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EXPERIMENTAL INVESTIGATIONS OF NATURAL DISTURBANCES IN THE MIDDLE-LATITUDINAL IONOSPHERIC D-REGION

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There are presented experimental investigations, using the partial reflection technique, of natural disturbance effects on parameters of the middle-latitude D-region. Characteristics of the disturbances generated or enhanced in this ionospheric region are studied.

INTRODUCTION

Our investigations of natural disturbances of the middle-latitude ionospheric D-region were carried out on the basis of a retrospective analysis of the stored data obtained at the Kharkov State University using the partial reflection technique near Kharkov over 1983-1992 for different year seasons. The main facility-parameters are as follows: the operation frequencies, $F=2-4$ MHz, the duration of sounding pulses, $T_1=25$ msec, the effective pulse power, $P_G < 10$ MW.

RESULTS AND DISCUSSIONS

1. Effects of remote earthquakes.

There were analyzed more than 50 records (1-10 hrs) made over periods of the earthquakes with energy $E > 10^{11}$ J at the distances from the observation place of $R < (1-15) \cdot 10^3$ km. There were studied parameters of the D-region disturbances; taking account of results from different references, there was worked out a classification of the wave disturbances generated and propagating in the ionosphere: magnetohydrodynamic (MHD) with the propagation velocities of $V = 100$ km/s and the periods of $T < 1$ min, gyrotopic with $V = 10-50$ km/s and $T < 1$ min, electromagnetic with $V = 6-8$ km/s and $T = 3$ min, bulk with $V = 5-6$ km/s and $T = 3$ min, Rayleigh surface with $V = 3-4$ km/s and $T = 2-3$ min, slow MHD with $V = 1.7-2.6$ km/s and $T = 2$ min, inner gravitational waves with

$V = 0.4-1 \text{ km/s}$ and $T = 3-3.5 \text{ min}$.

Under $R < 1000 \text{ km}$, in the D-region there is observed a stable response to the earthquakes with $E > 10^{12} \text{ J}$; under $R > (3-10) \cdot 1000 \text{ km}$, the same is valid for those with $E > 10^{13} \text{ J}$. At the moment of a seismic shock, there was found an intensity increase of the low-frequency disturbance components at $F = (1-8) \cdot 10^{-3} \text{ Hz}$.

2. Sun bursts and magnetic storms.

15 events were analyzed. It has been found that during sudden ionospheric disturbances with the duration of $T < 30 \text{ min}$, as a result of a sharp X-radiation intensity increase, there are generated or enhanced acoustic-gravitational waves with periods $T < 5 \text{ min}$, which are attenuated in 20-25 min after the event.

During the magnetic storms and 10-12 days after them, there were recorded the higher-ionization layers with the electron density $N = (2-7) \cdot 100 \text{ cm}^{-3}$, at heights $h = 45-65 \text{ km}$. It has been found that such events correlate with charged-particle precipitation. At $h = 78-90 \text{ km}$ during a magnetic storm, N becomes 1.6-6 times larger (in winter for a constant solar zenith angle,) if compared with that under the quiet conditions.

3. Strong thunderstorms.

The number of the observation series over the thunderstorm periods was 22. We have established the following: 1) strong thunderstorms in the atmosphere may generate infrasonic acoustic waves with $F > 0.5 \text{ Hz}$, penetrating into the D-region with $V > 300 \text{ m/s}$ (vertical ones); 2) sometimes $N(h)$ at $h = 55-65 \text{ km}$ increases up to $N < 600 \text{ cm}^{-3}$, appearing to be conditioned by charged particles precipitating during the strong storms; 3) at $h > 70 \text{ km}$ one cannot observe significant (>30%) changes in the diurnal N-variation; 4) probability of arising sporadic layers increases 2-4 times.

4. Sun terminator.

The total number of the observation series at the moments of the passing morning and evening terminators was about 100 with approximately uniform seasonal distributions. It has been established that the Sun terminator in the D-region generates or enhances acoustic-gravitational waves with the periods of $2 < T < 40 \text{ min}$, $4 < T < 15 \text{ min}$ being the most probable. The wave-process dura-

tion was $T = 10-120$ min. It is shown that the D-region response to this disturbance source (both in the morning and in the evening) is not instantaneous. At least, sharp $N(h)$ -changes were not established. As a rule, the D-region electron density at the passage moment of the morning terminator is $N < (5-7) \cdot 100 \text{ cm}^{-3}$, being $N < (5-10) \cdot 100 \text{ cm}^{-3}$ in the evening.

Thus, there were obtained elements (namely: periods, times of development, duration, apparent velocities) for the empirical model of the ionospheric D-region disturbances caused by natural disturbances, moreover possible types of the waves responsible for a transfer of the disturbances have been studied.