#103 Received 01/20/2015

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GNSS-Based Radio Tomographic Studies of the Ionosphere at Different Latitudes

Abstract:
The purpose of this work is to study the structure and dynamics of the ionosphere using the data from the Global Navigation Satellite Systems (GNSS). GNSS include the first-generation systems (low-orbiting Transit and Tsikada/Parus satellite famililes) and second-generation systems that are currently both in use (the high-orbiting GPS and GLONASS systems) and under development (the European Galileo, Chinese BeiDou, and Japanese QZSS systems).

The GNSS space segment and the networks of ground-based receivers provide the possibility to carry out radio sounding of the ionosphere along different directions and to apply tomographic methods for processing the obtained data. The results described in the presentation are obtained by the methods of the low-orbiting (LO) and high-orbiting radio tomography.

We demonstrate and discuss different examples of RT imaging for the ionospheric structures at different latitudes including the equatorial anomaly (EA), ionization troughs, blobs, finger-like and multi-extremum structures, patches, wave-like irregularities, travelling ionospheric disturbances (TIDs), ionospheric tracks of the anthropogenic perturbations (explosions, rocket launches, heating by power radiowaves, etc.) and many other. We analyze the spatiotemporal features and dynamics of the ionosphere as a function of solar and geophysical conditions.

We present the examples of comparing the RT images with the measurements by the ionosondes. Particular attention is paid on analyzing the results of RT imaging of the ionosphere above the Arctic, which illustrate different structures and processes caused by the convection (the characteristic ring-like circumpolar structures around the North Pole, tongues of ionization, the drift of the patches of ionization from the dayside to the night-side ionosphere). The GNSS-based RT is capable of reconstructing the ionospheric disturbances caused by the propagation of the tsunami.

We analyze a series of cases including the ionospheric perturbations after the strongest Tohoku earthquake of March 11, 2011. Recently, the ionospheric studies have started to widely use the 2D global ionospheric maps (GIMs) of the total electron content (TEC), which are generated from the IGS data assuming the thin sheet approximation.

We present and discuss the results of comparing the GIM data with the RT images.