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Ionospheric anomaly before the Mw6.1 earthquake in Greece, January 26, 2014.

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ABSTRACT

This work presents the analysis of ionospheric anomalies related to the Mw6.1 earthquake, which took place in Greece on January 26, 2014. An anomaly on the day before the earthquake occurrence that appears again in the day of the earthquake, has been identified. Their spatial and temporal distributions give grounds to assume a possible link with the earthquake preparation.

Key words: Lithosphere-Atmosphere-Ionosphere coupling, Earthquake precursors, TEC anomalies.

1. Introduction:

The soundest present theory to explain the lithosphere-atmosphere-ionosphere coupling has been developed by Pulinets and Ouzounov [1]. According to it, the main source of interference in the ionosphere located over seismically active areas are variations of atmospheric electricity caused by the ionization of the air and the formation of condensation nuclei of water in the area around the fault, due to radon gas released into the seismic process. The conductivity anomalies created on the surface move to the ionosphere by the Global Electric Circuit that is a quasi-stationary system of electric currents between the surface and the ionosphere governed by the global storm activity. These physical processes lead to changes in the vertical distribution of total electron content (TEC) and the height and the critical frequency of the E, F1 layers and, above all, F2 [2],[3].

2. Data and Methodology:

On 26 January 2014 at 13:55 UTC (15:55 local time), a Mw6.1 earthquake occurred at Argostólion, Cephalonia, (38.23º N, 20.48º E). The event took place at a depth of 15 km and was followed by several strong aftershocks. The earthquake sequence caused strong damage in the area.

The ionospheric behavior has been studied through the total electron content, TEC. This parameter is obtained from RINEX files processed using the calibration technique developed by Prof. Luigi Ciraolo [4]. The calibration technique assumes the ionospheric thin shell model to obtain vertical total electron content (vTEC) from slant total electron content (sTEC) at the Ionospheric Pierce Point. RINEX files from 53 stations belonging to International GNSS Service (IGS), EUREF Permanent Network (EPN) and University NAVSTAR Consortium (UNAVCO) GNSS networks have been processed. Ten days before the earthquake have been analyzed. The electron density peak of the F2 region, hmF2, and the critical frequency, foF2 have been also analyzed.

To analyze the variations of vTEC at every station, vTEC*Sigma parameter [5] has been used. This parameter is defined by the expression:

$$vTEC * Sigma = \frac{vTEC - vTECmean}{\sigma} \qquad (1)$$

Where vTEC is the observed value in each epoch, vTECmean and σ respectively are the mean value and the standard deviation of the vTEC values obtained at the same epoch during the previous 15 days. An explanation of these parameters is shown in Figure 1.

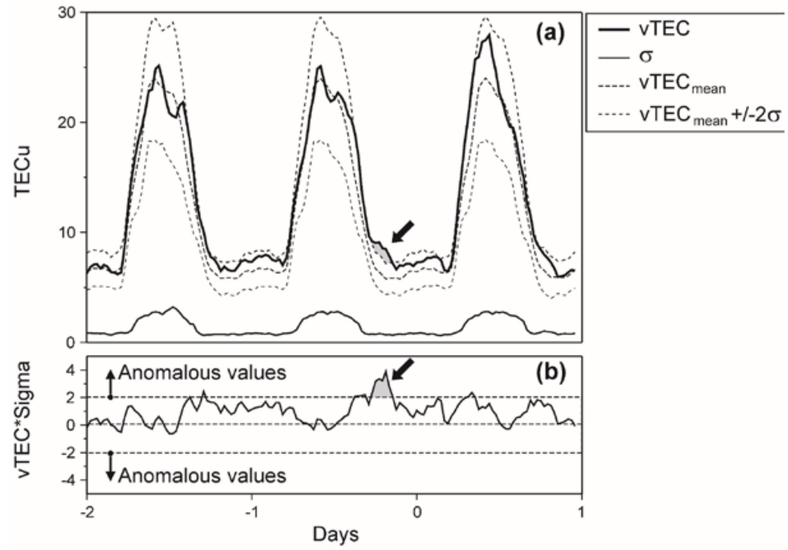

Figure 1**.** (a) vTEC (thick trace) evolution at PAT0 station. The mean value vTEC is displayed with a broken line and the limits corresponding to vTEC±2σ, with a dotted line. (b) vTEC*Sigma evolution. The values vTEC*Sigma=0 and vTEC*Sigma=±2 are displayed with a broken and a dotted line, respectively. The limits for vTEC*Sigma=±2 separate the normal values from the anomalous ones. The arrows indicate the more significant occasions in which these limits are exceeded during the day previous to the earthquake (-1 day).

The geomagnetic, solar, and meteorological conditions during the considered period were quiet conditions, no causing ionospheric disturbances.

3. **Results:**

Two anomalous values of vTEC*Sigma have been found in the days prior to the earthquake: one four days before and another the day before. As the effects of the first anomaly appear over the entire studied area cannot be associated to the earthquake. However, the second anomaly is limited at the earthquake area, as is shown in Figure 2. The temporal behavior of this anomaly is characterized by two maxima: the first between 17:00 UT and 20:00 UT on the day before the earthquake, and the second one on the same day that the earthquake within 7:00 UT and 8:00 UT. This anomaly agrees with an anomaly observed by Sanchez et al. [6] in very low frequency radio transmissions for the same earthquake.

4. Conclusions and future work:

vTEC*Sigma analysis shows a clear anomaly in the day before earthquake which appears only in stations nearby the epicenter. The temporal proximity to the earthquake occurrence and its spatial distribution indicate a possible connection with the earthquake preparation process.

Similar analysis is being carried out or earthquakes occurred in Mexico and Peru during geomagnetic quiet conditions.

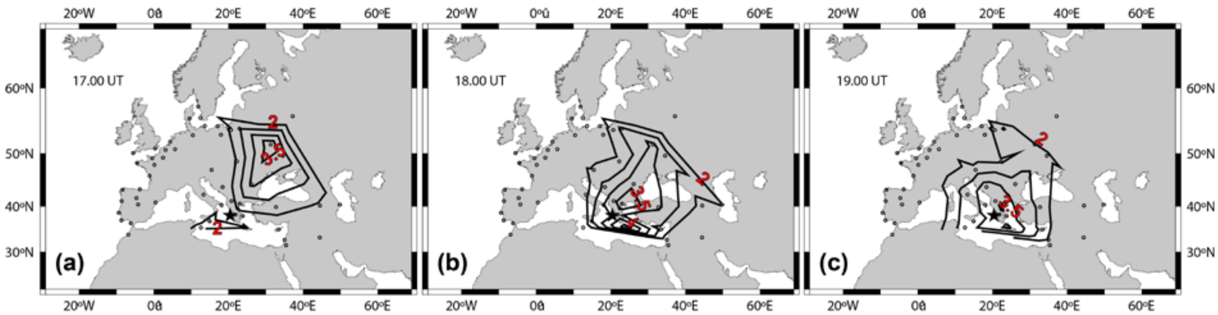

Figure 2**.** Maps of anomalous values of vTEC*Sigma (isolines represents vTEC*Sigma values equal or greater than 2) the day before the earthquake at 17:00 UT (a), 18:00 UT (b) and 19:00 (UT). The circles represent the GNSS stations and the star stands for the earthquake epicenter.

5. References:

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