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Acoustic-gravity waves generated by atmospheric and near-surface sources

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Numerical simulation of the acoustic-gravity waves (AGW) generated by long-period oscillations of the Earth's (oceanic) surface, earthquakes, explosions, thermal heating, seiches, and tsunami is carried out. Wavelike disturbances are quite frequent phenomena in the atmosphere and ionosphere. These events can be caused by the impacts from space and atmosphere, by oscillations of the Earth'as surface and other near-surface events. These wavelike phenomena in the atmosphere and ionosphere appear as the alternating areas of enhanced and depleted density (in the atmosphere) or electron concentration (in the ionosphere).

In the paper, AGW with typical frequencies of a few hertz - millihertz are analyzed. AGW are often observed after the atmospheric perturbations, during the earthquakes, and some time (a few days to hours) in advance of the earthquakes. Numerical simulation of the generation of AGW by long-period oscillations of the Earth's and oceanic surface, earthquakes, explosions, thermal heating, seiches, and tsunami is carried out. The AGW generated by the near-surface phenomena within a few hertz-millihertz frequency range build up at the mid-atmospheric and ionospheric altitudes, where they assume their typical spatial scales of the order of a few hundred kilometers. Oscillations of the ionospheric plasma within a few hertz-millihertz frequency range generate electromagnetic waves with corresponding frequencies as well as travelling ionospheric irregularities (TIDs). Such structures can be successfully monitored using satellite radio tomography (RT) techniques. For the purposes of RT diagnostics, 150/400 MHz transmissions from low-orbiting navigational satellites flying in polar orbits at the altitudes of about 1000 km as well as 1.2-1.5 GHz signals form high-orbiting (orbital altitudes about 20000 km) navigation systems like GPS/GLONASS are used.

The results of experimental studies on generation of wavelike disturbances by particle precipitation are presented. The ionospheric footprints of atmospheric disturbances are given. The effects of AGW evolution after launching the rockets are studied. One of the possible applications of RT imaging of wavelike disturbances is the study of AGW and TID as probable precursors of the earthquakes. The key difficulty here is to distinguish between the AGW and atmospheric and ionospheric disturbances of non-seismic nature (for example, those caused by the enhanced solar-geomagnetic activity), which can be done by analyzing spatial two-dimensional and three-dimensional structures revealed by tomographic methods. The examples of AGW RT imaging based on the real experimental satellite data measured in regions of the Europe, North America and Asia are demonstrated. The example of AGW and TID generation by the tsunami wave after the Tohoku earthquake is presented. Our results prove the capability of RT methods to detect wavelike disturbances in the ionosphere, which are caused by the near-surface sources, and to distinguish between these disturbances and the influence from the atmosphere and space.

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