Modeling of AGW and related electromagnetic phenomena caused by atmospheric and near-surface sources

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Abstract

Numerical simulation of AGW generation by long-period oscillations of the Earth's surface, earthquakes, explosions, thermal heating, seiches and tsunami is carried out. Acoustic-gravity waves (AGW) with typical frequencies of a few hertz - millihertz are analyzed. Results of experimental studies of wavelike disturbances generation by particle precipitation are shown. Examples of ionospheric manifestations of atmospheric perturbations are given. Examples are shown of AGW RT imaging based on the real experimental satellite data measured in regions of the south-east Asia, California and Alaska.

Summary

Wavelike disturbances are quite often observed in the atmosphere and ionosphere. These events can be caused by the influence from space and atmosphere, by oscillations of the Earth surface and other near-surface phenomena. To such near-surface sources refer long-period oscillations of the Earth's surface, earthquakes, explosions, thermal heating, seiches and tsunami waves. In the atmosphere and ionosphere these wavelike phenomena appear as alternating areas of enhanced and depleted density (in the atmosphere) or electron concentration (in the ionosphere).

In the paper, acoustic-gravity waves (AGW) with typical frequencies of a few hertz - millihertz are analyzed. AGW are often observed after atmospheric perturbations, during earthquakes and some time (a few days to hours) before the earthquakes. Numerical simulation of AGW generation by long-period oscillations of the Earth's surface, earthquakes, explosions, thermal heating, seiches and tsunami is carried out. Being caused by near-surface phenomena within a few hertz-millihertz frequency range, the AGW are built up at mid-atmospheric and ionospheric altitudes where they get 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 having polar orbits at about 1000 km altitudes are used as well as 1.2-1.5 GHz signals form high-orbiting (orbital altitudes about 20000 km) navigation systems like GPS/GLONASS.

Results of experimental studies of wavelike disturbances generation by particle precipitation are shown. Examples of ionospheric manifestations of atmospheric effects are given. Effects of AGW development after rocket launching are studied. One of possible applications of RT imaging of wavelike disturbances is the study of AGW and TID as possible precursors of earthquakes. Main difficulty here is to distinguish between the AGW and atmospheric and ionospheric disturbances of non-seismic nature (for example, those caused by enhanced solar-geomagnetic activity), which can be done by analyzing spatial two-dimensional and three-dimensional structures revealed by tomographic methods. Examples are shown of AGW RT imaging based on the real experimental satellite data measured in regions of the south-east Asia, California and Alaska. The results obtained proved the capability of RT methods to detect wavelike disturbances in the ionosphere caused by near-surface sources and to distinguish between these disturbances and the influence from atmosphere and space.