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Ionospheric perturbations related to earthquakes

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Ionosphere is disturbed by large earthquakes and tsunamis. When a vertical sudden displacement of the ground and sea surface caused by the earthquake and tsunami excites acoustic and gravity waves in the atmosphere, the acoustic and gravity waves propagate into the ionosphere and disturb ionospheric plasma. The M 9.0 Tohoku earthquake (Tohoku EQ) was a megathrust-type which occurred on March 11 of 2011 at 0546 UT in the western Pacific Ocean. After the Tohoku EQ, many types of ionospheric disturbances such as acoustic resonance and gravity wave were observed. Furthermore, large plasma depletion named ”tsunamigenic ionospheric hole” was observed. Similar plasma deletions were also found in the 2010 M8.8 Chile and the 2004 M9.1 Sumatra earthquakes. This occurs because plasma is descending at the lower thermosphere where the recombination of ions and electrons is high through the meter-scale downwelling of sea surface at the tsunami source area, and is highly depleted due to the chemical processes.

We also found a faster CID propagated at ˜3.0 km/s only in the west-southwest, while a slower CID propagated concentrically at 1.2 km/s or slower from the tsunami source area in the Tohoku EQ. Taking the propagation speed and oscillation cycle into account, the faster CID was associated with a Rayleigh wave but the slower CID was associated with an acoustic or gravity wave. The north-south asymmetry of the CID associated with the Rayleigh wave suggests that the Rayleigh wave did not act as a point source of the acoustic wave because a point source propagating in all directions produces CID in all directions. Therefore, a superimposed wave front of acoustic waves excited by the Rayleigh wave produced the north-south asymmetry of the faster CID due to the magnetic inclination effect.

Keywords: ionospheric disturbance, GPS-TEC, earthquake, Rayleigh wave, acoustic wave, ionospheric hole