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High- and Low-Orbiting Radio Tomography of the Ionosphere under Different Geophysical Conditions and Ionospheric Perturbation Indices

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The methods of ionospheric radio tomography (RT), which are currently actively developing, are suitable for reconstructing electron density distributions in the ionosphere from radio signals transmitted from navigational satellite systems and recorded by the ground-based receiving networks. The RT systems that use signals of low-orbiting (LO) navigational satellites provide 2D distributions above the chains of ground receivers. The RT methods based on the signals from high-orbiting (HO) satellite navigational systems yield time sequences of 3D electron density distributions, i.e. 4D images of the ionosphere in space and time. We present the results demonstrating the possibilities, advantages, and limitations of LORT and HORT techniques under different seasonal and geomagnetic conditions in the different regions of the world. Particular attention is focused on the periods of severe geomagnetic storms. The RT images illustrate the highly structured and rapidly varying ionosphere during the disturbed periods. The spatiotemporal changes in the disturbed ionosphere are induced by different factors including particle precipitation. We present and discuss the comparisons of the ionospheric RT images and the DMSP particle flux data. Our studies revealed cases of good qualitative coincidence between the spatial structure of the precipitation-related ionization observed in the RT images and latitudinal distributions of the precipitating particles. For describing and studying the degree of perturbation of the ionospheric plasma, we suggest a number of quantitative indicators based on the LORT and HORT data. These new indices take into account the specificity of their “source” data, which makes them highly efficient. The comparison of the constructed indices with the space weather parameters and geomagnetic activity indices shows that these RT-based ionospheric indices are highly sensitive to these factors. We discuss the RT-indices that are most sensitive to the presence of the correlation between the variations in electron density and geomagnetic disturbances. It is established that the ionospheric perturbations are delayed relative to the geomagnetic disturbances on the different scales of the ionospheric variations. The work was supported by the Russian Foundation for Basic Research (under projects nos. 19-05-00941 and 17-05-01250 for processing and the analysis of the LORT and HORT data, respectively).