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The Impact of Cosmic Dust on the Earth's Climate

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Abstract—Flows of material particles, viz., cosmic rays and cosmic dust, are perpetually coming from space into the Earth's atmosphere; these are particles sized from 0.001 μm to dozens or hundreds of μm. The paper shows that cosmic rays influence the main parameters of the atmosphere's electricity, and cosmic dust influences global cloudiness, albedo and the Earth's climate.

Key words: cosmic dust, cosmic rays, global climate of the Earth, spherical albedo of the Earth.

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INTRODUCTION

Cosmic rays were discovered about 100 years ago, while cosmic dust has been observed by people since antiquity. The meteor traces observed in the Earth's atmosphere are caused by the biggest cosmic dust particles. Although people have known about cosmic rays and cosmic dust for ages, it is only in the recent decades that they started to explore their impacts on the Earth's atmosphere.

The paper briefly presents the research outcomes on cosmic ray behavior in the atmosphere and their influence on the atmosphere electricity. It also summarizes research outcomes on how the cosmic dust coming into the atmosphere from the space affects the Earth climate.

COSMIC RAYS AND THEIR IMPACT ON THE ATMOSPHERE

Cosmic rays are flows of charged particles of high energies (from ~10^5 to ~10^{20} eV) that are mainly isotropically falling from cosmic space to the outer fringe of the Earth's atmosphere (primary radiation). The flow of this radiation is approximately 1 particle per sq. cm/sec. While penetrating the atmosphere, these particles collide with air atoms to form secondary radiation. One usually understands under cosmic rays both primary and secondary radiation.

In the Earth's atmosphere cosmic rays develop nuclear and electron-photon components. The latter, being the most intense, play a critical role in atmospheric processes. They conduct ionization, dissociation, and excitation of air molecules (atoms). Most of the impact of cosmic rays on the atmosphere is due to air ionization.

Cosmic rays are the major atmosphere ionizer at the height range from 0 to 60 km. At the same time, they produce the so-called columnar ionization, i.e., ions and electrons are distributed along the trace left by the ionizing particle. During the first 100 microseconds the trace's width is no more than 0.1 mm. With time, the ionized columns grow in width and thus produce general air ionization.

Due to the ionization of air, cosmic rays play a major role in the atmosphere's electricity. They provide the atmosphere's electric conductivity in the height range from 0 to 60 km. Without them the so-called global electric current circuit would not work. Neither would a negative electric charge of about 600000 coulombs be formed on the Earth's surface.

By ionizing the atmosphere, cosmic rays play a major role in shaping thunderstorm clouds. By producing columnar ionization, they participate in the formation of stepped and swept leader strokes. Linear lightning charges pass mostly along CR-ionized traces.

Some results of cosmic ray research in the Earth's atmosphere are presented in [1, 2]. Research results on the role of cosmic rays in atmospheric electricity and the physics of thunderstorm clouds are presented in [3–5].

Thunderstorm clouds are the electric generator of the global current circuit. About 2000 thunderstorms are simultaneously growing on our planet at any time. They fuel the global electric circuit with a current of about 2000 amperes. While the global current circuit is working, the negative charge accumulated by lightning

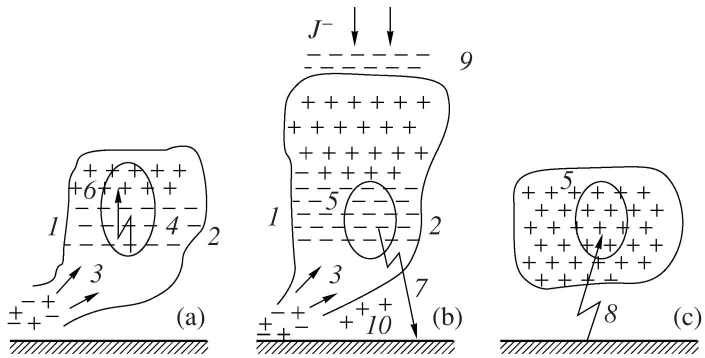

Fig. 1. Scheme of initiation, development (maturity), and decay of a thunderstorm cloud a, cloud initiation phase; b, cloud maturity phase; c, cloud decay; *J*, negative ions current from the ionosphere to the top of the cloud; 1, warm front; 2, cold front; 3, upward moist air flows; 4, 5, giant air showers formed by particles with $E > 10^{13}$ eV; 6, discharges inside the cloud; 7, downward lightning discharges; 8, upward lightning discharges; 9, negative charge at the top of the cloud; 10, positive charge at the bottom of the cloud.

strokes on the Earth's surface is partially neutralized by the global positive current flowing from the atmosphere onto the Earth's surface.

The work in [5] describes the physical mechanism of thunderstorm cloud formation, where cosmic rays play a key role. Thunderstorm cloud development is usually divided into three stages: initiation, development (maturity), and decay (Fig. 1). The initiation stage is characterized by the presence of sufficiently powerful upward flows of ionized warm moist air and the occurrence of the first lightning strokes. The lightning strokes mostly pass along CR-ionized traces. The beginnings of the lightning discharges initiate giant air showers (GAS). GAS are a powerful flow of secondary charged particles in the Earth's atmosphere, which is formed by cosmic ray particles of super-high energy ($E > 10^{15}$ eV). At the maturity stage of a thunderstorm cloud, there is intensification of its electric activity, internal upward flows, and moisture content. At the decay stage, upward air currents are observed to fade away, electric activity to decrease and precipitation to occur.

COSMIC DUST IN THE EARTH'S ATMOSPHERE

During its annual revolution around the Sun, the Earth is moving inside the zodiacal dust cloud. This cloud is located between the Sun and Mars' orbit, and concentrated in the ecliptic plane. Comets are the major supplier of dust to this cloud. When approaching the Sun at a distance less than 3–4 AU, they develop tails, i.e., throw off frozen-over "coats" of dust and gas. The dust-scattered sunlight is called zodiacal light.

During the Earth's orbital travel inside the zodiac cloud and under the action of the gravity forces, cosmic dust comes to the Earth's atmosphere. The biggest dust particles are destroyed when colliding with the atmosphere to form meteor traces.

The cosmic dust coming into the atmosphere gradually falls onto the Earth's surface. According to different observations, the quantity of the falling dust is within the limits: from ~10^2 tons per day (according to satellite observations, which do not record the smallest dust particles) to ~10^4 tons per day (by the observations of balloons, and from sea and ice sediments, which characterize the total quantity of the dust) [6, 7].

The cosmic dust particles contain big amounts of ferrum, magnesium, sulfur, aluminum, calcium, and natrium. The particles containing atoms of magnesium, sulfur, and natrium are effective condensation nuclei of the atmosphere water vapor. Cloud droplets are formed on these particles.

The more cosmic dust comes to the Earth atmosphere, the more droplets are formed and the thicker is the Earth's cloud cover. The clouds disperse the Sun's radiation back into the cosmic space. Therefore, the more cosmic dust that comes to the Earth's atmosphere and reaches the planet's surface, the less is the Sun's radiation flow. This results in climatic cooling.

IMPACT OF COSMIC DUST ON THE EARTH'S CLIMATE

The quantity of cosmic dust coming to the Earth's atmosphere depends on the mutual position of the planets, whose gravity field affects the comets' movement. Depending on their position, the number of comets occurring in the part of the zodiacal cloud penetrated by the Earth's orbit, is changing with time. Therefore, variations of cosmic dust and the Earth's climate must show periodicities characteristic of the planets' mutual positions. The periodicities in the positions of various planet pairs can be accurately calculated, since their orbits are known with precision.

To determine the temporal periodicities in the Earth's global climate changes, we used the temperature data of the global weather station network for the period 1880–2007. Spectral analysis of these data has

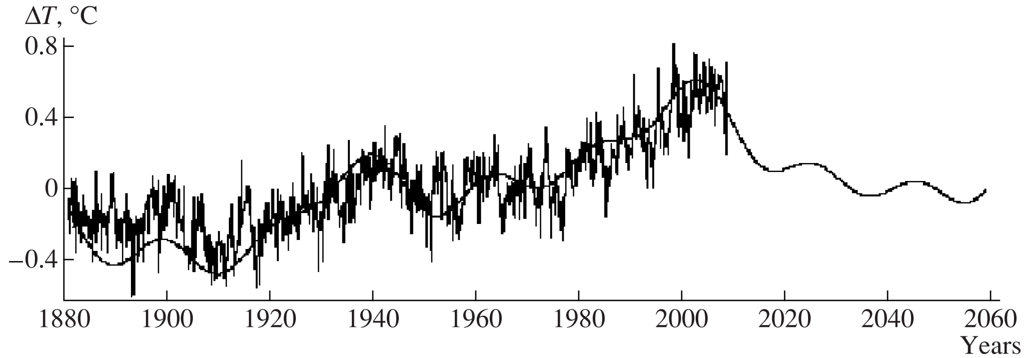

Fig. 2. Forecast for the Earth's climate change for the nearest 50 years. Average monthly values of global surface temperatures and sum (smooth curve) of the main (four) harmonics calculated until 2050.

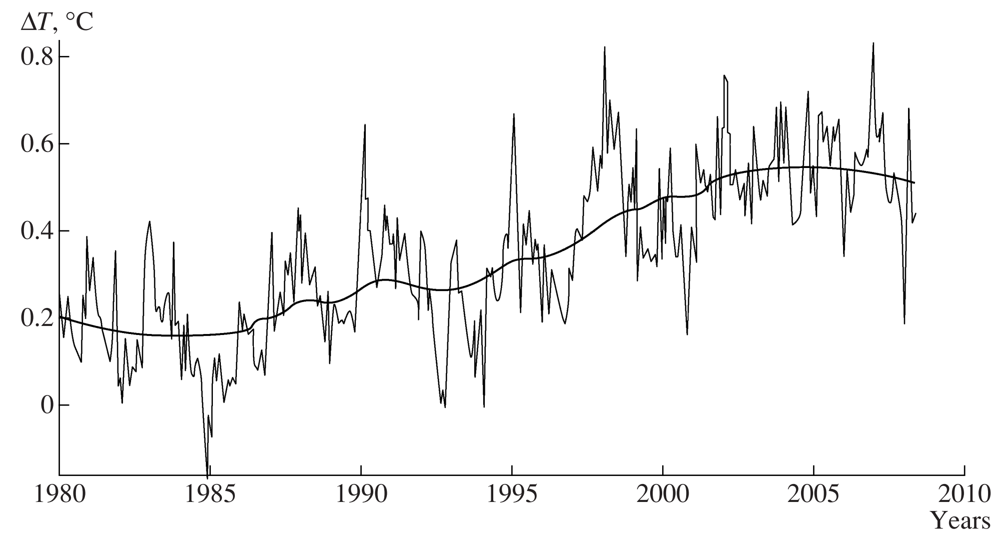

Fig. 3. Variations in the global surface temperatures in the recent years. Smooth curve, the data smoothed with a sliding second-degree polynomial by 150 points.

shown them to have a line spectrum with major periods of 195.9; 64.5; 33.1, and 21.0 years. They are in correspondence with the periods in the positioning of the following planet pairs: 197.9 years, (Neptune–Pluto); 62.7 years (Uranus–Pluto); 33.4 years, (Saturn–Pluto); and 20.7 years, (Jupiter–Uranus). Divergence between these two period series is within 1–3%.

The periodicities found in the temperature data were used to predict changes in the Earth's global climate for the next 50 years. Our forecast is presented in Fig. 2. It shows the average monthly temperature data of the global weather station network for the period from 1880 to 2007 and a smooth curve built by the sum of the above-mentioned four spectral lines found in these data. These lines were computed with respect to their calculated amplitudes, periods, and phases. The aggregate curve was prolonged by the time period of ~50 years. The figure shows that in the nearest 50 years there should be a global climatic cooling. This conclusion contradicts the forecasts on anthropogenic climate warming in the future.

Observations show that warming has ceased since 1998, the temperature has stopped rising, and a slight cooling has been in place. Studies on the impact of cosmic dust on the Earth climate have been published in [8, 9].

Figure 3 shows the climate change taking place in the recent years. For a clearer understanding of the process dynamics, the figure includes a curve smoothed with a sliding second-degree polynomial by 150 average monthly values. These data show that the climate change of the 20th century has stopped.

CONCLUSION

Material particles coming to the Earth atmosphere from the space, viz., cosmic rays and cosmic dust, affect not only atmospheric processes, but also all the life on the planet. They cause not only slow changes in the Earth's climate, but also short-time anomalous phenomena, first of all, thunderstorms, which always accompany hurricanes, strong gales, and typhoons.

We have shown that in the nearest 50 years there should be a global climatic cooling, rather than the warming predicted by the hypothesis of anthropogenic impacts on the Earth's climate.

To forecast climate changes one should monitor meteor flows and zodiacal light.

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