The INGV Tectonomagnetic Network: 2004 - 2005 Whole Dataset

F. Masci°, A. Meloni°°, P. Palangio° and S. Lepidi °

°Istituto Nazionale di Geofisica e Vulcanologia, Osservatorio Geofisico di L'Aquila, Italy

°°Istituto Nazionale di Geofisica e Vulcanologia, Roma, Italy

EGU06-A-05640

Contact: masci@ingv.it

Introduction

It is well established that earthquakes and volcanic eruption can produce small variations in the local geomagnetic field. The Italian Istituto Nazionale di Geofisica e Vulcanologia (INGV) Tectonomagnetic Network was installed in Central Italy since 1989 to investigate possible effects on the local geomagnetic field related to earthquakes occurrences. At the present time, total geomagnetic field intensity data are collected in four stations using proton precession magnetometers. We report the complete dataset for the period of years 2004-2005. The data of each station are differentiated respect to the data of the other stations in order to detect local field anomalies removing the contributions from the other sources, external and internal to the Earth. Unfortunately, no correlation between geomagnetic signal and the local seismic activity, recorded in Central Italy by the INGV Italian Seismic National Network, was found in this period. Some deceptive structures present in the differentiated data are pointed out. At the end, an application of an autoregressive model on the differentiated data is briefly discussed.

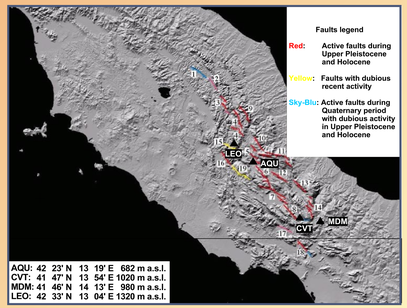

Figure 1. Faults distribution in Central Apennines. The locations and the geographical coordinates of the tectonomagnetic network stations are also reported. (Adapted from the INGV-GNDT map of active faults in Central Italy)

Volcanic eruptions and earthquakes can produce variations in the local geomagnetic field. The value of this variation is about few nT. Some studies report a variation about 1-5 nT relating to earthquakes and a variation up to 10 nT relating to volcanic activity. In literature, two main phenomena have been suggested to explain the observed variation in local geomagnetic field: piezo-magnetic effects, resulting from variations of the rocks magnetization induced by mechanical or thermal stress and associated to slow variations (from weeks to months), and electro-kinetic effects, due to the presence of electric currents in the crust associated to rapid variations (from seconds to days). The Italian Istituto Nazionale di Geofisica e Vulcanologia (INGV) Tectonomagnetic Network was installed in Central Italy since 1989 to investigate possible effects on the local geomagnetic field related to the tectonic activity. Total geomagnetic field intensity data has been detected in some stations using proton precession magnetometers. This network is part of the INGV L'Aquila Geomagnetic Observatory and is located in Central Italy in an area extending about between latitude 41.6°N and 42.8°N, and between longitude 13.0°E and 14.3°E. From a seismic point of view, Italy is one of the most active areas in Central Mediterranean with several active faults. Actually the network consists in four stations located in L'Aquila (AQU), Monte di Mezzo (MDM), Civitella Alfedena (CVT) and Leonessa (LEO). The sampling rate of the stations is set to 15 minutes for each station except for AQU in which the sampling rate is 1 minute. The instrument accuracy is 0.1nT and the expected drift is 0.2 nT / yr.

In figure 1 are shown the locations in Central Italy and the geographical coordinates of the network stations. General information on the geological structure of the Central Apennines is also reported showing the known faults. For the details on the geological faults you can consult the link http://emidius.mi.ingv.it/GNDT/P512/home.html of the INGV-GNDT (Italian Gruppo Nazionale per la Difesa dai Terremoti).

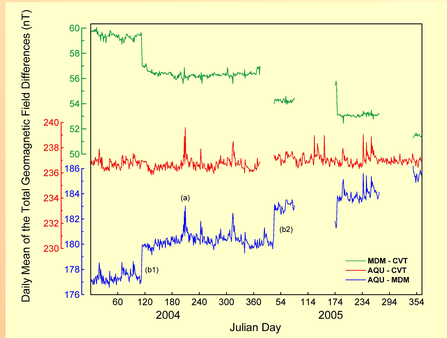

Figure 2. Daily mean of the total geomagnetic field differences for the couple of station AQU-CVT, AQU-MDM, MDM-CVT during the period of two years 2004-2005. The colour of each plot is the same of the corresponding vertical axis.

Here we report the complete dataset of the tectonomagnetic network for the period of two years 2004-2005 and the results of the preliminary analysis of the data. The total geomagnetic field data recorded in each station is differentiated respect to the data of the other stations in order to detect local field anomalies. The differentiation procedure removes the contributions from the other sources, external (i.e. electric currents in the ionosphere and magnetosphere) and internal to the Earth (ie. secular trend of internal origin, due to the Earth's core electric currents). The only one remaining is due to local variation in crustal magnetization and to tectonic activity as well. Moreover, a daily mean of the differentiated data is calculated to remove the diurnal variation.

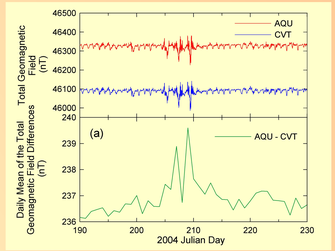

Figure 3. The event marked (a) in figure 2 is reported in details for the AQU-CVT differences. In the upper panel are shown the total geomagnetic field intensities registered in the station of AQU and CVT for the period of days JD=190-230 2004. Both the signals show the presence of a magnetic storm beginning at JD=204 and ending at JD=211. In the lower panel is reported the daily mean of the differences of the two signals shown in the upper panel. A clearly latitude dependence of the magnetic storm can be noted. See text for details.

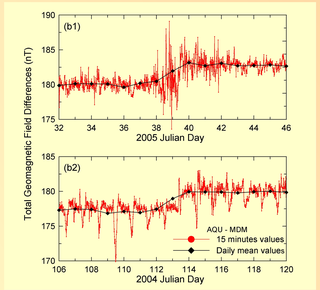

Figure 4. The events marked (b1) and (b2) in figure 2 are reported in details. Both the events show a jump of ~2.5 nT in the differences AQU-MDM during 2 days. At the moment, there is no reasonable explanation for these events. See text for details.

In figure 2 are shown the daily mean of the differences among the stations of AQU, CVT and MDM. The differences with LEO station dataset are not reported because of the large number of gaps in the data due to technical and logistical problems. Bad weather conditions, and the location of the LEO station in a rather inaccessible place, at relatively high altitude, also affect the continuity of the measurements. During the period of two years 2004-2005 no significant telluric activity is registered in Central Italy (see Bulletins of INGV Italian Seismic National Network at the link http://www.ingv.it/~roma/reti/rms/bollettino/index.php). The maximum magnitude of the earthquakes registered during this period is about M=3, so no significant variations in the local geomagnetic field is expected. In any case in figure 2 the differentiated data show some structures that can mislead. First of all, in the differentiated data can be pointed out some peaks with an amplitude about 2-3 nT in the AQU-MDM and in the AQU-CVT differences. These peaks do not appear in the differentiated dataset MDM-CVT. For example, we can analyze the peak marked (a) in figure 2. In the lower panel of figure 3 is shown in details the peak (a) in the period of days JD=190-230 during 2004, whereas in the upper panel of figure 3 are reported the signals of the total geomagnetic field for the stations AQU e CVT in the same period. Note that the total geomagnetic field differences are reported as daily mean, while total geomagnetic field signals, shown in the upper panel, are reported with the original time interval of acquisition. Both the total geomagnetic fields show a magnetic storm beginning at JD=204 and ending at JD=211. In the same period of days a peak can be found in the differences between AQU and the two stations of MDM and CVT and it doesn't appear in the differences MDM-CVT. This effect can be explained with an evident latitude dependence of the magnetic storm between AQU and the other two stations. In the differences MDM-CVT the latitude dependence of the magnetic storm is not so obvious because the latitudes of the two stations are different about 1'. We can found similar peaks during 2004 on JD= 24, 244 and 315, while during 2005 on JD=18, 128,135,150, 191,237, 243 and 255. Looking at the figure 2 is also obvious the presence of another kind of events marked as (b1) and (b2). In figure 4 are reported in details the two events, beginning on the JD=38 2004 e on the JD=112 2005. In the differences AQU-MDM both the events consist in a jump, between two levels, of ~2.5 nT during 2 days. These effects are due to the MDM total geomagnetic field intensity as they are present in the difference AQU-MDM and MDM-CVT and are not evident in the differences AQU-CVT. We can exclude instrumental problems as, after the event (b1), we changed the MDM instrumentation with a new calibrated magnetometer, but, after about a year we have recorded the event (b2) in MDM with the new instrumentation. Figure 2 shows a probable event like (b1) and (b2) for about the day JD=175 2005, happened unfortunately immediately after a gap in MDM dataset. Note that in MDM-CVT differences the mean values calculated in the periods of days JD=40-80 2005 and JD=180-270 2005 are different about 1 nT. In any case the lack of data doesn't permit to study in depth. A similar event has probably happened also during the data gap occurred in the period of days JD=272-345 since the mean values of the MDM-CVT differences before JD=272 and after JD=345 are different about 1.5 nT. Anyway, there are no relations between the events (b1) and (b2) and seismic activity in Central Italy. At this time, we have no reasonable explanation for these events and in the future it is needed more investigation to explain the cause. From the point of view of the data analysis, at the end of 2005 a new approach is attempted on the differentiated datasets using an autoregressive model to fit the data. Preliminary analysis shows a second order autoregressive stationary model as the best fit. Future developments of this kind of analysis are in program trying to use the autoregressive model in a forecasting approach.

Summary

We have reported the whole dataset of the INGV tectonomagnetic network for the period of two years 2004-2005 as differences between the geomagnetic total field intensity collected in each network station. No relation with the local recorded earthquakes by the INGV Italian Seismic National Network has been found. On the other hand, during the period of two years 2004-2005 no significant seismic activity is registered in Central Italy. The maximum earthquakes magnitude registered during this period is about M=3, so no significant variations in the local geomagnetic field is expected. Anyway, some evident structures that show latitude dependence of magnetic storms are highlighted in the differentiated data. Moreover, in the differences involving the MDM station dataset are shown two events with no reasonable explanation at this moment. More investigation is needed for a right interpretation. Preliminary results, using an autoregressive model to fit the data, show a second order autoregressive stationary model as the best fit of the differentiated data.

Acknowledgements: *The authors would like to thank the technical-administrative staff of the INGV L'Aquila Geomagnetic Observatory for the basic support in the research activity.*