The new Easter Island magnetic observatory

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Abstract

A new magnetic observatory has been installed in 2008 in Easter Island, as part of a collaboration project between Direccion Meteorologica de Chile (DMC) and Institut de Physique du Globe de Paris (IPGP). The new observatory is located on the premises of Mataveri airport, at enough distance from the planes but still within the secured area. It is designed to meet INTERMAGNET's operational standards and data quality requirements and to provide one-second data. Variation data are provided on a continuous basis since August 2008 and absolute measurements are expected to begin before the end of 2008. This new observatory is extremely isolated, at about 3900 km from the closest INTERMAGNET observatory in Huancayo, and will thus significantly improve the global distribution of magnetic observatories at the Earth's surface. Data from the new Easter Island magnetic observatory will be particularly useful for main field and secular variation modeling, and for global studies of magnetic variations of external origin, such as geomagnetic pulsations and the Sq daily variation.

1. Introduction

Considering its geographical location, Easter Island is an ideal spot for installing a new magnetic observatory. It is located in the Southern Pacific Ocean, about 3700 km west of continental Chile, and actually is one of the world's remotest inhabited island. The Huancayo observatory (Peru), which is currently the most isolated INTERMAGNET observatory (IMO), is located 3153 km from Kourou (French Guyana), its nearest neighbor. An IMO in Easter Island would become the most isolated of the network, about 3927 km from Huancayo in the East direction and 4249 km from Pamatai (Tahiti) in the West direction (Fig. 1). It would be one of the very few IMOs in the Pacific Ocean, with Pamataï, Honolulu (Hawaï) and Guam (Marianna Islands), and one of the few IMOs in the Southern hemisphere. It would thus significantly improve the global geographical distribution of INTERMAGNET, which would make it useful for a wide range of scientific studies (Love, 2008). An observatory in Easter Island would provide useful data for main field and secular variation modeling, particularly at times when no satellite data are available (for example in 2010), for investigating geomagnetic jerks (e.g., Olsen and Mandea, 2007), for validating global models of the mid-latitude Sq field (Sabaka et al., 2002) and of the quiet-time magnetospheric field (Maus and Lühr, 2005), and for studying other external variations such as magnetic pulsations (e.g., Uozumi *et al.*, 2000) and solar flare effects (Gaya-Piqué *et al.*, 2008).

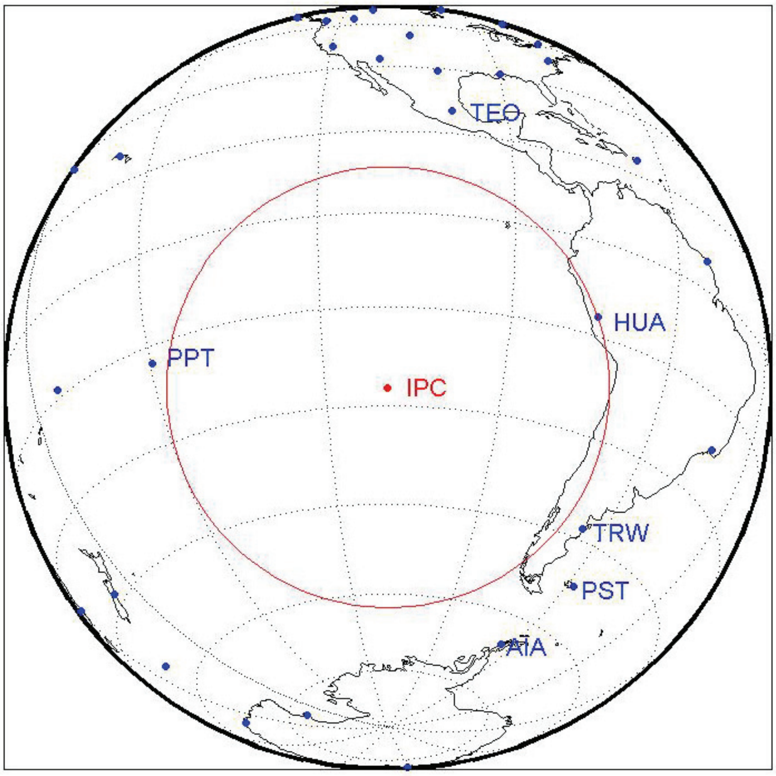

Figure 1: Geographical situation of the new Easter Island magnetic observatory (temporary code IPC) with respect to the nearest INTERMAGNET observatories. The represented observatories are (in distance increasing order) Huancayo (HUA), Pamataï (PPT), Trelew (TRW), Port Stanley (PST), Vernadsky (AIA), Teoloyucan (TEO).

Based on this motivation, INTERMAGNET recommended about ten years ago the installation of a magnetic observatory in Easter Island. IPGP volunteered for this installation, but difficulties with a first Chilean partner slowed down the project for several years. The project restarted in 2006 with a new partner, the Direccion Meteorologica de Chile (DMC), with whom a formal agreement was signed in November 2007. The installation began soon afterwards and was completed in August 2008. Absolute measurements are set to begin in Spring 2009. This paper presents the layout and instrumentation of this new observatory, as well as its first data.

Note that it is not the first time a magnetic observatory is installed in Easter Island. According to the Data Catalogue of the WDC for Geomagnetism, Kyoto, an observatory (of IAGA code EIC) was in operation in Easter Island from March 1958 to January 1964. This observatory seems to have experienced several interruptions and problems and only one year of definitive hourly values (from February 1963 to January 1964) is available.

2. Layout and instrumentation

The new Easter Island observatory is located on the premises of the Mataveri airport, at the end of the runway opposite from the terminal and other airport buildings (Fig. 2). The airport single runway is 3.3 km long and was once designed as an emergency landing site for NASA's Space Shuttle. There are usually between one and two flights everyday from and to Easter Island. Most take-offs and landings occur on the western side of the runway. Occasionally a plane will pass in front of the observatory site (at about 100 m) but the perturbation is of short duration (up to a few min) and easily detectable in the recordings. Another source of perturbations is a stone quarry nearby with a few trucks coming and going and producing disturbances of a few nT for a few sec.

Figure 2: Google Earth view of the Mataveri airport area on Easter Island. The new magnetic observatory is indicated by a yellow marker.

These perturbations would certainly be considered unacceptable in a less remote observatory. However, in the case of Easter Island it was decided to live with them, as the choice of the observatory site was heavily constrained by several factors. The site had to: (a) be within short distance and easily accessible from the meteorological station (Fig. 3), where the team in charge of absolute measurements is based, in order to reduce the amount of time needed to travel to and from the observatory site; (b) be within the gated airport area, in order to avoid vandalism by human beings and degradations and / or perturbations by wild horses (there are several thousand wild horses on Easter Island, many of them with steel horseshoes); (c) be far enough from the airport terminal, from the planned location of a second runway to be constructed in the coming years, and from the road exiting from the city of Hanga Roa in the North; (d) comply with safety regulations imposed by the airport authorities.

Figure 3: View of the Easter Island meteorological station.

A local survey of the observatory site was carried out using an Overhauser proton magnetometer in order to avoid large magnetic anomalies. As Easter Island is the summit of a large volcanic mountain, the magnetic gradient is high everywhere and there are a lot of intense anomalies. This was confirmed by quick surveys in other sites on the airport. We selected an area where the gradient is about 20 nT / m in all directions, which was considered suitable for the installation of the observatory instruments.

The observatory was built in two steps. In February 2008, two reinforced fiberglass pillars were built at about 20 m from each other. Each pillar was rooted in a 80 cm thick non-magnetic fiber-reinforced concrete basement buried in the soil. A 2 m x 2 m platform made of non-magnetic fiber-reinforced concrete was then built around each pillar, but dissociated from it. In May 2008, the absolute hut and the variometer container were installed (Fig. 4). The walls of the 2 m x 2 m x 2.20 m absolute hut are made of aluminum and honeycomb fiberglass panels, and its roof is a transparent plastic dome enabling the sun light to enter the hut from above. There is a sliding door on one face of the hut, and a small hole on another face enabling the observer to target the azimuth mark with the theodolite. In order to reduce the daily temperature variation in the variometer container, a 14-layer thermal insulation cover was wrapped around it and dozens of bottles filled with water (450 l) were placed inside of it to increase thermal inertia. As a result, the daily temperature variation within the container is less than 1°C.

Figure 4: View of the absolute hut (front) and variometer container (back) of the new magnetic observatory in May 2008.

The magnetic variations are continuously recorded by two instruments located within the variometer container and distant by about 2 m from each other: a 3-axis homocentric fluxgate magnetometer IPGP VM391 (Fig. 5) and an Overhauser-type scalar magnetometer GEOMAG SM90. The IPGP VM391 has been developed by one of us (X. Lalanne) at IPGP since the mid-1990s and is installed in all IPGP magnetic observatories and in several other magnetic observatories throughout the world (Courtillot and Chulliat, 2008). It is homocentric, that is, it measures the three components of the magnetic field at the same point. This property is particularly useful in volcanic islands like Easter Island, where the magnetic gradient is large. The fluxgate magnetometer samples the magnetic field at 5 Hz and produces one-second data using a Gaussian digital filter (see Chulliat et al., 2009). The scalar magnetometer samples the field every five seconds.

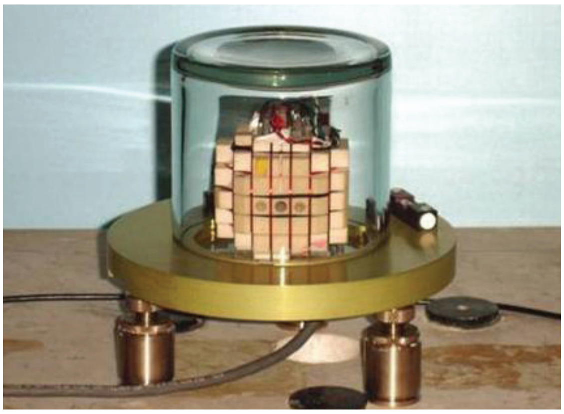

Figure 5: The IPGP VM391 fluxgate magnetometer.

Electric power is supplied by the airport and is available from a nearby meteorological station. Magnetic data and environmental station parameters are transmitted via an Ethernet radio link to the meteorological station office, where the data logging computer is installed[1]. This method was preferred to a fiber-optic cable because of the large distance between the container and the office and the impossibility to cross the runway. Data are then automatically transmitted to a server in Paris via ftp. Due to an unexpected delay in the customs of some pieces of the radio link, the data transmission system started operating in August 2008.

Absolute measurements will be performed by the staff of the airport meteorological station, using a DI-flux constituted of a thedolite Zeiss 010 and a fluxgate magnetometer Bartington MagO1H. Pillar differences (between the absolute measurement pillar and the scalar magnetometer pillar in the variometer container) will be regularly measured using a scalar magnetometer Geometrix G856. These measurements have not started yet, in part because of the lack of data transmission which hampered the training sessions during our visit to the island in May 2008. They are planned to start in Spring 2009, once additional on-site training has been carried out. The observatory site is easily accessible by airport vehicles having permission to drive on the runway. The airport VOR (VHF Omnidirectional Range navigation system) antenna, located about 1 km from the absolute measurement pillar, is used as azimuth mark. Its precise azimuth was determined using two geodetic GPS receivers to within an accuracy of ±10”. The pillar position (in WGS84 geodetic coordinates) is: Latitude = 27°10’16.69656” S, Longitude = 109°24’35.53131” W, Elevation = 82.834 m, with an accuracy estimated at ±0.0002” (latitude, longitude) and ±0.01 m (elevation).

3. First data

The magnetometers and data acquisition system have been working without interruption since their start in mid-August 2008. As an illustration, the variation data for August 30, 2008 are displayed on Fig. 6, with a vector magnetometer oriented in HEZ. A daily variation is visible on both horizontal components and on the scalar field, with amplitude of about 20 nT on the H component and 50 nT on the E component. A very similar daily variation was observed at the Pamataï observatory (Tahiti) a few hours later (Fig. 7), thus confirming the satisfying operation of the variation recordings in Easter Island. Note that the amplitude of the scalar residual is slightly larger in Easter Island, where filtered one-second data are recorded, than in Pamataï, where filtered one-minute data are recorded; this is not surprising since the amount of noise increases with the cut-off frequency. The amplitude of the scalar residual daily variation is much smaller than 1 nT, and seems even slightly smaller than in Tahiti.

[1] We recently found preferable to install the data logging system near the instruments and to transmit the data to an internet node in the station office via the radio link. This upgrade will be implemented in Spring 2009.

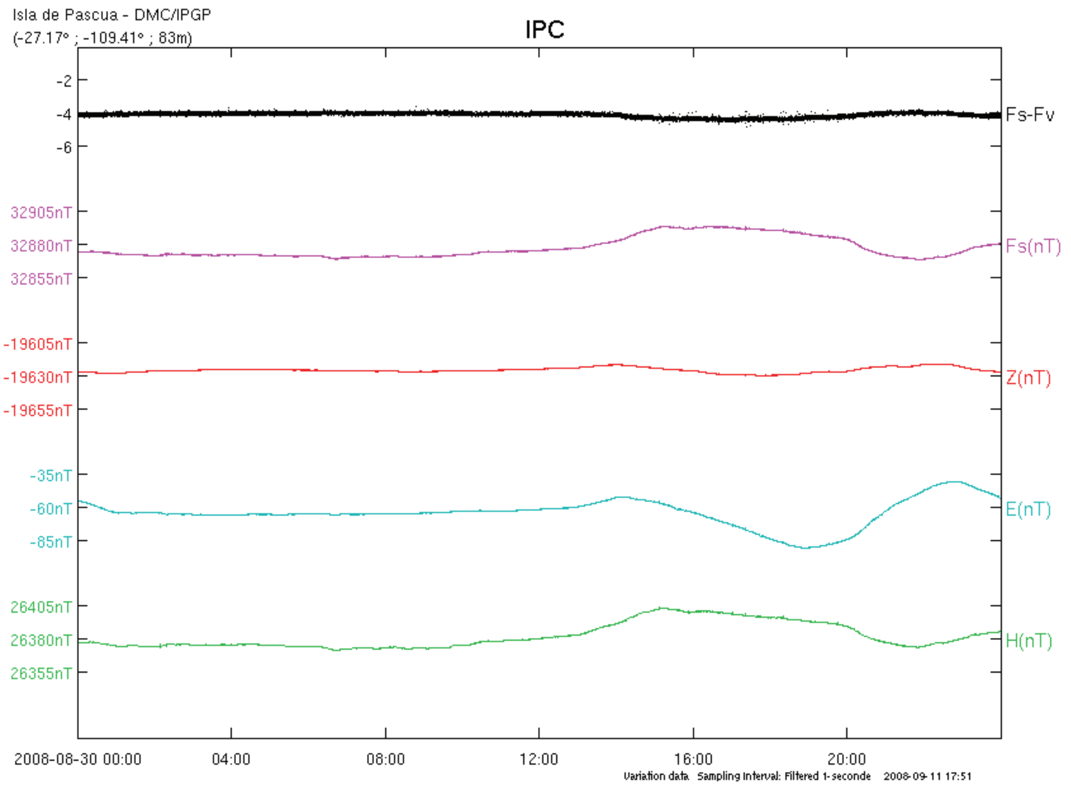

Figure 6: Variation data recorded at Easter Island observatory on August 30, 2008. H, E and Z (sampled every second) are the three components of the vector magnetometer, approximately oriented in the North, East and downward vertical directions. A constant, approximate baseline is applied to the data. Fs (sampled every five seconds) is the measured scalar field. Fv is the scalar field calculated from the vector components.

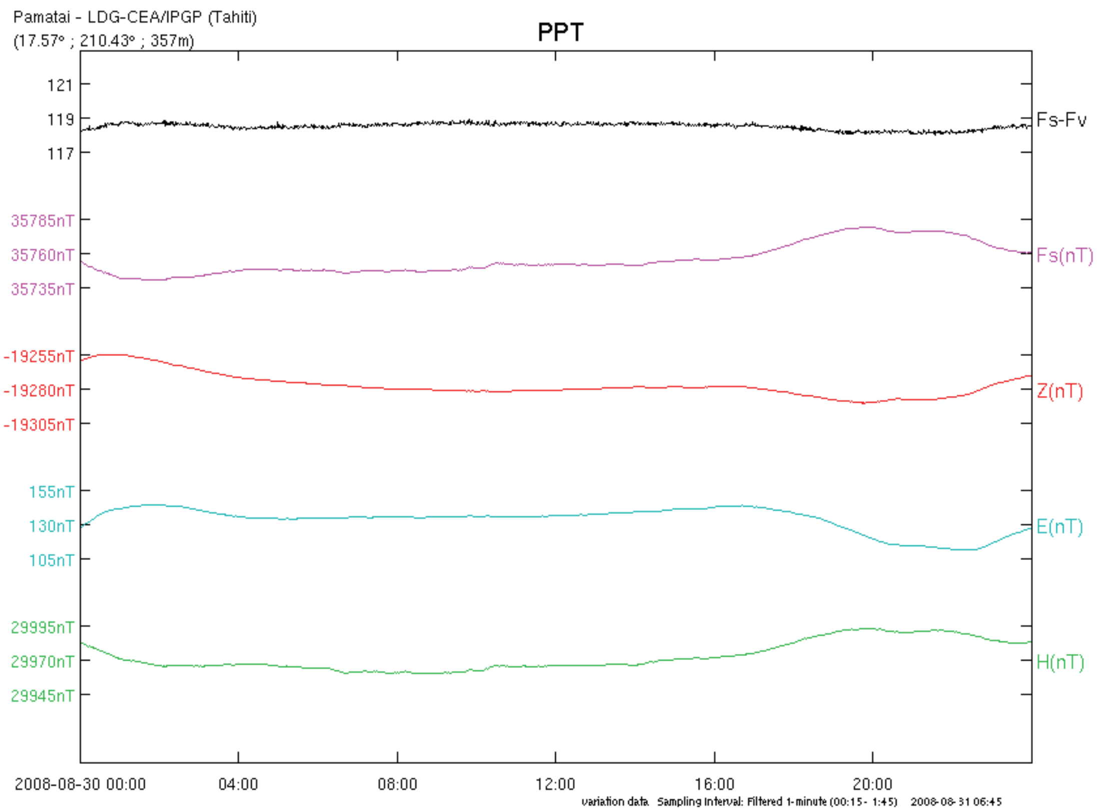

Figure 7: Variation data recorded at Pamataï observatory (PPT) on August 30, 2008. Same conventions as in Fig. 6, except that vector data are one-minute data.

The main problem with the data is the existence of disturbances produced by trucks circulating on the road to the nearby stone quarry. These disturbances last a few seconds and their amplitude never exceeds a few nT. They would remain unnoticed if only one-minute data were recorded. They have a typical signature that cannot be mixed with real sub-minute geomagnetic events and have to be removed by hand, leaving a few gaps every day (on average) in one-second data.

4. Summary

A new magnetic observatory has been installed in Easter Island, on the premises of the Mataveri airport, on the base of a cooperation between Direccion Meteorologica de Chile (DMC) and Institut de Physique du Globe de Paris (IPGP). The instruments and data acquisition system satisfy INTERMAGNET requirements and are able to produce filtered, accurately dated one-second data. The continuous variometer recordings started in August 2008 and are working properly, except some transmission problems that remain to be fixed. Absolute measurements will begin before the end of 2008, once the training of the local staff has been completed. This new observatory is designed to become an INTERMAGNET observatory after the starting phase.

The Easter Island observatory will provide high-quality magnetic data from an extremely isolated location, at about 3900 km from the nearest INTERMAGNET observatory. This unique geographical location should make it very useful in the future, for internal field studies as well as external field studies.

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