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NUMERICAL MODELING OF THE LONGITUDINAL VARIATIONS IN THE NEAR-EARTH PLASMA

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Abstract. The longitudinal variations of the electron concentration in the ionosphere and plasmasphere caused by the offset between the geomagnetic and geographic axes of the Earth have been calculated and compared with the data of the empirical IRI-95 model. A good agreement between the theoretical and empirical data have been obtained for the F2-peak heights. The relations between the longitudinal variations of the electron concentration in the geomagnetically conjugate F2-layers, at the basis of the protonosphere and at the tops of the geomagnetic field lines are very complicated and differ for the midday and midnight conditions due to the different responses of the ionosphere and plasmasphere to the longitudinal variations of the thermospheric winds and neutral gas composition.

Introduction

We have obtained the first numerical results of modeling of the longitudinal variations in the ionosphere and plasmasphere of the Earth for the March equinox of 1974 (low solar activity) using the global upper atmosphere model (UAM) (Namgaladze et al., 1998) and have compared these results with the data of the empirical International Reference Ionospheric model IRI-95. We have tried to find the relations between the longitudinal variations of the electron concentration in the geomagnetically conjugate F2-layers, at the basis of the protonosphere and at the tops of the geomagnetic field lines.

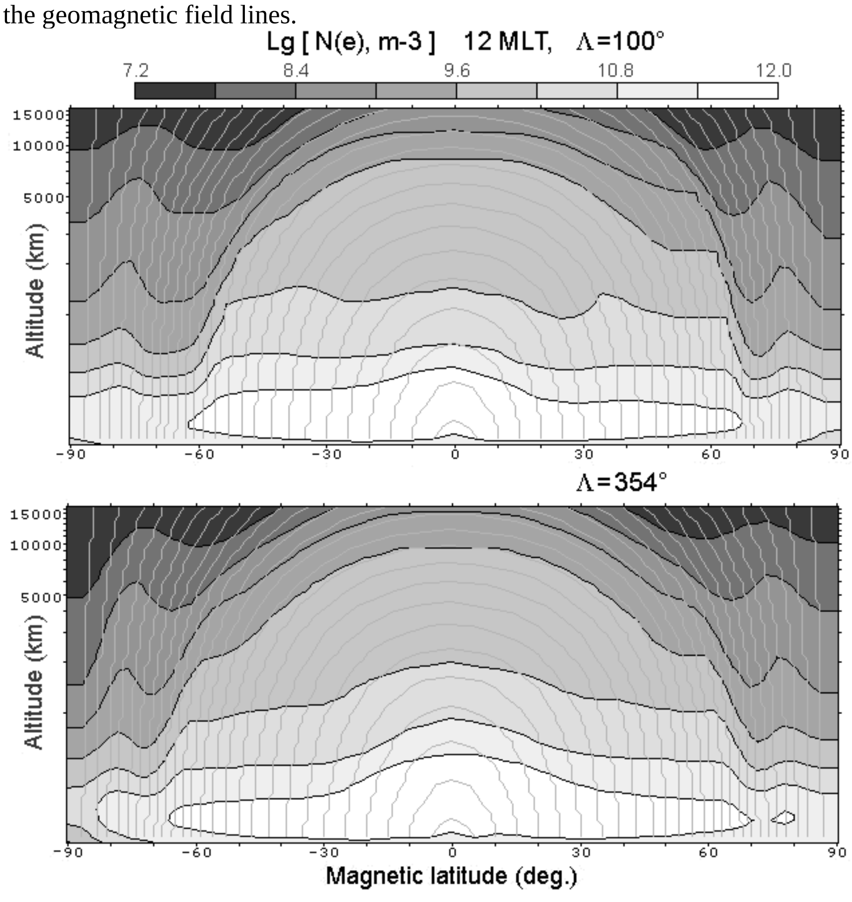

Fig. 1. The calculated midday height-latitude distributions of the electron concentration along the 100° (top panel) and 354° (bottom panel) magnetic meridians. The geomagnetic field lines are shown in this figure.

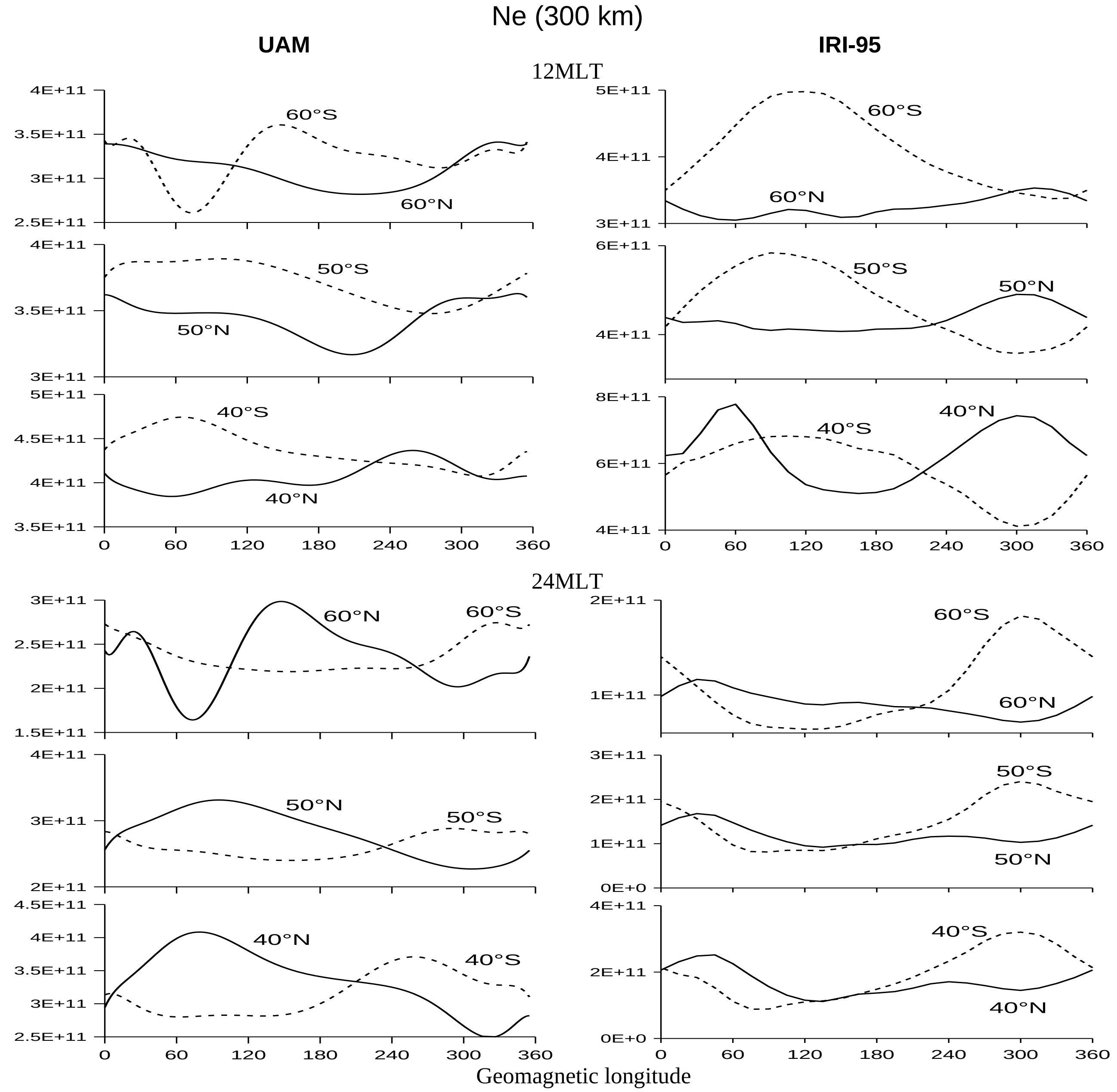

Fig.2. The longitudinal variations of the electron concentration at the 300 km height at the 40°, 50° and 60° northern (N, solid lines) and southern (S, dashed lines) geomagnetic latitudes for 12 MLT (three top panels) and 24 MLT (three bottom panels) calculated using UAM (the left column) and obtained from the empirical ionospheric model IRI-95 (the right column).

Calculations

In order to obtain the longitudinal variation of the upper atmosphere parameters we have calculated their diurnal variation after obtaining the steady state solution. During this calculation we stored the distributions of the modeling parameters at the midday and midnight geomagnetic meridian planes at height range from 80 up to 15000 km for every 20 min modeling time. The results have been plotted and analyzed in the geomagnetic coordinate system for the 12 and 24 MLT conditions.

Results

Considerable (and different) longitudinal variations of the electron concentration have been found at all altitudes. As an example, two snapshots of the height-latitude distribution of the electron number density along the midday geomagnetic meridians at the geomagnetic longitudes 100° and 354° are shown in Fig.1 together with the geomagnetic field lines.

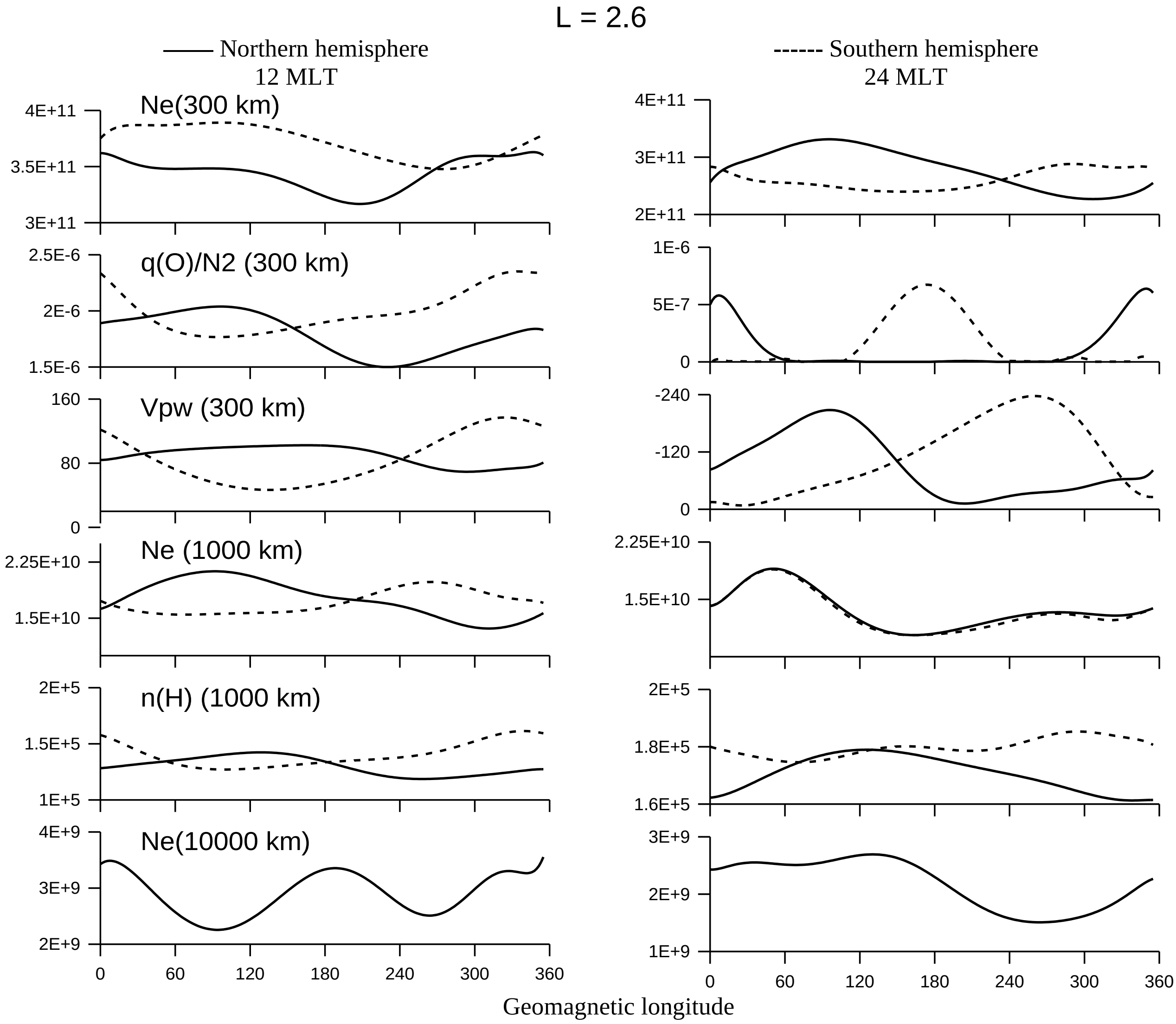

Fig.3. The longitudinal variations of the upper atmosphere parameters (electron concentration at the 300, 1000 and 10000 km heights, ionization production to loss ratio and poleward wind velocity at the 300 km height and neutral hydrogen concentration at the 1000 km height calculated using UAM along the geomagnetic field line with L=2.6 for 12 MLT (the left column) and 24 MLT (the right column).

Fig.2 illustrates the calculated longitudinal variations of the electron concentration at the 300 km height at the 40°, 50° and 60° northern and southern geomagnetic latitudes for 12 and 24MLT in comparison with those obtained from the empirical ionospheric model IRI-95. Rather good similarity is there between the theoretical and empirical longitudinal variations of the electron concentration near the F2-peak height.

Wind effects

To study the mechanism of the longitudinal variation generation at the F2-layer heights we have compared the longitudinal variations of the electron concentration, $q(O)/n(N_2)$ (production/loss) ratio and poleward thermospheric wind velocity at the same altitude 300 km. These variations are shown in Fig.3. We have concluded that not $q(O)/n(N_2)$ ratio but winds influence the electron density longitudinal variation at the F2-layer heights. To prove the neutral wind role on the electron density longitudinal variation generation we have repeated the modeling calculations under the same conditions but with the "frozen" wind (zero wind velocity) and these results are shown in Fig.4. As one can see in this figure, the electron density longitudinal variation at the 300 km altitude is caused indeed by the neutral wind.

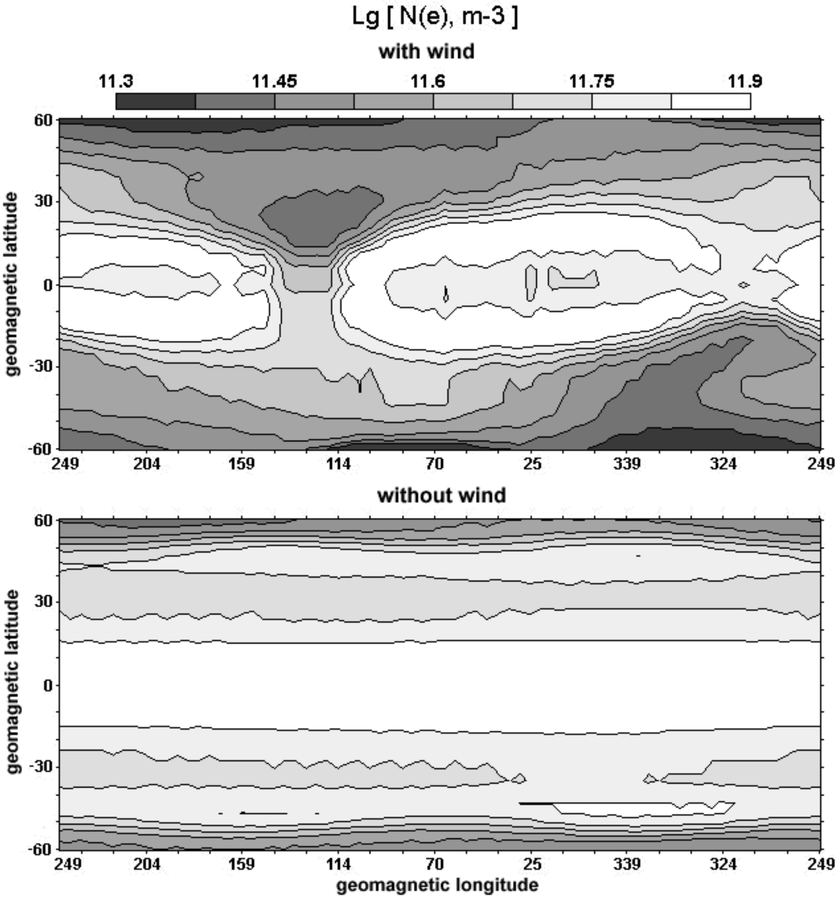

Fig. 4. The longitudinal variations of the electron concentration at the 300 km height at 12 MLT calculated with (top panel) and without (bottom panel) taking winds into account.

Relations between the ionospheric and plasmaspheric longitudinal variations

We have tried to find the relations between the longitudinal variations of the electron concentration in the geomagnetically conjugate F2-layers, on the basis of the protonosphere and at the tops of the geomagnetic field lines. These variations are shown in Fig.3 together with some other thermospheric parameters along the geomagnetic field line with L=2.6.

The relations between the ionospheric and plasmaspheric longitudinal variations are very complicated and differ for midday and midnight conditions due to different responses of the ionosphere and plasmasphere to the longitudinal variations of the thermospheric winds and neutral gas composition. Whereas the q(O)/n(N_2) ratio effects are suppressed by those of winds at the F2-layer heights, the influence of the neutral hydrogen density variation is important for the plasmasphere.

Conclusions

The longitudinal variations of the upper atmosphere parameters are significant and different for the ionospheric and plasmaspheric heights. All of them are caused mainly by the offset between the geomagnetic and geographic axes. Wind effects are important at the F2-layer heights and the influence of the neutral hydrogen density variation is important for the plasmasphere together with the ionosphere-plasmasphere plasma exchange.

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References

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