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CORRECTION OF THE UPPER ATMOSPHERE MODEL AURORAL INPUT DATA ON THE BASIS OF THE IONOSPHERIC ELECTRON DENSITY RADIOTOMOGRAPHY RECONSTRUCTIONS

I.V. Korableva[1], A.A. Namgaladze[2]

[1]*Polar Geophysical Institute, Murmansk, Russia; irinakorab@pgi.ru*
[2]*Murmansk State Technical University, Murmansk, Russia; namgaladze@mstu.edu.ru*

Abstract. The complex analysis of the input parameters used for setting auroral precipitation in the global numerical upper atmosphere model (UAM) has been carried out. Input model values of the mean energy and energy flux of the auroral precipitating electrons have been compared with the empirical data produced by Vorobjev, Roble, Spiro and Hardy. The radiotomography height-latitude reconstructions of the electron density observed during the geomagnetic storm on 26 October – 01 November 2003 have been analyzed and new functional dependences of the polar and equatorial boundaries of the auroral electron precipitation zone have been obtained. Numerical model results with the new variant of the auroral electron precipitation input have been compared with the radiotomography reconstructions of the electron density and a better agreement between them have been achieved.

Introduction

We have investigated ability of the numerical description of the electron density behavior in the subauroral and high-latitude ionosphere F-region using the global numerical Upper Atmosphere Model (UAM) (Namgaladze et. al., 1988, 1998). This paper continues the work (Korableva et. al., 2007) for the storms of October 2003. In that work it was found that the theoretical model UAM adequately reproduces the main ionospheric trough dynamics, especially its equatorial wall. The discrepancy with the observations exists in the areas of electron density to the pole from the trough. Some correction of the input distribution of the precipitating electron flux with the mean energy ~ 0.5 keV used in the UAM was introduced to decrease such disagreement. In other words, an inverse problem of the reconstruction of the precipitating magnetospheric electron characteristics has been solved for conditions of extreme intense geomagnetic disturbances.

This work represents results of the input parameter correction of the precipitating soft (mean energy ~ 0.5 keV) electron fluxes on the basis of data for disturbed conditions of October 2003. We have compared values of the mean energy and energy flux used in the UAM with data of six empirical auroral models (Vorobjev et. al., 2005, 2007, Roble et. al., 1977, 1987, Spiro et. al., 1982 and Hardy et. al., 1985). More 50 radiotomography reconstructions of the electron density were considered (Kunitsyn and Tereshchenko, 2003). The auroral zone boundaries taken from reconstructions were analyzed and new functional dependences of the equatorial and the polar boundaries on day and night sides have been derived.

Energy characteristics

In the UAM the spatial distribution of the precipitating electron fluxes at the upper boundary of the thermosphere (h = 520 km) is specified as intensity flux dependence on the latitude, the longitude and the precipitating electron energy:

$$I(\Phi,\Lambda,E) = I_m(E)\cdot\exp\left[-\left(\frac{\Phi-\Phi_m(E)}{\Delta\Phi(E)}\right)^2-\left(\frac{\Lambda(E)-\Lambda_m(E)}{\Delta\Lambda(E)}\right)^2\right],\Phi_m=\frac{\Phi_{md}+\Phi_{mn}}{2}+\frac{\Phi_{md}-\Phi_{mn}}{2}\cdot\cos\Lambda,$$

where Φ – the magnetic latitude, Λ - the magnetic longitude ($\Lambda = 0$ - corresponds to the midday magnetic meridian), E – the energy of precipitating electrons, $I_m(E)$ – the peak intensity of precipitating electron flux, $\Delta\Phi(E)$ - latitudinal half-width of peak intensity, $\Lambda_m(E)$ – the magnetic longitude of peak intensity, $\Delta\Lambda(E)$ - longitudinal half-width of peak intensity, Φ_{md} – the magnetic latitude of peak intensity at the midday magnetic meridian, Φ_{mn} – the magnetic latitude of peak intensity at the midnight magnetic meridian.

We have compared our model values of the mean energy E (eV) and the maximum energy flux F (eV cm^{-2} s^{-1}) with the data produced by Vorobjev (2005, 2007), Roble (1977, 1987), Spiro (1982) and Hardy (1985). Figure 1 illustrates model and empirical data of parameters of the auroral precipitating soft electron fluxes in the daytime and nighttime. The UAM energy values show the best agreement with the other data and lie in the range of empirical data dispersion.

For quite conditions (Kp < 2) model energy fluxes also lie in the range of presented data values. The unusual conditions of the great magnetic storm when the index Kp exceeded value 8 were not considered in works (Vorobjev et. al., 2005, 2007; Roble et. al., 1977, 1987; Spiro et. al., 1982; Hardy et. al., 1985). This fact explains the disagreement in energy flux values for disturbed conditions.

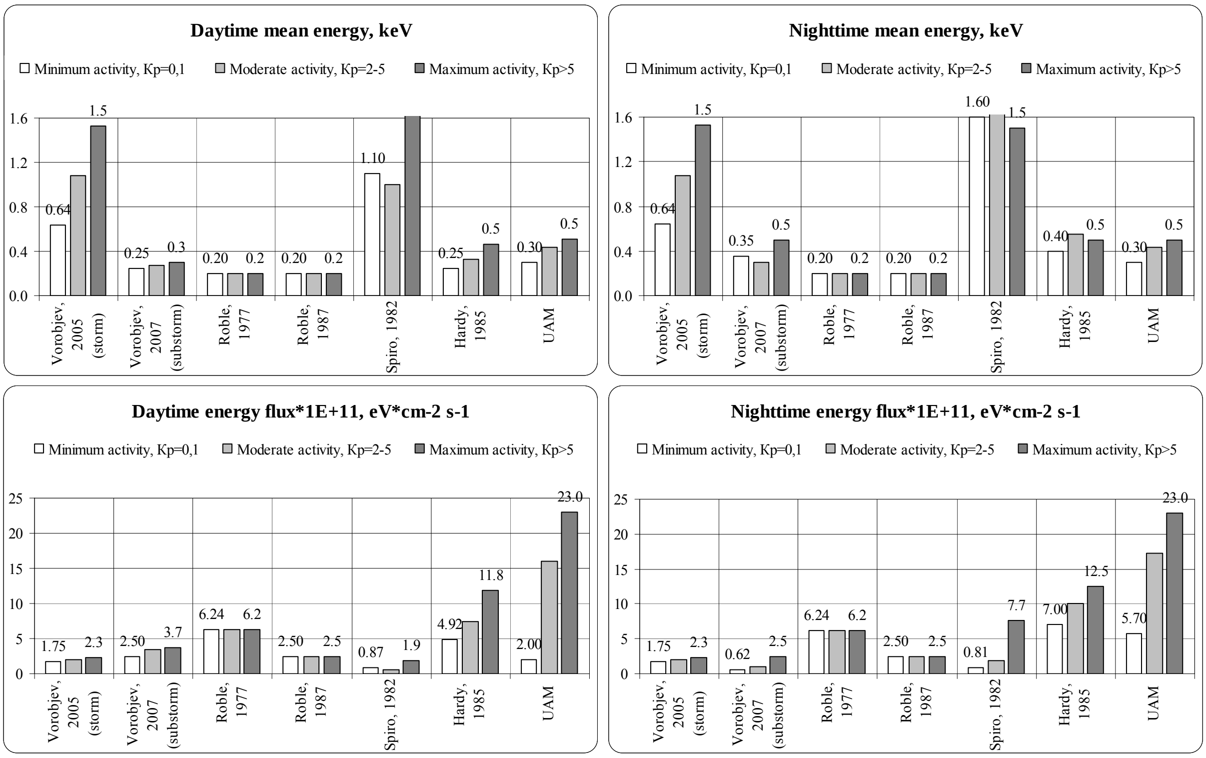

Fig. 1. Comparison of the auroral precipitating soft electron parameters (mean energy and energy flux) with empirical data.

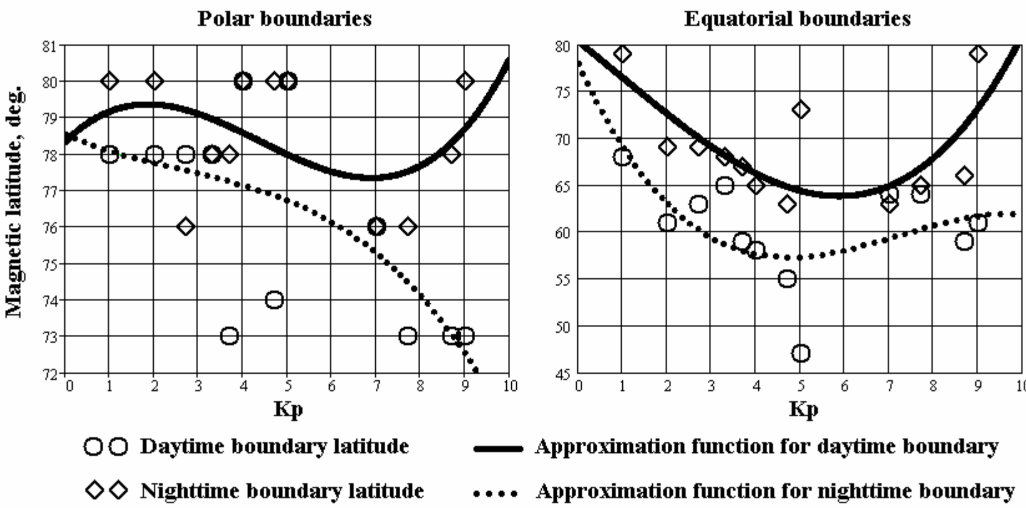

Fig. 2. Approximations of the polar and equatorial boundaries of the auroral electron precipitation zones by the least-squares polynomial fit.

Spatial characteristics

The auroral precipitation region is specified in the UAM by functional dependences its equatorial and polar boundaries on the day and night sides on the index Kp. Boundary formulas obtained from the work (Zubova et. al.,

2003) and used in the model UAM produce the latitudinal length of the precipitation region less than in the observed ionospheric tomography data. That is why we decide to develop new functional dependences.

We have processed 58 radiotomography reconstructions of the electron density for the October storm 2003 to obtain the equatorial and polar boundaries of the auroral zone for daytime and nighttime. They are shown in Figure 2. Using the least-squares method we obtained four third power polynomials determining our boundaries. Figure 2 illustrates approximation functions of the polar and equatorial boundaries of the auroral electron precipitation zone in the daytime and nighttime.

Correction results

Figure 3 shows altitude-latitude distributions of the electron density N_e (10^{12} m^{-3}) at the magnetic longitude Λ=125° obtained by radiotomography and the theoretical model results with new and old functional dependences of the input parameters of the auroral precipitation. As it is shown in the figure the new calculation results agree better with the radiotomography data not only by the density level at 300 – 350 km but by latitude length of the auroral precipitation zone.

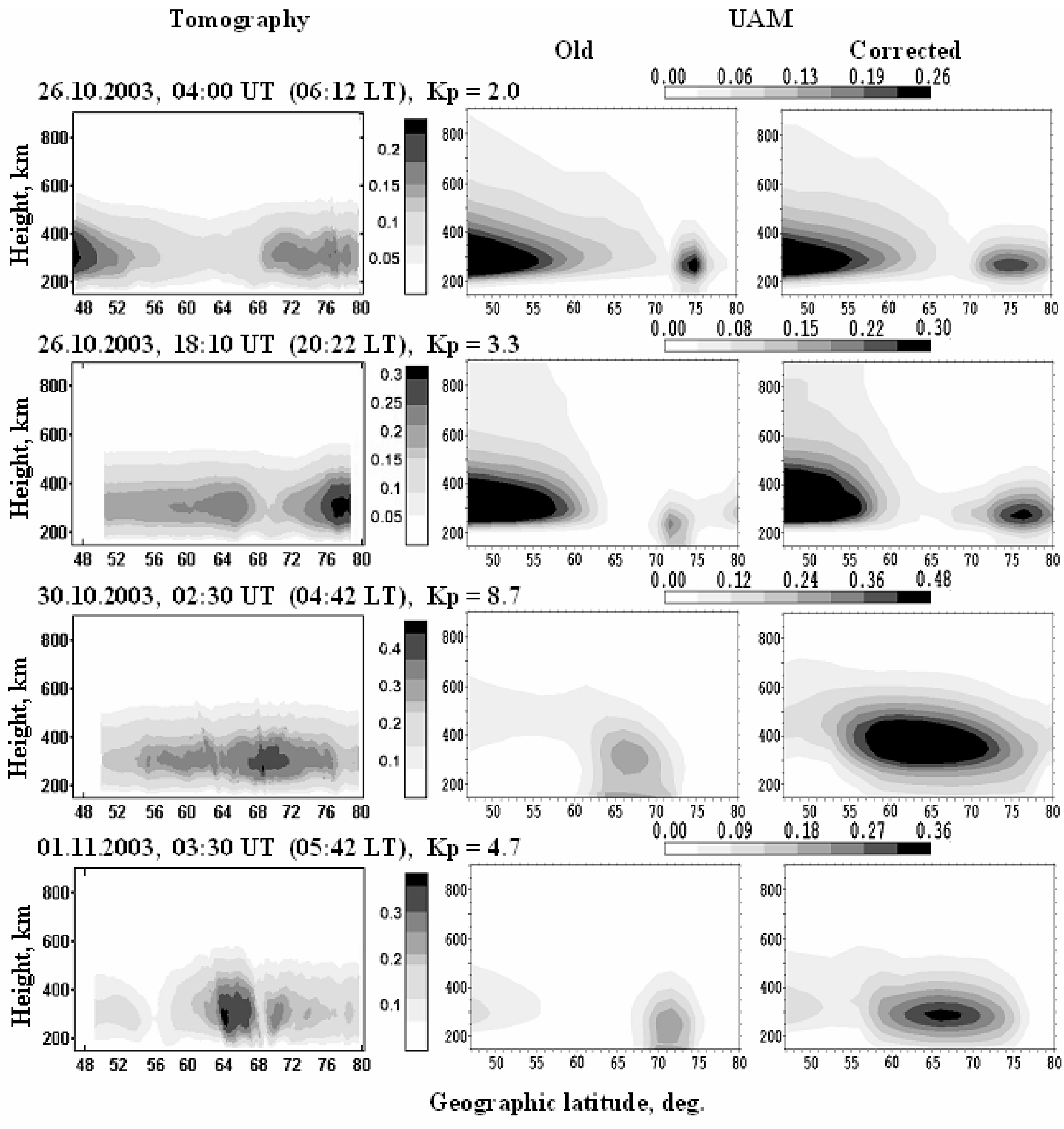

Fig. 3. Comparison of the UAM electron density after correction of the electron precipitation parameters with the radiotomography data (top panel) and old model results of the electron density (second panel), N_e (10^{12} cm^{-3}).

Conclusions

This investigation has shown that the mean energy value for the soft auroral electrons ~ 0.5 keV used in the UAM is right because this value lies in the dispersion range of empirical data produced by Vorobjev, Roble, Spiro and Hardy. Model values of the soft precipitation energy flux are two – ten times higher than the empirical values, but these values fit to the ionosphere radiotomography data most exactly. Note the storm of October – November 2003 was extreme disturbed (Kp >7, reaching 9), and such conditions were not considered in the woks (Vorobjev et. al., 2005, 2007; Roble et. al., 1977, 1987; Spiro et. al., 1982; Hardy et. al., 1985).

In the functional dependences used previously in the UAM extension of the precipitation region along a latitude does not reach values observed by the ionosphere tomography data. The new formulas of equatorial and polar boundaries obtained by processing the electron density radiotomography reconstruction in most cases reproduce better observations but nevertheless some disagreement remains. It is necessary to consider radiotomography data of other storms for solving this problem. It is necessary to find more exact functional dependences of the boundary positions of the auroral precipitation region.

References

Hardy D.A., Gussenhoven M.S., Holeman E. A Statistical Model of Auroral Electron Precipitation // *J. Geophys. Res.* V. 90. № 5. P. 4229-4248. 1985.

Korableva I.V., Namgaladze A.N., Tereshchenko E.D., Khudukon B.Z. Modeling of the ionospheric electron density dependence on the soft electron precipitation during geomagnetic storm on 26 October – 01 November 2003 // *The 30th Annual Seminar "Physics of Auroral Phenomena"*, Apatity, 27 Feb – 2 March 2007. –Abstracts. –P. 59.

Kunitsyn V. and Tereshchenko E. Ionospheric Tomography // Berlin: Springer-Verlag, 260 p. 2003.

Namgaladze A.A., Korenkov Yu.N, Klimenko V.V, Karpov I.V, Bessarab F.S, Surotkin V.A, Glushchenko T.A, Naumova N.M. Global model of the thermosphere-ionosphere-protonosphere system // *Pure and App. Geophys.* V. 127.№ 2/3. P. 219-254. 1988.

Namgaladze A.A., Martynenko O.V., Namgaladze A.N. Global model of the upper atmosphere with variable latitudinal integration step // Geomag. and Aeronomy Intern. V. 1. № 1. P. 53-58. 1998.

Roble R.G., Rees M.H. Time-Dependent studies of the aurora: effects of particle precipitation on the dynamic morphology of ionospheric and atmospheric properties // *Planet Space Sci.* V. 25. P. 991-1010. 1977.

Roble R.G., Ridley E.C. An auroral model for the NCAR thermospheric general circulation model (TGCM) // *Annales Geophys.* V. 5. № 6. P. 369-382. 1987.

Spiro R.W., Reiff P.H., Maher L. J. Jr. Precipitation electron energy flux and auroral zone conductances – an empirical model // *J. Geophys. Res.* V. 87. 1982.

Vorobjev V.G., Yagodkina O.I. Effect of Magnetic Activity on the Global Distribution of Auroral Precipitation Zones // *Geomag. and Aeronomy Intern.* V. 45. № 4. P. 438-444. 2005.

Vorobjev V.G., Yagodkina O.I., Starkov G.V., Feldstein Ya. I. Features of the Planetary Distribution of Auroral Precipitation Characteristics during Substorms // *Geomag. and Aeronomy Intern.* V. 47. № 2. P. 193-204. 2007.

Zubova Yu.V., Stakhov K.A., Dolmatova E.S., Martynenko O.V., Namgaladze A.A. The precipitating electron fluxes as input parameters for the April 15-25, 2002 magnetic storms modeling // *Proceedings of the XXVI Annual Apatity Seminar "Physics of Auroral Phenomena"*, Preprint PGI. P. 98-101. 2003.