

Ionospheric turbulence from TEC variations and VLF/LF transmitter signal observations before and during the destructive seismic activity of August and October 2016 in Central Italy

Michael E. Contadakis (1), Demetrios N. Arabelos (1), George Vergos (1), Spyrous Spatala (1), Christos Skeberis (2), Tomas D. Xenos (2), Pierfrancesco Biagi (3), and Emmanuel M. Scordilis (4)

(1) University of Thessaloniki, Department of Surveying & Geodesy, Thessaloniki, Greece (kodadaki@vergina.eng.auth.gr),

(2) Department of Electrical & Computer Engineering, Aristotle University of Thessaloniki, Thessaloniki, Greece, (3)

Department of Physics, University of Bari, Bari, Italy, (4) Department of Geophysics, Aristotle University of Thessaloniki, Greece

In this paper we investigate the ionospheric turbulence from TEC variations and VLF/LF transmitter signal observations before and during the disastrous seismic activity of August and October 2016 in Central Italy. The Total Electron Content (TEC) data of 8 Global Positioning System (GPS) stations of the EUREF network, which are being provided by IONOLAB (Turkey), were analysed using Discrete Fourier Analysis in order to investigate the TEC variations (Contadakis et al. 2009, Contadakis et al. 2012, Contadakis et al. 2015). The data acquired for VLF/LF signal observations are from the receiver of Thessaloniki(40.59N, 22.78E), Greece (Skeberis et al. 2015) which monitor the VLF/LF transmitters of the International Network for Frontier Research on Earthquake Precursors (INFREP). A method of normalization according to the distance between the receiver and the transmitter is applied on the above data and then they are processed by the Hilbert Huang Transform (HHT) to produce the corresponding spectra for visual analysis. The results of this investigation indicate that the High-Frequency limit f_0 , of the ionospheric turbulence content, increases as the site and the moment of the earthquake occurrence is approaching, pointing to the earthquake locus. In accordance, the analyzed data from the receiver of INFREP network in Thessaloniki, Greece show that the signals from the two VLF European transmitters, Tavolara (Italy) and Le Blanc (France), for which the transmission path crosses the epicentral zones, indicate enhanced high frequency variations, the last ten days before the moment of the earthquake occurrence. We conclude that the LAIC mechanism through acoustic or gravity wave could explain this phenomenology.

Reference

Contadakis, M.E., Arabelos, D.N., Asteriadis, G., Spatalas, S.D., Pikridas, C. TEC variations over the Mediterranean during the seismic activity period of the last quarter of 2005 in the area of Greece, *Nat. Hazards and Earth Syst. Sci.*, 8, 1267-1276, 2008.

Contadakis, M.E., Arabelos, D.N., Asteriadis, G., Spatalas, S.D., Pikridas, C. TEC variations over Southern Europe before and during the M6.3 Abruzzo earthquake of 6th April 2009, *Annals of Geophysics*, vol. 55, iss. 1, p. 83-93, 2012a.

Contadakis, M. E., Arabelos, D.N., Vergos, G., Spatalas, S. D., Skordilis, M., 2015, TEC variations over the Mediterranean before and during the strong earthquake (M = 6.5) of 12th October 2013 in Crete, Greece, *Physics and Chemistry of the Earth*, Volume 85, p. 9-16.

Skeberis, C., Zaharis, Z. D., Xenos, T. D., Spatalas, S., Arabelos, D. N., & Contadakis, M. E. (2015). Time-frequency analysis of VLF for seismic-ionospheric precursor detection: Evaluation of Zhao-Atlas-Marks and Hilbert-Huang Transforms. *Physics and Chemistry of the Earth*, Parts A/B/C, 85, 174-184