

地震・津波により励起された音波による電離圏擾乱 Ionospheric disturbances induced by acoustic waves excited by earthquakes and tsunamis

柿並 義宏^{1*}, 山本 真行¹

Yoshihiro Kakinami^{1*}, Masa-yuki Yamamoto¹

¹ 高知工科大学

¹Kochi University of Technology

Since the first report of atmospheric perturbation associated with earthquakes in 1960's, many evidences of ionospheric perturbation have been reported using ionosondes. A dense GPS array is a good 2-D monitoring tool for studying ionosphere because total electron content (TEC) can be estimated using the phase difference of two L-band ($f_1=1575.42$ MHz and $f_2=1227.60$ MHz) carriers emitted from GPS satellites. Recently, using the GPS-TEC, ionospheric disturbances induced by infrasound excited by earthquakes and tsunamis have been well investigated.

After the M 9.0 Tohoku earthquake (Tohoku EQ) occurred on March 11 of 2011, many types of ionospheric disturbance such as acoustic resonance and gravity wave were observed. The initial TEC variation was observed 9 min after the main shock. Distribution of the intensities of the initial TEC variation showed clear inclination and declination effect of magnetic field. After the initial TEC variation, deep plasma density depletion named "tsunamigenic ionospheric hole" was observed over the tsunami source area. Similar depletion was also found in the 2010 M8.8 Chile, the 2004 M9.1 Sumatra earthquakes and others.

Asymmetry of propagation of the initial TEC variation was found. A faster coseismic ionospheric disturbance (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 possibly induced by acoustic waves excited by a Rayleigh wave but the slower CID was associated with an acoustic or gravity wave. If the acoustic wave excited by the Rayleigh wave induced the faster CID at each point, the faster CID must be observed even at north of the epicenter because the Rayleigh wave propagated all directions from the epicenter. Therefore, the acoustic wave excited by the Rayleigh wave formed superimposed wave front and then it disturbed the ionosphere.

A CID associated with acoustic resonance also showed asymmetry of the distribution. North edge of the CID associated with acoustic resonance corresponded to north edge of the tsunamigenic ionospheric hole. Further, the propagation velocity of the CID is similar to that of acoustic waves. The results imply the source of acoustic resonance was located over the tsunami source area and acts as a point source.

キーワード: 電離圏擾乱, GPS-TEC, 地震, レイリー波, 音波共鳴, 津波電離圏ホール

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