Behavior of Parameters of Nighttime Electron Density Enhancements of the Ionospheric *F*2 Layer

Artur Yakovets, and Galina Gordienko

Institute of Ionosphere, National Center for Space Research and Technology, Almaty, Kazakhstan

(artyak40@mail.ru)

Abstract. Behavior of parameters of nighttime electron density enhancements of the ionospheric *F*2 layer has been studied based on vertical-incidence ionospheric sounding data in Almaty (76 55′E, 43 15′N). The results obtained in the framework of a unified concept of manifestation of different types of ionospheric plasma perturbations in variations of height and half-thickness layer, accompanied by increasing and decreasing NmF2 at moments of maximum compression and expansion layer. It is shown that between the height of h_{Am}, corresponding to the maximal enhancement amplitude, and the height (h_mF) of layer maximum there is a good correlation, with h_{Am} is always lower than h_mF. The difference between h_{Am} and h_mF increases linearly with h_mF increasing. If h_mF = 280 km difference is ~ 38 km and for the h_mF = 380 km difference is ~ 54 km. Good correlation is observed between amplitude of the electron density enhancement in the layer maximum (ΔN_m) and ΔN maximal amplitude at a fixed height, with the ΔN_m about 2-3 times less than the ΔN.

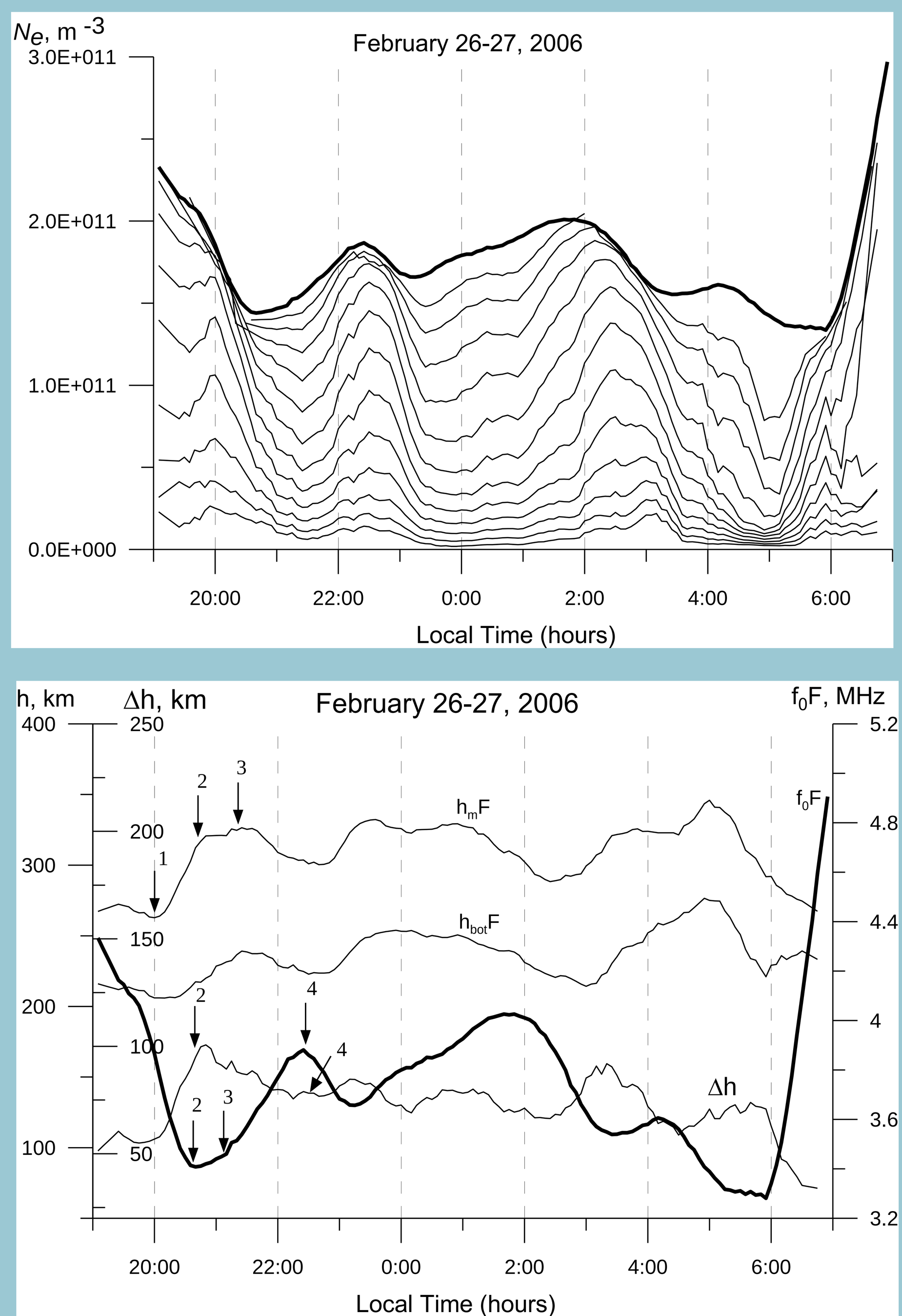

Figure 1 An example of the behavior of the parameters of the F2-layer during the night electron density enhancements.

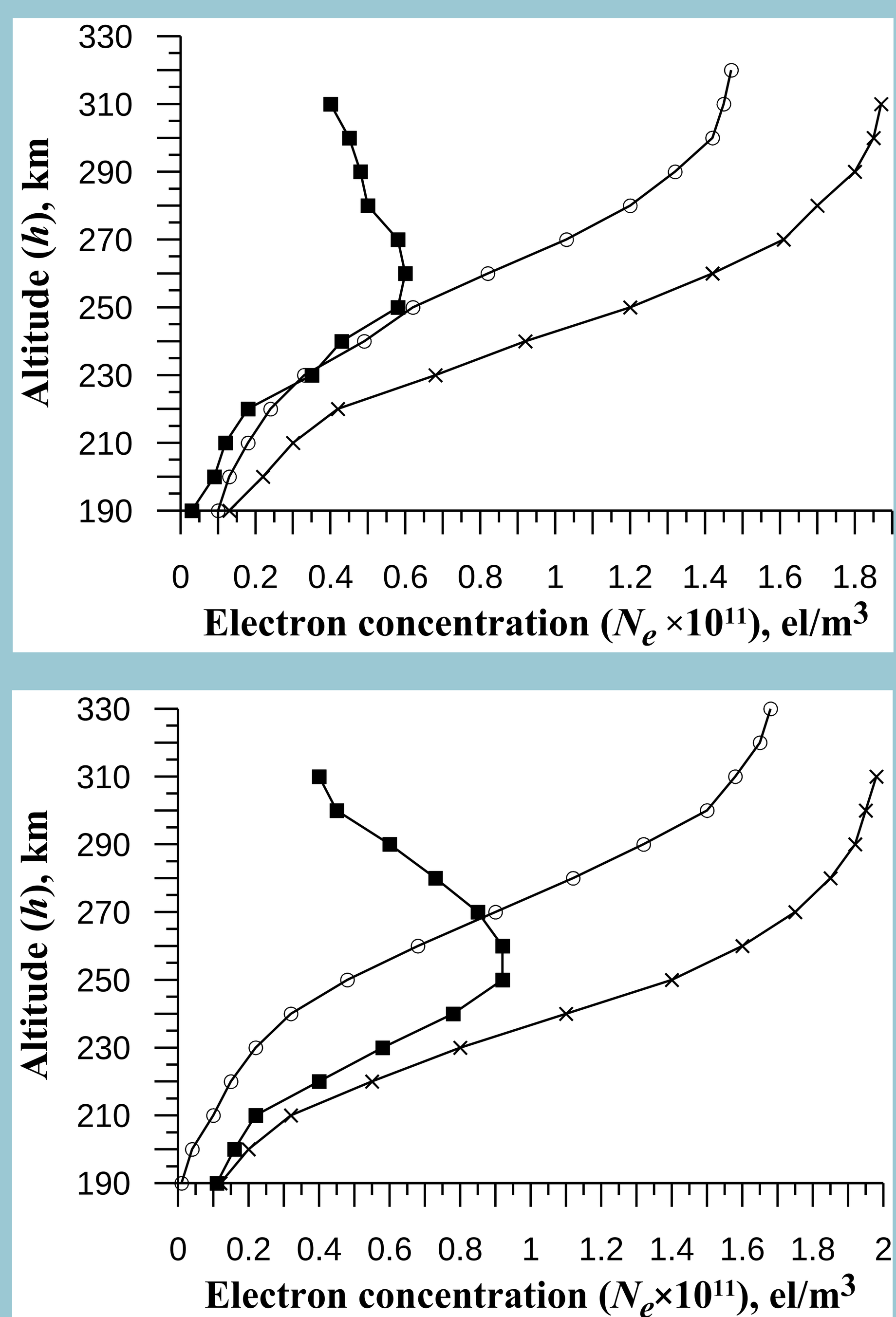

Figure 2. High-altitude profiles of magnitude of the electron density enhancements ( ) and N (h) –profiles to start ( ) and the end (x) of enhancements, which took place on 26-27 February 2006 and a - the first enhancement ($t_{нач}$ ~ 20:40 , $t_{кон}$ ~ 22:25); b - the second enhancement ($t_{нач}$ ~ 23:10, $t_{кон}$ ~ 2:00).

1 Introduction.

There is known a wide class of disturbances of the *F*2-layer of the ionosphere, which are superimposed on the regular diurnal variations of the electron density. Different types of disturbances are characterized by different mechanisms of their generation. Traveling ionospheric disturbances appear to be the most characteristic features of the inhomogeneous structure of the ionosphere. Another type of ionospheric disturbances presents the nighttime electron density enhancements in the ionospheric *F*2- layer maximum (N_mF2). This type of irregularities is described in numerous papers such as [1, 2]. Lynn et al. [3] revealed that, in spite of the various mechanisms of ionospheric disturbances generation a response of *F*2-layer parameters exhibits similar features associated with the upward lift and the simultaneous expansion of the layer and then its subsequent downward movement, including layer compression, which results in the formation of the electron density peak in the layer maximum at the moment of greatest compression. The aim of this study is a verification of this concept on the example of disturbances related with the nighttime electron density enhancements, and the definition of precise quantitative relationships between the variations of different *F*2-layer parameters for such disturbances.

2 Description of equipments and observation results

The vertical ionospheric sounding was conducted in the Institute of the Ionosphere (Alma-Ata) by using the "Parus" digital ionosonde. The information needed for calculations of various parameters of the F2 layer was read from the ionograms using the semiautomatic method with the participation of an experienced operator. Data processing included obtaining N(h) profiles from the ionograms, using the POLAN conversion program [5]. The sequence of N(h) profiles made it possible to obtain the behavior of several layer parameters, including the electron density at fixed altitudes (N) and at the layer maximum (NmF2). To obtain quantitative estimates of the parameters of the nighttime electron density enhancements of the F2 layer we constructed the electronic content behavior on a number of fixed height (Fig. 1, upper panel) (the distance between adjacent elevations is 10 km away, while the lower curve corresponds to the height h = 190 km) and temporal variations of the maximum layer height (h_mF2), the bottom height ($h_{bot}F2$), the layer half-thickness ($\Delta h = h_mF2 - h_{bot}F2$), and the critical frequency (f_oF2) (Fig. 1, lower panel). The bold curves presented electron content variations (N_mF2) at the maximum layer (Fig. 1, upper panel) and foF2 (Fig. 1, lower panel).

Figure 1 shows a typical example of the behavior of the parameters of nighttime F2-layer, which represents the sequence of the first (t ~ 20:40-22:25), second (t ~ 23:10 -02:00) and third (t ~ 03: 15 4:15) enhancements. The fall of the critical frequency at the beginning of the measurement session is due off the ionizing radiation of the sun after sunset and chemical losses related to plasma recombination. The rapid increase in electron density in the morning after 06:00 is due sunrise. Comparing the behavior of the temporal parameters of enhancements, one can notice that its characteristics are the same features as described in [3]. These behaviors include the expansion and simultaneous lifting of the layer and then lowering it and at the same time compression, leading to the formation of the maximum value N_mF2 at the moment of maximum compression. The latter conclusion is easily observed when comparing the behavior in time and Δh and f_oF2 shown in Fig. 1, which implies that these parameters vary in opposite phase. The behavior of the electron density in the number of fixed height allows obtaining the altitude dependence (profile) of enhancement amplitude. Figure 2 show altitude profiles of enhancement amplitudes for the first (Fig. 2, upper panel a) and second (Fig. 2, lower panel) enhancements and *N*(*h*) profiles for the beginning and end of the enhancements calculated from $N_e(t)$ variations presented on Fig. 1. In the measurement session, shown in Fig. 1, the height corresponding to the maximum amplitude for the 1st and 2nd enhancements, was found to be 260 km. Analysis of the entire volume of observations showed that

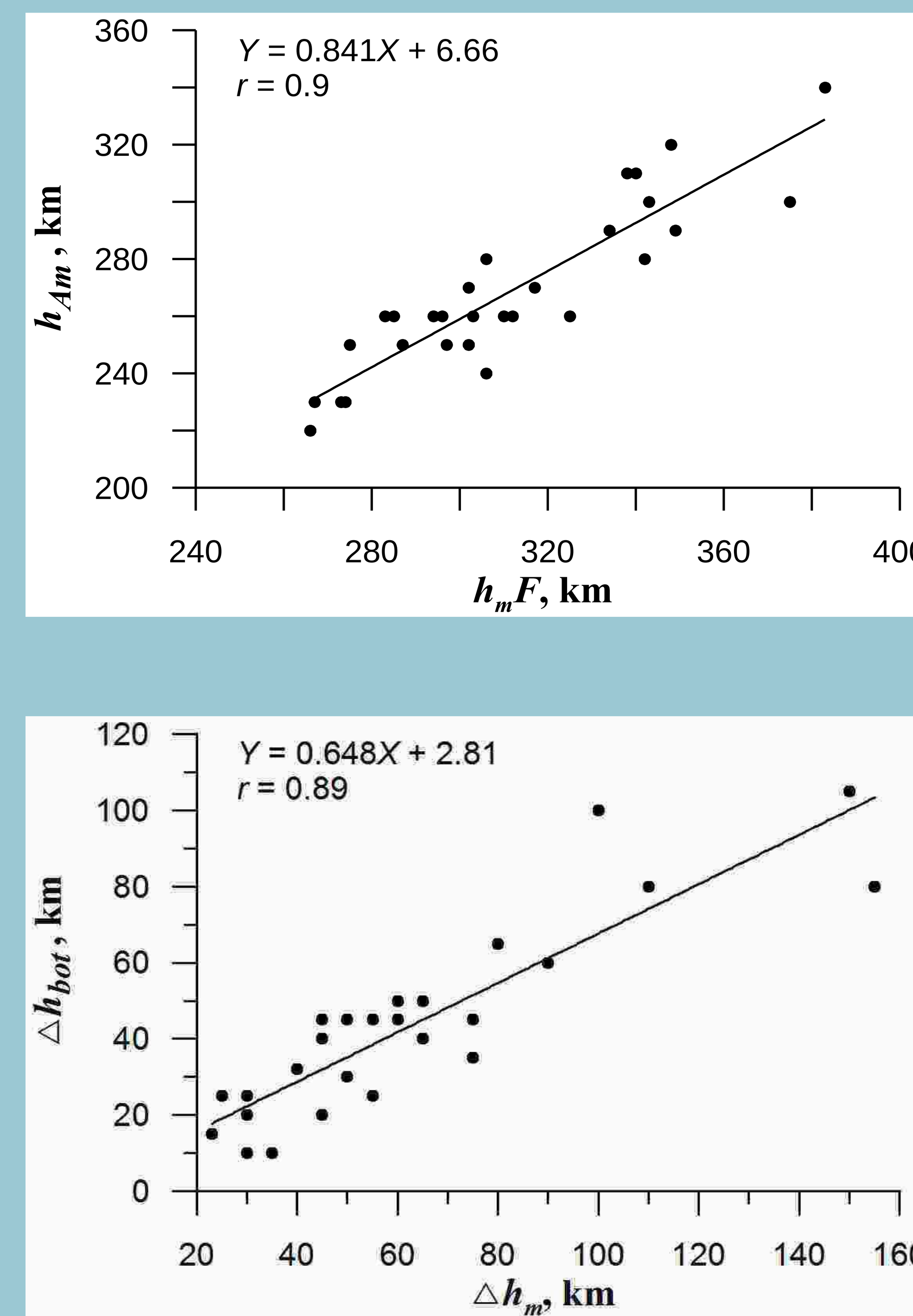

Figure 3. A scatter diagram between the heights h_{Am} and h_mF (a) and between Δh_{bot} and Δh_m (b) obtained from the entire array of data being analyzed (20 nights).

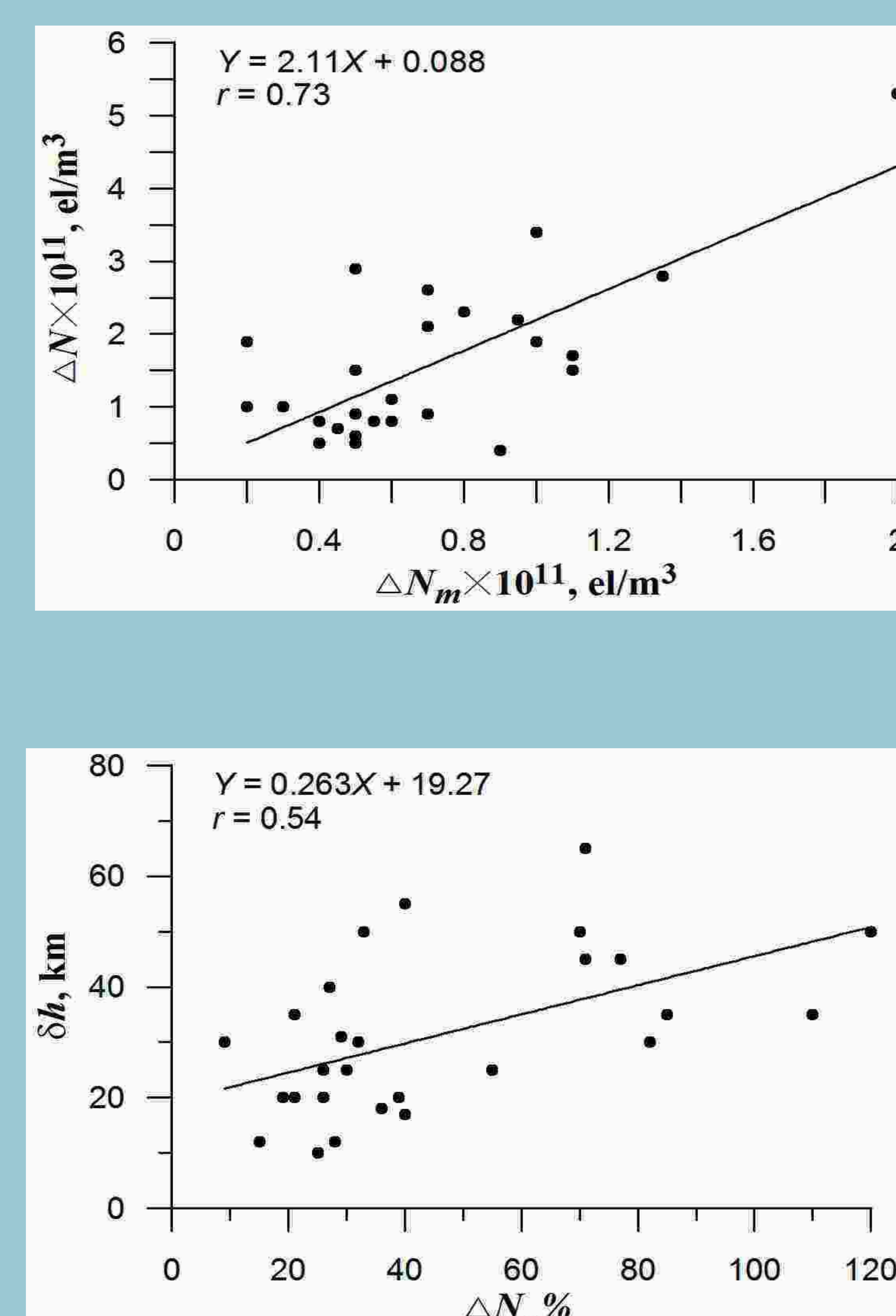

Figure 4. A scatter diagram between the enhancement amplitude in the maximum electron density layer ΔN_m and maximal enhancement amplitude ΔN (a) and between δh and ΔN_m% (b) obtained from the entire array of data being analyzed (20 nights).

discussed in Fig. 1 features are preserved during the formation of the enhancements in the other dates, attributable to the different seasons and years with different levels of solar activity. For a quantitative analysis of the parameters of nighttime enhancements we have selected for the period 20 nights characterized by low magnetic activity (Dst> -50 nT) and severe manifestations of nighttime enhancements. Figure 3 (upper panel) represents the scatterplot between the height h_{Am}, corresponding to the maximum enhancement amplitude and the height h_mF of the layer maximum. Interval of altitudes at which the maximum amplitudes were observed proved to be very broad. Calculated by least squares a regression line is depicted by the solid line. The expression for the line and the value of r = 0.9 the coefficient of correlation are shown in the upper part of the figure. The figure shows that the difference between h_{Am} and h_mF increases linearly with h_mF. If h_mF = 280 km difference is ~ 38 km to the h_mF = 380 km difference is ~ 54 km. According to Figure 1 (lower panel), it was observed that amplitude variations and h_mF and $h_{bot}F$ are not identical. To quantify their differences for the entire data set the scatter diagram was constructed between a value Δh_m that is a decrease of the layer maximum height in the period of N_m increase and Δh_{bot} that is a decrease of the layer base height at the same time interval (Figure 3, lower panel). The regression line allows to calculate that when the Δh_m from 30 km to 150 km Δh_{bot} varies from 22.3 km to 100.3 km.

Figure 4 (upper panel) is a scattering diagram between the amplitude of the electron density enhancement in the layer maximum ΔN_m and maximum amplitude ΔN at a fixed height. Calculated by the least squares a regression line is depicted by the solid lines. The figure shows that between these parameters there is a good correlation (r = 0.73). Changing ΔN_m from 0.4 · 1.6 · 10^{11} to 10^{11} el / m^3 mean value ΔN varies from 0.85 to 0.47 · 10^{11} el / m^3. This indicates that the amplitude of the enhancement in the layer maximum is about 2-3 times less than the maximum amplitude at a fixed height. Figure 4 (lower panel) shows the scattering diagram between the amount of reduction of the half-layer (δh) during ΔT, and the relative amplitude of the enhancement ΔN_m %. Calculated by the least squares regression line is shown solid. The figure shows that between these parameters there is a moderate correlation (r = 0.54). Low correlation between δh and ΔN_m%, apparently shows that the layer compression at nighttime contributes to enhancement, but does not completely define the magnitude of their amplitude.

3 Summary

A comparison of the behavior of the parameters of the F2-layer during nighttime electron density enhancements. Found quantitative relationships between parameters of enhancements amplitude in the maximum N_mF2 layer and at an altitude, characterized by the maximum rate of enhancements. Based on comparison of behavior in time parameters nighttime enhancements it was concluded that its characteristics are repeated ones described in [3] for several types of ionospheric plasma perturbations. These behaviors include the expansion and simultaneous lifting of the layer and then lowering it and at the same time compression, leading to the formation of the maximum value N_mF2 at the time of maximum compression. Thus, we extended nomenclature perturbation F2-layer parameters which, despite their different mechanisms generate, behave the same way.

References

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