Geomagnetic field observations in Amazon: implications for the new magnetic observatory

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Abstract

Magnetic observatories are important sources of continuous and precise geomagnetic data. Their spatial distribution around the globe is uneven, especially in ocean areas and South America. New magnetic observatories are being established in Brazil and the next one will be in Amazon. We installed a magnetic station to test data quality in the chosen location for the future observatory. In this work we analyse all magnetic data from Amazon that is available on the National Observatory: old measurements of repeat stations and the new station for the observatory placement. Some aspects about the installation, data quality and processing are discussed.

Introduction

The geomagnetic field varies in a wide temporal spectrum: from milliseconds to million of years. The internal field of the core is generated by the geodynamo process while the external field is produced by the interaction of the solar wind with the main field (Hulot *et al.*, 2010). The core field varies in a long-period time scale- from few years to centuries- called secular variation. The external field varies in a usually shorter time scale, from milliseconds up to the solar cycle (11 years). For example, daily variations and magnetic storms are originated in the magnetosphere-ionosphere system, from hours to days.

Geomagnetic data may be obtained in stations, surveys, observatories and satellites. Global field models usually include observatory and satellite data on the attempt to understand some open issues of geomagnetism, such as how the magnetic field is generated in the core. But satellite data were not continuous during the time; there was a gap from 1984 until 1998.

Magnetic observatories provide the most continuous and precise measurements of the Earth's magnetic field, from seconds to hundreds of years. They give the opportunity to study both the internal and external fields. However, the distribution of observatories around the globe is uneven, especially in South America. In Brazil, there are only three magnetic observatories (from the National Observatory): Vassouras (Rio de Janeiro), Tatuoca (Pará) and the new observatory in Pantanal (Mato Grosso) in collaboration with SESC-Pantanal.

We plan to construct six new observatories in Brazil, as showed in Figure 1. The next one will be installed in Amazon (Tefé), in cooperation with Mamirauá Institute.

Figure 1 –Map showing the present Brazilian observatories and the future ones.

Methodology

The installation of the new magnetic observatory in Amazon 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, see Figure 02).

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.

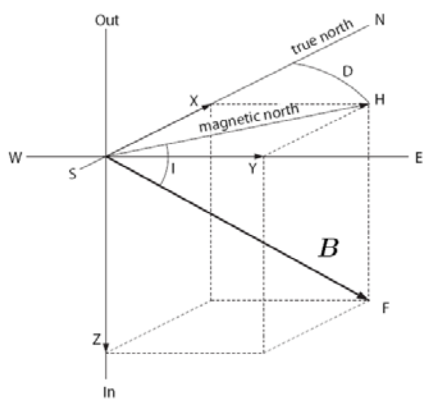

Figure 2 –Components of the Earth's magnetic field.

Magnetic observatories require absolute measurements twice a week. These measurements are used to calculate base-lines which calibrate the continuous records on the variometer house. One important issue is the training of the local staff that will do the base-lines from absolute measurements. It is also required internet conexion for transmitting the data in real time.

The Amazon magnetic data from repeat stations are compared with IGRF-11 model (International Geomagnetic Reference Field, Finlay *et al.,* 2010). The time evolution of the magnetic field in Amazon is discussed. Tests of data quality and noise in the magnetic station are done.

Results and Discussion

- Amazon Magnetic Station for the installation of a new magnetic observatory

The area chosen for the installation of the new magnetic observatory in Amazon (Figure 3) is in the campus of Mamirauá Institute, in Tefé city. The advantages are the available infrastructure, easy access to the area, local staff that works in Mamirauá and internet conexion.

We selected an area for performing tests of data quality and for the gradiometer survey, delimited from points P1 to P4 (Figure 3). The magnetic station changed in these four points in order to check if the four limits are not influenced by any noise. There are two small streets about 100 meters from the area. We have done some tests to check whether cars could cause any disturbance. Two magnetometers overhauser (GSM-90 and GSM-19) were used and the data was compared. Cars passing on the two streets did not affect the natural variation of the magnetic field.

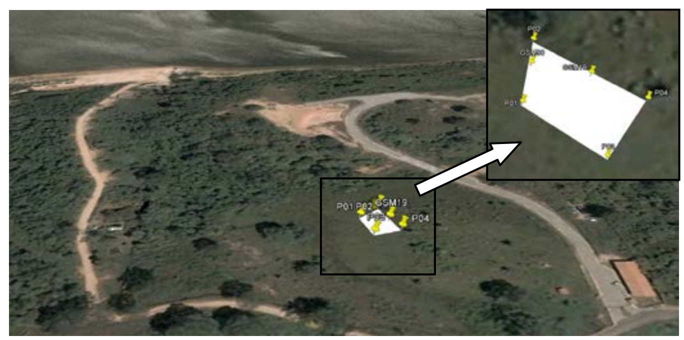

Figure 3 – Chosen area for the installation of Amazon observatory. The geographical coordinates of each point are (GPS precision of ±3m):
P01: 3°21' 17,3'' S, 64°43' 57,2'' W
P02: 3°21' 16,8'' S, 64°43' 56,9'' W
P03: 3°21' 18,0'' S, 64°43' 56,8'' W
P04: 3°21' 17,7'' S, 64°43' 56,3'' W

The installation of a magnetic station includes some issues, as how to provide energy necessary for the equipments. In the case of Amazon, an inverter was installed to transform from direct current (DC) to alternating current (AC), for the laptop use. We noticed in the data that the inverter caused some noise (Figure 4) and that it should be removed. We measured the magnetic field in the next day without the inverter during the same time of the previous day, and notice no such noise in the data.

Amazon Repeat Stations

There are nine repeat stations in the Amazonas state, shown in Figure 5. The first measurement was done in 1910 in Manaus. Tefé city has also repeat station measurement since 1952. The time variations of the total field and horizontal component are shown in Figure 6.

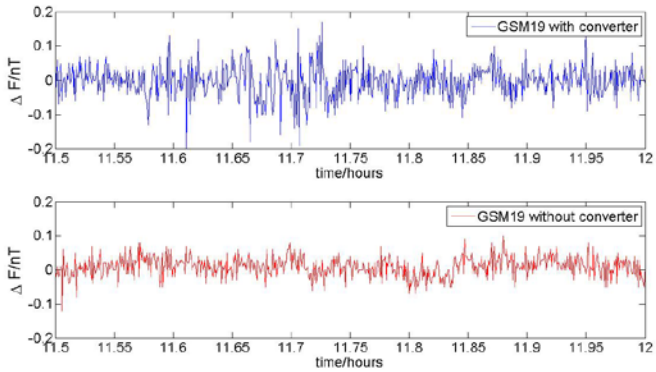

Figura 4 – Tests with inverter close to the magnetometer GSM19 and without the inverter.

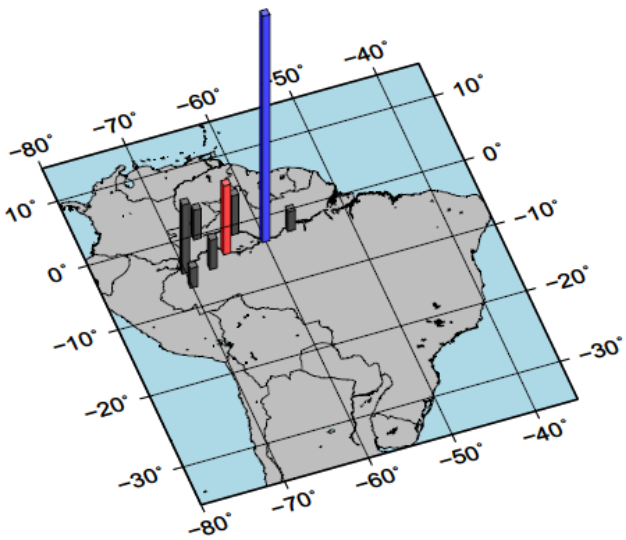

Figura 5 –Map showing the repeat stations in Amazon. The bars represent the number of data measured. The blue bar is located in Manaus with 24 data measured and the red bar located in Tefé (8 data measured).

Note by figure 6 that the horizontal component of the magnetic field (H) in Amazon region is close to total magnetic field intensity (F). That shows the proximity of Amazon region to the magnetic equator. This is an interesting geomagnetic region to be analysed due to the existence of the equatorial electrojet.

Manaus station data was selected to be compared with the IGRF global model from 1900 until 2015. Annual values were calculated from IGRF models to compare with the available data (Figure 7). The results show that the dataset and the model agree considerably well and that the total magnetic field is close to the value of the horizontal component. The projection for the future shows that the magnetic equator will get even closer to Amazon region.

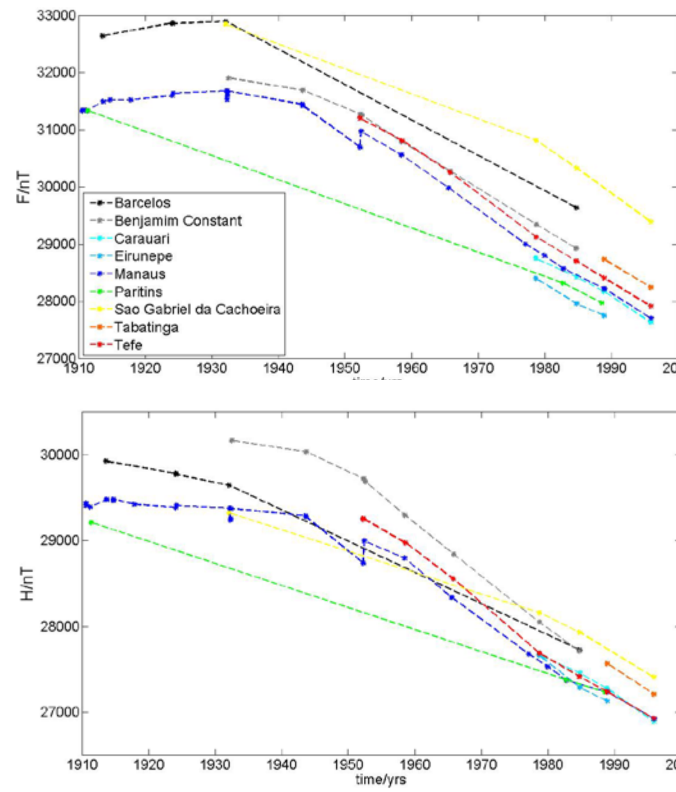

Figura 6 –Time variation of the total magnetic field (upper panel) and horizontal component (lower panel) of nine repeat stations in the Amazonas state, as shown by the legend.

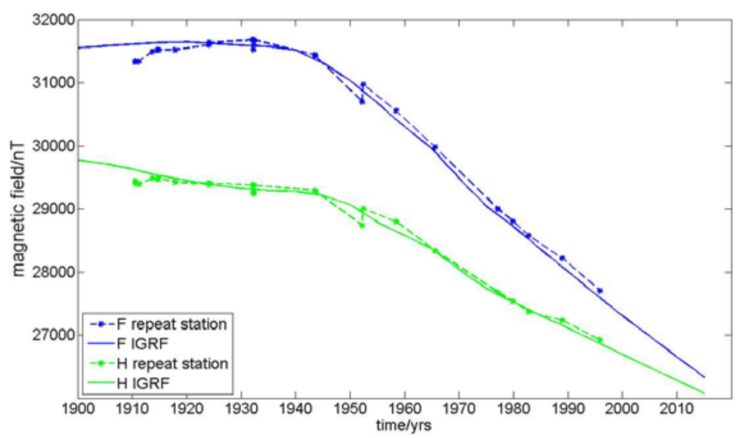

Figure 7– Comparison of Manaus repeat station with the IGRF model, calculated for the same location.

Conclusion

Two datasets from Amazon were analysed in this work: repeat stations and magnetic station for the installation of the future observatory. The results of the repeat stations analysis agree with the IGRF model. Both indicate that the magnetic equator is getting closer to the Amazon region (in Manaus). The location chosen to install the magnetic observatory in Tefé (Mamirauá Institute) was tested and it is free from magnetic noise. This location presents the advantage of having all the necessary infrastructure and staff available. The Amazon region is interesting due to the presence of the magnetic equator and equatorial electrojet. More data and modeling will provide the chance to better understand about the interaction between the internal and external fields in this location.

Acknowledge

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References

Finlay, C. C. et al. (06 co-authors), 2010. Evaluation of candidate geomagnetic field models for IGRF-11. Earth Planets Space, 1–19.

Hulot, G. et al. (05 co-authors), 2010. The Magnetic Field of Planet Earth. Space Sci Rev (2010) 152: 159–222 DOI 10.1007/s11214-010-9644-0

Jankowski, J. & Sucksdorff, C., 1996, Guide for magnetic measurements and observatory practice. International Association of Geomagnetism and Aeronomy.