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PRECIPITATING ELECTRON FLUXES AS INPUT PARAMETERS FOR APRIL 15-25, 2002 MAGNETIC STORMS MODELING

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Abstract

Problem of setting precipitating electron fluxes as input parameters for April, 15-25, 2002 magnetic storms modeling in the framework of the Upper Atmosphere Model (UAM) is considered. Auroral oval boundary positions as well as maximum intensities of precipitating electron number and energy fluxes, are examined versus geomagnetic indexes Kp, AL and AE and based on DMSP data for the period of interest. The conclusion is made that dependence of auroral oval boundary locations on the Kp index approximates the real data with minimum dispersion. Functional relations of the equatorial and polar boundary latitudes in the dayside and nightside auroral oval on the Kp index have been found. Magnetic storm effects in the Earth's upper atmosphere are simulated using UAM under three ways of setting locations of auroral oval boundaries and precipitating electron number and energy flux intensities. The difference in the model results obtained under different inputs is analyzed.

1. Introduction

During April 15-25, 2002 magnetic storms (see Fig.1 in *Namgaladze et al.,* 2003), a unique research campaign was held. Behavior of ionospheric parameters was observed by six incoherent scatter radars (ISR): Arecibo, Kharkov, Millstone Hill, Irkutsk, EISCAT Svalbard, Sondrestrom, with covering low, middle and high latitudes of the northern hemisphere. Changes of ionospheric conditions for this storm period were also numerically calculated using the Upper Atmosphere Model (*Namgaladze et al.,* 1998, 2003). A rather good agreement between the radar measurements and model results was achieved, but in order to improve it, in the present work we have tried to set the input model parameters as close to real geophysical conditions as possible.

Spatial distribution of precipitating magnetospheric electron fluxes is of primary importance when setting input parameters in numerical modeling of magnetic storm effects in the framework of UAM. In the model calculations of *Namgaladze et al.* (2003) they were set as a function of Kp, with some average values of the mean energy and flux intensity taken from the statistical model of *Hardy et al.* (1985). Flux distributions set in such a manner can not reproduce the real pattern of precipitating electron fluxes for specific geophysical conditions. Since at present the spectrograms of the DMSP satellites are available in Internet (*http://sd-www.jhuapl.edu/Aurora/dataset_list.html*), they were used in April 15-25, 2002 magnetic storm modeling in order to improve the procedure of precipitating electron flux setting.

2. Setting of precipitating electron fluxes

DMSP satellite data on electron precipitations are represented in Internet as auroral oval patterns for almost any time. Using these data, we determined the positions of the polar and equatorial boundaries of the auroral oval for 00, 06, 12, 18 MLT. We also obtained locations and values of maximum flux intensities from precipitation oval patterns for the whole interval of April 15-25, 2002 with time resolution of 1 hour.

Based on these data, we investigated auroral oval parameters (e.g., oval day and night polar and equatorial boundary locations) versus geomagnetic indexes Kp, AL and AE. The conclusion is made that the relations of auroral oval boundary positions to the Kp index approximate the real data with minimum dispersion and can be presented by linear functions. In deriving these functions we used both the whole data set and several subsets related to quiet and disturbed geomagnetic conditions. The relations obtained are the following

$$\Phi_1 = 72 - 0.5\ \mathrm{Kp};\quad \Phi_2 = 70 - 2.5\ \mathrm{Kp};\quad \Phi_3 = 76.5 - 0.75\ \mathrm{Kp};\quad \Phi_4 = 73 - 1.5\ \mathrm{Kp},$$

where Φ_1 is midnight polar boundary latitude, Φ_2 is midnight equatorial boundary latitude, Φ_3 is noon polar boundary latitude, Φ_4 is noon equatorial boundary latitude of the auroral oval.

In order to choose the best approximation for oval parameters, plots of boundary locations for investigated time period were built in accordance with DMSP data, and using both the relations to Kp and relation to AL, obtained by *Vorobyov et al.,* (2000). From comparing the plots presented in Fig. 1, one can see that auroral oval boundary setting by Kp formulas seems more adequate for storm modeling.

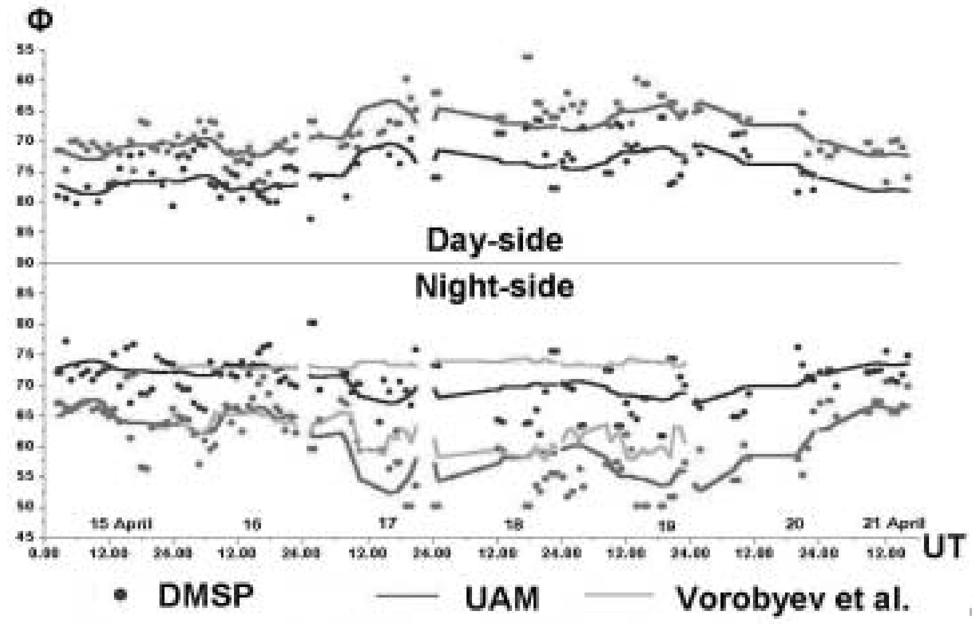

Fig.1 Behavior of the latitude of auroral boundaries according to DMSP data, Kp formulas (marked as UAM) and formula of *Vorobyev et.al*. (2000) for 15-21 April, 2002.

At the next stage, the auroral oval with boundary locations taken directly from DMSP data and maximum flux intensities from (Hardy et al., 1985) was set in the model. Then, both oval boundaries and flux intensities were taken from DMSP data. An example for 01:00 UT, April 18, 2002 is shown in Figure 2 for energy fluxes in the northern hemisphere. As seen from Figure 2, case D is most consistent with the oval taken from Internet, whereas version B used in the model calculations of Namgaladze et al. (2003) differs significantly from the real oval.

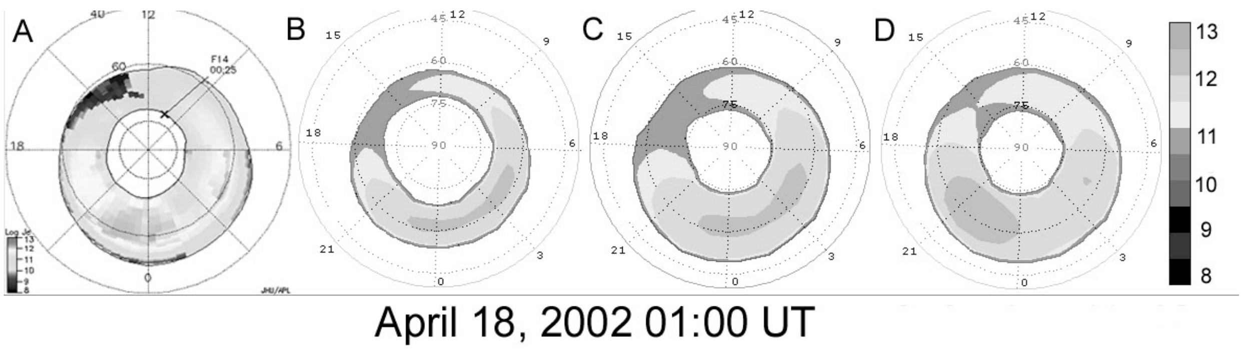

Fig.2 Different ways of auroral oval setting
A – the auroral oval taken from Internet;
B – boundary locations are set from Kp formulas, flux intensities - from Hardy's model;
C – boundary locations are taken from DMSP observations, flux intensities - from Hardy's model;
D – boundary locations and flux intensities are set according to DMSP data approximated by analytical expressions

3. Magnetic storm effect modeling with different ways of auroral oval setting

Behavior of ionospheric parameters during April 17-20, 2002 was modeled using UAM under three above manners of setting precipitation. The plots of electron density distributions over the ISR sites for the same period were built to compare the results of radar measurements and model calculations. As an example, Figure 3 illustrates the behavior of electron density over EISCAT Svalbard observatory on April 17, 2002 obtained from numerical modeling under three ways of precipitation setting. The electron density observed by EISCAT is shown in Fig.7 of the paper by *Namgaladze et al.* (2003). Figure 3 shows that dependence of the model results on the manner of auroral oval setting is rather significant. The results of model calculations with auroral oval boundaries and fluxes taken from DMSP data (the bottom panel) are more consistent with ISR measurements than those obtained by *Namgaladze et al.* (2003, see Fig. 7 there).

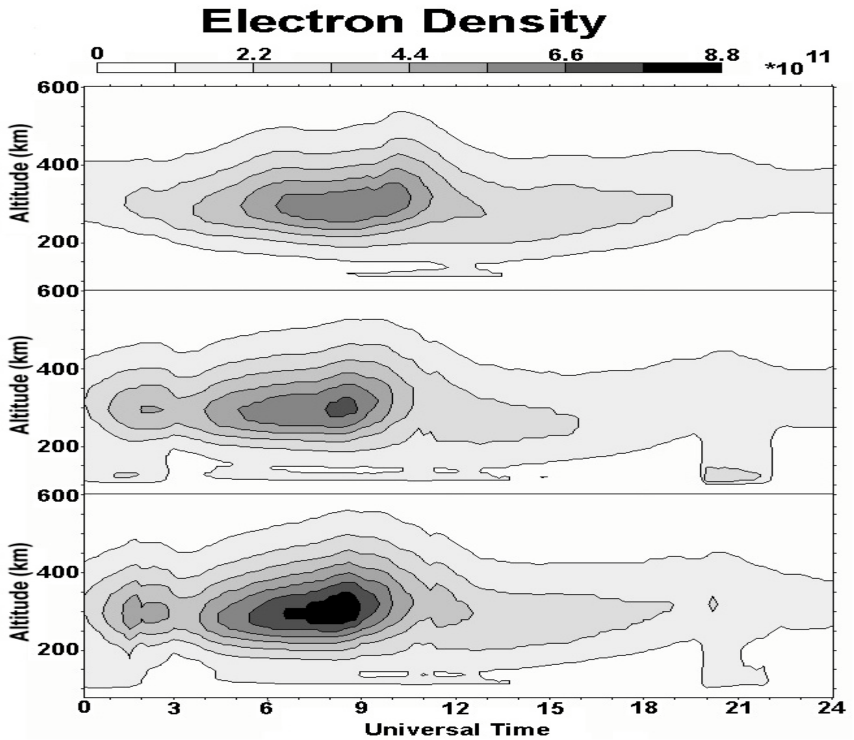

Fig. 3 Electron density over EISCAT Svalbard on April 17, 2002 calculated under different ways of auroral oval setting:
(top) boundary locations are set from Kp formulas, flux intensities from Hardy's model;
(middle) boundaries are set from DMSP data, flux intensities from Hardy's model;
(bottom) boundary locations and flux intensities are set from DMSP data approximated by analytical expressions.

4. Conclusion

The auroral oval boundaries calculated by Kp formulas sometimes disagree with those observed by the DMSP satellites, though the relation of auroral oval boundary positions to the Kp index approximates the real data with minimum dispersion. To achieve the best agreement between model and observed ionospheric electron densities one has to use real UT dependence of auroral oval boundary locations and precipitating electron fluxes as model input parameters.

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