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STRATIFICATION OF THE MAIN IONOSPHERIC TROUGH AS AN EFFECT OF NONCOINCIDENCE OF THE EARTH'S GEOMAGNETIC AND GEOGRAPHIC AXES

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Abstract. The global numerical Earth's upper atmosphere model (UAM) has been used to investigate how the noncoincidence of the Earth's geomagnetic and geographic axes affects the electron density distribution at the latitudes of the main ionospheric trough under quiet geomagnetic conditions. It has been shown that noncoincidence of the axes leads to main ionospheric trough stratification at some longitudes due to time dependence of the magnetospheric convection on terminator location.

1. Introduction

The main ionospheric trough (or "mid-latitude trough") is a depletion of the F2-region electron density equatorward of the auroral zones. The probability of the main ionospheric trough occurrence is highest at night under winter conditions, it is also known to grow with the growth of magnetic activity (*Moffett and Quegan*, 1983; *Brunelli and Namgaladze*, 1988). Through the last years the main ionospheric trough has been investigated by new radiophysical methods, such as the method of satellite radiotomography (*Nygren et al.,* 1997). Physical interpretation of observations is performed by mathematical modeling with using global ionospheric models (*Aladjev et al.,* 2001; *Namgaladze et al.,* 2000, 2003).

2. Tomographic results

In the tomographic experiment during the winter of 1999, based on observations of four receivers in the Kola Peninsula, the altitude-latitude images of ionospheric electron density were obtained. The observational sites were located approximately along 125° geomagnetic longitude and had the following geographic coordinates: 64,95°N and 34,57°E (Kem), 67,37°N and 32,49°E (Polarny Zory), 68,59°N and 31,76°E (Verkhnetulomsky), 69,4°N and 30,99°E (Nickel).

Some tomographic images reveal rather interesting features of the main ionospheric trough behavior. Fig. 1 illustrates such features for the evening hours on January 30, 1999. Geomagnetic conditions were quiet, the average Kp-index being ~0.3. Existence of increased electron density area in the center of the trough with two minima from both sides, i.e. "stratification" of the trough, is the peculiarity investigated in this paper.

In the present work an attempt of physical interpretation of trough stratification under quiet geomagnetic conditions is made on the basis of mathematic modeling.

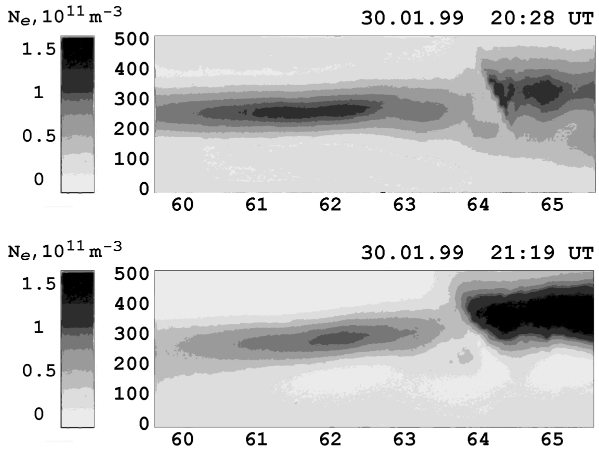

Fig. 1. Tomographic images of electron density in the altitude-versus-geomagnetic latitude plane on January 30, 1999.

3. Numerical modeling

To explain formation of the area with increased electron density at the bottom of the main ionospheric trough we performed numerical experiments using the UAM – the global Upper Atmosphere Model (*Namgaladze et al*., 1998).

In the modeling we suggested that trough stratification is related to noncoincidence of the geographic and geomagnetic axes of the Earth. This suggestion is based on the results of *Klimenko and Namgaladze* (1981), who showed a possibility of trough stratification owing to non-stationary character of the magnetospheric convection.

Namely, if the magnetospheric convection is time-dependent, plasma at some drift trajectories can occasionally get to sunlit sites of the ionosphere, with its density increasing due to solar ionization, and then bring this concentration enhancement to depleted areas. And, vice versa, at other trajectories plasma can be removed or depleted owing to recombination.

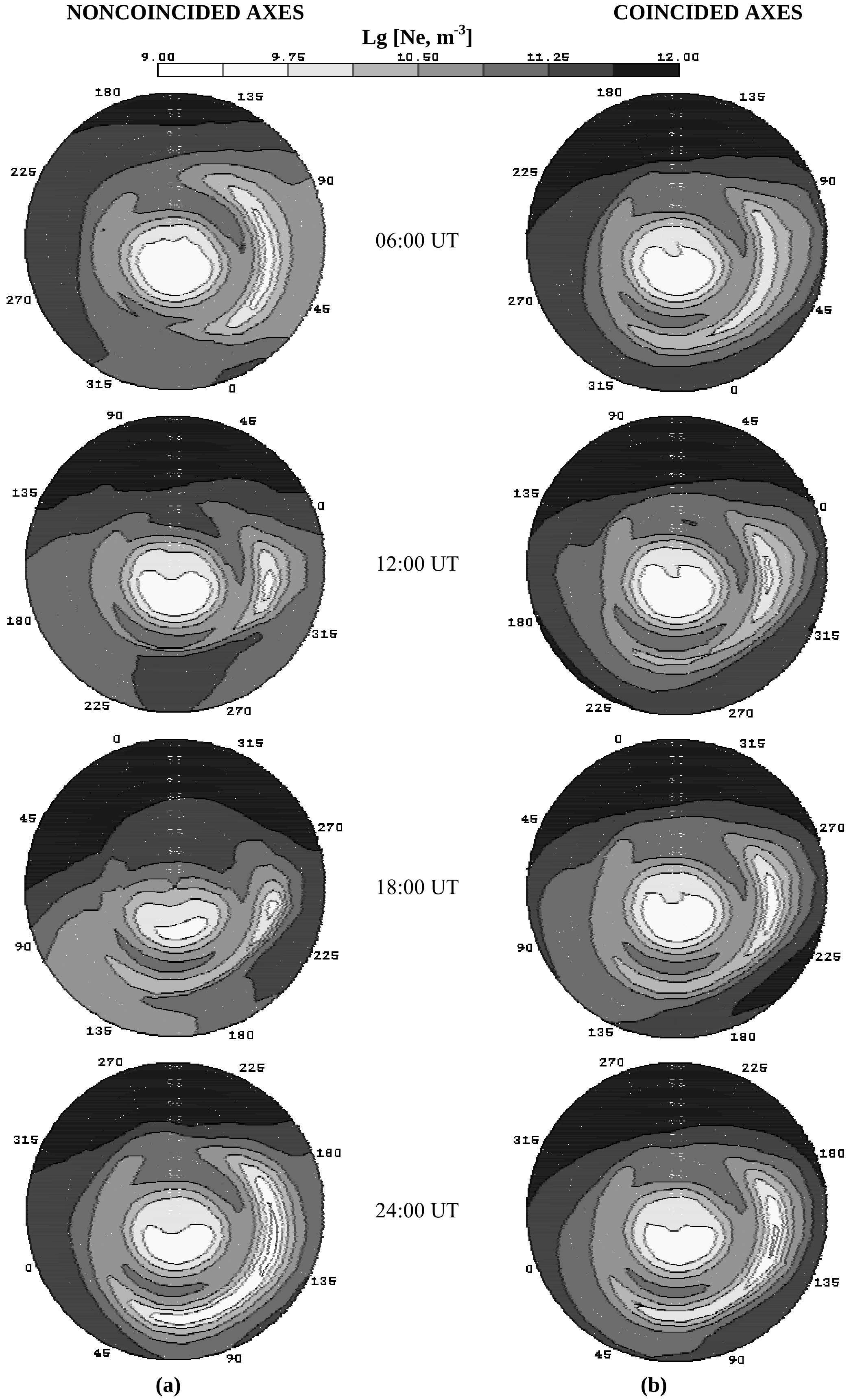

Fig. 2. Calculated distributions of the electron density at height of 300 km in the winter hemisphere at 06, 12, 18 and 24 UT on January 29, 1999. The calculations have been performed for noncoincident (a) and coincident (b) geographic and geomagnetic axes

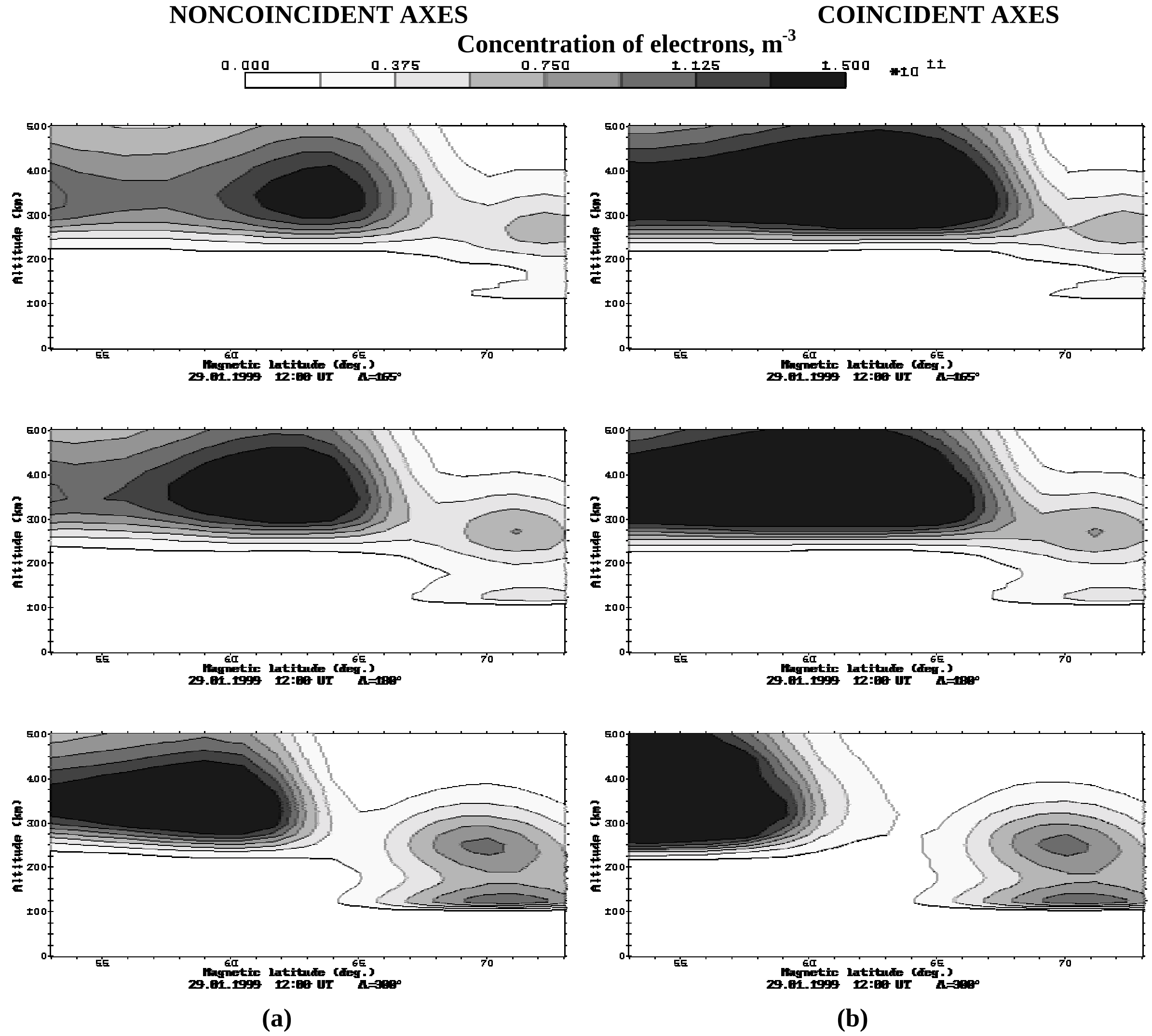

Fig. 3. Calculated distributions of the electron density in the meridional plane (winter hemisphere) at 12 UT on January 29, 1999 for noncoincident (a) and coincident (b) geographic and geomagnetic axes

Manifestation of these effects can be different, including narrowing or expansion of the trough, change of its form, e.g. stratification, etc. In the work by *Klimenko and Namgaladze* (1981), the distinction between geographic and geomagnetic Earth's axes was not taken into account, only the effects of time dependent magnetoshperic convection were considered.

Under quiet geomagnetic conditions the magnetospheric convection does not vary in time or varies insignificantly in the geomagnetic coordinate system, so it can be considered as stationary in this system. However, the convection pattern connected with the magnetic field rotates around the geographic axis and, hence, is non-stationary in the geographic coordinate system, i.e. some trajectories occasionally come on the sunlit sites.

In the geomagnetic coordinate system terminator position is non-stationary due to rotation of the convection around the geographic axis. This is equivalent to the non-stationary convection in the geographic coordinate system and should cause effects in the main ionospheric trough, similar to those obtained in the work by *Klimenko and Namgaladze* (1981).

To clarify this suggestion, we performed calculations of the electron concentration for both noncoincident and coincident geographic and geomagnetic axes under the quiet geomagnetic conditions in winter by using UAM. Coincidence of the axes was simulated in the model by setting identical transition between geographic and geomagnetic coordinate grids. The potential drop across the polar cap and precipitating electron fluxes, which determine the convection pattern, were set constant in time.

4. Results of the model calculations and their discussion

Results of modeling have shown that the effects of noncoincidence of the geographic and geomagnetic axes in distribution of electron concentration are especially distinct in the subauroral region. The polar plots of the electron density at height of 300 km obtained in two runs are shown in Fig.2. It is seen that in case of coincident geographic and geomagnetic axes, the distribution of electron density varies insignificantly with time (there is a transition process to the steady state). At the same time, the results for noncoincident axes reveal a significant UT-effect, i.e. dependence on universal time.

Calculated electron density distribution at height of 300 km in case of noncoincident axes strongly varies with time, with either one or two areas of depleted electron concentration being formed in the subauroral region. The results of calculations with the coincident axes (Fig. 2 (b)) show that the depletion of the electron density is located at the same LT-longitudes and its form does not change with time.

For noncoincident geographic and geomagnetic axes practically at any UT large-scale structures with two minima (stratification) in the height-latitude distribution of electron density can be seen (Fig. 3 (a)). The calculations with coincident axes presented in Fig. 3 (b) don’t reveal such features.

Thus, the suggestion on formation of areas with enhanced electron density between equatorial and polar walls of the main ionospheric trough due to noncoincidence of the geographic and geomagnetic axes is verified in calculations with the Upper Atmosphere Model applied. The occurrence and location of these large-scale structures depend on numerous factors, such as model inputs, initial and boundary conditions, season, solar and magnetic activity, etc., and will be subjects of further studying.

5. Conclusions

Numerical modeling of electron density planetary distributions under quiet conditions in winter season with using the global model of the Earth’s upper atmosphere (UAM) has been performed for both coincident and noncoincident geographic and geomagnetic Earth's axes. The results obtained prove that stratification of the main ionospheric trough may be associated with time dependence of the magnetospheric convection in the geographic coordinate system. This feature can be due to noncoincidence of the geographic and geomagnetic axes and rotation of the geomagnetic axis around the geographic one, which leads to UT dependence of solar light exposure of convection trajectories. Thus, a diurnal variation of the convection pattern with respect to the terminator position affects the trough form and location.

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