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Availability of geomagnetic information

Mario Brkić

Abstract

The issue of public availability of the Earth's magnetic field data is not adequately regulated. The paper presents a proposal to declare geomagnetic information publicly available only when its reliability drops to the reliability of the currently best publicly available global geomagnetic model. With such a criterion, the monitoring and prediction of the unreliability of the current geomagnetic information model GI2022 suggests a reliability period of the original geomagnetic information of at least three years from the epoch of reduction of the last geomagnetic network measurements. The same should be the period of geomagnetic information public unavailability in Croatia. During this period it is necessary to pay adequate attention to the data safety.

Keywords

geomagnetic models, geomagnetic information, data dissemination, data safety

Introduction

After the end of 2nd renewal cycle of geomagnetic information in the Republic of Croatia – (Brkić & Pavasović, 2022) carried out for the State Geodetic Administration and the Ministry of Defense of the Republic of Croatia, arose the question of public availability and use of data on the Earth's magnetic field, especially the so-called geomagnetic information (declination and its annual variation). Although the use of geomagnetic information – GI is limited in defense matters nowadays (Rasson & Delipetrov, 2006; Brkić et al., 2020), it is still subject of cycles of measurements of the national territory with the aim of creating GI models and maps, since it reduces risks related to navigation and orientation (Brkić et al., 2017), and maintains this capability after after a possible (nuclear) electromagnetic pulse (Critical National Infrastructures, 2008). Required standard accuracy (6') of national GI models cannot yet be achieved by free and publicly available global models of the Earth's magnetic field such as Enhanced Magnetic Model EMM2017, International Geomagnetic Reference Field IGRF-13, or World Magnetic Model WMM2020 (Chulliat et al., 2020). On the other hand, producing national model is an independent way of securing the GI – a must for a sovereign state.

Since there is a legitimate right of the academic or scientific community and the public in general to use geomagnetic data, the sovereign is required to resolve the issue of data availability without aiding the hidden threat. The Rulebook on basic geodetic works (Official Gazette, 2017), as well as the Rulebook on confidentiality of defense data (Official Gazette, 2018), does not have a suitable answer to that issue. Regardless of legislation, geomagnetic data in the world are *de facto* unavailable only for a limited time, spanning from a few years in Western countries to a decades in Eastern ones. In some countries, geomagnetic data is not publicly available at all (seek for examples in British Geological Survey). The purpose of the paper is thus to motivate and offer a principle for solving a potential security issue in context of state of Croatia.

Reliability period of geomagnetic information

By geomagnetic data let us consider all processed and analyzed data of geomagnetic survey of the Croatian Geomagnetic Repeat Stations Network (Brkić et al., 2013), assuming the conditions of the Geomagnetic Survey Protocol were met: the disturbance index of the Earth's magnetic field K or Kp < 3, the absence of civilization noises, ground anomalies, etc. (Chulliat et al., 2020). Such a data reduced to a certain reference epoch, the middle or beginning of the year, determine the declination, while the annual change of declination is derived from the reduced declinations of successive epochs and modelled into normal annual variation model (Brkić & Pavasović, 2022). Such a geomagnetic information could be found on geomagnetic models or topographic maps. Since the annual variation of the Earth's magnetic field is by its very nature unpredictable, therefore models and maps need to be periodically updated (see e.g. Brkić et al., 2013, and the references therein).

The reliability of the original geomagnetic information for the epoch of publication of a GI model or the reliability of the GI model, determines |errD| or the absolute difference of the declination predicted by the GI from the actual or measured declination. Due to the unpredictable change in declination, GI reliability decreases over time, so renewed GI models are valid or reliable (within a given standard accuracy of 6') for about three years. The increase of unreliability in time is monthly monitored (Brkić, 2019) by comparison of the GI model declinations to quiet days (Matzka et al., 2021) measurements at the observatory.

By monitoring the actual GI2022 model (based on latest network surveys in 2018 and 2021) in relation to LONjsko Polje observatory, the monthly maximal absolute unreliabilities max|errD| were determined and ploted in Figure 1. In April 2023, max|errD| for the GI2022 model was around 1.9', and it can be expected that its reliability will reach the standard error (6') in the next year at the earliest (see Figure 1). Thus the suggested period of unavailability of the actual geomagnetic information in that case would be about 2.8 years from the last reduced survey (epoch 2021.5).

The behaviour of unreliability is rather nonlinear (Brkić et al., 2013) so one can expect predictions in between faster exponential and slower linear trends; how these functions fit the data will only become clear after the end of monitoring. According to the latest (May 2023) predictions, the reliability of the GI2022 model will become 9′ and equal the reliability of the best available Enhanced Magnetic Model EMM2017 for the territory of the Republic of Croatia around August 2024. Therefore, the period of GI reliability or GI unavailability period should be defined as the period of time required for the reliability of the GI (model) to drop to the reliability of the best model at the repeat stations or obsevatory. This is currently 9′ for the EMM2017, so the suggested period of unavailability of geomagnetic information would be about 3.2 years from epoch 2021.5.

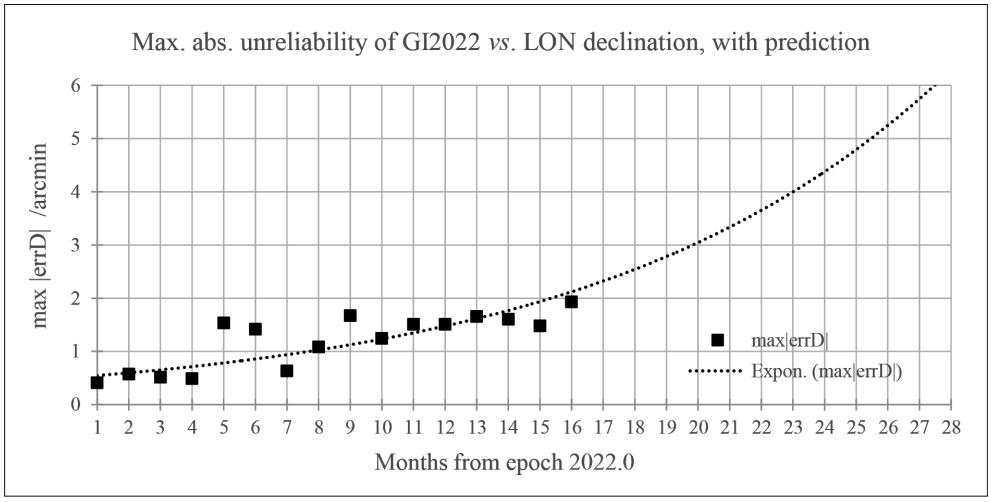

Figure 1. Max. abs. unreliability of GI2022 *vs*. LON declination, with prediction.

The principle can be applied to the other two global publicly available models, IGRF-13 or WMM2020, which are of comparable reliability of about 15′ at the territory of Croatia. Current GI reliability will deteriorate to that limit around 2025.0. If only those models were available, the period of unavailability will amount to approximately 3.7 years from epoch 2021.5. Note that the each inclusion of new monthly data slightly changes the coefficients in exponential

fitting function, affecting more the far away predictions; this means that a lower limits (6′ or 9′) are expected to be reached in about 3 years from epoch 2021.5. However, the GI renewal should be based not only on predictions but firstly on regular monitoring of model unreliability (Brkić, 2019).

These considerations refer to the INTERMAGNET's LON observatory, and it is assumed that the same essentially applies to the entire geomagnetic repeat stations network of Croatia. For a more trustworthy assessment, it is desirable to establish more (at least temporary) observatories or variometer stations near the borders of the national territory. Other reasons for the establishment of the second Croatian geomagnetic observatory can be found in the aforementioned papers.

Cnclusion

The unavailability of geomagnetic information is justified if it can provide an advantage in situations of (potential) threat. However, after some period of time the geomagnetic information should be available to the public. Geomagnetic information may become publicly available only when its reliability drops to that of the currently best publicly available global model. In practice, the reliability limits can be set, for example, to 6′, 9′ or 15′, corresponding to GI (model) reliability periods, i.e. GI unavailability periods of about 2.8, 3.2 or 3.7 years. These periods are more or less realistic predictions; reliability should be monitored monthly up to the limit set. Anyway specified reliability limits provide periods comparable to the Western geomagnetic data availability periods. At a times when war is in the neighborhood and can spill over into the Croatian national territory, it is justified to set a reliability limit at least to 9′. Only in peace, or in the absence of the probability of war, it is reasonable to relax the limit to 6′. Accordingly, it is proposed to adjust (rise) the degree of secrecy of the geomagnetic information, and to remove the degree completely after the expiry of the reliability period, whenever the monitoring will impose it. Note that the issue of public availability loses its meaning if the preservation and access to geomagnetic information, as well as appropriate legislation and supervision, are not properly resolved as well.

References

British Geological Survey. Available from: http://www.geomag.bgs.ac.uk/ [Accessed 2nd May 2023].

Brkić, M. (2019) Monitoring Geomagnetic Information in the Territory of Croatia (Praćenje geomagnetske informacije na teritoriju Hrvatske). *Geofizika*. 36 (1), 1-15.

Brkić, M. & Pavasović, M. (2022) *III. ciklus obnove geomagnetske informacije RH – 1. faza;* Project of the 3rd Geomagnetic Information Renewal Cycle in the Republic of Croatia – 1st phase – Technical report of the Geodetic Faculty of the University of Zagreb for the State Geodetic Administration and the Ministry of Defense of the Republic of Croatia, Zagreb. (In Croatian).

Brkić, M., Varga, M., Grgić, M., Radović, N. & Bašić, T. (2020) Model of the working compass correction for year of 2020. *Strategos.* 4(1), 7-29. (In Croatian).

Brkić, M. (ed.), Vujić, E., Šugar, D., Jungwirth, E., Markovinović, D., Rezo, M., Pavasović, M., Bjelotomić, O., Šljivarić, M., Varga, M. & Poslončec-Petrić, V. (2013) *Osnovna geomagnetska mreža Republike Hrvatske 2004. – 2012. s kartama geomagnetskog polja za epohu 2009.5* (Basic geomagnetic network of the Republic of Croatia 2004 – 2012, with maps of the geomagnetic field for the epoch 2009.5). Zagreb, State Geodetic Administration. (In Croatian).

Brkić, M., Vujić, E., Radović, N., Matika, D., Bašić, T. (2017) Geomagnetic Information Risk Revisited: a case study of Croatia. *CODATA-Germany Lecture Notes in Information Sciences Vol. 8, Risk Information Management, Risk Models and Applications, Selected Papers*, Kremers, H., Susini, A. (ed.). 31-38.

Chulliat, A., Brown, W., Alken, P., Beggan, C., Nair, M., Cox, G., Woods, A., Macmillan, S., Meyer, B. & Paniccia, M. (2020). *The US/UK World Magnetic Model for 2020–2025: Technical Report*. National Centers for Environmental Information, NOAA.

Critical National Infrastructures, *Report of the Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack* (2008). Available from: https://apps.dtic.mil/sti/pdfs/ADA484672.pdf [Accessed 2nd May 2023].

Enhanced Magnetic Model (2017), National Oceanographic and Atmospheric Administration. Available from: https://www.ngdc.noaa.gov/geomag/EMM/ [Accessed 2nd May 2023].

INTERMAGNET – the global network of magnetic observatories monitoring the Earth's magnetic field. Available from: https://intermagnet.github.io/ [Accessed 2nd May 2023].

International Geomagnetic Reference Field, International Association of Geomagnetism and Aeronomy (IAGA). Available from: https://www.ngdc.noaa.gov/IAGA/vmod/igrf.html [Accessed 2nd May 2023].

Matzka, J., Bronkalla, O., Tornow, K., Elger, K. & Stolle, C. (2021) *Geomagnetic Kp index*. V. 1.0. GFZ Data Services. Available from: https://doi.org/10.5880/Kp.0001 [Accessed 2nd May 2023].

Matzka, J., Stolle, C., Yamazaki, Y., Bronkalla, O. & Morschhauser, A. (2021a) The geomagnetic Kp index and derived indices of geomagnetic activity. *Space Weather.* Available from: https://doi.org/10.1029/2020SW002641[Accessed 2nd May 2023].

Official Gazette, Rulebook on basic geodetic works, NN 112/2017. Available from: https://narodne-novine.nn.hr/clanci/sluzbeni/2017_11_112_2627.html [Accessed 2nd May 2023].

Official Gazette, Rulebook on confidentiality of defense data. NN 67/2018. Available from: https://narodne-novine.nn.hr/clanci/sluzbeni/full/2018_07_67_1379.html [Accessed 2nd May 2023].

Rasson, J. L. & Delipetrov, T. (eds.) (2006) *Geomagnetics for Aeronautical Safety: A Case Study in and around the Balkans*. Dordrecht, Springer.

World Magnetic Model WMM2020. Available from: https://www.ngdc.noaa.gov/geomag/WMM/ [Accessed 2nd May 2023].

About the author

Full Professor MARIO BRKIĆ, PhD (mario.brkic@geof.unizg.hr) is Head of Chair for Mathematics and Physics at the Faculty of Geodesy of University of Zagreb, Kačićeva 26, HR 10000 Zagreb, Croatia. As a full professor he holds physics and geomagnetism classes. He has been leading geomagnetic information renewal projects for the Croatian MoD and State Geodetic Administration as well as Ministry of Science since 2002.

Dostupnost geomagnetske informacije

Sažetak

Pitanje javne dostupnosti podataka o Zemljinom magnetskom polju u Hrvatskoj nije odgovarajuće riješeno. Rad predstavlja prijedlog kojim se geomagnetska informacija proglašava javno raspoloživom tek kada njena pouzdanost padne na onu od trenutno najboljih javno dostupnih globalnih geomagnetskih modela. Uz takav kriterij, praćenje i predikcija nepouzdanosti aktualnog modela geomagnetske informacije GI2022 sugerira razdoblje pouzdanosti izvorne geomagnetske informacije od najmanje tri godine od epohe redukcije posljednje izmjere nacionalne geomagnetske mreže. Jednako bi tako trebalo biti razdoblje nedostupnosti geomagnetske informacije u hrvatskoj javnosti. Naravno, tijekom tog razdoblja nužno je posvetiti prikladnu pozornost sigurnosti samih podataka.

Ključne riječi

geomagnetski modeli, geomagnetska informacija, diseminacija podataka, sigurnost podataka