

## Preseismic ionospheric electron enhancements, revisited : Discrimination from TID and interfrequency receiver bias estim

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Possible enhancement of ionospheric Total Electron Content (TEC) immediately before the 2011 Tohoku-oki earthquake (Mw9.0) has been reported by Heki [2011]. Later, Kamogawa and Kakinami [2013] attributed the enhancement to an artifact falsely detected by the combined effect of the highly variable TEC under active geomagnetic condition and the occurrence of a tsunamigenic ionospheric hole [Kakinami et al., 2012]. Recently, Heki and Enomoto [2013] showed that preseismic TEC increase did occur by studying vertical TEC (VTEC) rather than slant TEC (STEC) before and after the 2011 Tohoku-oki earthquake and by comparing them with other geophysical data including the electron density profile from radio occultation, foEs at the Kokubunji ionosonde, and geomagnetic declination changes. In this paper, I focus on a few remaining problems in preseismic TEC enhancement, i.e. (1) possibility to discriminate preseismic TEC anomalies from space-weather origin TEC changes represented by the large-scale traveling ionospheric disturbances (LSTID), (2) estimation of site-specific inter-frequency biases for stations outside Japan, (3) possible difference of amplitudes of preseismic TEC anomalies between mid-latitude and equatorial regions, and (4) comparison between the TEC drops occurring ~10 minutes after earthquakes with preseismic enhancements.

### References

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(Figure caption) Residual vertical TEC time series for seven large earthquakes for which precursory TEC enhancements have been observed. Below the two examples of the 2011 Tohoku-oki earthquake, the rest (six) of the events are arranged by their moment magnitudes. Distinct trend changes seem to occur about 40 minutes before the earthquake. In some cases, they are cancelled by sudden drops 10 minutes after the earthquakes (e.g. 2007 Bengkulu, 2004 Sumatra-Andaman). In other cases, they decay gradually with a timescale of 20 minutes or so (e.g. 2012 North Sumatra earthquakes). Site names and satellite PRN numbers are given at the right end of the time series.

Keywords: GNSS, GPS, ionosphere, earthquake, precursor, TEC

MIS29-04

Room:313

Time:April 29 15:00-15:15

