Seismo-ionospheric anomalies and disturbances induced by the 11 March 2011 M9.0 Tohoku Earthquake

J. Y. Liu[1]
[1] Inst. Space Science and CSRSR of National Central University, and NSPO, Taiwan

In this paper, the total electron content (TEC) derived from ground-based GPS (global positioning system) receiving networks are used to observe the seismo-ionospheric anomalies and traveling ionospheric disturbances associated the 11 March 2011 M9.0 Tohoku earthquake. To identify the pre-earthquake anomalies, the TEC of the global ionosphere map (GIM) is examined. The Thermosphere Ionosphere Electrodynamics General Circulation Model (TIEGCM) is applied to simulate the observed anomalies. The observation shows that the TEC over the epicenter significantly enhances on 6-8 March 2011, 4-2 days before the earthquake. The spatial analysis further demonstrates that the enhancement anomaly specifically and persistently appears in the northern epicenter area. Simulation results well agree with the observations, which suggest that the electric potential around the epicenter has been distorted and significantly affect the TEC during the earthquake preparation period. On the other hand, the seismic and tsunami waves of the Tohoku earthquake excited atmospheric pressure waves near the Earth's surface, which then traveled into the ionosphere and significantly disturbed the electron density within it hereafter referred to as the seismo-traveling ionospheric disturbances (STIDs). The TEC derived from nationwide GPS receiving networks in Japan and Taiwan is employed to monitor STIDs triggered by seismic and tsunami waves of the earthquake. The STIDs first appear as a disk-shape TEC increase about 7 minutes after the earthquake occurrence centered at about 200 km east of the epicenter, near the west edge of Japan Trench. Fast propagating disturbances related to Rayleigh waves quickly travel away from the epicenter along the main island of Japan with a speed of 2.3-3.3km/s, accompanied by sequences of concentric circular TEC wavefronts (acoustic gravity waves) and followed by circular ripples (tsunami waves whit a speed of about 720-800km/hr) travel away from the STID center together with various confounded acoustic gravity waves of 290-1500 m/s. These are the most remarkable STIDs ever observed where signatures of Rayleigh waves, acoustic gravity waves, and tsunami waves, etc. simultaneously appear in the ionosphere.