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THE STUDY OF UNDULAR PERTURBATIONS IN THE LOWER POLAR IONOSPHERE

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Abstract. In this paper the preliminary results of the undular motions observations in the lower polar ionosphere are introduced. The spectral analysis of the short-term and long-term data records revealed the medium oscillations with the different periods. Such oscillations of the medium are generated by the famous phenomena as the internal gravity waves, lunar tides, geomagnetic activity and infrasonic waves. But there were discovered unknown periods which did not correlate with those processes. The variations of the power spectra characteristic frequency correspond to the medium temperature fluctuations. Furthermore, the undular motions influence the formation of the mesospheric effects such as Polar Mesosphere Summer Echo (PMSE).

Introduction

During many years the PGI carries out radar studies of the lower ionosphere in the medium wave range [Vlaskov and Bogoljubov, 1998; Tereshchenko et al., 2001]. Measurements of the magnetoionic components amplitudes of the back scattered radio signals in the lower ionosphere, the transversal velocities of plasma motion and the electron density have shown, that time variations of the parameters are, mainly, caused by the undular processes which constantly exist in the lower ionosphere and have different nature. An experimental and theoretical investigation of wave disturbances of the ionospheric plasma, which are caused by internal gravity waves (IGW), tides and other wave processes, is one of the major problems of the upper atmosphere physics [Belikovich et al., 1999].

Results and conclusions

In Fig. 1 an example of time-altitude variations of the amplitude of the ordinary wave A_o for the measurements of August 7 1999 is shown. Figure clearly demonstrates undulating time-altitude variations of the amplitude A_o. In accordance with the applied theory which considers, that radioreflections occur at the irregularities of electron density $\Delta N/N$, these measurements allow one to investigate the detailed D-region structure.

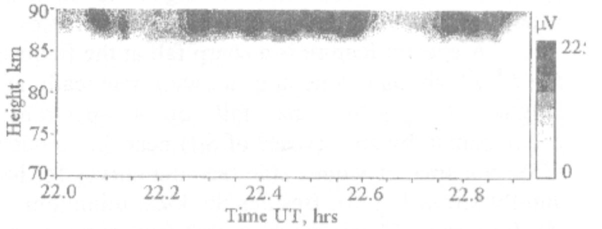

Fig. 1. The time-altitude distribution of the ordinary wave amplitude (µV).

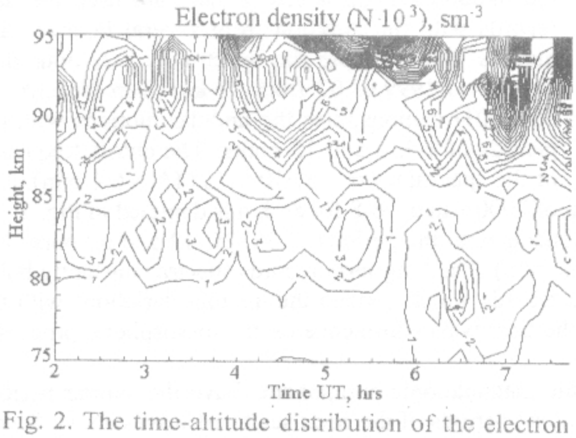

Fig. 2. The time-altitude distribution of the electron density depicted by the isolines for 1999.07.28.

The similar displays of the undulating variations can be observed in Fig. 2 by the electron density isolines for measurements of 1999.07.28. The isolines are marked by the electron density values multiplied by 10^{-3} sm^{-3}. Variations of an isoline height at a considered time interval was not uniform for the most part of the region. The figure shows the closed lines which evidences of the appearance of the additional layers. Thus an electron distribution can be not only horizontally-layered but also vertically-layered. Furthermore, there can also appear oblique layers of the electron density.

The spectral analysis allows one to determine the prevailing frequencies (periods) making the main contribution to the dynamics of the radioreflections' amplitude variations at different heights. The power spectral density of the O-wave amplitude fluctuations was calculated by the direct Fourier transformation of an autocorrelation function by the 60-minute data record and smoothed out by Tuckey spectral window [Vlaskov and Bogoljubov, 1998]. Examples of the spectra for four heights are depicted in Fig. 3 for the altitude range of 75-90 km 1999.08.08. Spectra A_o calculated for other heights and time intervals, have a similar shape.

It is possible to note that such spectra contain dropped parts which are circumscribed by the following dependence of the spectral density versus the frequency – $S(f)$ f^p. The spectral factor p 0.3 – 1.1 for f f^k and p 1.9 for $f > f$. The period T^k, corresponding to the frequency f^k, is possible to interpret as the period of the

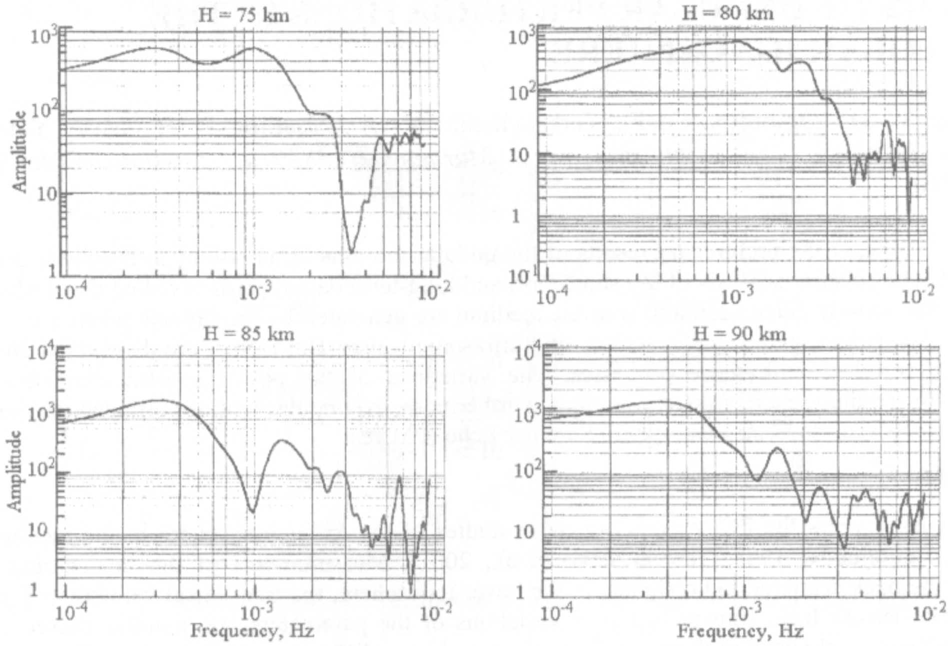

Fig. 3. The spectra of one-hour data records at the fixed heights during 10:30 - 11:30 UT for 1999.08.08

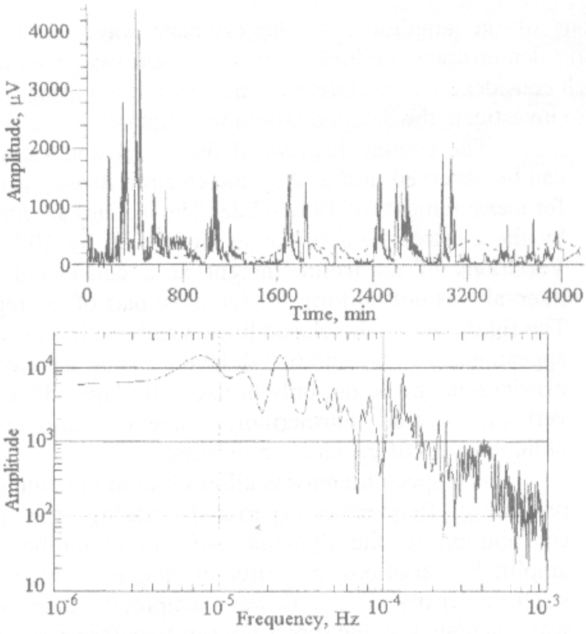

Fig. 4. The three-day data records and power spectrum of 2000.08.06-08 measurements for 86 km.

Brenta-Visyalya frequency in the IGV spectrum [Belikovich et al., 1999]. It is known that IGW with periods less than the Brenta-Visyalya period can not exist. The Brenta-Visyalya frequency is connected with the medium temperature. Determining the frequency of the atmosphere eigentones from the spectrum of the power amplitude signal fluctuations, it is possible to estimate the mesosphere temperature.

A spectra feature is a sharp fall at the frequency $f > f^k$ which, as a rule, appears well practically at all heights. Frequently, the fall of a spectrum is accompanied by an increase of $S(f)$ near the frequency f^k on the smaller values side (see the curves for h=85 and 90 km in Fig. 3). Besides the local minimum near the frequency f^k can be observed (the same curves). The cutoff periods of the spectra vary within 4.2 – 8.3 minutes.

For investigation of long-period variations of the radioreflections intensity there are used the data records with the duration from several hours to 1-2 months. For example the spectrum of 22-hour data records of 1999.08.07 from 82 km [Tereshchenko et al., 2001] demonstrates the undular motions with the periods of 1.4, 6 and 12 hours. The cutoff frequency of the spectrum $f = 1.57 \cdot 10^{-3}$ Hz ($T^* = 6.4$ min). The three-day data records and the corresponding power spectrum of 2000 August 6-8 for 86 km is depicted in Fig. 4.

The spectrum contains the pronounced Fourier components with the periods of 35, 25, 12 and 6 hours. The Brenta-Visyalya frequency equates $f^k = 1.52 \cdot 10^{-3}$ Hz ($T^k = 6.6$ min). The long-term records spectra constantly holds the daily component. Furthermore, there are intervals of the records which contain the undular variations with the periods of 1.5, 5, 7 and 11 days. It is possible that there is the tidal waves influence on the mesospheric processes such as the formation of PMSE.

The spectral analysis shows that the amplitudes of the magnetoionic components have the similar periods from 6-11 to 8.3 hours at 80 km height. However the oscillations periods of the back scattered waves above 80 km are similar by the magnitude only. Besides, the amplitudes and the geomagnetic field components had almost identical periods for that time with duration from 11.5 up to 111 minutes. There were also observed the intensive oscillations with the periods from 4 up to 30 s which do not correlate with the geomagnetic activity (infrasonic waves).

Thus, the observation of MF radioechoes amplitudes allows one to reveal and investigate the undular motions in the lower ionosphere, furthermore, to determine the characteristic frequencies of mesosphere oscillations and to use them for an estimation of the medium temperature.

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