

Sporadic plasma perturbations in the E region of the terrestrial ionosphere

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Goals of the investigations: 1) To present some results of statistical processing of vertical ionospheric sounding data obtained at a number of mid-latitude stations. 2) Report on the revealed features of the formation of sporadic heterogeneities of the E region of the ionosphere at mid-latitudes, during the periods around the winter solstice. 3) To present the results of probabilistic and altitude-frequency characteristics of such sporadic inhomogeneities. 4) To consider the influence of these sporadic inhomogeneities on propagation conditions of radio waves.

Sporadic Es-layer of the ionosphere. Sometimes (sporadically) in the ionosphere, at the heights of the E region (altitudes of 90 - 140 km), a very dense (more than 10^6 electrons/ions per cubic centimeter) layer appears capable of effectively reflecting radio waves of sufficiently high frequencies and with very little absorption. The E_s layer is usually very thin, several hundred meters, extended horizontally by hundreds of kilometers and are clouds of increased ionization of pancake-like form, consisting, as a rule, of long-lived metal ions, the time of its spreading in the presence of only ambipolar diffusion is tens of hours. During this time, the layer can shift horizontally due to neutral winds by several hundred kilometers. One of the main characteristic frequencies, determined from the ionogram for vertical sounding, is the screening frequency $f_b E_s$. As is currently accepted, it corresponds to the maximum ionization density in the sporadic layer, $f_b E_s \sim (N_{\max})^{1/2}$. Another characteristic parameter of the layer, determined from the ionograms, is the limiting frequency $f_o E_s$, at which the layer ceases to be reflective for the ordinary wave. As it turned out, this characteristic frequency, the limiting frequency $f_o E_s$, depends quite strongly on the fine structure of the electron concentration of the E_s layer (the spot and ionization island, stratification), and is determined by the turbulence of the plasma of the sporadic layer. Sporadic layers often have a fine structure horizontally and vertically. Small-scale turbulence can be characterized by a range of translucency ($f_o E_s - f_b E_s$). There were cases when for 2 - 5 minutes $f_o E_s$ changed by 1 - 2 MHz. The daily distribution of the probability (PE_s) of the formation of sporadic inhomogeneities in the E region of the mid-latitude ionosphere is significantly dependent on the season and slightly on the level of solar activity. In the pre-dawn time of the day (long before the local sunrise) the maximum occurrence of sporadic formations in the E region of the mid-latitude ionosphere was detected. The data of ground vertical radiosounding were used with a discreteness of 15 minutes. This maximum is most marked near the winter solstice (a specially developed procedure / method for averaging the experimental data has been applied).

The influence of sporadic Es layers on propagation conditions of radio waves. Through sporadic layers communication is provided for thousands of kilometers, or they can screen overlying areas, change the trajectory and characteristics of the transmitted signal. Knowledge of the behavior of the ionosphere ensures the reliability of the operation of radio communication lines and various radio systems, including navigation, satellite, telephone and other systems. In the presence of sporadic E_s layers, an additional ionization maximum appears in the ionosphere, respectively in the regions E and F, near which the radio waves can be reflected. Depending on the operating frequency, the angle of incidence of the radio signal and the state of the ionosphere, reflection may occur in one or another region of the ionosphere; In this case, different wave propagation paths are possible. It is established that in the presence of sporadic E_s layers, reception of radio waves is always accompanied by an increase in signal fading, i. e., a change in the level of the received signal in time, and this change is of an accidental nature. Signal fading is caused by scattering of radio waves by ionospheric irregularities and by interference of scattered waves. The interference of the ordinary and extraordinary components of the magneto-split wave also leads to fading. In addition to interference fading, polarization fading takes place.

Conclusions

1. As a result of statistical processing of vertical ground-based ionospheric sounding data obtained at a number of mid-latitude stations, a pre-dawn increase in the probability of sporadic irregularities in the E region of the ionosphere, during the periods around the winter solstice, was revealed.
2. Time variations of the altitude-frequency characteristics of sporadic inhomogeneities were studied. On their basis, it was concluded that there is a strong turbulence of the plasma in the E-region of the ionosphere in the pre-dawn period of time, near the winter solstice.
3. It was found that, in the pre-dawn period, the limiting frequency $f_o E_s$ of the layer E_s exceeds the critical frequency $f_o F_2$ of the regular F2 layer, as a result of which sporadic formations substantially change the propagation conditions of a radio wave in a wide frequency range, often completely screening the overlying regions of the ionosphere.

In the future, it is proposed to investigate in detail the causes of the increase in the probability of formation of sporadic formations in the E-region of the ionosphere in the pre-dawn period, near the winter solstice, using experimental data from other stations.