

# **Ionospheric Anomaly as an Earthquake Precursor : Case and Statistical Studies during 1998-2012 around Japan**

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Many anomalous electromagnetic phenomena possibly associated with large earthquakes have been reported. TEC (Total Electron Contents) anomaly is one of the most promising phenomena preceding large earthquakes. We investigated statistically TEC anomalies before large earthquakes around Japan region during 1998-2012. In this study, superposed epoch analysis (SEA) and Molchan's error diagram (MED) analysis have been taken to investigate correlation and predictability in the statistical manner. The results of SEA show that positive anomaly 1-5 days before the large earthquake ( $M \geq 6.0$  and depth  $\leq 40$  km) is significant. The results of MED analysis indicate the some gain against the random estimation (Poisson model). That is, the prediction using TEC anomaly around Japan is not random and has an information. Furthermore, in order to understand the mechanism, monitoring of 3D distributions of ionospheric electron density is considered to be effective. In this study, to investigate the three-dimensional structure of ionospheric electron density prior to large earthquake, the neural network based tomographic approach is adapted to GEONET and ionosonde data for the 2011 Off the Pacific Coast of Tohoku Earthquake (Mw9.0) and other earthquake which investigated in above statistical analysis. As for the M9 Tohoku earthquake, the reconstructed distribution of electron density decreases just below the F-region and was enhanced over F-region in comparison with 15 days backward median distribution. Moreover the enhanced area seems to be developed to upper ionosphere from sub-ionosphere with time. Similar precursor tendency is found for the earthquake with longer duration of GIM-TEC anomalies. These tomographic results suggest the existence of additive horizontal electric field of eastward, which is possibly related to the seismic activity. The details will be shown in the presentation.