Vertical velocity of acoustic wave detected with GNSS total electron content

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Acoustic waves are generated by the ground and sea surface motion after large earthquakes. The acoustic waves reach upper atmosphere and disturb plasma in the ionosphere though collision with neutral atmosphere. The ionospheric disturbance are observed ionospheric observation such as ionosonde and GNSS total electron content (TEC). Using dense GNSS network, the ionospheric disturbance associated with the earthquakes (co-seismic ionospheric disturbance, CID) has been investigated. Several type of traveling ionospheric disturbances are often observed. The one is associated with acoustic wave generated at the epicenter/tsunami source area. The velocity of the disturbance around 1 km/s. The other is associated with Rylie wave whose velocity is around 3 km/s. Further, localized ionospheric depletion (ionospheric hall) is observed after the earthquakes accompanied with tsunami. Since the center location of the ionospheric hall are located at the place of maximum vertical displacement, namely tsunami source area, it is concluded that the ionospheric hall is created by acoustic wave generated at the tsunami source area. Therefore, it is a quite plausible conclusion that the source of CID is generated at the maximum vertical displacement. Similar result is also obtained in the CIDs after Nepal earthquake occurred on 25 April 2015. The CIDs are mainly observed over the maximum vertical displacement located at east side of the epicenter. The result indicates that the conclusion is valid for not only submarine earthquake inducing tsunami but also inland earthquake. However, ambiguity of the location of the CID still exists because sub-ionospheric point is located at away from (close to) the sensor when the ionospheric layer is assumed at higher (lower) altitude. Therefore, the location of generation of acoustic wave has not been confirmed enough.

The CIDs are also observed after the foreshock of Tohoku earthquake occurred on 9 March 2011. In this case, initial point of CID were observed by using the signal of 3 GPS satellites When estimation of the center of the CID is performed with triangulation using 3 satellites data, it is possible that accurate location of the center of the CID is estimated. Further, we found altitude difference of the estimated altitude of the disturbance from the results. From the result, vertical velocity of the acoustic wave is estimated at 1.03 km/s. These results suggest that using GNSS TEC is effective tool to estimate the location of maximum vertical displacement and vertical velocity of the acoustic wave.

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