Effects of small ocean floor earthquakes on the ionosphere

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A number of observations have indicated that the ionosphere is significantly affected by strong earthquakes or tsunamis. Previous studies suggested that atmospheric acoustic waves and gravity waves generated by seismic waves or tsunamis propagate upward up to the upper atmosphere, resulting in variations in the ionosphere. The amplitude of seismically excited acoustic waves in the thermosphere is estimated to be about 10^4 or 10^5 times larger than the amplitude of seismic waves on the ground [Shinagawa et al., 2013; Maruyama and Shinagawa, 2014]. In the ocean, compressibility of water becomes important for seismic waves with a period of about 10 seconds or less, and acoustic waves are generated by sudden motion at the sea floor, propagating upward up to the sea surface. For acoustic waves with certain periods, resonance of the acoustic waves in the vertical direction could occur, which results in large oscillations at the sea surface. Previous theoretical studies suggest that the amplitude of sea surface oscillation at resonant frequencies could reach about 100 times larger than the sea floor oscillation [Williams and Guo, 1991; Izumiya et al., 1996]. The large amplitude oscillation driven by resonant acoustic waves generate atmospheric acoustic waves, which propagate upward into the upper atmosphere, resulting in the amplitude of acoustic waves of about 10^6 or 10^7 larger than the sea bottom oscillation. Small oscillations at the sea bottom may generate significant variations in the ionosphere. In order to quantitatively investigate those processes, I developed an axisymmetric three-dimensional compressible fluid model of the ocean, and a compressible one-dimensional atmosphere-ionosphere model for the atmosphere and the ionosphere. Using the models, I studied the variations in the ionosphere associated with earthquakes in the deep ocean. I found that there are two types of effects of resonant sea floor oscillation on the ionosphere: (1) wave-like variations in the electron density, and (2) electron density enhancement driven by viscous heating in the thermosphere. It depends on the amplitude and period of the oscillation in the sea floor whether those variations become observable or not. I will report some results of the ionospheric variations obtained by the models.

References

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