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LOW ENERGY GAMMA RAYS DYNAMICS MEASUREMENTS NEAR GROUND LEVEL IN TROPICAL REGION OF BRAZIL DURING JANUARY TO APRIL 2020

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ABSTRACT

Measurements of gamma radiation between 200 keV at 10.0 MeV, omnidirectional and at 25 meters above the ground level were carried out between January 27 and April 6, 2020. This uninterrupted observation in the period and at 1 minute intervals each measure was made in the ITA campus in São José dos Campos, tropical region of Brazil. A Sodium Iodide scintillator doped with Thallium [NaI (Tl)] of (3x3) inches was used as a gamma detector. In every observed period, the gamma ray measurements indicate 4 well-marked increases. These increases clearly show that they were caused by rains with different intensities at the site. Also a long period between 40,000 to 90,000 minutes without rain at the site, measured radiation counts show day / night and weekly variations indicating changings in meteorological parameters in the region in that time interval. This work tries to show experimentally the possible correlation existing in a tropical region of the Earth between variations of the intensity of gamma rays versus changes of meteorological parameters in the place.

I. INTRODUCTION

At the ground level interface of the Earth's surface, ionizing radiation it is composed mainly of gamma ray, soil telluric radiation, primary and secondary cosmic ray radiation [1]. 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 and ^{232}Th disintegration's series that are constant for each region. The gamma ray and neutrons coming from radon gas arriving through the ^{238}U in Earth's crust disintegration to ^{226}Ra and ^{222}Rn reaching the stables isotopes ^{214}Pb, ^{214}Po and ^{214}Bi. Radioactive elements such as Uranium, Thorium and Potassium are found in almost all types of rocks, sands, soils and water [2]. The Radium ^{226}Ra and its decay products are responsible for a major fraction of the dose of internal emissions received by humans. ^{226}Ra has a half-life of 1,600 years, and decays to Radon ^{222}Rn, which has a half-life of 3.82 days. The decay of ^{222}Rn was followed by successive disintegration of short half-life alpha, beta and gamma ray emitters. After decay stages, the radioactive chain ends with stable lead ^{206}Pb. The alpha particles coming from radon gas in interaction with elements of ground level can produce neutrons. With regard to soils and rocks, the ^{226}Ra is present in virtually all soils and rocks in varying amounts. Areas with high levels of background radiation found in some soils are due to geological conditions and geochemical effects and cause increased terrestrial ionizing radiation. Researches in the world, and specifically in Brazil, show these conditions. Several studies report variations throughout the day of radon concentrations. Maximum concentrations are observed in the first hours of the day and the lowest values are found late near afternoon, when concentrations are about one third of morning values [3]. The same profile are observed with the gamma ray intensity variation in the tropics regions. However, it is likely that variations in concentrations in localities of gamma ray intensity are dependent on local meteorological parameters (rain, wind, pressure, temperature and cloudiness) in the gamma ray detector site. Electrical discharges in low atmosphere of the region also can contribute with production of low energy gamma ray and neutrons near ground level according lightning [4].

II. METHOD & MATERIAL

To monitor the gamma radiation in energy interval 200 keV to 10.0 MeV, it has been used a portable system detector composed of Sodium Iodide scintillator doped with Thallium NaI(Tl).This crystal (3" x 3") inches (diameter and height) placed in a thin cylinder of aluminum foil and coupled with a PM (photomultiplier) with source power circuit settled in 1700 VDC and with data acquisition system provided by the company (Aware Electronics-Inc., USA)[5]. Detector and associated electronics of gamma ray were previously calibrated in ITA

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(Technological Institute of Aeronautics) laboratory using radioactive sources (Cs- 137) and (Co-60) in terms of energy from emitted photons 662 keV and 1,17 MeV, 1,33 MeV respectively [6]. The data acquisition in terms of gamma radiation and intensity of rainfall was performed using 1-minute time interval between each measurement [7]. This detail contributes to verify possible correlations between variation of rain intensity, and local ionizing gamma radiation.

The rainfall intensity in (mm) was measured with a pluviometer (bascule/bucket) rain gauge and data logger acquisition developed in ITA according to the international recommendations. *Using these three tools properly calibrated for the measurements of gamma rays, radon gas and rainfall intensity placed in the tower ACA [8] at 25 meters high for simultaneous monitoring see Figure 1.*

Fig. 1 - Aerial and ground view of the tower ACA and his environmental field region in São José dos Campos, SP, Brazil (23° 12'45" S, 45° 52'00" W)

III. RESULTS AND DISCUSSIONS

The main series of measurements of gamma radiation between 200 keV - 10.0 MeV and in the period from 27/01 to 04/06 2020, held in the tower in the room above 25 meters above the ground as shown in Figure 1. The measurements in this interval were recorded every minute, totaling a total time of 105,000 minutes, totaling about 74days, as shown in Figure 2.

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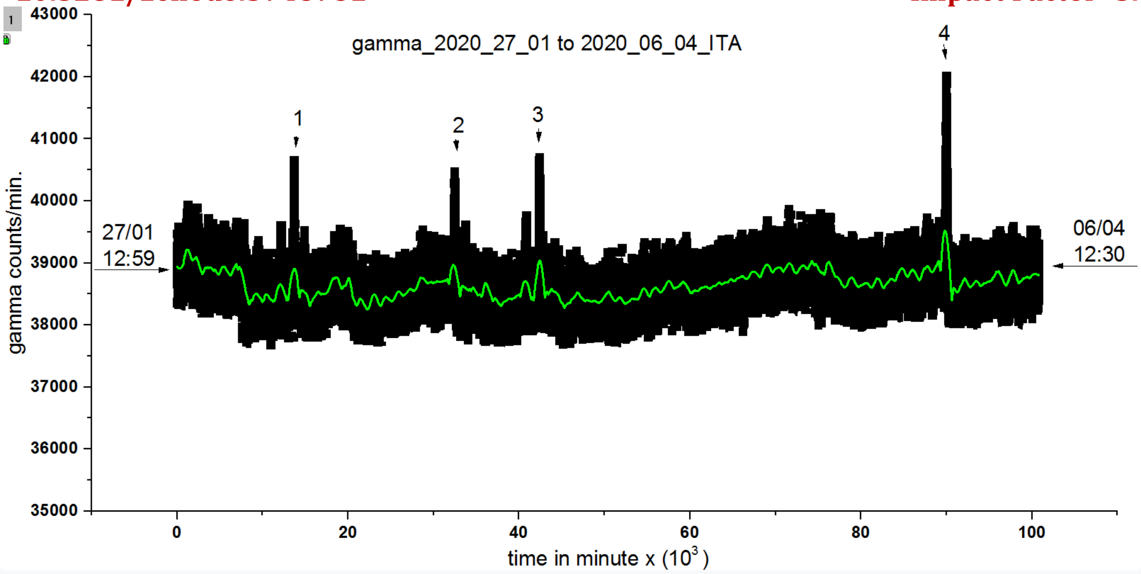

Fig. - 2 Serie of gamma radiation measurements made in the upper room of the tower ACA. The green line shown 1 day smoothed value

From the front left side to the right side of Figure 2, the presence of 4 peaks with intensity greater than 40,000 counts per minute is noted. These peaks in radiation increases correspond to the presence of rain in this region. The first radiation peak measured from left to right, which occurs between 10,000 and 20,000 minutes of measurements can be seen best by zooming close to the peak 1 as shown in Figure 3.

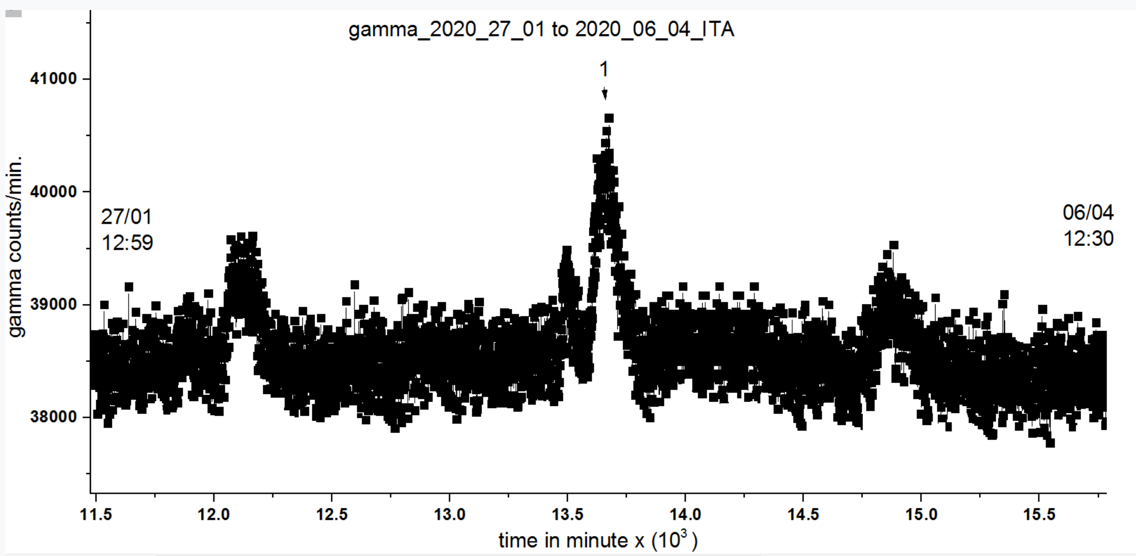

Fig. 3 – Sampling of the four existing rains near peak 1 with measured gamma radiation

Next to the time of 33000 minutes, the second relevant peak is also shown in Figure 4.

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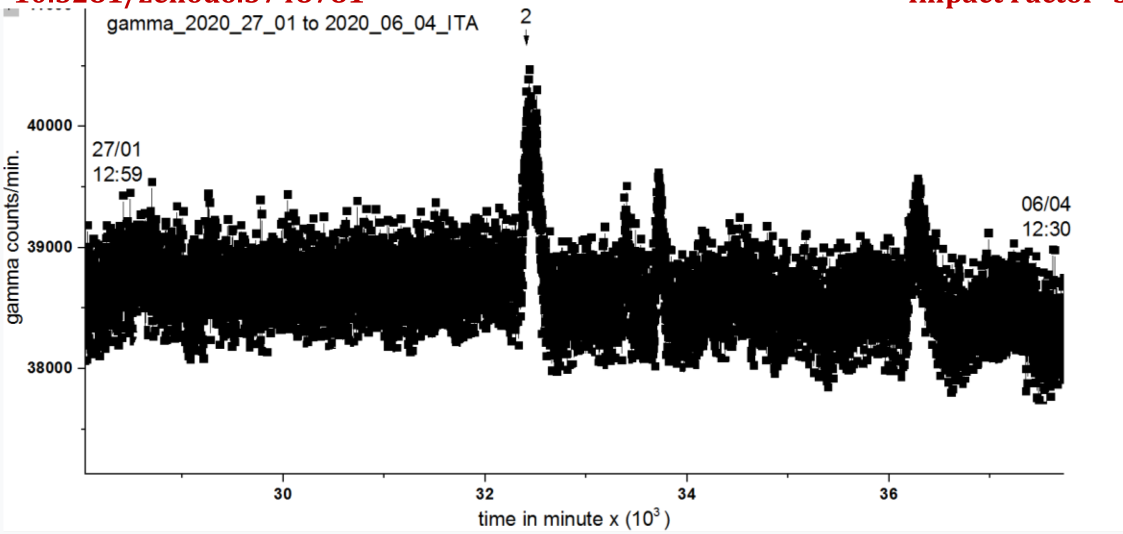

Fig. 4 Expansion of the series of measures next to point 2 where there are also four small rains

Also in Figure 5, the third measured peak of gamma radiation is shown around the time of 42500 minutes after the start of the series seen through the zoom at that location.

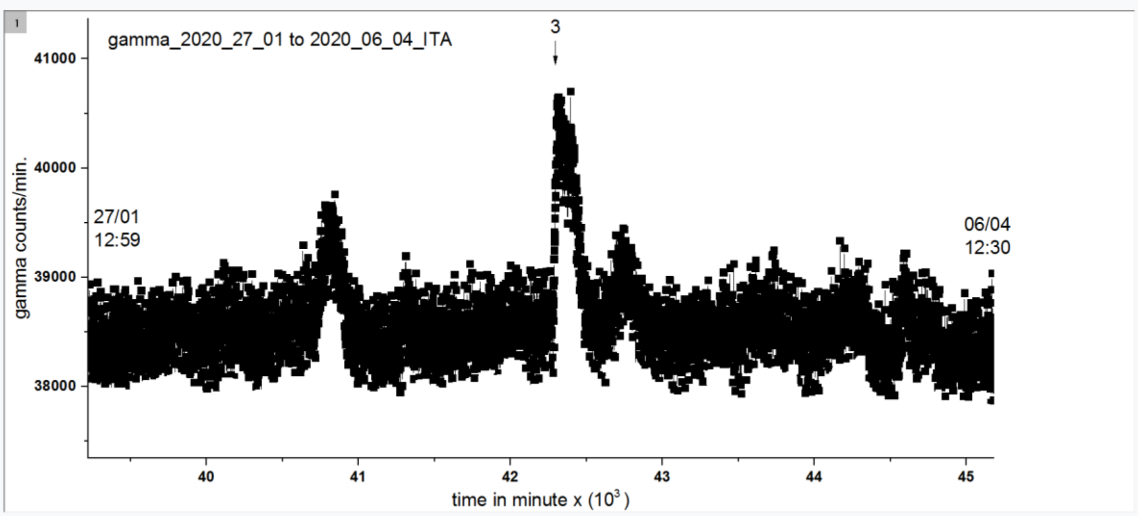

Fig. 5 – Radiation measurements expanded close to point 3 of Figure 2, showing 3 rains

The greatest highlight was observed in Figure 6 in the time of approximately 90000 minutes from the begin of measurements, see Figure 2, with the highest intensity of rain measured in these series. Also see in this Figure 2 that the time without intense or moderate rains was very long between points 3 and 4, in the order of 45000 minutes, that is, 31 days. In that interval the land on the local surface was very dry. The rain arrived intensively and during less than 7 hours, it is rained in the place net of 45 mm. At the beginning of the rain, there was an intense washing of the air nearby, causing all the radon gas that was suspended in this region at the lower atmosphere to fall to the ground. For this reason, the peak of gamma rays was very evident, as shown in Figure 6. Also between that time points 3 to 4, there was the passage of 5 cold fronts coming from the south of Brazil. These fronts composed of hot and cold days can be seen in the graph in Figure 2.

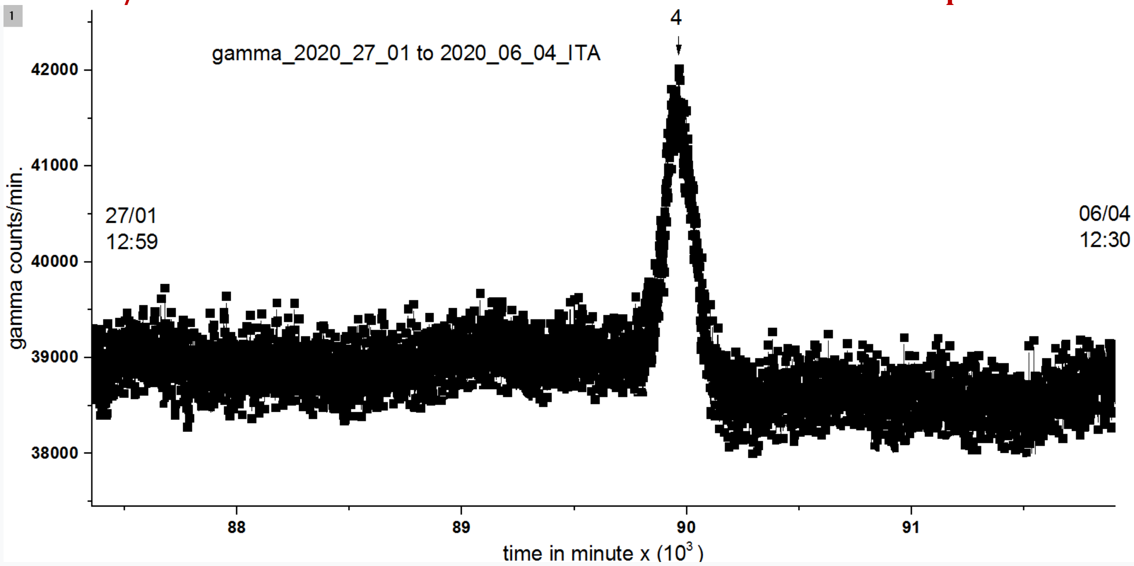

Fig. 6 - View of an intense rain (net = 45mm) in a short time of duration

Figure 7 shows the joint graph containing the measurements of rainfall and gamma radiation in the all period examined above (see Figure 2). It can be seen that there is a good correlation between peaks in the intensity of rainfall and the peaks of measured gamma radiation.

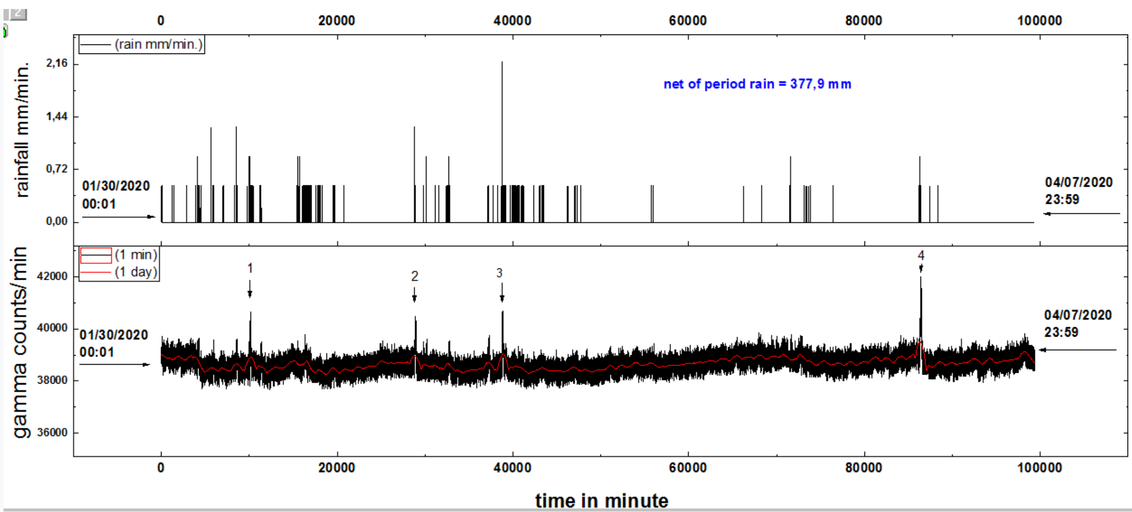

Fig. 7 - Rain intensity and gamma counts radiation (every minute) at the same place and same time

In that same place, the intensity of radon gas per hour during the entire period was also monitor edusingan alpha particleionization chamber (RadonEYE). A positive e agreement was also observed in rain / radongas.

IV. CONCLUSION

During the total period from January 27 to April 4, 2020, gamma ray counts between 200 keV - 10 MeV were monitored every minute and the rainfall intensity of the ACA tower on the ITA campus at every minute. They made it possible to observe the dynamics between the intensity of gamma radiation and the intensity of rainfall in the same place. It was also possible to identify through the gamma radiation measurements the number of cold fronts passages and the (day / night) variations in radiation caused by the presence and also variations of radon gas in the tropical region of Brazil.

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