

Numerical simulations of ionospheric disturbances induced by tsunami and tsunami source

Mitsuru Matsumura^{1*}, Takuya Tsugawa², Hiroyuki Shinagawa², Akinori Saito³, Yuichi Otsuka⁴, Toshihiko Iyemori⁵

¹Center for Space Science and Radio Engineering, University of Electro-Communications, ²National Institute of Information and Communications Technology, ³Department of Geophysics, Graduate School of Science, Kyoto University, ⁴Solar-Terrestrial Environment Laboratory, Nagoya University, ⁵Data Analysis Center for Geomagnetism and Space Magnetism, Graduate School of Science, Kyoto Univ

Observational, theoretical and numerical studies have revealed that tsunamis excite atmospheric gravity waves and induce ionospheric disturbances. To understand the response of the ionosphere to an extreme tsunami and its source is useful to understand upward coupling of the atmosphere and the ionosphere, and to apply ionospheric observations to tsunami early warning systems. TEC (Total Electron Content) observed by Japanese GPS receiver network after the 2011 Tohoku-oki earthquake had propagating oscillations with phase velocities of 220-290 m/s, similar to that of a tsunami. Not only the tsunami but also its source could be sources of the TEC oscillations because the tsunami and its source were close to each other. Contributions of tsunami and its source to the TEC oscillations should be separated to understand the each response. In this study, a coupled model of two-dimensional tsunami, three-dimensional nonhydrostatic and compressible atmosphere, and three-dimensional ionosphere is developed to investigate the tsunami and the tsunami source contributions to the TEC oscillations. Our simulations reveal that the amplitude of TEC oscillations of 220-290 m/s induced by the tsunami source is comparable to that induced by the tsunami. The observed and simulated TEC also have propagating oscillations with phase velocities of 420-780 m/s, and other oscillations confined near the epicenter with periods of about 4 min. These oscillations are shown to be induced only by the tsunami source. The relation between the TEC amplitude and the tsunami amplitude can be derived indirectly by using the relation between the TEC amplitude and the tsunami source amplitude.

Keywords: gravity wave, acoustic wave, earthquake, tsunami, TEC