METEOR MATTER INTERACTION WITH THE EARTH'S ATMOSPHERE AND THE IONOSPHERIC E-REGION STRUCTURE

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The exploration of the ionospheric E-region is a pressing problem both in the applied and fundamental studies. A lot of previous work was dedicated to the problem. However, up to now it remains unsolved. The present paper presents results of an investigation a) to estimate the meteor ionisation contribution to the night-time E-layer and influx; b) to study the phenomenon of intensive sporadic layer formation following cessation of meteor stream activity; and c) to access the role of metallic ions of meteor origin in the diurnal and seasonal variations in the occurrence probabilities of mid-latitude E_s.

Examination of ionosonde vertical probing data shows that in the most cases, the night-layer diurnal appearance and the maximum number of weak sporadic meteors observed on λ = 15-17 m wavelength coincide in time and occur at 6 a.m. local time. Using well-known data on ion formation rates from two different sources (CHASOVITIN and NESTEROV, 1975; and JOFFE and RUBTSOV, 1980), we evaluated the contribution of meteor matter, Lyman radiation and corpuscular particles to the electron concentration of the night E-region. The table shows ratios of equilibrium electron concentrations $N_{em}/N_{eL\alpha}$, $\nu_{em}/N_{eL\beta}$, N_{em}/N_{ep} (N_{em} - caused by meteors, $N_{eL\alpha}$, $N_{eL\beta}$ - by Lyman radiation, N_{ep} - by corpuscules) as a function of height.

h, km	$N_{em}/N_{eL\alpha}$	$N_{em}/N_{eL\beta}$	N_{em}/N_{ep}
90	0.43	20.0	20.0
95	1.75	16.6	16.6
100	3.33	3.33	2.22
105	7.55	2.22	2.66
110	13.6	3.00	4.80

It follows from the table that the ionization of the night E-layer is most probably caused by meteor particles.

The ionosonde vertical probing data also often shows a simultaneous appearance of several types of sporadic E (E_s). In these periods of maximum probability, the appearance of several types of E_s is 1.5 to 2.0 times more probable than in quiet periods. Meteor streams are not homogeneous in their structure. They have bodies of different density. It is clear that bodies of different density produce ionisation at various heights that, in its turn, may bring about meteor-induced ionisation at several height maxima. The simulation and analysis indicates that the inhomogeneous density structure of meteor streams might be responsible for the creation of the stratified structure of the sporadic E-layer.

When analysing vertical ionosphere probe data obtained in Dushanbe and Ashkhabad, it was found out that after stoppage of the active stage of the Lyrids and η-Aquarids some delay in the formation of intensive E_s with $f_oE_s \geq 4$ MHz is observed. Fig. 1 presents the variation of probability of E_s appearance in 1964 and 1971 for Dushanbe and in 1966 for Ashkhabad. The X-axis shows the dates and Y-axis gives the percentage of E_s appearance probability. The arrows show the dates of meteor streams maximum activity. It can be seen that a marked increase of the number of cases of E appearance with $f_oE_s \geq 4{,}0$MHz is really observed following 10-12 days after the stoppage of the meteor streams' active stage.

Now for the physical interpretation of the observed phenomenon. It is common knowledge that metallic ions of meteoric origin play an important part in the formation of narrow sporadic layers in mid-latitude ionosphere. According to the theory of wind shear, the maximum value of electron concentration in the E_s layer is determined by equillibrium concentration of metal ions of meteor origin. During the period of meteor streams activity the Earth's atmosphere receives a great number of meteor matter in the form of neutral atoms. Then these atoms, owing to change exchange with the atmspheric ions NO^+ and O^+_2 and photoionisation become ionized. Obviously, the active influence of meteor matter on the upper atmosphere brings about primary accumulation of these ions M^+. These species disappear mainly due to the reaction $M^+ + O_2 \rightarrow MO_2^+ + h\nu$. Proceeding from the data on effective periods of meteor ion life times and reaction constants (MAC-EWAN M. and PHILLIPS, 1978) the value of time delay $T \simeq 9$ days was obtained which is in keeping with the observations.

The influx of metal ions into the Earth's atmosphere is due mainly to sporadic meteor matter and shows diurnal and seasonal variations. Of interest here is the problem of influence of such variations on behaviour of metal ions. If N_1 and N_2 are the atomic and ionic concentrations, the differential equation of these values within the framework of equilibrium photochemistry are as follows:

$$\frac{dN_1}{dt} = Q_a - \frac{N_1}{\tau_1} \; ; \; \frac{dN_2}{dt} = \frac{N_1}{\tau_1} - \frac{N_2}{\tau_2} \tag{1}$$

where Q_a is the function of atoms of meteor origin formation; τ_1, τ_2 are effective periods of metal atoms and ions respectively. The solution of these equations with a model distribution Q_a shows that the diurnal variation of metal ions is of extreme character. The time of maximum ionization for different kinds of ions is different. Since f_oE_s is determined by the maximum value of electron concentration which, according to the wind shear theory, depends in turn on the distribution of metal ions variations cannot be ruled out.

Considering the problem of seasonal behavior of N_1 and N_2 values we can assume that $dN_1/dt = \phi$ and $dN_2/dt = \phi$ and thus

$$N_1 = Q_a \tau_1 \; ; \quad N_2 = Q_a \tau_2 \tag{2}$$

Consequently, the equilibrium of metal ions concentration depends on only the seasonal variations of the number of sporadic meteors. Fig. 2 shows the seasonal variations of the monthly average number of appearances of E_s with $f_oE_s \geq 5{,}0$ MHz as revealed by vertical probing over Tajikistan. The variations of meteor numbers are also given there. It can be seen that

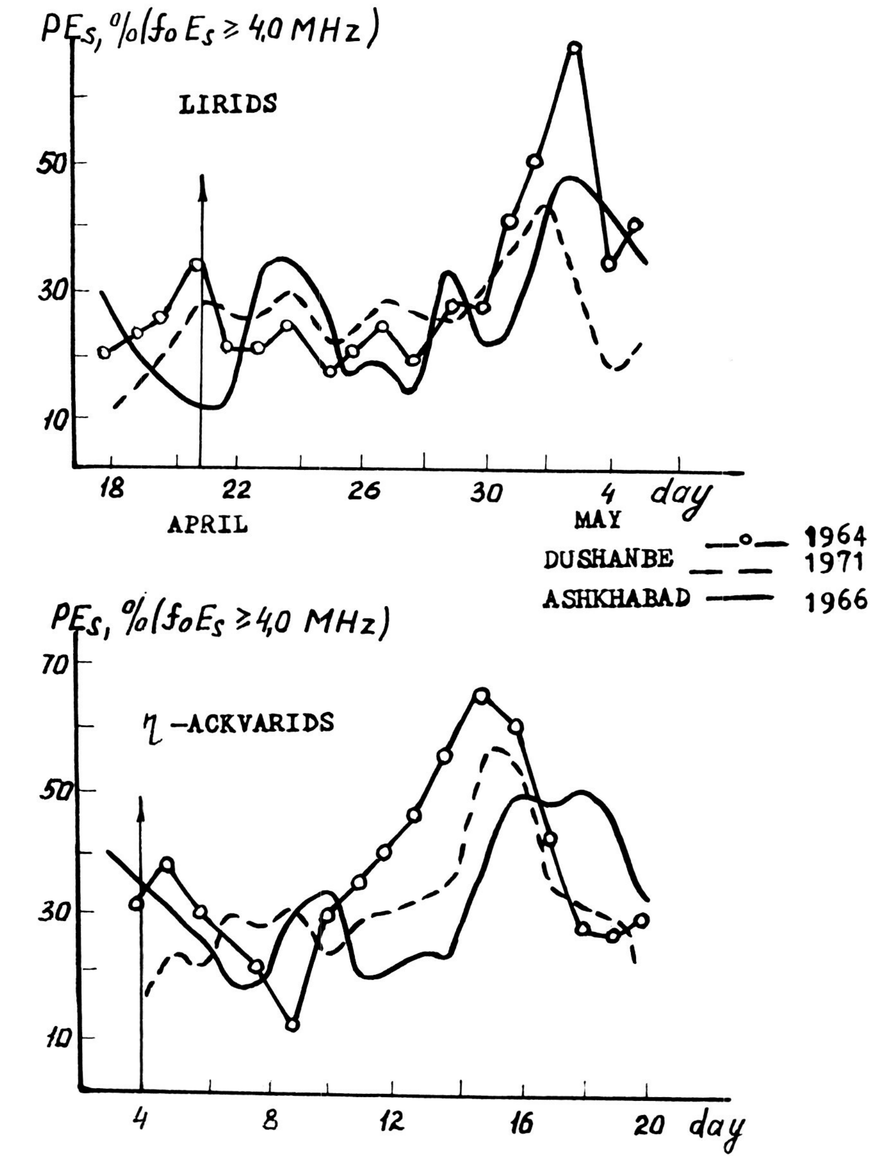

Fig. 1 The variation of the probability of occurrence of E_s in 1964 and 1971 for Dushanbe, and in 1966 for Ashkhabad, and the possible connection to the Lyrid and η Aquarid meteor showers.

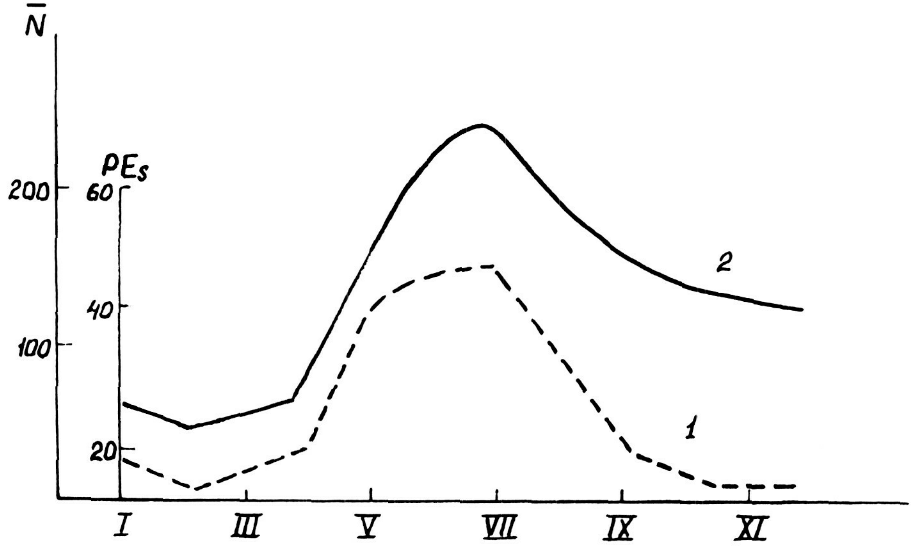

Fig. 2 The seasonal variation of the monthly average number of occurrences of E_s with $f_oE_s \geq 5.0$ MHz from vertical incidence soundings over Tajicistan (1), together with the daily average hourly radio meteor count (2).

these values are well correlated, and such correlation becomes quite understandable if we take into account the fact that the probability of mid-latitude E_s layer formation is determined by the metal ions concentration whose seasonal change depends on the seasonal influx of sporadic meteor matter into the Earth's atmosphere.

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