A fast acoustic wave detected in GNSS total electron content after the foreshock of the 2011 Tohoku Earthquake

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Acoustic waves are often emitted from large earthquakes, reach the thermosphere and disturb the ionosphere. The disturbances are observed by using of GNSS total electron content (TEC). After the foreshock of the 2011 Tohoku Earthquake, which occurred on 9 March 2011, traveling ionospheric disturbance induced by tsunami was detected. When vertical propagation of acoustic wave from the tsunami source area is assumed, the onset points of co-seismic ionospheric disturbance (CID) must coincide. However, the onset points of the co- CID were detected at different locations in different satellite data assuming that the altitude of CID were the same (ex. at 300 km). Furthermore, we found the onset times were different in the different satellite data. The results suggest that the altitudes of CID are different and timings of observation are also different in the different satellite data. By changing the altitudes of CID, we found coinciding onset point. Once the coinciding onset point is found in the different data sets, the altitudes of the CID are also estimated because the sub-ionospheric point is a function of the altitude of observation. The CID altitude were found at 155.4 and 234.9 km. Considering the time difference of the onset time (399.9 s to the altitude of 155.4 km and 476.1 s to 234.9 km), the acoustic wave velocity is estimated to be 1.04 km/s which is 1.4 times higher than the velocity calculated using the empirical model NRLMSISE-00. The fast acoustic wave would arise from temperature elevated by the limited degrees of freedom of motion of atmospheric molecules, and dissipation of the acoustic wave. Especially, the neutral temperature with heating by the dissipation of the acoustic wave would increase by a factor of 3 for acoustic waves with 0.1 Hz and a pressure at sea level of ~2 Pa, which is on the order of the pressure of the acoustic wave emitted from the sea surface during the observed event. The elevated temperature explains the fast acoustic wave.

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