Gamma-ray variations in the low atmosphere on a row of stations from Spitsbergen to middle latitude plain

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Monitoring of background gamma-rays, coming from the atmosphere to the surface level i.e. electromagnetic component of secondary cosmic rays, is performed in Polar Geophysical Institute (PGI) since 2009. There are a number of monitoring points in polar and middle latitude regions at the present moment. Two variation kinds annual and sporadic are observed. Features of sporadic variation are present in all stations. A way of explaining these features are suggested.
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1. Introduction

Monitoring of gamma-rays (20-400 keV), coming from the atmosphere to the surface level, is done in PGI since 2009 on the station line: Barentsburg (arch. Spitsbergen), Apatity (foothills of Khibiny mountains), Tixie (shore of a polar sea), Mondy (Sayany mountains), Rostov-on-Don (plain). There are used identical detectors based on Ø60×20 mm NaI(Tl) crystals. Detectors have a 5-cm lead shell opened to top. The shell protects the crystal from radiation coming from soil and environment and gets a view cone about 150 degrees. Due to the thick lead shell the crystal accepts only secondary cosmic ray radiation from the atmosphere. It is the important note to exclude consideration of ground reason of observing variations [1].

![Detector Image]

Figure 1: At the left. The operating detector is in 5-cm lead shell opened to top. At the right. View of the detector of gamma-rays with the microcontrolled data collection system.

2. Results of monitoring: increase events

The presence of a large database of gamma-rays detectors in different places allows the studying of their variations. There are two distinct variation: annual and sporadic. The annual variation is more than 30 % with a "winter-spring" depression and a summer flat top on the polar stations. The sporadic variation we called the increase event because it is enhancement above a background level. It was found the next [2,3]:

a) increase events in 95% of cases are accompanied by solid or liquid precipitations and take place whole year round;

b) increase event amplitude is up to 60% and the average value is ~25 %;

c) increase events are only in the electromagnetic component, the radiation fluxes in charged components are constant;

d) there is absent any radionuclide contamination of precipitation.

It is usually to measure a variation in relation to the background gamma-rays level on a station. It is reasonable because each station has the peculiar level caused by local characteristics like altitude, geographic latitude and other uncounted reasons including the shell shape. In this way amplitude of increase events vary up to ~60 % in Apatity, up to ~35 % in
Barentsburg, up to ~15 in Tixie and Rostov, up to ~25 % in Mondy. There is absent any law in the amplitude distribution along stations. In this paper we present increase profiles on the stations in absolute count rate (Fig.3). It is quite reasonable to take the absolute count rate because the detectors are identical and were calibrated under a conventional radioactive sauce. The shell is similar and made of conventional lead bricks.

So one can see the polar station (Barentsburg and Tixie) have increase amplitudes about 300 pulses/min, other stations from the sub polar region to the muddle latitude plain have another amplitude level about 800 pulses/min. Barentsburg and Tixie are sea shore station against another which are continental. The main result of this experiment is next. Due to similar energetic spectra on the stations the increase events in count rates can be calculated to integral energetic flux through the detectors. Equal amplitude level on the station is equal additional energetic flux of gamma-radiation which produces in the atmosphere during precipitation. Without difference on all continental stations there is the same additional gamma-radiation flux under a rain. This result is according to our hypothesis of gamma-radiation producing. According to our hypothesis additional gamma-radiation is generated by light charged particles which gather additional energy in electric fields into nimbostratus rain clouds. It is known by direct measurements [4, 5] there are electric fields up to 16 kV/m strength into rain clouds. Nimbostratus rain clouds are the same over Rostov plain or Apatity hills. Nimbostratus rain clouds are the main source of precipitations [6]. We consider the result to prove our hypothesis of gamma-rays increasing.
3. Results of monitoring: annual variations

The next result of monitoring is carrying out of annual variation (Fig.3). It was found in the gamma-rays background coming from the atmosphere. As it was mentioned above, the detectors are in lead shell opened to the top. They are in the thermostable box on the building loft. The roof is very steep snow is not accumulated on it during a winter, so a matter amount above the detectors is constantly. Hence the annual variation of gamma-rays corresponds to real flux changing along year. Energetic spectrum measurements (it is monitoring too) in Apatity carried out that the annual variation is up to 600-800 keV.

![Figure 3: At the left. Average annual variation profiles in Apatity and Barentburg. Flat top corresponds to warm season. Minimum corresponds to time of deepest snow cover at this station. At the right. Gamma-rays profile along 2010-15 years and snow thickness in Apatity station. Scale of snow depth is on right side and inverted to be more distinctively. The flux of gamma-rays follows strongly snow depth. The fringe on the gamma-rays profile corresponds to increase events in gamma-rays, caused by precipitations [2, 3].](image)

The annual variation has a flat top corresponding to the warm season. With beginning the cool season and snow accumulating on the soil, gamma-rays flux decreases according to snow depth and comes to minimum at the deepest snow cover to the spring beginning. With snow melting gamma-rays flux restores quickly to the summer level. One could say the annual variation exactly follows to thickness of snow cover. Average maximum snow depth in Apatity is about 80 cm and variation magnitude is ~25 %. In Barentsburg they are 170 cm and ~50 % correspondently.

The annual variation is present at Tixie and Mondy stations too, but they are in windy places. There is usual 15-20 m/s wind, snow blow away from the opened areas and is gathered in small gauges and ravines. In this case snow depth measurement is not reliable.

Rostov-on-Don is the key station for us. Due to warm winter steady snow cover is absent in Rostov. Sometimes the negligible snow cover (~5 cm or less) lays about a week then under a warmer weather the snow cover melts. The annual variation is absent in Rostov station. We consider it to cause by absence of the steady snow cover. The annual variation is not explained till now because the station row is short. It would be useful to have data of places with moderate snow cover and warm places. Now it is found that snow cover decreases the gamma-ray flux...
from the atmosphere. There are only two distinct annual variation in the secondary cosmic rays: in gamma-rays flux and in moderate and thermal neutrons. Variation in charged particles (electrons, positrons and muons) is absent [7]. We suggest that these two variations are connected and have a common reason. It is known [8, 9] that free thermal neutrons are captured by environment nuclei and not decay. Nucleus reactions with neutrons are accompanied with gamma-quanta. This is a possible way of explaining of deep connection of annual variations in gamma-rays and moderate neutrons.

Figure 4: Annual variation in Rostov in comparison to polar station ones.

4. Conclusions

During the monitoring of background gamma-rays, coming from the atmosphere to the surface level, two variation kinds annual and sporadic are carried out. The sporadic variation (or increase) is present in all stations and accompanies precipitation. On the row of stations continental ones have the similar magnitude in absolute count rate (pulse per minute). Putting into account that nimbostratus rain clouds are the main source of precipitations, we explain the same gamma-rays increase magnitudes on different stations of electric fields into rain clouds. The annual variation is present at all station with steady snow cover at winter. Furthermore its magnitude depends on snow cover thickness. We suggest the variation is connected to thermal and moderate neutron density in the environment.

References


