Journal of large-scale research facilities

Journal of large-scale research facilities, 2, A83 (2016) http://dx.doi.org/10.17815/jlsrf-2-136

Published: 09.08.2016

Geomagnetic Observatories

GFZ German Research Centre for Geosciences *

Instrument Scientists:
- Jürgen Matzka, GFZ German Research Centre for Geosciences, Telegrafenberg, 14473 Potsdam, Germany, phone: +49 (0)33841 624-18, email: jmat@gfz-potsdam.de

Abstract: In this article we briefly describe the geomagnetic observatories operated or supported by the Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences (GFZ), their scientific and societal use in the light of a global approach, their main data products and their dissemination process, as well as their instrumentation. The geomagnetic observatories of GFZ are part of the 'Modular Earth Science Infrastructure' (MESI).

1 Introduction

The geomagnetic field is generated by electric currents in the Earth's core, ionosphere and magnetosphere as well as induced electric currents in the Earth's mantle and oceans. An additional contribution originates from the magnetisation of the lithosphere. Geomagnetic observatories are a versatile tool to study these currents and the associated processes in Earth and its surrounding space environment. In contrast to variation magnetometers or absolute scalar magnetometers, observatories provide calibrated vector data in an absolute reference frame (Matzka et al., 2010). Long-term, homogenous time series allow the study of secular variation of the core field and of trends in space climate. Geomagnetic observatories and geomagnetic measurements from satellites (e.g. ESA's Swarm mission, Olsen et al. (2013)) complement each other due to their different space/time constellation, e.g. for the characterisation of geomagnetic variations with local time. Observatories are in particular important for studying long-term trends and induction phenomena. GFZ globally operates geomagnetic observatories and plays an active role in supporting geomagnetic observatories worldwide through cooperation agreements (see Figure 1 for a full overview on geomagnetic observatories with GFZ cooperation). A focus area for GFZ geomagnetic observatories is the South Atlantic Anomaly, i.e. the area from South America to South Africa that is characterised by low, and decreasing, geomagnetic field strength.

*Cite article as: GFZ German Research Centre for Geosciences. (2016). Geomagnetic Observatories. *Journal of large-scale research facilities, 2*, A83. http://dx.doi.org/10.17815/jlsrf-2-136

2 Data products and their dissemination

Data are typically given in local Cartesian coordinates in a topocentric geodetic coordinate system (geographic North X, geographic East Y and vertical down Z) in units of nT, and time is given in UTC. The data is provided in three different types, representing a progressively improved calibration and quality control: provisional (near real-time), quasi-definitive (with about 1 to 2 months delay) and definitive (typically 3 to 18 months delay).
Definitive yearly, hourly and minute mean values are distributed through the World Data Centre for Geomagnetism (Edinburgh), UK, (abbreviation: WDC, http://www.wdc.bgs.ac.uk/) and through INTERMAGNET (www.intermagnet.org, e.g. (St-Louis, B. and INTERMAGNET, 2012). INTERMAGNET is a consortium that sets and controls international standards for geomagnetic observatories and organises a peer review of the definitive data prior to publication. Preliminary mean values are available from INTERMAGNET in near real time (up to a few days delay), quasi-definitive minute mean values are typically available on a monthly basis (Matzka, 2013; Peltier & Chulliat, 2010).
The International Association of Geomagnetism and Aeronomy (IAGA), INTERMAGNET and the WDC for Geomagnetism are closely cooperating with users, data providers and also with each other. The free and open access to geomagnetic observational data for scientific purpose has a long tradition in the geomagnetic community. Commercial data use, e.g. in support of navigating horizontally-drilled oil wells, typically leads to commercial agreements with the customers, e.g. oils service companies.
Some of the geomagnetic data from observatories operated or supported by GFZ that currently do not fulfil INTERMAGNET standards is available through SuperMAG (Gjerloev, 2012), which is one of several projects to provide such data from a single website (http://supermag.uib.no/). Data are routinely redistributed, e.g. from INTERMAGNET to the WDC for Geomagnetism as well as to SuperMAG. Acknowledgement is given directly to GFZ or indirectly to INTERMAGNET. Download statistics are available from INTERMAGNET.

3 Global approach

GFZ operates the geomagnetic observatories Niemegk (established in 1930) and Wingst (established in 1938) in Germany as well as one each in the British Overseas Territories St Helena (Korte et al., 2009) and Tristan da Cunha (Matzka et al., 2011, 2009). An observatory on the Azores is in the process of being set up. GFZ currently has cooperation agreements with various partners (for a full list see the acknowledgements) regarding the operation of geomagnetic observatories in Antarctica, Bolivia, Brazil, Bulgaria, India, Indonesia, Namibia, Portugal, Romania, Russia, and Ukraine.
There are various levels of involvement by GFZ ranging from providing instrumentation to observatory planning, set up, maintenance, training, sharing of operating costs, data calibration and quality control, depending on the cooperation. Niemegk serves as a central observatory and on its premises there are test, calibration and archive facilities as well as workshops and computer infrastructure maintained by staff specialized on observatory operations to run or support all observatories in our network. The observatory network allows GFZ and its partner institutions to close gaps in global coverage or to concentrate on monitoring and exploring regional phenomena of special scientific interest, like the South Atlantic Anomaly, or specific high, low and mid-latitude current systems in Earth's space environment. Fig. 1 shows a map of the geomagnetic observatories operated or supported by GFZ, including those that are in the process of being established.

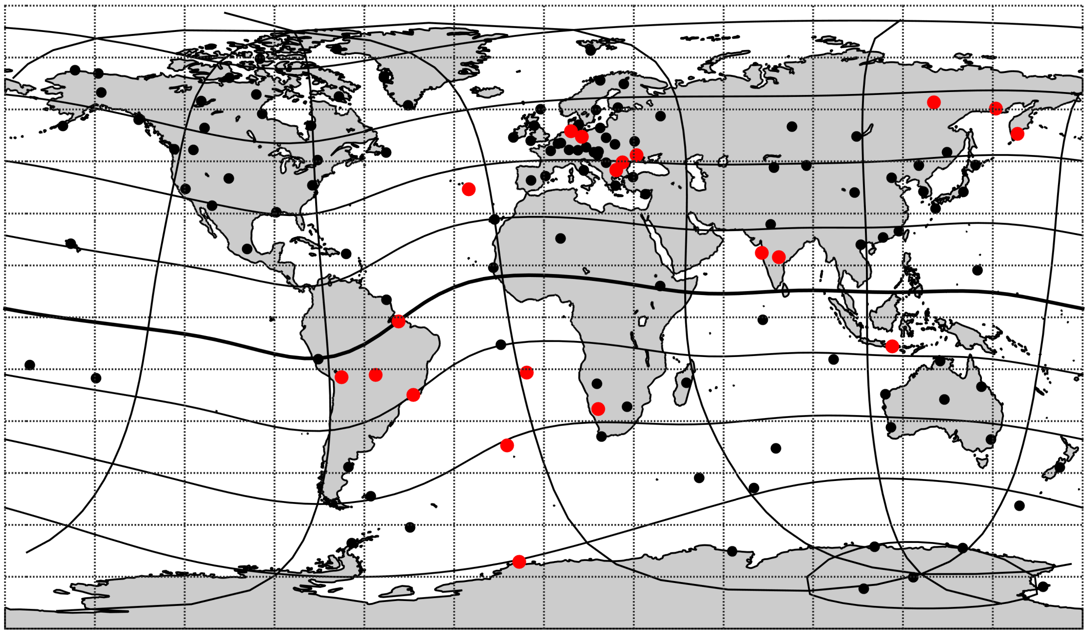

Figure 1: Geomagnetic observatories operated and supported by GFZ (red dots) of which, at the time of writing, 13 are INTERMAGNET observatories. The black dots are other INTERMAGNET observatories (see text).

4 Instrumentation

Typically, three instruments are operated in an observatory. These measure (i) the absolute field strength, (ii) the absolute direction of the geomagnetic field vector, and (iii) variations of certain vector components. In the following, we list what can be considered as standard instruments for geomagnetic observatories and these are typically used at GFZ's geomagnetic observatories. Absolute field strength is usually measured by GSM-19 or GSM-90 proton or Overhauser magnetometers manufactured by Gem Systems, Canada. Absolute field direction is measured with a fluxgate probe mounted on a non-magnetic theodolite of type Theo 010 or Theo 020 previously manufactured by Zeiss Jena, Germany. Variations are measured by suspended 3-compent fluxgate vector magnetometers of type FGE manufactured by Technical University of Denmark. The variations are logged with 1 Hz or faster. The absolute measurements are performed manually on a weekly basis and are used to calibrate the variation measurements to yield the absolute data stream. An absolute accuracy of 1 nT can ideally be achieved.

Acknowledgements GFZ's staff members Oliver Bronkalla, Heinz-Peter Brunke, Jürgen Haseloff, Achim Morschhauser, Carsten Müller-Brettschneider, Hannelore Podewski, Stefan Rettig, Manfred Schüler and Katrin Tornow at Niemegk geomagnetic observatory are acknowledged. The cooperating institutes Universidad Mayor De San Anders (Bolivia), National Institute of Geophysics, Geodesy and Geography (Bulgaria), South African National Space Agency (SANSA, South Africa), Institute of Cosmophysical Research and Aronomy (IKFIA, Russia), Institute of Cosmophysical Research and Radio Wave Propagation (IKIR, Russia), Indian Institute of Geophysics (IIG, India), National Geophysical Research Institute (NGRI, India), Geological Institute of Romania (IGR, Romania), Observatório Nacional (ON, Brasil), Institute of Geophysics (IGF, Ukraine), Mataram University (Indonesia), Technical University of Denmark (DTU, Denmark), Alfred-Wegener-Institute (Germany) are acknowledged. Kirsten Elger is acknowledged for valuable comments that greatly improved the manuscript.

References

Gjerloev, J. W. (2012). The supermag data processing technique. *Journal of Geophysical Research: Space Physics*, *117*(A9). http://dx.doi.org/10.1029/2012JA017683

Korte, M., Mandea, M., Linthe, H.-J., Hemshorn, A., Kotzé, P., & Ricaldi, E. (2009). New geomagnetic field observations in the South Atlantic Anomaly region. *Annals of Geophysics*, *52*(1). http://dx.doi.org/10.4401/ag-4631

Matzka, J. (2013). Preparation of quasi-definitive (QD) data for the observatories Narsarsuaq, Qeqertarsuaq and Tristan da Cunha. In P. Hejda, A. Chulliat, & M. Catalan (Eds.), *Real instituto y observatorio de la armada en san fernando* (pp. 50–53).

Matzka, J., Chulliat, A., Mandea, M., Finlay, C. C., & Qamili, E. (2010). Geomagnetic observations for main field studies. *Space Science Reviews*, *155*(1), 29–64. http://dx.doi.org/10.1007/s11214-010-9693-4

Matzka, J., Husøy, B. A. W. D. P. L. W. S. C., B.-O., Repetto, R., Genin, L., Merenyi, L., & Green, J. J. (2011). The geomagnetic observatory on tristan da cunha: Setup, operation and experiences. *Data Science Journal*, *10*, IAGA151–IAGA158. http://dx.doi.org/10.2481/dsj.IAGA-22

Matzka, J., Olsen, N., Maule, C. F., Pedersen, L. W., Berarducci, A. M., & Macmillan, S. (2009). Geomagnetic observations on Tristan da Cunha, South Atlantic Ocean. *Annals of Geophysics*, *52*(1). http://dx.doi.org/10.4401/ag-4633

Olsen, N., Friis-Christensen, E., Floberghagen, R., Alken, P., Beggan, C. D., Chulliat, A., … Visser, P. N. (2013). The Swarm Satellite Constellation Application and Research Facility (SCARF) and Swarm data products. *Earth, Planets and Space*, *65*(11), 1189–1200. http://dx.doi.org/10.5047/eps.2013.07.001

Peltier, A., & Chulliat, A. (2010). On the feasibility of promptly producing quasi-definitive magnetic observatory data. *Earth, Planets and Space*, *62*(2), e5–e8. http://dx.doi.org/10.5047/eps.2010.02.002

St-Louis, B. and INTERMAGNET (Ed.). (2012). *Technical Reference Manual Version 4.6, INTERMAGNET*. Retrieved from http://www.intermagnet.org/publication-software/technicalsoft-eng.php (accessed on 10 March 2016)