Improvements planned for European geomagnetic repeat stations

Monika Korte, Moira Mandea

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Direct measurements of the Earth's magnetic field are continuously made around the world at magnetic observatories; they are obtained at all kinds of locations, ranging from ocean to land and even air. All this activity has prompted the question, Why all the effort in the magnetic satellite epoch?, or, Why observe the Earth's magnetic field in such different locations? To answer these important questions, a workshop on European geomagnetic repeat station surveys was organized at the Adolf Schmidt Observatory for Geomagnetism in Niemegk, Germany.

Magnetic repeat stations are permanently marked sites where high-quality magnetic observations are made every few years for a few hours or sometimes a few days [*Newitt et al.*, 1996]. Their main purpose is to track changes in the core-generated magnetic field. However, unlike at geomagnetic observatories, the field is not continuously recorded. To obtain final data that is comparable to those provided by the geomagnetic observatories, specific data reduction methods have to be applied. Repeat station data offer better spatial resolution than do observatory data alone. They are used for detailed secular variation studies, updating the magnetic charts using secular variation models, better spatial resolution for global modeling, lithospheric induction, conductivity studies, reduction of aeromagnetic surveys, and for describing the crustal field (although much denser station networks are needed for that task). Issues related to these studies have to be discussed by the community involved in operating repeat station measurements, and the European meeting provided a forum for this sharing of information.

The meeting focused on the following:

• The geomagnetic field is a global phenomenon, and large parts of its spatial wavelengths are longer than most European countries' geographical dimensions. This is true, in particular, for the secular variation, the temporal change of the main field produced within the core. In secular variation studies, the repeat station measurements could play a major role, but the current inhomogeneous repeat station data distribution over Europe complicates detailed modeling of the European secular variation considerably.

• After the first magnetic vector satellite MAGSAT in 1979/1980, no other missions of that class were flown for 20 years. The situation changed in February 1999, when the Danish Ørsted mission was launched, soon followed by the German CHAMP mission in July 2000, the Argentinian SAC-C mission in November 2000, and the very new Australian FedSat mission in December 2002.

This series of launches initiated an era of continuous monitoring of the planetary field from space, which could last until the end of the decade, as recommended by the International Union of Geodesy and Geophysics; this period would fall within the International Decade of Geopotential Research. However, these satellite measurements are taken at different altitudes of several hundred kilometers, and thus, cannot resolve short wavelength features of the magnetic field. Continuous observation of the geomagnetic field from ground and space, combined with advanced modeling techniques, are indeed ideally suited for separating the signal of internal origin from that of external origin, better resolving the crustal field, deciphering the complex behavior of the core dynamics on the decade time scale, and identifying weak signals from induced currents. We consider that a general effort will improve the number and quality of ground-based data.

• The political changes in Europe over more than a decade have facilitated data exchange and open, new cooperation among all European countries. The time is right to take these opportunities and to obtain a more homogeneous picture of the detailed European geomagnetic field and secular variation.

During the two-day meeting, about 50 participants from 20 European countries presented their work and discussed different repeat station topics. One important result of the meeting is the overview of repeat station status in Europe. Representatives from Bulgaria, Croatia, the Czech Republic, Denmark, Finland, France, Germany, Hungary, Ireland, Italy, Latvia, Norway, Poland, Romania, Sweden, Slovakia, Spain, the United Kingdom, Ukraine, and Yugoslavia gave short presentations. In addition, summaries for Albania, Austria, Belarus, and Lithuania—countries not directly represented at the meeting, but interested in this subject—were given. These presentations clearly showed that European repeat station surveys still differ significantly among countries. Station spacings vary from tens to hundreds of kilometers, and time intervals range from 1 to 5 years. Moreover, in some countries, repeat stations are located mainly along the borders; as so far, mainly the own country's data was used to map the field over territory, and interpolation is more reliable than extrapolation. Of course, this cannot lead to a uniform data distribution when a data set based on data from several countries is considered.

Improvements and cooperation were planned during fruitful half-day sessions in preparation for a common European magnetic repeat station network. The surveys have to be carried out in all of the participating countries within the same year; this will occur for the first time in 2004 or 2005 and will be followed by surveys over equal time intervals thereafter. A density of one station in 15000 km^2 or mean station distance of about 125 km, is considered desirable, motivated by the horizontal gradient of secular variation. However, scientists involved in regional modeling were asked to estimate the needed spatial density for this kind of model. If a survey of the whole network of stations cannot be completed within 1 year, measurements on an evenly distributed subset of stations in the years of "European surveys" are encouraged. The importance of highly accurate results has been emphasized, as well as the importance of making the data available at world data centers (WDC Edinburgh). The former can only be achieved by closely following the guidelines for measurement practice and data reduction as recommended by *Newitt et al.* [1996]. Modelers would appreciate the availability of more raw data, such as the absolute values at the time of observation, or, in particular, data reduced to an undisturbed nighttime level close to the time of observation.

Establishment of a committee was proposed that would work toward measuring the magnetic field in a common European repeat station network. It consists of: Monika Korte (Germany), Andrzej Sas-Uhrynowski (Poland), Jean-Jacques Schott (France), and Gerhard Schwarz (Sweden). This committee will recommend minimum requirements for a European magnetic repeat station network based on the agreements of the workshop and will support common survey planning in individual countries.

More information about the status of repeat station surveys in Europe, the topics of the workshop, and progress toward a common European magnetic repeat station network can be found at http://www.gfz-potsdam.de/pb2/pb23/GeoMag/eurepstat.html.

This is a first step in a more general effort to assess the status of the worldwide network of repeat stations. The Workshop on European Geomagnetic Repeat Station Surveys was held 20–21 February 2003.

Reference

Newitt, L. R., C. E. Barton, and J. Bitterly, *IAGA Guide for Magnetic Repeat Station Surveys*, International Association of Geomagnetism and Aeronomy Special Publication, Boulder, Colorado, 114 pages, ISBN 0-9650686-1-7, 1996.

—MONIKA KORTE, GeoForschungsZentrum Potsdam, Germany; and MIOARA MANDEA, Institut de Physique du Globe de Paris, France