Action on Cosmic Rays on Latent Energy of the Atmosphere

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Abstract

It is shown that cosmic rays (CR) can influence the aggregate transitions of water in free atmosphere through the air ionization and then so that influence the changes of atmospheric parameters. In this case the value of effect over diffirent regions can differ by a factor of 2-3 times (in Moscow it is ≈ 6 mb, in Yakutsk ≈ 1,5 mb, in Apatity ≈ 3 mb

The water at the atmosphere represents in the form of three components: a) in the form of separate molecules; b) in the form of clusters and compounds representing the heteronuclear particles and microscopic aerosols (many of them can serve as nuclei of condensation and sublimation of the water steam and also influence the passing of radiant energy of the Sun). Small uncharged water drops can't exist in the free atmosphere [1]. As a result of these processes the portion of the water consisting in the atmosphere in the form of isolated molecules will change in sufficiently wide ranges which will lead to the changes of the ground pressure. For the noticeable effect from the release of latent energy on vast territories of the planet the times several days are required. So in order to study the action of cosmic rays on the ground pressure at latitudes significantly remote from the auroral zone but at which the Forbush-effects are noticeably manifested, two points of Moscow and Yakutsk have been chosen. They are essentially remote in longitude but they are within the middle latitudes. For comparison such a point has been taken near the auroral zone, it is Apatity. The duration of "response" in the ground pressure from cosmic rays is expected in the interval of ≈ 5÷27 days. Fig.1 presents the temporal change of the ground pressure in Moscow from January 1, 1988 to December 31, 1997. The first day is taken for the unit. From Fig.1 (the upper graph) it is seen that the largest fluctuations of the ground pressure in Moscow are in the interval up to ≈ 5 days and in the seasonal change. If we suppose that the expected effect amplitude is ≈ 1 mb then as sun from this plot, the fluctuations with periods less than 5 days are greater by a factor of 10, approximately, and a seasonal change is greater by a factor of 20 than the expected effect. It is better seen on the lower plot of Fig.1 which

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presents the 5-day trend from the upper plot data shifted by -50 mb (the shift has been carried out only in order to represent both plots in one Figure only). Thin vertical lines in Fig.1 correspond to the time moments of Forbush-decrease onsets by the Yakutsk neutron monitor data. After almost each such line in the interval of 5-27 days the rise of pressure in the form of burst of ≈ 10 day duration takes place. For Moscow such changes are shown in Fig.2 (the third plot from above). The material for the Yakutsk (lower plot) and Apatity (the second plot from above) stations has been treated analogously. The upper plot in Fig.2 is the mean average Forbush-effect obtained by using the superposed epoch technique near the reper lines normalized to the 5700 reading. As sun from Fig.2, the value of changes of the ground pressure at various different longitudes and latitudes is different: the least value is in Yakutsk ($\approx +\ 1.5$ mb) and the most is in Moscow ($\approx +\ 6$ mb). Near the auroral zone at longitudes of eastern Europe the effect is $\approx +\ 3$ mb. In spite of large differences of the effect value, the general character of the temporal change and position of its maximum remains to be invariable. The maximum is $\approx 13 \div 14$ days behind the onset of Forbush-effect. The change of pressure begins $\approx$ 3-5 days earlier from the main phase onset. It is apparently caused by the fact that, on the average, the temporal change of cosmic rays variations begins much earlier ($\approx 7 \div 10$ days) than the onset of the main phase of Forbush-effect (su. Fig.2, upper plot). Thus, as the experiment shows after the Forbush-decrease on the $\approx$ 13-14 days the increase of the ground pressure by a factor of $\approx 1{,}5 \div 6$ mb takes place almost on the whole area of Russia. Really, it is necessary to study two possibilities. Below we'll try to study both possibilities.

The cosmic rays in ionization of neutrol components of the atmosphere and in the ion-molecular cycles (the total number of such processes is more than 22 [2]) form ions O_2^+ and NO^+. The particles O_2^+ and NO^+, in their turn, initiate the reactions with the formation of heavy ions (the total number of such reactions is ≈ 12 [3]). One of the product of such reactions is clusters of hydro $H_3O^+(H_2O)$ and $H_3O^+(H_2O)_2$. The hydro cluster is very hygroscopic. In the upper layers of troposphere where mainly the cosmic ray absorption takes place (at latitudes $\approx$ 6-8 km), it is equal to $\approx 10^{11} \div 10^{12}$ particles/cm^3. The particle concentration in the upper edge of clouds is of the order of 10 particles/cm^3 [4]. This value is less by a factor $10 \div 100$ milliards than the number of NH_3 and HNO_3 particles which support the processes (1). So even if the performance coefficient of aerosol generation processes by cosmic rays will be only $10^{-10} \div 10^{-11}$ then in this case the number of condensation nuclei will be the value comparable with their background content. All of it indicates to the fact that in principle, the cosmic rays can influence the change of the ground pressure and, on the whole, any atmosphere parameters through the processes of formation of hygroscopic aerosols.

The complexity is caused by the fact that in this case in large volumes of the atmosphere substance is evolved and high energy ($\approx 800 \div 900$ cal/g [5]) is used which is transformed into dynamic processes and passing the radiant solar energy. The pressure in the atmosphere is represented by a sum of partial pressures of different gases and microscopic aerosol (P). For our task let's represent it in the form of a sum of dry air pressure (P_c), water pressure existing in the form of molecules (P_m) and pressure formed by microscopic aerosols (P_a). Let's consider two extreme cases when water exists in the form of separate molecules, then the atmospheric pressure will be: $P_1 = P_c + P_m$. If water exists in the form of microscopic aerosols then it will be: $P_2 = P_c + P_a$. The expected maximum of pressure change effect will be $\Delta P = P_1 - P_2 = (n_m - n_a)kT$, where n_m and n_a is a concentration of water molecules and water aerosols existing in free atmosphere. Because $n_m > n_a$, then it is reduced to the value $\Delta P \approx n_m kT$. To estimate ΔP let's use the annual average values of water content at 5 and 9 km heights at 50^o latitudes. They are equal to $6.14 \cdot 10^{-6}$ and 10^{-6} g/cm^3 that corresponds to concentrations of water molecules $2.04 \cdot 10^{17}$ and $3.34 \cdot 10^{16}$ particles/cm^3. From these data of water content, during its transformation into separate molecules at temperature T = 250÷300 K, the additional pressure at 5 km height (7.04÷8.45) mb, at 9 km height (1.15÷1.38) mb is created. In the interval of 5÷9 km ≈ 50% of GCR is absorbed. In the same interval the aggregate transition from microscopic water drops into molecules can change the pressure, an the average, by a factor of ≈ 4.8 mb.

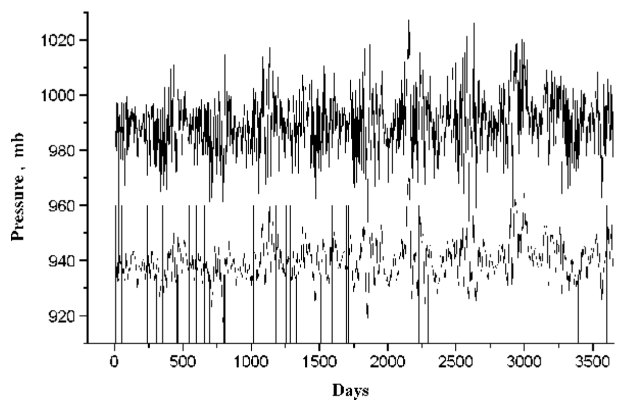

Fig. 1. The temporal change of ground pressure in Moscow from January 1, 1988 to December 31, 1997. The lower plot is a 5-day trend from data of the upper plot shifted by 5 mb. The onsets of Forbush-decrease main phase are marked by lines.

Forbush-decreases causes the increase of pressure by 1÷6 mb. In this case, the value of effect over various regions can differ by a factor of 2-3 (in Moscow is ∼ 6 mb, in Yakutsk is 1,5 mb, in Apatity is 3 mb). At sufficiently large difference by an amplitude the form of temporal change of pressure has no essential differences. At all three stations the effect maximum is on the 13-14 days from the onset of Forbush-effect main phase. Its mean duration at all stations is approximately

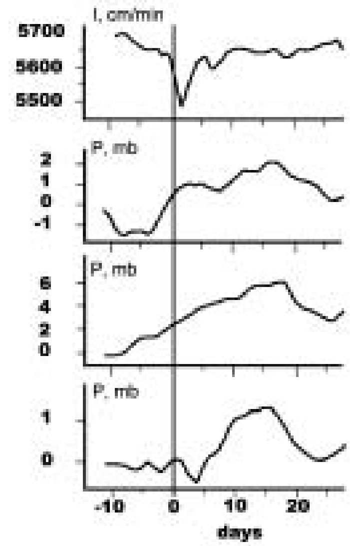

Fig. 2. The temporal change of CR and ground pressure in Apatity, Moscow and Yakutsk averaged near reper moments.

equal to 10÷15 days. The air ionization at the expense of GCR can considerably influence the processes where the generation of water aerosols takes place. In the atmosphere the physical-chemical conditions always exist in which the changes of the ground pressure by approximately (1÷6) mb will take place. In this case, in the warmer and wetter atmosphere such changes can be stronger by a factor of 2-3.

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