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Investigation of Ionospheric Precursors of 23 October 2011, Mw=7.2 Earthquake in Van, Turkey

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In recent years, a strong coupling between ionospheric disturbances and seismic activity has been observed through the increase of ion temperatures, critical frequencies of ionospheric layers and Total Electron Content (TEC) before high magnitude earthquakes. TEC is defined as total number of electrons over a ray path through the ionosphere. TEC can be estimated in a cost-effective way with dual-frequency Global Positioning Satellite (GPS) System receivers. The unit of TEC is given by TECU where 1 TECU = 10^{16} el/m^2. In this study, the disturbances in daily TEC values before 23 October 2011, Mw=7.2 Earthquake in Van, Turkey are investigated using Turkish National Permanent GPS Network (TNPGN-Active). Earthquake Day Period (EDP) is chosen between October 1 and 31, 2011. Daily TEC values, for each station and each day, are estimated as IONOLAB-TEC (www.ionolab.org) with 30 s time resolution. EDP-TEC values are compared with an Average Quiet Day TEC (AQDT) which is obtained by averaging the TEC values between 25 and 28 March, 2011. Statistical comparison is accomplished using Symmetric Kullback-Leibler Divergence (SKLD), which is also a method for measuring entropy of a system. It has been previously observed that SKLD is a better method for measuring the amount of disturbances compared to L2 norm and cross-correlation coefficient. AQDT is also compared with magnetically Quiet Day Period (QDP) from 25 to 28 April, 2011, during which Kp and Dst indices indicate a very quiet ionospheric and magnetospheric period. Also, in order to measure the variability between the consecutive days, TEC values for each day during EDP and QDP are compared with the TEC values of the following day. A third measure of W-index is also applied to identify the local disturbances in the ionosphere, where TEC of a given day is compared to the median of seven days prior to the day of investigation logarithmically. Since W-index is obtained for each epoch, the within-the-day variability can also be monitored. It has been observed that peak TEC values for all stations in TNPGN increase 10 to 15 TECU two days prior to the earthquake. The SKLD values for comparison of EDP and AQDT also peak on 21st of October, 2011, two days prior to the earthquake. Since ionospheric disturbance can be observed on all days prior to the earthquake, comparison of TEC for consecutive days for each station using SKLD does not provide extra information. The W-index values indicate that there may be small scale variability for stations closer to the earthquake epicenter. When compared with previous earthquakes that occurred in Turkey with magnitudes 4.5 and 5.2 on Richter scale, this 7.2 magnitude earthquake has been felt as an ionospheric disturbance for stations especially on Northern Anatolian Fault. The results also indicate the need for constant monitoring and statistical decision theory for detection of earthquake precursors.

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