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Studies of the Influence of Galactic Cosmic Rays on the Cloud Cover of the Earth. Review of Research in Recent Decades

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ABSTRACT

A review of scientific studies of the existence of the influence of galactic cosmic rays on cloudiness on Earth and, accordingly, on climatic fluctuations is given. Corresponding illustrations are presented. Describes the work on this topic, carried out in the international center CERN (project "CLOUD"). The article examines the research of the last decades.
Key Words: *Galactic cosmic rays, cloud cover, temperature anomaly, global temperature.*

It is known that clouds form in the troposphere, under different conditions of distribution of moisture, temperature, aerosols. Cosmic rays have a definite influence on these parameters [1]. Consequently, cloud cover caused by changes in cosmic factors may affect the radiation balance of the Earth's surface and, consequently, climate change.

In the last decade of the twentieth century, during a satellite observation led by Henry Svensmark, Danish scientists discovered that cloudy areas change with changes in the intensity of cosmic rays. Svensmark put forward a hypothesis that cosmic rays contribute to the development of low cloud cover and thus influence the Earth's climate. He later used a special camera to experimentally prove that cosmic rays ionize water vapor molecules, thereby ensuring the formation of cloud droplets. According to his theory, the sun's magnetic field (especially during periods of solar activity) deflects galactic cosmic rays and lowers the ionization potential of clouds. Therefore, the increased magnetic field of the sun can indirectly reduce the Earth's albedo and cause climate warming [2].

The following four conditions must be met to prove the validity of Svensmark's theory:

1. The magnetic field of the sun should have a long-term positive trend of change;
2. The flow of galactic cosmic rays should have a long-term negative trend;
3. Cosmic rays should intensively ionize low-tier clouds;
4. Low cloud cover should have a long-term negative trend.

Studies have shown that neither the magnetic field nor its other characteristics of the sun have changed significantly in the last 30 years [3]. Observations of cosmic ray fluxes have also shown that no significant change has been observed since the mid-twentieth century. According to Benestad [4], galactic cosmic rays undergo a change, but not in the direction that explained the increase in temperature on Earth (Fig. 1). According to studies by American scientist Richard Meweldt [5], the intensity of cosmic rays has increased by 19% over the last 50 years.

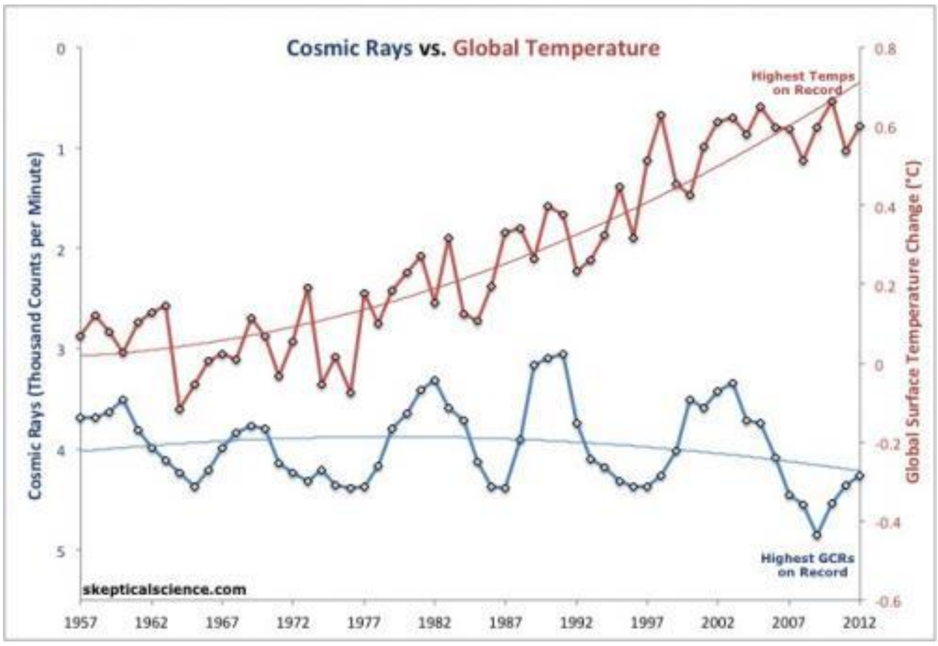

Fig. 1. Comparison of average annual values of galactic rays taken from the Neutron Monitor database (bottom chart) with average annual global temperature data (top chart) NOAA NCD.

GCK record values were observed, which should have caused an increase in cloudiness and cooling, but 2009 and 2010 were the hottest (NASA GISS)

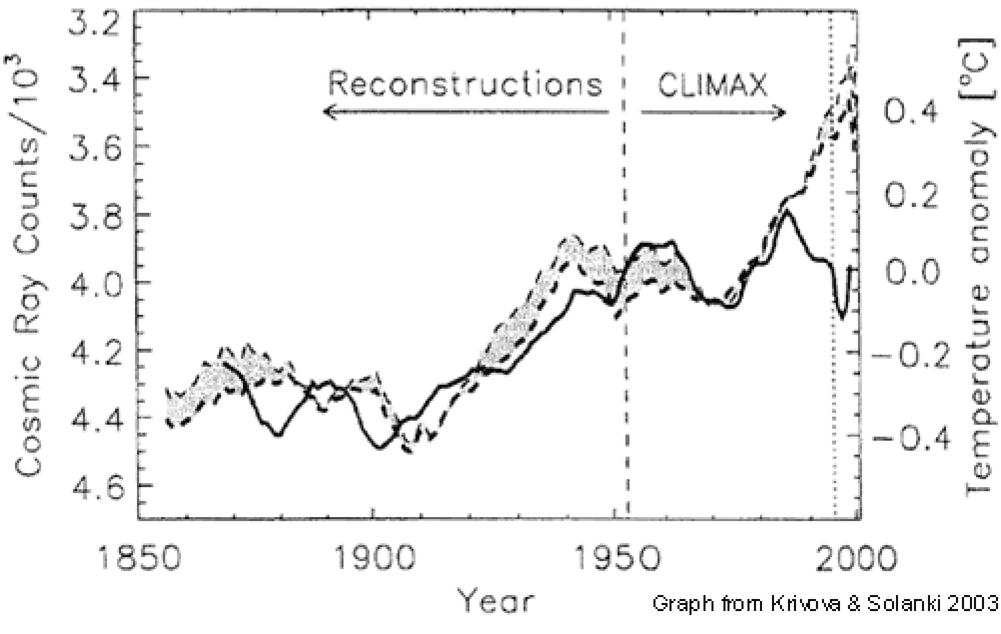

Fig. 2. Comparison of cosmic radiation (whole line) recovered before 1952 and observed after 1952 with global temperature (point) [6].

The flux of cosmic rays varies almost uniformly with respect to temperature between 1970 and 1985 (Fig. 2), although by 2000 the course of these two parameters is quite different from each other and does not allow us to prove that the cause of the 15% increase in temperature is cosmic rays. In order for the clouds to be successfully sown with GCR, the following must be performed:

GCR should cause the formation of aerosols; these newly formed aerosols must be large enough to form condensation nuclei; condensation nuclei must form clouds intensively.

Fulfillment of the first condition is doubtful. Relevant studies are conducted at CERN. Pierce and Adams [6] used a model with online microphysics to estimate the growth rate of ionized aerosols and found that the growth rate is very small and cannot play a significant role in cloud formation, and therefore in climate change. Numerous studies [7-11] have shown that no statistically significant correlation was found between the galactic cosmic rays and the four characteristics of the cloud.

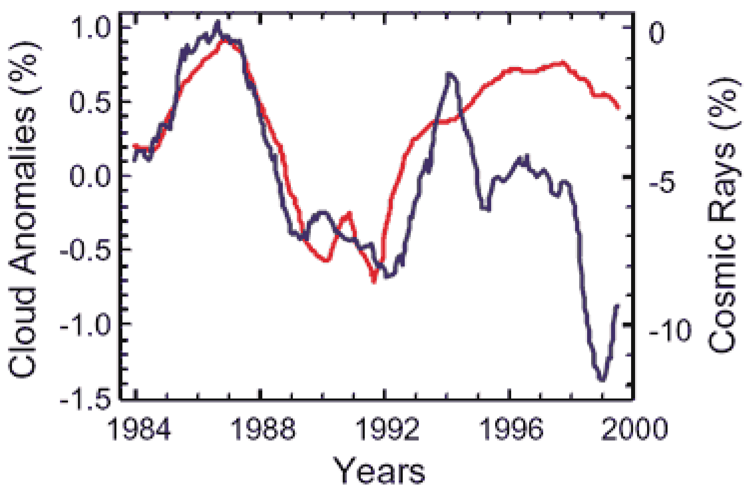

Fig. 3. Comparing the lower tier cloudiness (lower curve) and the intensity of the galactic cosmic rays (upper curve).

According to Fig. 3, the correlation between cosmic radiation and low tier cloudiness existed only until 1991, after which the picture was reversed, cloudiness is 6 months behind cosmic radiation, while cloud formation occurs in a few days.

Analysis of satellite and other terrestrial observations has shown that there are large differences in the mean time period between low-lying cloudiness and total cloudiness, although artefacts are also present. Observed low-cloud cover averages suspicion over the average ocean around the world, as cloud cover is fairly high and reduced solar energy absorption between 1952 and 1997, according to these data. This fact must have led to a drop in global temperature on Earth, which is not true.

Sloel and Wolfendal [10] studied the effects of cosmic rays on the climate over the last billion years and found that variations in galactic cosmic rays were small and could not have a significant impact on Earth's climate.

In addition to the papers mentioned above, there are many other papers that prove that at the turn of the last centuries, the correlation between cosmic rays and the cloud on Earth was broken. There are relatively few papers that cite the probable causes of this event. One such paper is presented by a group of scientists from the Joffe Institute of Physics and Technology in St. Petersburg. The above studies were performed within the framework of the international project "Satellite Climatology". This paper states:

„The question of cloud-GCR links remains controversial and requires new studies, both experimental and theoretical, to evaluate a real contribution of galactic cosmic rays to solar activity influence on the Earth’s climate [12]. The data presented in this chapter show that possible links between clouds and GCR variations on the decadal and longer time scales could involve not only direct (microphysical) effects, but mostly indirect ones mediated by circulation changes. This should be taken into account when considering long-term GCR effects on the cloudiness state.

The stratospheric polar vortex plays an important role in the formation of long-term impacts GCR on cloudiness at mid-latitudes (30º-60º). This hurricane controls the confluence of the stratosphere and the troposphere, which contributes to the GCS influencing extratropical cyclonic activity and, consequently, cloudiness under strong hurricane conditions.

This may explain the high correlations between GCR and cloud cover in the 1980s and 1990s, when there was a strong hurricane period.

The sharp weakening of the polar vortex in 2000 in both the northern and southern hemispheres changed the nature of the GCR impact on cyclone evolution and led to the disappearance of the correlation between GCR and "cloud cover".

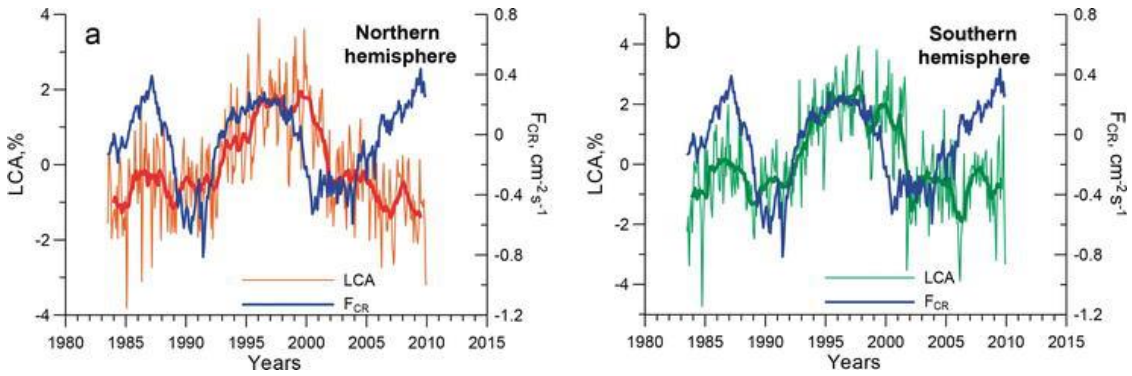

Fig. 4. Temporal variations of the monthly values of cloudiness (LCA) and GCR (FCR) in the northern (a) and southern (b) hemispheres. A thick line shows the 12-month values of cloudiness.

An interesting opinion was published by Kh. Abdusamatov (ГАА (Пулково) РАН), which follows, he writes [13], that the so-called The Sversmark hypothesis does not take into account the variations of nearly 200 years of solar radiation, and the fact that an increase in GCS flux at a large minimum of solar activity causes cloud formation and heat energy to be reflected back into space. Because of this, the Earth's heat balance takes on negative values, i.e. the climate cools down. The authors of the hypothesis do not take into account the variability of physical processes in the atmosphere - increasing reflection and absorption of heat energy from the Earth's surface, reflection of solar radiation from the Earth's surface, narrowing of atmospheric transparency windows and enhancing the thermal effect. These processes compensate for the cooling.

According to Abdusamatov and his group, the difference in the average global energy balance between Earth and space during a 2% increase or decrease in low cloud cover is almost zero: E1-E0≈0 The potential increase in cloud cover will practically not cause a change in the average global energy balance between Earth and space, nor will it affect climate change. The potential increase in cloud cover will have virtually no change in the average global energy balance between Earth and space, nor will it affect climate change.

As you know, the grandiose CLOUD project is being carried out at CERN. For scientific research, the project uses a super clean chamber made of super pure materials, in which real atmospheric processes are simulated - the growth of aerosol particles and their transformation into cloud droplets. Atmospheric parameters are monitored - gas concentration, ultraviolet radiation, cosmic ray intensity measured by a proton synchrotron [14].

Despite the fact that aerosol processes are not well understood, from a climatic point of view, it is possible to assume that 50% of their amount turns into cloud droplets.

Specialists in aerosols and elementary particle physics from 22 research institutes, both in Europe and the United States, are working on the project.

The data are processed by combining statistics and optimized software, in which elementary particle physics plays a leading role compared to climate models.

The main goal of the project is to investigate the impact of cosmic rays on climate and cloud cover. The great uncertainty is not the study of greenhouse gases, but the understanding of how much the number of aerosols and clouds has increased as a result of human action since the beginning of the industrialization period. This raises the question - what part of aerosols is compensated by greenhouse gases? Numerous experiments are aimed at elucidating the role of aerosols in anthropogenic climate change.

Experiments are carried out under different ionization conditions, which allow quantifying the impact of GCR on the research processes. Significantly studies on smog generation in megacities Experiments have shown that ammonia and nitric acid grow newly formed particles 100 times faster than previously known. The process is interrupted as it takes place in a much polluted atmosphere of cities. The layer where this happens becomes under the inversion layer.

To assess anthropogenic impacts, the baseline state of the atmosphere is considered to be the era before industrialization. The fact that biogenic gases form large amounts of aerosols and cloud droplets suggests that cloudiness and temperature do not differ much between now and before. An important result of the research is that it has been experimentally established that only trees can form large numbers of condensing nuclei. Previously it was thought that sulfuric acid was necessary for the formation of aerosols. Since sulfuric acid was 5 times less in the atmosphere before industrialization, according to climate models, clouds were also less.

Under the influence of GCR, the rate of production of biogenic particles increases 100 times. Therefore, before the industrialization period, the atmosphere was more sensitive to cosmic rays than in the current polluted atmosphere. It turned out that sulfuric acid itself is not a nuclide, it needs ammonia. Before the CLOUD project, particles were measured, not molecular composition, so the experiments were not pure, many

The results obtained with CLOUD are used in the models of the so-called IPCC– Intergovernmental Panel on Climate Change. The project established a link between theory, experimentation and modeling. Several institutes are working on regional and global aerosol cloud models. New experimental zones should be developed in the future. The project will last for another 10 years. But, according to the press secretary of the project, it takes more than 80 years to answer all the questions.

In Georgia studies of the effects on cosmic rays on cloudiness also began recently. In particular, in the works [14-16] the effects of cosmic radiation on the formation in the atmosphere of the secondary aerosols, which have an effect on cloudiness, are studied. In the works [17,18] the inter-annual distributions of cloudless days and cloudless nights in Abastumani Astrophysical Observatory, at various helio-geophysical conditions, and their coupling with cosmic factors were studied. In the work [19], a study of the relationship between the annual variations in the intensity of galactic cosmic rays and the variability of cloudiness and air temperature in Tbilisi was carried out according to the data of 1963-1990. In the work [20] results of the study of the connection between annual variations of intensity of galactic cosmic rays and the changeability of the total cloudiness, atmospheric precipitation and air temperature in 1966-2015 in Tbilisi. The statistical characteristics of the indicated parameters (trends, random component, linear correlations between real and random components, etc.) are studied. In particular, it was found that, within the variation range, the contribution to total cloudiness variability from cosmic ray intensity is 5.3%, and random components of cosmic ray intensity - 7.4%.

And here is how Jasper Kirkby [21] answers the question; will humanity be able to survive catastrophic climate change?

“The Earth has undergone much greater natural fluctuations in climate. Earth's climate is fundamentally stable. The oceans occupy 2/3 of the earth's surface, and the latent heat of their evaporation is the greatest stabilizer of the climate. The oceans never evaporated and never froze. In addition only 2% of CO2 is in the atmosphere, the rest is diluted in the ocean. So for several hundred years the amount of CO2 in the atmosphere will be almost the same as it was before the industrialization period. Some scientists have suggested that in the current conditions there may be some turning point in the climate, but many things have happened and life has not disappeared. And in general, the problem of environmental pollution should not be equated with the problem of climate. It should be considered separately” Advises us to be more optimistic.

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გალაქტიკური კოსმოსური სხივების დედამიწის ღრუბლიანობაზე გავლენის გამოკვლევა. ბოლო ათწლეულების სამეცნიერო კვლევების მიმოხილვა

ი. მკურნალიძე, ნ. კაპანაძე

რეზიუმე

განხილულია მთელი რიგი სამეცნიერო ნაშრომებისა, რომლებიც ეხება გალაქტიკური კოსმოსური სხივების დედამიწის ღრუბლიანობასა და კლიმატზე შესაძლო გავლენის არსებობას. მოყვანილია შესაბამისი გრაფიკები. გაანალიზებულია საერთაშორისო ცენტრში CERN (პროექტი "CLOUD"), ბოლო ათწლეულში ჩატარებული, აღნიშნულ თემატიკისადმი მიძღვნილი კვლევები. მოყვანილია პროექტის წამყვანი სპეციალისტის მოსაზრება დედამიწის კლიმატის შესაძლო კატასტროფული ცვლილების შესახებ.

Исследования влияния галактических космических лучей на облачный покров Земли. Обзор исследований последних десятилетий

И.П. Мкурналидзе, Н.И. Капанадзе

Резюме

В данной статье дан обзор ряда научных работ, в которых представлены исследования существования влияния галактических космических лучей на облачный покров Земли и её климат. Представлены соответствующие графики. Описаны работы, проводимые в международном центре CERN, посвященные данной тематике (проект «CLOUD»). Приведено мнение ведущего специалиста проекта по поводу возможности катастрофического изменения климата на Земле. Рассмотренные в данной статье исследования проведены в последние десятилетия.