A Digital Magnetic Observatory in Trelew, Patagonia

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Resumen

Describimos la modernización del Observatorio Magnético Argentino de Trelew. Justificamos la selección de este observatorio en base a consideraciones científicas.

Se describe la nueva instrumentación instalada en el observatorio: magnetómetro de protones, variómetro "fluxgate", teodolito "Diflux" y sistema de adquisición de datos digitales. También se discuten los aspectos presupuestarios y administrativos.

Abstract

We present the modernization or the Argentinian Magnetic Observatory of Trelew. We justify the choice of this observatory on scientific gounds.

The new instrumentation installed in the observatory is described: proton magnetometer, fluxgate variometer, Diflux theodolite and digital data acquisition system. The budgetary and administrative aspects are also dealt with.

Introduction

The second resolution of the International Association of Geomagnetism and Aeronomy (IAGA) adopted at the Vienna General Assembly of the International Union of Geodesy and Geophysics in 1991 recommends "that those organizations in the developed countries that run magnetic observatory programs should each adopt one

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or more observatories facing problems and provide the necessary assistance and training to ensure continuing operation at a satisfactory standard, and that government funding agencies should consider this as a routine part of their international obligation to developping countries" (IAGA, 1991). In 1992, IAGA announced Program Outreach which provides a central point through which contacts between potential donor observatories and those in need can be made (Williams, 1992).

Given the good relations existing between argentinian and belgian geophysicists, contacts were already established in late 1991 for studying the possibility for Belgium to help in improving the geomagnetic observatories of Argentina.

Choice of Trelew

We finally opted for a modernisation of the Trelew Observatory situated in the Chubut province, Argentinian Patagonia. The coordinates are:

Latitude: -43.27° Longitude: 294.62°

The main reason for which we choose this observatory is that it is situated in a region where Observatories are very scarce. It is one of the few to lie between -40° and -60° degrees of latitude. The second reason is that the morphology of the geomagnetic field is extremely peculiar over this part of South-America. There is presently a record low in the modulus of the geomagnetic vector over eastern Brasil and Argentina. For instance, the mean value of the modulus is about 27000 nT at the Observatory of Trelew. This large scale feature of the geomagnetic field is of importance in a number of recent studies on the mechanism for geomagnetic polarity reversals (Gubbins, 1987), effect of the Earth's inner core on geomagnetic fluctuation and reversals (Gubbins, 1993) (Hollerbach, Jones, 1993) and dynamo models (Gubbins, Sarson, 1994). A third reason is that the Trelew observatory is a reference station for computing the K index and that it is chronically late for providing this data to the data center.

Therefore, it was felt that the help needed would better be materialised in the form of a complete digital observatory consisting of fluxgate sensors and a recording proton precession magnetometer. For good baseline control a DIflux would also be needed.

Management of the budgetary aspects

It was decided that the instrumentation (except the recording PC) would be a free long term loan from the Royal Meteorological Institute of Belgium (RMIB) to the University of La Plata (UNLP). In this manner, we did not run into difficulties with the administration at RMIB since nothing was effectively removed from RMIB's estate. The instrumentation was mainly assembled from the unused pool of instruments belonging to the belgian magnetic observatories of Dourbes and Manhay. Specifically new equipment was a custom fluxgate sensor, digitizer and parallel I/O interface cards, a dual power (24VDC 220VAC) PC and system power supply and battery charger. As the installation in Trelew was to be done directly after the 1993 IAGA assembly in Buenos Aires, this equipment was transported as cabin and compartment luggage by one of us attending the assembly.

UNLP bought the PC and the batteries, cared for transport from Buenos Aires to Trelew and for our living expenses during the two weeks necessary for the installation.

All those arrangements were registered in an "Acuerdo" undersigned by UNLP and RMIB before the operation began.

Instrumentation

The variometer

The design goal was to realize a Declination-Inclination (DI) variometer for Trelew with a variational sensitivity of about 1 second of arc for both variables and a dynamic range of 2 degrees of arc. The long term stability should be better than 30 seconds of arc per year and the temperature coefficient lower than 10 seconds of arc per degree K. We tried to achieve this by combining the following devices: The frame of an Askania rotating coil inclinometer. A biaxial ringcore fluxgate magnetometer.

The ringcore was a custom product made by the Special Design Division of the Institute of Physics and Mechanics in Lviv, Ukraine. The specifications called for a range of 2000 nT, 0.1 nT variational sensitivity, and nonorthogonality of the sensitive axis lower than 10 minutes of arc. We removed all the rotating coil parts of the inclinometer and constructed an aluminium-teflon-marble assembly (Figure 1) destined at holding the fluxgate in the correct position at the centre of the now absent coil. The inclinometer frame has a vertical rotation axis and a horizontal rotation axis, just like a theodolite. Levelling is done with the special Askania levelling device which is temporarly positioned on the horizontal axis journals and by obtaining equal readings of the level in orthogonal directions. The inclinometer frame provides all the mechanical controls and the slow motion adjustments necessary to position the ringcore correctly, i.e. with its axis aligned with the geomagnetic field vector. As the ringcore has its two sensitive axis perpendicular to each other and in its plane, the next adjustment is done by rotating the marmor cylinder carrying the ringcore with respect to the aluminium support. The correct position is reached when one sensitive axis (this is the declination axis D) is perfectly horizontal, that is parallel to the horizontal rotation axis of the inclinometer. It is easy to check the correctness of this adjustment since any rotation around the horizontal axis of the inclinometer should give no change in the D output signal of the fluxgate electronics. Of course

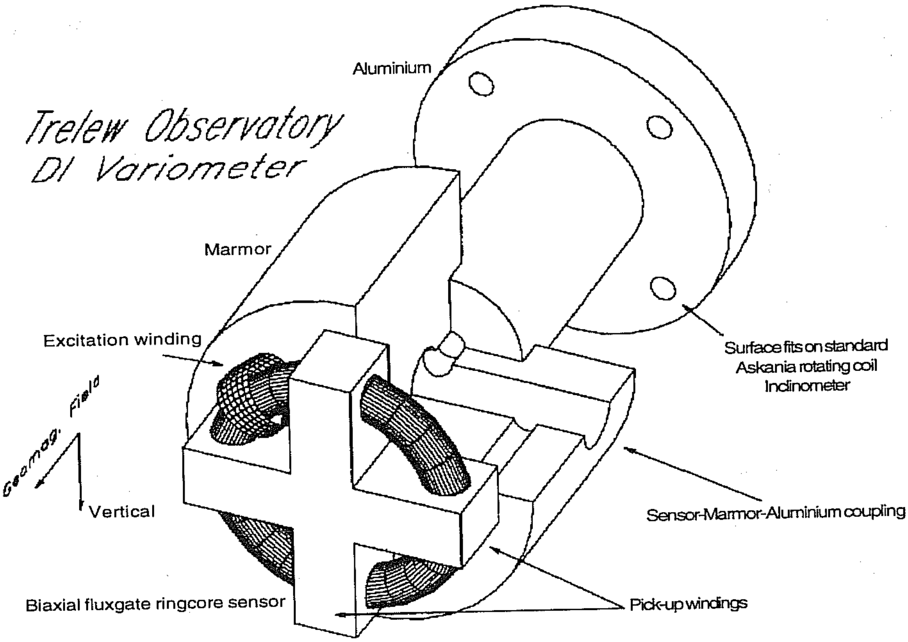

Figure 1. The aluminium-teflon-marble assembly. It allows the mounting of the biaxial fluxgate on an inclinometer frame. It is held by 4 screws at the rear. The hole in the marble cylinder allows insertion of a teflon rod on wich the fluxgate is fixed by two screws (not shown). An axial screw in the aluminium support also clamps the marmor cylinder on the support by insertion in the teflon rod.

the other sensitive axis (this is the inclinaition axis I) is then optimally adjusted to record the variation in inclination within the specified nonorthogonality.

It is noteworthy to point out that both the fluxgate sensors in the ringcore are working in "zero field" when set-up like that. The measurements are made around the null point of the sensors and no compensation field has to be generated. This removes one of the sources of thermal and long term drift in the fluxgate variometer.

Another advantage comes from the fact that the two measured components of the geomagnetic field are identical to the ones measured by a DIflux. This ensures complete independence in the data processing and the baseline determination. Should one channel of the variometer fail or should one measurement of the absolute session be bad or even should the proton precession magnetometer malfunction, it would leave the measurement of the other channel unaffected, valid and usefull. This is not true for a XYZ variometer whose bases are determined with a DIflux and a proton precession magnetometer. The formula allowing to compute the variations in declination dD and in inclination dI in degrees from the data D and I stored on diskette is given by:

$$dD = \arcsin\{(D/V)x(1/H)\}$$

and

$$dI = \arcsin\{(I/W)x(1/F)\},$$

where H and F are the mean value of the horizontal and total component respectively of the geomagnetic field in Trelew (typically H:20000nT, F:27000nT). V and W are the scale factors and were measured in Dourbes by comparing with other variometers having well known scale value. They depend on the fluxgate electronics, the preamplifier gains and the AD converter gain. They were found to be given with an accuracy of about 2% by:

$$V = 7.6\ , W = 7.6.$$

The recording proton precession magnetometer

The proton precession magnetometer (ppm) is of ELSEC 880 type. It was set for continuous measurement. We suitably transformed it for communication with a parallel I/O PC card. Therefore the BCD and digit lines coming from the MC145345 decade counter chip in the ppm electronics along with some control lines where level-shifted to 5V and sent to the I/O card. This gave a compact interface unit allowing the ppm electronics to stay well away from the PC computer. This also left most of the acquisition job to be done by the software.

The ppm was tested in Dourbes (F = 48000 nT) in an artificially decreased field to confirm its satisfactory operation at around 27000 nT. Upon installation in Trelew, considerable difficulties were experienced with this magnetometer: It would not make any reasonable measurement at the beginning. After extensive troubleshooting, it was noted that the PC was perturbing the ppm operation. Indeed, PC's are known to radiate a lot of electromagnetic noise. The problem was corrected by installing the ppm electronics as far as possible from the PC and by installing a ground (earth) plate with an earth line connected to the PC chassis. The ppm will continuously measure the total magnetic field at a rate of 1 sample every 6 seconds with a resolution of 0.25 nT.

The DIflux

The DIflux was assembled from a F.W. Breithaupt & Sohn brass theodolite and an ELSEC type 810 fluxgate magnetometer. The theodolite has better than 1 second of arc accuracy but has no automatic height index like the Zeiss 010B. Hence, the horizontal reference for the vertical circle has to be observed with the height index

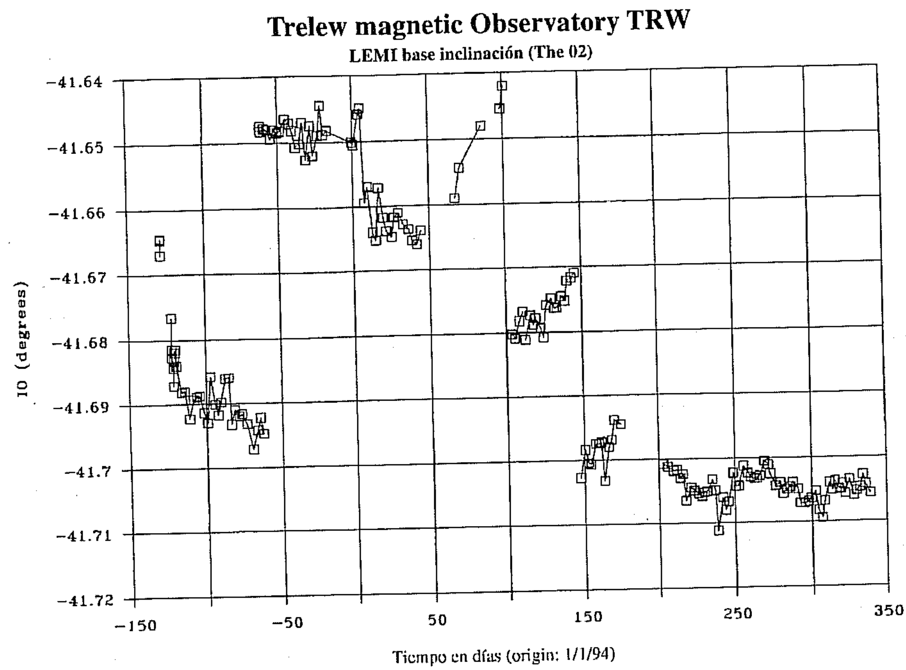

Figure 2. Evolution of the inclination baseline of the variometer as given by the DIflux for more than 400 days after the installation in Trelew. The jump are due to baseline adjustments.

bubble (Deumlich, 1980). The graduated circles are read by two separate microscopes at 180°. The modifications done to the theodolite were:

- Replacement of several magnetic parts by corresponding non-magnetic aluminium items.
- Mirror-based lighting of the circles, compatible with the Zeiss requirements.
- Mounting bracket on the telescope for the fluxgate sensor.

This instrument was tested for two years in the Manhay observatory. The tests were comparison measurements with a standard Zeiss 010B DIflux. A measurement protocol for the Breihaupt was found which led to no noticeable difference (< 5 seconds of arc) between the two instruments. Figure 2 gives a drawing of the variometer inclination baseline measurement in Trelew for more than 400 days of recording. After an initial drift following the installation and some operational problems with the electronics, the instrument stabilised to a long term noise level of less than 10 seconds of arc. Interruptions in the continuous curves indicate programmed baseline corrections. Note that this data includes absolute measurement noise and variometer noise.

The data acquisition

The acquisition is based on a IBM PC XT compatible computer equipped with real time clock, with one 360 kilobytes 5 1/2" and one 3 1/4" 720 kilobytes disk drive but without a hard disk. There is also a Hercules graphic adapter and display, a 14 bit 16 channel ADDA converter card and a digital 48 lines I/O card. The software for running the magnetometers and for the acquisition is the same as the one used for all belgian observatories (Rasson, 1991) except for the acquisition of the ppm.

The dual input power supply (WEIR ADC1502400) is able to power the PC either from the mains or from a 24V lead-acid battery. It also charges said battery at constant current. Moreover it powers the biaxial fluxgate electronics and the ppm. In this way an autonomy of two days is ensured for the digital magnetic observatory from mains failure.

Conclusion

It is shown in this paper how the IAGA resolution 2 (1991) could be implemented to "revaluate" the Trelew magnetic observatory. This has been achieved with a modest level of funding but nevertheless permitted the installation of a modern digital magnetic observatory with all facilities needed to produce high quality data. We hope that in a near future we will be able to connect an INTERMAGNET transmitter to this equipment.

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