Geomagnetic observational activities at Alibag India

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Abstract

Before the introduction of the INTERMAGNET system (July, 1994) for nearly a century a geomagnetic observational schedule with digital magnetic observations (DIMARS) at Alibag (Lat 18° 37'N and Long 72° 52'E) was in operation. Since then the one minute digital data have been used to check and countercheck the manual scaling of photographic records, K-indices derivation, and baseline stability for both digital and analogue recordings with respect to VPPM absolute values. After the installation of 'INTERMAGNET' it became very easy to check any artificial shifts in the data. Absolute values for the horizontal, vertical, declination and inclination (H,Z,D,I) geomagnetic elements observed from different instruments such as the VPPM, BMZ, QHM, DIM, NO-7 old etc., are continuously checked before supplying the data to WDC (IIG), Mumbai. Special software routines are developed for checking the accuracy of the observations made by more than one standard and all observers will strictly adhere to the checking of the correctness of the data.

Alibag observatory attained a special status with all checks to perform on the various absolute instruments and continuous recording units of the geomagnetic field kept under an ideal electromagnetic environment. Also, the geomagnetic instruments available are periodically calibrated according to international standards and the same calibration facilities are extended to all the geomagnetic observatories functioning in the country under different agencies. Standards and facilities existing at Alibag are highlighted in this presentation.

Introduction

The study of the Earth's magnetic field is one of the oldest scientific disciplines with a history going back to Thales of Miletus (Circa 500 B.C.) who first noted the repelling action of lodestones. Ancient texts from India mentioned the specific property of iron being attracted by magnets. The Purans (4th century A.D.), in defining the devotion to the Supreme, compare it to the attraction of a magnet for an iron needle. Although magnetic materials were known long back but it only became popular with the publication of Sir William Gilbert's *De Magnet* in 1600 mentioning that the "The Earth globe itself is a great magnet". Alexander von Humboldt was the first to discover the dependency of magnetic intensity on latitude based upon measurements taken during his voyage through the America's from 1799-1805. The scientific study of the spatial and temporal structure of the Earth's magnetic field is referred to as Geomagnetism. In the 19th century, C.F. Gauss made use of mathematics to show that 99% of the observed geomagnetic field originates in the Earth's interior, and the remaining 1% comes from external sources. It was suggested that the external source lay in the electrical currents flowing in the Earth's upper atmosphere (now known as ionosphere and magnetosphere), and that the observed daily variations in the geomagnetic field reflected regular variations in these atmospheric currents. Simultaneous observations of the Earth's magnetic field were made at 50 different locations during 1836-1841, marking the beginning of the magnetic observatory system under the Gottingen Magnetic Union. Three of these locations were at Madras, Simla and Trivendrum in India. These observatories were subsequently discontinued after the project. The history of geomagnetism in India is discussed in detail in Rajaram and Pisharoty (1998).

The purpose of this presentation is to highlight the history of one of the oldest magnetic observatories in the world along with the observational procedure at this observatory.

Establishment of Magnetic Observatory at Colaba, Bombay

A regular magnetic observatory was built in Colaba, Bombay in the year 1841. This observatory was an outcome of a fortunate accident. Due to lack of proper facilities at Aden, the magnetometers meant for the observatory at Aden were diverted to the Astronomical observatory at Bombay in 1840 (both being under the control of East India Company). It took 5 years for working out the regular system of observations. The observations continued until 1905 without interruption. Initially the absolute values of horizontal intensity were determined by a unifilar magnetometer. Declination measurements commenced only in 1868. Self recording magnetographs were received in 1870 and the photographic recording commenced in 1872 and continued until 1905. The 60 years' data collected were analysed by Moos (1910 a, b) and the results were summarized in two volumes. These two volumes represent a monumental work (Chapman and Bartels, 1962).

Establishment of Alibag Observatory

In early 1900, Bombay decided to convert ordinary tram lines to electric traction. The proposed traction was within 3 km of the observatory site and hence the magnetic observations were bound to be seriously affected. Moos realized that the situation would worsen. Consequently, a farsighted decision was made to establish a new observatory at some protected site in the close neighbourhood of Bombay as early as possible, which would allow operation undisturbed from technical and urban influences for the foreseeable future. A suitable site was selected at Alibag (Lat 18°37' N, Long 72° 52' E) about 27 km SSE of Bombay, which is distant enough to be beyond the influence of electrification but near enough to have similar and comparable geomagnetic conditions, and after parallel operations of observatories for two years in 1904-05, the Colaba observatory was finally closed in 1906.

The absolute values of the geomagnetic field showed significant differences mainly due to the distances between the two locations (maximum in Z which was about 600 nT). The comparison of simultaneous observations revealed that the diurnal and seasonal variation of magnetic elements were in close agreement (to within +/- 2 nT for H and Z and 0.1' for D).

The variometers are housed in a special nonmagnetic room with effective insulation to keep the daily change in temperature inside close to zero and seasonal changes to within 3-4° C. For thermal insulation a thick wall and a wooden wall with packed saw dust and air corridor were built.

Magnetic measurements at Alibag

Various instruments for absolute and variation measurements were used at Alibag observatory since its inception as discussed by Rangarajan (1992). The old kerosene lamped variometers were subsequently replaced by the modern variometers. Presently, Bobrov quartz sensors are used to get photographic records of variations in H, Z and D. This system is still functioning as the primary variometer and is extensively used. In 1994, Alibag observatory became a part of INTERMAGNET and a Narod ring core fluxgate magnetometer was installed. The data from this system is transmitted to Kyoto in real time using a satellite facility. Although the data is made available to the International community in near real time, the same magnetic weather could not be monitored at the station in real-time. Thus, in 2001 a Danish Meteorological Institute (DMI) fluxgate was installed to monitor magnetic weather in real-time. All the variometer sensors (Quartz, Narod, DMI) are installed in triangular positions in the same room with a separation of about 8 meters between them to avoid any interference.

The old Kew pattern magnetometers for measuring H and D and the Earth inductors for measuring I have been replaced by Quartz Horizontal Magnetometers (QHM) and Zero Balance Magnetometers (BMZ) in 1950. Now modern electronic magnetometers like a Declination-

Inclination Magnetometer (DIM) and Vector Precession Magnetometer (VPPM) are used to measure the absolute values of various components of the magnetic field. These absolute instruments are used to carry out observations at least twice a week (DIM every alternate day, and VPPM thrice a day) and are checked with different baseline values obtained from photographic and digital ordinates. If any shift of baseline data is noticed, a fresh observation is made to get a new absolute. After satisfying the validity of both the absolute and variations, the data is forwarded to the Indian Institute of Geomagnetism (IIG), Mumbai for further processing and publication.

Results and Discussion

The most important features of measurements carried out at Alibag during more or less the last hundred years are summarized here:

a) The annual means of H, Z and D at Colaba and Alibag Observatories for the period 1848 to 1995 are shown in the Fig.1. Abrupt changes seen in the year 1906 are due to the relocation of the observatory from Colaba to Alibag as mentioned earlier. It is clearly seen that H attained a maximum value in the year 1965 and since then it is decreasing at the rate of 20 nT/ year. Declination was easterly till the year 1926 and became westerly after that. It was at a westerly maximum around the year 1965 and then a gradual decrease was seen after that. Z attained its maximum value around 1930 and shows a near sinusoidal secular trend with an 80 year periodicity as reported by Bhardwaj and Rangarajan (1997). 11 year solar cycle variation or the jerk observed at many observatories in 1969-70 is not clearly evident at Colaba and Alibag observatories.

b) As mentioned earlier different magnetometers are used to carry out absolute measurements. Vector proton precision magnetometer (VPPM) is used to measure absolute H and Z while declination and inclination are observed by a Declination Inclination Magnetometer (DIM). The inclination measured with the DIM is used to estimate H and Z using total field (F) measurements with PPM. Quartz sensors are used as the primary variometers while the narod fluxgate magnetometer (INTERMAGNET) is basically a backup variometer for the observatory. Combinations of various absolute instruments and variometers are found to provide quite stable baselines. The base lines for some observations using these combinations are shown in Fig. 2. Monthly mean base lines for the period August 1995 to July 2001 are drawn in Fig.3. It can be seen that the quartz variometer has frequent adjustments due to seasonal changes.

c) As mentioned earlier three different variometers are operated simultaneously to avoid any data loss. The output of these variometers is seen to be well correlated even during severe magnetic storms. The magnetic storm of 23 March 2002 recorded at Alibag by the INTERMAGNET system is shown in Fig. 4. All the finer features of the storm are clearly evident in the magnetogram. The correlation between variations of individual elements H,Z and D of the same magnetic storm recorded by the INTERMAGNET and DMI fluxgate systems are shown in Fig.5. It is clearly seen that the two systems provide identical outputs during the disturbances.

Other services

The Alibag observatory caters also the needs of other observatories and organizations in calibrating their magnetic instruments. The observatory facilities are also used to calibrate magnetic aspect sensors used on board rockets, datum and landing compasses.

Conclusion

It is well known that the objective of a geomagnetic observatory is to record continuously the time variation of the magnetic field and to maintain accurate absolute standards of measurements over a long term.

The geomagnetic observations at Colaba which began in 1841, and became very regular and systematic from 1846, has given a continuous record till now - a span of more or less 160 years. This is despite the fact that the magnetic observatory shifted from Colaba to Alibag in 1904, and the continuity of the data recording has been maintained through simultaneous measurements during 1904-1906. The importance of such a long continuous time series of data can not be overstressed. From a mere magnetic observatory in 1904, Alibag has become a calibration centre where all the instruments used in geophysical and space studies are calibrated. The observatory is scheduled to have a celebration for completing 100 years of continuous measurements at low latitudes. Only three other observatories on the Earth share this honour but they are all at high latitudes. The data collected at this observatory has been extensively used in studying the daily, seasonal, annual and secular changes in the magnetic elements, day-to-day variability, the solar control and lunar daily variations of the changes. The vertical field measurements at Alibag are used to study the coastal induction effects as it is situated on the Arabian sea coast. The one minute digital data from this station is used in deriving ASY and SYM indices.

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