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Abstract 3-07

Anomalies observed in VLF and LF radio signals on the occasion of the western Turkey earthquake (M_w=5.7) at May 19, 2011

P.F. Biagi[1)], T. Maggipinto[1)], L. Schiavulli[1)], T. Ligonzo[1)], A. Ermini[2)], I.A. Moldovan[3)], H.G. Silva[4)], M. Bezzeghoud[4)], M.E. Contadakis[5)], D.N. Arabelos[5)] and A. Buyuksarac[6)]

1) *Department of Physics, University of Bari, Bari, ITALY*

2) *Department of Industrial Engineering, University of Tor Vergata, Rome, ITALY*

3) *National Institute of Earth's Physics, Seismological Depth., Bucharest, Magurele, ROMANIA*

4) *Geophysical Centre of Évora and Physics Department, ECT, University of Évora, PORTUGAL*

5) *University of Thessaloniki, Department of Surveying & Geodesy, Thessaloniki, GREECE*

6) *Canakkale Onsekiz Mart University, Depth. of Geophysics, Canakkale, TURKEY*

Figure 1 shows the European VLF/LF Radio Network. The receivers are the Elettronika, the OmniPal and the MSK models described in [1,2]. The first ones can collect, with a sampling rate of 1*min*, the intensity of both VLF signals and LF signals (10 in total), the others the intensity and the phase of VLF signals (5-8 at least) with a sampling rate of 20*s*. All data from the various sites are collected generally on a weekly basis, at the Central Node of the Network located in the Department of Physics of University of Bari (Italy) and are processed for suitable analysis, even if not systematically at the moment.

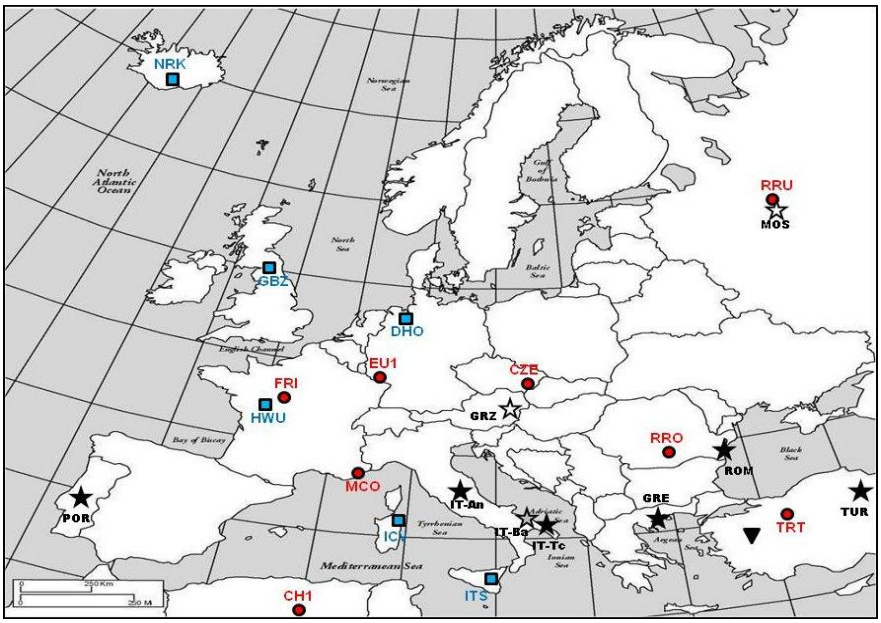

Fig. 1 Map showing the different receivers and the VLF and LF transmitters of the European Radio

Network. The stars show the location of the receivers (black≡Elettronika, white≡MSK, grey≡OmniPal); the squares indicate the VLF transmitters and the circles the LF transmitters, the signals of which are collected by the different receivers. The triangle indicates the epicentre of the western Turkey earthquake (M = 5.7) occurred on May 19, 2011.

In a recent study [3] the data collected up to April 2011 by the receivers of the Network have been analysed. The earthquakes with $M_w \geq 5.0$ occurred in the same period, located in a 300 *km* radius around each receiver/transmitter and within the 5th Fresnel zone related to each transmitter-receiver path, have been selected. The Wavelet analysis was applied on the time series of the radio signals intensity and some anomalies related to the above mentioned earthquakes have been revealed.

On May 19, 2011 an earthquake with magnitude M_w= 5.7 struck in Simav, Kutahya (Turkey); the location is indicated in Figure 1. An intense aftershocks activity occurred for more than one month releasing an energy equivalent to an earthquake with the same magnitude of the main shock. The epicentre of the mentioned earthquake is inside the 300 *km* radius circle around the TRT (180 *kHz*) transmitter, the signal of which is sampled by three receivers (GR, IT-An, IT-Tc) of the Network and it is inside the 5th Fresnel zone defined by the ITS (45.9 *kHz*) transmitter and the TUR receiver of the Network (Figure 1).

In this study the two previous situations have been investigated in details and the Wavelet spectra, the Standard Deviation trends and the Principal Component technique were used as different methods of analysis in order to reveal possible anomalies.

As a first step, the radio data used in this study have been separated in day-time data and the night-time data. With regard to the VLF signals, we have selected different time ranges in order to obtain data related at proper night time conditions (basically related to darkness) along all the paths. As regard the LF signals, we selected the range from 8.00 to 13.00 (UT) for the day-time and the range from 20.00 to 22.00 (UT) for the night-time; this last choice is forced by the occurrence of an interruption of 3-4 hours in some radio broadcasts generally after the local 24.00. Then the radio data have been examined using the previous methods. The results we obtained have confirmed that the VLF and LF radio signals are able to give information on the preparatory phase of earthquakes with $M_w \geq 5.5$.

In conclusion we can state that: a) the earthquake located inside some (5th ad example) Fresnel zone defined by a transmitter and a receiver can produce anomalies, but also those occurring near enough (some hundred kilometres) to a transmitter can do the same. b) The anomalies are related to disturbances produced in ionosphere, lower atmosphere or both. c) The Wavelet spectra and the Standard Deviation trends seem valid methods of data analysis for revealing these anomalies.

In this study the above mentioned methods were used on data sets including the anomalies. In order to reveal anomalies in "real time" it is necessary to introduce some modification in the technique of analysis; as for the Wavelet spectra a sufficient number of data, not affected by disturbances, must be added to avoid spurious edge effects and for the Standard Deviation plots, the time interval where the SD mean value is calculated must be defined according to reasonable criteria.

References

[1.] F. Biagi, T. Maggipinto, F. Righetti, D. Loiacono, L. Schiavulli, T. Ligonzo, A. Ermini, I.A. Moldovan, A.S. Moldovan, A. Buyuksarac, H.G. Silva, M. Bezzeghoud and M.E. Contadakis, The European VLF/LF radio network to search for earthquake precursors: setting up and natural/man-made disturbances, Natural Hazards and Earth System Sciences, Vol. 11, 333-341, 2011.

[2.] K. Schwingenschuh, G. Prattes, B.P. Besser, K. Mocnic, M. Stachel, O. Aydogar, O. Jernei, Stangl G., M.Y. Boudjada, A. Rozhnoi, M. Solovieva, P.F. Biagi, M. Hayakawa and H.U. Eichelberger, The Graz seismo-electromagnetic VLF facility, Natural Hazards and Earth System Sciences, Vol. 11, 1121-1127 ,2011

[3.] F. Righetti, P.F. Biagi, T. Maggipinto, L. Schiavulli, T. Ligonzo, A. Ermini, I.A. Moldovan, A.S. Moldovan, A. Buyuksarac, H.G. Silva, M. Bezzeghoud, M.E. Contadakis, D.N. Arabelos and T.D. Xenos, Wavelet analysis of the LF radio signals collected by the European VLF/LF network from July 2009 until April 2011, Annals of Geophysics, Vol. 55, No. 1, 171-180, 2012.