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Gamma radiation dynamics between (0.2-10.0) MeV with respect to meteorological phenomena near ground level in São Jose dos Campos, Brazil

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ABSTRACT
Gamma radiation monitoring between (0.2 - 10.0) MeV was performed at ITA campus in the São Jose dos Campos, Brazil region. Measurements were taken from 12/08 to 07/10 2019 using a (3”x 3”)NaI (Tl) scintillating crystal with associated power and data acquisition electronics. During this period investigated was evidenced by gamma ray measurements, two rains being one more intense and the other moderate. Two periods of clear skies and very warm, with two other periods of cloudy skies Thus, the objective of this work is to show experimentally that in any location near the Earth's surface in tropical and equatorial regions, the minute-by-minute monitoring of gamma radiation in the above energy range, describes the variation of the local meteorological phenomena. This facility is very important for observing in a remote region the dynamics of meteorological parameters measuring only the gamma radiation counts per minute on site.

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I. INTRODUCTION

To monitor environmental ionizing radiation from anywhere on the ground / air interface, proportional counters (Geiger) and / or thallium activated NaI or CsI scintillating crystals can be used. In the case of Geiger they depend on the sensitive type tubes that are manufactured. They depend on the gas inside, the internal pressure of this gas and the high operating voltage of this pipe. The best and cheapest Geiger tubes are made in Russia and China. Nowadays Geiger-associated electronics are found in international trade market at reasonable prices. The Arduino electronic system can be used for this task of feeding and acquisition data measurements. Geiger can only show the count per unit time of the environmental ionizing radiation from the site to a previously chosen energy range. Sodium iodide or cesium iodide crystal with thallium activated allow to measure local environmental ionizing radiation by the scintillation process. This process with a more elaborate electronics allows determining the radiation energy being measured. Environmental ionizing radiation consists of photons and particles that vary depending on local geology, surface high relative to sea level, and primary - secondary cosmic radiation. It is also function of atmospheric pressure and relative humidity, drought and local rainfall regime. This environmental ionizing radiation strongly depends on the presence of radon gas intensity at the measurement site [1] and [2].Uranium-238's nuclear decay series and cosmic radiation from outside of planet Earth are responsible for producing gamma radiation on the Earth's surface [3].

II. MATERIALS & METHODS

A thallium-doped Sodium Iodide crystal scintillator [NaI (Tl)] were used to measure gamma photon counts between 200 keV to10.0 MeV [4].The scintillator-associated electronics consist of a 1500 VDC continuous source and a minute data acquisition system. All of this electronics and crystal scintillator were designed and calibrated in energy and intensity by Aware Electronics Inc, USA [5]. Figure 1 shows the photomultiplier-coupled scintillator that were used in this work. Both radiation measurements (counts / minute) and rainfall intensity measurements (mm / minute) were recorded during this work in (.txt) files and saved to PC computer. 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 [6]. 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. The data acquisition in terms of ionizing radiation and intensity of rainfall was performed using 1-minute time interval between each measurement[7].

Fig. 1 – Sodium Iodide scintilator and photomultiplier used in this gamma radiation measurements, (Aware Electronics, INC, USA).

III. RESULTS & DISCUSSIONS

Gamma radiation in the energy range described above was measured at each one-minute interval continuously between 08/12 to 07/10 of 2019. It is observed in this interval that there were two peaks with increased radiation intensity caused by local rainfalls. There are two periods showing variations in radiation intensity due to the presence of cloudy sky in the region. Also variations in radiation intensity show the passage of four cold fronts moving in the region.

Figure 2 below shows these details being plotted on the vertical axis counts / minute and on the horizontal axis time variation in minutes from start to end of on-site measurements.

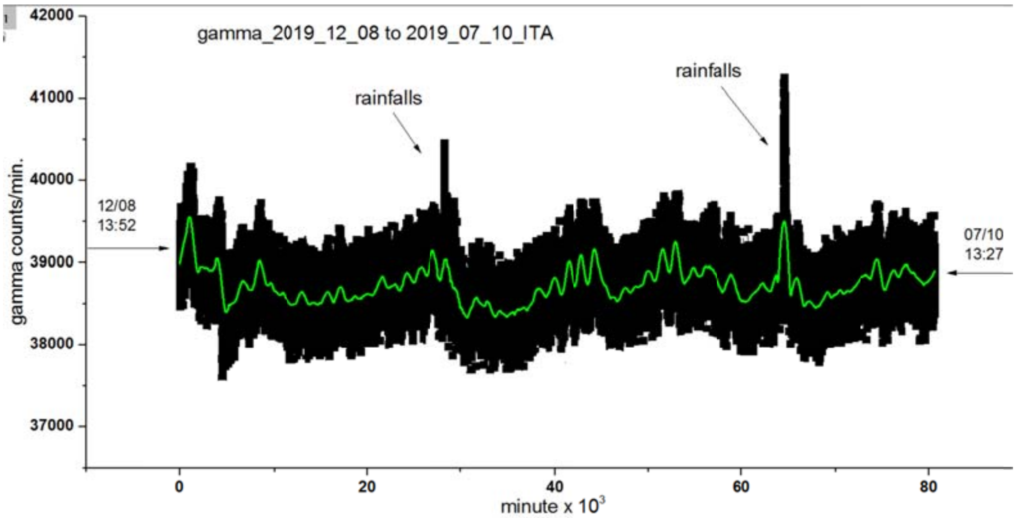

Fig. 2 – Measurements of gamma ray radiations in (counts/min.) during 55,5 days of 2019.

During the start of measurements up to 12000 minutes the sky was cloudy. This predominant weather condition altered the dynamics of the local gamma radiation intensity as shown in Figure 3. This figure was obtained by zooming on the initial 12000 minutes of. Figure 2.

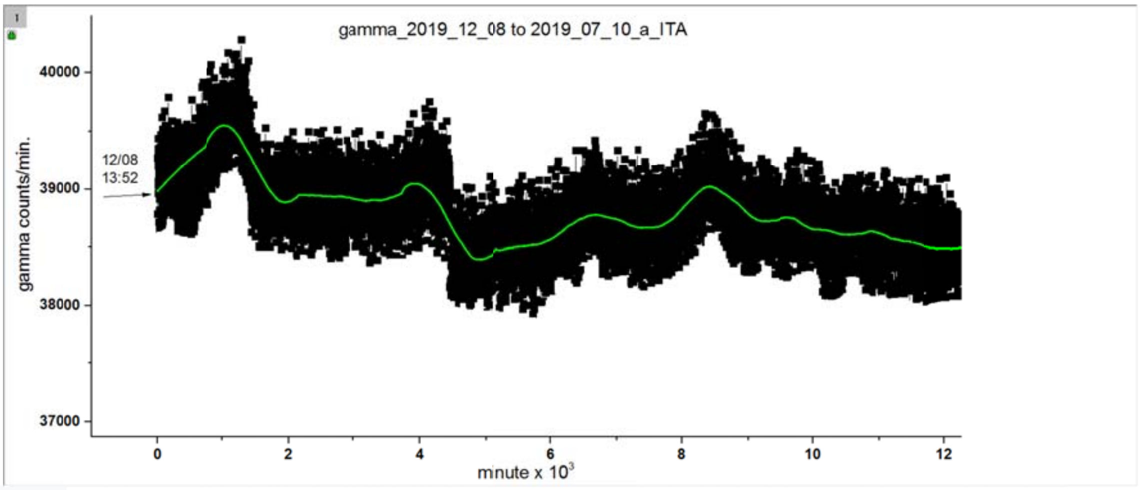

Fig. 3 – Cloudy weather with higher and lower relative humidity in the region. The 3 peaks represent the sunny days.

The stretch in the figure above between 1800 to 4000 minutes has a constant average radiation intensity of 39000 counts / min. This means that this time the sky was very cloudy. Figure 4 shows the next period and during the first rain observed in the graph of Figure 2 between the time intervals of 20,000 to 30,000 minutes of measurements.

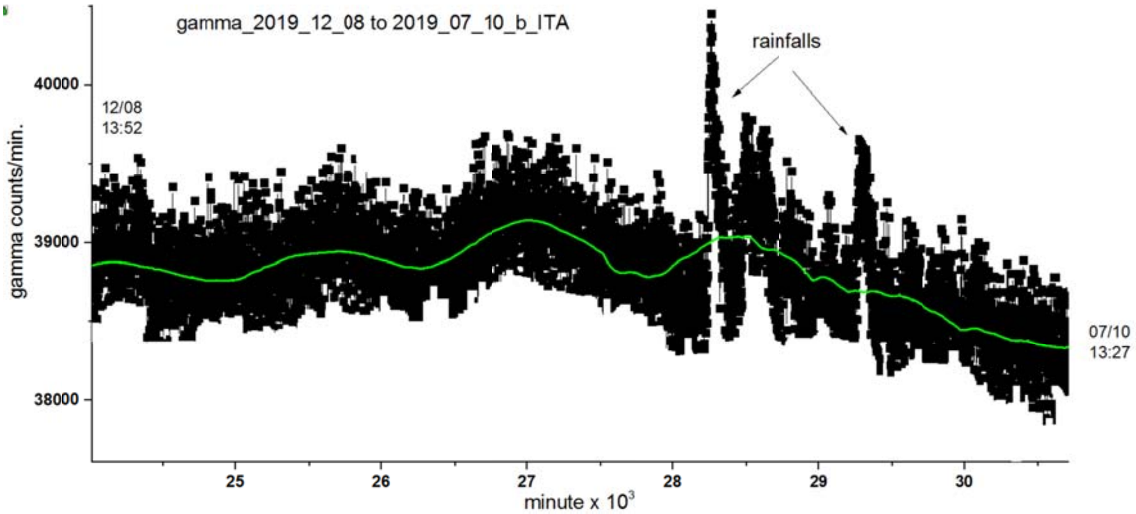

Fig. 4 – Hot sun and rain interval (zoom) shown in figure 2 with net rainfall = 27, 7 mm.

The total rainfall period observed in the figure above did not exceed two days with a net intensity of 27,7 mm. Figure 5 shows the measurement of radiation between the time intervals of 60000 to 88000 minutes. An increase in radiation over this period means the arrival of a net 25 mm of rain.
The total rainfall time was less than one day between 64000 and 65000 minutes.
Figure 6 shows the zoom of radiation measurements between the time interval seen in Figure 2 from 36000 to 46000 minutes with no rain on clear and very hot days.
At this time of measurement due to the presence of clear cloudless skies it becomes possible to visualize the (day / night) cycle of gamma radiation influenced by the variation of radon gas in the region.
This average time of 7 days indicates the beginning and the complete passage of a cold front that originates in southern Brazil and moves north bringing clouds and rain on this time measurement date.

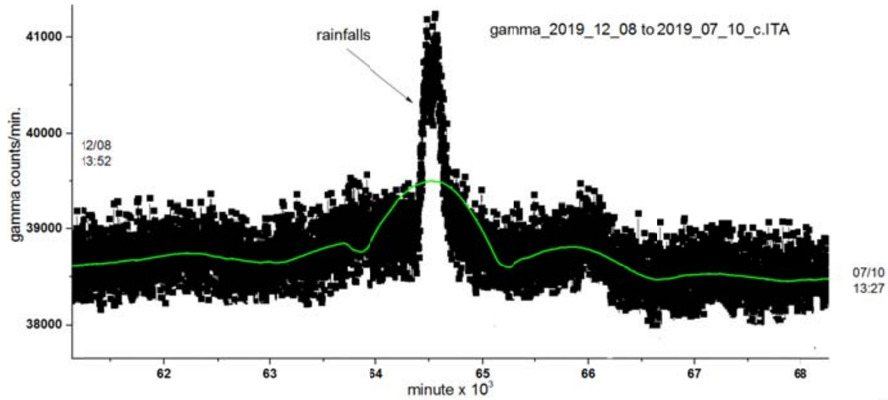

Fig. 5 – Presence of the second rain in period being revealed by the radiation measurement with net rainfall = 25 mm.

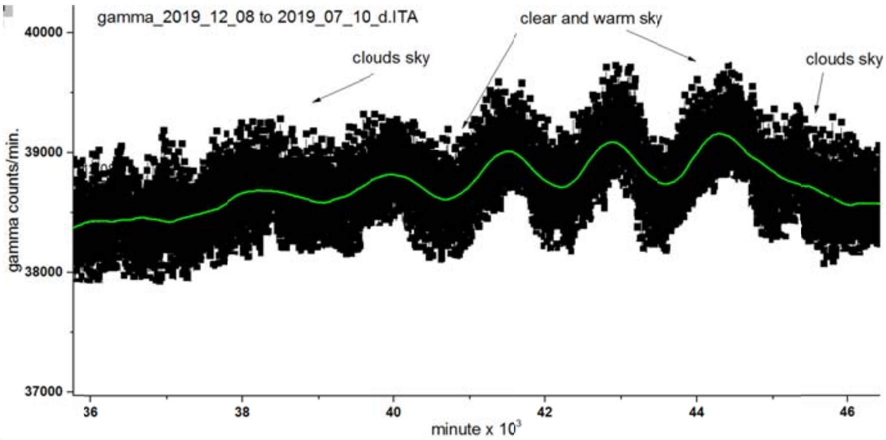

Fig. 6 – Very clear and warm day's radiation measurements shown (day/night) variations and no rainfalls were present in this interval.

It can be seen from the figure above that the intensity of gamma radiation measured in this time interval from 36000 to 44800 minutes grew to a maximum in the range 41000 to 44800 minutes with 39500 counts / minutes. Immediately afterwards the sky becomes very cloudy and the radiation decreases again in intensity. It can be seen from Figure 7 that rainfall measured at the same location as gamma radiation shows two occasions of occurrences ~ 30000 and ~ 60000 minutes that coincide with the measured radiation graph, see Figure 2.Thus it can be stated that the monitoring of gamma radiation with a precision interval of one minute showed the dynamics of meteorological parameters that occurred in this region in studies.

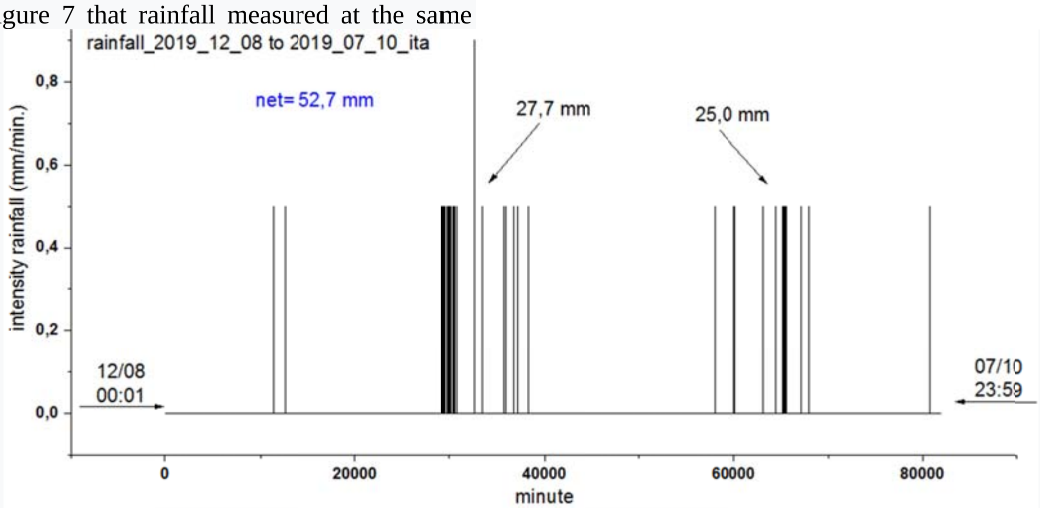

Fig. 7 – Monitoring of rainfall from 12/08 to 07/10 of 2019 in the same place of gamma radiation measurements.

The rainfall spectrum shown in the graph above intensity (mm / min.) as a function of time in minutes, allows correlating rainfall with gamma radiation at the site. This was the main objective of this experimental work.

IV. CONCLUSION

During all monitoring time from August 12 to October 10 of 2019, there were varied periods of dry and rainy weather. The uninterrupted continuous measurements of gamma radiation every minute throughout 2019 clearly show the variation of gamma radiation with rainfalls in the region. The gamma radiation is correlated with intensity of local rains. During long and continuous period of rains gamma radiation is less sensitivity of rains intensity. In the drier and warm periods both gamma radiations and intensity of radon gas measurements shows a periodicity of 24 hours. This behavior is due to the phenomenon of radon gas exhalation in the region, who’s Radium226 during decay, produce gamma rays and alpha particles in the (soil/atmosphere) interface, which should be responsible to produce more gamma radiation near ground level.

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