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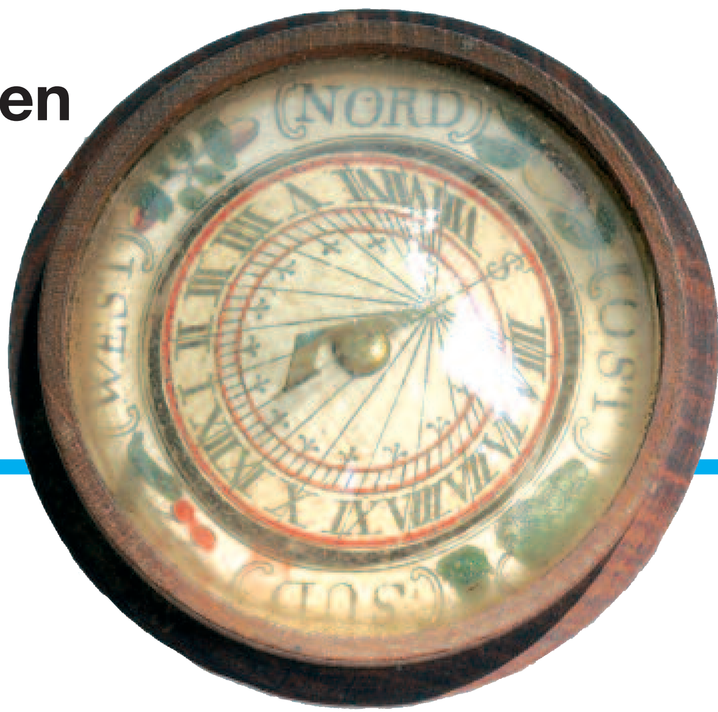
POTSDAM

75 Jahre erdmagnetische Messungen in Niemegk



Das Adolf-Schmidt-Observatorium für Geomagnetismus des GeoForschungsZentrums Potsdam

DOI: 10.2312/GFZ.b103-niemegk750

Niemegk 1999

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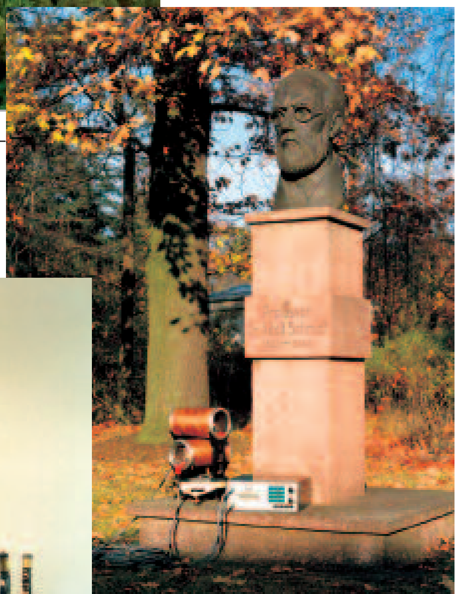
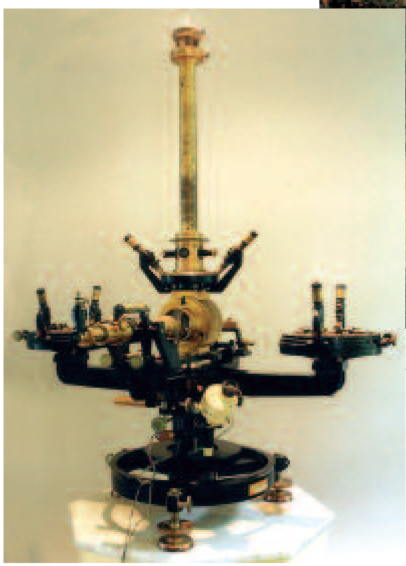
Brief history of Geomagnetism in Germany





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Instrumentation

I N H A L T
C O N T E N T S

Das Observatorium im WWW

Weitere Informationen über das Observatorium und die produzierten Daten gibt es auf den Internetseiten des Observatoriums:

www.gfz-potsdam.de/pb2/pb23/Niemegk/dt/index.html

Dort finden sich zum Beispiel noch mehr Bilder des Observatoriums und historischer Messgeräte, weitere Details zur Geschichte und über Adolf Schmidt und Gerhard Fanselau sowie eine Publikationsliste. Magnetogramme, die alle 10 Minuten aktualisiert werden zeigen die aktuellen Schwankungen des Erdmagnetfelds. Aus einer Datenbank lassen sich dort die registrierten Minutenwerte seit 1994 herunterladen und die letzten Jahrbücher sind im pdf Format verfügbar.

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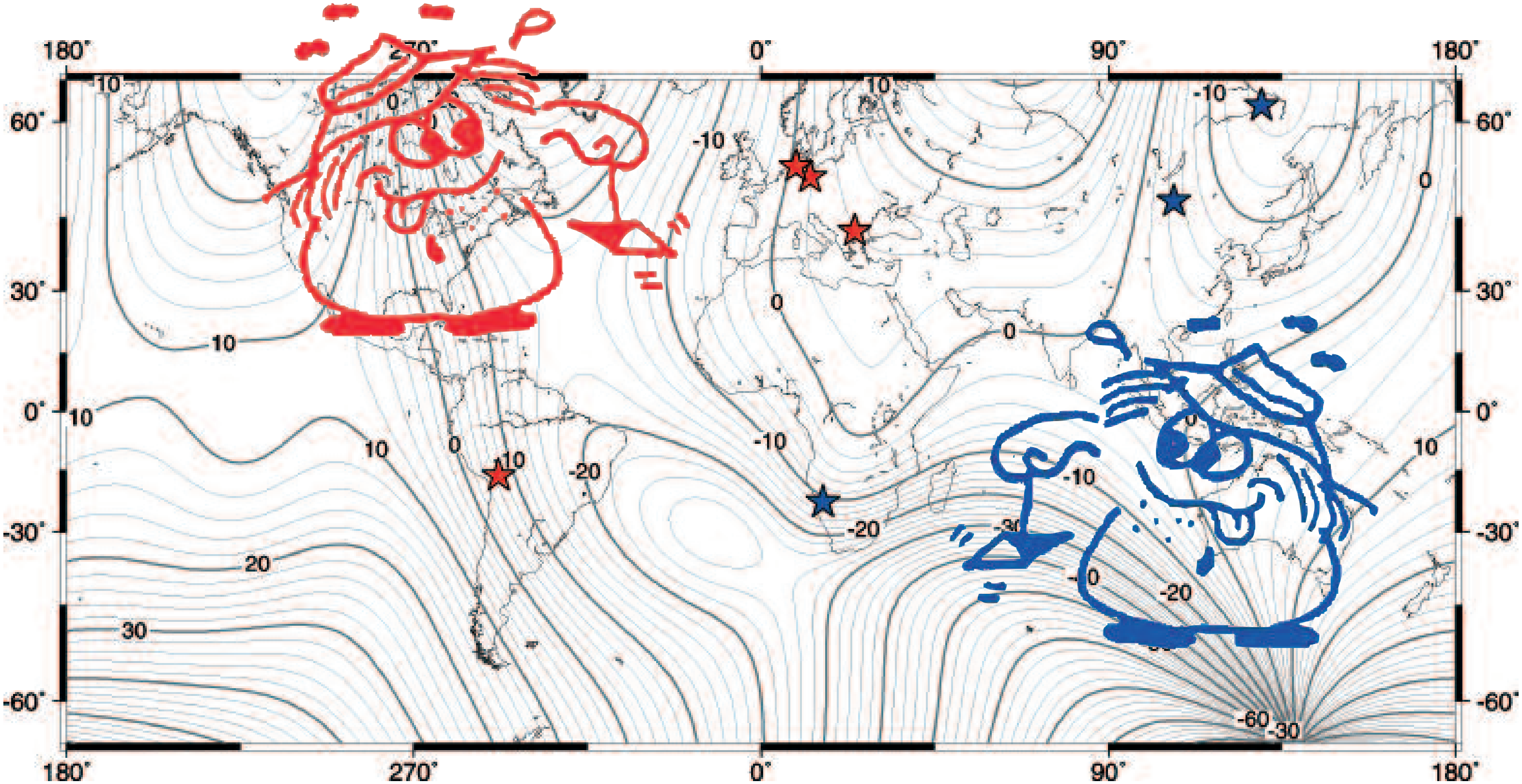

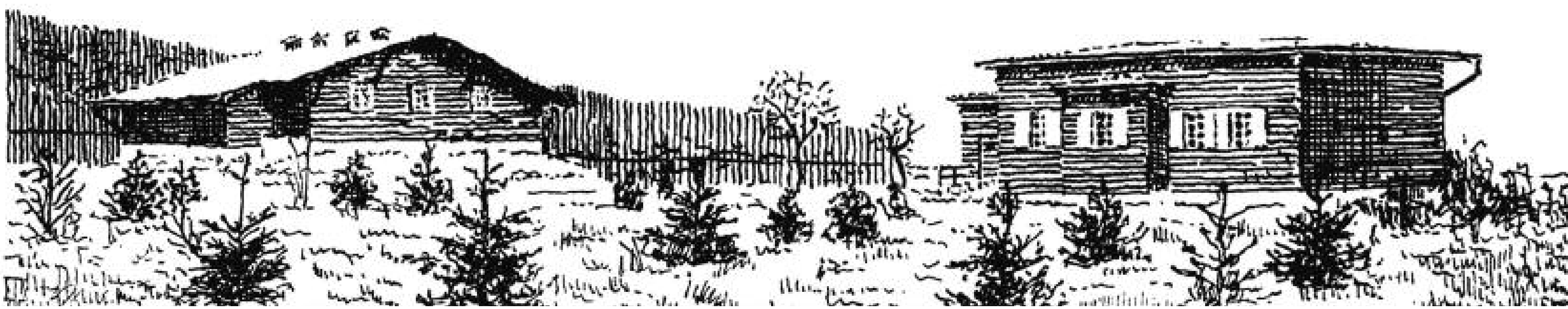

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75 JAHRE GEOMAGNETISCHE MESSUNGEN IN NIEMEGK

Prof. Adolf Schmidt ist dafür verantwortlich, dass sich das Observatorium in Niemegk befindet. Zu Ehren seiner Verdienste in Theorie und Praxis trägt es seinen Namen. Niemegker Daten tragen zur Produktion weltweiter Deklinationskarten (hier für 2005) bei. Um die weltweite Datendichte zu verbessern werden bereits drei weitere Observatorien von Niemegk aus betrieben oder unterstützt (rote Sterne). Weitere Kooperationen sind in Vorbereitung (blaue Sterne).

Prof. Adolf Schmidt chose the location in Niemegk for the observatory. It carries his name in honour of his important theoretical and practical achievements. Niemegk data contribute to the production of global declination maps (here for 2005). To improve global data coverage, three other observatories are already supported or run by the Niemegk observatory (red stars). Further cooperations are planned (blue stars).

Am **23. Juli 2005** waren es 75 Jahre, seit in Niemegk systematische erdmagnetische Registrierungen aufgenommen wurden. Das Adolf-Schmidt-Observatorium wird heute vom GeoForschungsZentrum Potsdam betrieben. Es gehörte in seiner Geschichte verschiedenen Instituten an. Messgeräte und Datenverarbeitung haben sich weiter entwickelt, doch die Hauptaufgabe ist geblieben: die kontinuierliche Registrierung des Erdmagnetfelds und seiner Variationen mit höchster Genauigkeit. Heute zeigt die Datenreihe, dass der Standort vor 75 Jahren gut gewählt war: auch heute noch sind die Messungen unbeeinflusst von anthropogenen Störungen, und die Datenqualität des Observatoriums Niemegk ist unter den besten weltweit.

Das Erdmagnetfeld, wie wir es an der Erdoberfläche registrieren, ist tatsächlich eine Kombination von Magnetfeldern verschiedener Quellen, die sich überlagern und miteinander in Wechselwirkung stehen. Mehr als 90% des gemessenen Feldes kommt aus dem Inneren der Erde und wird im flüssigen äußeren Erdkern erzeugt. Dieser Anteil des Magnetfelds, der als Kern- oder Hauptfeld bezeichnet wird, entsteht durch elektrische Ströme, welche durch einen Dynamoeffekt im Erdkern aufrechterhalten werden. Die Untersuchung der langfristigen Änderungen des Erdmagnetfelds kann Aufschluss über die Funktionsweise dieses Geodynamo geben. Ebenfalls internen Ursprungs ist das lithosphärische oder Krustenfeld, erzeugt durch magnetisierte Gesteine in der Erdkruste.

Das magnetische Hauptfeld erfüllt einen Bereich im interplanetaren Raum, der Magnetosphäre genannt wird und wie ein Schutzschild gegen den Sonnenwind wirkt. Die Magnetosphäre lenkt den Großteil der Sonnenwind-Partikel um die Erde herum, während die magnetischen Feldlinien die Bewegung der in die Magnetosphäre eindringenden geladenen Teilchen bestimmen. Die Bewegung von Ionen und Elektronen innerhalb der Magnetosphäre führt zu Stromsystemen, die Variationen im Erdmagnetfeld verursachen. Diese externen Ströme in Ionosphäre und Magnetosphäre schwanken auf wesentlich kürzeren Zeitskalen als das Kernfeld und können zu magnetischen Störungen mit Stärken bis zu 10% des Hauptfeldes führen („ magnetische Stürme“). Eine weitere Quelle ist durch Induktionseffekte der externen Schwankungen im leitfähigen Erdboden gegeben, da die dort induzierten Ströme wiederum Magnetfelder induzieren.

Wir möchten hier einen kurzen Abriss der Geschichte und Bedeutung des Adolf-Schmidt-Observatoriums geben. Weitere, im englischen Text beschriebene Details, sind in den angeführten deutschsprachigen Referenzen zu finden.

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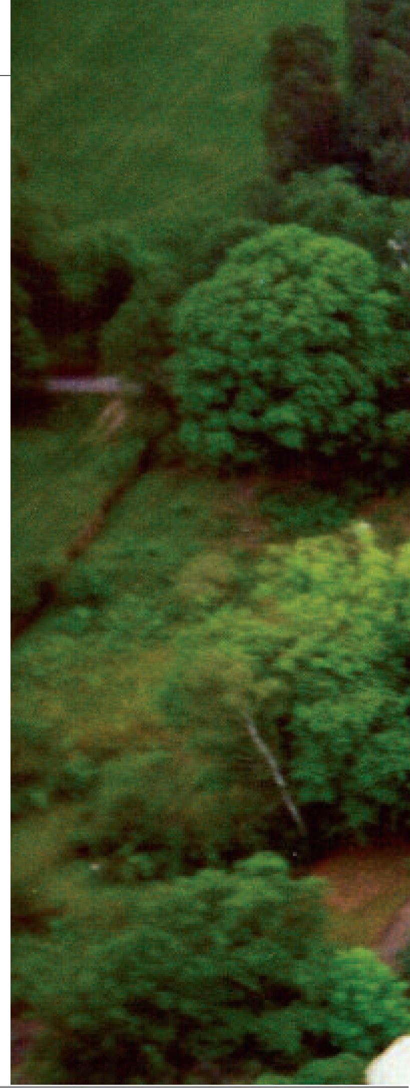
Von Potsdam über Seddin nach Niemegk

Die ersten geomagnetischen Messungen in der Berliner Gegend sind Alexander von Humboldt zu verdanken. Von 1836 bis 1872 wurden an der Berliner Sternwarte regelmäßige Beobachtungen des Erdmagnetfelds durchgeführt, bis sie durch zunehmenden Verkehr und Industrialisierung zu stark gestört wurden. Wilhelm Julius Förster bewirkte den Bau eines erdmagnetischen Observatoriums auf dem Telegrafenberg in Potsdam, welches am 1. Januar 1890 den Betrieb aufnahm. Schon 1906 wurden jedoch auch hier die Störungen durch den elektrischen Treidelbetrieb auf dem Teltowkanal und die spätere Elektrifizierung der Straßenbahn so stark, dass das Observatorium verlegt werden musste. Der neue Standort war bei Seddin, etwa 20 Kilometer südwestlich von Potsdam. Als jedoch die Berliner Stadtbahn mit Gleichstrom elektrifiziert wurde, traten selbst noch in Seddin Störungen der Messungen auf, und wieder musste ein neuer Standort gesucht werden.

Adolf Schmidt war seit 1902 Leiter der magnetischen Abteilung des Preußischen Meteorologischen Instituts in Potsdam. Er hatte schon für die Verlegung des Observatoriums nach Seddin gesorgt und war auch für die erneute Verlegung verantwortlich. Dass das Observatorium sich heute bei Niemegk befindet, ist auch der Unterstützung der damaligen Stadtverwaltung zu verdanken. Das neue Observatorium wurde am 23. Juli 1930 eingeweiht. Zu Ehren der großen Verdienste Adolf Schmidts, sowohl auf theoretischem Gebiet als auch in der Entwicklung von Messinstrumenten, erhielt es den Namen „Adolf-Schmidt-Observatorium für Erdmagnetismus“. Zum Zeitpunkt der Einweihung des Niemegker Observatoriums verzögerte ein Grundwassereinbruch in das Variationshaus die Aufnahme der magnetischen Beobachtungen. Erst im Laufe des Jahres 1931 wurden die Instrumente von Seddin nach Niemegk überführt und nach einer angemessenen Zeit paralleler Messungen in den beiden Observatorien der kontinuierliche Betrieb in Niemegk zu Beginn des Jahres 1932 aufgenommen. Seitdem produziert das Observatorium Niemegk eine fast ununterbrochene Messreihe hochqualitativer erdmagnetischer Daten. Während der 75 Jahre änderte sich jedoch mehrmals die organisatorische Zugehörigkeit. Nach der Wiedervereinigung wurde das Observatorium 1992 vom neu gegründeten GeoForschungsZentrum Potsdam übernommen. Dort gehört das Observatorium heute zur Sektion 2.3, Erdmagnetfeld.

Mit der Zugehörigkeit änderten sich auch einige der Aufgaben. In den ersten Jahren war die Magnetfeldbeobachtung die Hauptaufgabe, während wissenschaftliche Arbeit in Potsdam betrieben wurde. Nach dem 2. Weltkrieg hatte die Entwicklung und Kalibrierung von Messgeräten zeitweise große Bedeutung. Auch die Anzahl der direkt am Observatorium beschäftigten Wissenschaftler nahm zu, so dass zeitweise über 50 Mitarbeiter dort beschäftigt waren. Heute ist



1930 bis 2005

Luftbild eines Teils des Observatoriumsgeländes heute und das Gelände kurz nach Errichtung des Observatoriums.

Current aerial view and premises of the Niemegk Observatory shortly after construction.

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die wissenschaftliche Arbeit wieder in Potsdam konzentriert, aber das Observatorium entwickelt sich zu einem Zentrum erdmagnetischer Messungen in Europa und weltweit. Seit 2000 wird das zuvor vom Bundesamt für Seeschifffahrt und Hydrographie Hamburg betriebene Observatorium Wingst (zwischen Hamburg und Cuxhaven) in eine von Niemegk aus betriebene Außenstelle umgewandelt. In Villa Remedios (Bolivien) wurde 2002 ein Observatorium vom GeoForschungsZentrum Potsdam mit Geräten ausgestattet. Es wird von Niemegk aus in Zusammenarbeit mit der Universität von La Paz betrieben. Im Juli dieses Jahres wurde das bulgarische Observatorium Panagjurishte vom Observatorium Niemegk mit modernen Geräten ausgestattet. Der Betrieb bzw. die Unterstützung weiterer Observatorien in Afrika und Asien ist in Vorbereitung.

Weiterhin ging vom Observatorium Niemegk die Initiative zur Koordination der magnetischen Säkularpunktvermessungen (repeat stations) in ganz Europa aus. Säkularpunkte sind zusätzliche, über das Land verteilte Orte, an denen Stärke und Richtung des Erdmagnetfelds in regelmäßigen Zeitabständen zwischen 1 und 5 Jahren bestimmt werden. Die Ergebnisse dienen der Bestimmung der Deklination an jedem Ort, der Erstellung magnetischer Karten, und der Untersuchung der magnetischen Säkularvariation. Mit einem internationalen Workshop am Adolf-Schmidt-Observatorium am 20.-21. Februar 2003, den über 40 Teilnehmer aus 20 europäischen Ländern besuchten, wurde die Grundlage für bessere und einheitlichere europäische Säkularpunktvermessungen geschaffen. Der Erfolg dieser Initiative zeigte sich Anfang des Jahres 2005 bei dem 2. “European Repeat Station Workshop” in Warschau. Vom Observatorium Niemegk aus werden alle zwei Jahre etwa 40 Säkularpunkte in Deutschland vermessen.

Seit einigen Jahren gibt es mehrere Satellitenmissionen, die unter anderem Messwerte des Erdmagnetfelds liefern (Ørsted, CHAMP, SAC-C). CHAMP ist von der Ent-

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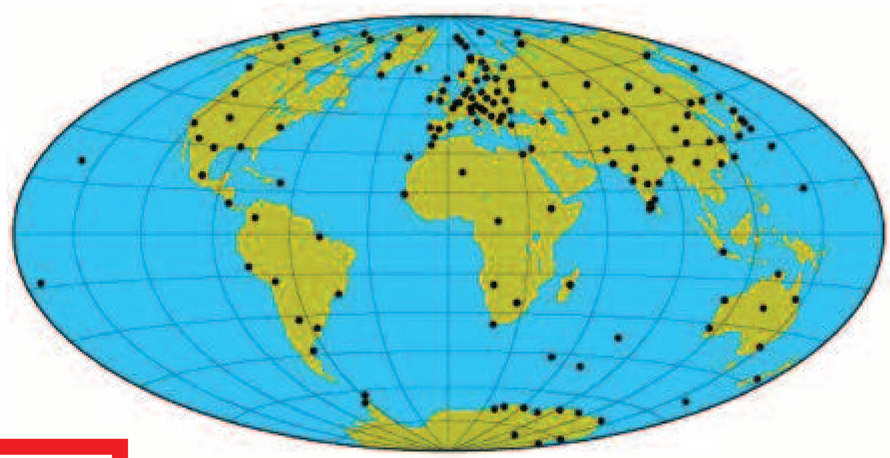

Niemegk - in der Welt zu Hause

Kirchturm und Wasserturm der Stadt Niemegk dienen als geografische Referenzpunkte bei den magnetischen Messungen. Das Adolf-Schmidt-Observatorium ist eines von weltweit etwa 200 geomagnetischen Observatorien.

The church and water tower of Niemegk are used as geografic reference for the magnetic measurements. The Adolf Schmidt Observatory is one of about 200 geomagnetic observatories around the world.

wicklung bis zum Betrieb ebenfalls ein Projekt des GeoForschungsZentrums Potsdam, welches auch maßgeblich am ESA-Projekt SWARM zur Forführung magnetischer Satellitenmessungen mit 3 Satelliten und geplantem Start im Jahr 2009 beteiligt ist. Angesichts der Tatsache, dass Satelliten in kurzer Zeit eine fast komplette Daten-Überdeckung der ganzen Erde liefern, taucht immer wieder die Frage auf, warum wir überhaupt noch Observatorien brauchen. Die Antwort ist einfach: Aufgrund ihrer unterschiedlichen Charakteristiken ergänzen sich Observatoriums- und Satellitendaten hervorragend, können sich aber nicht gegenseitig ersetzen. Erst die Satellitendaten mit ihrer guten globalen Abdeckung ermöglichen eine detaillierte Untersuchung der Struktur des Hauptfelds. Für Untersuchungen dessen zeitlicher Änderung (Säkularvariation), die Informationen über den Geodynamo liefern, sind sie jedoch alleine kaum brauchbar, da die Lebensdauer der Satelliten viel zu kurz ist. Selbst die bisher etwa 170 Jahre systematischer Observatoriumsbeobachtungen reichen gerade erst an den Periodenbereich heran, der für das Verständnis des Geodynamos wichtig ist. Nur die günstigeren und robusteren Observatorien können ununterbrochene Beobachtungsreihen auch in der Zukunft garantieren. Für die Untersuchung der weiteren Feldanteile sind die Observatorien ebenso wichtig. Satellitendaten sind aufgrund ihrer hohen räumlichen und zeitlichen Dichte hervorragend zur Beschreibung der externen Feldanteile geeignet, welche eine wichtige Voraussetzung zur Trennung der verschiedenen Anteile und damit ihrem detaillierten Verständnis ist. Die gleichzeitige Bewegung der Satelliten durch Raum und Zeit erschwert jedoch die Datenanalyse und die reinen Zeitreihen der Observatorien können zur Trennung der räumlichen und zeitlichen Effekte beitragen. Observatoriums- und Satellitendaten haben aufgrund ihres unterschiedlichen Abstands zu den verschiedenen Quellen unterschiedliche Informationsinhalte, die noch in vielfältiger Weise ausgenutzt werden können. Aus diesen Gründen wünschen wir uns sogar noch eine Erhöhung der weltweiten Observatoriumsdichte gerade während der Satellitenmissionen.

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75 YEARS OF GEOMAGNETIC MEASUREMENTS IN NIEMEGK

The **23rd of July, 2005**, marks 75 years of geomagnetic field recordings made at a site close to the small town of Niemegk. The Adolf Schmidt Geomagnetic Observatory now belongs to GeoForschungsZentrum Potsdam. During its history it has belonged to different institutions and its role has changed more than once. Instrumentation and data processing have been updated, but the main goal is still the same: to obtain continuous high-quality measurements of the geomagnetic field and its variations. The long time series of Niemegk Observatory data shows that the site was well chosen 75 years ago: today there are still no problems with anthropogenic disturbances, and the quality of data remains among the best in the world.

The geomagnetic field measured at any point on the Earth's surface is a combination of different magnetic fields originating from several sources. These fields are superimposed on and interact with each other. More than 90% of the measured field is internal in origin and is generated in the Earth's outer fluid core. This part of the geomagnetic field, known as the “core” or “main” field, is due to electric currents sustained by a “dynamo” situated within the core. Studies of the long-term behaviour of the geomagnetic field can be used to discover how the geodynamo works. Also of internal origin is the lithospheric (crustal) field frozen into the magnetized rocks of the crust.

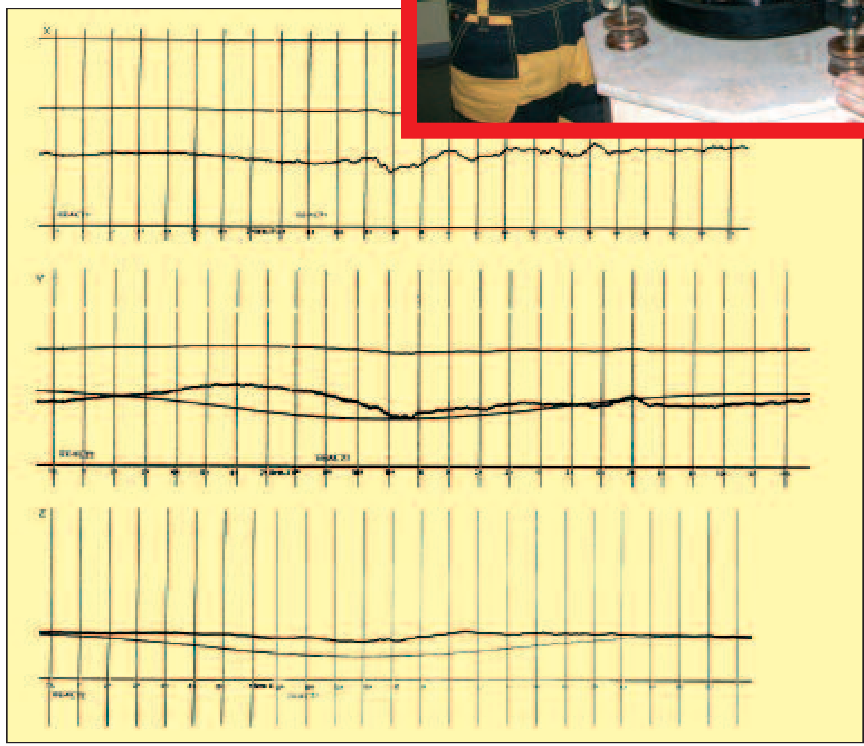
The core field creates a region in interplanetary space, called the magnetosphere, where the Earth's magnetic field dominates over the interplanetary magnetic field. The magnetosphere deflects the flow of most solar wind particles around the Earth, while the geomagnetic field lines guide the motion of those charged particles entering the magnetosphere. The differential flow of ions and electrons inside the magnetosphere and in the ionosphere form current systems, which cause variations in the intensity of the Earth's magnetic field. These external currents in the ionized upper atmosphere and magnetosphere vary on a much shorter time scale than the core field and may create magnetic disturbances as large as 10% of the geomagnetic field. Other important sources are the fields arising from electrical currents flowing in the ionized upper atmosphere and the fields induced by currents flowing within the Earth's crust.

In appreciation of 75 years of successful operation of the Adolf Schmidt Geomagnetic Observatory, we present this retrospective.

Education and Outreach

Visit of the "Tigerenten Club", a famous german TV-series for children, at the Niemegk Observatory. Guided tours of the observatory are offered for groups upon request.

Der Tigerenten Club war zu Besuch bei den Niemegker Wissenschaftlern. Auf Anfrage werden Führungen für Besuchergruppen durchgeführt.



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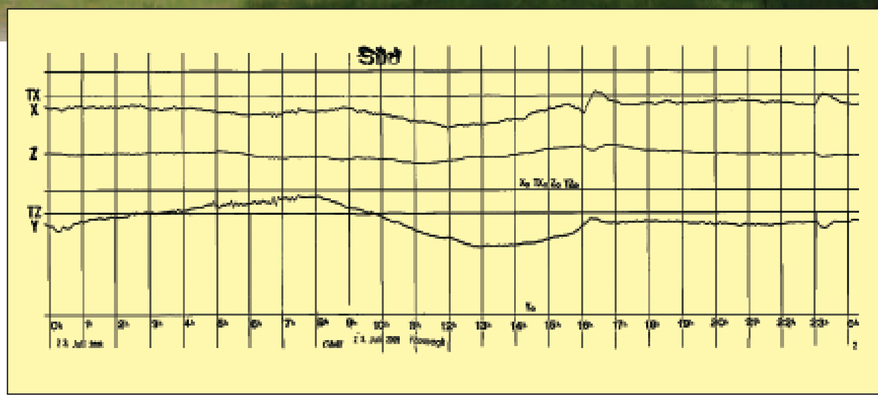
An Eye on the Earth's Magnetic Field

Although modern systems provide continuous digital recording, the traditional systems are still operational. Photographic magnetograms from July 23, 1930 (left) and July 23, 2005 (right) show the variations of the North (X), East(Y) and downward vertical (Z) magnetic field components.

Obwohl moderne Systeme heute kontinuerlich digitale Aufzeichnungen liefern, sind die traditionellen Systeme noch funktionstüchtig. Fotografische Magnetogramme vom 23. Juli 1930 (links) 23. Juli 2005 zeigen die Variationen der Nord- (X), Ost- (Y) und Vertikalkomponente (Z) des Erdmagnetfelds.



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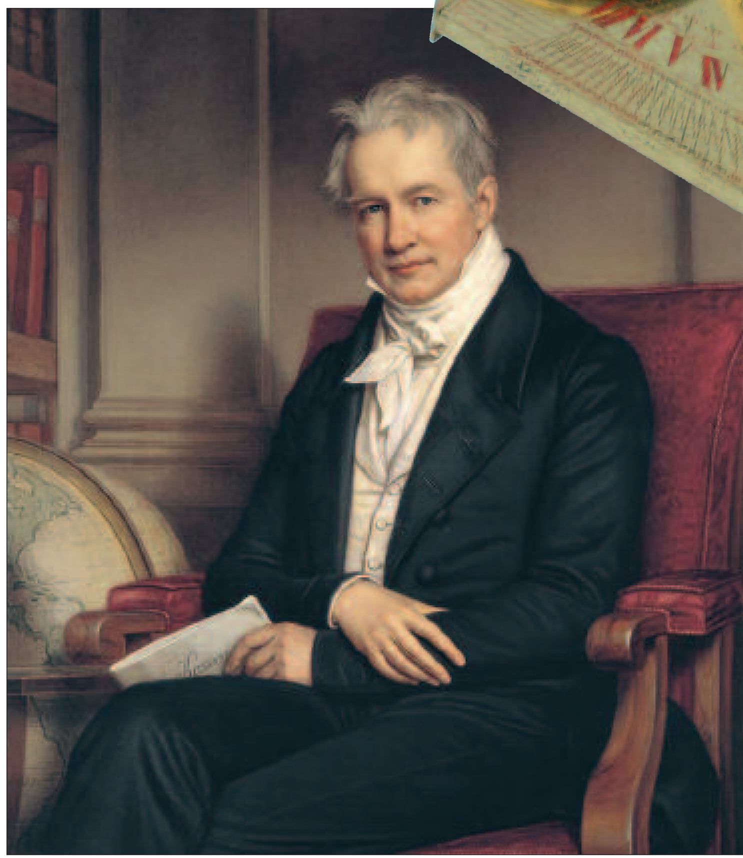
Brief history of Geomagnetism in Germany

For several centuries it has been known that the magnetic compass does not point to the true geographical North, but that the deviation of the needle (declination) varies considerably over the Earth's surface. The earliest map that included magnetic information was a road map produced by a German around 1500: Das ist der Rom Weg von meylen zu meylen mit punkten verzeychnet von eyner stat zu der andern durch deutzsche landt (This is the way to Rome, miles by miles listed [recorded] by points, from one town to another, through the German land), indicating the pilgrimage route from Germany to Rome. The author, Erhard Etzlaub, presented on this map a pictorial pocket sundial (known at that time as a compass), on which he clearly showed an eastern declination (Hellmann, 1909).

During the last three centuries, three German scientists played a great role in establishing worldwide geomagnetic observatories, measuring the complete vector field, and facilitating its global study.

Alexander von Humboldt (1769-1859) was highly interested in geomagnetism. He carried out magnetic measurements on several of his expeditions and initiated the development of geomagnetic ob-



The Beginnings

Magnetic declination was known in Europe since the 12th century. The figure shows a sundial with compass by Pfersich from about 1750. Alexander von Humboldt opened the way to modern geomagnetic research, initiating systematic magnetic observations from Germany to South America.

Die magnetische Deklination war in Europa schon seit dem 12. Jahrhundert bekannt. Die Abbildung zeigt eine Sonnenuhr mit Kompass von Pfersich (etwa 1750). Alexander von Humboldt war der Wegbereiter der weltweiten Erforschung des Erdmagnetismus durch Einführung systematischer Beobachtungen in Deutschland und Südamerika.

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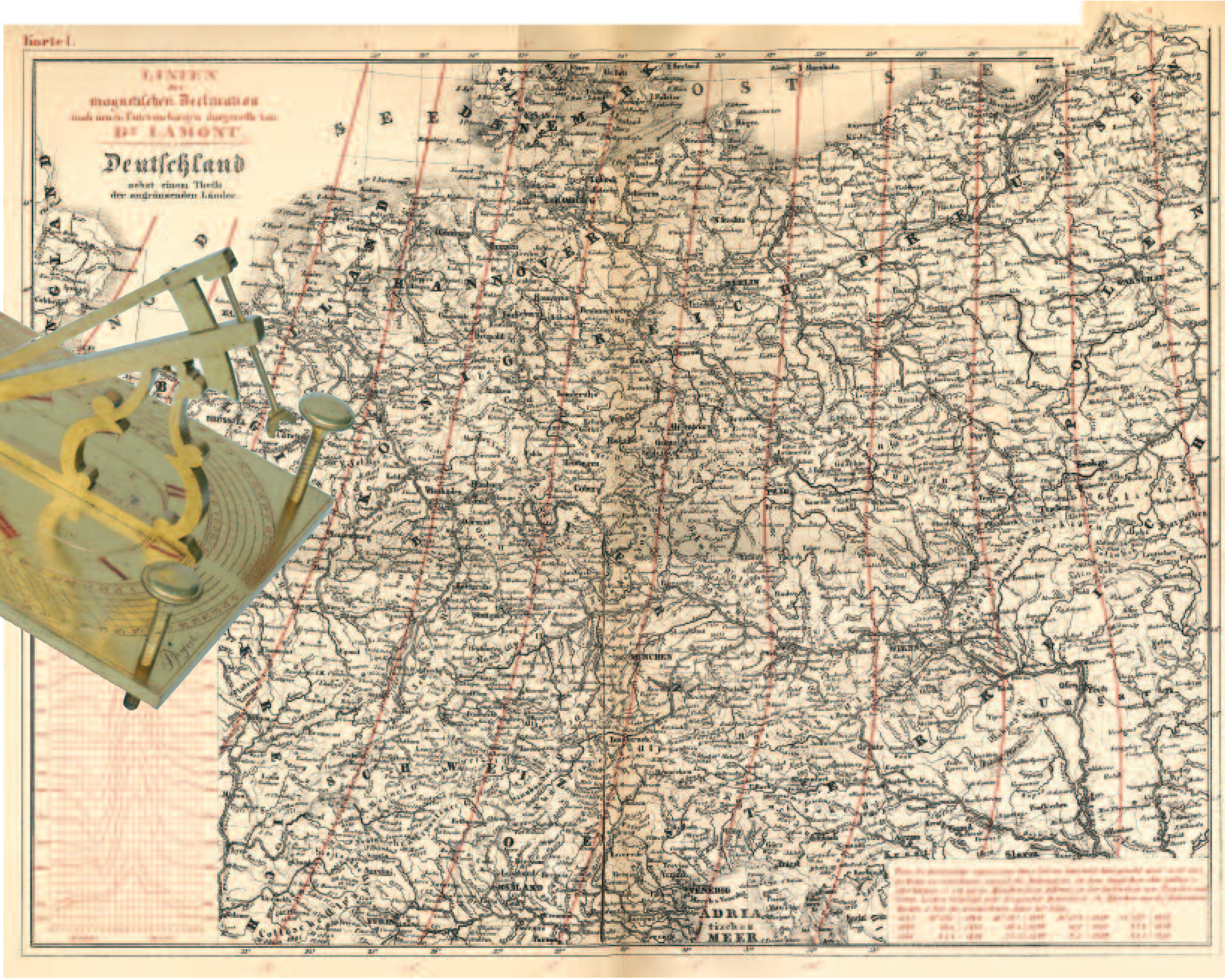

On the map of Germany by Johann von Lamont the declination is given as difference to that of Munich, which is listed for 1841 to 1952.

Die Deutschlandkarte von Johann von Lamont. zeigt die Abweichung der Deklination von der in München, welche für die Jahre 1841 bis 1852 angegeben ist.

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servatories in many countries. He produced the first chart of magnetic field intensities, covering the Northern part of South America (Humboldt, 1804). On this map, the geographic and magnetic equators are indicated, and five “isodinamique zones” are defined by the average number of oscillations per minute of the magnetised needle used during Humboldt's expeditions (Malin, 1891). According to Hellmann (1909), the first “true” magnetic field intensity map was produced by Hansteen (1824) for a region of Northern Europe. The intensity values shown on this chart are in relative units (“Humboldt units”), because a method to measure the field intensity in absolute units was not yet devised.

Carl Friedrich Gauß (1777-1855), who became interested in geomagnetism through Humboldt, solved this problem soon afterwards. Specifically, he developed a method to determine the horizontal intensity of the geomagnetic field using two complementary experiments. By determining the oscillation period of a swinging magnet, and then measuring the deviation angle of a magnetic needle from magnetic North under the influence of this magnet, he could determine both the magnetic moment of the magnet and the horizontal intensity of the geomagnetic field from two equations. With spherical harmonic analysis, Gauß also developed a mathematical method to globally describe potential fields such as the geomagnetic field. The method takes advantage of the fact that, in source-free regions, the geomagnetic vector field can be described as the negative gradient of a potential. It can distinguish between contributions from sources internal and external to the Earth, and is still the most commonly used method in global geomagnetic field modelling. Gauß and Wilhelm Eduard Weber founded the “Göttinger Magnetischer Verein” (Magnetic Union of Göttingen) in 1834, establishing fixed times to read magnetometers at observatories worldwide (Gauß, 1939).

Adolf Schmidt (1860-1944), whose name the Niemegk observatory carries, also contributed significantly to geomagnetic theory, e.g. with his widely known normalisation of the Legendre functions in spherical harmonic analysis and the introduction of geomagnetic coordinates. As head of the Potsdam geomagnetic observatory, he significantly

An honourable legacy

A bust in the historic library of GFZ Potsdam shows Carl Friedrich Gauß, one of the pioneers of geomagnetic research.

Monument of Adolf Schmidt, director of the Potsdam Magnetic Observatory for many years (1902-1928). In 1907 he developed a widely used knife-edge balance for field measurements.

Büste von Carl Friedrich Gauß, einem der Pioniere in der Erforschung des Erdmagnetismus, in der historischen Bibliothek des GFZ Potsdam.

Das Denkmal zeigt Adolf Schmidt, den langjährigen Direktor (1902-1928) des magnetischen Observatoriums Potsdam. 1907 entwickelte er eine Schneidenwaage, die für Feldmessungen weite Verbreitung fand.

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improved measurement practices, particularly with his theodolite and magnetic field balance.

Some other names should be mentioned in association with Niemegk observatory. Julius Bartels, who worked with Adolf Schmidt, developed the local K and planetary Kp indeces, the latter is still widely used as a measure for global geomagnetic activity (Bartels, 1957). Gerhard Fanselau, who later became director of the Geomagnetic Institute Potsdam, played an important role in re-establishing the geomagnetic recordings in Niemegk after World War II. In addition to his theoretical work on several aspects of external field contributions, he contributed to the improvement of magnetic measurement technique by developing the Fanselau-coil for calibration purposes (these provide a larger homogeneous field area than Helmhotz coils) and an improved field balance. Around 1950, certain geomagnetic variations of opposite sign were noticed at the observatories of Niemegk and Wingst, the latter situated between Hamburg and Cuxhaven. Otto Meier realized that telluric currents were responsible for this effect (Meier, 1951), and Horst Wiese exploited this result by developing the method of geomagnetic depth sounding or magnetotellurics (Wiese, 1955; Wiese 1965).

Two more geomagnetic observatories exist in Germany today apart from the Niemegk Observatory. The Wingst Geomagnetic Observatory, started operation in 1938 after the Wilhelmshaven Geomagnetic Observatory (1874-1936) had to be closed due to anthropogenical disturbances to the measurements. The Wingst Observatory was operated by Bundesamt für Seeschiffahrt und Hydrographie until 1999, then GeoForschungsZentrum Potsdam took over the scientific responsibility. Today, the Wingst Observatory is operated as a remote station by the Niemegk Observatory. The Fürstenfeldbruck Geophysical Observatory, with a geomagnetic and a seismological branch, belongs to the Ludwig-Maximilians-University in Munich. This geomagnetic observatory was preceded by two others, located in Maisach and Munich. The measurements in Munich were started in 1840 by Johann von Lamont, who also carried out the first regional ground vector survey in Bavaria in 1850.

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History of the Adolf Schmidt Geomagnetic Observatory

In 1836, Alexander von Humboldt initialized regular observations of the geomagnetic field at the astronomical observatory (Sternwarte) in Berlin. Around 1872, the measurements became too disturbed by development of industry in the area, and it was of no further use to continue the measurements there. Wilhelm Julius Förster was responsible for the construction of a geomagnetic observatory in Potsdam, which started regular operation on January 1, 1890 (Körber, 1965, Tiemann, 1990). The old observatory building on Telegrafenberg in Potsdam has recently been renovated and now hosts the Paleomagnetic Laboratory of GeoForschungsZentrum Potsdam. However, in 1906 the observatory had to be moved after less than 20 years of operation, as electricity used for towing ships on Teltowkanal and the new electric trams disturbed the measurements in Potsdam. The new site was at Seddin, about 20 km southwest of Potsdam. When the Berlin S-Bahn was extended to Potsdam and electrified in 1927 the influence of this DC powered

Past and present

The absolute building in Niemegk in 1932 and in 2005, shortly after renovation put its appearance back into the original state. The old observatory building (1890) on Telegrafenberg in Potsdam is now used as Paleomagnetic Laboratory of GeoForschungsZentrum Potsdam.

Das Absoluthaus in Niemegk 1932 und heute, kurz nachdem es durch eine Renovierung sein ursprüngliches

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Erscheinungsbild zurück erhalten hat. Das alte Observatoriumsgebäude von 1890 auf dem Telegrafenberg in Potsdam beherbergt heute das Paläomagnetiklabor des GeoForschungsZentrums Potsdam.

railway was noticed even in Seddin and the observatory had to be moved again. As Adolf Schmidt had been head of the Magnetic Department of the Prussian Meteorological Institute in Potsdam since 1902, he had previously organized the move to Seddin. Thus, he was also responsible for planning the move to a new site. The town of Niemegk, 50 km Southwest of Potsdam, strongly supported the idea of installing the observatory in the area. The new observatory was inaugurated on July 23, 1930, on the 70th birthday of Adolf Schmidt. In honour of his remarkable scientific achievements, both theoretical and practical, the new magnetic observatory was named the Adolf Schmidt Geomagnetic Observatory. However, at that date, not yet finished construction work and problems with groundwater leaking into the variometer building delayed the start of observatory operation at Niemegk. During 1931 the instruments were moved from Seddin to Niemegk and full, continuous operation started at Niemegk in the beginning of 1932.

The observatory has remained in Niemegk and continues to produce an almost uninterrupted series of high-quality measurements through present time. However, during those 75 years significant changes in institutional affiliation have occurred. Upon foundation, the observatory belonged to the Meteorological-Magnetic Observatory Potsdam department of the Prussian Meteorological Institute in Berlin. From 1936 to 1945, the observatory was affiliated to the Geophysical Institute in Potsdam of Berlin University. Due to the war and resulting damages to the observatory, the measurements stopped on April 19, 1945 and could only be continued from February 2, 1946. The observatory became affiliated with the Geophysical Institute, later the Geomagnetic Institute, belonging to the Meteorological Survey. In 1949 the Geomagnetic Institute was assigned to the Berlin Academy of Science. With the academy reform of the GDR in 1968/1969, the observatory became affiliated to the Central Institute of Physics of the Earth, Potsdam and in 1982 to the Heinrich-Hertz Institute Berlin-Adlershof. When the structure of scientific institutes in the Eastern part of Germany was reorganized in 1992 after the reunification, the Adolf Schmidt Geomagnetic Observatory was adopted by the newly founded GeoForschungsZentrum Potsdam, Department 2, Physics of the Earth. More details on the history of the Adolf Schmidt Geomagnetic Observatory Niemegk can be found in Bock (1939), and Best (1997).

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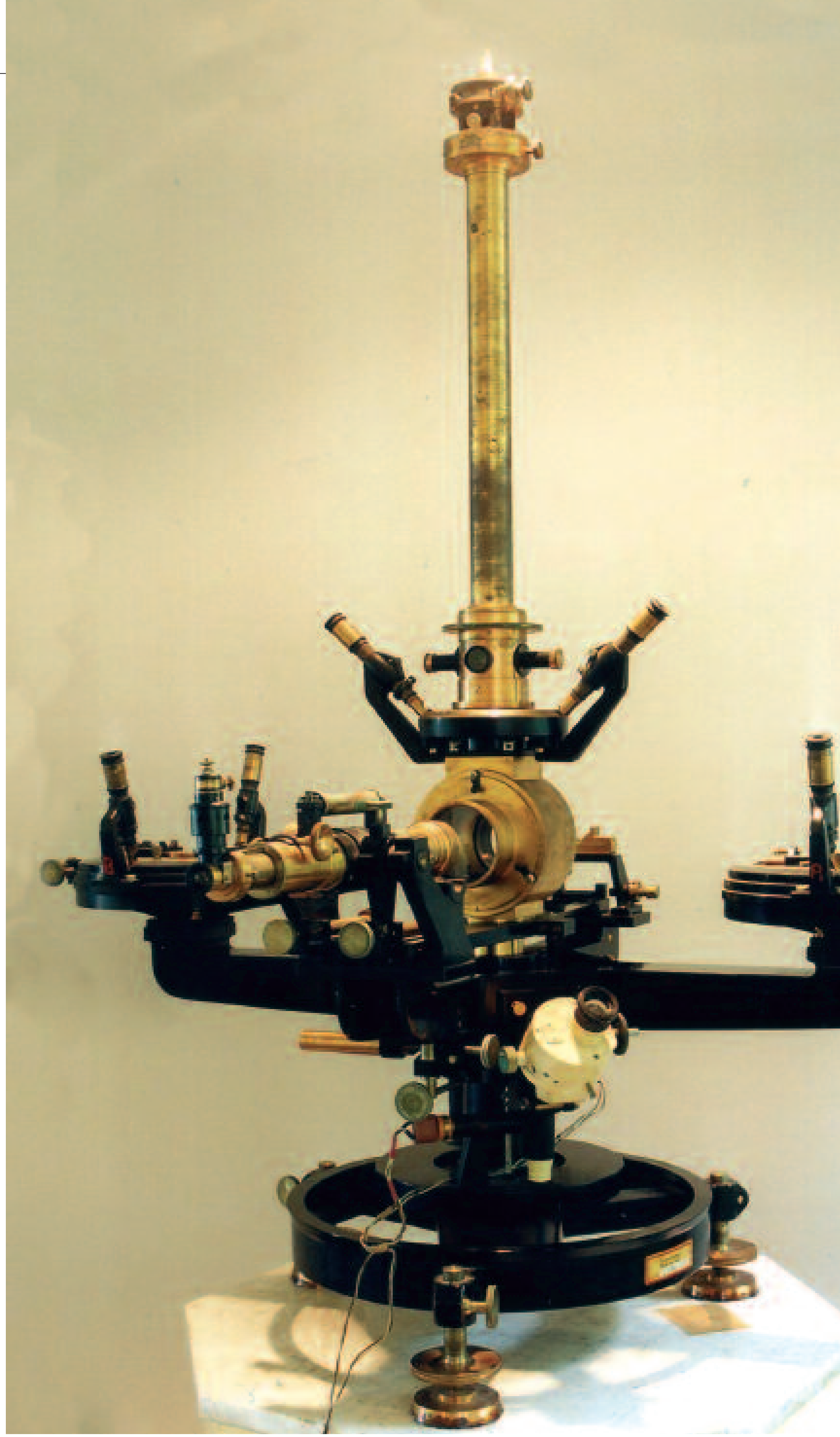
Instrumentation

To obtain the full information about the geomagnetic vector field, it is necessary to measure three componentens, e.g. the intensity (scalar measurement) and two angles of direction (declination and inclination), or three perpendicular components. The main difficulty in running a magnetic observatory arises from the different nature of absolute and variation measurements. A scalar measurement of the field intensity obtained by a proton magnetometer is absolute: this means it depends only on knowledge of a physical constant (the proton gyro ratio) and a measurement of frequency, which can be achieved with great accuracy (at least 10 ppm). In contrast, a vector measurement made with a fluxgate magnetometer is subject to instrument drift arising from sources both within the instrument (e.g. temperature effects) as well as from the stability of the instrument mounting. Because these measurements are not absolute, they are referred to as "variation" measurements, and the instruments are referred to as "variometers". It is possible to make an absolute measurement of the direction of the geomagnetic field, but this can only be performed with an instrument known as a "fluxgate-theodolite", which requires manual operation and takes about 15 minutes. At the Niemegk Observatory, such absolute measurements are typically made twice a week and are used to monitor the drift of the fluxgate variometers. The fluxgate-theodolite measures the direction of the geomagnetic field with respect to the horizontal plane (inclination) and the angle in the horizontal plane between magnetic north and true north (declination).

Before the development of the modern instruments, obtaining the full vector information was much more time-consuming, and in particular determining the absolute strength of the field was somewhat cumbersome. The measurement of declination was done in a similar way as it still is today by a theodolite with a magnetic needle like the one Adolf Schmidt introduced. Inclination was determined through the current induced in a coil rotated in the geomagnetic field with the so-called Earth-inductor. The attitude of the coil itself could be changed horizontally and vertically and the coil was aligned with the magnetic field lines when no cur-



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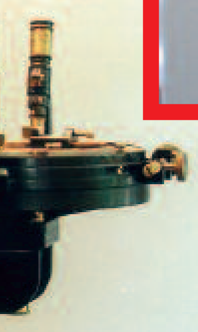
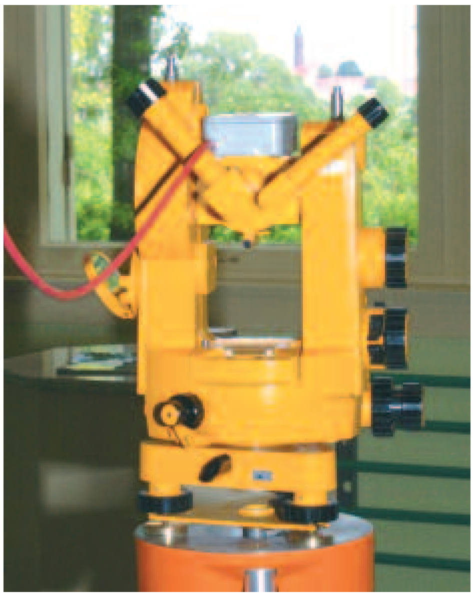
rent was induced. The absolute strength was determined for the horizontal intensity by two experiments, giving two equations with the magnetic moment of a magnet and the horizontal geomagnetic field intensity as two unknown variables. The experiments were first to measure the deviation of a magnetic needle in the field of a magnet and then to observe the oscillation period of the magnet swinging in the horizontal plane, with the theodolite and a so-called oscillation box, respectively.

Currently three modern recording systems are operated at the Niemegk Observatory. These are three-component fluxgate magnetometers of the types FGE, GEOMAG and MAGSON. One GSM Overhauser proton magnetometer complements the variation recordings and provides continuous absolute intensity values. The directional absolute measurements are carried out by a Zeiss theodolite with a Bartington fluxgate sensor. Additionally, a three-component induction coil system and two telluric lines in NS and EW direction are utilized. The traditional analog variometer systems with photographic recording are still operational while the current supply of photographic papers lasts. More details on the current instrumentation of the observatory are published each year in the Niemegk yearbooks.





Observing the Geomagnetic Field

Twice a week manual measurements are taken in the absolute building. Currently used instruments stand side by side with historical ones. Although modern instruments are much easier to use than historical equivalents, like the theodolite developed by Adolf Schmidt, a reading of the direction of the church tower is still necessary as geographic reference.

Zweimal die Woche werden im Absoluthaus Messungen von Hand durchgeführt. Die heute benutzten Geräte stehen Seite an Seite mit historischen Instrumenten. Obwohl die modernen Geräte wesentlich einfacher zu bedienen sind als ihre Vorgänger, wie der von Adolf Schmidt entwickelte Theodolit, muss nach wie vor der Kirchturm als geographischer Bezugspunkt angepeilt werden.

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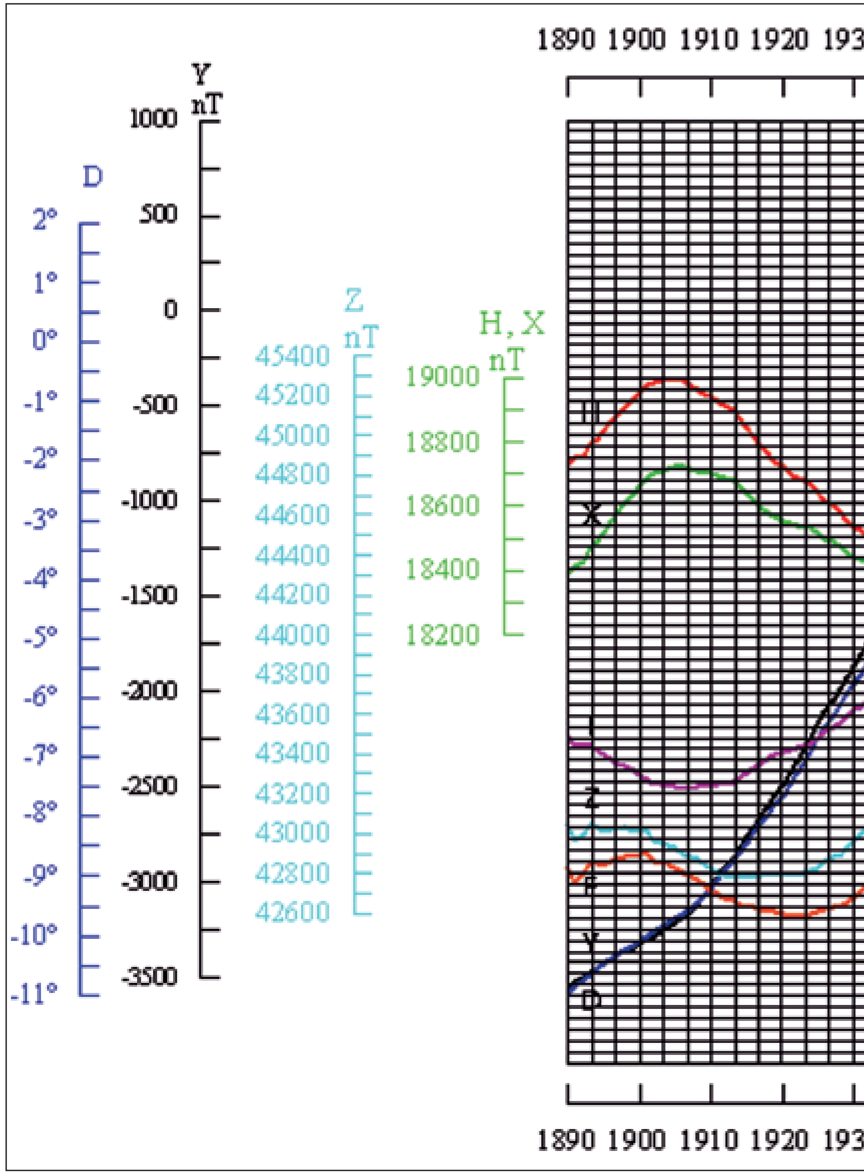
Data processing

As with other geomagnetic observatories, the geomagnetic variations at Niemegk were recorded by analog photographic magnetograms until relatively recently, when digital systems became available. Hourly mean values, read manually from the magnetograms, were the temporally highest resolution data routinely produced. In 1994, the present digital recording system was installed. The sampling rate of the variometer is 2 Hz, fulfilling the INTERMAGNET standard of 1 second sampling at 0.1 nT resolution. The main product, delivered to INTERMAGNET and the World Data Centers, however, are one-minute values, which are important for studying variations in the geomagnetic field external to the Earth, particularly the daily variation and magnetic storm effects. Data recorded in observatories in near-real time are "variational" or "preliminary"; being arbitrary to within a baseline offset, which itself may have a slow drift. For many applications, such preliminary data are sufficient, particularly for investigators concerned with relatively rapid changes in the magnetic field occurring over time windows of less than one day. Studies involving longer time-spans usually require absolute series. These are obtained through data processing, with adjustments made for baseline drift using the periodic absolute measurements. The very stable baseline values of Niemegk Observatory are given in the yearbooks each year. Specialized data-processing software has been developed, making the production of absolute, so-called "definitive" data relatively efficient. The steps involved in obtaining definitive magnetic data insure the minimum requirements for an INTERMAGNET Magnetic Observatory (IMO): the long term stability of the order of 5 nT/year, and an accuracy of 10 nT for 95% of reported data, and 5 nT for the definitive data. The Niemegk Observatory is well suited to fulfilling these requirements. In addition to the one-minute values, hourly, daily, monthly, and annual mean values also are calculated and published. It is the monthly and annual mean values that capture the secular variation emanating from the Earth's core. The quality of estimates of secular variation depends critically on the quality of absolute measurements. Data from the Niemegk Observa-



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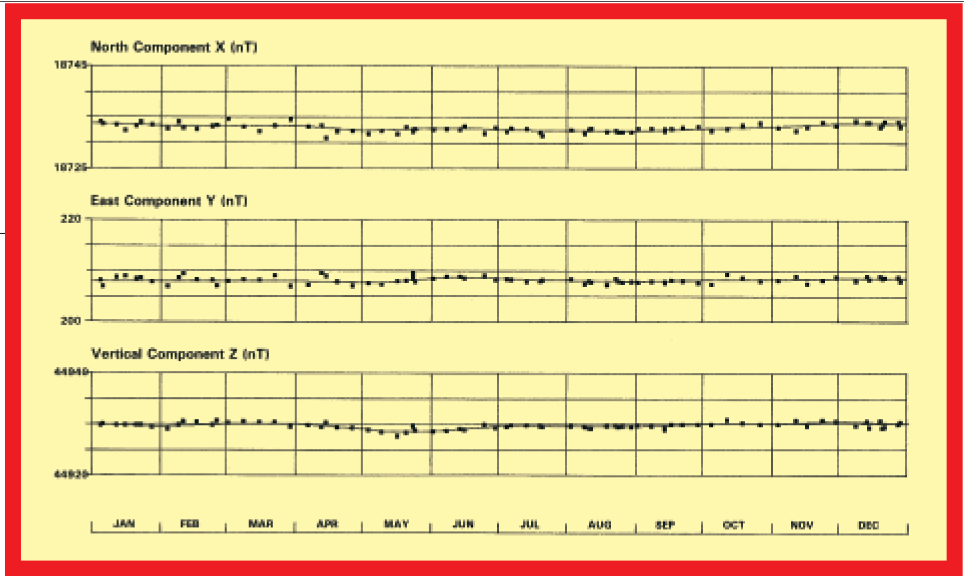

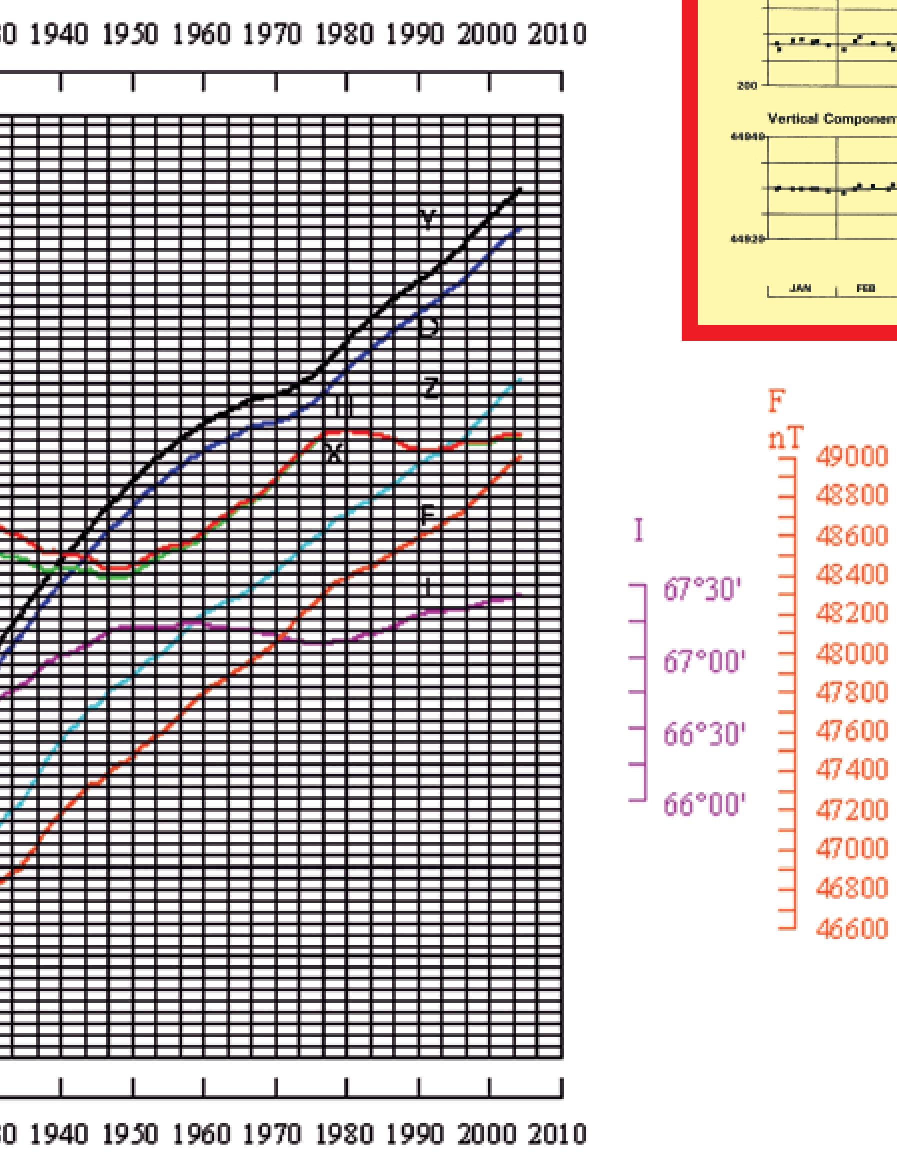

Data for the world

Left: Annual means of all magnetic components from Niemegk Observatory with data from Seddin and Potsdam adjusted to the current location.
Above: Baselines of the main recording system in 2004.

Links: Jahresmittelwerte der einzelnen Magnetfeldkomponenten des Observatoriums Niemegk mit Daten aus Seddin und Potsdam auf den heutigen Standort reduziert.
Oben: Basislinien des Hauptregistriersystems für 2004.

tory are delivered to INTERMAGNET daily and made available through a web-interface database. Current magnetograms and the local K-index of geomagnetic activity are displayed in near real-time on the observatory web-pages. Niemegk is not only a contributing observatory for the determination of the Kp index, but also currently hosts the IAGA (International Association of Geomagnetism and Aeronomy) service to calculate and distribute this index. Annual yearbooks are published and made available as pdf documents on the observatory web-pages. Observations are delivered annually to the World Data Centers. In addition to the usual magnetic measurements, pulsation data and recordings from two telluric lines (NS and EW, both 1000m) are available. Declination maps and grid values for Germany are compiled and upon request dedicated data-sets for specific purposes are made available.

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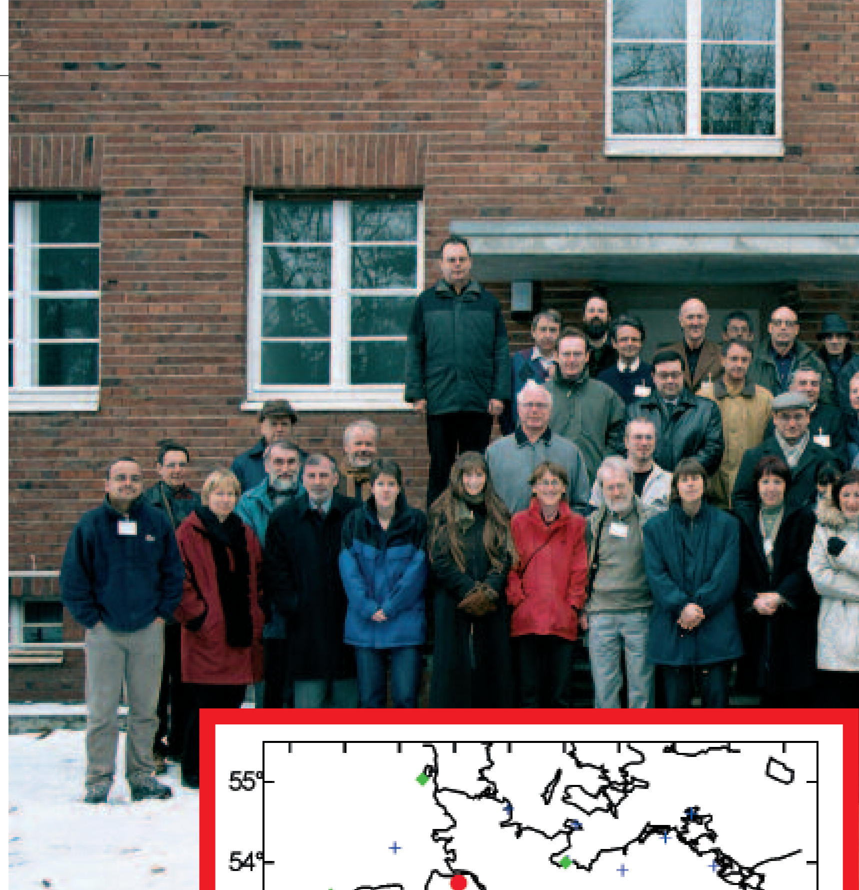
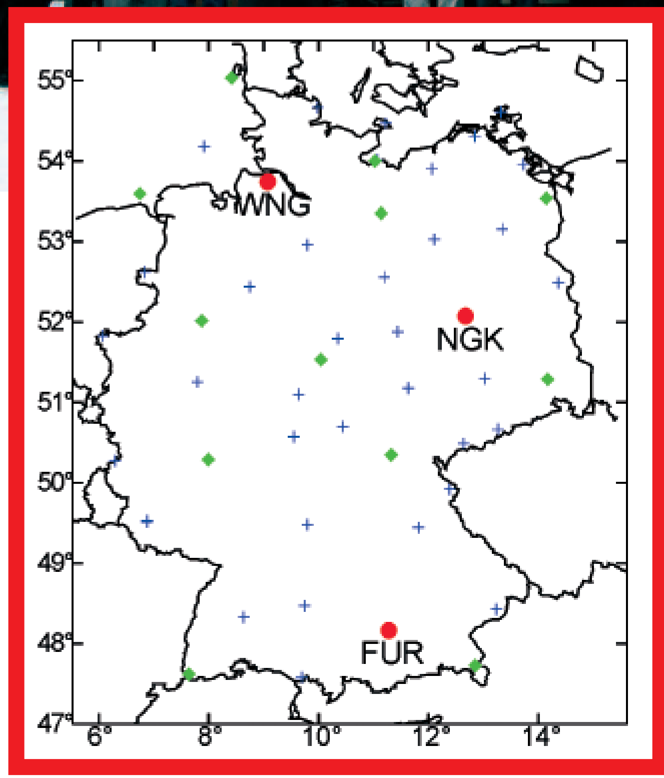
Niemegk Observatory contributions in Geomagnetism

Over time, the role of the observatory has also been modified along with the affiliation changes. Before 1945, the main task of the observatory was to record the geomagnetic field, and the scientific work was based at the institute in Potsdam. In the following years, however, the tasks for the observatory were expanded. In cooperation with industry, development and calibration of instruments for explorational surveys were carried out. With the advent of electromagnetic depth sounding, the short period variations and geoelectric signals had to be recorded. A magnetic survey covering the whole of the GDR was carried out between 1953 and 1962 on a very dense network of stations. A repeat station network of 12 points was installed and occupied annually from 1985 to 1990. Several scientists also worked directly at the observatory and, during the peak period, more than 50 people were employed there. Today, the scientific evaluation of the data is back in Potsdam, and the role of the observatory is concentrated on its main task of recording the geomagnetic field with high accuracy. Constant improvements to instrumentation and data processing are necessary to ensure state-of-the-art data quality. High data quality is required not only for observatory data, but also for repeat station results. The German repeat stations network, in its current form, was established in 1990 and consists of approximately 40 stations. The task of taking measurements at these sites every two years belongs to the Niemegk Observatory. With the adoption of the Wingst Observatory in 2000, which was formerly operated by the Bundesamt für Seeschifffahrt und Hydrographie, the Niemegk Observatory started operation and support of observatories worldwide. The Villa Remedios Observatory in Bolivia is operated in cooperation with the University of La Paz and new equipment, sponsored by GeoForschungsZentrum Potsdam, was installed in the observatory at Panagurishte (Bulgaria) in June 2005. The installation or support of further observatories, particularly in Africa and Asia, is planned. For the European region,





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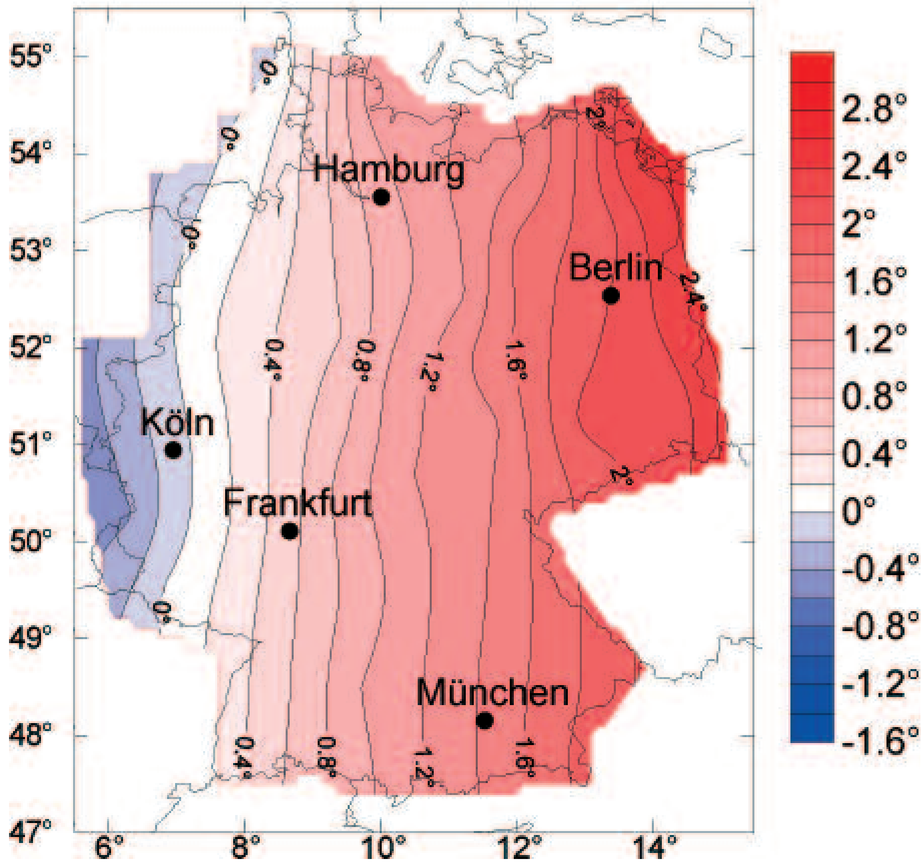

Niemegk - an European Observatory

Declination map for 2004 from the measurements on the German repeat station network and the three observatories Niemegk (NGK), Wingst (WNG) and Fürstenfeldbruck (FUR). To obtain high quality measurements for the whole of Europe, international scientists have gathered at the 1st European Repeat Station Workshop in Niemegk in 2003.

Deklinationskarte für 2004 aus den Messwerten des deutschen Säkularpunktnetzes mit den drei Observatorien Niemegk (NGK), Wingst (WNG) und Fürstenfeldbruck (FUR). Um aus ganz Europa hochqualitative Messergebnisse zu erhalten haben sich internationale Wissenschaftler beim ersten Europäischen Repeat Station Workshop 2003 in Niemegk versammelt.

Niemegk plays a leading role in the better coordination of repeat station surveys of the different countries. This successful initiative, now named MagNetE (Magnetic Network in Europe), started with a workshop at the Niemegk Observatory in February 2003, which was attended by more than 40 participants from 20 countries. When the Niemegk Observatory became part of GeoForschungsZentrum Potsdam, it was assigned to Section 2.3, Geomagnetic Field and Electromagentic Depth Sounding. The depth sounding part of Section 2.3 was recently transferred to Section 2.2, but the magnetotellurics part of the Geophysical Instrument Pool of GeoForschungsZentrum Potsdam is still located at Niemegk Observatory. A facility to calibrate induction coils is also provided there.

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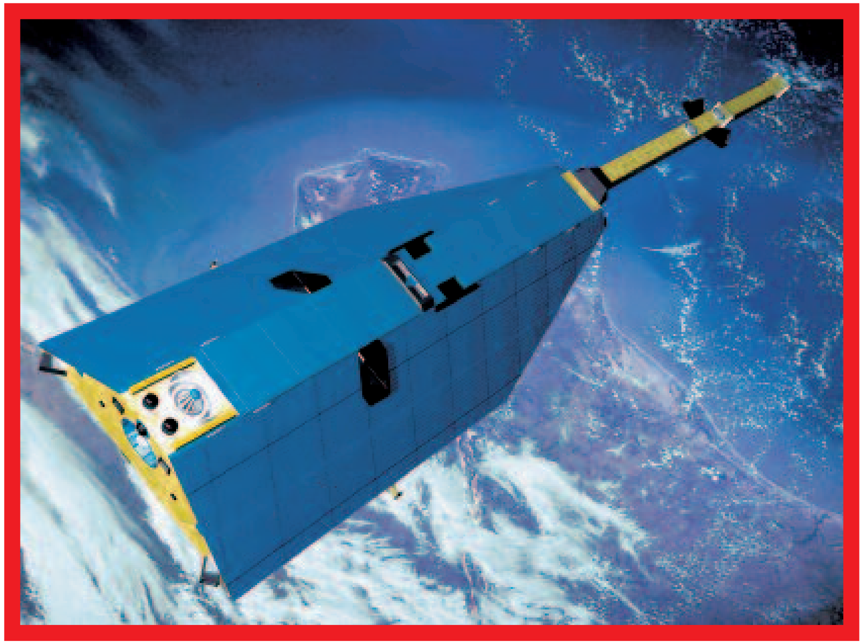
Why do we need observatories when we have satellites?

The data gathered by geomagnetic observatories form the backbone of the effort to continuously track magnetic field variations. This data is made available in a variety of time frames, ranging from near real-time to 5-year summary information, depending on needs and requirements. In recent years, however, several new satellites (Ørsted, CHAMP, SAC-C) were launched by different agencies to measure the Earth's magnetic field from space. From development to operation, the CHAMP satellite also is a project of GeoForschungsZentrum Potsdam, which moreover significantly contributes to the ESA project SWARM. This mission is planned to continue magnetic observation from space with three satellites to be launched in 2009. The satellite data are made available by the data centres of each mission. Satellites provide large datasets, covering the whole globe in a short time. The worldwide distribution of magnetic observatories, on the other hand, is highly non-uniform, with the Northern hemisphere covered significantly better than the Southern hemisphere. The question might arise why we still need observatories when we have satellites measuring the magnetic field. The answer is simple: satellite and observatory measurements cannot replace each other. On the contrary, they complement each other perfectly. For the study of the main field, the data provided by each of the three satellites currently in orbit ensures good, fast coverage of the Earth's surface, but only for a short period of time compared to the time-scales of secular variation. The long time series data from observatory recordings give the greatest available amount of information about the geodynamo process. Systematic measurements at observatories are available for approximately 170 years, and the earliest historical measurements of declination date back to the 15th century. However, all these measurements only begin to capture the important long term periodicity of the secular variation. Furthermore, only observatories, being more robust and less expensive, can ensure uninterrupted recordings into



A Glimpse into the Core from Outer Space

Studies of previously inaccessible spatial and temporal features of the magnetic field become feasible by combining observatory and satellite data, like detailed investigations of external fields, influencing for example the aurora indicated in green on the picture. The map of the comparably weak lithospheric field derived from CHAMP data shows the anomalies caused by magnetised rocks (altitude 400 km, units: nano-Tesla). The measurments also offer views deep inside the Earth where the largest part of the main field originates.

Erst die Kombination von Observatoriums- und Satellitendaten ermöglicht die Untersuchung vorher unzugänglicher raum-zeitlicher Strukturen des Magnetfelds, z. B. in der Erforschung der externen Anteile die unter anderem das Polarlicht beeinflussen (in der Zeichnung in grün stilisiert) . Die auf Messungen von CHAMP beruhende Weltkarte des vergleichsweise schwachen Lithosphärenfelds verzeichnet die von magnetisierten Gesteinen hervorgerufenen Anomalien (in 400 km Höhe, Maßangabe in Nanotesla). Die Messergebnisse ermöglichen auch einen Blick ins tiefe Erdinnere, denn die Ursache des Magnetfelds liegt überwiegend im äußeren Erdkern.

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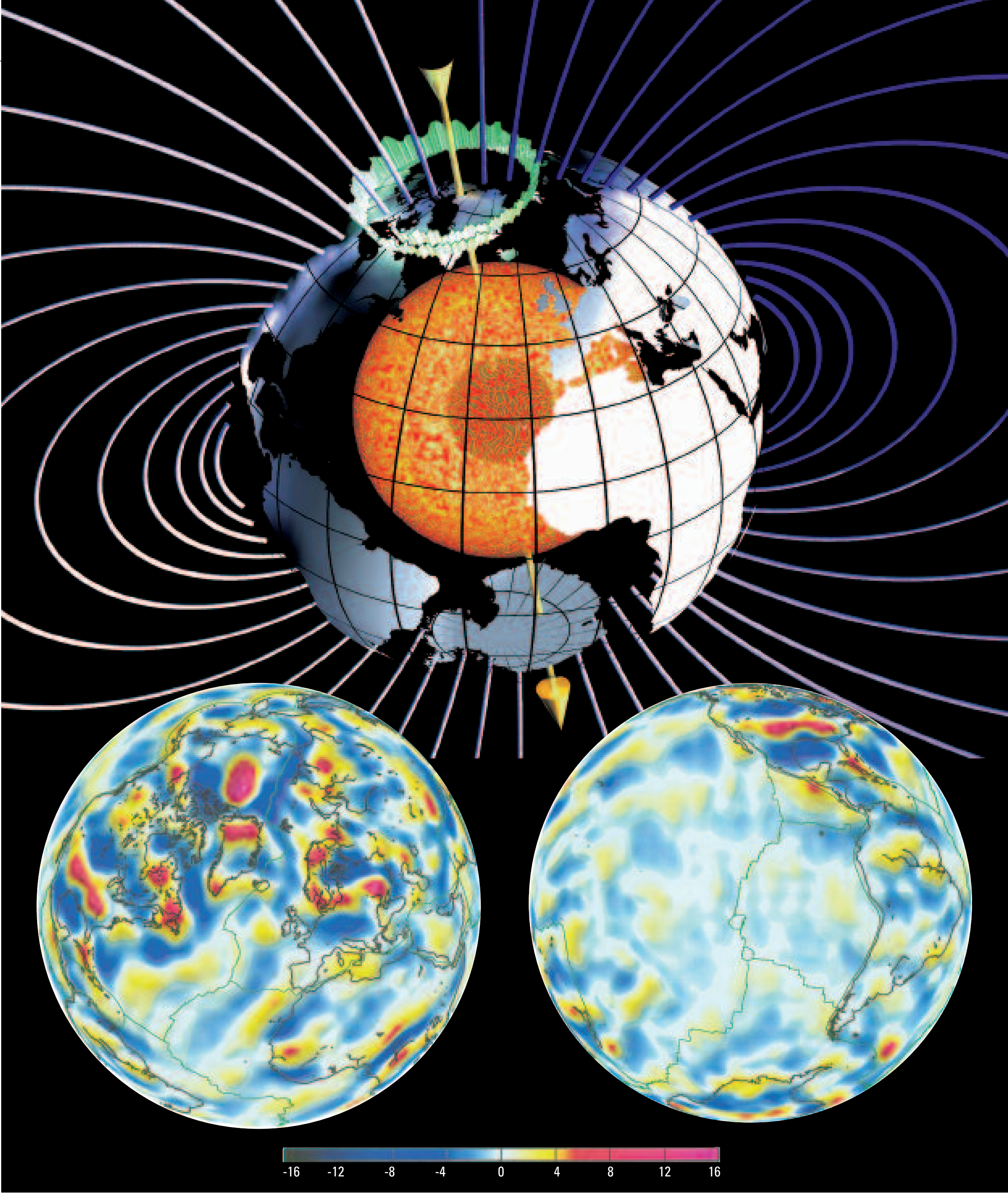

the future. The combination of observatory and satellite data is also vital for separating the different contributions of the magnetic fields internal and external to the Earth. For rapid external variations, satellite observations are a prime source of global information, but data analysis is impeded by the coeval movement of the satellite through time and space and subsequent mixing of temporal and spatial signal in the data series. Observatories, providing pure time series from individual locations, help in solving these ambiguities. Last but not least, the differences in distance from the various field sources for satellites and ground-based observatories provide certain differences in information content within the data that can be exploited in several ways. For all these reasons, it is desirable to have more, rather than fewer, observatories while the satellite missions last

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Further information

Further information about the Niemegk Observatory and its data products can be found at the observatory webpages:

http://www.gfz-potsdam.de/pb2/pb23/Niemegk/dt/index.html.

There, one can find such things as more photographs of the observatory and historical instruments, further details about the history, more about Adolf Schmidt and Gerhard Fanselau, and a publication list. For those interested in the data products, there are current magnetograms which are updated every 10 minutes, recent yearbooks in pdf format, a database of minute mean values back to 1994, and other products.

Geomagnetic data and other related information can also be obtained from INTERMAGNET and the World Data Centers (WDC):

http://www.intermagnet.org

http://www.ngdc.noaa.gov/seg/geomag/geomag.shtml

http://web.dmi.dk/projects/wdcc1

http://www.geomag.bgs.ac.uk/gifs/on_line_gifs.html

http://swdcdb.kugi.kyoto-u.ac.jp

http://www.wdcb.ru/stp/index.html

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Alle Abbildungen GFZ Potsdam (Fotos: E. Gantz, R. Holme, F. Ossing, E. Pulz, B. Stöcker) außer Seiten:

S. 4 Skizze: Preuß. Hochbauamt, 1932
S. 8,9 (Fotos) Stadtkontor Niemegk
S. 12 (Humboldt) Stiftung Preußische Schlösser und Gärten Berlin-Brandenburg/Fotograf.
S. 13 (Karte) aus "Lamont's magnetische Karten von Deutschland und Bayern", München 1854
S. 22/23 (Foto) H.-D. Scherz
IV.Umschlagseite: Zeichnung R. Muth

Titelbild: Büchsensonnenuhr mit Kompaß, wahrscheinlich 18. Jahrhundert
Sundial with compass, about 18th century

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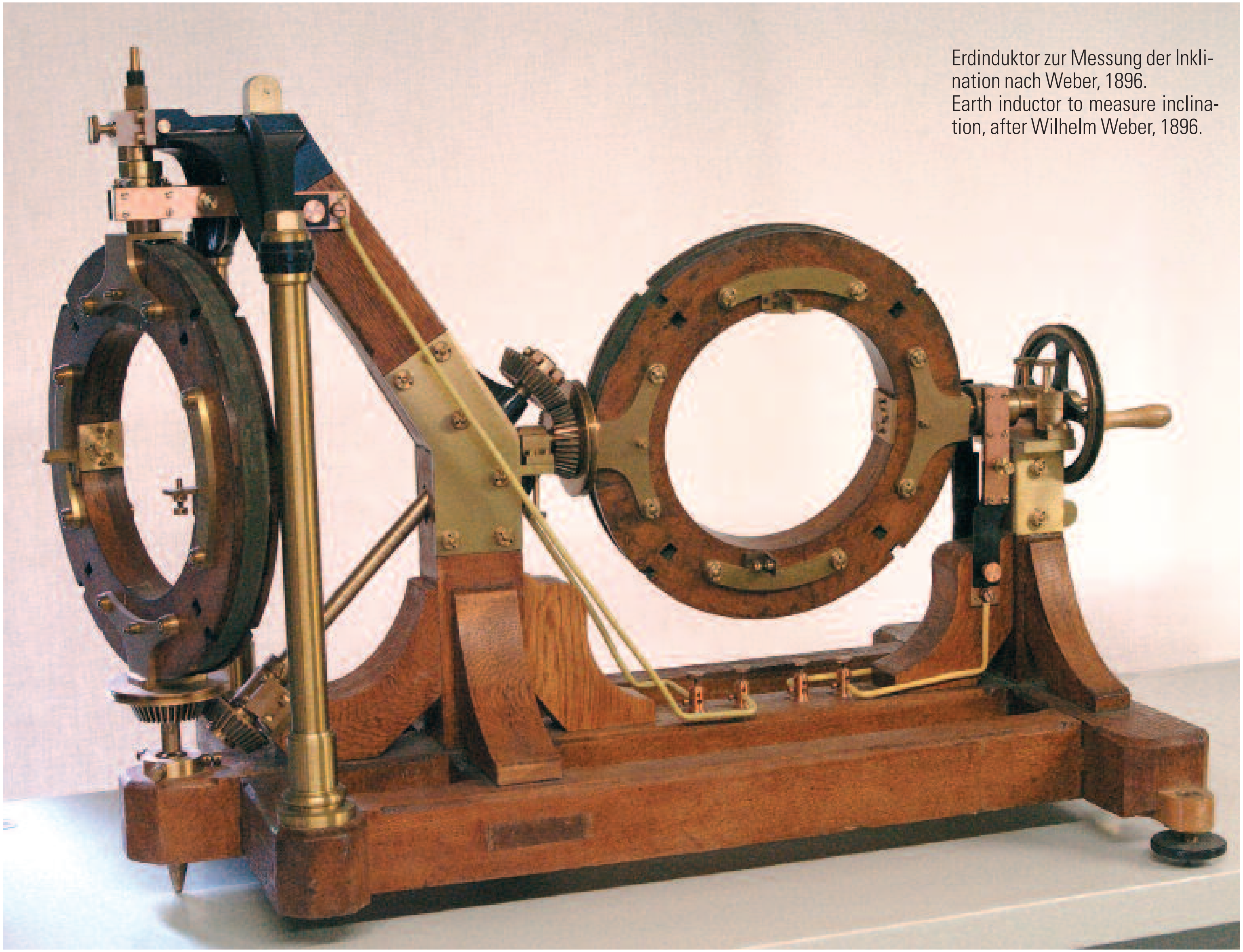

Erdinduktor zur Messung der Inklination nach Weber, 1896.
Earth inductor to measure inclination, after Wilhelm Weber, 1896.

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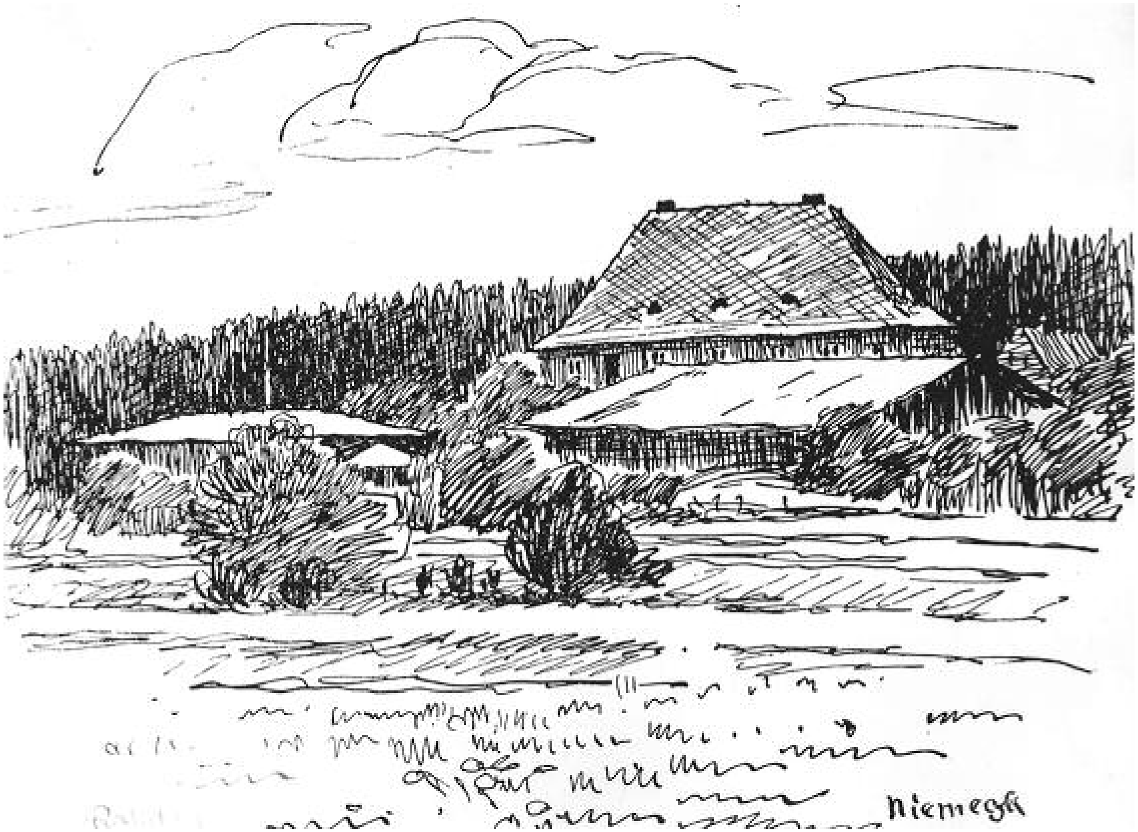

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