BUREAU CENTRAL DE MAGNÉTISME TERRESTRE
France

Bureau Central de Magnétisme Terrestre

Report of the Scientific Council Meeting

held on 6 April 2009

Foreword

This document is the report of the first meeting of the Scientific Council of the Bureau Central de Magnétisme Terrestre (BCMT) held on 6 April 2009 at the Institut de Physique du Globe de Paris. The Council is the main advisory body to the BCMT.

The Scientific Council has provided a list of findings and recommendations for the consideration of the Director, BCMT, based on its deliberations on the evidence of BCMT activities and plans provided by staff of the BCMT component institutes. The scope of the findings and recommendations is defined by the Terms of Reference under which the Scientific Council operates.

David Kerridge
Chair, BMCT Scientific Council
20 May 2009

Membership of the BCMT Scientific Council

Jacques Hinderer	EOST
Gauthier Hulot	IPGP
Andrew Jackson	ETH Zürich
Dominique Jault	LGIT
David Kerridge	BGS
Stefan Maus	CIRES / University of Colorado / NOAA
Christophe Sotin	JPL
Erwan Thébault	IPGP
Susanne Vennerstrøm	DTU Space

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Executive Summary

The first meeting of the Scientific Council of the Bureau Central de Magnétisme Terrestre (BCMT) took place at the Institut de Physique du Globe de Paris on 6 April 2009. Following discussion of the evidence provided in a series of presentations on the work of the BCMT, the Council produced a set of findings and recommendations. The principal findings and recommendations are listed below. (The number in parentheses after each item gives its position in the complete list of findings and recommendations appearing in Sections 3.1-3.7.)

1. The Scientific Council **congratulates** the BCMT on establishing a network of 16 observatories widely distributed around the globe, all of which operate to INTERMAGNET standards. The Council recognises that many of the observatories run by the BCMT are operating in challenging locations (for combinations of logistical, environmental and political reasons). The observatories occupy important positions, generally distant from other observatories, and are of high value for scientific research purposes. (12)
2. The Scientific Council recognises that the BCMT observatories produce and promptly publish data of excellent quality, and **commends** the staff of the BCMT component institutes who have demonstrated great commitment and dedication in working to achieve high standards. (13)
3. The Scientific Council **affirms** the continuing importance of magnetic observatories in the satellite era and the complementary nature of ground- and space-based data in addressing important scientific questions. (5)
4. The Scientific Council **affirms** the importance of magnetic observatories in providing data needed for the generation of data products such as magnetic activity indices and global geomagnetic field models. Such data products are used widely in scientific research and are applied in a variety of ways to bring benefits to society. (6)
5. The Scientific Council **welcomes** the recognition by the staff of the BCMT of the need for magnetic observatories to deliver quality-controlled data in a timely manner to facilitate integration with data from the Swarm satellite mission and **strongly supports** the plans to publish quasi-definitive data within about one month of observation. The combination of satellite and observatory data is likely to lead to new scientific results. (21)
6. The Scientific Council recognises that increasing the time resolution of observatory data to one second will widen the take-up of data by the space physics research community and that near real time delivery will promote the use of observatory data for both research and applications. Accordingly, the Scientific Council **strongly supports** the plans to record data at one-second resolution and to deliver the data in near real time, guided by the standards defined by INTERMAGNET. (22)
7. The Scientific Council **recommends** that the three BCMT component institutes develop a joint approach to developments in, for instance, instruments, data acquisition systems, and software for data processing and data management. (Such cooperation may already exist, but the evidence for it was not apparent to the Council.) (18)
8. The Scientific Council recognises an impending staffing crisis at IPGP and **strongly supports** the case made for recruitment into the posts that are about to become vacant through staff retirements and transfers. The Director, BCMT is **urged** to take steps to ensure that replacement staff are appointed in good time, preferably allowing for training of new staff by the departing members of staff. (33)
9. The Scientific Council believes that failing to act on the recommendations on staffing at the BCMT component institutes will put a strong national competence at risk. The Council **strongly recommends** that the matter is addressed urgently, as loss of expertise will threaten the quality of BCMT data and reduce the ability of BCMT staff to play an active and influential part in international organizations and projects such as IAGA and INTERMAGNET. (35)

1. Introduction

The Scientific Council of the Bureau Central de Magnétisme Terrestre (BCMT) was established in April 2009 by the Director, BCMT, Prof Vincent Courtillot who invited nine scientists to become members. The Council's inaugural meeting took place at the Institut de Physique du Globe de Paris (IPGP) on 6 April 2009.

The meeting consisted of a series of presentations in open session given by BCMT staff and by members of the Scientific Council, and two private sessions for the Council to meet and deliberate. During the first private session of the Council the members elected David Kerridge as Chair and Erwan Thébault as Secretary.

Summaries of the presentations describing the BCMT component institutes' activities and plans, and on more general aspects of geomagnetism, are given in Section 2. The findings and recommendations of the Scientific Council appear in Section 3. The meeting Agenda is given in Appendix A. The membership of the Council is listed in Appendix B, along with the names of the members of the BCMT Management Committee and other guests who attended the meeting. The Terms of Reference for the Scientific Council, provided by Prof Courtillot, are given in Appendix C. The decree establishing the BCMT, dated 28 July 1921, is reproduced in Appendix D. Appendix E lists the acronyms used in this report of the meeting.

2. Meeting Report

2.1 Introductory remarks

The meeting was opened by Prof Courtillot who described the history of the Institut de Physique du Globe de Paris (IPGP) since its establishment in 1921, the organizational mission, and the current staffing and funding arrangements. He outlined the relationship and responsibilities of IPGP to the Ministry of Education and to the Centre National de la Recherche Scientifique (CNRS), through the Institut National des Sciences de l'Univers (INSU). Prof Courtillot explained that the BCMT was also created in 1921 and placed under the custodianship of IPGP.

Prof Courtillot stressed the high importance given to observatory operations within IPGP; the Director, IPGP, is formally head of observatory operations and this responsibility is not delegated. He also stated that an important and long-established tenet of the IPGP philosophy is to maintain strong coupling between observatory practice, research and training.

Dr Denis Hatzfeld described the interests of INSU in observatories covering many scientific fields, which are grouped within the INSU structure as OSU (Observatoires des Sciences de l'Univers). He also noted the importance of linking observational science to research, and remarked on the challenges presented by rapidly increasing volumes of data in some areas of science. Dr Hatzfeld said that the BCMT has the status of an INSU committee.

Information on BCMT operations and ideas on various aspects of magnetic observations were then provided to the Scientific Council by means of a series of oral reports.

2.2 The IPGP magnetic observatories

Dr Arnaud Chulliat described the IPGP contribution to the BCMT network and recent advances in installing new observatories. He noted that connecting the records from the Parc Saint-Maur (1883), Val Joyeux (1901-1935) and Chambon-la-Forêt observatories provided an uninterrupted data series from 1883. A project to digitise the hourly mean values from the three observatories had been completed in 2008.

Chambon-la-Forêt is the current national magnetic observatory and in addition to the data it provides on the geomagnetic field it offers facilities used by industry and space agencies including a non-magnetic room and calibration coils. Dr Chulliat also described the French magnetic repeat station network, plans to redesign the network around sites at airports, and the uses to which the repeat station data are put.

Dr Chulliat showed a map of the magnetic observatories participating in the INTERMAGNET programme (107 observatories in 38 countries in 2007), noting that 16 of them were observatories supported by IPGP and the other BCMT component institutes. He said the general IPGP model for the eight observatories it currently supports overseas is a collaboration agreement with a local organization: IPGP supplies instrumentation and carries out data processing, where necessary; the local organization is responsible for housing and maintaining the equipment and performing absolute observations. Dr Chulliat described the (well advanced) plans to extend the BCMT network through installation of new observatories on Easter Island and at Dalat, Vietnam. He suggested that once these two new observatories were up and running IPGP should not pursue further installations for the foreseeable future.

(INTERMAGNET is the International Real-time Magnetic Observatory Network programme helping to define operating standards for modern magnetic observatories and coordinating the activities of its member institutes and their observatories.)

Dr Chulliat provided statistics on the use of data from the BCMT magnetic observatories showing that hundreds to thousands of data requests are received every month. This is evidence of the relevance and value of the current network for both scientific and civil purposes. Data distribution policy follows INTERMAGNET recommendations.

Referring to a statement from the Swarm Mission Advisory Group regarding the desirability of rapid access to baseline corrected data from magnetic observatories, Dr Chulliat outlined work being carried out to define methods to produce quasi-definitive data quickly (within about a month of recording). The aim was to have this facility included in a computer program called the MAGnetic observatories Information System (MAGIS).

Dr Chulliat described instrument developments. The fluxgate magnetometer installed at the IPGP-supported observatories (model VM 391) has been developed over a number of years by IPGP in collaboration with industry. A new in-house project is underway to develop a scalar helium magnetometer, and tests are to continue on a vector helium magnetometer built by CEA-LETI. In a further project, the technical requirements for data acquisition at one sample per second, based on the results of a user survey carried out by INTERMAGNET, are guiding developments of the VM 391 fluxgate magnetometer and the EN03 data logger.

In discussing resources applied to magnetic observatory operations Dr Chulliat outlined the budgets provided by the different contributing organizations for observatory maintenance and developments and drew particular attention to staffing issues. Two members of the engineering and technical staff (there are currently a total of six at IPGP working in support of magnetic observatories) will retire in the near future, another is leaving, and only one replacement post has been agreed. This raises questions about the possible impacts on data quality due to the loss of experience and expertise, and the maintenance of the Paris INTERMAGNET GIN (Geomagnetic Information Node).

2.3 The EOST magnetic observatories

Dr Jean-Jacques Schott reported on the six magnetic observatories operated by the Ecole et Observatoire des Sciences de la Terre, Strasbourg (EOST), in Madagascar (Antananarivo) the Southern Indian Ocean (Amsterdam Island, Crozet, and Port au Français) and Antarctica (Dumont d'Urville and Dome C). This network is a major contribution to INTERMAGNET in the southern hemisphere. The three-component vector instruments deployed at the observatories were described. In four cases the instrument is a fluxgate magnetometer developed by Thomson; at two sites a suspended magnetometer manufactured by the Danish Meteorological Institute is in operation.

Dr Schott described the logistical arrangements for supporting the observatories and the roles of the members of the EOST staff involved. He showed that financial support for the operations had been received from seven funding streams from 2004-2008 and that increasing support in recent years from BCMT and INSU had corrected, to some extent, what was otherwise a downwards trend. The greatest financial contributor was the Institut Polaire Français, Paul-Emile Victor (IPEV). Dr Schott said that two members of staff would retire in the near future and that this was a matter of serious concern.

The various means of data transmission from the EOST observatories and the procedures for data processing were described. Statistics on data requests made to INTERMAGNET were presented to illustrate the usage of the observatory data. Data plots showed some of the geomagnetic field behaviour observed at the EOST observatories, and baseline plots illustrated the quality control procedures.

Dr Schott concluded by describing future plans. These include upgrades to instrumentation and data acquisition systems to enable one-second data samples to be gathered to the standards recommended by INTERMAGNET, and the provision of quasi-definitive data on a monthly basis to support the Swarm mission.

2.4 The IRD magnetic observatories

Dr Remy Louat discussed the challenges of maintaining the IRD-supported magnetic observatories at M'Bour (Senegal) and Bangui (Central African Republic) in what can be politically unstable regions, while noting that Africa is an IRD priority region. He listed the major themes for IRD research and said that magnetic observatory operations fit most closely with the Natural Hazards and Climate theme. Dr Louat said that IRD membership of the BCMT provides motivation and rationale that is vital to the continuation of the IRD-supported observatories, and helps to ensure that they operate to international standards. He described recent investments made in improved data recording and instrumentation.

Dr Louat noted the association of the IRD site with the CTBTO operations in Bangui which would be a seismological alpha-station. He said it was regrettable that absolute observations were not currently being made in Bangui due to the reluctance of local staff. In contrast, the staff at M'Bour were showing excellent commitment and producing good results. Data records extending for more than 50 years from the two observatories were displayed. Dr Louat referred to efforts being made to digitise photographic records, noting that software had been developed by the IRD as part of the Soutien aux Projets InfoRmatiques dAns Les Equipes Scientifiques (SPIRALE) programme.

Dr Louat described plans to improve the African operations in 2009, while again noting the challenges in finding effective local support. He also outlined plans to install a new observatory in New Caledonia.

Dr Louat said that the IRD is being reorganized and, as a result, responsibility for magnetic observatory operations will be taken over by a new and larger management unit. He noted that because of the impeding retirements of Mr Gilbert Juste and himself, who between them currently have primary responsibility for the magnetic observatories, and the greatest depth of knowledge of the purpose and requirements for observatories, it would be useful to reaffirm the value of the observatory work carried out by IRD, as part of the BCMT, to the Director, IRD.

2.5 The International Service of Geomagnetic Indices

Prof Michel Menvielle presented the history of the International Service of Geomagnetic Indices (ISGI). He described ISGI as an academic research body, a federation of collaborating institutes (in France, Germany and Japan) responsible for the production of the various IAGA-sanctioned magnetic activity indices (*AE, am, aa, Kp* and *Dst*). He noted the importance of having a body responsible for the official version of indices to avoid the confusion that would be caused by users obtaining different versions from different organizations. The ISGI Bureau, which coordinates the work of the contributing institutes, has its headquarters in France at the Laboratoire Atmosphères, Milieux, Observations Spatiales (LATMOS). (The headquarters were at the Centre d'Etude des Environnements Terrestre et Planétaires (CETP) until the end of 2008).

Prof Menvielle described the various magnetic activity indices produced by ISGI and the electrical current systems in the ionosphere/magnetosphere they attempt to characterize. He stressed that the derivation of the indices relies on data from ground-based magnetic observatories. There is a demand for rapid on-line access to quick-look indices for various purposes, and it is a challenge to provide 24-hour/7-day service. The ability to do so naturally depends on the rapid availability of data from the contributing magnetic observatories.

Currently, ISGI has no means to count the number of users of the indices or to track the applications they are used for.

Activities carried out by the Bureau in 2005-2008 were described, including web developments, involvement in international projects and committees (including the ESA Space Weather European Network, SWENET), new scientific applications (the example of thermospheric forcing was described in some detail) and ideas for the development of new indices.

The ISGI Bureau runs with an editor/webmaster (25% full time), a computer engineer (15% full time) and the Director (15% full time). Financial support for ISGI is received from the International Council for Science (ICSU) via the Federation of Astronomical and Geophysical Data Analysis Services (FAGS), and, in France, CNES and CNRS/INSU make contributions. There is a potential difficulty arising from the recent reorganization of the institute that hosted the service until the end of 2008 (CETP) as the locations of the technical staff and the Director will now be split between two different organizations (LATMOS and the Laboratoire de Physique des Plasmas (LPP)).

2.6 The role of magnetic observatories in the satellite era

Dr Stefan Maus presented an overview of the role of magnetic observatories in the satellite era.

Dr Maus said that the primary distinction between observatory and satellite magnetic measurements is their different geographical and temporal coverage of the Earth. In 24 hours, a magnetic observatory rotates through all local times at a fixed geographical location. In contrast, polar-orbiting geomagnetic field survey satellites are more or less fixed in local time. In 24 hours a single satellite provides global geographical coverage of the Earth, but only in two local time sectors, one on the ascending and one on the descending part of its orbit. The different spatial and temporal sampling of the Earth by observatories and satellites constitutes a complementary aspect of the (combined) global geomagnetic measurement infrastructure.

To appreciate this complementary aspect, it is important to understand that geomagnetic field measurements are the sum of contributions from a number of very different sources. To separate, characterize and understand these various contributions is a fundamental challenge in geomagnetism. By providing a view from two different frames of reference, magnetic satellites and observatories play a complementary role in this endeavour. The contributions to the geomagnetic field are themselves organized in different reference frames: fields from sources internal to the Earth are naturally organized in an Earth-fixed frame; fields originating from electric currents in the upper atmosphere (ionosphere) and magnetosphere tend to be organized in a Sun-synchronous frame. Given only satellite data, it is difficult to separate temporal from spatial variations of the field. Magnetic observatories, on the other hand, lack the global coverage of satellite observations, but provide excellent temporal resolution. Ground observatories provide an important ‘bridging infrastructure’ during periods of time without magnetic satellite coverage. For example, they will be the most important source of geomagnetic observations after the end of the CHAMP mission (expected 2010) until the launch of Swarm (expected 2011).

For the upcoming Swarm satellite constellation mission, the French magnetic observatories will be an essential part of the ground-based infrastructure supporting the mission. The European Space Agency plans to establish a high-level scientific data processing facility, which will make use of observatory data in several of its scientific products. In particular, observatory data will complement the Swarm satellite observations in monitoring the magnetospheric field and its induced counterpart. This will in turn assist in the derivation of global 3D conductivity models of the mantle.

In his presentation, Dr Maus also made remarks on the role of observatories in other aspects of geomagnetism. Traditionally, observatories have been a major source of data on the main magnetic field originating from electrical currents in the Earth’s metallic core, and its slow changes with time, the secular variations. Main field models such as the International

Geomagnetic Reference Field (IGRF), widely used in navigation, have depended on observatory data. With the superior geographical coverage of satellite observations, the role of observatories has nowadays shifted towards providing a means of separating and correcting for external disturbances of the geomagnetic field. Present scientific models do not accurately represent all of the contributions to the geomagnetic field at the Earth's surface, leading to difficulties in estimating main field models using datasets including both satellite and observatory measurements. Extending geomagnetic field models to adequately represent both satellite and observatory measurements is an important topic of ongoing and future research.

Dr Maus said that the ability of observatories to resolve temporal changes is extremely valuable in monitoring ionospheric and magnetospheric currents and their induced counterparts in the solid Earth and the oceans. The vulnerability of modern spaced-based communication and navigation systems to ionospheric and magnetospheric disturbances drives the rapidly evolving field of 'Space Weather Prediction', creating a new and growing basic and applied science market for magnetic observatory data and data products. Magnetic observatory measurements can be delivered within minutes, while typical downlink times for low-orbiting satellites are of the order of hours.

Dr Maus illustrated his remarks with a specific example. Magnetic observatory measurements reveal not only the structure and strength of ionospheric currents, but also the electric fields that drive them. From a space-weather monitoring perspective, a key parameter is the day-side eastward electric field that drives the plasma fountain responsible for the equatorial ionospheric anomaly. The strength of this plasma fountain can be monitored by a pair of observatories, with one station situated within a few hundred kilometres of the magnetic equator and a second station at about a thousand kilometres to the north or south. The IRD observatories in Africa and two IPGP observatories in the equatorial region are well situated for this purpose.

In his summary, Dr Maus said that magnetic observatories are ideally suited to track temporal changes of the magnetic field, and noted that a number of observatories have valuable time series extending over more than a century. Real-time data availability makes magnetic observatory measurements particularly important for the emerging field of space weather prediction. Magnetic observatories will, therefore, continue to remain an essential component of the geomagnetic observational infrastructure, complementing satellites in many important ways.

2.7 The role of magnetic repeat stations in the satellite era

Erwan Thébault discussed the value of repeat station data in France during the satellite era. He showed that for the traditional purpose of deriving magnetic declination maps of the French territory with standard spatial resolution, repeat stations and satellite based main field models performed equally well. However, repeat station data are ground vector data covering the territory as homogeneously as possible and an advantage could be to develop a vector lithospheric field model working from the ground to satellite altitude.

A major difficulty is maintaining the stability of the network. Many stations have had to be moved in the past, and two of the stations used in the most recent survey will need to be replaced. Mr Xavier Lalanne made a proposal to improve on this situation noting that when stations are lost or abandoned, and then replaced, the measurements are not truly repeated. He suggested replacing lost repeat stations with new sites at the nearest airport. This could help secure the future of the repeat stations as the civil aviation sector is a major client for information on magnetic declination.

2.8 Societal benefits of magnetic observatory data

David Kerridge commented on applications of magnetic observatory data and the resulting benefits to society. He said that national observatories are part of a wider global observational infrastructure and the significance of this global contribution should not be overlooked. In a 1992 report of the Royal Society the term 'synoptic measurements' was used to describe observatory-type measurements. The term was defined as follows:

"Data acquired in a consistent fashion over a long period of time, generally at several sites, providing a general survey of conditions"

For many years, the value of long-term routine measurements were not well appreciated, but current concerns over global change have created a more sympathetic attitude (for example, the value of long-term ozone and carbon dioxide measurements is now well understood). The Royal Society report identified fundamental research, studies of global change, the potential for new discoveries and practical applications as benefits of the datasets resulting from making synoptic measurements.

Dr Kerridge used the example of the BGS magnetic observatory operations and the organization of environmental science in the UK to illustrate some points, and to stimulate thinking about parallels for the BCMT. BGS is part of the UK Natural Environment Research Council (NERC) which, in its 2007-2012 strategy organizes its science in seven themes. It is important for BGS to identify where magnetic observatories (and the subject of geomagnetism) contribute to the themes. Dr Kerridge listed the following NERC themes where some contribution is made: Climate system; Sustainable use of natural resources; Forecasting and mitigation of natural hazards; Earth system science; and Technologies. He also noted that the concept of 'National Capability' had been introduced and defined as:

"**National capability** enables the UK to deliver world-leading environmental science, support national strategic needs, and respond to emergencies. It includes the research and development activities which keeps this capability at the cutting-edge."

NERC provides support for environmental surveys and monitoring as part of National Capability. Geomagnetic observatory operations fall within this definition.

Dr Kerridge said that, more generally, there were a number of areas where magnetic observatory data and data products brought benefits to society. It is clear that the scientific research and education sectors are beneficiaries. In economic terms there are applications designed to generate wealth, or to prevent or reduce losses. More strategically, and especially in respect of knowledge of magnetic declination, there are applications bearing on the safety of individuals and on national security. Because of the global nature of geomagnetism there are opportunities to develop overseas links, as the BCMT has done very effectively, which can be viewed as an aspect of foreign policy.

Dr Kerridge said that judging the value of individual magnetic observatory operations is difficult because magnetic data are embedded in (often global) data products such as magnetic field models used for navigation (the IGRF and the World Magnetic Model (WMM) are examples) and the ISGI magnetic activity indices. He went on to describe some of the applied science that the BGS Geomagnetism Team has carried out. Directional drilling for oil in the North Sea has created a new opportunity for application of observatory data because the geomagnetic field is used as a directional reference for borehole surveys conducted as drilling progresses. To achieve the best accuracy, the magnetic reference values at a drilling site are constructed from a global core field model, local aeromagnetic or marine data, and near real time data from one or more observatories. This is a modern navigational application of geomagnetism.

Geomagnetic field variations measured at magnetic observatories monitor space weather conditions that pose hazards to technology in space and on the ground through various mechanisms. Dr Kerridge described the effects of Geomagnetically Induced Currents (GIC) on electricity distribution systems and outlined work carried out by BGS on the problem. He also referred to work carried out for the European Space Agency (ESA) on solar and geomagnetic activity forecasting applied to mission planning and to the management of low Earth orbit satellites.

In the discussion following the presentation, Arnaud Chulliat and Erwan Thébault commented on their recent contacts with the "Bureau d'enquête et d'analyses pour la sécurité de l'aviation civile" after an airplane incident due to a deficiency of a GPS instrument that indicated the wrong position (as a result of a 10° declination error). It is clear that compasses still remain an

important backup navigational tool for aircraft. Michel Menvielle said that GPS accuracy and correct functioning are very sensitive to ionospheric scintillations. To assess the severity of the problem at a particular time requires monitoring data, now-casting, and forecasting of rapid time variations of the geomagnetic field, all of which depend on (rapid) access to data from magnetic observatories.

3. Findings and Recommendations of the Scientific Council

During the meeting the Scientific Council met twice in closed session to discuss the information provided in the presentations and through the responses to questions. At the second closed session a preliminary set of findings and recommendations was drawn up and this formed the basis of the presentation made by David Kerridge at the meeting's final open session. Formally, this preliminary report was made to the BCMT Director, Prof Courtillot, who gave his immediate response. The findings and recommendations listed below have been extended and refined through discussion between members of the Council by electronic mail after the meeting.

3.1 General remarks

1. The Scientific Council **thanks** the representatives of the BCMT component institutes attending the meeting for the quality and clarity of the presentations made and their openness in discussions and in responding to questions.
2. The Scientific Council **endorses** the view expressed by the BCMT Director that magnetic observatory operations and research should be closely integrated.
3. The Scientific Council **affirms** the continuing importance of magnetic observatories in making long-term, high-quality, continuous magnetic field measurements at stable sites.
4. The Scientific Council **affirms** the continuing importance of absolute observations and baseline control at magnetic observatories.
5. The Scientific Council **affirms** the continuing importance of magnetic observatories in the satellite era and the complementary nature of ground- and space-based data in addressing important scientific questions.
6. The Scientific Council **affirms** the importance of magnetic observatories in providing data needed for the generation of data products such as magnetic activity indices and global geomagnetic field models. Such data products are used widely in scientific research and are applied in a variety of ways to bring benefits to society.
7. The Scientific Council **recognises** the important roles that several staff from the BCMT organizations have played in the success of INTERMAGNET, contributing knowledge and expertise and providing leadership since the programme began in the late 1980s.
8. The Scientific Council recognises the importance of providing evidence of usage of observatory data, **welcomes** the steps taken by the BCMT component institutes to provide such evidence, and encourages these efforts to continue.

   (Magnetic observatory data are regarded as part of the general scientific infrastructure and the efforts of institutes and individuals running magnetic observatories are often not fully recognised in research publications. Both IAGA and INTERMAGNET have strongly advocated acknowledgement of the sources of magnetic observatory data in research publications, and this has improved the situation to some extent. While it is important for observatory operators to provide evidence of the importance and value of their operations by gathering statistics on data usage, the Council recognises that it is a difficult task.)

3.2 Reports provided to the Scientific Council

9. The information and evidence provided to the Scientific Council at this meeting was mainly by means of oral reports. The Council discussed types of information that would be useful to its work in the future. Ideally there would be a strategy document setting out the longer-term vision for the BCMT operations and a series of delivery plans and annual

reports providing measureable evidence of progress towards the long term objectives. The annual reports would include information on the staff and other resources used to achieve the deliverables.

10. During the meeting the Scientific Council was told that a planning document is produced, but written in French. The members of the Scientific Council have varying degrees of competence in French but nevertheless agreed that being supplied with the latest version of the document prior to meetings would be useful. However, on matters where specific recommendations from the Council are requested by the Director, BCMT, any necessary background material must be provided in English.

11. The Scientific Council was clear in its view that it did not wish to increase bureaucracy by requesting the production of new documents, and recognised that various documents are already prepared for different funding agencies. The Council asks the Director BCMT to **consider** whether there is the scope to produce one document that will serve multiple purposes, including providing information to the Council.

3.3 Magnetic observations

12. The Scientific Council **congratulates** the BCMT on establishing a network of 16 observatories widely distributed around the globe, all of which operate to INTERMAGNET standards. The Council recognises that many of the observatories run by the BCMT are operating in challenging locations (for combinations of logistical, environmental and political reasons). The observatories occupy important positions, generally distant from other observatories, and are of high value for scientific research purposes.

13. The Scientific Council recognises that the BCMT observatories produce and promptly publish data of excellent quality, and **commends** the staff of the BCMT component institutes who have demonstrated great commitment and dedication in working to achieve high standards.

14. The question of whether efforts to expand the IPGP component of the BCMT network should continue was raised during the presentations. The Scientific Council considers that the nature and size of the network is a strategic choice to be made by the BCMT but **recognises** that, given the pressures on staffing, it is a considerable challenge for IPGP to support the operations of 10 magnetic observatories, the expected number by the end of 2009. The Council **supports** the suggestion that the next few years should be a period of consolidation so that the observatories currently operating under agreements with IPGP can be maintained to a high standard.

15. The Scientific Council was concerned at the lack of absolute observations at Bangui and **recommends** that the Director, BCMT brings this unsatisfactory situation to the attention of IRD, and asks for remedial action to be taken.

16. The Scientific Council **notes** with interest the efforts being made by IRD to establish a new magnetic observatory in New Caledonia, **encourages** this initiative, and looks forward to learning of further progress at its next meeting.

17. The presentations on the French repeat station network and the proposal to establish new stations at airfields were **noted** by the Scientific Council, but there was insufficient time for discussion. Further consideration of the repeat station programme was deferred until the next meeting.

3.4 Instruments and data acquisition systems

18. The Scientific Council **recommends** that the three BCMT component institutes develop a joint approach to developments in, for instance, instruments, data acquisition systems, and software for data processing and data management. (Such cooperation may already exist, but the evidence for it was not apparent to the Council.)

19. The Scientific Council **was unclear** about the general strategy on instrumentation. Instruments have been, and still are, developed in house, some with other research organizations, and some jointly with industry (but apparently with no commercial spin-

offs). The rationale for in-house development, as opposed to purchasing equipment from external suppliers, was not transparent.

20. The Scientific Council noted that high sampling rates are routine in other science areas such as seismology and **suggests** that the advice of appropriate technical experts is sought to expedite progress in the developments planned for geomagnetic data acquisition.

3.5 Data products based on ground magnetic data, and future needs

21. The Scientific Council **welcomes** the recognition by the staff of the BCMT of the need for magnetic observatories to deliver quality-controlled data in a timely manner to facilitate integration with data from the Swarm satellite mission and **strongly supports** the plans to publish quasi-definitive data within about one month of observation. The combination of satellite and observatory data is likely to lead to new scientific results.

22. The Scientific Council recognises that increasing the time resolution of observatory data to one second will widen the take-up of data by the space physics research community and that near real time delivery will promote the use of observatory data for both research and applications. Accordingly, the Scientific Council **strongly supports** the plans to record data at one-second resolution and to deliver the data in near real time, guided by the standards defined by INTERMAGNET.

23. The Scientific Council **congratulates** the BCMT component institutes on their efforts to preserve historical data, to make the data available in digital form, and affirms the scientific value of these efforts. The Council **recommends** that further projects of this type are undertaken as resources permit.

24. The Scientific Council noted the dependence of the ISGI-produced magnetic activity indices on data from (subsets of) the global magnetic observatory network and **welcomes** the ISGI proposals to develop other indices, based on observatory data, characterising the sources of magnetic disturbances.

25. During the meeting a question was asked concerning the possible advantages of integrating databases of magnetic observatory, archaeomagnetic and palaeomagnetic data. The Scientific Council believes there is **no advantage** in attempting to combine these quite different types of measurement and that there are no major obstacles to research scientists in accessing the different data types as currently organized.

3.6 BCMT internal organization

26. At this inaugural meeting the Scientific Council had to absorb a great deal of information concerning the individual institutes operating under the BCMT umbrella. It would be inappropriate for the Council to make recommendations on changes in the relationships between the institutes in this first report. However, as a general observation, the Council **believes** there is a clear need for joint strategy development and planning and asks that evidence of joint working is presented at future meetings.

27. The Scientific Council notes the valuable role played by IRD as a member of the BCMT and is **concerned** that the imminent changes in organizational arrangements within IRD, and the retirements of experienced and knowledgeable members of staff, may have undesirable consequences.

28. The Scientific Council **recommends** that the Director, BCMT contacts the Director, IRD to reaffirm the importance of the IRD-operated observatories as part of the BCMT network and to seek assurance that the organizational responsibility for support of the observatories will be clearly identified when new structures are established.

29. ISGI serves both the solid Earth and space physics scientific communities, and although it is formally independent, it has historically been associated with the BCMT, and the Director, ISGI has a place on the BCMT Management Committee. The Scientific Council believes the arrangements linking ISGI and the BCMT are appropriate and **recommends** that they continue.

30. The Scientific Council **recommends** that the Director, BCMT provides support to the Director, ISGI by making appropriate representations should the recent changes in the organizational arrangements at the former CETP create difficulties in securing the necessary staff support for ISGI operations in the future.

3.7 Resources

31. The budgetary figures presented to the Scientific Council during the oral presentations were the marginal costs associated with instrumental and other developments, excluding salary costs. The Council **believes** the marginal costs are modest and represent good value for money.

32. The Scientific Council learnt that there is a variety of funding organizations for the BCMT component institutes, but has insufficient information to comment on the levels of funding provided. It would be useful if the Council was given information on bids made for funding in advance of future meetings. The Council recognises that several Government departments, not only the Ministry of Education, benefit from the outputs of the BCMT and **suggests** that the Director, BCMT identifies key Government stakeholders and considers whether they should be invited to contribute to operational costs.

33. The Scientific Council recognises an impending staffing crisis at IPGP and **strongly supports** the case made for recruitment into the posts that are about to become vacant through staff retirements and transfers. The Director, BCMT is **urged** to take steps to ensure that replacement staff are appointed in good time, preferably allowing for training of new staff by the departing members of staff.

34. The Scientific Council recognised similar potential problems at EOST because of staff retirements in the near future. Again, the Director, BCMT is **urged** to take steps to ensure that replacement staff are appointed in good time.

35. The Scientific Council believes that failing to act on the recommendations on staffing at the BCMT component institutes will put a strong national competence at risk. The Council **strongly recommends** that the matter is addressed urgently, as loss of expertise will threaten the quality of BCMT data and reduce the ability of BCMT staff to play an active and influential part in international organizations and projects such as IAGA and INTERMAGNET.

Appendix A : Agenda

BCMT Scientific Council Meeting, 6 April 2009

Meeting Agenda

1. Morning session (blue room)

9h00-9h30	Opening Vincent Courtillot: Welcome address. Purpose and scope of the meeting Election of council chair and secretary Approval and changes of/to agenda
9h30-10h15	Presentation of BCMT activities Arnaud Chulliat: IPGP magnetic observatories (35' + 10')
10h15-10h45	Coffee break
10h45-12h15	Presentation of BCMT activities (continued) Jean-Jacques Schott: EOST magnetic observatories (30' + 10') Gilbert Juste: IRD magnetic observatories (15' + 10') Michel Menvielle: International Service of Geomagnetic Indices (15' + 10')
12h15-13h00	*Working meeting #1 – council members only*
13h00-14h00	Lunch break

2. Afternoon session (green room)

14h00-15h00	Discussion #1: What role for magnetic observatories in the satellite era? Stefan Maus: Introductory talk Discussion
15h00-15h30	Discussion #2: What role for magnetic repeat stations in the satellite era? Erwan Thébault: Introductory talk Discussion
15h30-16h00	Coffee break
16h00-16h30	Discussion #3: Societal applications of magnetic observatory data. David Kerridge: Introductory talk Discussion
16h30-17h30	*Working meeting #2 – council members only*
17h30-18h00	Preliminary report and recommendations of scientific council

Appendix B : List of participants

Scientific Council meeting, 6 April 2009

List of participants

BCMT Scientific Council

Jacques Hinderer	EOST
Gauthier Hulot	IPGP
Andrew Jackson	ETH Zürich
Dominique Jault	LGIT
David Kerridge	BGS
Stefan Maus	CIRES / University of Colorado / NOAA
Christophe Sotin	JPL
Erwan Thébault	IPGP
Susanne Vennerstrøm	DTU Space

BCMT Management Committee

Vincent Courtillot	IPGP	Director of IPGP / Director of BCMT
Arnaud Chulliat	IPGP	Director of IPGP magnetic observatories
Xavier Lalanne	IPGP	Head of Chambon la Forêt station
Michel Granet	EOST	Director of EOST
Jean-Jacques Schott	EOST	Director of EOST magnetic observatories
Remy Louat	IRD	Executive at IRD
Gilbert Juste	IRD	Director of IRD magnetic observatories
Michel Menvielle	IPSL	Director of ISGI / SIIG

Guests present at the meeting

Mireille Perrin	INSU	Scientific delegate at INSU
Denis Hatzfeld	INSU	President of INSU Observatories Commission
Gérard Jugie	IPEV	Director of IPEV
Danielle Fouassier	IPGP	Engineer
Aline Peltier	IPGP	Associate physicist
Armelle Bernard	EOST	Engineer
Aude Chambodut	EOST	Associate physicist
Marcellin Fotze	EOST	Engineer

Appendix C : Scientific Council Terms of Reference

The following Terms of Reference are dated as 6 April 2009.

Purpose

The Scientific Council is the main *advisory* body of the BCMT.

The BCMT was created and attached to the Institut de Physique du Globe de Paris (then part of the Paris University) by a decree published in 1921 (attached). In 2008, the Institut National des Sciences de l'Univers (CNRS-INSU) set up an Observation Service in Magnetism, which was delegated to the BCMT.

Membership

The Council members are nominated by the BCMT Director, after consultations of the BCMT Management Committee and CNRS-INSU.

The Council elects its chair and secretary from among its members.

Roles and responsibilities

The Scientific Council shall:

- Receive reports from the Director and advise on the BCMT observational strategy.
- Make specific recommendations to the Director on:
    1. the start / stop of magnetic observatories and other ground observations;
    2. the status of existing and the development of new instruments and data acquisition systems;
    3. the status of existing and the development of new data products based on ground magnetic data.
- Advise the Director on the BCMT internal organization.
- Advise the Director on its funding strategy (requests to funding agencies for money and positions).
- Help the BCMT identify and anticipate future scientific and societal needs in terms of ground magnetic observations.
- Write reports with recommendations on the BCMT activity (typically every year) and forward it to institutions participating in the BCMT and to funding agencies, including CNRS-INSU.

Appendix D : Decree establishing the BCMT

Le Président de la République française,

Sur le rapport du ministre de l'instruction publique et des beaux-arts;

Vu les décrets des 25 novembre et 6 décembre 1920;

Vu les délibérations des conseils de l'université de Paris et de l'université de Strasbourg en date des 4 juillet et 25 juin 1921,

Décrète:

Art. 1er. — Il est créé un bureau central de magnétisme terrestre pour toute la France et les colonies.

Le fonctionnement de ce bureau sera assuré par l'institut de physique du globe de la faculté des sciences de l'université de Paris.

Le directeur de cet institut sera chargé de la direction du bureau central de magnétisme terrestre.

Un comité spécial sera créé auprès de ce bureau pour l'organisation et la coordination des observations et des recherches de magnétisme terrestre. Sa composition et ses attributions feront l'objet d'un arrêté du recteur de l'académie de Paris, après avis du conseil de la faculté des sciences de l'université de Paris et des organisations compétentes.

Art. 2. — Il est créé un bureau central sismologique pour la France et les colonies.

Le fonctionnement de ce bureau sera assuré par l'institut de physique du globe de la faculté des sciences de l'université de Strasbourg.

Le directeur de cet institut sera chargé de la direction du bureau central sismologique.

Art. 3. — Le ministre de l'instruction publique et des beaux-arts est chargé de l'exécution du présent décret.

Fait à Paris, le 28 juillet 1921.

A. MILLERAND.

Par le Président de la République:

Le ministre de l'instruction publique et des beaux-arts,

LÉON BÉRARD.

Appendix E : Acronyms

BCMT:	Bureau Central de Magnétisme Terrestre
BGS:	British Geological Survey
CEA:	Commissariat à l'Énergie Atomique
CETP:	Centre d'Etude des Environnements Terrestre et Planétaires
CNRS:	Centre National de la Recherche Scientifique
CTBTO:	Comprehensive Test-Ban Treaty Organization
ESA:	European Space Agency
FAGS:	Federation of Astronomical and Geophysical Data Analysis Services
GIC:	Geomagnetically Induced Currents
GIN:	Geomagnetic Information Node (INTERMAGNET)
ICSU:	The International Council for Science
IGRF:	International Geomagnetic Reference Field
INSU:	Institut National des Sciences de l'Univers (INSU)
IPEV :	Institut Polaire Français, Paul-Emile Victor
IPGP:	Institut de Physique du Globe de Paris
IRD:	L'Institut de Recherché pour le Développement
ISGI:	International Service of Geomagnetic Indices
LATMOS :	Laboratoire Atmosphères, Milieux, Observations Spatiales
LETI:	Laboratoire d'Electronique et de Technologie de l'Information
LPP :	Laboratoire de Physique des Plasmas
MAGIS:	MAGnetic observatories Information System
NERC:	Natural Environment Research Council
OSU:	Observatoires des Sciences de l'Univers
SPIRALE:	Soutien aux Projets InfoRmatiques dAns Les Equipes Scientifiques
SWENET:	Space Weather European Network (ESA)
WMM:	World Magnetic Model