

## Radioactive $\gamma/\beta$ tracer to explore dangerous technogenic phenomena

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**Abstract.** A radioactive  $\gamma/\beta$  tracer to explore dangerous technogenic phenomena has been proposed: the ratio of the measured flux density of  $\beta$ - and  $\gamma$ -radiations in the surface layer of the atmosphere. The time dependence analysis of the ratio of  $\beta$ - and  $\gamma$ -pulse count rate has been carried out. A significant increase of the  $\gamma/\beta$  ratio was recorded under the cyclone passing through Japan (Fukushima) to Kamchatka. The proposed  $\gamma/\beta$  tracer can be a very sensitive indicator of non-stationary processes related to hazardous natural and technogenic phenomena.

### 1. Introduction

The study of artificial radioactivity caused by nuclear weapons testing and technological processes and accidents [1–3] is still dominant in atmospheric radioactivity studies. The Automated Radiation Monitoring System of Russian is aimed to solve these problems. Its main activity is  $\gamma$ -background monitoring. The  $\gamma$ -radiation is chosen due to its high penetrating ability. Monitoring of the atmospheric  $\beta$ -radiation is mainly replaced by monitoring of  $\beta$ -activity of individual radionuclides. Monitoring of the atmospheric  $\alpha$ -radiation is carried out sporadically for scientific purposes.

The level of  $\gamma$ -background is known to be significantly higher in precipitation [2–6]. According to [3–6] rain and snow play a major role in the atmospheric  $\gamma$ -background variations and cause a short-term abrupt increase (spikes) in the recorded characteristics of  $\gamma$ -radiation field of 125% [6] and even up to 7 times [5]. To describe this phenomenon, a special term “radon washout” was introduced abroad to describe the washout of  $\gamma$ -emitting decay products of radon and thoron onto the Earth's surface by precipitation. However, the expected significant correspondence between the intensity of precipitation and the level of  $\gamma$ -radiation dose has not yet been found [5, 6].



## 2. Statement of the problem

The methods to analyze the back trajectories of air masses, transport rate of air masses and information about the emanation of radon from the lithosphere are used to estimate the level of ionizing radiation [2, 5, 7]. It is difficult to predict  $\gamma$ -radiation increase reliably due to precipitation, since the concentration of radon decay products in precipitation depends on the concentration of radon in the atmosphere, the formation and transport of clouds and the type of precipitation [2, 5]. The data on  $\gamma$ -radiation is only used in papers devoted to the assessment of ionizing radiation level. It is known that the decay processes of radon and its decay products form not only  $\gamma$ -background, but also  $\alpha$ - and  $\beta$ -background. However, this factor is not considered to analyze the level and variations of the background radiation components.

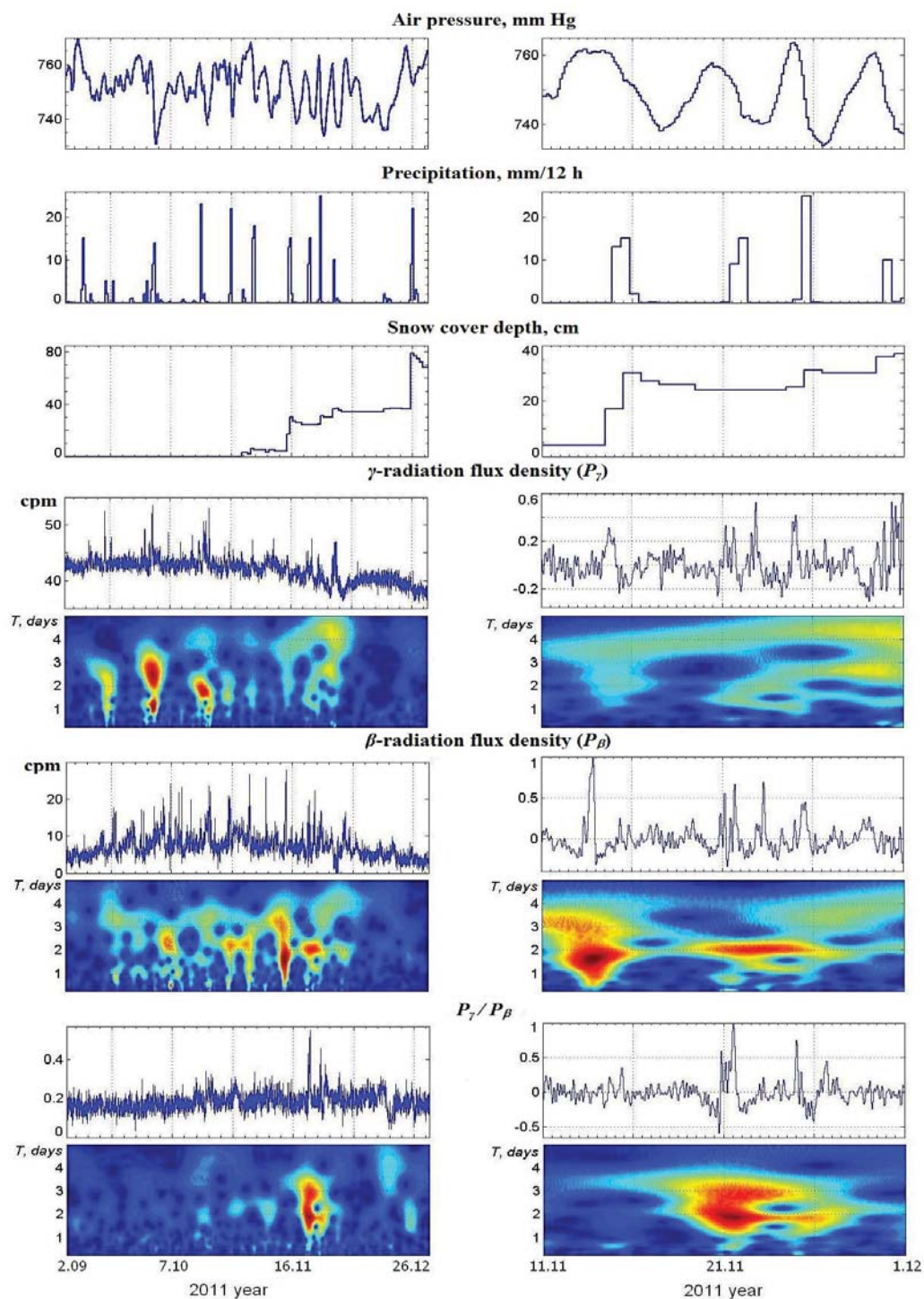
One more important fact should be emphasized: the direct impact of ionizing radiation on the environment, biological objects and human beings is determined by the type of radiation. The fluxes of short-range  $\alpha$ -particles in the air can only affect the skin and lungs. The fluxes of  $\beta$ -particles are capable of passing through the air from tens of centimeters to several meters. In biological tissues the path of these particles lies within the range from parts to units of centimeters (affects the skin and subcutaneous tissue). The  $\gamma$ -radiation flux has a high penetrating power and can pass more than 1 km in the air (affects the entire body).

Our previous studies [2, 8] proved that variations of  $\beta$ - and  $\gamma$ -background are not completely consistent within the intra-day and inter-day intervals and within the longer intervals as well. The determined difference in the dynamics of  $\gamma$ - and  $\beta$ -background is the basis for the current research, which includes the investigation of the dynamics of  $\gamma/\beta$  tracer, which is the ratio of the flux density of  $\gamma$ - and  $\beta$ -radiation measured in the surface layer of the atmosphere.

## 3. The results of monitoring and analysis

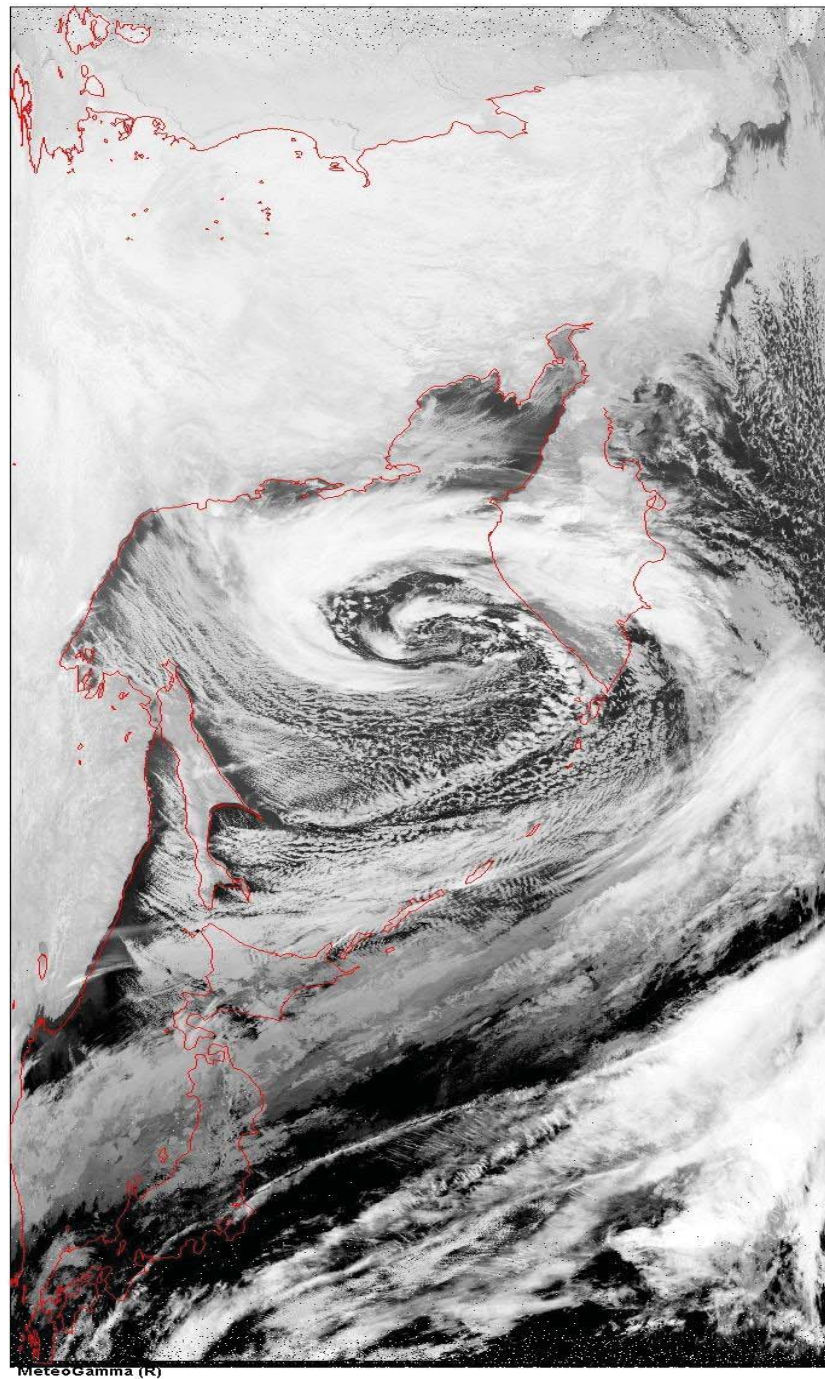
Monitoring of the analyzed variables was performed by the method described in [8] in Tomsk city in Russia (aseismic region with a continental climate) and in Paratunka, Kamchatka, Russia (seismically active region with maritime climate). The monitoring data results were supplemented with current data on space weather (solar radio wave, Wolf number, indices of geomagnetic activity, cosmic rays intensity, etc.).

As indicated previously [2, 4, 5, 7], synoptic processes play a significant role in the dynamics and level of atmospheric emissions of  $\beta$ - and  $\gamma$ -radiation and these processes can lead to the increase of background level by several times. This can be clearly seen in Figure 1, which shows the data obtained in seismic regions (Paratunka, Kamchatka). In Figure 1: on the left – variations of meteorological and radiation quantities for the period 2 September 2011 – 31 December 2011; on the right – the enlarged fragment (11 November 2011 – 01 December 2011). The data on  $\gamma$ - and  $\beta$ -flux densities variations and their ratio (right column) were smoothed by a bandpass filter with the band periods 4 hours – 10 days and then normalized. Waveletspectrograms were also constructed for obtained data. As can be seen in Figure 1, air pressure fall caused by the passage of cyclone is followed by rain (or snow) and corresponding spikes in  $\beta$ - and  $\gamma$ -background. It can be seen that the spikes in the levels of ionizing radiation component background ( $\beta$  and  $\gamma$ ) caused by the next cyclone do not result in a significant change in their ratio. The exceptions are variations of the atmospheric  $\beta$ - and  $\gamma$ -radiation in the second half of November 2011 during the passage of cyclone through the area of Fukushima (Japan) to Kamchatka. The scheme of the cyclone route is shown in Figure 2.



**Figure. 1.** Variations of atmospheric pressure, precipitation, snow cover depth, number of pulses  $\gamma$ - and  $\beta$ -radiation flux densities measured at 5m height and their normalized ratio.





NOAA 19 29.11.2011 16:06:38 GMT

**Figure. 2.** The data of IR channel from NOAA weather satellite about the cyclone at the territory of Kamchatka and Japan.

The capture of radioactive aerosols of technogenic origin by the cyclone in the region of Fukushima nuclear power plant is a possible cause of spikes in the time dependence ratio of  $\beta$ - and  $\gamma$ -count rates. The presence of radioactive aerosols of technogenic origin in the atmosphere must be followed by the formation of new radioactive elements or corresponding changes in the variations of atmospheric  $\beta$ - and  $\gamma$ -radiation flux densities and their ratio.

#### 4. Conclusion

The proposed  $\gamma/\beta$  tracer can be a very sensitive indicator of non-stationary processes related to hazardous natural and technogenic phenomena. This owes to the fact that technogenic, lithosphere and atmospheric processes result in qualitative changes of the radionuclide composition in the atmosphere and as a consequence in the change of the  $\gamma/\beta$  ratio. The variations of the  $\gamma/\beta$  tracer cause changes in the mechanisms of ionizing radiation impact on the environment, which is an important factor to assess the environment.

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