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Experimental Investigations of the Ionospheric Processes during Solar Activity Minimum Period

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Investigation of the diurnal and seasonal variations of the physic processes parameters in quiet periods is one of the important problems in geospace physics. Results of these investigations are useful to development of new models of environment and specification already existing.

The objective of this study is observations, analysis and physical interpretation of the ionospheric processes parameters variations in very low solar activity period (2006 – 2009).

The experimental data (electron density, electron and ion temperature, vertical drift velocity etc.) were obtained using the Kharkov incoherent scatter radar of the Institute of Ionosphere.

It is confirmed that basic ionospheric plasma parameters exhibit significant seasonal and diurnal variations for mid-latitudes of the Central Europe. As it was expected, electron density variations at the heights below peak F2-layer are controlled, mainly, by the solar zenith angle value both in winter and in summer. At night local maximum appears at heights above ionization maximum due to particles flows from plasmasphere to ionosphere.

Electron temperature also exhibits significant diurnal variations. Two maximums – morning (near 11 LT) and daily (near 16 LT) ones take place in these diurnal variations. Ion and electron temperatures increase with height increasing, morning and daily maximum location in diurnal variations shifts at more early and later times respectively.

Seasonal anomaly effect existence including the exceeding of winter daily electron density values over summer ones near peak F2-layer was confirmed. The basic mechanism, that explains the seasonal anomaly, can be caused with ion composition seasonal variations at heights near peak F2-layer and the thermospheric circulation seasonal variations.

The observations were carried out for the wave disturbances of the electron density N in the ionosphere at altitudes of 120 – 600 km. Measurements were carried out during the spring and autumnal equinoxes and summer and winter solstices in minimum of the 23-rd solar activity cycle. The altitude-time dependences of the absolute ΔN and relative $\Delta N/N$ amplitudes and spectral composition of the disturbances were analyzed. It is shown that the wave disturbances in ionosphere with periods of 10 – 180 minutes there at almost any time of day and in all seasons. Their absolute amplitude varied $6{\cdot}10^9$ to $6{\cdot}10^{10}$ m^{-3}, and the relative amplitudes – from 0.01 to 0.5. Maximum values of ΔN and $\Delta N/N$occurred at an altitude of 200 km.

Considered conditions (deep minimum of solar activity) were characterized by the greatest sizes of the relative maintenance of hydrogen ions $N(H^+)/N$ in comparison with other phases of the 23-rd solar cycle. So, for December 14, 2009 value of the $N(H^+)/N$ reached at night 95 % already at heights about 600 km, and even for a summer solstice (on June 23, 2010) for the same heights and time size $N(H^+)/N$ exceeded 60 %.

$N(H^+)/N$ for all considered heights at any time it is possible to consider as a common feature of a seasonal course of parameter N an accurate tendency to increase in the relative maintenance of hydrogen ions from summer by the winter.

Comparison of the results received on the Kharkov radar with the data of model IRI–2001 has shown that the model gives considerably underestimated in comparison with results of experiment of $N(H^+)/N$ value. For example, at height of 450 km for 01:00 on December 14, 2009 experimental $N(H^+)/N$ value was equal 57 %; model IRI for such conditions gives value of 20 %. At the same height for June 23, 2010 of$N(H^+)/N$ value made 18 % and 5 % accordingly. Complex researches convincingly testify to inapplicability of model IRI for adequate forecasting of variations of the maintenance of hydrogen ions over the Central European region.