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Global ionospheric effects of geomagnetic storm on May 2–3, 2010 and their influence on HF radio wave propagation

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In this work we have investigated the global ionospheric response to geomagnetic storm on May 2–3, 2010 using GSM TIP (Global Self-consistent Model of the Thermosphere, Ionosphere and Protonosphere) simulation results. In the GSM TIP storm time model runs, several input parameters such as cross-polar cap potential difference and R2 FAC (Region 2 Field-Aligned Currents) varied as a function of the geomagnetic activity AE-index. Current simulation also uses the empirical model of high-energy particle precipitation by Zhang and Paxton. In this model, the energy and energy flux of precipitating electrons depend on a 3 hour Kp-index. We also have included the 30 min time delay of R2 FAC variations with respect to the variations of cross-polar cap potential difference. In addition, we use the ground-based ionosonde data for comparison our model results with observations. We present an analysis of the physical mechanisms responsible for the ionospheric effects of geomagnetic storms. The obtained simulation results are used by us as a medium for HF radio wave propagation at different latitudes in quiet conditions, and during main and recovery phase of a geomagnetic storm. To solve the problem of the radio wave propagation we used Zakharov's (I. Kant BFU) model based on geometric optics. In this model the solution of the eikonal equation for each of the two normal modes is reduced using the method of characteristics to the integration of the six ray equation system for the coordinates and momentum. All model equations of this system are solved in spherical geomagnetic coordinate system by the Runge–Kutta method. This model was tested for a plane wave in a parabolic layer. In this study, the complex refractive indices of the ordinary and extraordinary waves at ionospheric heights was calculated for the first time using the global first-principal model of the thermosphere-ionosphere system that describes the parameters of an inhomogeneous anisotropic medium during a geomagnetic storm. A comparison of the ordinary and extraordinary modes of HF radio ray paths in quiet and disturbed conditions has been done. We considered in more detail the features of the radio ray paths in the presence of F3 layer in the equatorial ionosphere, the main ionospheric trough and tongue of ionization at high latitudes. It is shown that the results obtained with use of radio propagation and GSM TIP models adequately describe HF radio ray paths in the Earth's ionosphere and can be used in applications.
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