

# Oscillations and traveling perturbations observed from ground to the ionosphere after the 2011 Mw9.0 Tohoku earthquake

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This study examined the multi-source data including seismometers, COSMIC radio occultation (RO) soundings of refractivity index (RI) in the lower atmosphere (from 0 to 60 km) and total electron content (TEC) in the ionosphere (from 150 to 550 km), as well as ground-based GNSS TEC after/during the 2011 Mw9.0 Tohoku earthquake/tsunami. The horizontal propagation characteristics of the seismo-traveling ionospheric disturbances were identified combining the seismometers and ground-based GNSS TEC data. The post-seismic ionospheric infrasound and gravity wavefronts were vertically scanned by individual RO TEC profiles. The traveling perturbations indicates that earthquake/tsunami can induce atmospheric acoustic-gravity waves in the Earth's upper atmosphere and ionosphere. On the other hand, the RI observations show the first evidence of the Tohoku earthquake/tsunami-induced vertical oscillations in the lower atmosphere. In addition, acoustic resonant oscillations are recorded in ionosphere by ground-based GNSS TEC after Tohoku earthquake, and the spectra are corresponding to the fundamental and harmonic of the atmospheric trapped acoustic modes, which are explained by the normal mode simulation and substantiated using ground seismic data. The study suggests that the coupling between the solid Earth and the atmosphere can excite both the traveling perturbations and harmonic motions from ground to the ionosphere.

Keywords: Tohoku earthquake, oscillations, vertical structure, traveling ionospheric disturbances, radio occultation

