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Ionospheric electron enhancement immediately before the 2011 NE Japan earthquake

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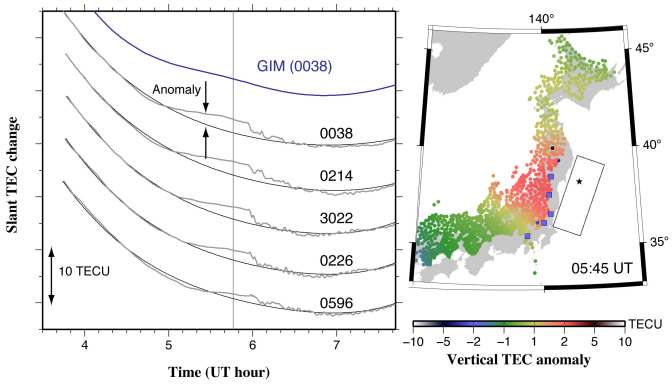
The 2011 March 11 earthquake in NE Japan (Mw9.0) caused vast damages to the country. Large events beneath dense observation networks could bring breakthroughs to seismology and geodynamics, and here I report one such finding. The Japanese dense network of Global Positioning System (GPS) detected clear precursory positive anomaly of ionospheric total electron content (TEC) over the region within 200-300 km from the focal region. It started ˜40 minutes before the earthquake and reached nearly ten percent of the background TEC. It lasted until atmospheric waves arrived at the ionosphere. Similar preseismic TEC anomalies, with amplitudes dependent on magnitudes, were seen in the 2010 Chile earthquake (Mw8.8), and possibly in the 2004 Sumatra-Andaman (Mw9.2) and the 1994 Hokkaido-Toho-Oki (Mw8.3) earthquakes. The ionospheric electrons might have been attracted by the positive electric charges appeared above the faults during the nucleation stage. The claim that earthquakes are inherently unpredictable may not be true at least for M9 class earthquakes.

The left panel of the figure shows the change of slant TEC observed with the satellite 15 at five GPS stations (their sub-ionospheric points are shown as blue squares in the right panel). The curvature of the time series comes mainly from the change in the satellite elevation. The vertical TEC was modeled with a cubic function of time as shown by black smooth curves, and the departures of the observed TEC from the models are defined as anomalies. Positive TEC anomalies are seen to grow immediately before the earthquake at GPS points close to the epicenter. Such positive TEC anomalies disappear after the passage of acoustic waves from the epicenter (i.e. the occurrence of coseismic ionospheric disturbances ˜10 minutes after the earthquake). The geographical distribution of these anomalies at 05:45 UT (1 minute before the earthquake) was plotted in the right panel. Latitudinal extent of the positive anomaly (shown in red) approximately overlaps with the ruptured fault. The blue curve in the left panel was drawn using a Global Ionospheric Map (GIM) downloaded from the University of Berne.



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