DALAT, VIETNAM: THE REOPENING OF A GEOMAGNETIC OBSERVATORY

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SUMMARY

The Dalat geomagnetic observatory, Vietnam, was reinstalled in April 2011 and joined the INTERMAGNET global network in September 2012. It is run in collaboration between the Institute of Geophysics, Vietnam Academy of Science and Technology, and the Institut de Physique du Globe de Paris. The new observatory is located in the South East of Vietnam, at about 1000 km to the South of the Phu Thuy geomagnetic observatory, which was the first Vietnamese observatory to get the INTERMAGNET magnetic observatory (IMO) status in 1996. One-second and one-minute variation data have been provided on a continuous basis since April 2011. Absolute measurements began at the same time and have been used to calculate quasi-definitive data following the IPGP method. Due to its location, far away from the closest IMO and close to the geomagnetic dip-equator, the Dalat geomagnetic observatory will be particularly useful for global geomagnetic field modeling and the study of the equatorial electrojet.

1. INTRODUCTION

The Dalat geomagnetic observatory (IAGA code DLT, latitude 11.940°N, longitude 108.480°E, elevation 1583 meters), Vietnam, was first opened in 1981. In April 2011, new equipment was installed and training was delivered to observers for absolute measurements by the Institut de physique du globe de Paris, in collaboration with the Institute of Geophysics, Vietnam Academy of Science and Technology (IGP VAST). The Dalat observatory is situated in the south of Vietnam, at 1040Km to the South of Phu Thuy (PHU), a geomagnetic observatory. It produces vector data sampled every second, and was the first Vietnamese observatory to join INTERMAGNET in 1996. The Dalat observatory gained official INTERMAGNET magnetic observatory (IMO) status in October 2012 and is now transmitting 1second real time and quasi-definitive data via the Paris Geomagnetic Information Node (GIN) to the scientific community.

Dalat represents a useful addition to the global network of geomagnetic observatories. It is far enough from the nearest observatory, Phu Thuy, to bring useful measurements for global geomagnetic modeling. The latitudinal distribution of the Dalat and Phu Thuy observatories, of dip-latitudes 4.0°N and 13.2°N, respectively, is particularly well suited to studying the equatorial electrojet, which flows along the geomagnetic dip-equator.

This extended abstract presents the particularities of the observatory site and the instrumental setup. After more than a year of recording, the quality of the variation data and baseline are evaluated based upon the INTERMAGNET criteria.

2. OBSERVATORY SITE AND INSTRUMENTS

The Dalat geomagnetic observatory is installed in the premises of the IG VAST, situated on the hilltop in the outskirts of Dalat. It is surrounded by small houses and fields of flowers, the main production of the area. It includes two buildings dedicated to magnetic measurements. In the first building, we find the variation room at one end, containing the continuously recording vector magnetometer mounted on a stable pillar. A few meters away, a scalar magnetometer is fixed on the wall in a thermally controlled environment. A different room, at the other end of the building, is used as the absolute room, containing the equipment for absolute measurements. A second building few meters away from the first one is used as the control room where computers, back up batteries, and Internet connection for data transmission are connected.

The three components of the Earth's magnetic field are measured by a homocentric (measuring the three components at the same point) IPGP VM391 tri-axis fluxgate magnetometer. This instrument produces 1 Hz data using a method described in Chulliat et al. (2009). One minute values are then produced using the standard INTERMAGNET Gaussian digital filter. The modulus of the magnetic field is

measured every five second by a Geomag SM90R Overhauser-type scalar magnetometer. Vector and scalar data are acquired by an IPGP ENO3 data logger, which is based on a PC system, and transmitted to the Paris Geomagnetic Information Node (GIN) via Internet. In order to compensate the small instrument drift, temperature variations and slow pillar movement, a minimum of one absolute measurement per week is made using a Bartington Mag01H single-axis fluxgate magnetometer mounted on a Zeiss 010A amagnetic theodolite. The magnetic field difference between the absolute pillar and the variation pillar is measured by an additional scalar magnetometer to compensate a local field gradient.

The observatory suffers from frequent thunder strikes in the area. This caused a two-week long loss of data in August 2011 after the electronic of the acquisition system was damaged. A thunder detection system has been installed along with a fiber optic connection between buildings to protect the equipment. During the installation, in April 2011, two observers were trained for absolute measurement and data entry (Figure 1). In order to facilitate the work of the observer and reduce the duration of the measurements, the lighting in the measurement room was improved.

Figure 1 –Training session at the Dalat geomagnetic observatory, April 2011.

3. QUALITY OF THE DATA

Variation data and absolute measurements are available from April 2011. In order to assess the quality of the data, two aspects are evaluated. First, the variation data by looking at the continuity of the data and the scalar residual, that is, the difference between the field modulus directly measured by the scalar magnetometer and the modulus calculated from the vector measurement after correction of the drift by the baseline curve. Secondly, the quality of the baselines is evaluated, that is, the calibration curves used to correct the slow drift in time of the vector magnetometer.

A. VARIATION DATA

The continuity of the recordings are at the upmost importance for the study of the geomagnetic secular variation and the geomagnetic jerks. Except from a 2-week cutout in 2011 due to a electronic damage following a thunder storm, there were no malfunction of the acquisition and very few data gaps since the opening of the observatory. The continuity of the variation data improved considerably from 2011 to 2012. The percentage of missing 1-minute values went from 20.2% on H, E and Z and 2.9% on F in 2011 to 1.1% on all components up to now.

As seen on Figure 2, the scalar residual of hourly mean values remained less than 2nT during the last 12 months of measurements, well within INTERMAGNET's requirements of 5nT accuracy on definitive data.

Figure 3 shows a typical 1-second data, 24 hour magnetogram displaying vector and scalar data along with ΔF (Fs-Fv, where Fs is the modulus measured by the scalar magnetometer and Fv is the modulus recalculated from the vector components). Typical perturbations are caused by relatively frequent flashes of lightning (in the form of 2 or 3 second large spikes on all components, not seen in Figure 3), occasional errors in the scalar acquisition (Figure 3(a), in the form of a 1-second spike on the F component) and a daily 1 nT shift of unknown origin and lasting several hours (Figure 3(b)). Tests to determine if the 1 nT shifts in the data (mostly visible in E component) were caused by human activity or by a dysfunction of the solar panel power source were inconclusive. Human disturbances, possibly caused by the security guard leaving his motorbike nearby the magnetometer room for example, were first suspected, but this hypothesis was ruled out by observing these steps during days when none of the observatory staff was working. During a future travel to Dalat, it is

planned to record the magnetic field with a spare vector magnetometer to rule out equipment malfunction. The Dalat observatory is on top of a hill surrounded by greenhouses (Figure 4), an inefficient ground connection of a nearby electricity apparatus (like the greenhouses lighting system or a large power pump to water the growing flowers/vegetables) may produce ground currents causing these small ΔF steps.

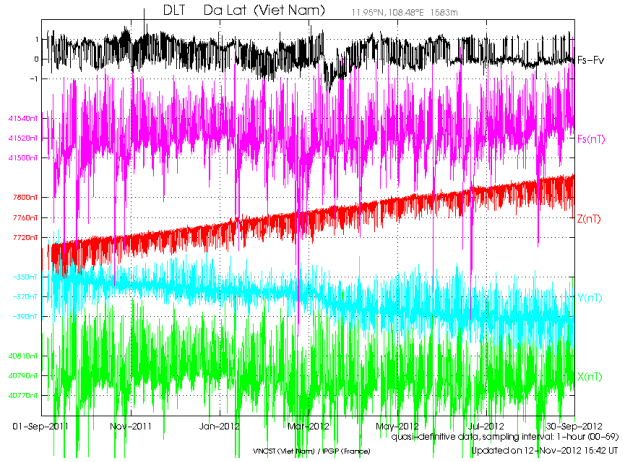

Figure 2 –Quasi-definitive data showing the three components of the vector magnetometer, the modulus values Fs from scalar magnetometer and the scalar residuals of hourly mean values for the past 12 months.

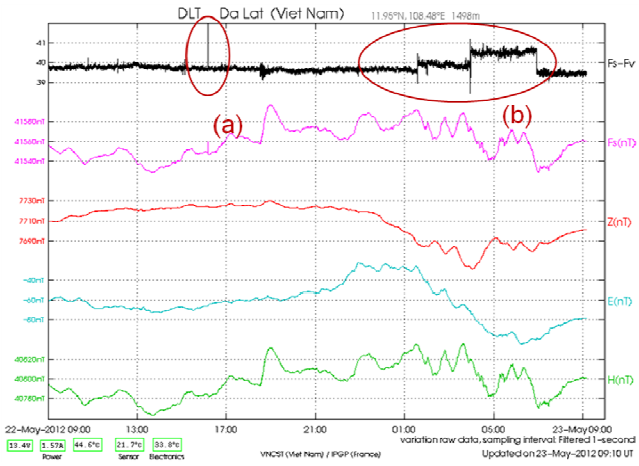

Figure 3 –Variation data recorded at Dalat observatory on May 22, 2012. H, E and Z (sampled every second) are the three components of the vector magnetometer, approximately oriented in the North, East and downward vertical directions. Fs (sampled every five seconds) is the measured scalar field. Fv is the scalar field calculated from the vector components.

Figure 4 –Aerial view of the Dalat magnetic observatory.

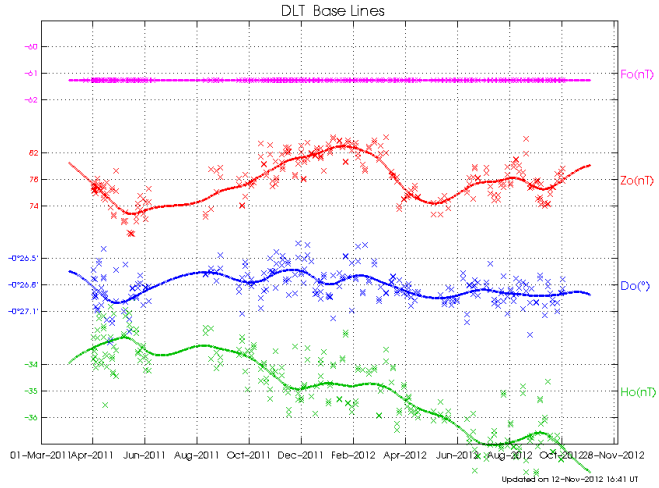

Figure 5 –Baseline of the DLT observatory since the beginning of the measurements in spring 2011 , plotted on October 2012. The baseline values are calculated by spline smoothing.

B. BASELINE

Figure 5 shows the baselines for Dalat observatory obtained for the H (horizontal), D (declination), Z (downward vertical) and F residuals (difference between variation and absolute pillars) components by fitting a spline curve to the correction values deduced from the absolute measurements (see the method described in Peltier and Chulliat, 2010). There was an improvement in the frequency and quality of the absolute measurements over time. 66 double absolute measurements were made in 2011 and so far 71 in 2012 by the local observers, each one represented by a coloured cross. For each component, the quality of the absolute measurements can be assessed by calculating the standard deviation of the differences between the measurements and the baseline curves. The obtained standard deviations are 0.58 nT for H, 9.54 arcsec for D, 1.4 nT for Z and 0 nT for F, being a constant value, which are within INTERMAGNET requirements. These

variations are expected to decrease with time as local observers improve absolute measurement accuracy. Calculated baseline curves have amplitudes of about 5 and 10 nT for H and Z, respectively, and 0.4 arcmin for the declination.

4. DISCUSSION

There is a need for constant and regular support, training and encouragement to the local observers stationed in Dalat to provide reliable data and measures to ensure that INTERMAGNET requirements are followed. The Dalat observatory is now producing quality data for the geomagnetic community.

It currently delivers the following data:

- Real-time 1-second data (every 10 sec) using Earthworm based real-time system on IPGP data platform "Magis" (Truong et al., 2009)
- Real-time 1-minute data on the Bureau Central de Magnétisme Terrestre (BCMT) website (www.bcmt.fr)
- 1-second data and derived means to the BCMT and INTERMAGNET (www.intermagnet.org)
- Quasi-definitive data (every month, see Peltier and Chulliat, 2010) to the BCMT and INTERMAGNET

From now, definitive data will be prepared within a couple of months after the end of the year. After a final cross-check by specialists from other institutions participating in INTERMAGNET, definitive data will be retrievable from the websites of INTERMAGNET and of the Bureau Central de Magnétisme Terrestre (BCMT) and will be published on a DVD together with the definitive data from the whole INTERMAGNET network. A report on the data processing and the events happening every year will be published in the regular BCMT yearbook.

5. CONCLUSION

Due to its geographic location, the value of DLT data for the scientific community data is important. After more than a year of variation data and absolute measurements, the magnetic data quality of DLT is now up to the INTERMAGNET standards. Quasi-definitive data are already produced every month. The observatory has been fully accepted in the INTERMAGNET network in September 2012. The Dalat observatory, given its geographical location, will be very useful in the future, for internal as well as external field studies.

6. ACKNOWLEDGEMENTS

The authors would like to acknowledge the local staff of the Vietnam Institute of Geophysics in Dalat and Hanoi for their cooperation and help insuring continuity in data recording and absolute measurements. On the French side, the Dalat observatory reinstallation and its operation are supported by CNRS-INSU and the IPGP. On the Vietnam side, the Dalat observatory is supported by VAST (Vietnam Academy of Science and Technology) and IGP (Institute of Geophysics).

7. REFERENCES

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