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Propagation Characteristics of Neutral Atmospheric Waves Associated with Earthquakes Using a Numerical Simulation

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By using HF Doppler and GPS ionospheric total electron content (TEC) observations, it is found that atmospheric waves excited by earthquakes cause ionospheric disturbances. In this study, we examined the relationship between seismic ground perturbations and ionospheric disturbances in order to mechanism of the propagations of atmospheric waves using a numerical simulation. In this simulation, we calculated temporal evolutions of neutral atmospheric waves by solving basic equations of neutral atmosphere.

The effects of the artificial viscosity used in the numerical simulation are evaluated. In compressible fluids, shock waves occur when advection velocity is faster than the sound velocity. Although shock waves correspond to discontinuous planes mathematically, they have the thickness of the mean free path of air molecules approximately. When we run the simulation without artificial viscosity, the simulation is diverged. Thus, we add Von-Neumann-type artificial viscosity. In adding the artificial viscosity, it is necessary to determine an adequate artificial viscosity coefficient. Therefore we compared the simulation results with the theoretical equations (*Chum et al*., 2012) obtained by subtracting attenuation from law of the conservation of energy flux. The simulation results were determined with the various artificial viscosities. As the artificial viscosity becomes larger, the amplitude of simulation results become small and the amplitude depend on the period of input disturbance as compared to the theoretical equations. This result means that the adequate artificial viscosity coefficient must be determined owing to the period of input disturbances. At the wave front, the waveform is elongated, the amplitude is larger than theoretical equation. We discussed temporal waveforms to find the cause of this waveform. It is found that the waveform includes the lower frequency component than input disturbance. The theoretical equation shows that the atmosphere works as low pass filter, and that the cut-off frequency become lower with the higher altitude because high frequency components are attenuated due to viscosity and heat conduction. Due to these characteristics, low-frequency component is dominant at higher altitude.

Keywords: Earthquake, Neutral atmospheric wave, Numerical simulation, Ionospheric disturbance