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LOW ENERGY GAMMA RAYS MEASUREMENTS DURING JANUARY TO FEBRUARY 2017 IN SÃO JOSÉ DOS CAMPOS, SP, BRAZIL REGION

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ABSTRACT

During the month of January 2017, the region of São José dos Campos, SP, Brazil, was affected by abnormal rainfalls of twice the historical average recorded in this place. However in the month of February of 2017 this same region suffered very high temperatures and very low presence of rains. In that period the intensity of natural γ- radiation between 200 keV-10.0 MeV at a fixed altitude of 25 meters above the ground with a sampling intervals of 1 minute. In the same place was measured also every minute. The dynamics of the measured gamma radiation and rainfall intensity during the period are analysed in this paper and supposed phenomena involved in this correlation are discussed.

KEYWORDS: Rainfall, Gamma Radiation, Meteorological Parameters

INTRODUCTION

In the ground level interface of the Earth's atmosphere, ionizing radiation is mainly results from radon decay gas, the telluric radiation from the ground and the primary and secondary cosmic radiation produced in ground and low atmosphere interface [1]. However, it is difficult to separate over time the intensity of ionizing radiation of each component as the energies overlap. The telluric radiation is constituted by ^{238}U, ^{235}U, ^{40}K, ^{232}Th decay products, and it is constant in each specific region [2]. Radon gas ^{220}Ra and Rn-222 are measured by isotopes ^{214}Pb, ^{214}Po and ^{214}Bi originating from the uranium decay in the earth's crust [3, 4]. The primary cosmic radiation consisting mainly of high energy galactic and extragalactic protons and those from the Sun which interact with the Earth's atmosphere produces the EAS (Extensive Air Showers) [1, 5]. The intensity of this radiation is maximal at altitudes between 13 km and 17 km (Pfotzer maximum) in the tropics forming secondary cosmic rays flux with muonics, hadronics and electromagnetic components that propagate to the Earth's surface in the same region. This radiations cause health problems for the crew and passengers of civil and military aviation and are more intense present at the beginning of the stratosphere at 13 to 17 km.

However, this component contributes less to radiation concentration on the Earth's surface. Another possible natural ionizing radiation source in the lower atmosphere of the Earth are by electrical discharges between clouds-earth ground; clouds-clouds and earth ground-clouds. X-rays, gamma rays, neutrons and beta particles are produced all the way of the lightning cone [5, 6, 7]. Other ionizing radiation sources are those in industry, medical or dental clinics and hospitals, but these radiations are mostly controlled in small areas.

METHODS

To monitor the gamma radiation in interval between 200 keV to 10.0 MeV, it has been used a portable system detector composed of one Sodium Iodide scintillator activated 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 1500 VDC and with data acquisition system provided by the company (Aware Electronics-Inc., USA) [8]. Detector and associated electronics were previously calibrated in ITA (Technological Institute of Aeronautics) laboratory using radioactive sources Cs-137, Sr-90 and Po-210 in terms of energy from emitted photons and particles: 1.17 MeV, 0.90 MeV and 5.4 MeV respectively [9]. The rainfall intensity in mm was observed with a pluviometer (bascule/bucket) rain gauge and data logger acquisition developed in ITA according to the international recommendations. The data acquisition in terms of ionizing radiation and intensity of rainfall was performed using 1-minute time interval between each measurement. This detail contributes to verify possible correlations between variation of rain intensity, and local ionizing radiation. The set of devices were installed at a room 25 meters high from the ground where it was monitored gamma rays and all associated electronics [10]. The rain detector is placed on the outside on top of the room with electrical and electronic interface with cables connected in computers and data logger inside room. Figure 1 shows the structure of the tower on the outside view, closed with controlled room temperature of 20 degrees Celsius.

Figure 1: Outside View of Room on the Top of Tower with the Detectors and Electronics

This same tower it was employed to observe lightning's in the region since 2000 year up to now.

RESULTS AND DISCUSSIONS

The gamma-rays records in the period of December 18, 2016 to January 22, 2017, are shown in Figure 2. It is possible to see in this Figure 2 that the gamma radiation during all intervals of measurements presents many variations keeping one mean value of 35500 counts/min. The peaks above 37000 counts/min were produced in intensive rainfalls mostly in 20000 and 70000 minutes. Taking the data in these times from Figure 2 and making a "zoom" it is possible to see in Figure 3 and in followed Figure 4, an influence of rainfall in increases of low energy in gamma rays intensity.

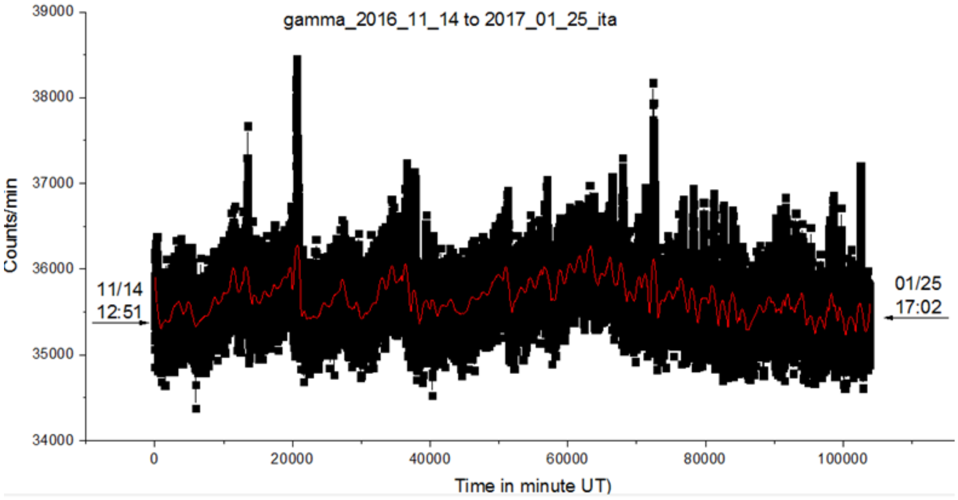

Figure 2: Measurements Performed Between 11/14/2016 To 01/25/2017. Red Line Represents Smoothed by day from the 1 Minute Data.

Figure 3 shows measurements performed at near 19000 minutes after detector starting using a “zoom” from the data of Figure 2 near this time.

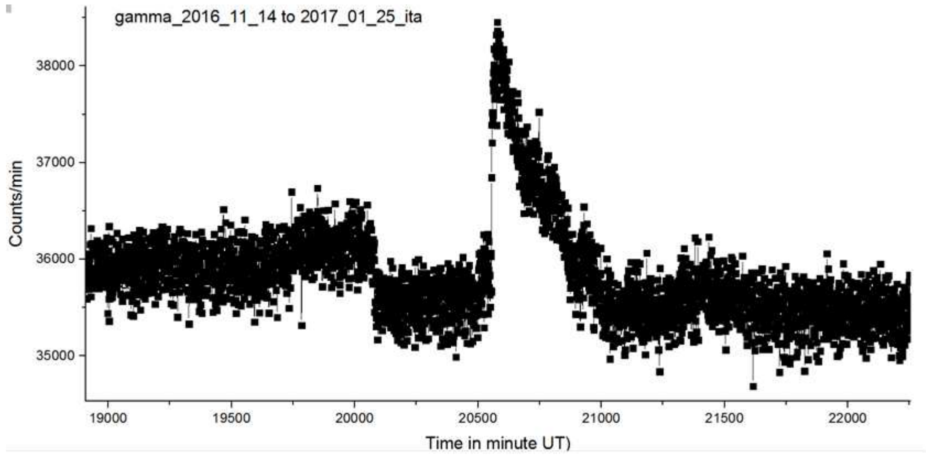

Figure 3: The Increase Gamma ray Intensity during Rainfall Between 20500 to 21000 Minutes from the Start of Measurements.

During about 2 days it was possible to see four rainfalls with one more intense that is marked with one number 3 in the same Figure 4. The others peaks 1, 2 and 4 in same Figure 4 represents rains of much less intensity. In the Figure 5 it was plotted one week of ionizing radiation measurements. The gamma ray increases each day by quasi semi time due to the presence of regularly rainfalls. From 76000 to 86000 minutes all the days during these week, rainfalls arrived each day at same time (~ 16:00 L.T.), so correlation with gamma radiation and rain precipitation becomes visible. The Figure 6 and Figure 7 show this phenomenon during several days in January, 2017 in that region. During the month of February 2017 the rainfall intensity in the region was much lower than the historical average. The local temperature remained very high during the day and at night, ranging from 25°C to 33°C. This weather condition caused a typical presence of gamma ray intensity variation which can be visualized in Figure 8.

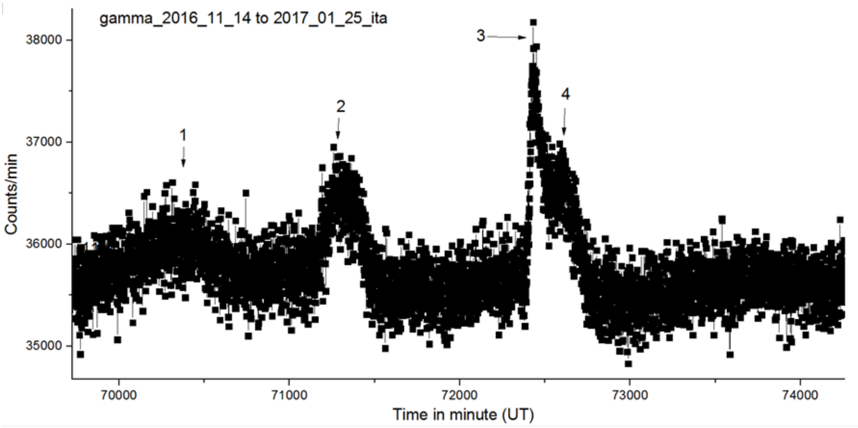

Figure 4: “Zoom” Plot of Data from the Figure 2 Showing Four Peaks of Gamma Radiation.

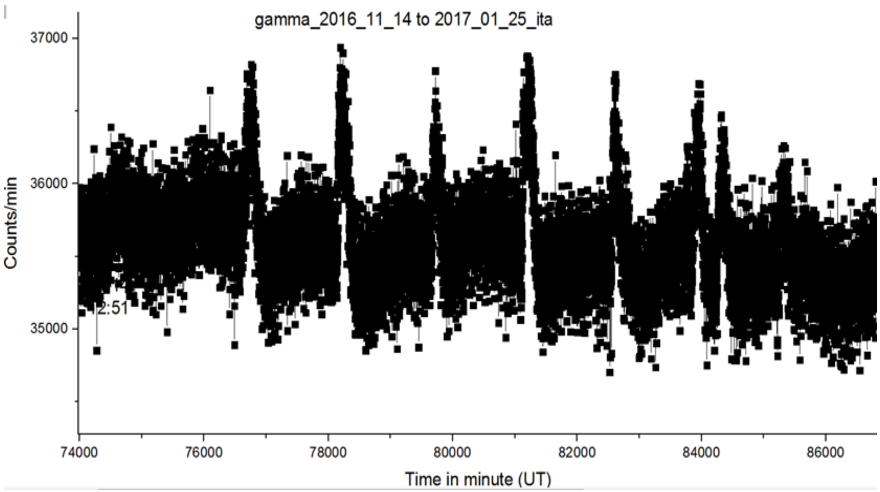

Figure 5: “Zoom” from Data of Figure 2, during one Week, Showing the Afternoon Regularly Rain and Increases of Gamma Radiation Provoked by Afternoon Regularly Rains

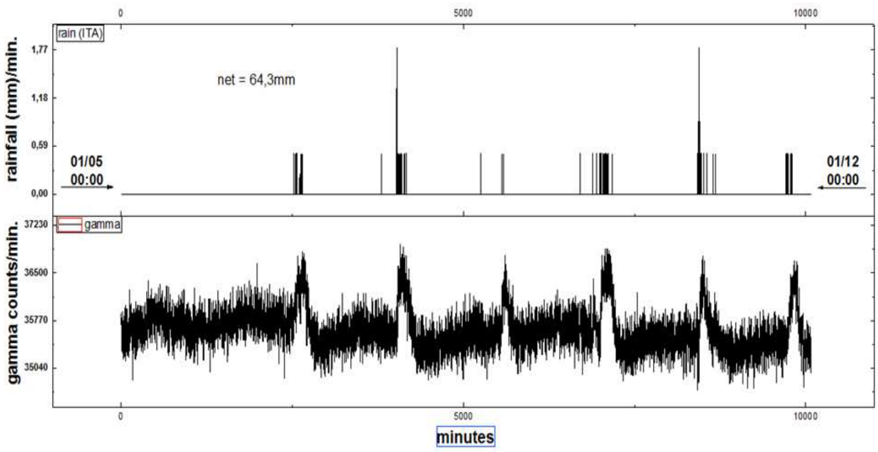

Figure 6: Correlations between Gamma Rays and Rain Precipitation during 01/05 To 01/12

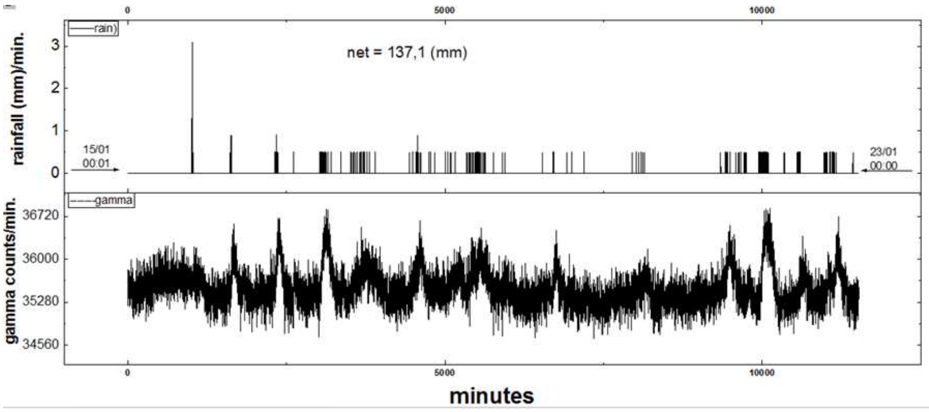

Figure 7: Correlations between Gamma Rays and Rain Precipitation during 01/15 To 01/23

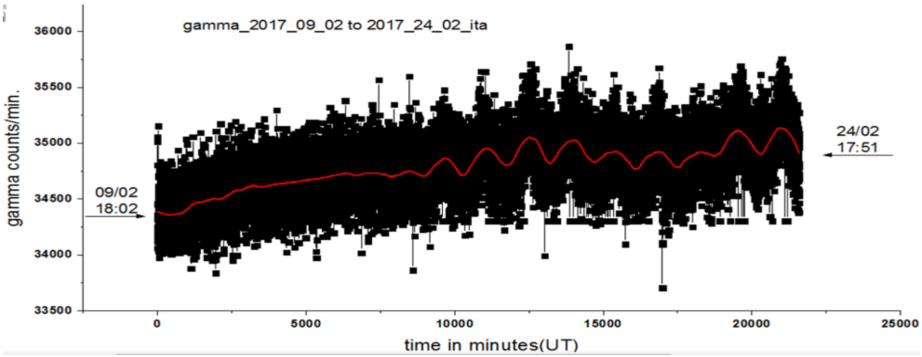

Figure 8: Gamma Rays Variation from 02/09 to 02/24 of 2017 during the Dryer Period Red Line Show Days Smoothed Value

It can be seen from the data plotted in Figure 8 that from beginning to around 10000 minutes of measurements after start up there was a very little increase in variation of intensity of gamma rays. Due to high temperature and low relative humidity the average intensity of gamma radiation increases between these days. Certainly this fact occurs due to the greater release of radon gas from the earth's crust to the air due to high temperature in the region. From about 10000 to 23000 minutes from the beginning the weather becomes so hot (~30^0C) day and night and the air relative humidity near 30% that the radon gas make regularly day/night variations.

CONCLUSIONS

The uninterrupted continuous measurements of gamma radiation every minute throughout 2016 and begin of 2017 clearly show the variation of rainfalls in the region, even identifying with relative value its intensities. It is verified that in dry periods with low and constant relative humidity of the air as indicated in Figure 8, the intensity of the radiation varies with the presence (day/night) with exact period of 1 day. It is stated that this perfect periodicity in the measured intensity of the gamma radiation is linked to higher and lower exhalation of the radon gas (Rn-222) due to the (day/night) temperature effect in the earth crust region. This periodicity is partially or totally destroyed with the presence of fog and rain or drizzle in the region. It can soon be said that the region of São José dos Campos has intense radon gas exhalation activity as measured by local ionizing radiation measurements throughout these periods. Depending of calibration (volume of radon gás exalated and gamma ray intensity) this procedure can be proposed to monitoring long period of radon gas in the region.

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