THE FRENCH NETWORK OF MAGNETIC OBSERVATORIES

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Abstract

In magnetic observatories, the Earth's magnetic field is continuously recorded and the acquired data are calibrated so that the evolution of the field can be studied on time scales ranging from seconds to decades.
The French network (the so-called BCMT) includes 17 observatories around the world and the different types of data produced are freely accessible in several data centres.
We will describe a typical infrastructure of a magnetic observatory, the measurement techniques, the instruments used, the general processing applied to obtain calibrated data and finally the environmental constraints that have to be respected in order to acquire suitable data.
If magnetic observatories were originally set to monitor the slow variations of the Earth's main magnetic field, they are more and more often used for space-weather monitoring and to study signal generated in the ionosphere and magnetosphere. This new range of applications implies an evolution of the network, of the acquisition and distribution techniques. The strategy we developed to respond to these new challenges will be also presented.

Magnetic Observatories

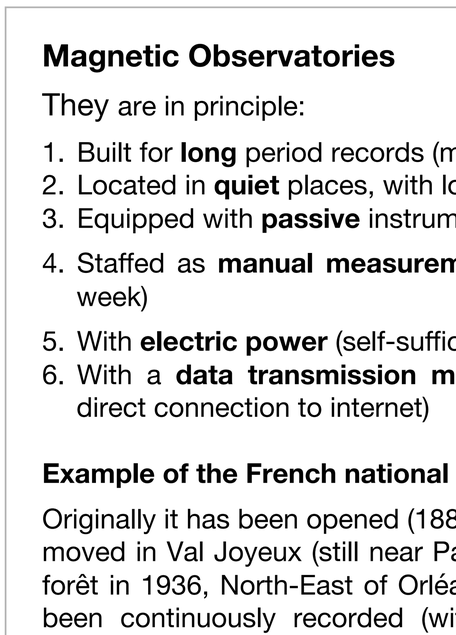
They are in principle:

1. Built for **long** period records (minimum 10 years)
2. Located in **quiet** places, with low anthropogenic noise
3. Equipped with **passive** instruments
4. Staffed as **manual measurements have to be made regularly** (each day or week)
5. With **electric power** (self-sufficient - as solar panels- or main power supply)
6. With a **data transmission mean** (radio, 3G/4G, satellite communications or direct connection to internet)

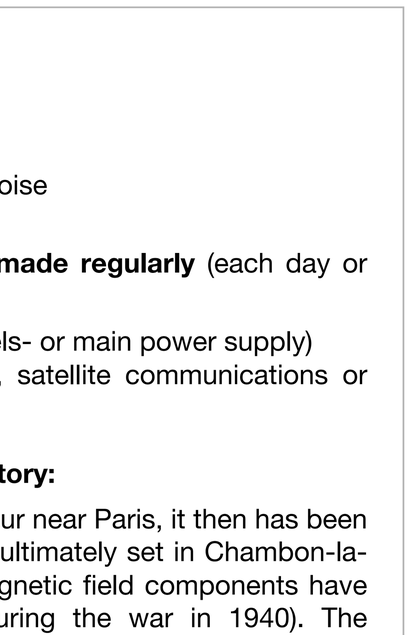
Example of the French national magnetic observatory:

Originally it has been opened (1883) in Parc Saint-Maur near Paris, it then has been moved in Val Joyeux (still near Paris) in 1900, to be ultimately set in Chambon-la-forêt in 1936, North-East of Orléans. Since then magnetic field components have been continuously recorded (with a small gap during the war in 1940). The environment has not changed significantly since this epoch. Three families are living on site, and the first village is some 5 *km* away. Magnetic, Electric, Seismic and Meteorological instruments are used on site.

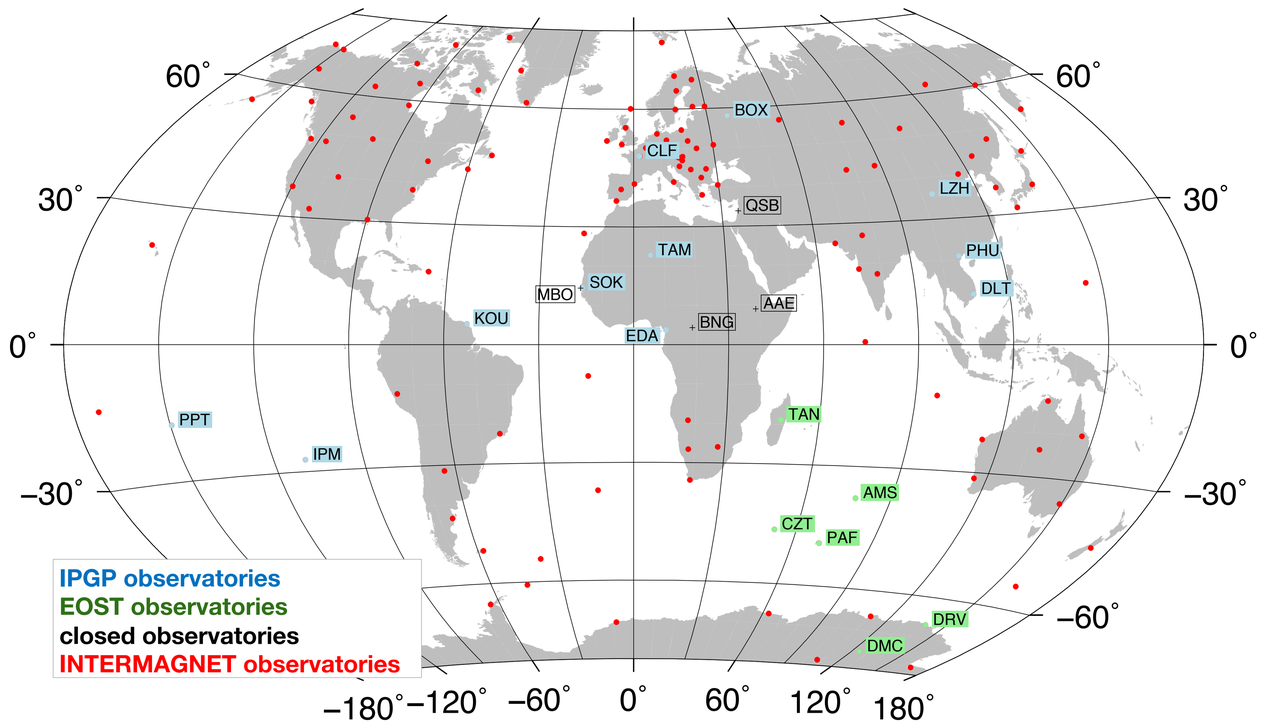
Newer observatories tend to have much lighter infrastructures.



Vector instrument used in IPGP's observatories (VM91 © BCMT)



Observer making an absolute measurement with a theodolite (© BCMT)



Map of INTERMAGNET & BCMT observatories

Aerial view of the French national magnetic observatory in Chambon-la-Forêt (© BCMT).

Instruments

Instruments for magnetic field monitoring are:

1. At least one scalar absolute magnetometer recording the magnetic **field strength**
2. A (non-absolute) vector instrument recording continuously the **variations of the magnetic field in the 3-dimensional space** (recommended sampling rate is 1s)
3. Non-magnetic theodolite associated with a single-axis fluxgate probe, to measure manually the **direction of the magnetic field** (observer perform the so-called manual absolute –but noisy- measurements)

The instruments are placed under **controlled environmental conditions** (humidity, temperature, stability of piers) in order to attenuate, as far as possible, disturbances and noise in the recorded data.

The whole observatory infrastructure (instruments, acquisition chain, observer practice) is designed such that the acquired measurements are of the highest possible stability and homogeneity and thus can be compared over long time span.

Data Types

Magnetic data collected at observatories are distributed under different formats:

1. **Variometer data**: are distributed in near **real-time** and are generally **raw second data**, direct output of vector instrument. They are used mainly for space weather applications.
2. **Quasi-definitive data**: are **partially processed data**, where identified noisy periods have been selected out, and data have been partially corrected for drifts using manual absolute measurements. These data are typically available within three months after data acquisition. They are used to complete and check observations made by magnetic survey satellites.
3. **Definitive data:** are **fully calibrated data**. They have been corrected for all discontinuities and noise. They have been also adjusted using manual absolute measurements. They are delivered yearly as second, minute, hourly, monthly and yearly means. They are mainly used to monitor long term variations of the geomagnetic field.

Data Citation

Two DOIs have been minted so far onto BCMT data

- For Definitive data, DOI: 10.18715/BCMT.MAG.DEF
- For Variational data, DOI: 10.18715/BCMT.MAG.VAR

Data Access

BCMT magnetic data are distributed through different repositories and services:

- BCMT - National service of geomagnetic observatories: http://www.bcmt.fr/
  ➔ full range of data kinds
- International databases:
  - INTERMAGNET - worldwide organization drawn from institutes operating geomagnetic observatories: http://www.intermagnet.org/
    ➔ second and minute data (strict quality checks for definitive ones)
  - SuperMag - : http://supermag.jhuapl.edu/
    ➔ variational data
- National and European infrastructures:
  - ForM@Ter – National Data Pole for Solid Earth: https://en.poleterresolide.fr/
  - EPOS – ERIC for Solid Earth Sciences: http://www.epos-ip.org/

Acknowledgments *(alphabetical order)*: A. Bernard, P. Coïsson, M. Fotze, B. Heumez, T. Luc, V. Maury, E. Parmentier, J.P. Rivierre, A. Telali, I. Wardinski and all the observers, essential workers in the shadow, without whom the observatories could not operate.