Nat. Hazards Earth Syst. Sci., 12, 1717–1719, 2012
www.nat-hazards-earth-syst-sci.net/12/1717/2012/
doi:10.5194/nhess-12-1717-2012

Natural Hazards and Earth System Sciences

Comment on "Ultra Low Frequency (ULF) European multi station magnetic field analysis before and during the 2009 earthquake at L'Aquila regarding regional geotechnical information" by Prattes et al. (2011)

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Received: 18 August 2011 – Revised: 18 November 2011 – Accepted: 29 November 2011 – Published: 25 May 2012

Abstract. Prattes et al. (2011) report ULF magnetic anomalous signals claiming them to be possibly precursor of the 6 April 2009 $M_W = 6.3$ L'Aquila earthquake. This comment casts doubts on the possibility that the observed magnetic signatures could have a seismogenic origin by showing that these pre-earthquake signals are actually part of normal global geomagnetic activity.

1 Introduction

During the last twenty years, a huge number of papers have claimed the observation of magnetic anomalous signals which the authors consider as precursors of pending earthquakes. However, in the majority of the cases the authors did not carefully check the seismogenic origin of the claimed anomalies. As a matter of fact, any potential anomalous signal before being considered as a reliable earthquake precursor should be excluded as an anomaly correlated with any other possible source. Obviously, it is likely that an anomalous variation of a geomagnetic field parameter may be observed before the occurrence of an earthquake, but relating the anomaly with the seismic event without further validations is just an oversimplified conclusion. As a consequence, some authors (see Campbell, 2009; Thomas et al., 2009; Masci, 2010, 2011a, b) have recently put into question well-known magnetic seismogenic precursors by showing that these anomalous signals are actually induced by normal geomagnetic activity.

2 Comments and conclusions

Prattes et al. (2011), hereafter cited as P11, report the analysis of ULF magnetic data coming from the South European Geomagnetic Array (SEGMA) during the period 2008–2009. See P11 for the location of the SEGMA stations. P11 claim the observation of possible seismogenic magnetic signals which emerged in L'Aquila station about two weeks before the 6 April 2009 earthquake. L'Aquila is the closest SEGMA station to the seismic area and it is located about 6 km away from the epicentre of the main shock. The authors put in evidence the magnetic pre-earthquake anomaly by using a standardized polarization method; refer to P11 for further details. The principal claims of P11 are: (1) the magnetic anomaly has been observed in L'Aquila station mainly in the [10–15] mHz sub band of the [10–500] mHz frequency range by applying a 5-day running mean to the standardized polarization time-series; (2) the anomaly was not present in the two other SEGMA stations of Castello Tesino and Nagycenk which are very far from the earthquake epicentre. Since the magnetic anomaly occurs only at the L'Aquila station, the authors conclude that it could have been a precursor of the 6 April earthquake. Figure 1 shows the main result of P11; the shaded area in the lower panel highlights the claimed seismogenic magnetic anomaly which occurred during the period 11–20 March 2009.

In my opinion, P11 underestimate the influence of normal geomagnetic activity on the magnetic field measurements. In Fig. 1, the time-series of the standardized polarizations reported by P11 are compared with the index ΣK_p which is taken as representative of the geomagnetic field average disturbances over planetary scale. I would like to point out

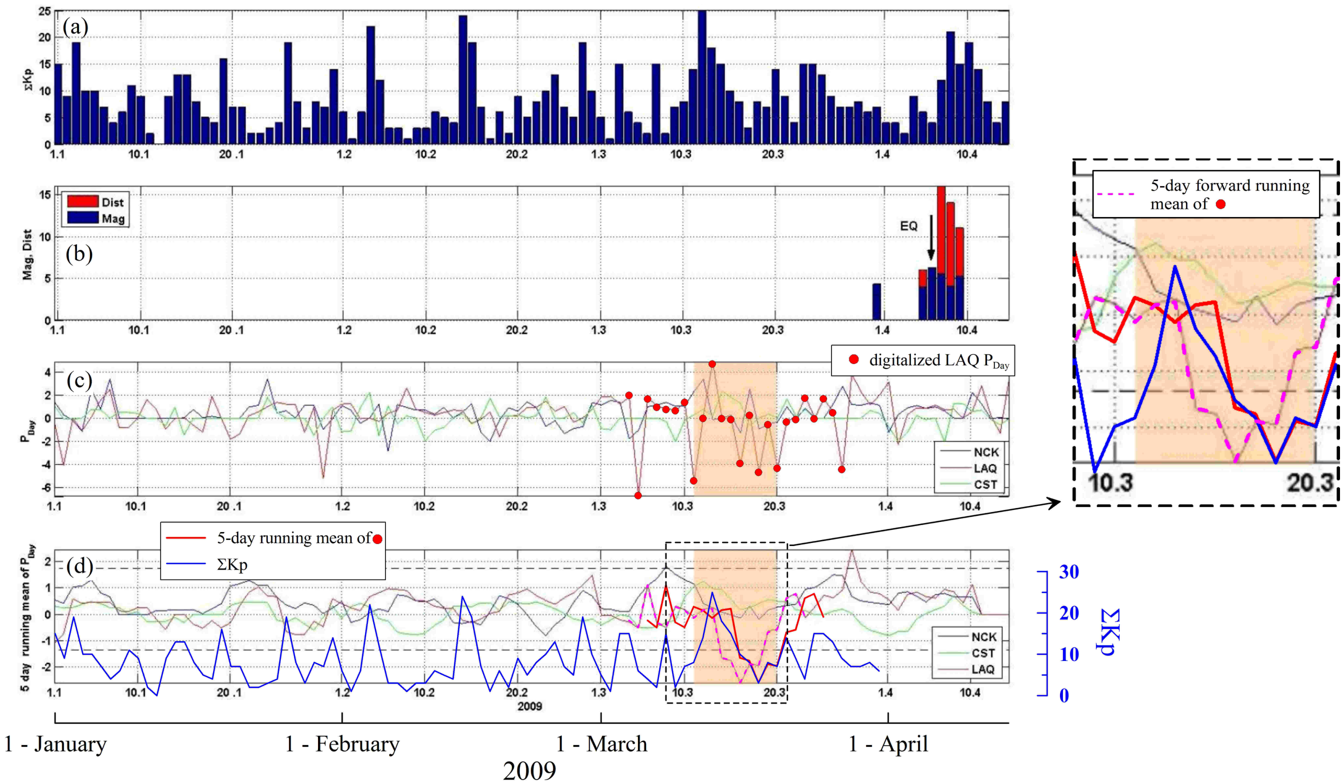

Fig. 1. A reproduction of Fig. 6 by Prattes et al. (2011). **(a)** ΣK_p time-series; **(b)** magnitude and distance from L'Aquila station of seismic events; **(c)** standardized polarization and **(d)** 5-day (presumably forward) running mean of the standardized polarization for the stations of Nagycenk (NCK), Castello Tesino (CST), and L'Aquila (LAQ). Shaded area refers to the period of the claimed seismogenic ULF anomaly. Consider that in panel **(a)**, after 3 March ΣK_p index is 1 day shifted backward since the authors forgot to report ΣK_p value (15) of 4 March (see http://swdcwww.kugi.kyoto-u.ac.jp/). In panel **(c)** red dots represent the digitalized values of L'Aquila standardized polarization. In panel **(d)** red line represents the 5-day running mean calculated by the digitalized values reported in panel **(c)**, whereas blue line represents the ΣK_p time-series. An enlarged view of the claimed pre-earthquake magnetic anomaly is also reported on the right side of the figure. See text for details.)

that the results shown later in this work can be obtained also by using standardized ΣK_p indices since the standardization procedure adopted by P11 slightly modifies the behavior of the ΣK_p time-series. In addition, the 5-day running mean of L'Aquila standardized polarization has been calculated again by digitalizing the values reported by P11 (red dots in Fig. 1, panel c). We can note that the recalculated 5-day running mean (red line in Fig. 1, panel d) results to be shifted forward of 2 days with respect to the P11 5-day running mean. This fact can be easily explained assuming that P11 probably calculated the 5-day forward running mean of the standardized polarization instead of the ±2-day running mean. I have obtained the same results of P11 by calculating the 5-day forward running mean of the digitalized standardized polarization values (see the magenta dashed line in the enlarged view reported on the right side of Fig. 1).

The panel (d) of Fig. 1 shows that a close correspondence between my 5-day running mean of L'Aquila standardized polarization (red line) and ΣK_p time-series (blue line) really exists during the period highlighted by the shaded area. This correspondence suggests that the magnetic signature which occurs during this period is part of the global geomagnetic activity. On the other hand, it is also evident that ΣK_p and L'Aquila standardized polarization were not always correlated during the period January–April 2009. A further lack of a close correspondence between ΣK_p and the standardized polarization is evident at Castello Tesino and Nagycenk as well. In addition to that, we can note that the figure shows also several differences between the standardized polarizations of the three SEGMA stations. According to my opinion, all these differences are not a fundamental issue in the investigation of the real origin of the magnetic anomaly claimed to be seismogenic by P11. That is, the lack of a close correspondence between the standardized polarization and ΣK_p over the whole period reported in Fig. 1 could have a double nature:

1. P11 regarding to the standardized polarization of SEGMA stations write: *"Geomagnetic events commonly occurring in all observatories and compared to ΣK_p index are eliminated"*. Obviously, taking into account this statement, we should not expect that a close

correspondence between ΣK_p and the standardized polarization of SEGMA stations always exists. That is, if the geomagnetic events have been really eliminated, the previous correspondence should be negligible. The fact that this correspondence is sometimes satisfied, (e.g. during the period of the claimed seismogenic anomaly appearance), could suggest that the authors do not eliminate completely the influence of the global geomagnetic activity in L'Aquila data.

2. ULF geomagnetic events are not always expected to be observed at all the observation points, especially if the stations are several hundreds of kilometres far away and located at different geomagnetic latitudes, as in the case of the three SEGMA stations. More precisely, ULF PCs pulsation signals are mainly caused by solar-terrestrial interaction and are generated by different sources which give their contribution to the signals observed on the ground (McPherron, 2005). Some of these signals have a worldwide extension, whereas others have a latitude dependence (Saito, 1969).Therefore, even if PCs pulsations, (particularly PC_2, PC_3 and PC_4), have a clear positive relation with the geomagnetic index ΣK_p (Saito, 1969), we should not expect that a close correspondence between a ULF parameter of the geomagnetic field (in this case the standardized polarization) and the geomagnetic index will always exist everywhere, otherwise the time-series of this parameter would be the same at all the observation points.

Taking into account these remarks, the standardized polarization of the SEGMA stations should not be necessarily always coincident. Likewise, we should also not expect that in an observation site, (e.g. L'Aquila), a close correspondence between ΣK_p and the standardized polarization exists during a long time range (see Masci, 2011a). In brief, as claimed by Masci (2011b), the main issue is: a close correspondence between changes of an ULF geomagnetic field parameter (in this case the standardized polarization) and ΣK_p indicates that these changes are part of normal global geomagnetic field variations driven by solar-terrestrial interaction. On the other hand, we should not expect that this correspondence is everywhere and always satisfied.

In conclusion, bearing in mind the previous considerations and the close correlation with the ΣK_p index, the magnetic signature which occurs during the period 11–20 March 2009 seems to be actually caused by the influence of interplanetary space and magnetospheric signals to the magnetic field observed at the L'Aquila station. Therefore, the pre-earthquake anomaly reported by P11 may not be described as a seismogenic signal related to the 6 April 2009 earthquake.

Acknowledgements. The author would like to thank the Editor F. Guzzetti and an anonymous reviewer for his constructive comments that were useful to improve this manuscript. The geomagnetic indices have been downloaded from Kyoto World Data Center for Geomagnetism (http://swdcwww.kugi.kyoto-u.ac.jp/).

Edited by: F. Guzzetti
Reviewed by: one anonymous referee

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