DYNAMIC AND THERMAL PROCESSES IN GEOSPACE DURING NOVEMBER 13 – 15, 2012 MAGNETIC STORM OVER KHARKOV (EASTERN UKRAINE)

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Abstract

Modeling results of the dynamic and thermal process parameter variations in geospace plasma during November 13 – 15, 2012 magnetic storm over Kharkov are presented.

For modeling were used experimental data obtained on single in European mid-latitudes Kharkov incoherent scatter radar.

The aim of this study is modeling of the dynamic and thermal process parameter variations in geospace plasma during November 13 – 15, 2012 magnetic storm.

The main theoretical relations

$$v_z = (v_{d\|})_z + (v_{n\|})_z + (v_{\perp})_z \;^{*}$$

$$v_z = v_{dz} + v_{nx}\sin I\cos I\cos D - v_{ny}\sin I\cos I\sin D + v_{nz}\sin^2 I + \frac{E_x}{B}\cos I\sin D + \frac{E_y}{B}\cos I\cos D \;^{*}$$

$$D_a = \frac{kT_p}{m_i \nu_{in}}$$

$$H_p = kT_p/mg, \quad T_p = T_e + T_i$$

$$v_{dz} = -D_a \sin^2 I\left(\frac{1}{H_p} + \frac{1}{N}\frac{\partial N}{\partial z} + \frac{1}{T_p}\frac{\partial T_p}{\partial z}\right)^{*}$$

$$\Pi_p = v_z N, \quad \Pi_d = v_{dz} N$$

$$E_y = (0{,}55 - 0{,}01AE)\cdot 10^{-3} \;^{**}$$

$$v_{EB} \approx (E_y/B)\cos I \;^{*}$$

$$v_{nx} = (v_z - v_{dz} - v_{EB})/\sin I\cos I$$

* *Bryunelli B.E., Namgaladze A.A.* Physics of the Ionosphere – Moscow: Nauka, 1988, 528 p. (in Russian).

** *Sergeenko N.P.* Estimates of electric fields during ionospheric disturbances // Ionospheric forecasting. – Moscow: Nauka, 1982, p. 91-96, (in Russian).

The calculation results

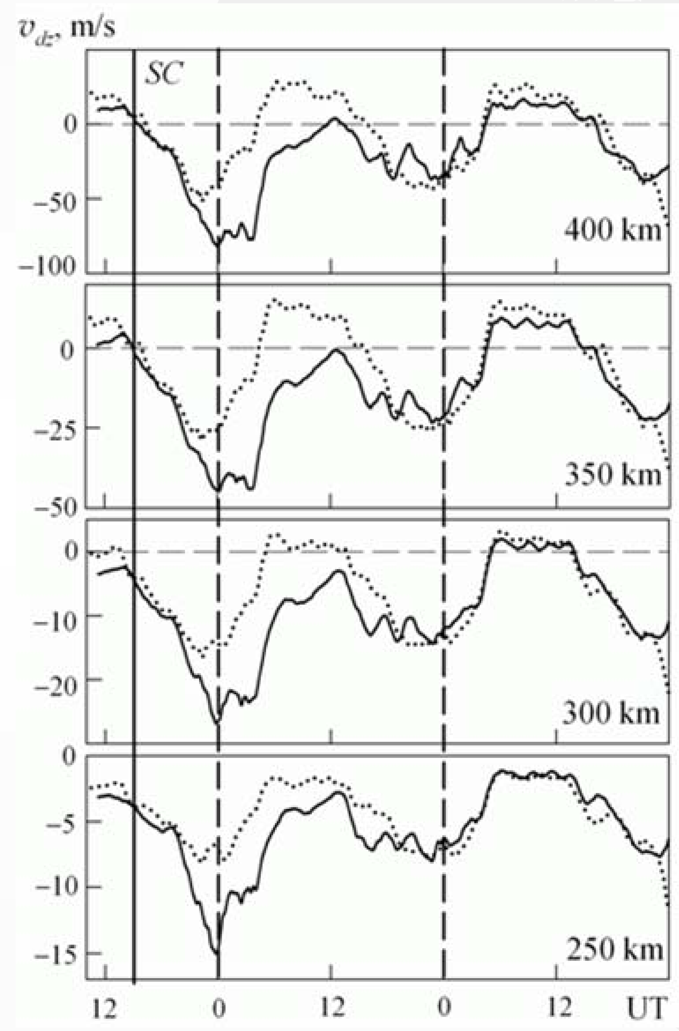


Fig. 1. Temporal variations of the vertical component of the plasma transfer velocity due to ambipolar diffusion during November 13 – 15, 2012 magnetic storm (solid line) and quite condition period on November 21 – 23, 2012 (dots)

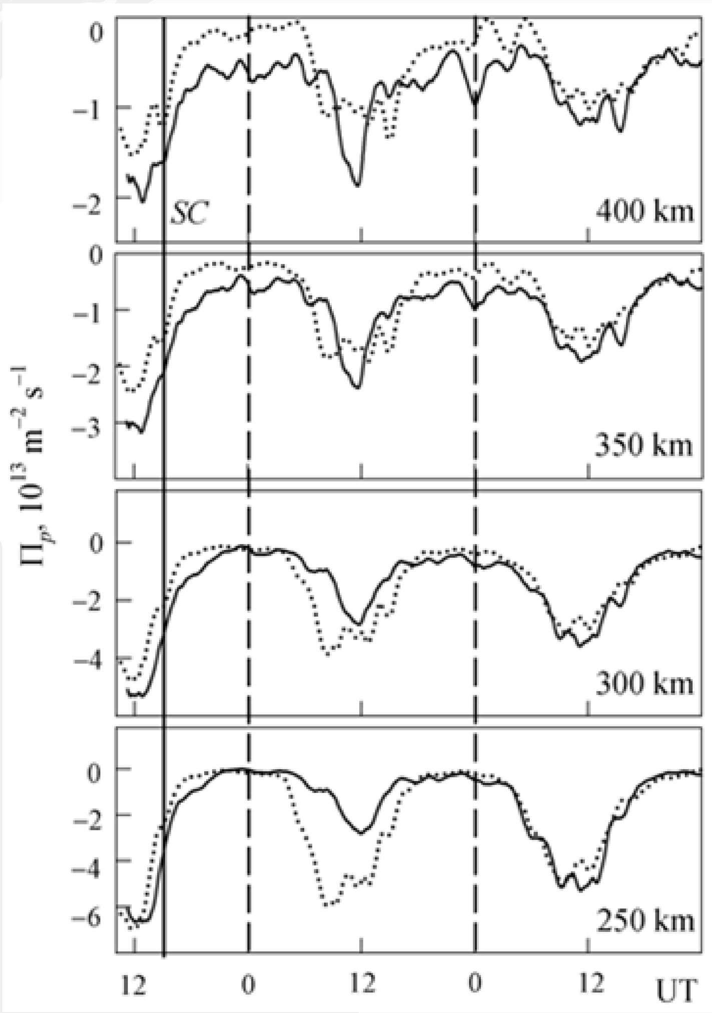


Fig. 2. Temporal variations of the full plasma flux density during November 13 – 15, 2012 magnetic storm (solid line) and quite condition period on November 21 – 23, 2012 (dots)

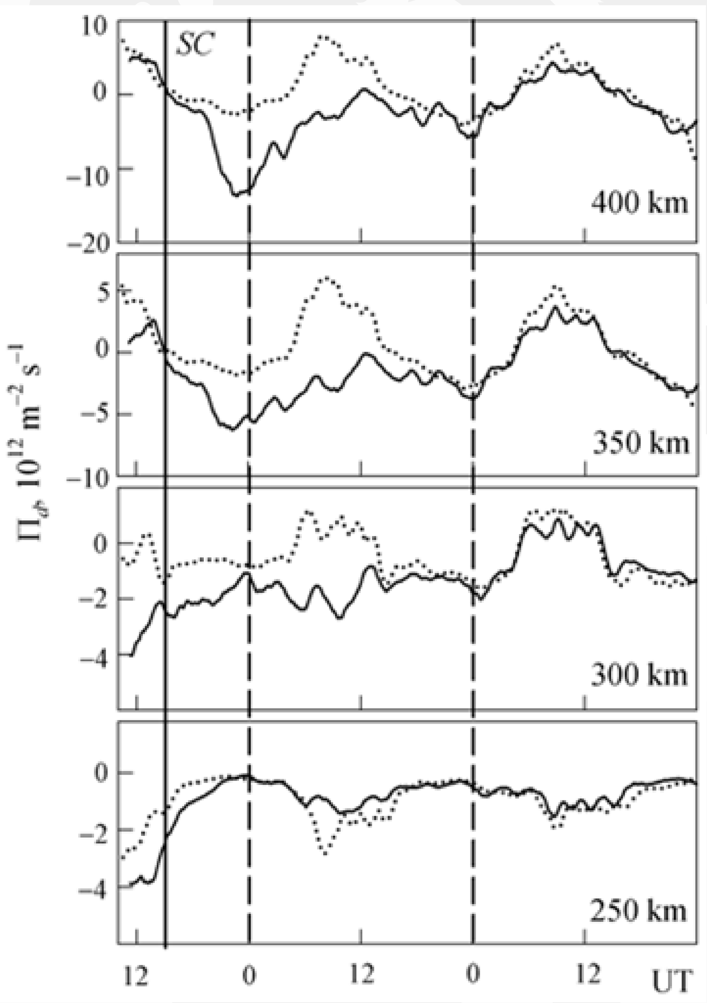


Fig. 3. Temporal variations of the plasma flux density due to ambipolar diffusion during November 13 – 15, 2012 magnetic storm (solid line) and quite condition period on November 21 – 23, 2012 (dots)

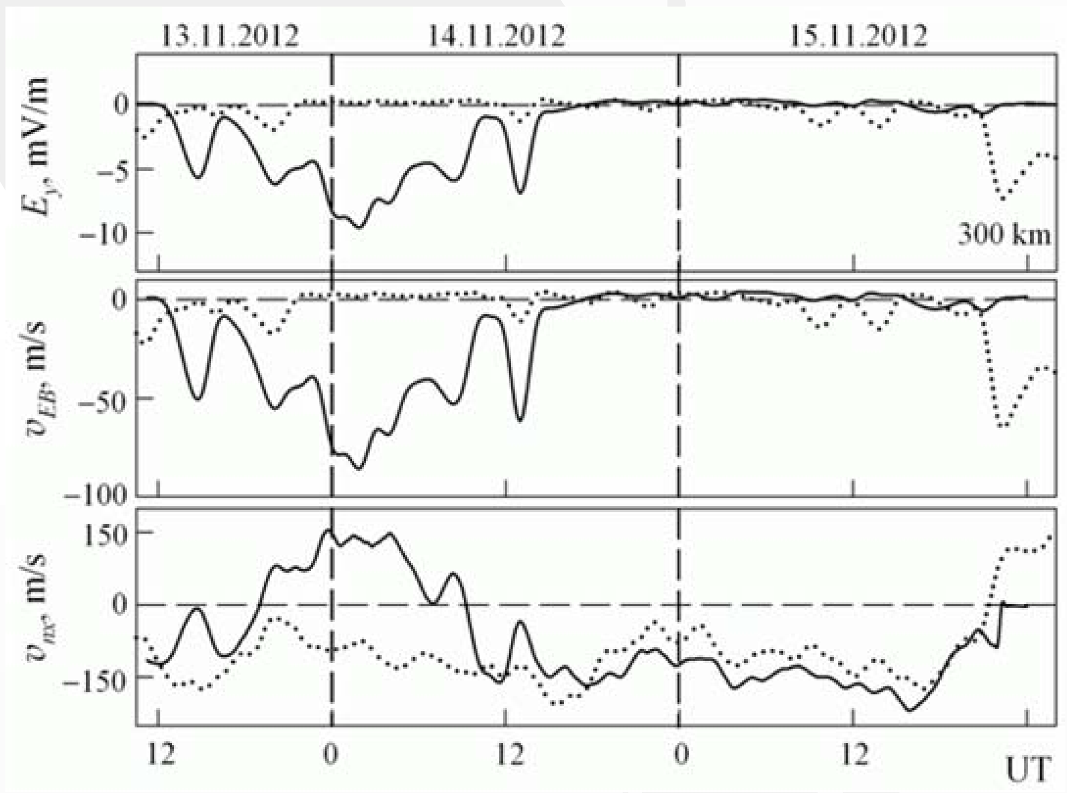
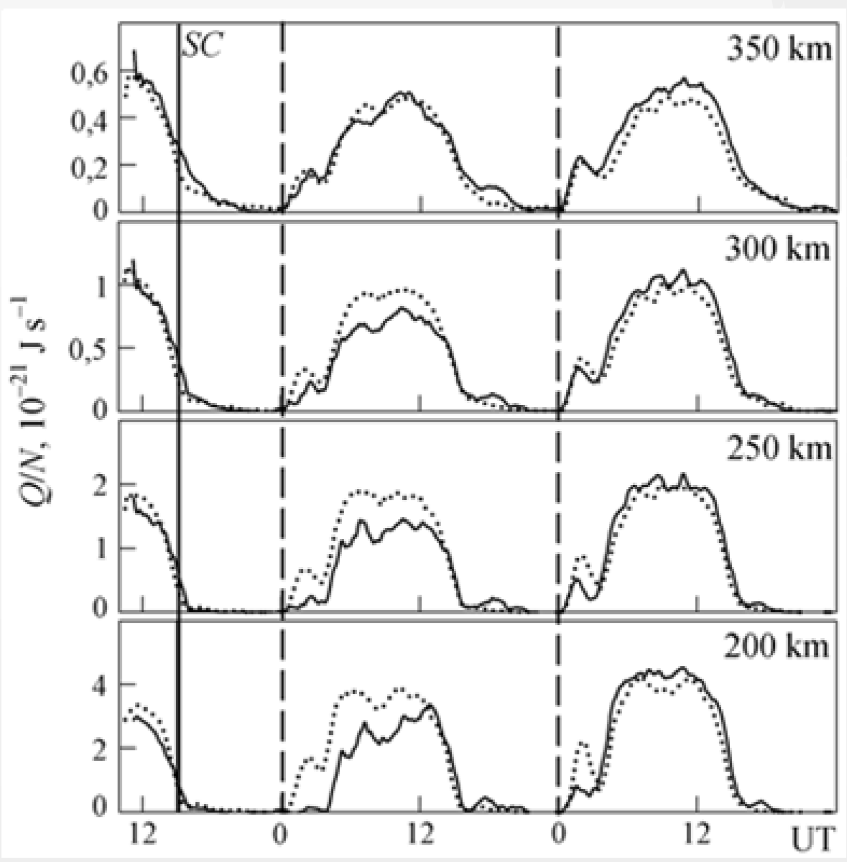


Fig. 4. Temporal variations of the electric field zonal component values, vertical component of the plasma drift velocity and neutral wind velocity during November 13 – 15, 2012 magnetic storm (solid line) and quite condition period on November 21 – 23, 2012 (dots)



$$Q = L_{ei} + L_e$$

$$L_e = 6.4\cdot 10^{-37} N N(\mathrm{O})(T_e - T_i)T_n^{-1}$$

$$L_{ei} = 8\cdot 10^{-32} N^2 (T_e - T_i) T_e^{-3/2}$$

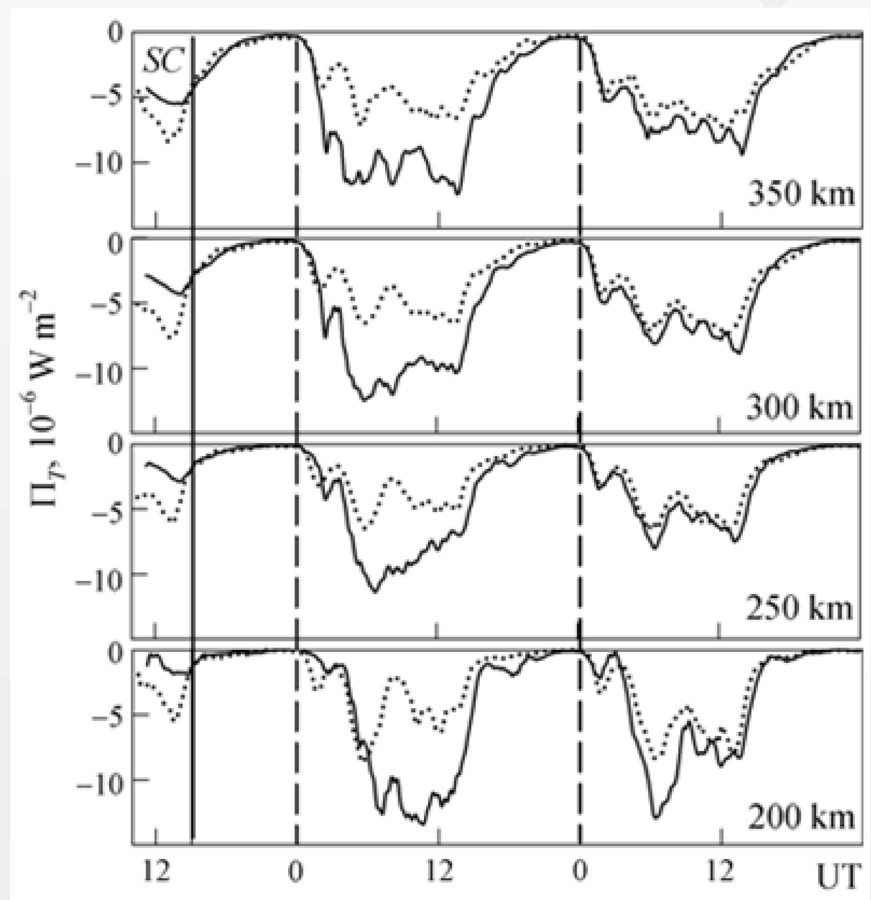
Fig. 5. Temporal variations of the energy supplied to the electron gas Q/N at the fixed altitudes during November 13 – 15, 2012 magnetic storm (solid line) and quite condition period on November 21 – 23, 2012 (dots)

$$\Pi_T = -\kappa_e \sin^2 I \frac{\partial T_e}{\partial z}$$

$$\kappa_e = 2.08\cdot k^2 N T_e / m\nu_{ei}$$

$$\nu_{ei} \approx 5.5\cdot 10^{-6} N T_e^{-3/2} \ln(2.2\cdot 10^4 T_e N^{-1/3})$$

Fig. 6. The temporal variations of the heat flux density $_T$ during November 13 – 15, 2012 magnetic storm (solid line) and quite condition period on November 21 – 23, 2012 (dots)



Summary

1) The simulation results showed that the November 13 – 15, 2012 magnetic storm over Kharkov led to a substantial restructuring of the dynamic and thermal regimes in the ionospheric plasma.

2) Calculations showed that during magnetic storm took place increasing by modulus values of vertical component of transfer velocity due to ambipolar diffusion up to 2.1, 1.9, 1.7 and 1.9 times at altitudes of 250, 300, 350 and 400 km respectively.

3) The plasma flux density due to diffusion increased up to 1.25 – 5.9 times in altitude range of 300 – 450 km.

4) During magnetic storm took place decreasing of the value of the energy input to the electron gas about 34, 26, and 20% at the altitudes of 200, 250 and 300 km respectively.

5) Calculations showed that heat flux density transferred by electrons from plasmasphere to ionosphere in the main phase of the magnetic storm increased up to 2 in the altitude range of 200 – 350 km.

6) During the November 13 – 15, 2012 magnetic storm the value of the electric field zonal component was –9.5 mV/m. In quiet conditions, the value of the electric field does not exceed units of mV/m.

7) For November 13 – 15, 2012 magnetic storm obtained that the drift velocity reached its peak shortly after the beginning of the magnetic storm and equaled –85 m/s.

8) Calculations showed that in quiet conditions v_{nx} velocity ranges from 0 to –150 m/s. The highest value of the neutral wind velocity occurred after the beginning of the magnetic storm and was 150 m/s.