

RESPONSE OF THE POLAR THERMOSPHERE AND IONOSPHERE IN THE VICINITY OF THE CUSP TO THE FIELD-ALIGNED CURRENT VARIATIONS

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The thermospheric and ionospheric effects of the field-aligned current variations in the cusp corresponding to *By* variation of the IMF from 0 to about -9 nT and back to 0 within an hour have been modelled by means of the global numerical time-dependent three-dimensional model of the Earth's upper atmosphere [Namgaladze *et al.*, 1988, 1995]. The responses of the electric field potential, electron concentration, ion, electron and neutral temperature, meridional and zonal thermospheric wind velocity to the variations of the field-aligned current density in the cusp have been calculated by solving the corresponding continuity, momentum and heat balance equations.

We used the following model input variations of the field-aligned currents based on the data by Taguchi *et al.* [1993], Yamauchi *et al.* [1993], Ohtani *et al.* [1995]. We added the field-aligned current flowing into (out) the ionosphere at the Northern (Southern) Hemisphere along the 80° geomagnetic latitude at the 11:30-14:00 MLT sector and flowing out at the 10:00-11:30 MLT sector (left bottom panel in Fig.1). These currents are closed by the additional zone 1 currents. The time variation of all these additional field-aligned currents has the following form. Their density increases linearly from 0 to the maximum value within the first half of the hour (00:00 - 00:30 UT) and then recovers to 0 within the second half of the hour (00:30 - 01:00 UT). The maximum density of the field-aligned current flowing into the ionosphere at 80° geomagnetic latitude is 1.6 A/km² which is ten times larger than the field-aligned current density in the quiet zone 1. The corresponding magnetic disturbance in the cusp region is estimated approximately as 600 nT. Such a disturbance was observed in the cusp region when *By* component of IMF was equal - 9 nT [Taguchi *et al.*, 1993]. It means that the modelled situation corresponds to the case when *By* changes from 0 to -9 nT and back to 0 within an hour.

Four variants of the calculations have been performed: 1) the cusp position is fixed, and only the sudden precipitation of 0.23 keV electrons takes place within half an hour (from 00:00 UT to 00:30 UT); 2) the cusp is moving, and the linearly increasing and then decreasing precipitation takes place within an hour; 3) the same as in variant 2, but the additional field-aligned currents being linearly increasing and then decreasing within an hour are included; 4) the same as in variant 3, but the additional field-aligned currents retain their maximum values after 00:30 UT.

The calculated electric field potential patterns in the north polar ionosphere are shown in Fig.1(right plots). The undisturbed potential pattern (top panel) consists of two well known convection cells with positive potential values in the morning sector and with the negative potential values in the evening sector. The disturbed potential pattern (bottom panel) obtained when the additional field-aligned currents are included consists of three convection cells: two with positive potential values in the midday-morning sector and one with negative potential in the evening sector. Such a convection pattern corresponds to the type G by Reiff and Burch [1985]. The maximum electric field intensities are of about 30 mV/m.

Fig.2 shows the calculated time variations of the ionospheric and thermospheric parameters at various north geomagnetic latitudes in the range 60-85° for the daytime 240° geomagnetic meridian at the height of 300 km. Variants 1, 2, 3 and 4 of the calculations are presented by the dashed, solid, black circle curves and open circles, correspondingly.

Comparison of the results shown by solid curves and black and open circles in Fig.2 demonstrates the differences between the effects caused by the joint action of precipitation and field-aligned current variations and those caused by the precipitation only. It can be seen that the main differences are in the thermospheric wind and ion temperature disturbances in the cusp region. The latter are much more intensive (up to about 600K) at the geomagnetic latitudes of 75-80° in case of the joint precipitation and field-aligned current action due to Joule heating of the ion gas in the cusp region whereas the neutral temperature increases not so considerably.

The most significant changes are in the zonal thermospheric wind variations due to the ion drag. The eastward wind disturbances of about 140-200 m/s appear at the geomagnetic latitudes of 75-80° in the midday sector and of about 200-300 m/s in the afternoon sector. The meridional wind disturbances are of about 90 m/s at the geomagnetic latitudes 80-85° in the midday sector and of about 180 m/s in the afternoon sector. They are also

caused by the ion drag which acts in the opposite direction in comparison with the pressure gradient forcing in the midday sector.

As for the electron density response to the field-aligned current disturbances it is very localized near the 80° of the geomagnetic latitude being negative because of ion temperature increase due to Joule heating of the ion gas. The electron temperature changes rather insignificantly. The differences between the results of the calculations in the variants 3 and 4 are seen practically only in the ion temperature and both zonal and meridional thermospheric wind variations at the geomagnetic latitudes of $75-85^\circ$.

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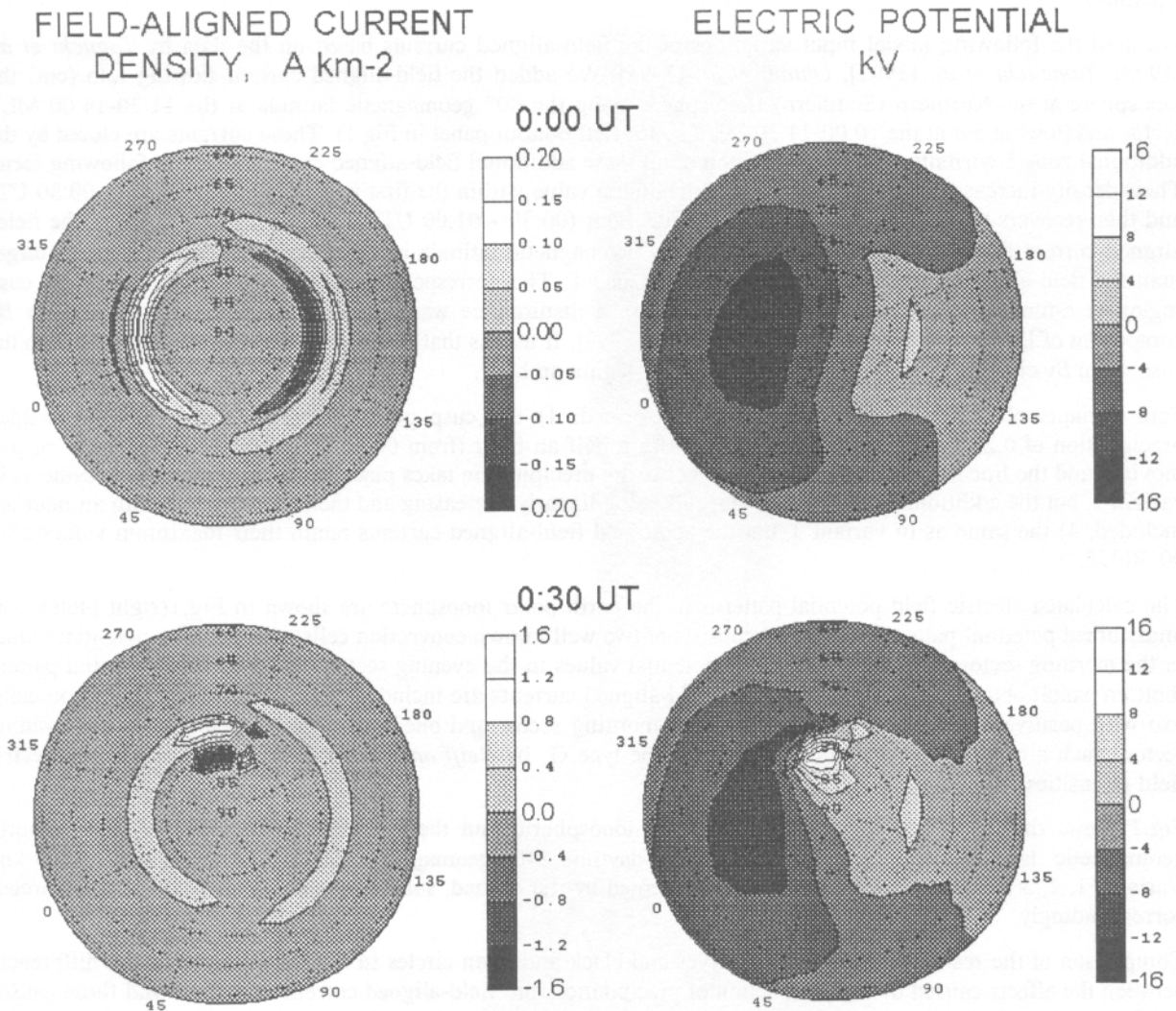


Fig.1. North geomagnetic polar plots (60-90°) of the input field-aligned current density (left plots) and calculated electric field potential (right plots) at 00:00 UT (top) and 00:30 UT (bottom).

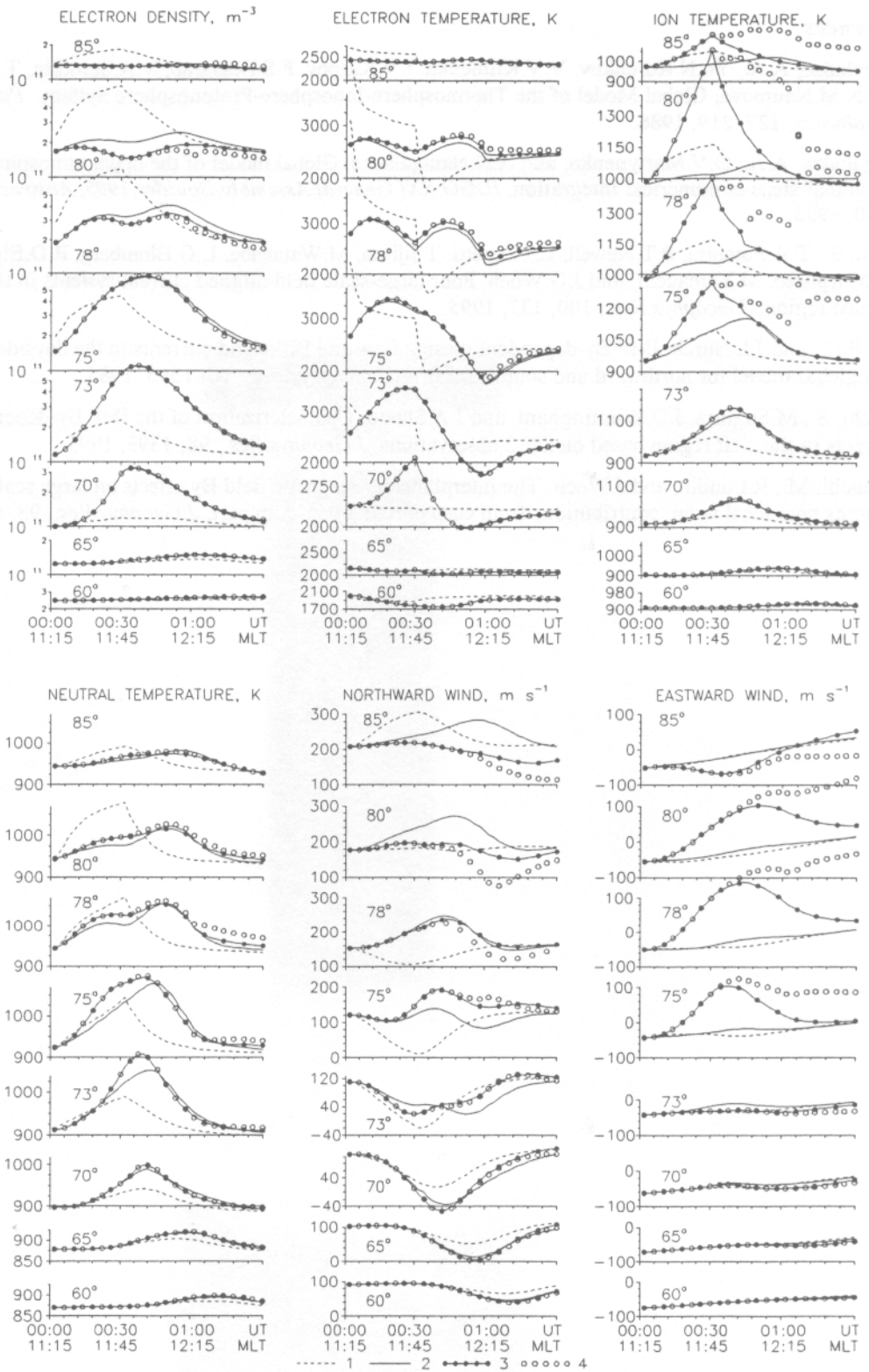


Fig.2. Time variations of the calculated ionospheric and thermospheric parameters at the 300 km altitude, $\Lambda = 240^\circ$, at various geomagnetic latitudes in variants 1 (dashed curves), 2 (solid curves), 3 (black circle curves) and 4 (open circles) of the calculations .

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