BUREAU CENTRAL DE MAGNÉTISME TERRESTRE
Director: M. Chaussidon

Activity Report 2023-2025

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Foreword

This document reports on the activities carried out by the BCMT between the last BCMT council meeting in June 2023 and the first months of 2025. The planned activities were defined in the Strategic Plan 2024-2028 [Lesur and Chambodut, 2023] and presented and discussed during the BCMT council meeting.

Contents

1 Introduction

The "Bureau Central de Magnétisme Terrestre" (BCMT) is a French National Service of Observation (SNO) for geomagnetism of the CNRS-INSU and its role is to record and distribute ground-based geomagnetic observations. Created in 1921 by decree and steered by the Institut de Physique du Globe de Paris (IPGP), the current activities of the BCMT are described in a five-year strategic plan [Lesur and Chambodut, 2023] and follow the advises and recommendations of a scientific council [Love, J. J. et al., 2023]. This council meets regularly and the present report has been established for the midterm review of BCMT activities for the period 2023-2028.

Maintaining an observation service such as the BCMT requires significant resources, and these are justified by the importance of the scientific objectives for which magnetic data are needed. We recall in this report these scientific objectives in section (2). We review in a synthetic form the current resources of the service in section (3). We present the observational infrastructure status in section (4), and the undertaken activities since June 2023 in section (5). Next, in section (6), each of the actions suggested by the scientific council in its last report are reviewed. The activities for the next three years, planned to address the pending tasks and projects described in the strategic plan 2024-2028 [Lesur and Chambodut, 2023], are then presented in section (7).

2 Scientific objectives

In academic research, magnetic data are used for core dynamic, mantle conductivity, tectonic and space-climate studies, all linked to the past history of our planet. They are also used to understand the current dynamics of the ionosphere and magnetosphere through space-weather data products and services. In more applied fields, particularly in industry, magnetic data are used for mineral and oil exploration, for navigation and orientation purposes through reference models of the main field. Possibly the latter is the best example of how useful are magnetic data: main field models are used for the orientation of numerous devices ranging from smartphones, vessels, planes, and satellites to boreholes. As a national service and as the French contribution to the international magnetic observation infrastructure, the BCMT aims at providing data for most of these applications.

Magnetic observatories have traditionally been set up to follow, and ultimately understand, the slow evolution of the main field. This goal remains our main objective. It requires maintaining long-term coherence in the data and contributing as much as possible to a homogeneous and global coverage of the Earth. This is achieved by maintaining remote and isolated observatories. Calibrated data have to be distributed in due time as they are essential for instance for an optimal interpretation of data collected by satellite missions such as the current European Space Agency (ESA) Swarm multisatellite mission. In particular, observatory data are heavily used for building magnetic field models, including the 14^{th} version of the International Geomagnetic Reference Field (IGRF) that has been released in early 2025 (https://www.ncei.noaa.gov/products/international-geomagnetic-reference-field).

A second objective, with growing importance for our society, is to provide the necessary data to describe and understand the fast variations of the fields of external origins: the ionospheric and magnetospheric fields. They are particularly difficult to separate from fields generated inside the Earth and are therefore the main limitations to accurately describe the core field. These fields are also strongly affected by perturbations in the ionosphere and magnetosphere that impact our technologies, our positioning and communication systems, and, at high latitudes, the human infrastructures (e.g. power lines). Although global coverage is important to describe the large-scale magnetospheric field, ionospheric disruptions remain at relatively short spatial scales with sometimes very short temporal scales. In order to provide the relevant magnetic data to the scientific community for studying these magnetospheric and ionospheric fields, we first are developing an

observational infrastructure over France made up of a relatively dense network of variometer stations and, second, we are building the necessary data flow system to provide magnetic data and derived products in quasi-real time.

3 Resources and Infrastructure

3.1 Involved scientists and technicians

Two institutions are participating to the BCMT: the "Institut de physique du globe de Paris" (IPGP, https://www.ipgp.fr), part of the "Univeristé de Paris Cité", and the "Ecole et observatoire des Sciences de la Terre" (EOST, https://eost.unistra.fr), part of the "Université de Strasbourg". The scientists and technicians of these institutions that contribute to BCMT activities are listed in Table 1.

Name	**Grade & Activity**	FTE
Lesur V.	Physicist (IPGP). Head of IPGP magnetic observatories. Observatory service and BCMT management. Data processing and quality control.	30%
Chambodut A.	Physicist (EOST). Head of EOST magnetic observatories. Management & maintenance of the observatories. Data processing and quality control. Responsible of relationships with IPEV.	33%
Coïsson P.	Associate Physicist (IPGP), Ionospheric and Space weather applications. Data processing and quality control.	30%
Wardinski I.	Associate Physicist (EOST). Data processing, analysis and quality control.	30%
Bernard A.	Senior engineer, CNRS (EOST). System administrator. Computing infrastructure. Data management, workflows and quality control. Observatory Maintenance. Responsible of annual training of observers.	40%
Maury V.	Senior engineer, CNRS (IPGP). Head of the information system. System administrator. Computing infrastructure & Data management.	100%
Heumez B.	Engineer, CNRS (IPGP). Geomagnetic network management. Data processing and observatories maintenance.	100%
Smith Y.	Engineer, CNRS (EOST). Observatory maintenance. Scientific instrumentation. Annual training of observers.	50%
Telali A.	Engineer, CNRS (IPGP). Scientific instrumentation R&D Instrumentation and observatories maintenance.	100%
Bergerard-Timofeeva M.	Engineer, IPGP. Scientific instrumentation R&D. Instrumentation and observatories maintenance.	100%
Parmentier E.	Senior technician CNRS (IPGP). Maintenance of the national observatories infrastructure.	100%

Table 1: List of personnel involved in BCMT activities

During the past two years, since the production of the strategic plan of the BCMT, significant changes in the workforce manpower occurred at both Institutes. At IPGP, a technician left the team, but a new engineer, Maria Bergerard-Timofeeva, has been hired working at 100% FTE. She is currently on a three-year contract with IPGP and we hope that she will be able to obtain a permanent position next year. We also expect that a new scientific position will be obtained to take the responsibility of the variometer network under development. At EOST, the engineer, in charge of all aspects related to electronics (instrumental chains) at 100% FTE, left the institute in May 2023. In December 2024, a new engineer has been hired at 50% FTE to provide the electronic engineering expertise that has been lacking for the past year and half. Since the last council meeting, the IPGP team has roughly the same workforce, while the EOST team shows a decrease of 50% FTE.

3.2 Funding and grants

There are four main sources of funding for BCMT activities[1]:

- the CNRS-INSU (∼111 k€ /year)
- the OSUs – i.e. IPGP (∼60 k€ /year) & EOST (∼20 k€ /year)
- the French polar institute – i.e. IPEV (> 70 k€ /year)
- other funding agencies, mainly the French spatial agency – i.e. CNES (∼27 k€ /year)

We recall that BCMT observatories established in Africa, Asia, and South America are set and maintained in collaboration with local agencies that typically provide a preserved area to set the observatory, staff to look after the site and make calibration measurements, and often energy and communication means. The contribution of the French Polar Institute is not limited to this consumable budget given above, but also covers the travels, fluids network (electricity and communications), technical support and on-site observers, in Sub-Antarctica and Antarctic territories, giving a consolidated cost larger than 920 k€ /year.

For 2024, the overall budget of BCMT was 275 k€ . This value has only marginally increased over the last ten years, essentially due to the increase of the CNES contribution to maintain the Kourou observatory.

3.3 Observatory network

Currently, the BCMT is running 17 observatories around the world (see Figure 1). Among all these observatories, only 5 are currently producing definitive data accepted by INTERMAGNET. Some others are experiencing failure or problems:

- The Borok observatory (BOX, Russia) has not been delivering data to BCMT since the beginning of the Russian-Ukrainian war in spring 2022.
- The Edéa observatory (EDA, Cameroon) stopped producing data in April 2024.
- The Sop Niahar observatory (SOK, Senegal) stopped producing data in September 2024. A recovery mission is organised in May 2025.
- The Amsterdam island observatory (AMS, Subantarctic territories) was stopped in January 2025 due to a fire that devastated the entire island.
- The Fihaonana observatory (FIH, Madagascar) experienced technical problems on both instrumental and communication chains in early 2024, in addition to the impossibility for local observers to carry out absolute measurements (due to the weather or insufficient means of transport). No data are distributed for this observatory.

[1]Provided values correspond to the year 2024

All other stations are in principle operational – i.e. are producing variometer data. Unfortunately, absolute measurements are not systematically collected once a week in all observatories, in particular in the Edéa and Easter Island observatories. Therefore, definitive or quasi-definitive data cannot be produced for some observatories.

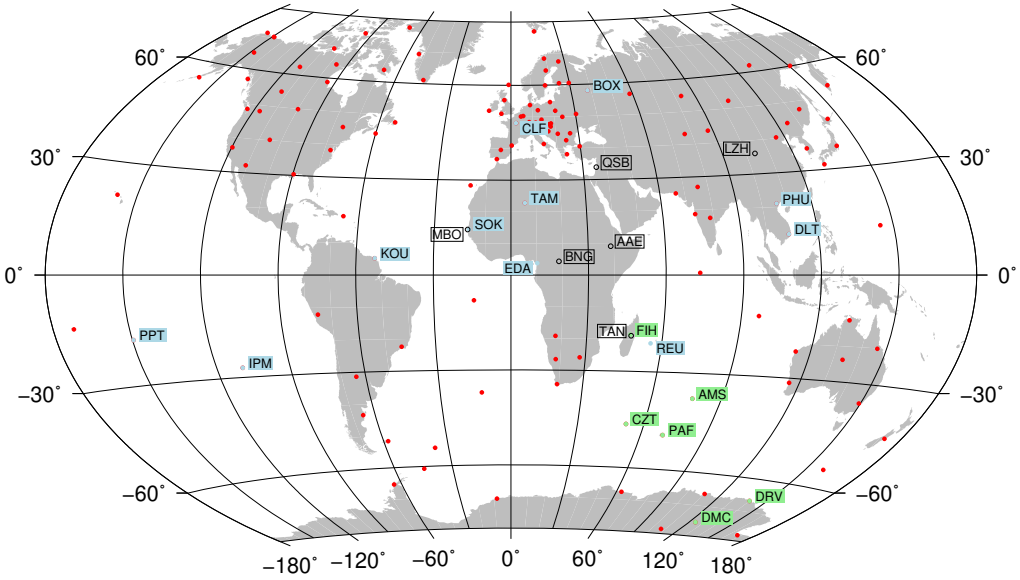

Figure 1: Map of magnetic observatories run by the BCMT. In blue are those handled by IPGP, in green are those under EOST responsibility. The observatories labeled in black are former BCMT observatories, now closed. Red dots are positions of INTERMAGNET observatories.

The position and status of each BCMT observatory are given in Table 2. Data are integrated to BCMT data repository and distributed through its website and related workflows/API.

IAGA code	Colat.(^{o})	Long.(^{o})	alt.(km)	Status	open	INTERMAGNET
AAE	9.035	38.766	2.441	closed-2016	1958	1998 - 2015
AMS	127.80	77.57	0.050	active – v (on hold since Jan. 2025)	1981	1992 - 2020
BNG	85.667	18.566	0.395	closed-2011	1955	1992 - 2011
BOX	31.930	38.230	0.115	unclear	1957	2002 - 2022
CLF	41.975	2.260	0.145	active – dr	1936	1936 - now
CZT	136.43	51.87	0.160	active – v	1974	1991 - 2020
DRV	156.67	140.01	0.030	active – v	1957	1991 - 2020
DMC	165.25	124.167	3.250	active – v	2005	2009 - 2020
DLT	78.055	108.482	1.583	active – vr	1978	1978 - now
EDA	86.221	10.153	0.035	active – vr (on hold since Apr. 2024)	2018	-
FIH	108.5716	47.187	1.442	active (on hold on since oct 2023)	2014	-
IPM	117.171	250.59	0.083	active – vr	2008	2008 - now
KOU	84.79	307.269	0.010	active – dr	1995	1995 - now
LZH	53.913	103.845	1.560	closed-2019	1959	1998 - 2019
MBO	75.608	343.02	0.007	closed-2020	1952	1992 - 2020
PAF	139.35	70.26	0.035	active – v	1957	1991 - 2020
PHU	68.971	105.96	0.005	active – vr	1957	1992 - now
PPT	107.567	210.426	0.357	active – dr	1968	1995 - now
QSB	33.871	35.644	0.525	closed-2007	2000	2000 - 2007
REU	111.21	55.576	1.580	active – dr	2023	-
SOK	75.505	343.54	0.010	active – dr (on hold since Sep. 2024)	2020	-
TAM	67.208	5.530	1.373	active – dr	1935	1992 - now
TAN	108.917	47.552	1.375	closed-2008	1889	1992 - 2008

Table 2: List of BCMT observatories. Active observatories have an extension "-d" if definitive data are already produced for 2024, or "-v" if variation data are produced. An extension "-dr" or "-vr" indicates that variometer data are distributed in near real-time. Observatories that were active only before year 2000 are not listed. Details are provided in section 4.

3.4 Variometer station network

As described in the BCMT strategic plan [Lesur and Chambodut, 2023], a variometer station network is being developed in France (see Figure 2). There are currently four stations running, one of them was recently installed and is still under test (LZC). The position and status of each variometer station are provided in Table 3. Data are integrated into the BCMT data repository and made available, in near real-time, through the BCMT website.

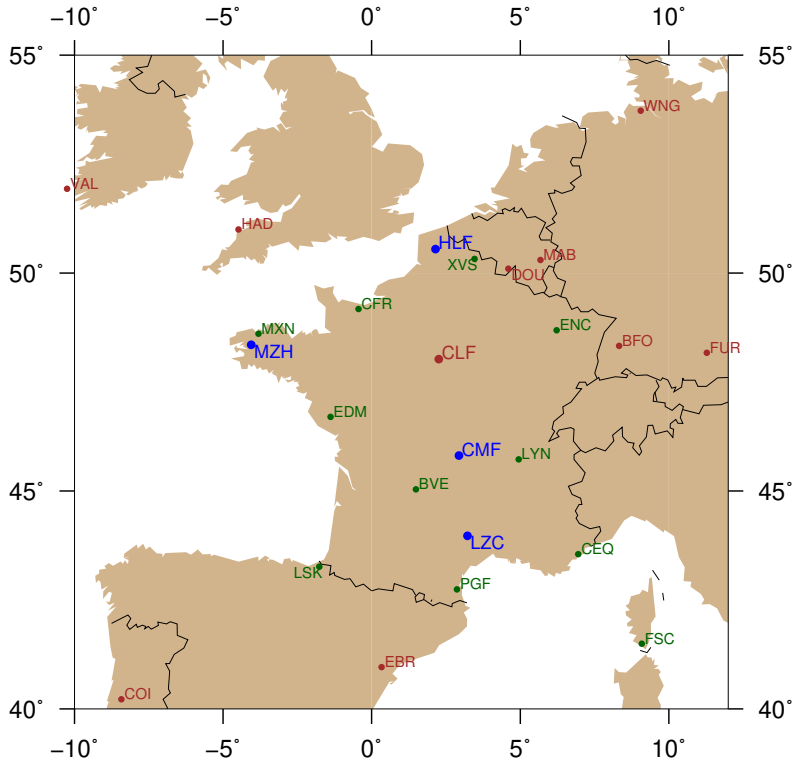

Figure 2: Map of variometer stations (in blue), repeat stations (in green) over France, and INTERMAGNET magnetic observatories (in red) in Western Europe.

Code	Colat.(^{o})	Long.(^{o})	alt.(km)	Status	open	Remark
MZH	41.6543	355.949	0.306	active	2023/05	
CMF	44.1864	2.9359	0.953	active	2021/11	
HLF	39.300	2.25	0.100	active	2024/07	
LZC	46.0301	3.2214	0.708	active	2025/02	under test

Table 3: List of BCMT Variometer stations. All active stations provide data in quasi real-time.

3.5 Repeat station network

The network of repeat stations in France (see Figure 2) has been reduced several times in the last decades and will be replaced in the coming years by the variometer station network, where absolute measurements will be made yearly.

In 2007, the network consisted of 31 stations established between 1947 and 1977. Measurements over this network were collected every five years. Surveys were increasingly difficult for several reasons, including changes in land use in several locations. In 2012, to reduce costs and workload, this network was downsized to 11 new stations, located in small airports. This network has been surveyed regularly since, at two- or three-years intervals. However, some airport managers have been reluctant to allow access to runways, and significant discontinuities are observed in the data series when magnetic material is used for runway maintenance. Overall, the data quality and their usefulness are limited.

The repeat stations that will be surveyed during the next measurement campaign are listed in Table 4. This new survey is planned for June and July 2025.

Code	Lat.(^{o})	Long.(^{o})	alt.(km)	last surveyed	Remark
ENC	48.68663	6.22691	0.229	June 2022	
CFR	49.17612	359.55569	0.078	June 2022	
EDM	46.69979	358.61651	0.090	June 2022	
LSK	43.26252	358.2391	0.605	June 2022	in Spain
CEQ	43.55002	6.95132	0.004	June 2022	
FSC	41.49718	9.08992	0.026	June 2022	

Table 4: List of BCMT repeat stations to be surveyed in 2025

3.6 Data distribution infrastructure

The teams of the BCMT in IPGP and EOST each have their own data processing chain adapted to their specific needs. They also maintain their own raw and processed data storage facilities. The data distributed by the BCMT are the variational, provisional, quasi-definitive and definitive observatory data, together with variometer and repeat stations data and other derived products. All of these data are stored in the BCMT data repository located in IPGP. The amount of space required to store these data was reaching 1.1 TB on April 2025.

The variational, provisional, quasi-definitive and definitive data of affiliated observatories are sent to INTERMAGNET (https://intermagnet.org/). From INTERMAGNET they are also made available to EPOS ERIC (https://www.ics-c.epos-eu.org/). Definitive data are also sent towards World Data Center for Geomagnetism Edinburgh (https://wdc.bgs.ac.uk/data). All data hosted by BCMT repository will also be soon referenced through their interoperable metadata in the FormaTerre's catalogue and in the national meta-catalogue of DataTerra e-infrastructure (both infrastructures have been recently created in France), and thus made available through them to the general public and scientific community. Obviously, these data, as well as the other data products, can all be accessed directly from the BCMT website (https://www.bcmt.fr/).

3.7 Calibration facilities

A platform facility for the calibration of magnetic instruments is available at the French national observatory in Chambon-la-Forêt. It is used by BCMT engineers for instrument calibration, but it is also available for other academic, scientific, or industrial purposes. It has been used in the past for satellite instrument calibration and also for verifying the magnetic cleanliness of satellite observation systems – e.g. the JUICE mission to Jupiter icy moons. More recently, it has also been used to test drones devoted to magnetic surveys.

The platform includes a set of large Helmoltz coils that allows to impose a magnetic field with an amplitude of ± 60000 nT in a roughly 0.25 m^3 volume, at a frequency ranging from DC to few kHz. A temperature controlled room (from 0^oC to 45^oC) and a room with low field intensity ($\sim$ 150 nT) are also available to test magnetic cleanliness.

4 Network Status

4.1 IPGP magnetic observatories

Outside the Borok observatory (BOX) that has been offline for 3 years, all the other observatories and variometer stations are in working order. Despite our efforts, we cannot produce definitive data for some observatories. There are several reasons for this: difficulties in collecting absolute measurements – e.g. EDA, IPM; or discontinuities, due to anthropogenic disturbances, are observed in the data series – e.g. DLT, PHU; or difficulties with variometer data acquisition – e.g. SOK. For these latter cases, specific missions are being organised to fix the problems. In particular, since June 2023 missions have been conducted to:

- Reset the Kourou observatory (KOU). The observatory scalar instrument failed to work in December 2022. It was replaced in 2023 but the new instrument also failed to work. The observer on site tried to restart the whole system that finally completely collapsed end of June 2023. In August 2023, a recovery mission has been performed to replace the failing data acquisition system and upgrade the local data distribution infrastructure. Since then, the observatory has been providing continuously second data, available on the BCMT website less than 5 minutes after acquisition, without major difficulties.
- Upgrade the Pamatai observatory (PPT). The magnetic observatory in Tahiti has been working flawlessly these last years, but the local data distribution system was old. A mission

has been organised in end 2023 to upgrade the data distribution infrastructure and check the good health of the acquisition chain. As all other IPGP observatories, the PPT observatory data are now distributed under five minutes on the BCMT website.

- Refurbishing the Easter Island observatory (IPM). The observatory failed before the Covid-19 pandemic and as travels were not possible during this period, the mission to refurbish the observatory took place only recently in 2024. The cost and workload required to prepare and run such a mission is large. However, the infrastructure has been cleaned and re-installed. The acquisition and distribution chains have been upgraded. The local staffs have been trained again to make accurate calibration measurements. The observatory is again operational, but the quality of calibration measurements remains low. It is planned to install an instrument able to make automatically these measurements. It will probably take more than a year to have the instrument built and tested before installation. Variometer data are available under five minutes after acquisition on the BCMT website.

- The Phu Thuy and Dalat observatories are both set in Vietnam. These observatories have been running for decades but have shown an increased level of anthropogenic noise over the last years to the point where we are not able to guarantee the baseline quality of the provided data. We have therefore not been delivering definitive data to INTERMAGNET from 2021 for Dalat and from 2022 for Phu Thuy. In 2024, a typhoon partially destroyed Phu Thuy absolute measurements pavilion, that needs to be completely rebuilt to guarantee the safety of the observers. The question remains open if we should maintain open these observatories or try to find other locations. Currently, no alternative locations have been proposed by our collaborating institute.

- The Edéa observatory has been particularly difficult to run these last years due to issues linked to the payment of the local costs. This problem has been solved in 2024 and there should be no further administrative problems for the coming five years. A large mission has been organised in 2024, but the data acquisition stopped again due to major power supply difficulties. Edéa is a place where running an observatory is not easy due to recurrent lightning strikes and poor quality of the power supply. The high workload for 2025 prevents the possibility to go in all the observatories that need maintenance. The urgency in Vietnam requires priority actions. If possible, we plan to restart the observation system in Edéa at the end of 2025; or at the beginning of 2026.

- The Menez-Meur variometer station in Brittany opened in 2023 and has been revised and improved in 2024 and 2025. A new station has been installed in Helfaut in the North of France during two successive missions in 2024. It is now operational and this is our first attempt to take advantage of the existing infrastructure of a seismic station to set a variometer station. It appears to be a success as the data are of good quality, the energy provision and data distribution flawless. Absolute measurements reference values have been measured in Clermont-Ferrand and Menez-Meur stations, a reference absolute measurement will be made in Helfaut in June this year. A new station in the Larzac plateau is under test on a site already used for seismic and gravimetry field monitoring. As the initial measurements in Larzac are of good quality, we plan to strengthen this station and make it permanent over the summer.

4.2 EOST magnetic observatories

Five magnetic observatories managed by EOST team are situated in territories that are accessible exclusively through the logistical framework of the French Polar Institute. As the sole national agency with the mandate, resources, and operational expertise to support scientific research in the subantarctic and polar regions, the Institute plays an indispensable role in maintaining access to and continuity of research in these remote areas.
However, at national level, the French polar Institute (*Institut Polaire Français*, https://institut-

polaire.fr/en/) is currently facing a strong injunction from the French Ministry of Higher Education and Research to integrate it into another agency. This proposal is a strong structural change that has raised many concerns among the whole scientific community (observatories and research programs) working in the Southern Territories and Antarctic (CNFRAA, https://cnfraa.org/). Such a merger could compromise the institute's unique expertise and operational autonomy, particularly its agility in recruiting personnel for polar missions [2]. While the official rationale mentions the strengthening of polar research capabilities and the need to evolve to meet future challenges, the underlying driver appears to be financial [3]. However, the anticipated cost savings are unlikely to materialize when weighed against the loss of expertise and the disruption such a restructuring would cause. The last meeting the scientific community had at the French National Assembly at the beginning of April 2025 [4], attended by all the scientists and the CNRS INSU management, did not reassure.
Furthermore, at international level, the planned failure to fund a large part of the American polar logistics will have an impact on all future summer campaigns (from all countries) in Antarctica [5].

EOST is currently participating to the scientific community effort in compiling consolidated information to be sent to the Ministry to support the French Polar Institute. On the operational point of view, EOST team is therefore in the process of contributing to the drafting of all required documents such as multiple scenarios and feasibility diagrams with all the possible combinations of: at best 'nominal operation' and at worst 'no possibility', not only for logistics (transport of equipment and/or summer campaigners and observers), but also for human resources (no overwinterers, no observers, etc), as well as for simple technical support or the financing of consumables, etc.

The five magnetic observatories in the sub-Antarctic and Antarctic territories managed by EOST are therefore statutorily in danger.

Since June 2023, 2 missions have been conducted towards Subantarctic territories (during Marion Dufresne Vessel's rotation in March-April 2024 and in April 2025), and 2 missions towards Antarctic stations (during Summer campaigns over December 2023-January 2024 and December 2024-January 2025). Apart from routine maintenance of the 3 subantarctic and 2 antarctic observatories, it is important to note that:

- Amsterdam island observatory (AMS, Subantarctic territories) experienced a minimal maintenance in 2024 as the possible stay on site was shorten by logistics and with reduced manpower (only one summer-campaigner for magnetic and seismological observatories). On January 2025, a fire devastated the entire island, all winterers and personnel were evacuated in emergency. On March 2025, French Austral territory prefecture had organised a security check with military investigators, firemen and engineer. On April 2025, the routine rotation of the Marion Dufresne vessel allowed the EOST personnel on field-mission to check the installations and infrastructure of the magnetic observatory. At the time of the redaction of this document, life infrastructures are beginning to be repaired. Nobody knows when it will be possible to reconnect scientific systems to a functioning electricity network or when winterers will be welcomed back on the island.

- Crozet archipelago observatory (CZT, Subantarctic territories) was reinstalled in 2023, in-

[2] https://www.lefigaro.fr/sciences/pourquoi-les-bases-francaises-en-antarctique-sont-en-danger-20250408

[3] https://www.francetvinfo.fr/sciences/l-institut-polaire-francais-paul-emile-victor-est-en-danger-alerte-l-ambassadeur-des-poles-olivier-poivre-d-arvor_7185642.html

[4] https://www2.assemblee-nationale.fr/17/les-groupes-d-etudes/les-comptes-rendus/comptes-rendus-ge-arctique-antarctique-terres-australes-et-antarctiques-francaises-et-grands-fonds-oceaniques/compte-rendu-de-la-reunion-du-mercredi-2-avril-2025

[5] https://www.nature.com/articles/d41586-025-01055-6?utm_source=Live+Audience&utm_campaign=f73875af41-nature-briefing-daily-20250409&utm_medium=email&utm_term=0_b27a691814-f73875af41-51957852

struments, acquisitions and communication. It is now operating in routine mode.

- Kerguelen observatory (PAF, Subantarctic territories) was reinstalled in 2024, instruments, acquisitions and communication. It is now operating in routine mode.
- An EOST mission towards Fihaonana observatory (FIH, Madagascar) was not possible in 2024 due to the lack of technical staff. Unfortunate technical problems occurred on both instrumental and communication chains in early 2024. If possible, a mission is planned in June 2025.

5 Project progress

In the strategic plan, several projects and tasks were presented, organised into three categories: O – for the observational infrastructure, D – for data management, and I – for instrument development. This section describes the actions taken to advance towards the realisation of these projects. Their numbers reproduce the numbering defined in the strategic plan [Lesur and Chambodut, 2023].

5.1 Observational infrastructure over France (tasks O1.1 – O1.3)

O1.1 - As advised by the scientific council, we discarded the idea of setting a station to the west of the Paris-Orléans railway to mitigate, through a challenging processing, the noise level in the Chambon-la-Forêt magnetic second and minute data.

O1.2 - The project of a variometer station network progresses as planned. Two stations, Menez-Meur and Clermont-Ferrand, were already in place at the last scientific council meeting. The Menez-Meur setting has recently been adjusted to improve the quality of scalar data. A third station has been open in Helfaut in northern France, and a fourth one is under test on the Larzac plateau, north of Montpellier. This latter station has been set with the view of aligning four observation stations from North to South of metropolitan France. It was also a request from the SHOM ("service hydrographique de la marine") to establish a station in the south of France for monitoring the magnetic field variations during marine magnetic surveys in the Mediterranean Sea. We expect that the data quality, in the period range from 1 s to 1 h, will be good for this station.

O1.3 - The repeat stations network will be surveyed this summer 2025. However, only repeat stations sufficiently far from one of the new variometer stations will be surveyed (see the list given in table 4). Absolute measurements will be made at the four variometer stations to complete this survey.

5.2 Observatories upgrade and integration into INTERMAGNET (tasks O2.1–O2.5)

O2.1 - Administrative difficulties have been resolved for the Edéa observatory (EDA) by rewriting part of the convention on the maintenance and exploitation of the observatory. However, the absolute data are still not collected on a regular basis and the instruments stopped producing data in April 2024. The integration of this observatory into INTERMAGNET has to be postponed by another two to three years.

O2.2 - The situation has improved at the Easter Island observatory (IPM) after a reinstallation work in 2024. The acquisition of variational data is now flawless, but absolute measurements performed by the new observers lack precision and frequency. For this observatory, very important for geomagnetic study, we secured the funding of an automatic absolute DI instrument that we plan to deploy in 2026. We therefore hope to be able to produce good quality definitive data for

the second part of that year.

O2.3 - We recently re-applied for integration of La Réunion observatory (REU) in INTERMAGNET., We have been asked to provide a revised version of the data set for 2024. An abrupt drift of the baseline in September/October 2023 and 2024 due to a seasonal pillar movement during the dry season made us adopt a continuous baseline, rather than a daily baseline to minimise the existing steps at day transitions. Our goal is to obtain INTERMAGNET approval for this observatory by the end of the summer.

It is worth to point out that all IPGP observatories are now upgraded to the new ENO4 acquisition system.

O2.4 - In synergy with French Polar Institute, we have pursued our initiatives to acculturate TAAF personnel (from District managers to technicians) to the practices of geophysical observatories (need for magnetic cleanliness, avoidance of anthropogenic disturbances - carrier currents, radio transmissions, DC/AC transformers, etc). A department of the French Austral territory (TAAF) prefecture is now referencing the possible electromagnetic pollution around and on the scientific stations by making an inventory of the frequencies used by the scientific programs and communications.

O2.5 - In 2024, EOST team did not manage to strengthening the absolute measurement achievement by finding an agreement with observers of the host organisation of FIH observatory. We aim at collaborating with another French organism (CEA - French Atomic and Alternative Energies Commission) that has a seismological station close to the magnetic observatory and a long tradition of working with the Geophysical Institute of Antananarivo. We hope to organise the observer's journey to the station (60km one way).

5.3 Data Management (tasks D0.1 – D2.4)

D0.1 TO D0.3 - The action to move towards a certification process for the BCMT data repository remains underway, but is not a priority in view of operational constraints.

D1.1 - Regarding the upgrade of IPGP data processing and distribution software, several functionalities have been removed from the old MAGIS software and incorporated into the new MAGPROC and MAGSUITE processing infrastructure. This produced significant progress in the distribution of data and derived products in quasi-real-time. In addition, the necessary interface and database to expose metadata and distribute through the French national e-infrastructure have been implemented. We expect that in a year the full upgrade of the data management chain will be completed. We point out that a significant amount of work is required to handle the INTERMAGNET GIN maintained by IPGP.

D2.1 - Following the advice of the scientific council, we have changed our strategy to digitise our old photographic magnetic records. We defined the scan protocol for the La Cour magnetograms and started to systematically scan entire years of data. The scan resolution has been fixed at 600 dpi. At the time of this report, scans of the years 1957 and 1958 have been completed for Chambon-la-forêt.

D2.2 - The software to digitise magnetograms now includes a set of capabilities enabling the treatment of magnetograms from a variety of instruments. It has been shared with some interested scientists, who in turn suggested further improvements. Its development is currently paused, due to the lack of workforce.

D2.3 - No progress has been made toward building tools to handle magnetograms on paper rolls.

D2.4 - Magnetogram images are not yet distributed through the BCMT web-interface, because we still need to properly define which file formats and metadata to include. This project will be presented during the next IAGA assembly with the objective of discussing with the community the needs and possible common solutions.

5.4 Data products (tasks D3.1 – D3.2)

D3.1 - Little progress has been made regarding the production of hourly local magnetic activity indices for all IPGP observatories. This is still handled through the old IPGP MAGIS software. Nonetheless, a new software is being tested to produce hourly and 30 minutes local magnetic activity index values in cooperation with Igor Mandić from Zagreb University. These products are not yet distributed through the BCMT website.

D3.2 - Regarding data products, a new Sudden Impulse / Sudden Commencement detection system was tested during 2023 and is now in production since 2024. Email alerts are sent to subscribers, along with a summary document, that is stored, updated at the end of the day to complete the time-series and distributed through the BCMT interface. A publication on this work is in preparation. The next developments concern the production of models of the magnetic signals generated in the magnetosphere. The CNES has been funding the development of these two products.

5.5 Instruments (tasks I1.1 – I3.1)

We had to change the priorities in instrument developments, due to the obsolescence of the GPS receiver chips used in our acquisition systems. A complete redesign of the electronic boards has been necessary in order to integrate GPS receivers from a new supplier.

I1.1 - We had to pause the production of new vector fluxgate instruments. As soon as the new electronic cards will be available, we will be able to produce immediately up to three new fluxgate magnetometers.

I2.1 - We did not make significant progress on the development of optically pumped scalar magnetometers due to difficulties in the production of pure helium cells. For observatories and stations deployments, we still rely on proton magnetometers, which are expensive instruments. We need to buy at least one scalar absolute magnetometers this year for the new variometer station. We did not have the budget to buy scalar instruments in 2024; if we do not face unexpected expenses, we should be able to do that this year.

I2.2 - We still plan to work on developing a self-calibrating instrument in the coming years, but this project is strictly related to the development of the scalar magnetometer.

I3.1 - The activities related to higher frequency data acquisitions are currently paused due to other priorities in instrument development. We will resume this activity using search-coils sensors that have been lent to IPGP for testing purposes.

6 Action reviews

In its report, the scientific council pointed out some problems or weaknesses. In the following, we describe our attempts to address these remarks.

6.1 Delays in producing variometer and calibrated data

Following the upgrade of the data acquisition chains of all its observatories, all IPGP magnetic data are now available on the BCMT distribution site under 5 minutes.
In the last year, a special effort has been made by the EOST team, in collaboration with the French Polar Institute, to implement real-time workflows. Indeed, for magnetic observatories managed by EOST: Crozet (CZT), Dumont d'Urville (CZT) and Concordia (DMC) are real-time, their data workflows will be incorporated to BCMT data repository. Kerguelen (PAF) magnetic observatory will be real-time soon; magnetic observatory systems are ready but technical implementation by French Austral territories/French Polar Institute is needed.

Regarding the acquisition of absolute data, although we conducted training sessions in Edéa (EDA) and Easter Island (IPM), respectively, in 2023 and 2024, we see very little progress regarding the quality of the produced data, although these data are acquired more frequently.

As pointed above, for some observatories the baselines present significant discontinuities that prevent from producing definitive data of the expected quality. EOST has made progress on the production of definitive data, but has not yet managed to overcome the entire backlog. Regular meetings and teamwork have been organized for periods outside field-missions or training of the observers. Definitive data have been recently produced and will be delivered to BCMT data repository as soon as possible, from EOST towards IPGP. IPGP and EOST teams will continue working to progress towards producing timely quasi-definitive and definitive data.

6.2 Data dissemination

As suggested by the scientific council, significant efforts have been made to more efficiently disseminate BCMT data to the scientific community and the general public. Following a DDoS attack on the BCMT data distribution server in January 2025, the organization of the latter has been completely revised. The BCMT IT engineer had to interrupt the service and work on a secure solution: the website was divided into a back-end (data reception) and a for-end (data publication) and implemented on two different virtual machines. Specific security solutions have been implemented on the for-end and the data repository has been moved to a secure storage infrastructure, ensuring optimal protection and accessibility of information.
There is now a clear separation between the data repository and the server devoted to data distribution. The latter can now be easily reconstructed in case of problems. The access has also been modernized and secured.
A new interface (Application Protocol Interface, API) has been built for the data to be accessible through FormaTerre thematic cluster (https://service.poleterresolide.fr/bcmt/). All these new tools have been set on virtual servers to avoid dependencies on a specific hardware.

6.3 Staffing and resources

The Scientific council repeatedly pointed out over the past years the necessity to increase the manpower in EOST to maintain and run the magnetic observatories under their responsibility and, of course, to process and deliver variation and calibrated data to the BCMT data repository and to INTERMAGNET. This lack of manpower was identified in the 2016, 2018, 2021 and 2023 SC reports, and sill remains low to this day. In December 2024 an engineer (Y. Smith) has been hired to fulfill the vacant position and to provide the electronic engineering expertise that has been lacking for the past year and a half. However his working time dedicated to the BCMT is only 50% of a normal full time position.

IPGP benefits from a larger manpower, however, the CNRS-INSU agreed that a new scientist is needed, with specific duties related to the new network of variometer stations. Since this position

depends on a public service competition, it is not possible to know in advance if it will be filled this year, or the next.

6.4 Standardization

In its last report, the scientific council of the BCMT suggested to introduce standards regarding instruments and processing chains, inside the BCMT, to gain in efficiency and produce definitive data for all observatories. The objective being to have all observatories affiliated to INTERMAGNET. It is clear that standardization of the data acquisition systems and of the data processing chains appears desirable from an exterior point of view. This standardization is effective inside the IPGP and EOST services, but is not possible at BCMT level. Indeed, magnetic observatories in French Austral and Antarctica territories have recent instruments from commercial solutions, as EOST does not develop or produce instrumentation. Furthermore, each observatory managed by EOST is located in a nature reserve, or strictly protected area, where no new building or environmental change are permitted, no matter how small. The sub-antarctic and antarctic infrastructures in place can not be changed and require to install adapted acquisition chains in the close vicinity of instruments, inside the same shelter.

7 Planned activities

The planned activities for the next three years are in line with what has been described in the strategic plan 2024-2028 [Lesur and Chambodut, 2023]. An update of the time line is given in the Gantt Chart of Figure 3. Obviously, on top of the activities described below, BCMT tasks also include the routine work of daily data processing and maintenance in working order of observatories and data acquisition chains.

- Tasks O1.1 & O1.3: The repeat station network will be surveyed during the summer 2025. It is possible that few stations will be surveyed again in 2027 or 2028, depending on the status of the variometer network at that time. However, if everything goes as planned, two to three further variometer stations will be installed in southern France in the two coming years and no further survey of the repeat station network will be required.

- Tasks O2.1 to O2.5 We will visit the EDA observatory in 2025 for maintainance and try to involve local scientists to secure regular absolute measurements. We plan to install an automatic DI instrument in IPM and aim at obtaining a continuous flow of absolute measurements at the end of 2026.

- Task O2.4 The communication towards French Austral (TAAF) personnel and prefecture is now firmly established in practice and in synergy with the French Polar Institute. It will be pursued as planed.

- Task O2.5 A mission to Madagascar for Fihaonana magnetic observatory will take place in 2025 depending on the authorisation from the CNRS and Strasbourg University security and safety officers.

- Tasks D0 The action to initiate a certification process for the BCMT data repository is going on. The changing practices of data repositories in France, spurred on by the implementation of the national e-infrastructure, as well as the recent work on BCMT data repository, will be taken into account.

- Tasks D1.1 to D1.2 We want to continue the evolution from the old MAGIS software to the new MAGPROC and MAGSUITE processing infrastructure. Progresses in this area are heavily dependent on the availability of a software engineer and scientific expertise for supervision of the work.

- Tasks D2.1 to D2.4 The scan of paper daily magnetograms will continue for CLF, BNG, MBO observatories in the years around the solar maximum of 1958, with the aim of covering at least one decade. This is a long and tedious task that we will undertake when there is available work force. An article is in preparation to describe this activity and the digitization software. We aim to make the software available to other scientists. We will start testing data recovery from magnetograms on rolls of paper during 2026. Further activities will depend on the outcomes of the tests. We plan to include the scanned magnetogram images on the BCMT data repository along with relevant metadata and the recovered traces, as soon as proper distribution formats will be defined.

- Task I1.1 At least three instruments have to be built as soon as the new electronic boards are available. Further instruments could be built if requested either by EOST or to cover the needs of new variometer stations.

- Tasks I2.1 to I2.2 Some issues regarding helium cells have not yet been solved. The development of optically pumped magnetometer will start only when helium cells are available. It is unlikely that the production of scalar absolute instruments will start before the term of this five-year plan. The development of a self-calibrating instrument is therefore unlikely in the coming few years.

- Task I3.1. This task is likely to be postponed by another few years.

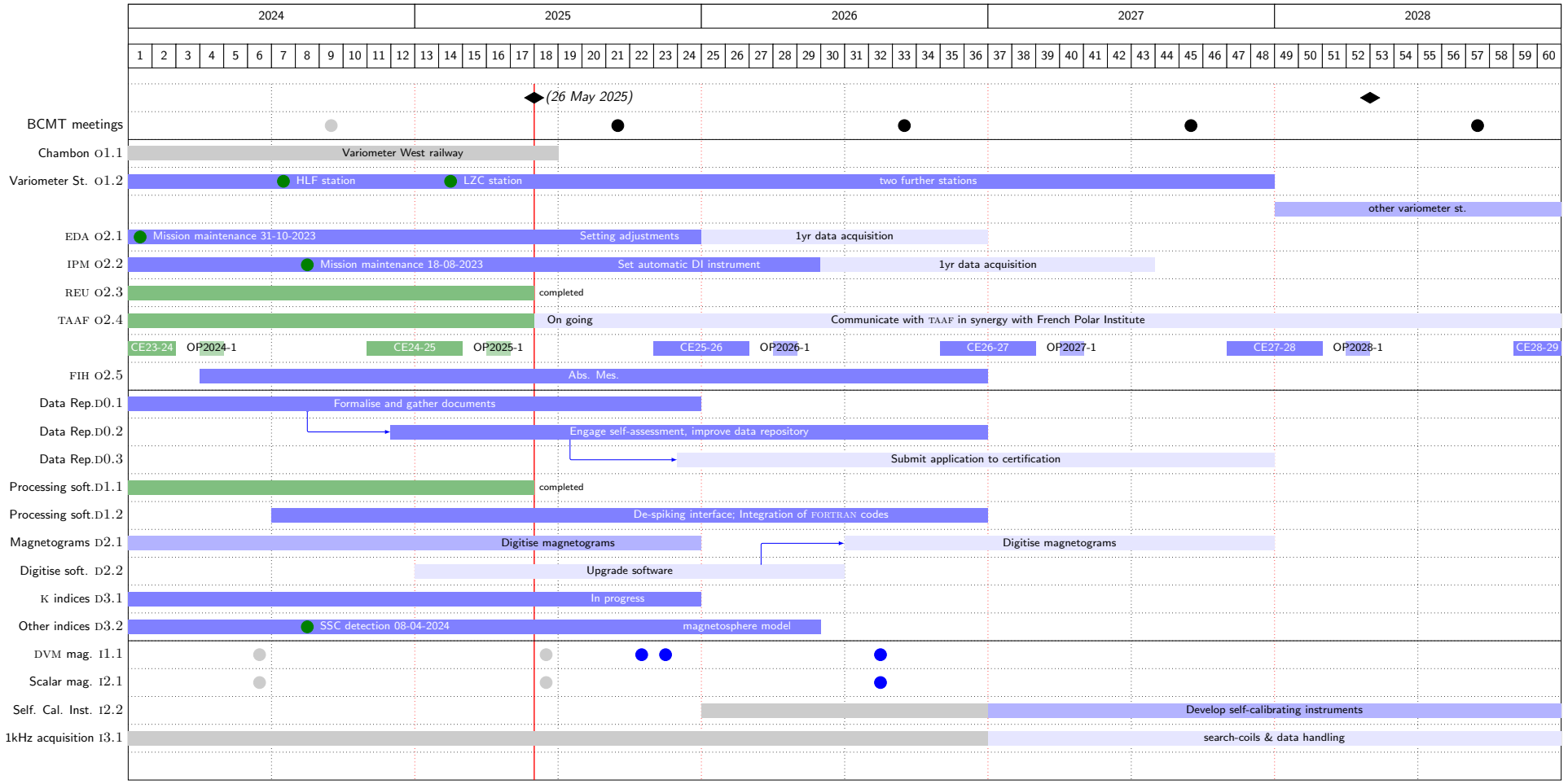

Figure 3: Gantt chart of projects and tasks: in green are shown completed tasks, in grey are tasks that have been dropped either because of delays or because they were not supported by the scientific council, in dark blue are tasks with high priorities, and in light blue those that either are low priority or that cannot be handled in the immediate future. This chart does not include the routine tasks of data processing and maintenance of observatories and data acquisition chains.

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