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Effects in background gamma radiation fluxes on the Barentsburg-Apatity-Rostov-on-Don station row

Balabin Y.V., Germanenko A.V., Shur L.I.

POLAR GEOPHYSICAL INSTITUTE, APATITY

INTRODUCTION

The background gamma radiation flux in the surface layer of the atmosphere in the range of 20-400 keV has been monitored for several years via scintillation detectors in the PGI Cosmic Ray laboratory. In this paper we present the results of gamma-radiation fluxes long-term measurements at different observation points, performed with the help of the same type detectors. The main observation points are Apatity of the Murmansk region (67.56 N, 33.40 E) and Barentsburg, arch. Svalbard (78.06 N, 14.21 E) for which there is a large database of measurements. Since 2016, one detector has been installed in Rostov-on-Don (42.25 N, 39.72 E). A number of similar effects are observed on all detectors. In particular, there are short-term increases in the intensity of gamma radiation during precipitation, which are up to 60%. Also for the Arctic (Barentsburg) and Subarctic (Apatity) regions, there are steady annual variations. For the mid-latitude observation point (Rostov-on-Don), such variation is absent. We suppose that the short-term increases in the intensity of gamma radiation during precipitation are associated with electric fields in the rain/snow low level clouds, and the annual variations of gamma radiation are due to accumulation and melting of the snow cover.

To monitor gamma (X-ray)-background at the ground level in Apatity, Barentsburg and Rostov-on-Don we used the scintillation spectrometer based on the *NaI(Tl)* crystal of 6 cm in diameter and 2 cm thick. The signal after the photomultiplier and the amplifier is continuously recorded in 4 integral channels with a threshold photon energies > 20, > 60, > 100 and > 200 keV. Detection in integral channels allows us continuous estimation of the integral spectrum of high energy photons.

<u>This paper presents the measurement of the following locations:</u>

- **Svalbard, Barentsburg, coordinates 78.06 N, 14.21 E**
- **Murmansk region, Apatity, location 67.57, N 33.39 E**
- **Rostov Region, Rostov-on-Don, coordinates 47.25 N, 39.72 E**

Fig. 1. The Apatity scintillation gamma-detector with lead shell.

Fig. 2. The Barentsburg scintillation gamma-detector with steel and lead shells.

Fig. 3. The Rostov-on-Don scintillation gamma-detector with microcontroller-based registration system.

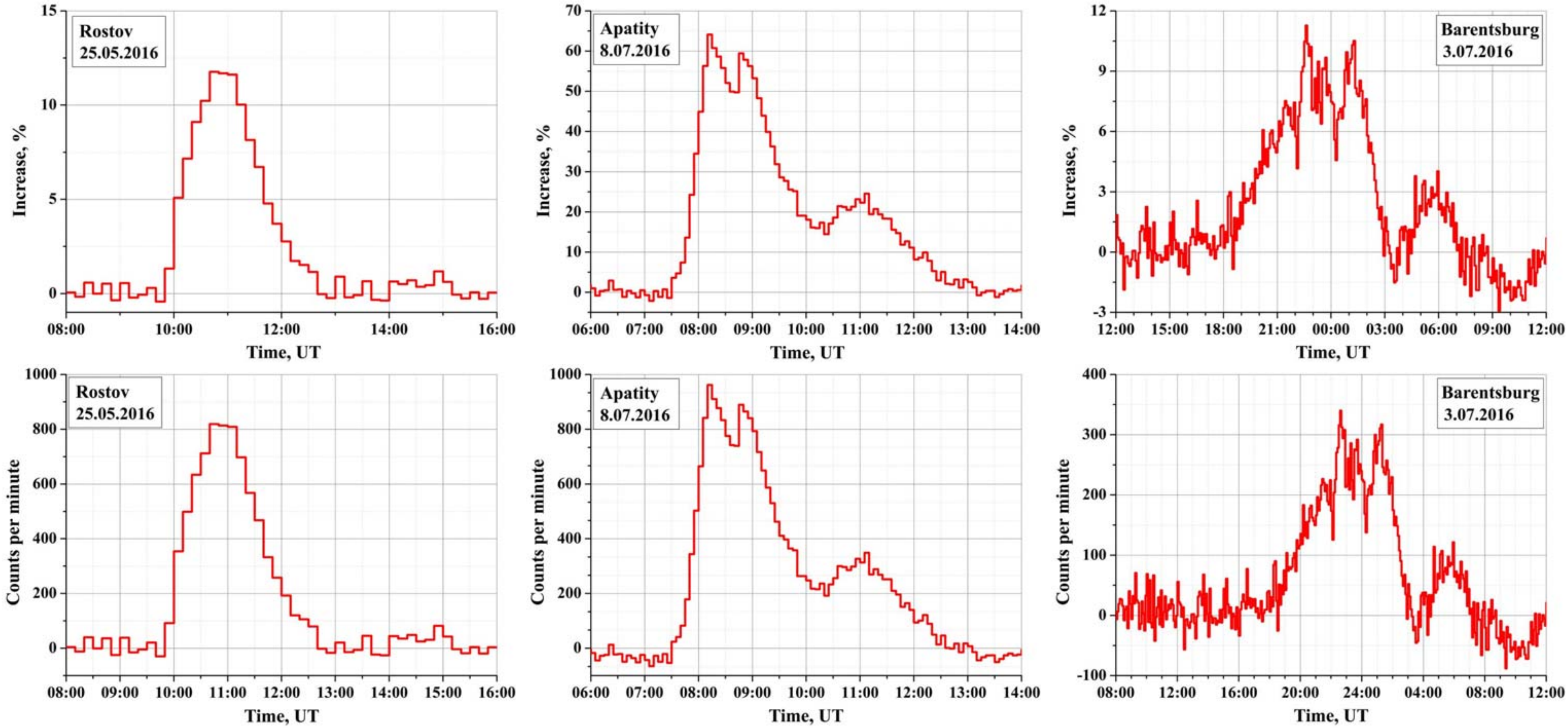

Fig. 4. Gamma ray increase events in different locations connected with precipitations. The upper row is relative increases, the lower row is in absolute ones.

In general, all events for different locations are similar, but their amplitude varies widely. First of all, this happens because the background level in each locality is different, and the profiles are calculated as a percentage of the background. Typical events are shown for each location. All of them were accompanied by a moderate rain (without a thunderstorm) lasting 1-2 hours.

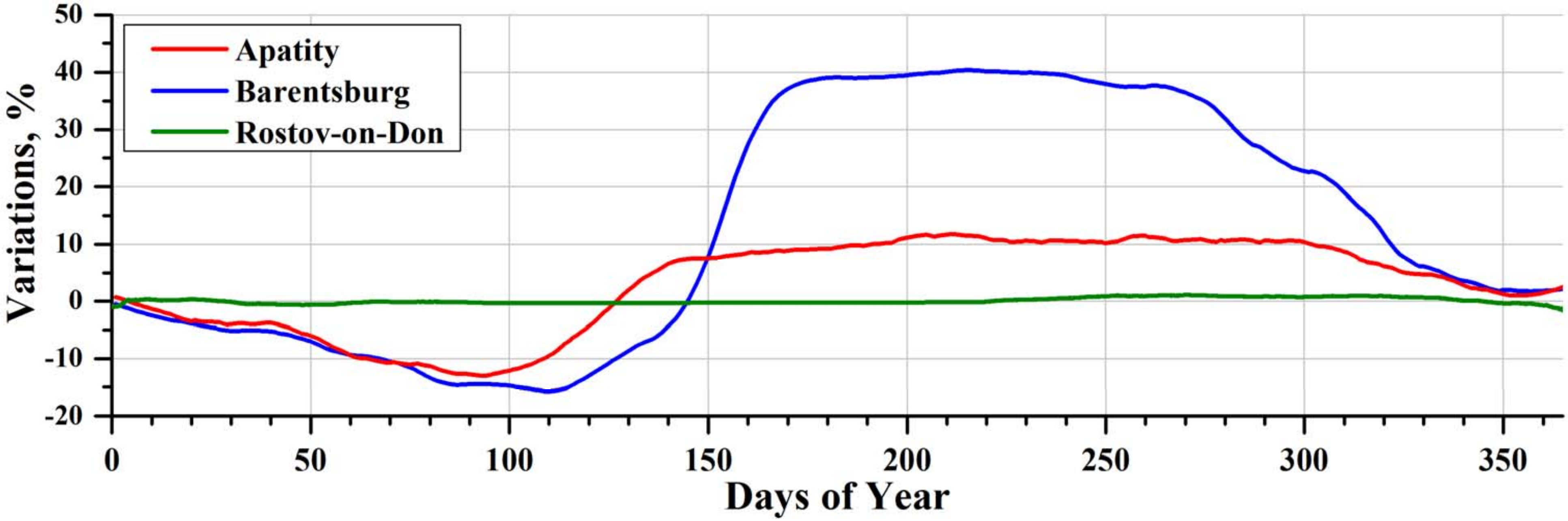

Fig. 5. Annual variations of gamma rays in different locations.

Annual variation in the soft gamma-ray is huge at Apatity (~25 %) and Barentsburg (~50 %) and almost absent at Rostov-on-Don. These variations are in good coincidence with snow cover depth. Based on the superimpose method we have studied annual variations in the different components of the secondary cosmic rays.

The measurements of the differential GR-spectrum in the minimum of the annual variation and in the maximum have shown that the annual variation is caused exclusively by an increase of the gamma-quanta flow, with energies not exceeding ~500 keV. The hypothesis is proposed which consistently coordinates all the facts revealed.

DISCUSSION

The carried out experiment showed that in absolute values the effect of increase is approximately the same for all continental points. Common to all of them is the presence of a quiet rain.

As can be seen, the effect of increasing precipitation occurs in different climatic zones. The most important result of the experiment is that the absolute value (in pulses / min or in energy, if we convert the pulses into quanta) the value of the effect in different places is approximately the same. The profiles for each item are typical.

This established fact seems to be very important: regardless of the place of observations, the effect of an increase in the gamma radiation flux with precipitation is approximately the same in absolute units. And this fits very well into the hypothesis that we accepted as the main one: the observed effect is associated with the acceleration of charged particles of secondary cosmic rays in the electric fields of rain (stratus-rain) clouds. The presence of such fields is established by direct measurements. The field strength in such clouds does not exceed 10 kV/m. This type of cloud (layered rain) is the main one that produces precipitation without thunderstorm activity. We believe that the relationship between the increases and the layered rain clouds in this experiment is confirmed.

Annual variation in the soft gamma-ray is huge (~25 % at Apatity, ~50 % at Barentsburg). These variations are in good coincidence with snow cover depth. Based on the superimpose method we have studied annual variations in the different components of the secondary cosmic rays.
The measurements of the differential GR-spectrum in the minimum of the annual variation and in the maximum have shown that the annual variation is caused exclusively by an increase of the gamma-quanta flow, with energies not exceeding ~500 keV. The hypothesis is proposed which consistently coordinates all the facts revealed.

CONCLUSIONS

1. **Measurements of gamma-ray variations (range 20-400 keV) related to precipitation in different geographical locations of different climatic zones (Barentsburg, Tiksi, Apatity, Mondy, Rostov-on-Don) were made using the same type of detectors.**
2. **The events of increasing gamma radiation with precipitation were observed in all locations. It was also noted that the increase events almost always were accompanied by intense precipitations, with dense and low altitude (200-600 meters) cloudiness**
3. **Moreover, the absolute values of the additional flow for such geographically and climatically separated points are not too different. This is in good agreement with the assumption that this phenomenon (the increase in the radiation flux in precipitation) is associated with electric fields in layered rain (not thunderstorm!) Clouds. In such clouds, there are moderate electric fields ~ 10 kV / m, insufficient for direct acceleration of charged particles. However, an additional set of energy by high-energy particles is possible.**
4. **Seasonal variations of gamma rays have been measured on different location. More northern observation locations give a larger annual variation. We believe that this is due to the thickness of the snow cover at the observation points.**