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Evaluation of Ionospheric Earthquake Precursor Signatures: Statistical and Tomographic approaches over Japan area

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ABSTRACT

Many papers on ionospheric anomalies possibly associated with large earthquakes have been reported[1][2][3]. We investigate the distribution of ionospheric electron density (total electron content (TEC) and tomography) prior to large earthquakes in this paper.

As for the Ionospheric approach, it is important to reduce the effect of geomagnetic storms. The influences of a magnetic storm on TEC variations depend on the intensity and onset time of the storm. In this study, to clarify such dependences, we applied classification analysis method to the storm data (Dst) and discussed the response of TEC variation to each type of storm. We picked out all the 294 geomagnetic storms during 1998-2013, and classified them into 3 types in magnitude and 4 types in the onset time (local time). A bootstrap method is used to calculate the average variation of the TEC for each type of storm. Then, we could find the accurate period affected by each type of storm. Next we performed statistical analysis of the TEC anomalies possibly associated with large earthquakes in Japan area during 1998-2013. There are statistical significance of TEC anomalies 1-5 days before and 16-20 days after M>=6.0 earthquakes. The significance of 16-20 days after earthquakes may be due to aftershock effects of the Tohoku earthquake. Then, we used the Molchan's error diagram to evaluate the efficiency of TEC anomalies for short-term earthquake forecasts [4]. The results indicates that the predictions based on TEC anomalies are better than random guess, which suggests that the TEC anomalies contain certain precursory information of earthquakes.

As for the tomographic approach [5], we investigate the spatial and temporal distribution of ionospheric electron density prior to the 2011 Tohoku earthquake (Mw9.0). TEC increase on 3－4 days prior to the earthquake was remarkable and the electron density was decreased around the east-region of reconstructed area above the epicenter around 250 km altitude and increased the wide area around 3-400 km, respectively.

These results show the statistical significance between the earthquake and ionospheric anomaly and indicate the highly suggestive of precursor signatures of large earthquakes. Especially, tomographic results give us the key information on physical mechanisms and further studies will be required.

Key words: ionospheric anomalies possibly associated with large earthquakes, statistical significance, Molchan's error diagram, short-term earthquake forecasts, tomographic approach.

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