Observatories – an Overview

Geomagnetic observatories carry out continuous and accurate monitoring of the strength and direction of the Earth's magnetic field over many years, making measurements at least every minute. Observatory data reveal how the field is changing on a wide range of time scales from seconds to centuries, and this is important for understanding processes both inside and outside the Earth. It is estimated that there are approximately 180 observatories currently operating around the world (Figure 1) (for more information on observatories in particular countries or regions of the world see *Observatories in* ————, see also Plate ?). The distribution of observatories is largely determined by the location of habitable land and by the availability of local expertise, funds, and energy supply, and as result, it is uneven and a little sparse in some regions. Many observatories have had to move because of encroaching urbanisation. However the continuity of their data series is generally maintained by simultaneous observations at the old site and new site over a period of time to allow site differences to be established.

Figure 1 Locations of currently operating observatories

The distribution of data in time is shown in Figure 2. International scientific campaigns such as the first International Polar Year in 1882/3, the second International Polar Year in 1932/3 and the International Geophysical Year in 1957/8 encouraged the opening of many observatories around the world. Geomagnetism is a cross-disciplinary science, and as a result, observatories are run by a wide variety of institutes whose interests range from geology, mapping, geophysics (including seismology and earthquake prediction), meteorology to solar-terrestrial physics and astronomy.

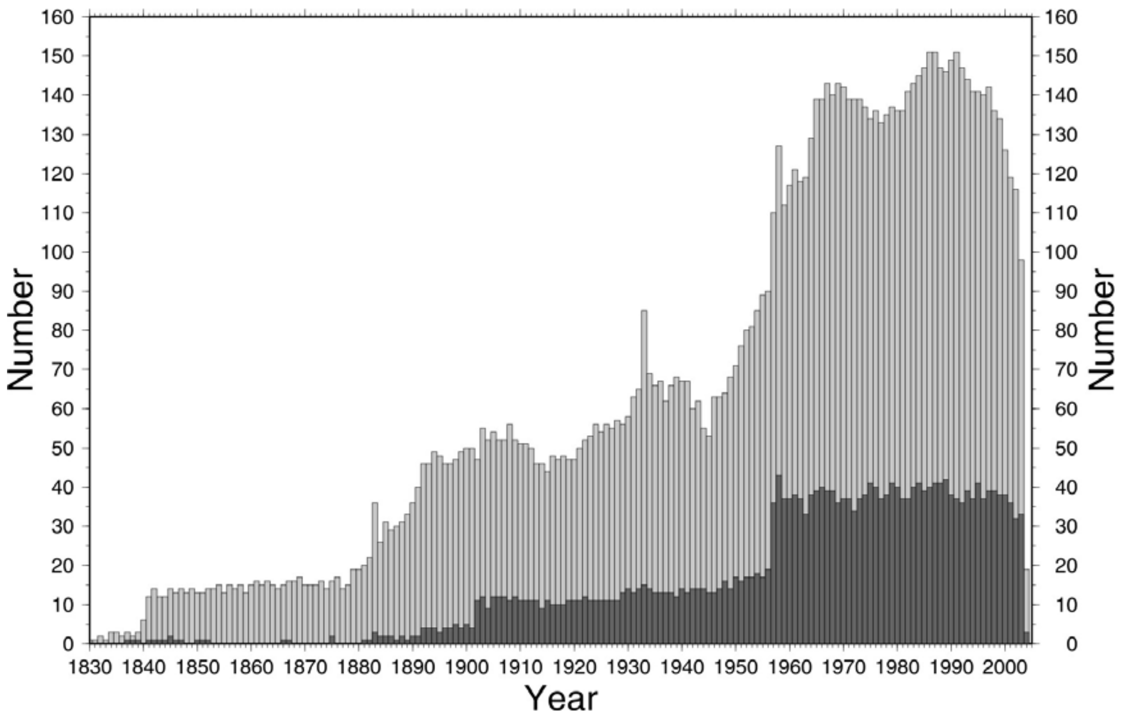

Figure 2 Numbers of observatory annual means per year in the northern and southern hemispheres

There are two main categories of instruments at an observatory. The first category comprises variometers which make continuous measurements of elements of the geomagnetic field vector but in arbitrary units, for example millimetres of photographic paper in the case of photographic systems or electrical voltage in the case of fluxgates (see *Observatory Instrumentation* and *Observatory Automation*).

Both analogue and digital variometers require temperature-controlled environments and installation on extremely stable platforms (though some modern systems are suspended and therefore compensate for platform tilt). Even with these precautions they can still be subject to drift. They operate with minimal manual intervention but the resulting data are not absolute.

The second category comprises absolute instruments which can make measurements of the magnetic field in terms of absolute physical basic units or universal physical constants. The most common types of absolute instrument are the fluxgate theodolite for measuring declination and inclination and the proton precession magnetometer for measuring total intensity. In the former the basic unit is an angle. The fluxgate sensor mounted on the telescope of a non-magnetic theodolite is used to detect when it is perpendicular to the magnetic field vector. True north is determined by reference to a fixed mark of known azimuth. This can be determined astronomically or by using a gyro attachment. In a proton precession magnetometer the universal physical constant is the gyromagnetic ratio of the proton and the basic unit is time (frequency). Measurements with a fluxgate theodolite can only be made manually whilst a proton magnetometer can operate automatically.

Final observatory data are produced by adjusting the variometer data, by application of a baseline, so that they closely fit the absolute data. In this process any long-term drifts or steps in the variometer data and differences between the sites of the variometers and absolute instruments are effectively removed. Various other instrument effects may also be included in the baselines. These are scaling factors, offsets, sensor alignments, temperature responses and timing errors. With modern digital variometers many of these effects are insignificant. If there is a back-up variometer, ideally housed in a different building on the observatory site, filling of gaps resulting from man-made noise and data loss may also be possible. Once a continuous clean time series of data reduced to the observatory reference location is obtained, final observatory products are produced and disseminated. These include one-minute means, hourly means, annual means and K indices.

There have been many efforts to standardise the operation of magnetic observatories and to expand the network. Current international efforts include the IAGA Observatory Workshops and INTERMAGNET but there are also many efforts made by individual institutes (see *Observatories in* ————). The International Association of Geomagnetism and Aeronomy (see *IAGA*) runs workshops every 2 years where information is exchanged on observatory practice and instrumentation. IAGA has also published a guide to observatory practice (Jankowski and Sucksdorff, 1996). Since the late 1980s INTERMAGNET (**Inte**rnational **R**eal-time **Mag**netic observatory **Net**work) has contributed to the establishment of global standards in the measurement, recording and dissemination of digital geomagnetic data (see *INTERMAGNET*). There are now about 100 observatories operating to INTERMAGNET standards.

The satellite magnetic survey missions of the International Decade of Geopotential Research, which started with the launch of the Ørsted satellite in 1999 (see *Ørsted* and *CHAMP*), along with increased appreciation of the effects of space weather on technological systems during magnetic storms (see *Geomagnetic Hazards*) has fuelled recent interest in geomagnetic observatory data. The many programmes to replace analogue systems with digital systems will also increase the utility of observatory data. The future for geomagnetic observatories is hopefully a bright one.

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Bibliography

Jankowski, J. and Sucksdorff, C., 1996. IAGA Guide for Magnetic Measurements and Observatory Practice. International Association of Geomagnetism and Aeronomy.

Cross References (from list at 8 August 2005)

CHAMP

Geomagnetic Hazards

IAGA

INTERMAGNET

Observatory Automation

Observatory Instrumentation

Observatories in ————

Ørsted