UDC 550.388.2

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SIMULATION OF IONOSPHERIC PLASMA VELOCITY ALONG THE GEOMAGNETIC FIELD LINES DUE TO THE HORIZONTAL NEUTRAL WINDS

With use of horizontal neutral winds model HWM93 there are calculated the elements of a global picture of thermosphere circulation, the changes of value and direction of thermosphere wind over Kharkiv. The calculations of constituent part of vertical component of ionospheric plasma velocity caused by horizontal neutral winds were made.

Keywords: horizontal wind model HWM93, dynamics of an ionosphere, ionospheric plasma velocity.

Statement of the problem. Motion of the ionospheric plasma is determined by the processes of diffusion, dragging by neutral wind and electromagnetic drift. The dragging by neutral wind characterizes the global processes in the ionosphere and, in some cases, may be the determining factor. Now the empirical model of horizontal neutral winds HWM93 [1] is successfully used. In general, it presents satisfactorily a global picture of the atmospheric circulation. However HWM93 as any empirical model, requires constant addition of observational data obtained in different regions. One of such informative tools of observation is incoherent scatter radar of the Institute of ionosphere. It gives possibility to determine the overall velocity of the plasma in the vertical direction. From these data, at the further processing, the component determined by neutral winds can be calculated [2]. Therefore it is necessary to know kind of data, given with the model, as these data are determined by time and solar activity. Subsequently, these data will be compared with the results of observations and used for model development.

The work purpose. Using the model HWM93 to calculate and interpret the dynamic processes in the upper atmosphere, caused by neutral winds at thermospheric altitudes.

Dynamic processes modeling. Dynamics of the upper atmosphere is one of the most important problems of geospace. This applies both to dynamics of neutral components and dynamics of an ionosphere. The dynamics of the neutral components is determined mainly by the tidal forces caused by heating of the upper atmosphere by solar radiation and, in a minor part, lunar tides. These movements are often decisive in the dynamic processes of the ionosphere and play the important role in formation of global distribution of electron density.

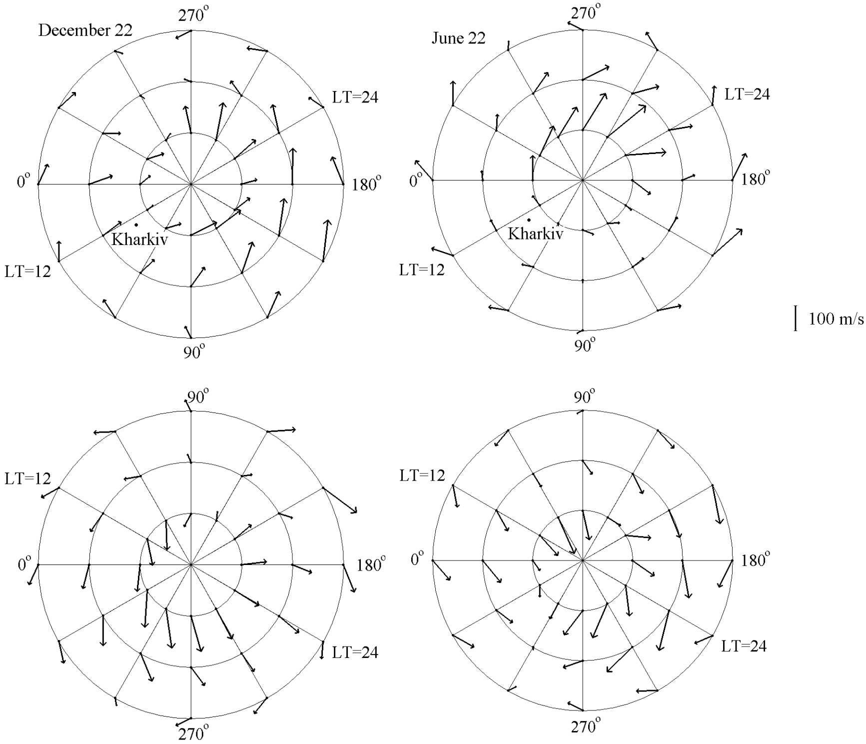

Fig. 1 – Distributions of the horizontal neutral winds in northern and southern hemispheres at altitude of 300 km in the winter and summer solstices when $F_{10.7}$=100 and A_p=2

Fig. 1–2 shows the global distribution of neutral velocity vectors for winter and summer solstices, vernal and autumnal equinoxes at low solar activity. The calculations are executed on model HWM93 [3 – 5] of horizontal winds of neutral components. For the calculations there were taken magnetically quiet conditions (A_p=2); the level of solar activity (SA) was characterized by index $F_{10.7}$=100. The calculations of neutral winds were carried out for altitude of 300 km.

The graphs show that there is a significant difference between the summer and winter periods. It is noteworthy that in the local summer almost round the clock thermospheric wind is directed toward equator, changing in value and direction. In local winter one can see a clear change of direction during the day: in the afternoon – in a direction of a corresponding pole, at night – through the pole in the opposite direction.

As to the equinox periods, the same tendency of change of a wind vector direction is shown, as well as in local winter time. It can be seen that both in direction and value of velocity, the equinox periods are very similar.

Now we will show the variations of thermospheric wind direction over Kharkiv (see Fig. 3–4).

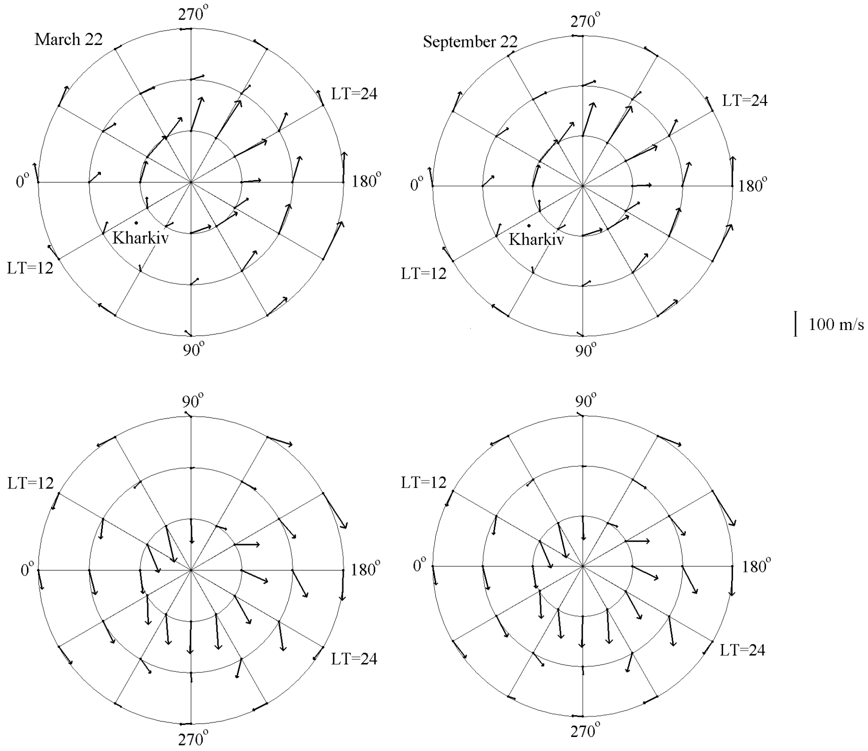

Fig. 2 – Distributions of the horizontal neutral winds in northern and southern hemispheres at altitude of 300 km in days of vernal and autumnal equinoxes. Character of the distributions of velocity vectors is almost the same

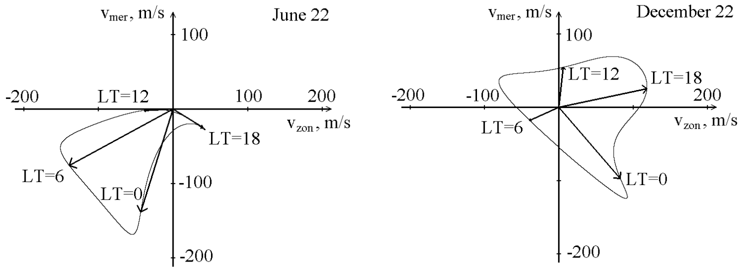

Fig. 3 – Variation of value and direction of horizontal wind over Kharkiv in winter and in summer during the day. In summer at low solar activity in magnetically quiet conditions during all time a northern wind component is absent

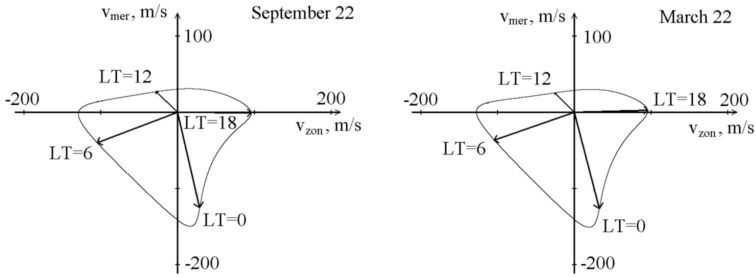

Fig. 4 – Variation of value and direction of horizontal wind over Kharkiv at vernal and autumnal equinoxes during the day

Finally, to connect the given model calculations with studies of the ionosphere by incoherent scatter method, we calculated the vertical component of the velocity of the ionospheric plasma dragged by thermospheric wind. The fact is that due to the magnetization of ionospheric plasma horizontal wind forces the plasma to move along the geomagnetic field lines. In turn, this movement has a vertical projection, which can later be compared with the ionospheric observations data. The results of calculations are shown in Fig. 5–6.

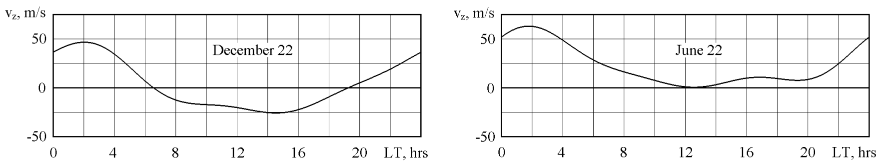

Fig. 5 – The vertical component of the drag plasma velocity in the summer and winter time

It is seen that in summer at low SA thermospheric wind during the whole day gives a contribution to upward component of overall plasma velocity. In winter during the daytime there is a significant downward movement.

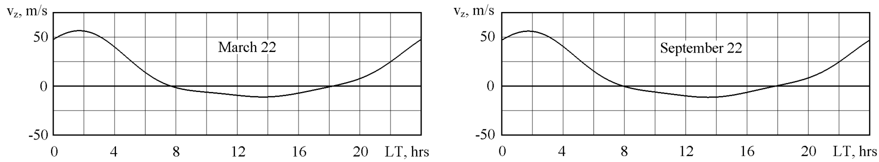

Fig. 6 – The vertical component of the plasma drag velocity in the vernal and autumnal equinoxes

Equinox periods occupy an intermediate position and are almost identical in nature.

Conclusions. There are analyzed the details of a global picture of thermosphere circulation for Kharkiv region during various seasons. There is executed the simulation of constituent part of vertical component of ionospheric plasma velocity caused by horizontal neutral winds. To confirm or to correct the presented model calculations will be possible by processing of ionospheric plasma velocity observations obtained by incoherent scatter method.

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Received 09.09.2014

UDC 550.388.2

Simulation of ionospheric plasma velocity along the geomagnetic field lines due to the horizontal neutral winds / S. V. Grinchenko, D. A. Dziubanov, Iu. E. Ziuzgina // Bulletin of NTU "KhPI". Series: Radiophysics and ionosphere. – Kharkiv: NTU "KhPI", 2014. – No. 47 (1089). – P. 99-104. Ref.: 6 titles.

С использованием модели горизонтальных нейтральных ветров HWM93 рассчитаны элементы глобальной картины термосферной циркуляции, изменения величины и направления термосферного ветра над Харьковом. Проведены расчёты компоненты вертикальной составляющей скорости движения ионосферной плазмы, обусловленной горизонтальными нейтральными ветрами.

Ключевые слова: модель горизонтальных нейтральных ветров HWM93, динамика ионосферы, скорость движения ионосферной плазмы.

З використанням моделі горизонтальних нейтральних вітрів HWM93 розраховані елементи глобальної картини термосферної циркуляції, зміни величини і напряму термосферного вітру над Харковом. Проведено розрахунки компоненти вертикальної складової швидкості руху іоносферної плазми, зумовленої горизонтальними нейтральними вітрами.

Ключові слова: модель горизонтальних нейтральних вітрів HWM93, динаміка іоносфери, швидкість руху іоносферної плазми.