The 4th MagNetE Workshop on European Geomagnetic Repeat Station Survey

Helsinki, Finland,
8-10 June 2009

Program and abstracts

FINNISH METEOROLOGICAL INSTITUTE

Program

Monday, June 8

9:00 - 10:30	*Registration, poster setup and coffee with sandwich*
10:30 - 10:40	Opening remarks, Kari Pajunpää
	National Reports, chair Gerald Duma
10:40 - 11:00	***Barbara Leichter***, *J. Berger* and *G. Duma* : Repeat station measurements in Austria 2006-2008
11:00 - 11:20	***Tom Shanahan*** and *S. Macmillan* : UK 2007-2008 repeat station report
11:20 - 11:40	***Kari Pajunpää***, *H. Nevanlinna* and *J. Kultima* : Past and present of repeat station measurements in Finland
11:40 - 12:00	Other short national reports and discussion
12:00 - 13:00	*Lunch*
	Contributed papers, chair Heikki Nevanlinna
13:00 - 13:20	***Crisan Demetrescu***, *V. Dobrica* and *I. Vaduva* : On the high frequency ingredients of the secular variation
13:20 - 13:40	***Monika Korte*** and *V. Lesur* : Secular variation in Germany from repeat station data and a recent global field model
13:40 - 14:00	***Pavel Hejda*** : Some remarks to the derivation of hourly mean values with incomplete data
14:00 - 14:20	***Gerald Duma*** : Update of the MagNetE-Report/2006: Magnetic Repeat Station Measurements in Europe
14:20 - 15:00	*Coffee break*
	Contributed papers, chair Mioara Mandea
15:00 - 15:20	***Heikki Nevanlinna*** and *L. Häkkinen* : Historical geomagnetic observations - Data sources for secular variations and space weather studies
15:20 - 15:40	***Gerald Duma*** : Geomagnetic data and surveys of Austria-Hungary in the 19th century
15:40 - 16:30	Poster session
	Exhibition of Historical Magnetic Instruments of the FMI

Program

Tuesday, June 9

Contributed papers, chair Monika Korte

9:00 - 9:20	***Mioara Mandea***, *G. Verbanac* and *M. Korte* : The European geomagnetic secular variation and acceleration over the last four decades
9:20 - 9:40	***Tom Shanahan*** and *S. Macmillan* : Status of Edinburgh WDC Global Survey Data
9:40 - 10:00	***Gerald Duma*** : RS-ENTER software for conversion of RS data into a standard format - evaluation of usefulness, modifications
10:00 - 10:30	*Coffee with sandwich*
10:30 - 12:00	Discussions on specific topics
12:00 - 13:00	*Lunch*
13:00 - 20:00	Excursion to Nurmijärvi Geophysical Observatory

Wednesday, June 10

9:00 - 10:00	Discussions on specific topics
10:00 - 10:30	*Coffee with sandwich*
10:30 - 12:00	Discussions on specific topics and closing the workshop
12:00 - 13:00	*Lunch*
13:00	Departure

Oral presentations

Repeat station measurements in Austria 2006 - 2008

***B. Leichter**, J. Berger and G. Duma*

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From 1999 on, magnetic repeat station surveys have been performed on an annual basis in Austria. The station network comprises 14 measurement sites, covering the country uniformly with an average spacing distance of some 100 km. The data serve to determine the secular variation of the Earth's magnetic field in Austria's territory very accurately and to obtain information on the specific magnetic and geological conditions at each station site.

The surveys were carried out in 2006, 2007 and 2008, the final results 2006 were sent already to the world data center in Edinburgh, UK.

Since data reduction in Austria is still based on analogue recording magnetometers at the geomagnetic observatory Wien-Cobenzl (WIK), the calculation of definitive station values is delayed. For this reasons, a new digital suspended dIdD system from GEM was installed at Cobenzl in 2008. The station provides minute values which are transmitted to the office of the Geomagnetic Service (ZAMG) via a dedicated data line.

The new dIdD magnetometer was installed in a 10 meter deep plastic tube, for reasons of natural temperature stability. Comparison measurements between the analogue and digital system confirmed a very stable operation of the new instrument. However, an unexpected overflow of the tube by ground water in spring 2009 caused severe damages to the instrument, but which were successfully repaired. A brief report on the novel station construction is given, as well as on Austria's plans for a new magnetic observatory close to the modern Conrad observatory, some 60 km southwest of Vienna, in the alps.

UK 2007-2008 Repeat Station Report

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The British Geological Survey is responsible for conducting the UK geomagnetic repeat station programme. Measurements made at UK repeat station sites are used in conjunction with magnetic observatories to produce a regional model of the local field each year. Best practices for conducting repeat station measurements continue to evolve as advances are made in survey instrumentation and as the usage of the data continues to change. Here, a summary of the 2007 and 2008 UK repeat station surveys is presented, highlighting the measurement process and results obtained. This report also describes the planned reduction in measurement sites to better serve modelling of the core field temporal variations over the local region.

Past and present of repeat station measurements in Finland

Kari Pajunpää [†], *Heikki Nevanlinna* [‡] *and Johannes Kultima* [§]

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The network of secular (repeat) stations in Finland was established during the magnetic survey in 1910 - 1915. The number of stations was over 60 until about 1980. Thereafter the need for a dense network was considered with respect to the modeling purposes and to the costs and the number of stations was considerably reduced. Today the number of repeat stations in Finland is six and the number of magnetic observatories is two. One station we operate in Estonia. All, except one, of the repeat stations have permanent variometers and they belong to the IMAGE magnetometer network. The quality of measurements is improved by stabile (concrete of rock) basements for absolute measurements. In the central and northern part of Finland the annual mean value is calculated as the mean value of all days as recorded by the IMAGE magnetometer. There the base-line stability of the magnetometer is the most important parameter.

On the high frequency ingredients of the secular variation

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The analysis of long geomagnetic observatory records reveals the existence of high frequency secular variation ingredients at 22 and ~80 years timescales, superimposed on a so-called steady variation that carries the largest part of the field. These ingredients are highly significant in terms of secular variation at regional and local scale, as well as in defining the geomagnetic jerks. Examples are given based on observatory data and main field models at European and global scales.

Secular variation in Germany from repeat station data and a recent global field model

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The German repeat station surveys have been improved since about 10 years by using local variometers for data reductions instead of relying on the assumption that external and induced field variations are the same at any station and the nearest geomagnetic observatory. For nearly the same time interval, magnetic field data obtained from satellites like Ørsted and CHAMP are available with a good coverage of the whole globe. Recent global field models based on these satellite data together with geomagnetic observatory data provide an improved description of the main field and secular variation. We use the data of one such model, the GRIMM2 model by Lesur et al. (manuscript in preparation) to compare the secular variation evolution in Germany predicted by that model between 2000 and 2008 to the repeat station data collected over that time interval. Possible origins of the observed differences in terms of data accuracy and global model resolution are discussed.

Some remarks to the derivation of hourly mean values with incomplete data

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The papers and discussions during the XIIIth IAGA Observatory Workshop in Golden revealed a diverse set of views regarding the problem of computing mean hourly values (MHVs) from one-minute data when some of the minutes are missing during the hour. As a result, a task force was established to look into the problem and report back to IAGA. Its members are Pavel Hejda (Prague), Don Herzog (Boulder), Hans-Joachim Linthe (Niemegk), Mioara Mandea (Potsdam), Jean-Jaques Schott (Strasbourg) and Leif Svalgaard (Stanford). The group has been in correspondence and is focusing on three main areas of concern:

1. How different institutes compute hourly means when data are missing.
2. The various parameters involved in determining the accuracy of MHVs including, but not limited to latitude, level of magnetic activity, number of missing data points and distribution of those missing data points during the hour(s).
3. How to determine the level of accuracy that can be accepted as a standard.

The task force is preparing a report for the 11th IAGA Scientific Assembly held in Sopron in August 2009. Some preliminary results and open questions, aimed at elicitation of a discussion, will be presented now at the MagNetE workshop.

Update of the MagNetE-Report/2006: Magnetic Repeat Station Measurements in Europe

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In 2006, a report on magnetic repeat stations in 22 European countries was compiled, including the dates of measurements in recent years, and the country's survey plans for 2006 and 2007. The report built on information which was provided by the participants in the previous MagNetE workshops in Niemegk, 2003, and in Warsaw, 2005. In total 399 European repeat stations and station co-ordinates were listed in the report. In addition, comments on the national survey practises and contact persons in each country are given there.

Meanwhile, the representatives of 20 countries have reported in the MagNetE workshop 2007 in Bucharest about their new surveys, on progress in data quality and improved survey methods. Also, many countries have sent additional information by answering the questionnaire *MagNetE Repeat Station Survey Description Form*.

Thus, it seems appropriate and easily feasible to update the 2006 version of the report. Moreover, the report can be structured in a way that also future updates can easily be added.

The documentation then represents a kind of comprehensive catalogue or handbook of the European repeat station survey, a product which matches well one of the MagNetE's objectives to coordinate magnetic measurements in Europe.

For practical usage, the documentation is best placed in electronic form on a CD. A first version of it is made available during the workshop in Helsinki.

Historical geomagnetic observations - Data sources for secular variations and space weather studies

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This talk reviews geomagnetic measurements carried out in the 19th century in Finland and in Russia. The main focus is in the observatory recordings.

The first magnetic measurements in Finland have been made in the 16th century. Since then, several hundreds of measurements have been carried giving a rather comprehensive picture of the time variation of secular variation for about four centuries.

A regular magnetic observatory (now the Finnish Meteorological Institute) started in Finland (Helsinki) in 1844. At that time period, there were about 20 magnetic observatories worldwide established in the 1830s and 1840s. The Helsinki observatory was instrumented with similar magnetic equipment than, e.g., the Russian observatories (5) and other coeval geomagnetic institutions in Europe. The quality and homogeneity of the old data are usual high and can be still utilized in analysis of the geomagnetic field variations. Typical time resolution of the observations was from 10 min to 1 hour making space weather analysis possible in hourly and daily basis. An example of this kind of studies is the work made on the famous magnetic storm of 1859.

The number of magnetic observations in Helsinki and Russian observatories exceeded about two millions (H and D). Utilization of these observations gives useful information about the space-time structure of the geomagnetic field in an area stretching from Finland through Russia to the East in Alaska during the 19th century.

There are a huge amount of historical geomagnetic observations available in yearbooks compiled in the 19th century and in the early 20th century not hitherto fully utilized in geomagnetic studies. Here we demonstrate a simple method that can be used for converting yearbook tables into digital form for further analyses.

Geomagnetic data and surveys of Austria-Hungary in the 19th century

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The territory of the Austrian-Hungarian empire, under the reign of the Habsburgs in the 19th century, was a quite huge area to perform there one of the world's first geomagnetic surveys. Karl Kreil, at this time director of the '*K. K. Centralanstalt für Meteorologie und Erdmagnetismus*' in Vienna, carried out this campaign very sucessfully. He started with measurements in the Bohemian Kingdom 1843-45, followed by the surveys in Austria and Hungary until 1851. Moreover, Kreil extended the survey southwards to the Adriatic coast in 1854, and continued with another campaign across the SE-Balkan countries and to the Black Sea coast in 1858. The field data of 241 stations were reduced to 1850.0, using the geomagnetic observatories in Praha and Vienna as references.

A second geomagnetic survey in the monarchy's territory took place from 1889 to 1893, performed by J. Litznar in Austria and by I. Kurländer in Hungary and parts of todays Rumania (Transsylvania, Bukovina), Ukraine (region Lviv) and Poland (Galicia). To the south, measurements were again performed at the Adriatic coast, by W. Kesselitz and F. Laschober of the K. K. Marine Corps 1889-1890. Litznar provided accurate data of 109 stations for the entire survey, reduced to 1890.0.

Magnetic observations were always strongly supported by the K. K. Navy, which maintained an important military base in Pola, S-Istria. There, a Hydrographic Service was established which also was in charge of regular magnetic measurements at the naval observatory in Pola. Therefore, observational results in Pola exist for the period 1847-1909, monthly and annual means. Also comparison measurements with Potsdam were done there in 1909.

All survey data 1850 and 1890 was carefully re-evaluated by A. Ita (2006). Thus, this data as well as the observations in Pola and at the Adriatic coast can be made available for research purposes.

The European geomagnetic secular variation and acceleration over the last four decades

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Geomagnetic secular variation, the generally slow, continuous change of the core magnetic field, is characterized by occasional rapid variations known as geomagnetic jerks. Detailed studies of these phenomena for a longtime suffered from the sparse distribution of geomagnetic observatories over many parts of the Earth. Recent studies on magnetic data obtained by satellites with a good global coverage suggest that more rapid and smaller scale features than previously thought occur in the field change. Taken advantage of the comparatively high density of geomagnetic observatories in Europe, we have derived a regional model for the detailed study of secular variation and acceleration over the past four decades. For this we have used an improved and regularized spherical cap harmonic analysis. We show the improvements of our regional model over a global model. All the known jerks are seen by this regional model, but further times with rapid changes in secular variation exist. Moreover, times of zero acceleration in general do not occur simultaneously in all magnetic field components, although this nearly is the case around 1969 and 1982. Secular variation and acceleration show very dynamic patterns indicating rapid and complex causal processes in the Earth's fluid core. To improve the robustness of the small-scale features we also plan to take advantage of the new high quality data provided by the MagNetE network.

Status of Edinburgh WDC Global Survey Data

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The Edinburgh World Data Centre holds geomagnetic data catalogues for global observatories and repeat stations. Data are received in a number of formats and converted to the Project Magnet Format. Here we present a summary of the current data holdings for European countries from 1900 onwards. Submitted data are validated against recent IGRF model values to detect large errors or anomalies as a quality control measure. Total field anomaly data is presented for all repeat station data since 1900 and since 1960 to suggest intuitive evidence of induced magnetisation dominating the source of the crustal field contribution in Europe.

RS-ENTER software for conversion of RS data into a standard format - evaluation of usefulness, modifications

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During the 3rd MagNetE workshop in Bucharest 2007, a User Interface entitled RS-ENTER (Version 6) was introduced which serves to type or paste in data of repeat station measurements and convert it into a standard data format. The latter, MagNetE_WDC_EDI_format_v6.0 (March 2007), was defined by the MagNetE Group in 2005 and 2006, and bases on the format already used at the WDC Edinburgh for international magnetic data. For each station measurement, a separate file is produced, which includes also values of the scatter of measured components and the IAGA Classification Letter and Number, referring to the chosen reference station and reduction procedure.

RS-ENTER also provides the option to create a national '*station network file*' the data of which (station name, co-ordinates) are then automatically inserted into each repeat measurement data file.

The presentation outlines the features of the RS-ENTER software and possible improvements are discussed. Comments from the MagNetE Group are very welcome, to which extend the software is used and has proved reliable or needs modifications.

Posters

Croatian Geomagnetic Surveys 2007-2008

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The establishment of Croatian Geomagnetic Repeat Stations Network was completed, and surveys were carried out in 2007 and 2008. The reduced geomagnetic field of 2007.5, its annual variation as well as the normal field was presented. The establishment and the survey of the first third of the dense Croatian Geomagnetic Network for Field Mapping, covering the southern Dalmatia, including islands, was completed in summer 2008.

The 2007-2008 geomagnetic repeat station survey – Romania

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The Romanian repeat station network is presented together with the results of measurements done in 2007 and 2008 by means of QHMs, Geometrics proton magnetometers, and a LEMI-016 DIFlux instrument. Considerations on the accuracy of data reduction based on the Romanian geomagnetic observatory records are made. The values obtained for the geomagnetic elements H, Z, F, reduced to the middle of the year (geomagnetic epoch year.5) in which measurements were taken would be presented. The geographical distribution of the three elements is presented. To reduce the measured data to the desired geomagnetic epoch, records of the Surlari geomagnetic observatory have been used, in lack of a local recording device.

Geomagnetic Survey of Italy at 2007.5

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In 2007 a survey on a 'selection' of the Italian repeat station network, that consists in full of 116 points, was carried out. The Istituto Nazionale di Geofisica e Vulcanologia has made measurements on 37 repeat stations with an average spacing around 85-90 Km reducing data to 2007.5. The magnetic measurements and the reduction procedure, established in the previous surveys, are reported. We account the expressions of yearly variation of the components computed for various periods from 1990.0 to 2007.5 and show the maps of yearly variation of the components for the last period (2005.0 - 2007.5). In September 2009 we will plan to start the 2010 survey beginning with Albania stations, in collaboration with the Center of the Geosciences of the Polytechnic University of Tirana and moving soon afterwards with the Italian station. All measurements will be completed in one year.

Geomagnetic field measurements at the Czech Republic territory for 2008.5

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Field geomagnetic measurements have currently been carried-out at 7 points (except the observatory) extracted from the primary first order network consisting of 199 points.

Because of need of interpolation for the whole territory, the repeat stations were selected in the border regions of Czech Republic.

The structure of the Czech Republic territory varies latitudinarily from the stable central part (crystallinic or sedimentary rocks) to the more various structure at the west- and east border of the Czech Republic.

West part of Czech Republic is more various with higher tectonic and seismic activity (just 2008 visibly occurred in comparison with previous long time) and the interpolation must consider frequent disturbances expressing by higher curvature of isogones in this region. Nevertheless, the point at the west ridge of the territory is located outside this active area.

East border of Czech Republic is more influenced by human activity and we can observe higher variance of measurements. Therefore, beside the five points located in the border regions, two repeat stations are situated in the Czech inland at the sites with minimum disturbances. The same represent the last two stations located in border regions.

The observatory is located in moldanubic area of biotitic migmatites in the South Bohemia with stable bedrock with minimum inductance disturbances.

Field measurements have been carried-out by two observers using uniaxial fluxgate magnetometer mounted on grade-scale theodolite and Overhauser proton magnetometer. Each observer made two sets of four measurement cycles. The data were reduced to Budkov (BDV) observatory. Measurements with high variance were filtered out.

The German Repeat Station Survey 2008

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Continuing the improved, bi-annual repeat station surveys in Germany started in 2000, measurements have been carried out at all our 43 stations between April and October 2008. A local variometer is used at first order stations, and second order stations, no further than 150 km away from the variometer sites, are surveyed while the variometer is recording for a couple of days. We present results from the 2008 German repeat station survey and the secular variation between 2006 and 2008 determined from the consecutive surveys. Moreover, we carried out a brief investigation of the importance of distribution and density of stations for standard field mapping purposes.

Latest results of the Hungarian repeat station surveys

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Hungary's repeat station network was established in 1965. The original network consisted of 15 primary and 22 secondary anomaly-free sites, among which 12-13 stations have been surveyed during the last 4 campaigns. The mean distance between the stations was about 80 km. Our last repeat station survey was completed between November of 2008 and May of 2009. The declination, inclination and the total field were recorded using one-axial DMI fluxgate magnetometer mounted on Zeiss20A theodolite and GSM 19 Overhauser magnetometer. The definite magnetic elements of the sites will be reduced to the epoch of 2008.5 with the use of the continuous record of the Tihany Geophysical Observatory. In stations located far from the reference observatory, morning and afternoon observations have been completed in order to decrease the error of the temporal correction. In 2008, an international multilingual geophysical metadata base system was established within the framework of the eContentplus European project, to that the metadata bases of the Hungarian country surveys and the last repeat station campaigns have also been integrated. In the poster, the results of the last campaign and the magnetic network related information of the new metadata base system will be presented.

Ukraine magnetic repeat stations survey (2006-2007)

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The last conditional component survey in the repeat station (RS) stations network in Ukraine was made in 1974. Periodical repeat measurements in the RS network allow to trace temporal variations of the Earth's geomagnetic field and to map secular variations (SV) elements of a magnetic field for observed epochs. Results of SV observations are very necessary for creating of international models of a normal magnetic field of the Earth and its secular variations (IGRF). Very important are investigations of the lithosphere impact into secular variations.

In 2005 were started works for foundation of a RS network. Were founded 51 RS. Measurements of D, H, I, F geomagnetic field components were done.

The density of RS is 1 station in 10,000 sq/km. Distances between them are 100 - 150 km. Measurements of a declination D and an inclination I were done by a flux-gate magnetometer LEMI-203.

Absolute values of Earth's magnetism components on RS were obtained by reduction to observatories Dymer (UA), Lviv (UA), Bielsk (PL).

The reduction of geomagnetic field components on RS to the mean of 2005 was done and the catalogue of the measurements results was created.

The comparison of obtained data with the analytic model IGRF-2005 was done.

In general, the structure of observed field is correlating with the field of IGRF model. Taking into account rare RS network and high intensity of an anomalous field correct may be considered only confirmations between D and I components.

Comparisons of obtained D with D in the Ukrainian IGRF model shows deviation between them 30-40 minutes. At that spatial structure of D highly adjusts with a regional magnetic field F structure.

The next cycle of observations in the RS network in Ukraine is planning in 2009 - 2010. In would allow obtaining data about secular variations of Earth's magnetism elements.

Spanish repeat stations surveys (2007 and 2008)

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The Spanish repeat stations network has changed substantially in the last years, mostly due to civil noise, but also as an implementation of the new methods of reduction with variometric stations.

Here we present the new network, showing the Spanish observatories, the variometric stations and the normal repeat stations. The circles centers correspond to either an observatory or a variometric station and the repeat stations that are in the area of influence of each of them and used for reduction.

For 2008 survey the variometric stations were firstly used, differences between both reduction methods are shown.

Magnetic ground and repeat station surveys in Slovakia for the 2006-2008 years

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New geomagnetic ground survey was carried out over the territory of Slovakia in the period of the last three years (2006-2009). The measurements of the geomagnetic field were reduced to epoch 2007.5 using geomagnetic data registered at the Hurbanovo Geomagnetic Observatory. Two geomagnetic repeat station surveys were carried out during this period, too. The data reduction of the repeat station surveys were made for the 2006.5 and 2008.5 epochs, respectively. In the paper the results of the surveys are compared, distribution of the geomagnetic field elements is shown, and secular variation of the geomagnetic field elements are presented.

Report about the measurements at the repeat stations

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Poster shows the magnetic network of the repeat stations in Poland and the results of measurements from 2005 to 2008 epoch.

Secular variations of the geomagnetic field in Europe, 1995-2005

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The poster shows the maps of secular variations of declination, total vector and horizontal vector of geomagnetic field. The maps with isopors were elaborated on the base of magnetic data from repeat stations in Europe for the period 1995-2005 and compared with IGRF isopors.