

## **Anomalous TEC Changes Possibly Associated with the 2011 Great East Japan Earthquake**

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Recently, there are many reports on earthquake-related electromagnetic phenomena. Anomalous Total Electron Content (TEC) changes preceding large earthquakes are one of the most promising phenomena among of them. In this study, we investigate TEC anomalous variations in time and space for the 2011 off the Pacific coast of Tohoku Earthquake.

In this study, TECs are computed with using the GEONET and Global Ionosphere Maps (GIM). In order to remove a daily variation of TEC, 15 days backward running average (TECmean(t)) and its standard deviation  $\sigma(t)$  at a specific time are taken for the normalization. The normalized TEC GPS-TEC\* (t) is defined as follows:  $TEC * (t) = (TEC(t) - TECmean(t)) / \sigma(t)$ .

For the Pacific coast of Tohoku Earthquake, GPS-TEC\* anomalies exceeding  $+2\sigma$  appear 3-4 and 5 days before the earthquake. Their total durations are 13 and 14 hours, respectively. GIM-TEC\* anomalies exceeding  $+2\sigma$  appear 3-4 days before the earthquake. The duration is more than 20 hours. In space, the region of GIM-TEC\* anomalies 3-4 days before the earthquake appears over northern Japan and remains more than 24 hours.

These results are consistent with the previous statistical analysis around Japan.

Detail will be give in the presentation.

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## References

- [1.] Liu, J. Y., Chuo, Y. J., Shan, S. J., Tsai, Y. B., Chen, Y. I., Pulinets, S. A., Yu, S. B., 2004a. Pre-earthquake ionospheric anomalies registered by continuous GPS TEC measurements. *Annales Geophysicae* 22, 1585–1593,2004.
- [2.] Liu, J. Y., Chen, Y. I., Chen, C. H., Liu, C. Y., Chen, C. Y., Nishihashi, M., Li, J. Z., Xia, Y. Q., Oyama, K. I., Hattori, K., Lin, C. H., 2009. Seismoionospheric GPS total electron content anomalies observed before the 12 May 2008  $M_w7.9$  Wenchuan earthquake. *Journal of Geophysical Research* 114, A04320, doi:10.1029/2008JA013698.
- [3.] Shimpei Kon., Masahide Nishihashi., Katsumi Hattori. Ionospheric disturbances possibly associated with  $M \geq 6.0$  Earthquakes in the Japan area during 1998–2008: statistical study and some case studies. *Journal of Asian Earth Sciences* 41, 410-420,2011