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INVESTIGATION OF THE POLAR CAP SOFT ELECTRONS FLUXES' INFLUENCE ON THE LATITUDINAL VARIATIONS OF THE IONOSPHERE TOTAL ELECTRON CONTENT AND PEAK F2-LAYER ELECTRON DENSITY

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Abstract

The paper presents the results of the investigation of the polar cap soft electrons fluxes' influence on the latitudinal variations of the ionosphere total electron content (TEC) and peak F2-layer electron density (NmF2).The results of the TEC and NmF2 modeling were compared with the data obtained from the empirical ionospheric model IRI-2007 and Global Ionosphere Maps (GIM) of the TEC. It was shown that to improve an agreement between the model case and observation it is necessary to increase the intensity of the "polar rain" for an order.

Introduction

The aim of the present work is to study of the polar cap soft electrons fluxes'("polar rain") influence on the latitudinal variations the total electron content(TEC) and peak F2-layer electron density (NmF2).

The "polar rain" is a flux of low energy (from a few to a few hundred eV) electrons precipitating in the polar caps. The "polar rain" was discovered and named by Winningham and Heikkila [1]. The "polar rain" electrons access the polar cap by open field lines.

The electrons with such energies effectively spend it on the ionization at F2-region altitudes. As a result, the electrons density at the peak F2-layer and TEC in the regions of the precipitations may increase. The model calculations by using the model UAM show that the polar caps F2-layers have the very low density of the electrons, and that is in contrast to the results of the empirical model IRI-2007 and TEC GPS observations.

In this paper, we tried to estimate "polar rain", fluxes' required to eliminate the above mentioned difference.

Model calculations

The computer modeling of the NmF2 and TEC latitudinal variations was performed using the global three-dimensional self-consistent numerical model of the Upper Atmosphere of the Earth (UAM) [2]. UAM describes the thermosphere, ionosphere, plasmasphere and inner magnetosphere of the Earth as a unite system. It covers the altitude range from 60-80 km up to the geocentric distance of $15R_E$. UAM calculates the concentrations of the main neutral and charged components of the upper atmosphere, the temperature of neutral, ion and electron gases, the velocities of charged and neutral particles by numerical integration of quasi-hydrodynamic equations (continuity, momentum and heat balance), as well as equation for the electric potential of the magnetospheric, thermospheric (dynamo) and seismogenic origin.

The UAM model calculations of TEC and NmF2 have been performed with using the empirical thermospheric NRLMSIS-00 model [3] for neutral components (UAM-TM). The model calculations have been carried out for equinox and solstice conditions and different levels of solar activity (F10,7 ~ 90 and F10,7 ~ 180).

In this paper, the model calculations used the following polar cap soft electrons fluxes': 1) according to [4], 2) and increased for an order.

The latitudinal variations of the TEC and NmF2 were analyzed for the meridional section 15–03 of the magnetic local time (MLT).

The results of the model calculations have been compared with the empirical model IRI-2007[5] and GIM of the TEC provided by the NASA in IONEX format derived from IGNSS network data [6].

Fig. 1 shows the latitudinal variations of the peak F2-layer electron density (NmF2) calculated by version of UAM-TM and empirical model IRI-2007 for the magnetic meridian 15-03 MLT.

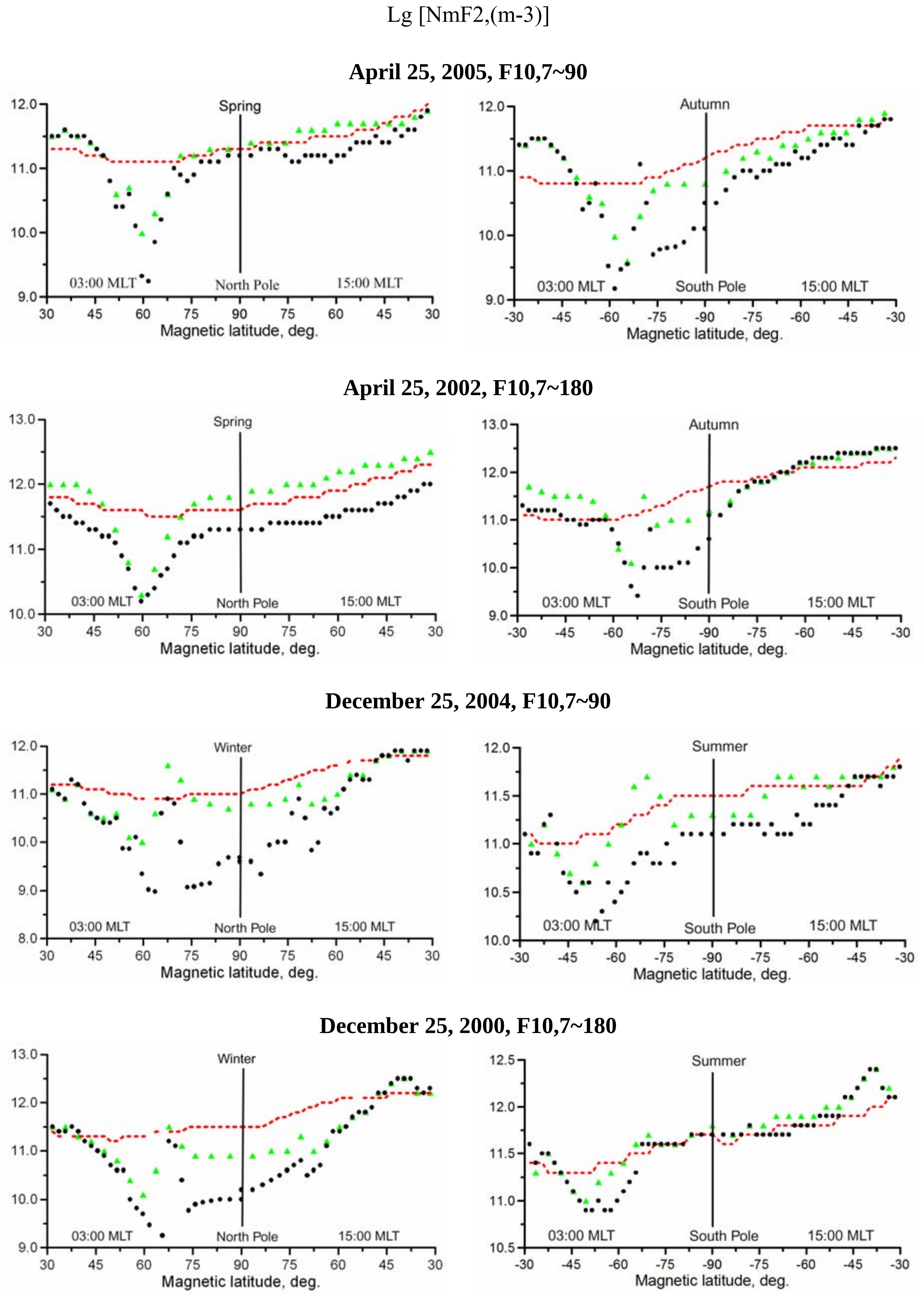
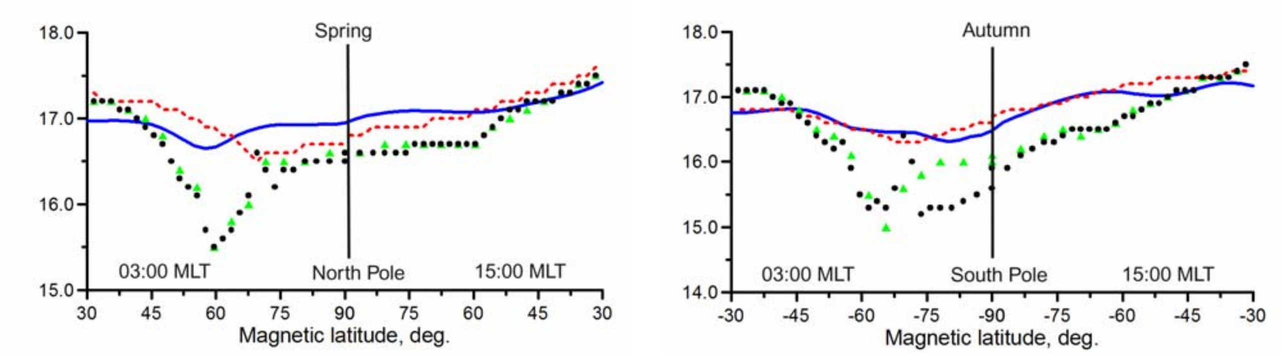


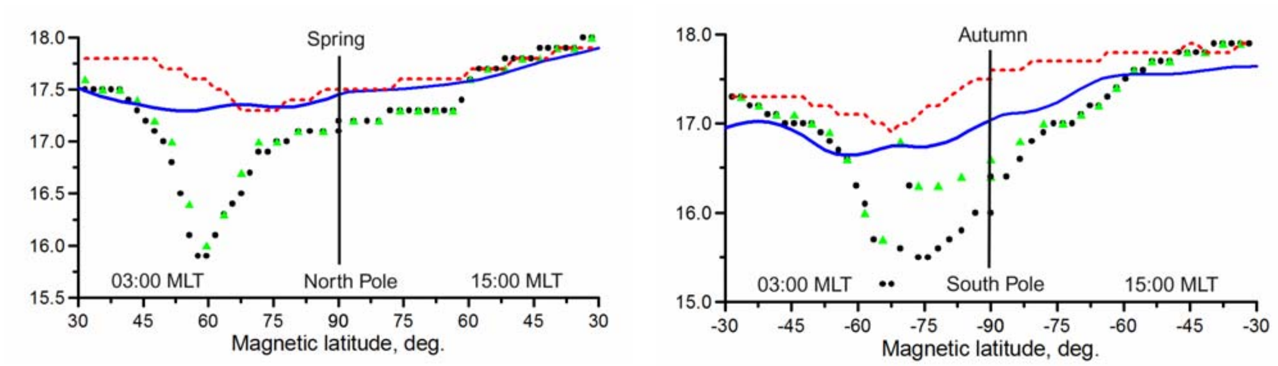
Fig. 1 Latitudinal variations of NmF2 for 15-03 MLT magnetic meridian, UT=24:00.
Black circles – UAM-TM, red dashed line – IRI-2007, green triangle–with the increased "polar rain".

Lg [TEC,(m-2)]

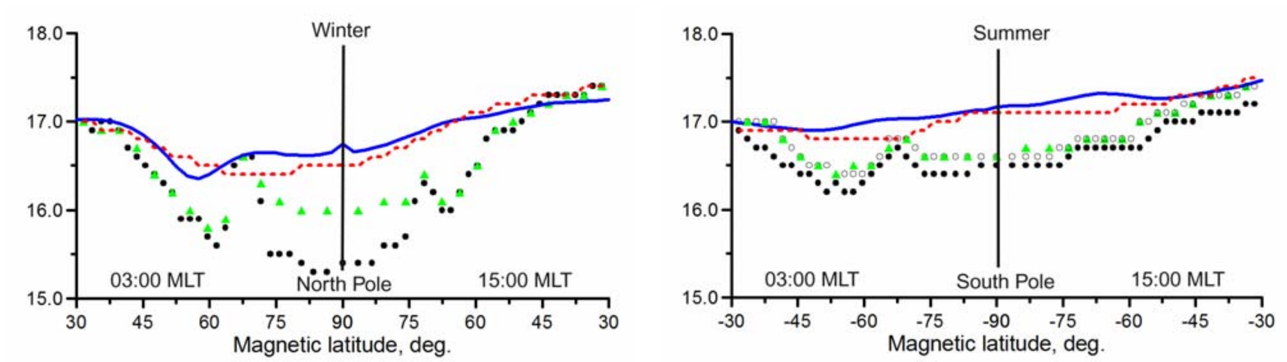
April 25, 2005, F10,7~90



April 25, 2002, F10,7~180



December 25, 2004, F10,7~90



December 25, 2000, F10,7~180

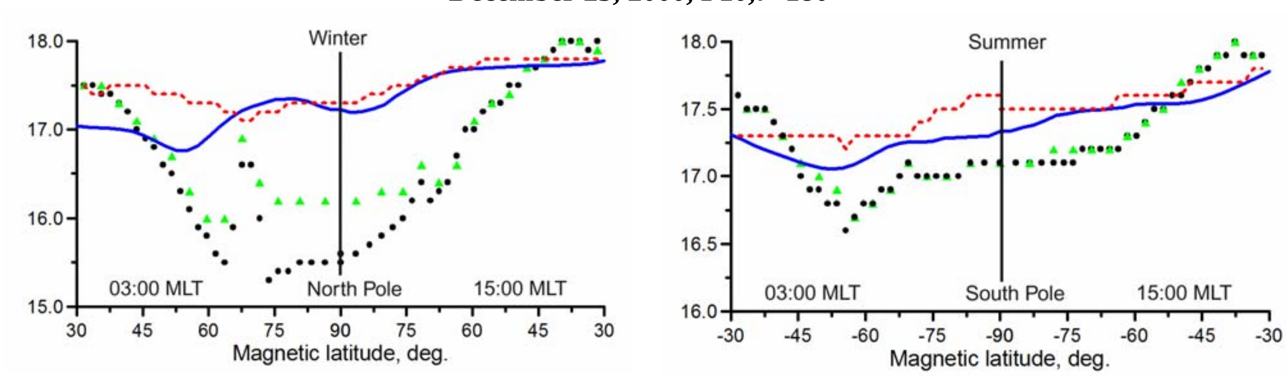


Fig. 2 Latitudinal variations of TEC for 15-03 MLT magnetic meridian, UT=24:00. Black circles – UAM-TM, red dashed line – IRI-2007, blue solid line – TEC GPS, green triangle–with the increased "polar rain".

Fig. 2 shows the latitudinal variations of the total electron content (TEC) calculated by version of UAM-TM and empirical model IRI-2007 and GPS data for the magnetic meridian 15-03 MLT.

Fig.1-2 shows that in the NmF2 variations:

1) The best agreement between the UAM, IRI and GPS results takes place over the South Pole for the summer conditions at high solar activity according to with [4], so they do not increased;
2) The good agreement takes place over the North Pole for the spring conditions at low solar activity;
3) The worst agreement takes place for the winter conditions over both poles at different levels of solar activity;
4) The worst agreement takes place for regions of the main ionospheric trough region in all seasons at different levels of solar activity.

The TEC variations keep the same features as they are determined by the variations in NmF2.

Conclusion

Fluxes' of the soft electrons precipitating at the polar caps, increased in our model calculations by an order, raise the electron density in the polar caps F2-layers to the level of the IRI empirical model and even exceed this level, but for the regions of the main ionospheric trough this increase does not improve the situation.

Thus, by increasing by an order of the flux of the soft electrons precipitating at the polar caps it is possible to reach the NmF2 and TEC values of the IRI empirical model and TEC GPS, but this increase is unrealistic. We consider therefore these differences between the values of NmF2 and TEC for UAM, IRI and GPS results are due to the lack of the ionospheric observations at the polar caps. We believe that the UAM model reproduces the real low F2-layer electron density and TEC over the polar caps and the main ionospheric trough resulting due to the polar wind and magnetospheric convection action.

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