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Generation and Upper Atmospheric Propagation of Acoustic Gravity Waves according to Numerical Modeling and Radio Tomography

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The acoustic-gravity waves (AGW) in the upper atmosphere and ionosphere can be generated by a variety of the phenomena in the near-Earth environment and atmosphere as well as by some perturbations of the Earth's ground or ocean surface. For instance, the role of the AGW sources can be played by the earthquakes, explosions, thermal heating, seisches, tsunami waves. We present the examples of AGWs excited by the tsunami waves traveling in the ocean, by seisches, and by ionospheric heating by the high-power radio wave. In the last case, the gravity waves are caused by the pulsed modulation of the heating wave.

The AGW propagation in the upper atmosphere induces the variations and irregularities in the electron density distribution of the ionosphere, whose structure can be efficiently reconstructed by the method of the ionospheric radio tomography (RT) based on the data from the global navigational satellite systems (GNSS). The input data for RT diagnostics are composed of the 150/400 MHz radio signals from the low-orbiting (LO) satellites and 1.2-1.5 GHz radio signals from the high-orbiting (HO) satellites with their orbits at $\sim$1000 and $\sim$20000 km above the ground, respectively. These data enable ionospheric imaging on different spatiotemporal scales with different spatiotemporal resolution and coverage, which is suitable, inter alia, for tracking the waves and wave-like features in the ionosphere.

In particular, we demonstrate the maps of the ionospheric responses to the tornado at Moore (Oklahoma, USA) of May 20, 2013, which are reconstructed from the HO data. We present the examples of LORT images containing the waves and wavelike disturbances associated with various sources (e.g., auroral precipitation and high-power heating of the ionosphere). We also discuss the results of modeling the AGW generation by the surface and volumetric sources. The millihertz AGW from these sources initiate the ionospheric perturbation with a typical scale of a few hundred km at the heights corresponding to the middle atmosphere and ionosphere. The results of numerical modeling based on the solution of the equation of geophysical hydrodynamics agree with the observations.