Report of the Scientific Council of the Bureau Central de Magnétisme Terrestre

July 17, 2023

Significant Applications: The Scientific Council (SC) of the Bureau Central de Magnétisme Terrestre (BCMT) recognizes the extremely high importance of the ground-based geomagnetic service provided by the BCMT. This SC understands that BCMT data are used in the study and evaluation of numerous geophysical subjects, including the Earth's deep interior and lithosphere; ocean currents; the ionosphere and magnetosphere; and solar-terrestrial interaction, as well as the broad utility of observatory data for individuals and agencies across the academic, commercial, and governmental sectors, including for the pursuit of fundamental scientific understanding, geomagnetic mapping and geophysical modeling, natural resource assessment and development, and space-weather monitoring and the assessment of related geomagnetic hazards. These are subjects of importance to the nation of France and the international scientific community.

Commendations: • The SC commends the staff in the magnetic services of both the Institut de Physique du Globe de Paris (IPGP) and the École et Observatoire des Sciences de la Terre (EOST) for their devotion to fulfilling the mission of the BCMT. • The SC commends the BCMT for its operation of magnetic observatories with broad geographic distribution and under a wide range of climatic and logistic conditions. • The SC commends the BCMT for its operation of magnetic observatories for long durations of time and with high levels of temporal continuity. • The SC commends on-going cooperation between IPGP and EOST in support of BCMT observatories, data, and services.

Funding: • The SC thanks the INSU for the ongoing support of the BCMT. • The SC thanks IPGP for support of the BCMT and ongoing support for observatories (CLF, DLT, EDA, IPM, KOU, LZH, MBO/SOK, PHU, PPT, TAM). • The SC thanks EOST for support of the BCMT and ongoing support for observatories (AMS, CZT, DMC, DRV, PAF, TAN). • The SC thanks the Centre National d'Etudes Spatiales (CNES) for ongoing support (the KOU observatory). • The SC thanks the Institut Polaire Français Paul-Emile Victor (IPEV) for support of the southern Indian Ocean observatories (AMS, CZT, PAF) and Antarctic observatories (DMC, DRV). • The SC thanks the Institut de Recherche pour le Développement (IRD) for their help towards setting up the new observatory in Senegal (SOK).

Meeting: The executive leadership of the BCMT, Vincent Lesur (IPGP) and Aude Chambodut (EOST) provided the SC with a strategic plan for 2024-2028. They hosted an SC meeting at the IPGP on June 16, 2023 where presentations were given. Presentations were given by Lesur and Chambodut, as well as by Pierdavide Coïsson, Benoit Heumez, Virginie Maury, and Abdelkader

Telali (each of IPGP, Chambon-la-Forêt). Additional BCMT members present included Armelle Bernard (EOST), Jean-Pascal Rivierre (IPGP), and Ingo Wardinski (EOST). Invited guests included Gautier Hulot (IPGP), Frédéric Tournier (IPGP), and Jérôme Vergne (EOST). Marc Chaussidon, director of the BCMT and IPGP, and Jérôme Vergne, deputy director for EOST observatories (representative of EOST director Jean-François Girard), were present at the meeting as members of the BCMT Management Committee.The SC developed this report and provided it to the BCMT after the meeting.

Narrative of Important Findings: The SC recognizes several present challenges that must be addressed before any new expansion or augmentation of BCMT services can be seriously contemplated.

Data are not being reported in near-real-time from several of the observatories. Several observatories are experiencing magnetic interference, or they are being relocated, or they are inadequately served by local observers -- as a result, some real-time data feeds (when they are available) are of reduced fidelity, and some processed data products are either being reported with considerable delay or they cannot be reported at all because no absolute measurements are being made. These shortcomings mean that several BCMT observatories are not meeting the operational standards of INTERMAGNET. In this context, the SC urges greater cooperation between BCMT and observatory-local authorities.

Simultaneously, the BCMT is facing new expectations and mandates from the European Plate Observing System (EPOS) and DATA-TERRA regarding observatory operations and the processing, management, and dissemination of observatory data. Generally, the data-related responsibilities of the BCMT data need to be streamlined and modernized.

For the IPGP, the SC perceives that, with proper prioritization, staffing and resources are sufficient to address these challenges (in one way or another). However, the SC recognizes a much more concerning problem for the EOST magnetic observatory service -- staffing levels are simply inadequate. This problem was identified in the 2016, 2018, and 2021 SC reports, and it remains a problem to this day. It must be addressed with as much immediacy as practically possible. The SC urges authorities of the Institut National des Sciences de l'Univers (INSU) and/or Strasbourg University to ensure an increase in staffing for the EOST magnetic observatory service: a 100% full-time electronic engineer and a 100% information technology engineer. Without these hires, the SC would be concerned about the long-term future viability of the EOST observatory program and its data services.

Regarding long-term priorities for the BCMT, in its 2018 report, the SC advocated for standardization in data acquisition systems and in data processing software and procedures among all BCMT observatories. The intent, then, was to find efficiencies that would result in reduced burden for BCMT staff, especially for the inadequately staffed EOST magnetic observatory service. The SC notes that very little progress has been made on this priority, possibly due to understaffing in the EOST magnetic observatory service. Once EOST is provided with adequate staff, and after immediate issues are addressed in EOST operations, the observatory services of EOST and IPGP should be able to devote attention to this issue and aim for showing progress in affecting standardization by the time of the next SC meeting.

Specific Comments on the Strategic Plan: In the experience of the SC, strategic plans for national scientific projects often cite contextual documents under which they operate. For example, if the IPGP, or EOST or their mother institutes themselves have strategic plans, then those higher-level plans should be cited in the BCMT strategic plan. The SC asks if the work of the BCMT is authorized or mandated by legal regulations or laws. If so, then those regulations and laws should be cited in the BCMT strategic plan.

The SC notes that the strategic plan emphasizes two scientific domains of application for magnetic observatory data: the Earth's core and space weather. And yet the SC notes in the statement of Significant Applications, given above in this report, that observatory data have many applications. This fact is supported by the considerable downloading of data from the BCMT platform, and might be appropriately represented in the strategic plan.

List of Specific Findings (referenced to the strategic plan):

6.1.1 Observational infrastructure over mainland France: The magnetic interference identified by the IPGP at the Chambon-la-Forêt (CLF) observatory as being caused by electrified train systems is intermittent, mostly confined to periods shorter than about 5 minutes, and of low amplitude. The SC knows that, with INTERMAGNET emphasis on the acquisition of 1-second data, many observatories are now identifying previously unknown noise. O1.1: The SC is skeptical about modelling projects that might be intended to report "clean" geomagnetic time series obtained through modelling of multiple magnetometer time series acquired at various sites in the region of CLF. The SC is uncertain that the benefits of such a project justify the significant effort to fully identify and remove the noise. The SC suggests that such projects be pursued with low priority. O1.2: The SC supports the reporting of less-noisy unprocessed data from a separate site within France. O1.3: The SC is of the opinion that repeat surveys across France can be discontinued with minimal impact to the scientific community. The SC is generally supportive of operating variometers across France in place of the repeat survey. The

SC is also supportive of suggestions to make absolute measurements at these stations during maintenance visits. As points of information, the U.S. Geological Survey (USGS) no longer performs repeat surveys, but it does operate numerous variometer stations across the United States and around the world. This latter accomplishment relies on a collaboration between the USGS Geomagnetism Program and the USGS Global Seismic Network -- the variometer data can be used to remove geomagnetic interference in seismic time series. The collaboration results in much improved geomagnetic monitoring, while saving labor and money. Perhaps a similar collaboration could be explored between BCMT and either GEOSCOPE or the Réseau sismologique et géodésique français.

6.1.2 Integration of observatories to INTERMAGNET O2.1, O2.2, O2.3, O2.4, O2.5: The SC supports all five objectives regarding observatory operations and the production of raw and processed data in accordance with INTERMAGNET standards as consistent with this report's Narrative of Important Findings and the high priority that must be assigned to improving and maintaining the operation of observatories. The SC is very concerned that several BCMT observatories are experiencing magnetic interference and are insufficiently supported by observatory-local authorities for regular maintenance and regular absolute measurements (AMS, DMC/Concordia, EDA, FIH, IPM). The SC urges the local partners and authorities to discuss proposed developments in the vicinity of observatories with the BCMT prior to their implementation. The SC furthermore urges cooperation between local agencies and the BCMT regarding observatory operations and absolute measurements. The SC appreciates that addressing these issues, including engaging with local support personnel, takes BCMT staff time, and this is one of the reasons why the SC advocates for increased staffing at EOST in this report's Narrative of Important Findings.

6.2.1 BCMT data repository improvements and 6.2.2 IPGP data processing & managing software D0.1, D0.2, D0.3 (added in meeting presentation), D1.1, D1.2: The SC supports these objectives regarding data management as consistent with this report's Narrative of Important Findings and the high priority that must be assigned to observatory data services. The SC urges that IPGP and EOST implement common data processing software and procedures. The SC asks if there are opportunities for exploiting data-related practices already in place in other (non-geomagnetic) projects within the IPGP and EOST. The SC notes that mandates for implementing and maintaining data infrastructure for EPOS and DATA-TERRA will require time from the information technology engineer that, per the Narrative of Important Findings, needs to be hired for the EOST magnetic observatory service.

6.2.3 Digitise old magnetic records D2.1, D2.2, D2.3, D2.4: The SC recognizes the uniqueness of historical paper magnetograms and paper metadata. The SC also recognizes the following facts:

(1) Converting analog records to digital form can be labor-intensive. (2) Hourly values are already available for Saint-Maur, Val Joyeux, and Chambon-la-Forêt, Bangui, M'bour, and Papeete from World Data Centers (WDC). (3) Per the Kyoto data catalog, many (though not all) related records are already preserved in film at the WDC. (4) The British Geological Survey (BGS) has photographed many (if not all) of their analog records. (5) It is important to avoid duplication. So, for example, there is no need to develop new digitizing methods, equipment, and software if adequate capacities already exist. (6) Work, here, should proceed according to a well-developed plan.

The SC holds the following priorities (from high to somewhat lower) for these records: (1) Paper records should be preserved in safe conditions. (2) Consult with the WDC to establish the status of related film records. The SC believes that the WDC film records might not be readily accessible. This should be checked. (3) Develop a catalog of all records (magnetograms and metadata), down to the nearest month. This should be obtained posted on the BCMT website so that interested researchers are aware of what exists. (4) Consult with other projects for preserving historical records, including within IPGP, EOST, the University of Paris-Cité, Bibliothèque Nationale de France, and the BGS.

The SC further emphasizes that work on this project should not subtract from the priorities set out in this report's Narrative of Important Findings.

6.2.4 Distribution of indices and other data products D3.1, D3.2: The SC supports these objectives regarding indices and data products as consistent with this report's Narrative of Important Findings and the high priority that must be assigned to observatory data services.

6.3.1 Build, test and put in production new digital vector instruments I1.1: The SC supports this objective regarding magnetometers as consistent with this report's Narrative of Important Findings and the high priority that must be assigned to improving and maintaining the operation of observatories.

6.3.2 Develop a new scalar absolute instrument I2.1: The SC supports this objective regarding magnetometers as consistent with this report's Narrative of Important Findings and the high priority that must be assigned to improving and maintaining the operation of observatories. But regarding I2.2 and the development of new instruments, the SC emphasizes that work on this project should not subtract from the priorities set out in this report's Narrative of Important Findings.

6.3.3 Develop an instrumentation to acquire data at 1 kHz sampling rate I3.1: The SC asks why a new instrument of this type needs to be "developed" when search coils are simple instruments that can be readily purchased from commercial vendors. The SC emphasizes that work on this project should not subtract from the priorities set out in this report's Narrative of Important Findings.

Specific Recommendations:

(1) Increasing the BCMT staff for the EOST magnetic observatory service:
The BCMT, being concerned about the delays in definitive data reporting from the EOST operated observatories and potential degradation of the EOST observatory network due to a severe understaffing, strongly urges the relevant funding agencies to enable EOST to hire a 100% full-time electronic engineer and to increase staffing for an information technology engineer to 100%.

(2) Protection of observatories, in particular the remote ones, from cultural noise
The BCMT SC, being concerned about increasing threats from anthropogenic noise to magnetic observatories in general, and in particular to the stations located in the French austral territories, urges the BCMT, local partners and authorities to make every effort to ensure a magnetically quiet environment and avoid any electromagnetic disturbances to the magnetic measurement infrastructure. Natural geomagnetic variations are small compared to many technical signals (see IAGA Guide for Magnetic Observatory Measurements and Practice, Jankowski and Sucksdorff, IAGA, Warsaw 1996). Protected zones of at least 100 m radius where man-made activities are not permitted around the magnetometers are ideal. If that is not possible, the SC urges the local partners and authorities to discuss any planned development close to the magnetometers with BCMT well in advance in order to find a solution that avoids technical disturbances to the geomagnetic observations.

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