Geophysical Research Abstracts,
Vol. 11, EGU2009-9057, 2009
EGU General Assembly 2009

Directivity of propagation and the waveform of TEC perturbation associated with large earthquake of 5 September 2004

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Nowadays Global Positioning System (GPS) is one of the most powerful tools for studying ionosphere. Good coverage around the globe and good time sampling (30 sec) made it possible recently to obtain important information about parameters of ionosphere disturbances of different origin.
Using GPS measurements of total electron content (TEC) by the Japanese dense GPS array (GEONET), we studiy ionosphere response to large earthquake of 5 September 2004 with magnitude 7.2 that occurred near Kii peninsula of Honshu Island (Japan) at 10:07 UT. Relative position of the earthquake's epicenter and the receivers provide a unique opportunity to track propagation of coseismic ionosphere disturbances (CID) northeastward, northward, northwestward, westward and southwestward from the epicenter. This shed light on the directivity of propagation of CID.
The response appears at the nearest GPS receivers 10-15 minutes after the main shock. The amplitude of the TEC variations varies from 0.1 to 0.6 TEC units depending on the distance from the epicenter and on the location of GPS receivers. Apart from the difference in amplitude, the waveforms of the registered signals differ depending on the azimuth of the CID registration: we observe regular N-type waves on the southwest and west from the epicenter, whereas GPS receivers on the north and northeast recorded inverted N-waves or simple negative disturbances of small amplitude. In order to obtain more information about the directivity effects, we performed a simple ray-tracing in the atmosphere and we found that synthesized signals differ from observational ones.
It is known, the final form of a wave and its amplitude depend on the geometry of line-of-sight, disturbance wavefront, and on the direction of the geomagnetic field. Most likely, in our case all these factors influenced the waveform of the observed disturbances. The observed strong attenuation of northward propagating signals is related to the influence of geomagnetic field (Afraimovich et al., Ann. Geophys., 19, 395, 2001; Heki and Ping, Earth Planet Sci. Lett., 236, 845, 2005).