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Statistical study on short-term earthquake forecast using TEC anomalies over Japan area

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To reduce the effect of strong geomagnetic activities such as geomagnetic storms, the TEC data of 2 days after Dst index exceed -60 nT were excluded in previous statistical studies of earthquake related TEC anomalies. Actually, 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 according to its magnitude and 4 types according to the onset time (local time). We checked the TEC data from 2 days before till 5 days after the onset of each geomagnetic storm. A bootstrap method (10000 times extraction) is used to calculate the average variation of the TEC for each type of storm. The average variation can be regarded as an average response of TEC to the related type of storm. If the average value of TEC exceeds the mean$\pm 2\sigma$ threshold, we consider it being affected by the storm. By this mean, we could find the accurate period affected by each type of storm.

We employed the results obtained above to remove the TEC data associated with geomagnetic storms. Next we performed statistical analysis of the TEC anomalies possibly associated with large earthquakes in Japan area during 1998/05-2013/12. There are statistical significance of TEC anomalies 1-5 days before and 16-20 days after M>=6.0 earthquakes. The significance of pre-earthquake anomalies is consistent with the results reported by Kon et al., 2011. The significance of 16-20 days after earthquakes may be due to aftershock effects of the Tohoku earthquake. To remove the influences of any per- and after- shock effects, we proposed a new method which considers 'isolate EQs' only. 'Isolate EQs' are earthquakes which is unique in a 61 days window centered by the day of the EQ. The result shows there are clear high possibilities of TEC anomalies 1-5 days prior to M>=6 earthquakes.

Finally, we used the Molchan's error diagram to evaluate the efficiency of TEC anomalies for short-term earthquake forecasts. The results indicates that the predictions based on TEC anomalies are better than random guess (Poisson model), which suggests that the TEC anomalies contain certain precursory information of M>=6.0 earthquakes.

Keywords: statistical analysis, geomagnetic storm, TEC anomalies, earthquake, SEA, Molchan's Error Diagram