Dynamics of low energy gamma rays near ground level during July to September 2017, in São José dos Campos, SP, Brazil.

Abstract

The variation of the intensity of the gamma radiation integrated between 200 keV to 10.0 MeV was measured, in the period from May 28 to September 25 of 2017. These measurements were taken at one-minute intervals at an altitude of 25 meters above ground in a tower in São José dos Campos, SP, Brazil. During this period there was a week of weak and moderate rains amounting to 27 mm total. There was a lot of cold and during the day the high temperature reached up to 32^{0} C, reproducing a desert-like climate. By monitoring the gamma radiation it was possible to observe the arrival of cold fronts from Southern Brazil and the day / night cycles due to the greater or lesser amount of radon gas present in the region. The dynamics of gamma radiation indicate in a simple way the variation of meteorological parameters in that location, which is very important for environmental studies.

Keywords: Gamma, Dynamics, Ground level

1. Introduction

At the ground / air interface of Earth's surface, the ionizing radiation is composed mainly of radon gas, the telluric radiation of the soil and the radiation of the primary and secondary cosmic rays. However, it is difficult to separate over time the intensity of the ionizing radiation emanating from each component as the energies overlap. The telluric radiation is given by ^{238}U, ^{235}U, ^{40}K, ^{232}Th and is constant for each region [1]. The radon gas that comes from the disintegration of ^{238}U of Earth's crust [2] into Ra-226 to Rn-222 arriving at the isotopes ^{214}Pb, ^{214}Po and ^{214}Bi giving α and gamma radiation. The primary cosmic radiation consists mainly of galactic and extragalactic protons and from the Sun with very high energy that interacts with Earth's atmosphere producing the EAS (Extensive Air Showers) [3]. The efficiency of this interaction is maximum when it occurs at altitudes between 15 and 17 km in the tropics, which form secondary cosmic rays with muonic, mesonic, and neutronic components that reach the Earth's surface in the region [4]. These radiations cause health problems for the crew and passengers of civil aviation and are present at the beginning of the stratosphere called Pfotzer maximum. However, this component contributes less to the concentration of radiation on the Earth's surface. Another possible source of ionizing radiation in the Earth's lower atmosphere is produced by electrical discharges between cloud-earth, earth-cloud and cloud-cloud. X-rays, gamma rays, neutrons and beta particles are all formed by the lightning cone [5]. Other sources of ionizing radiation are those produced in medical and dental clinics and hospitals, but these radiations are mainly controlled in small areas.

2. Materials and Methods

The gamma ray detector for the energy range of 200 keV to 10.0 MeV consists of a 3-inch-by-3-inch-diameter and high sodium iodide scintillation crystal (3” x 3”), doped with thallium. This crystal is directly coupled to a photomultiplier (PM), which registers the pulses coming from the scintillator and with amplification and an analog digital converter (ADC) these digitized signals are recorded by a computer [6]. This experimental set is seen in Figure 1 located in the inner room of a tower, 25 meters high in relation to the ground (ACA tower), belonging to the Institute of Aeronautics and Space (IAE).

Figure-1. View of the gamma scintillator with associated electronics and computer.
Source: Project Atmosrad 2017

The scintillator coupled to photomultiplier is wrapped in a thin layer of aluminum to make it portable. The set (scintillator + associated electronics + data acquisition) depends only on a laptop with a charged battery to measure radiation for up to 5 continuous hours. However, for series of long measurements it uses electrical network or photovoltaic energy. Scintillator and associated electronics were calibrated in terms of energy and counting intensity per minute, at the laboratory of experimental teaching physics of ITA, using radioactive sources and a spectral analyzer of counts versus energy in the range of 0.2 to 10 MeV (Million electron Volt), [7,8].

3. Results and Discussions

Gamma radiation measurements were carried out during the period of June 26 to September 25 of 2017, in the inner room above the tower, seen in Figure 2 below. During the interval described above, on the roof of the tower was the rain gauge that reported the intensity of rains in mm / min.

Figure-2. Exterior view of the tower with the room 25 meters from the ground.
Source: Project Atmosrad 2017

Figure 3 shows the measured gamma radiation intensity between June 26 to September 25 of 2017, with uninterrupted monitoring from minute to minute during this total time.

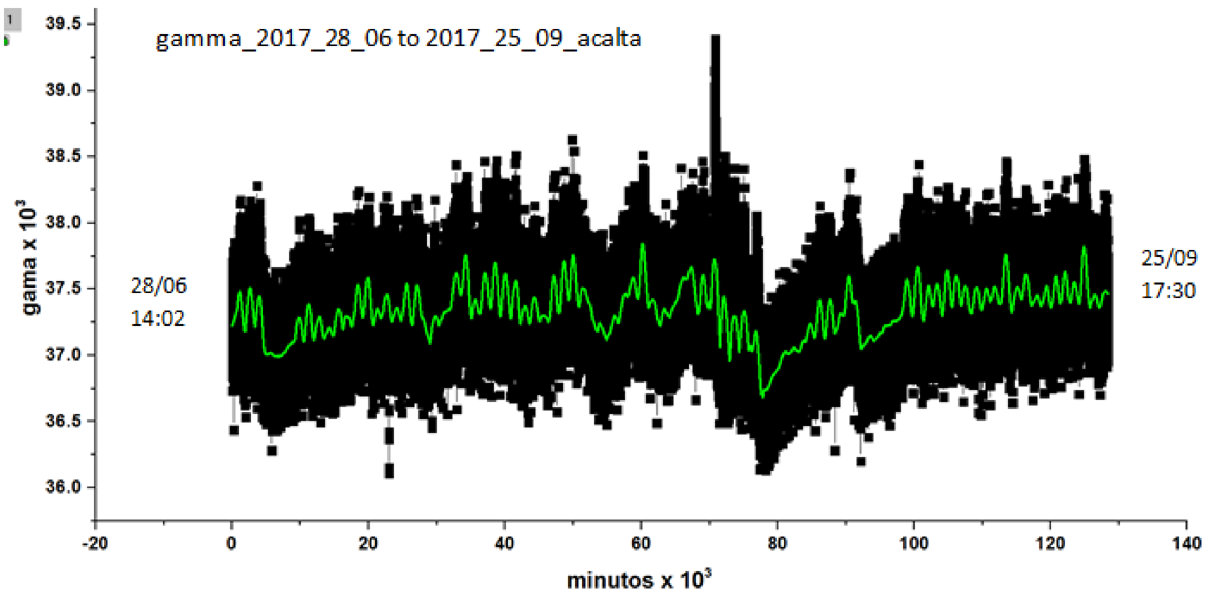

Figure-3. Monitoring of gamma radiation in the room at the top of the tower.
Source: Project Atmosrad 2017

Analyzing the dynamics of the radiation measurements, there are 3 large variations occurring in the whole period analyzed. Between the beginning of monitoring and close to 70 x 10^3 minutes, the mean intensity of the measured radiation was 37.5 x 10^3 counts / minute. It presents in this analyzed time also small variations indicating passages of cold fronts but without rain. See this dynamic in this period expanded in Figure 4, taken from the graph in Figure 3.

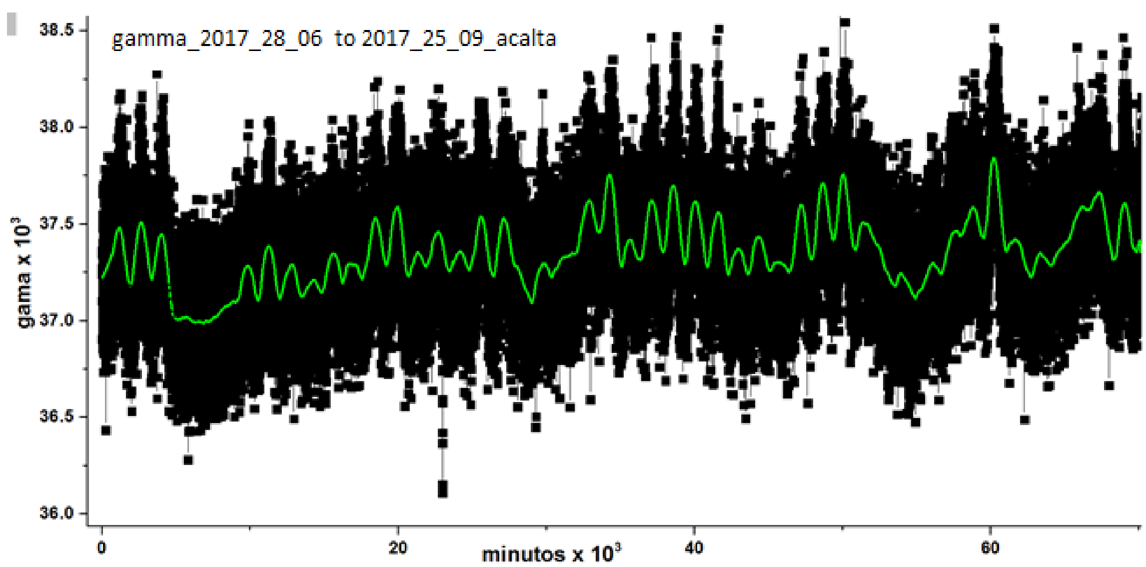

Figure-4. Monitoring of gamma radiation between the start time and 70 x 10^3 minutes.
Source: Project Atmosrad 2017

Figure 5 shows the radiation monitoring between 70 to 80 x 10^3 minutes after the start of the measures. It was a rainy week with intensities varying according to Figure 5.

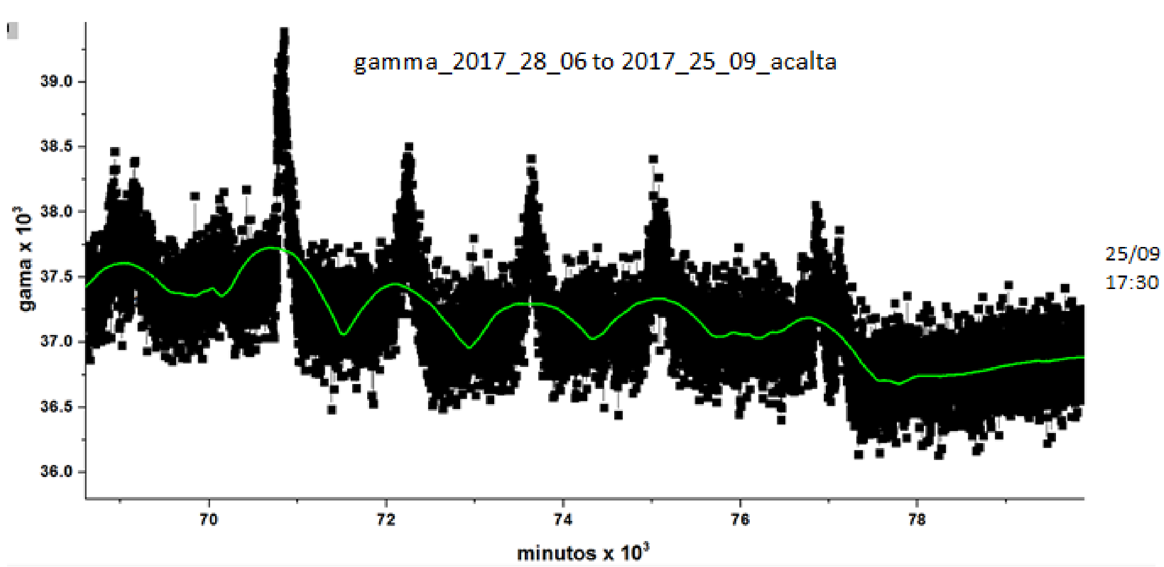

Figure-5. Gamma radiation monitoring during the rainy week.
Source: Project Atmosrad 2017

In the beginning between 70 and 71 x 10^3 minutes, there was an intense rain, where the level of radiation count reached the order of 40 x 10^3 counts / min. Then, on the other days there was always less intense rains, but always in the afternoon between 14 and 15 local time during that week, as shown by the radiation peaks caused by the rains. In Figure 6, taken during the measurement time of 80 to 100 x 10^3 minutes, there are variations in the dynamics of the radiation with passages of two cold fronts in the region, but without causing rains. However, the terrestrial surface was wet and with very little exhalation of radon gas. The arrival of the front causes an increase of the radiation due to the accumulation of radon gas that arrives with the cold front.

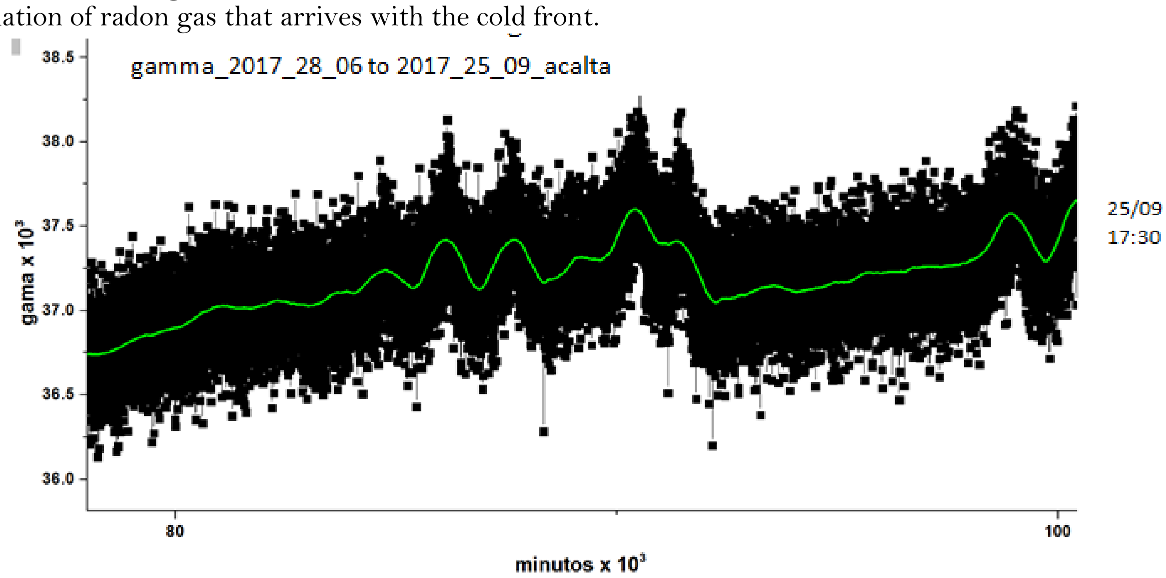

Figure-6. Monitoring of radiation during two cold front passages in the region.
Source: Project Atmosrad 2017

In Figure 7, the monitoring between the times of 100 to 130 x 10^3 minutes with average intensity of 37.3 x 10^3 counts / min. undergoes an influence of high pressure in the region with very dry soil. This occurs in the afternoon where the temperature varied between 25 to 30 ° C and the night between 12 to 20 ° C. This dynamics in temperature during this period facilitates greater and lesser exhalation of the radon gas, as shown in the figure 7 bellow with periods of exactly 24 hours. The two largest radiation peaks, shown in Figure 7, are caused by heavy fog in the morning of those days.

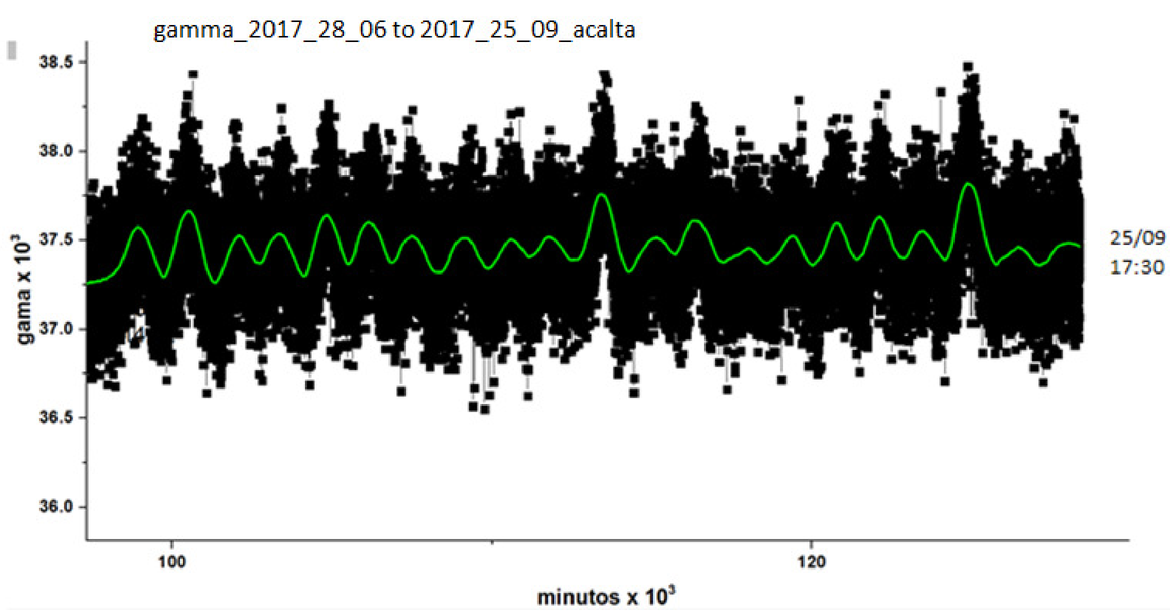

Figure-7. Radiation monitoring on dry soil hot by day and cold at night.
Source: Project Atmosrad 2017

Figure 8 shows the rainfall spectrum in mm / min. varying in time. During the whole period, only 27 mm of rain accumulated in the region in the course of a week.

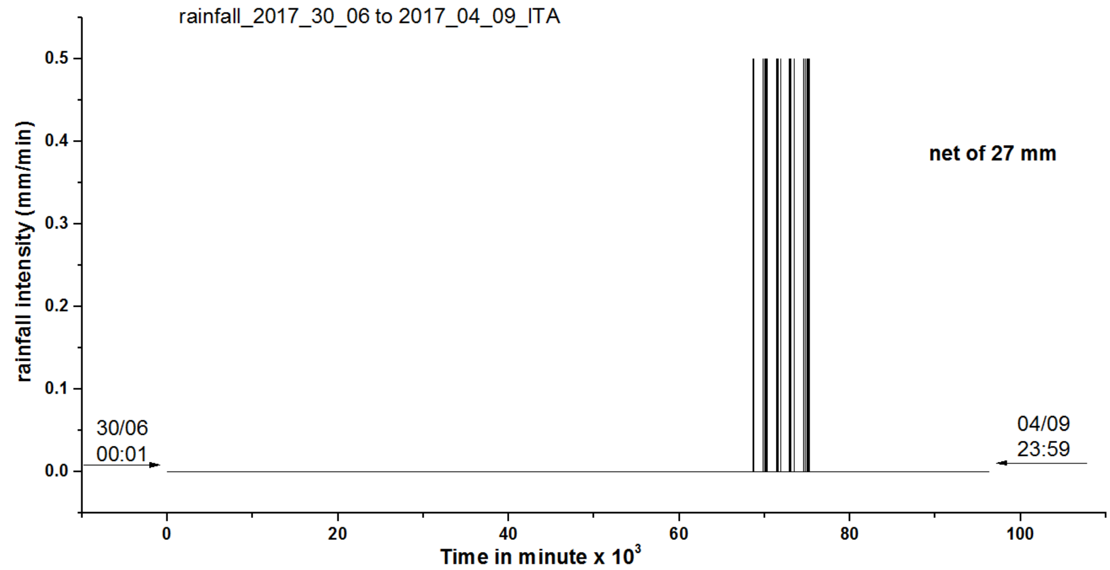

Figure-8. Spectrum in the time of the rains that occurred in the region during this period of measurements.

Source: Project Atmosrad 2017

In 2017, the region of São José dos Campos, SP, Brazil was severely punished by one of the longest droughts ever, due to climate change. There were many occurrences of large fires causing damage to agriculture, fauna and local flora. The net of rain statistic for the period is 170 mm.

4. Conclusion

In the period of August and September of 2017, the intensity of rains was monitored every minute and in the same place and at the same time the intensity of neutrons was also measured every minute. The analysis shows that during the single week of moderate and weak rains, there was a noticeable increase in the intensity of neutrons. The total rainfall in the period was 27 mm scattered in time, Figure 3 shows the difference caused by the rains in the measurement of neutrons. Also in this work, the perfect oscillation of the neutrons (day / night) in the dry period is evidenced, without cloud, fog or lightning. This oscillation is caused by the exhalation of radon gas (Rn-222) in the region and is larger during the local solar zenith. The alpha particles of the gas interact with the metallic materials of the local terrestrial surface generating the measured neutrons.

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