Improvements on the magnetic observatory network in Brazil

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Abstract

Magnetic observatories are an important complementation for recent geomagnetic satellite missions and the only source of information about the geomagnetic field changes when no satellite data are available. A good network of ground magnetic observatories is essential to understand the processes deep in Earth's core that form the geomagnetic field, which shields our habitat against cosmic rays and solar wind. In our increasingly technologized world this becomes more and more important to estimate and prepare for the influences of space weather events like strong magnetic storms. The area of the South Atlantic magnetic anomaly is a key region both to better understand the present dipole decay and in terms of vulnerability of satellites to space weather events. This work presents the recent installed magnetic observatory in Pantanal and the plan for the installation of new magnetic observatories in Brazil and improvement of the data quality of the existing ones, in cooperation with GFZ-Potsdam.

Introduction

Magnetic observatories provide valuable information for a better understanding of both the deep Earth and the ionosphere-magnetosphere systems. Short-time magnetic variations, from seconds to years, are used in studies about the external magnetic field, such as pulsations and magnetic storms. Although long-time variations allow researches on dynamic processes in the outer core that are responsible for the generation of the main Earth magnetic field. In addition, the mantle electrical conductivity has been investigated by using geomagnetic data.

Global models of the Earth's magnetic field require data from magnetic observatories and satellites in order to represent the main features of internal and external fields (Finlay *et al.*, 2010). However, the observatory global network is unequal at the Earth's surface with most data registered in the Northern Hemisphere (Figure 1). Oceans and South continents lack magnetic field observations, despite relevant features, such as the South Atlantic Magnetic Anomaly (SAMA) and the Equatorial Electrojet.

The SAMA is the region on the Earth's surface where the magnetic field presents the weakest intensity. In this area the Earth is less protected against the external field influences. Recent researches indicate that this anomaly is generated by a reverse flux process in the outer core. Nevertheless, the physical causes of this anomaly are not completely understood, neither the effects of the external magnetic field on the Earth's surface.

The Equatorial Electrojet is the ionosphere region where a current flows eastward along the magnetic equator. Magnetic observatories between one or two degrees from the magnetic equator register larger horizontal magnetic field variations due to the influence of this phenomenon (Winch, 2007).

Motivations for new observatories in Brazil are many, including the recognizable uneven distribution of observatories in the globe and the presence of the SAMA and the Equatorial Electrojet in the Brazilian territory. Currently, there are only three magnetic observatories in Brazil: Vassouras that is located in Rio de Janeiro State and provides magnetic data since 1915; Tatuoca which is placed on an island in Belém city and measures the magnetic field since 1957; and the recent installed Pantanal observatory, located in central Brazil.

Pantanal observatory was installed in October 2012 by an international cooperation between the National Observatory (Rio de Janeiro), GFZ (Potsdam) and SESC-Pantanal (Cuiabá). The instruments to measure the magnetic field (fluxgate, overhauser and DI-flux) were donated by GFZ-Potsdam. The main infrastructure was provided by SESC-Pantanal, from who belongs the area where the observatory was placed.

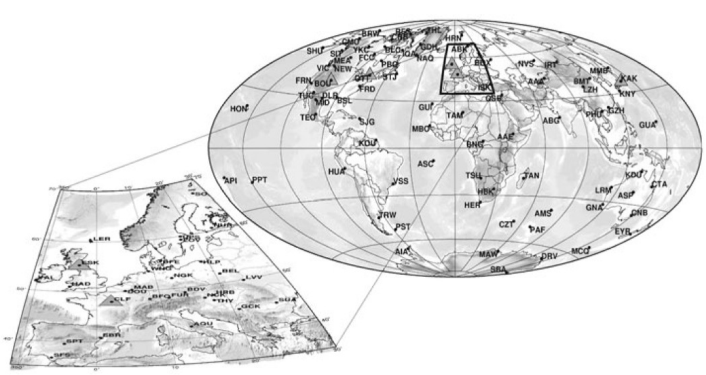

Figure 1: Global distribution of INTERMAGNET observarories. Taken from Hulot *et al.*, 2010.

Method

The installation of the new magnetic observatories in Brazil will follow the methodology applied to Pantanal Observatory (Jankowski & Sucksdorff, 1996). The first step is to choose an appropriate area, free from magnetic disturbances, as cars and electric power lines. After choosing the area, one should install a magnetic station to register the magnetic field intensity and test data quality. A magnetic gradiometer survey is performed to check whether there are any magnetic anomalies close to the locations where the instruments will be. Magnetic anomalies may be caused by a natural magnetization of the crustal field or by artifacts such as pieces of buried objects with iron content. In the last case, these objects should be removed, avoiding the possibility of strong induced fields.

After the gradiometer survey, it is possible to determine the better locations for the houses placing the instruments. The houses are planed to be about 20 meters apart to avoid any disturbance. A magnetic observatory has two main houses: the absolute house for the absolute measurements of the total field (F), magnetic declination (D) and inclination (I) and the variometer house, for the continuous measurements of three components of the magnetic field, usually north (X), east (Y) and vertical (Z).

The instruments are fixed in stable pillars inside the houses. The best is to have about three pillars in the absolute house for comparison between the measurements, and only one pillar is needed for the variometer house. The latter has to be thermally stable due to the instrument (fluxgate) sensitivity to temperature. Ideally the temperature variation should be smaller than 1ºC (Jankowski & Sucksdorff, 1996). Mires should also be constructed about 300 meters from the pillars.

After the pillars and mires placement, it is possible to fix the instruments base and determine the azimuth. There are different methodologies for azimuth determination: absolute and differential GPS and by astronomical methods. The determination of the true north is fundamental for the declination measurements. After the houses are in place, the instruments should be installed and tested.

The variometer house encloses a DTU fluxgate magnetometer, which measures three-component magnetic field, and an overhauser magnetometer (GSM19) that measures the total magnetic field, both each second. In the absolute house there is a fluxgate-theodolite (DI-flux) in order to make absolute measurements of declination (D) and inclination (I) and another overhauser (GSM90). The local staff was trained in order to do absolute measurements twice a week.

Results

In Pantanal Observatory we first investigated possible local interferences. The chosen location is about 180 km from Cuiabá city and 60 km from a small city called Poconé. A magnetic station measuring the total field component, using an overhauser magnetometer, measured the magnetic field in the region during four months. These data was analysed and no local magnetic interferences were observed (Figura 2).

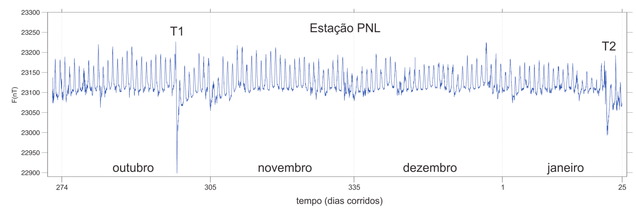

Figure 2: Data from Pantanal magnetic observatory location (total field F) from October, 2011 until January, 2012. T1 and T2 point to two magnetic storms that were registered in this data. Figure taken from Siqueira (2012).

The presence of local anomalies was also investigated by a gradiometer survey each one-meter. We selected an area of 20 x 35 meters, where mostly gradients of 0.5 nT/m were found. The maximum gradient detected was 3 nT/m and this specific location was avoided in the houses placements. All materials used to construct the houses were also tested. Pantanal Magnetic Observatory started working in 24^{th} October, 2012, when also the first absolute measurement was taken.

A new fluxgate magnetometer, the same as the one existing in Pantanal, will be installed in Vassouras magnetic observatory in November 2013. The goal is to improve data quality and transmit in real-time to INTERMAGNET. The data processing and first analysis will be performed following the same methodology as in Pantanal. For the Tatuoca magnetic observatory we plan a collaboration with the Geophysics and Meteorological Institute from the Federal University of Pará (UFPA) for improvements in the infrastructure, replacement of magnetometers and installation of new geophysical and meteorological instruments.

There is a plan to install a net of more five magnetic observatories in Brazil (Figure 3). There is a work in progress for the installation of a new magnetic observatory in Amazon (Tefé city) in collaboration with GFZ- Potsdam and Mamirauá Institute. The location was already chosen, inside Mamirauá Institute, which is protected and has all the necessary infrastructure and available local staff. A magnetic gradiometer survey was done and no local anomalies were detected in the chosen area.

Figure 3. Map showing the present Brazilian observatories and the future ones.

Conclusions

This work presents the planning for the improvement of the geomagnetic observatory network in Brazil. The installation of a new magnetic observatory in Pantanal was done in 2012 and the first results are showed. A new magnetic observatory in Tefé city (Amazon) is in the process of construction, which is also reported in this paper. The acquisition of new quality data in Brazil may contribute to the knowledge of geomagnetic phenomena as the equatorial electrojet and the South Atlantic Magnetic Anomaly. In addition, new observatories in Brazil will provide valuable data in the South American region, which will contribute to the global modeling of the geomagnetic field.

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