

Stratospheric Warming Influence on HF Radio Wave Propagation in the Low-Latitude Ionosphere

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The case of a strong sudden stratospheric warming (SSW), which took place on January 23-27, 2009 has been selected for study. This period was characterized by low solar ($F_{10.7} \sim 70$) and geomagnetic ($K_p < 3$) activity. Peak warming accounted for on January 23-24. We present our investigation results of thermosphere-ionosphere response to the SSW obtained using Global Self-consistent Model of the Thermosphere, Ionosphere and Protonosphere (GSM TIP).

The SSW effects were simulated with different low boundary conditions at the height of 80 km in the GSM TIP model: (1) by setting the stationary perturbations $s = 1$ of the temperature and density at high latitudes; (2) by setting the global distribution of the neutral atmosphere parameters, calculated in the different atmosphere models. It is shown that the selected low boundary conditions don't allow fully reproduce the observed variation in the ionospheric parameters during SSW 2009 event. Further, using the observational data of the vertical plasma drift velocity obtained by Jicamarca ISR, we set in the GSM TIP model the additional electric potential that allowed to reproduce the zonal electric field ($E \times B$ vertical plasma drift) and observed SSW effects in the low-latitude ionosphere. The change in zonal electric field is key mechanism driving the ionospheric response at low latitudes, but our model results don't completely reproduce the variability in zonal electric fields at low latitudes.

Figure 1 shows that the latitudinal distribution of the total electron content at longitude $75^\circ W$ during quiet conditions (15 January 2009) before SSW 2009 event, obtained in the model calculations for different local time epochs, is in a good agreement with the GPS *TEC* observation data.

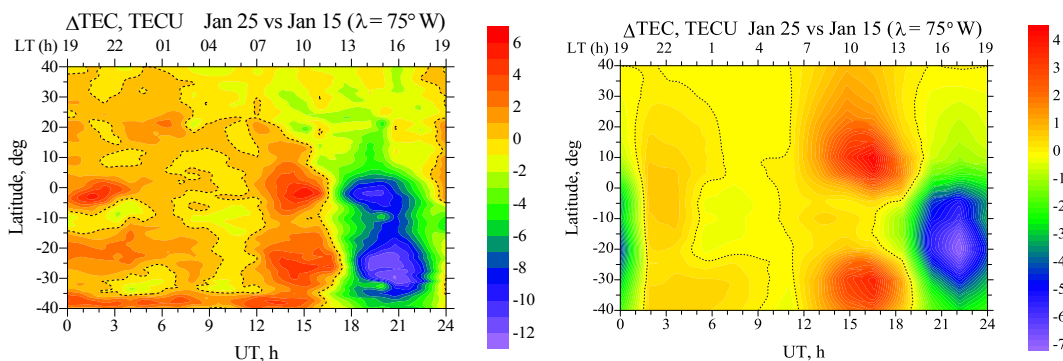


Fig. 1. *TEC* disturbances on January 25, 2009: GPS *TEC* observations (left), GSM TIP model calculations results (right).

We used GSM TIP modeled medium for the study of HF radio wave propagation during SSW event. We used the model Zakharov's (I. Kant BFU) HF radio wave propagation, based on geometric optics approximation. 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 path 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. We considered in more detail the features of the radio ray paths in the equatorial ionosphere. A comparison of the ordinary and extraordinary modes of HF radio ray paths were done.