 26 December 20 04, the massi ve earthq uake o ff no rthern Sum atra co ast (Indonesia) pro duced largest trans- oceanic tsunami in o ver 40 years. To understand the response dynamics o f marine eco system to tho se natural h azards, we have investigated variatio ns o f phytoplankton blooms an d oth er en vironmental factor s for the Asian w aters, including the northern Indian Ocean, China coastal waters, and the South China Sea, for lon g term using satellite rem ote sensing data, in situ observation, and historic records. Results show that typhoon can enhance offshore and ne ar-shore phytoplankt on bloom and primary production by typ hoon winds and subseq uent terrestrial rainwater runoff in the South C hina Sea; the offshore bloom was due to nutrient increase from by mixing and upwelling. The near-shore phytop lankton / chl a increase succeeded typhoon rain on Hainan Island in the no rthwest SCS (Zheng a nd Ta ng, 2007, Mar ine Ecology Pr ogress Series). Stronger typhoons generally i nduce mo re extensive ranges of phyto plankton bloom; translation-slower speed of typhoons can enhance the tendency of in creasing phyto plankton bio mass (Zhao and Tang, 2007). Special variations of phytoplankton concen trations, suspended sediments, a nd sea surfac e temperature (SST) were ob served related to the 2004 tsunami in the Indian Ocean. A large phytoplankton bloom occurred in so utheast of the No rthern Indian Ocean after the tsunami. Our study on dusts also indicate that yearly variation of phytoplankton bloom (and harmful algal bloom (HAB)) for the Bohai Sea and the Yellow Sea show similar tenden cy with yearly variation of dust storms in the northwester China. Both HAB and dust storm occurrences increased during 2000 to 2004 with one peak in the same year of 2001. Those studies indicate the in ter-linkages an d interactions among marine phytoplankton ecosystem and environmental changes / nat ural ha zards; Satellite remo te sensing has proved to be a very important tool in mapping of the changes related to natural hazards.

Keywords: naturalhazards, phytoplankton bloom, remote sensing

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US012 **Oral Presentation** **87**

Application of Satellite Data for Early Drought Detections and Impact Assessment on the Environment and Society

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The new millennium has st arted with nearly 20 percen t of the world stri cken by droughts every year. These drought s affected agri culture, fisheries, tr ansportation, to urism, energy co nsumption, human health, environment and wate r resources around the world. In poor countries, societal im pacts resulted in famine, malnutritio n, epidemics, human sufferi ng dea th and aband onment of wh ole geographic areas. This pre sentation describes how the new oper ational space techno logy helps to detect drought very early, evaluate affected area and assess drought impacts in any part of the globe. A new method is based on estimation of vegetation stress from AV HRR-derived vegetation health index (VHI), which is a numerical combination of visible near infrar ed an d therma l radiances= measurements. Now, dr ought can be detected 4-6 weeks earlier than from any other observations. Drought detection and ad vanced warnings help relief organizations to provide food to drou ght-stricken are as when the population is in great need. The VHI correlates highly with producti vity of crops and pastures and c an be used as numerical indicator of drought-related agricu ltural losses in much advance of harvest. In the last three years, drought-affected area increased considerably in Kenya (55% of the country), Ug anda (45%), in northern China 's J ilin pro vince (45%), Afghanistan (60%), Pakistan (40%), and in the USA's Texas (60%). Moreover, the Horn of Africa h as experienced severe drought seven years in a row (2000-2006) and in the wes tern USA, drought triggered many forest fires in the last f our years. The recent studies indicate that t he VHI in addition to early drought dete ction, prov ides lead-time information about potential for development of mosquito-borne epidemics, insects and crop diseases. The antecedent and physiological effects discernab le from the ne w method can be used for diagnosis of a ten dency toward deterioration of vegetation he alth and potential fo r vegetation stress devel opment three months before the drought started. This provides added w arning lead time, which is criti cally important for pinpointing the problem, making decisions and implementing me asures to mitigate drought consequences. The se measures are important steps for sustainability of the developing nations.

Keywords: avhrr, drought, environment

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US012 **Oral Presentation** **88**

Short- and long-term earthquake forecasting

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David D. Jackson

We developed a program for short- and long-term earthquake forecasting. The program uses past seismicity to evaluate earthquake occurrence probability: time, space, magnitude, and focal mechanism of future earthquakes are predicted. We discuss methods for optimizing both procedures and testing their forecasting effectiveness based on the stochastic point processes theory. Our forecasts are expressed as the rate density (that is, probability per unit of area, time, and magnitude). For our long-term forecast we assume that the rate density is proportional to a smoothed version of past seismicity. The forecast applies to the ensemble of earthquakes: Our method is not meant to predict any single earthquake, and no single earthquake or lack of one is adequate to evaluate such a hypothesis. Our short-term forecast, currently updated daily, makes explicit use of statistical models describing earthquake clustering (stochastic branching processes). Like the long-term forecast, the short-term version is expressed as a rate density in location, magnitude, and time. However, the short-term forecasts change significantly from day to day in response to recent earthquakes. If earthquake information is available in real-time, this program can predict earthquake occurrence right after the end of available data. The forecast applies to mainshocks, aftershocks, aftershocks of aftershocks, and mainshocks preceded by foreshocks. However, there is no need to label each event, and the method is completely automatic. According to the model, nearly ten percent of moderately sized earthquakes will be followed by larger ones within a few weeks. Since 1999 we have run this forecast program in the western Pacific area for magnitude 5.8 and larger earthquakes, using the CMT earthquake catalog. Around 55% of global earthquakes occur in the western Pacific seismic belt. We have recently extended this forecast to California earthquakes. We are working on extending the forecast by using space-geodetic, geodetic, geologic, and plate-tectonic information to improve our forecast based on seismicity and infer seismic occurrence parameters in areas with insufficient earthquake data. We test the efficiency of our long-term forecasting methods by calculating a likelihood ratio and a concentration diagram. These procedures estimate and improve the optimization of our smoothing algorithm. For the short-term forecast we evaluate the information gain (score). A retrospective test for California forecasts shows that the short-term model increases the average probability of an earthquake occurrence by a factor more than 10 compared to the time-independent forecast. If real-time earthquake data were available, this forecast score should increase significantly. We also calculate the error diagram for our forecasts. The error diagram is more informative than the likelihood ratio and uniquely specifies the information score. We derive an expression connecting the information score and error diagrams and obtain the estimate of the region bounds in the error diagram for any value of the information score.

Keywords: earthquake, prediction, seismicity

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US012 **Oral Presentation** **89**

CUACE/Dust – An Integrated System of Observation and Modeling Systems for Operational Dust Forecasting in Asia

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S. L. Gong, C. H. Zhou, H. L. Liu, Y.Q. Wang, T. Niu, Y Q Yang, Q Hou

Sand and dust storms (SDS) have caused devastating damages to properties and human health every spring in East Asia. Even though the occurrence of dust storms in China varies from year to year (Gong et al., 2006), the strength and frequency seem not to less en in the near future, especially under the influence of global climate changes. As a major natural aerosol source in mid-latitude of Northern Heimsphere, source strength of Asian SDS estimated to be ~ 800 Mt/year (Zhang et al., 1997) with very high spatial and temporal variability. Recently there has been an increasing concern over the formation and transport of soil dust and its contribution to the earth-climate system, essentially to the impact of a severe form of soil dust aerosols in the atmosphere - SDS. Because of its economical and social impacts, it is critical to understand the source strength, transport and deposition of soil dust and to establish the SDS forecasting and early warning (EW) capacity in the world to reduce its impact. A number of new developments have been achieved recently in China to formulate a SDS forecasting system based on previous researches. The CUACE/Dust (Chinese Unified Atmospheric Chemistry Environment for Dust) modeling system was transferred from a research model into an operational forecasting system of SDS in China in spring 2005 and 2006. This system consists of a comprehensive dust aerosol module with emission, dry/wet depositions and other atmospheric processes, and a data assimilation module using observational data from the CMA (China Meteorological Administration) ground dust monitoring network and a geostationary satellite - FY2-C for dust storms. By evaluating the performance of the forecasting system against observations, substantial insights into the predictability of the dust storms have been obtained that will benefit the future improvement of the system. Here the development of the CUACE-Dust system and its applications to the spring 2006 SDS operational forecasts will be summarized and presented here.

Keywords: dust storms, forcasting

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US012 **Oral Presentation** **90**

Use of Real Time Lightning Observations for Early Warning of Meteorological Hazards

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Today many countries around the world have ground-based lightning detection networks that supply real time lightning data with high spatial and temporal resolution. In addition, global networks are sprouting up based on the detection of very low frequency (VLF) radiation emitted by lightning discharges. Lightning intensity is strongly connected to convective precipitation processes, and hence can possibly be used to estimate regions of heavy rainfall, with possible nowcasting capabilities for flash floods. Furthermore, severe weather storms (producing tornados, derechos, hailstorms, etc.) appear to exhibit specific lightning signatures, particularly in the polarity of the lightning discharges. Finally, tropical lightning may also supply important information related to tropical hurricane genesis in the Atlantic Ocean. In the presentation a few examples of how lightning information may help in early warning systems will be presented.

Keywords: early warning, meteorological hazard

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US012 **Oral Presentation** **91**

GeoHazards in the International Year of Planet Earth

Dr. Tom Beer
CSIRO CMAR

The United Nations has declared 2008 to be the International Year of Planet Earth. The science activities for the IYPE, are being organised under the auspices of the International Union of Geological Sciences (IUGS) and UNESCO. IUGG is a partner in the enterprise. Information is available at http://www.yearofplanetearth.org/ The IYPE has established ten major science themes including Hazards. The Hazards theme is centred on the following key questions: 2.1. How have humans altered the geosphere, the biosphere and the landscape, thereby creating long-term changes detrimental to life and the environment and triggering certain hazards, while increasing societal vulnerability to geophysical (geological and hydrometeorological) hazards? 2.2. What technologies and methodologies are required to assess the vulnerability of people and places to hazards and how might these be used at a variety of spatial scales? 2.3. How do geophysical hazards compare relative to each other regarding current capabilities for monitoring, prediction and mitigation and what can be done in the short term to improve these statistics? 2.4. What barriers exist to the utilization of risk and vulnerability information by governments (and other entities) for risk and vulnerability reduction policies and planning (including mitigation) from each of the geophysical hazards? Following the 26 December 2004 Indian Ocean Tsunami, the UN World Conference on Disaster Reduction was held in Kobe, Japan in January 2005. This Conference adopted the Hyogo Framework for Action (HFA). In addition, ICSU decided to establish a major research program and initiative on Natural and Human Induced Environmental Hazards and Disasters. It is expected that IYPE, in association with UN-ISDR will run regional workshops during 2008 to examine the links between the key questions and the HFA with the regional workshops culminating in an international workshop to be held late in 2008 to bring together the outputs from the regional workshops.

Keywords: geosphere, vulnerability

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US012 **Oral Presentation** **92**

GEOWARN - A Volcano early warning system

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Quiescent but active volcanoes in regions of high geodynamic unrest represent a severe hazard and risk potential and require integrated monitoring, satel lite surveying and modellin g. The major aim of the European-funded project GEOWARN was the developm ent of a multimedia based geo-spatial early warning syste m (a modular web-ba sed cartographic Atlas Informatio n System AIS) which compris es graphical and numerical geo-spatial data, visualizations, derived satellite images (e.g . infrared thermal imaging), real time monitorin g of surface m ovements (interferometric analysis), seismic activity, heat and gas fluxes and chemical changes in fum arolic gases and hydrothermal waters. The software system consists of a set of cu stomized components that facilitate analysis and visualization of this huge amount of data. Integration of these parameters in a geospatial database has le d to development of modeling techniques that are suitable to detect dynamic processes such as reactivation of a dormant volcano a nd the occurrence of earthquakes related to magma emplac ement in the crust or fluid pressure changes in magmatic-hydrothermal systems. Deep crustal seis mic s oundings ha ve provided a regional volcano-tectonic and structural model derived by tomograp hic processing. The 'Vo lcano Early Warning Syste m GEOWARN' is designed to cover the most importan t gap, the step form green t o yellow of t he international 'Vo lcano Alert Levels', which is relate d to the earliest recognition of reactivation of magmatic activity within the crust that mi ght lead to a volcanic eruption at the s urface. In case o f reactivation, i mplementation of real-time monitoring int o the early-warning system would then permit volcanic eru ption prediction (long-term or t he step from yellow t o orang e) or forecast (th e sh ort-term step from orange to red). Uses of the application include scientific analysis, scenario modeling, land use, emergency an d mitigatio n planning. GEOWARN used the dormant volc anic isla nd of Nisyros (south Aegean volcanic arc, Greece,) as well as the Phlegrean volcanic field (Na ples, Italy) as test sites that show high seismic unrest and widespread fumarolic activity.

Keywords: volcano warning, nisyros volcano

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US012 **Oral Presentation** **93**

An integrated approach to natural hazards research

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There has been a continuing rise in the social and economic costs of natural and human-induced environmental hazards around the globe. In recognition of this and the role that science, across all disciplines can play, ICSU has established an International Planning group. Building upon 5 themes, namely: Improved understanding, monitoring and prediction of natural hazards; Integrated risk analysis incorporating socio-economic factors ; Societal resilience to hazards; Inter play of risks across different temporal and spatial scales; and Understanding effective science-policy interactions and the role of scientific assessments, the Planning Group has identified three core research projects on: Characterizing natural-societal complex risks; Understanding decision making in a changing risk context; and Reducing risk through knowledge-based actions. In addition there will be cross cutting activities on monitoring , assessment and capacity building. The scientific plan for this 10-y research initiative will be planned in consultation with the international scientific community and national and international organizations. Key to all these elements will be systems for early warning and for monitoring, from space as well as in situ, the global system, including human activities . This presentation will include background information on the rationale and planning for and some thoughts as to the evolution of the program.

Keywords: human induced, environmental hazards

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US012 **Oral Presentation** **94**

UNEP and Early Warning of Natural Hazards

Dr. Ashbindu Singh
OTHER OTHER

The United Nations Environment Programme (UNEP) has a mandate to keep the state of environmental situation under review. In case of natural hazards, UNEP is more concentrated on long-term programmes for preparedness thereby minimizing risks to life and property rather than focusing on short-term measures during the post-disaster period. UNEP approaches include followings: Advocacy for early warning systems: The basic question is 'how early is early warning'. Also, generally speaking, early warning systems don't have definitive predictive capabilities. In the case of developing countries due to rather poor infrastructure, lack of evacuation plans and high concentrate of population, most of disasters may arrive so quickly after its precipitating event that hardly any warning could be provided quickly enough to minimize the loss. This is a field in which science and technology is continuously evolving and long term investments may provide some sort of fool proof early warning systems in future. UNEP plays an 'advocacy role' and catalyze actions for investment in S& T for developing such systems at the global and national levels. Mapping efforts: Using the latest satellite and computer mapping capabilities it is possible to produce hazard maps to be used in zoning as well as emergency planning. Mapping efforts by regional and international organizations are, normally, focused on using rather coarse data which are valuable for visualization and drawing attention but not detailed enough for use in the field. The biggest challenge is availability of detailed input data on population centers, topography, land use/land cover etc to produce such maps which could be used in operational planning. Furthermore, while such maps assess how and where a particular hazard might impact but they do not address the question of how likely such an event might occur. So 'probabilistic hazard maps' need to be developed. This needs to be further researched. Watching and alert system: UNEP could play an important operational role in providing information emanating from monitoring and early warning systems to users in a real time mode. It is like setting up an 'Earth situation room'. Even in the United States, the National Weather Service tracks and watches hurricanes continuously, using satellite data and send aircraft in the eye of the storms, in the Caribbean and issue real time alerts about potential landfalls but they are unable to predict precise location and intensity of landfalls. Educating: There is a need to catalyze 'Disaster ready' public education program and prepare local communities to work with government officials and other agencies to prepare for impending disasters.

Keywords: disaster, warning, alert system

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US012 **Oral Presentation** **95**

Dust Storm Aerosols and Atlantic Tropical Storms

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Zafer Boybeyi, Donglian Sun

Our research in tropical cyclones and dust storm aerosols includes lon g-term analysis, modeling an d remote sensing observations in order to study their connection as well as to monitor and understand the development o f specific sto rms. Studies h ave sho wn t hat the Atlantic basin majo r hurricane (MH) activity is often associated with western Sahelian mo nsoon rainfall. Also, the Atlantic basin MH activity may be anti-correlated with African dust aerosol l oadings. The TOMS aerosol index (AI) positive values are associated with UV-absorbing aerosols, mainly dust, smoke and volcanic aerosols. We have studied long-term (1982-2005) TOMS aerosol index data, sea sur face temperature (SST), and tropical cyclone (TC) data in order to inves tigate the relationship between Africa n aerosol l oadings and Atlantic hurricane activity. No significant negative correlation between the TOM. AI and the Atlantic TC or major hurricane count or frequency was found. The initial locations of th e Atlantic tropi cal cyclones did occu r over the ocea n when aerosol loading was lower and SS T over the north part of t he Atlantic tropica l ocean is anti-correlated with the TOMS aerosol index. As such, the effe cts of the dust aerosols carr ied across the West African region likely lead to a lowering of SST and therefore inhibit tropical cyclogenesis. We have exa mined th e relationship between the occure nce of dust st orm aerosols and hurricanes in the recent past: During 2005, the ae rosol loading along the western African coast was unusually low, while SST was abnormally high, and 2005 became record-breaking year for the Atlantic TC/hurricane a ctivities. The oppo site seems to have occu red in 2006. Our ongoing modeling effor ts include the de velopment of computational methods to optimize the use of remotely s ensed data to improve the accuracy of the models. These modeling capabilities are applied to hurricane forecasting i n near real time, using, WRF, and OMEGA models. They also include run ning specific d ust model runs. The resu lts from ou r model ing simu lations combin ed w ith th e global model resu lts from n ational operational centers are then displayed in CEOSR web- based applications to inform the p ublic and other stakeholders. The modeling ef forts are complementary to utilizing remote sensing (RS) and other data for specific storms. The capabilities and limitations of RS are explored. For example, in particular, SS T data from remotely sensed infrared measurements, like GOES, AVHRR, and MODIS, show missing values over the cloudy regions associated with hurricanes; while satellite microwave measurements, like the Tropical Rainfall Measuring Mission (TRMM) microwave imager (TMI), can provide SST even under cloudy co nditions. Bo th satellite measurements an d buoy observation s show that S ST increases in advance o f significant hurricane intensificatio n. We d iscuss associated physical mechanisms. Also, hurricane intensification may be related to the actual location of high SST. Our results indicate that pre-existing high SST anomaly (SSTA) located at the right side of the storm track for Hurricane Katrina, and similarly for Ri ta and Wilma. Numerical si mulations also confirmed the importance of the locati on o f SSTA. On the contrary, if the re is no high SSTA at the rig ht location, a hurricane ma y not be able t o undergo further intensification. This may partially ex plain why not all tropical cyclones associated with warm ocean waters can attain peak intensity (category 4 and 5 strength) during their life cycle.

Keywords: cyclone, aerosols, katrina

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USSE013 **96 - 96**

Symposium
Our Understanding of Climate Change

Convener : Prof. Paola Malanotte-Rizzoli, Prof. Uri Shamir

A special evening event will be held at the IUGG Assembly in Perugia to inform the audience about the findings of the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) (published in early 2007). Representatives of the three IPCC working groups will present overviews of the scientific progress, findings, and the remaining challenges. These talks will address a) trends and projections of atmospheric composition and forcing, b) trends and projected changes in climate and sea level, c) observed and expected impacts on the environment and society, d) capabilities for adapting and building resilience to changes, and e) the status of options for limiting emissions through changes in the sources of energy and through carbon sequestration (separation and storage).

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USSE013 **Oral Presentation** **96**

Intercomparison of the Northern Hemisphere Winter Mid-LatitudeAtmospheric Variability of the IPCC Models by Wave Activity Performance Metrics

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Climate Speciale Project ENEA, Ente Nazionale Nuove Tecnologie Ambiente

Valerio Lucarini, Sandro Calmanti, Paolo M. Ruti, Antonio Speranza

We compare the estimate of the northern hemisphere mid-latitude winter atmospheric variability within the available 20th century simulations of 19 global climate models included in the Intergovernmental Panel on Climate Change4th Assessment Report with the NCEP-NCAR and ECMWF reanalyses. We compute the Hayashi spectra of the 500 hPa geopotential height fields and introduce an ad hoc integral measure of the variability observed in the Northern Hemisphere on different spectral sub-domains. The total wave variability is taken as a global scalar metric describing the overall performance of each model, while the total variability pertaining to the eastward propagating baroclinic waves and to the planetary waves are taken as scalar metrics describing the performance of each model phenomenologically in connection with the corresponding specific physical process. Only two very high-resolution global climate models have a good agreement with reanalyses for both the global and the process-oriented metrics. Large biases, in several cases larger than 20%, are found in all the considered metrics between the wave climatologies of most IPCC models and the reanalyses, while the span of the climatologies of the various models is, in all cases, around 50%. In particular, the travelling baroclinic waves are typically overestimated by the climate models, while the planetary waves are usually underestimated, in agreement with what found is past analyses performed on global weather forecasting models. When comparing the results of similar models, it is apparent that in some cases the vertical resolution of the model atmosphere, the adopted ocean model, and the advection scheme seem to be critical in the bulk of the atmospheric variability. The models ensemble obtained by arithmetic averaging of the results of all models is biased with respect to the reanalyses but is comparable to the best five models. Nevertheless, the models results do not cluster around their ensemble mean. This study suggests caveats with respect to the ability of most of the presently available climate models in representing the statistical properties of the global scale atmospheric dynamics of the present climate and, a fortiori, in the perspective of modeling climate change.

Keywords: intercomparison, wave activity, metric

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