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Intensive Rainfalls and Ionizing Radiation Measurements in February 2020 in São José Dos Campos Brazil Region

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Abstract

In the month of February of the last 30 years, the region of São Jose dos Campos in the tropical part of Brazil has an average rainfall intensity of 151 mm. In terms of temperature, the minimum average was 170°C and the maximum average was 300°C. With a lot of cloud cover and frequent rains and little sunshine that month, the variation in ionizing radiation was monitored every month, in every minute. Two Geiger counters were used, one with a Russian tube and the other with a Chinese tube. A sodium iodide NaI (Tl) scintillator was also used, coupled to a photomultiplier and associated electronics. All of these instruments are capable of measuring ionizing radiation between 200 keV and 10.0 MeV. It can be seen from the measurements made by the two Geiger and the scintillator that the detected radiation is related to the intensity of rainfall at the time of the observations.

Keyword: Gamma Radiation, Rainfall, Radon gas, Geiger counts

Introduction

In the interface ground/air of the Earth's surface, ionizing radiation is mainly composed of radon gas, ground telluric radiation, primary and secondary, cosmic ray radiation. However, it is difficult to separate over time the intensity of ionizing radiation emanating from each component as the energies overlap. Telluric radiation is given by 238U, 235U, 40K and 232Th that is constant for each region [1]. Radon gas from the disintegration of 238U on the earth's crust to 226Ra and 222Rn arrives in the 214Pb, 214Po and 214Bi isotopes, generating alpha and gamma radiation [2]. Primary cosmic radiation consists mainly of galactic and extragalactic protons and those from the Sun, with very high energy that interacts with the Earth's atmosphere producing Extensive Air Showers (EAS) [3]. The efficiency of this interaction is the maximum when it occurs at altitudes between 13 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 civil aviation crew and passengers and are present at the beginning of the stratosphere called the 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 lightning strikes between earth-clouds, clouds-earth and clouds-clouds. X-rays, gamma rays, neutrons and beta particles are formed by the lightning cone. These ionizing radiations near terrestrial surface may even be responsible for major fires such as those seen in Portugal, Australia and Brazil in 2018 and 2019 [5]. Other sources of ionizing radiation are those produced in medical, dental and hospital clinics, but these are mainly controlled in small areas. The objective of this work was to monitor low energy gamma rays and rainfall every minute in São Jose dos Campos, São Paulo, Brazil. The rains when intense and with short intervals of time causes a sudden increase in the intensity of the measured ionizing radiation, in that place [6]. This effect of the increase in ionizing radiation can be explained by the increase, with intense and rapid rains, in the greater presence of local radon gas.

Materials and Methods

In these measurements of local ionizing radiation in the energy range between 200 keV and 10 MeV, the three instruments described below were used:

Geiger-China counter

Among the various ionizing radiation counters that have been developed and optimized throughout history, the Geiger-Muller counter is undoubtedly the most well-known and used today. Thus, this was the most obvious choice for the development of the experiment. Due to the accessible cost, the Geiger-China counter was chosen and, for pedagogical purposes, this counter is as accurate as other more developed ones, as demonstrated by Silva, et al. (2017) [7].

The Geiger-China counter reads in CPM (Counts Per Minute) and passes the information to the Arduino system, which in turn turns it into a table of points to which the WebLab user has access. The meter makes no distinction between the types of ionizing radiation, that is, the values shown are the sum of all ionizing radiation in the location, including environmental ionizing radiation (integrated radiation).

The Geiger-China tube (Figure 1) is made up of transparent glass whose measures are 8 cm long and 1 cm in diameter. The difficulty of using this meter is that the gas inserted in your tube detects visible light as well. Therefore, in order to perform good measurements of ionizing radiation, the tube must be covered to reduce the interference of visible light in the experiments (Figure 2).

Russian Geiger counter

Measurements obtained with Geiger-Russian is better in order to expose and discuss with students how environmental ionizing radiation are influenced by some parameters such as rain, altitude and others, some experiments were organized using Geiger-Russian as the counter. The Geiger-Russian tube (Figure 3) is made of (aluminum/ceramic) material whose measurement is 20 cm long and 2 cm in diameter. As the material that lines the tube is possibly opaque to ultraviolet radiation and its size is approximately twice that of Geiger-China, consequently greater precision in its measurements is obtained (Figure 4).

Sodium Iodide Scintillator

Variation of environmental ionizing radiation as a function of precipitation this work discusses how the interaction of environmental ionizing radiation are influenced by ambient temperature, and, on rainy days, with radon gas. In order to identify the influence of rain in the detection of environmental ionizing

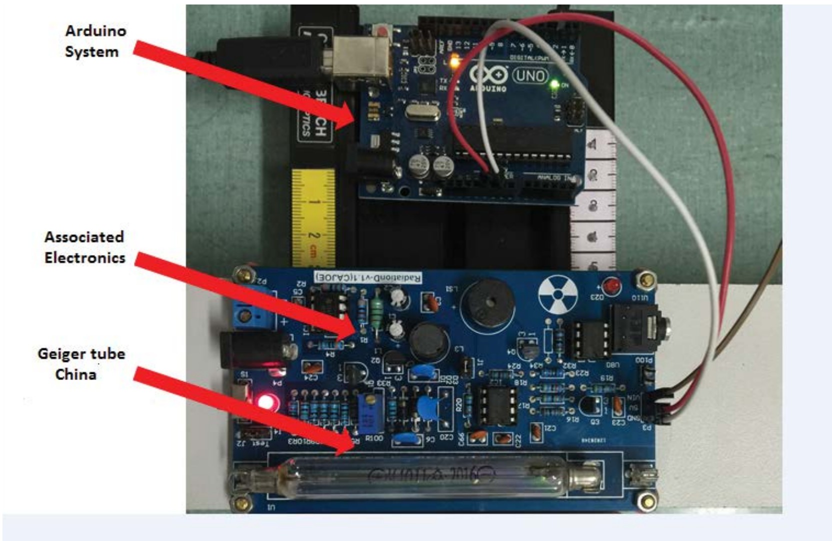

Figure 1: Arduino system, associated electronics and Geiger tube – China [7].

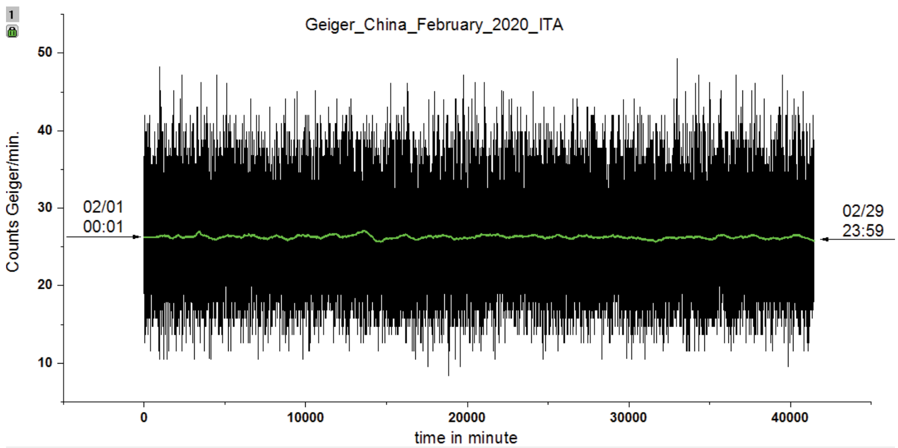

Figure 2: Measurements of ionizing radiation from 200 keV to 10 MeV using Geiger-China. Green line showing the one day smoothed curve for February, 2020.

Figure 3: View of Russian Geiger counter [7].

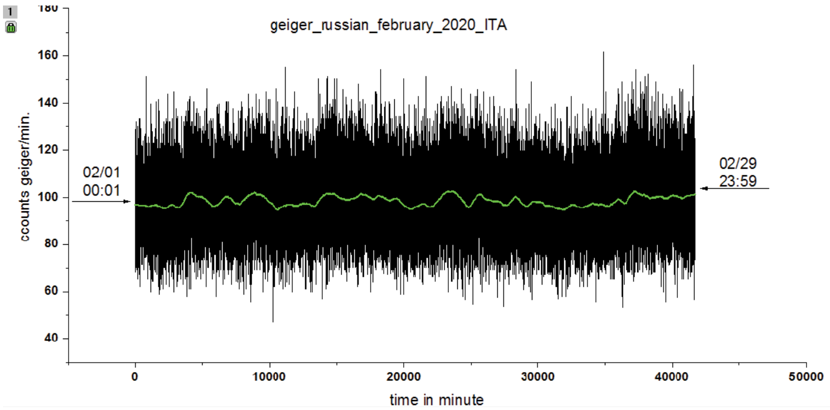

Figure 4: Measurements of ionizing radiation from 200 keV to 10 MeV using Russian tube Geiger. Green line showing the one day smoothed curve for February 2020.

Figure 5: High precision Gamma Detector. Sodium Iodide crystal [NaITl)] doped with Thallium [9].

radiation, it was necessary to use a more accurate detector called the Gamma detector (NaI(Tl)) Sodium Iodide Scintillator [8], see Figure 5.

Monitoring of ionizing radiation, varying with rain, was carried out at the ITA (Figure 6) located in São José dos Campos, Brazil tropical region. The Gamma detector is in a room with an air-conditioned environment (200 C) so that temperature fluctuations do not affect the data of the experiment.

It can be seen in these February 2020 gamma radiation measurements that 3 blocks centered on 15000, 35000 and 45000 minutes after start, showed an increase in radiation intensity. Figure 7 below shows the measurements of the intensity of rainfall at the same site every minute, making a net of 287.5 mm in February 2020. The average rainfall intensity for February in the last 30 years was 151 mm. In February 2020, the intensity of rainfall for the place practically doubled. It is observed that in 15000 and 35000 the rains were very intense reaching the time of 45000 minutes. This fact of correlation (rainfall-gamma) is visible from a qualitative point of view, as shown in figure 6 and figure 7 above. In this month of February 2020, figure 7 shows three important rain block periods. In the same period, figure 6 shows 3 distinct blocks of the intensity of gamma radiation measured at same local. This fact was considered very important because after an accurate calibration of the gamma radiation and rain intensity detectors with time, it is possible to monitor rains from inside covered areas with greater facilities.

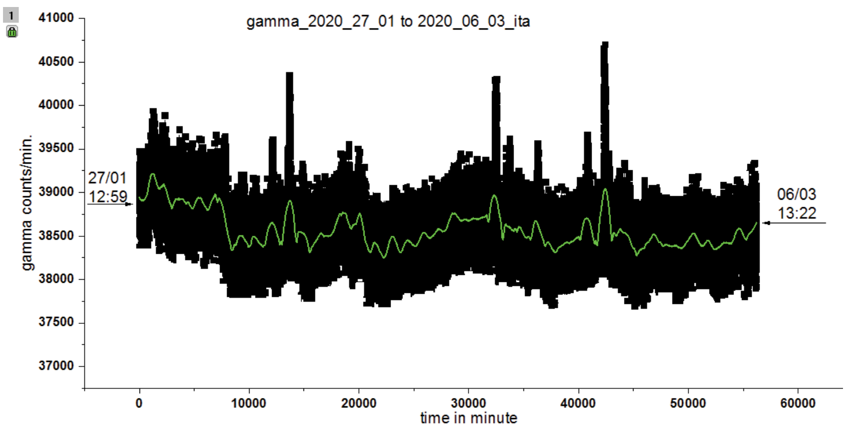

Figure 6: Counting's per minute of gamma rays radiation in the interval of 200 keV to 10 MeV, from 27/01 to 06/03 in 20220. The green line corresponds to one day smoothed curve.

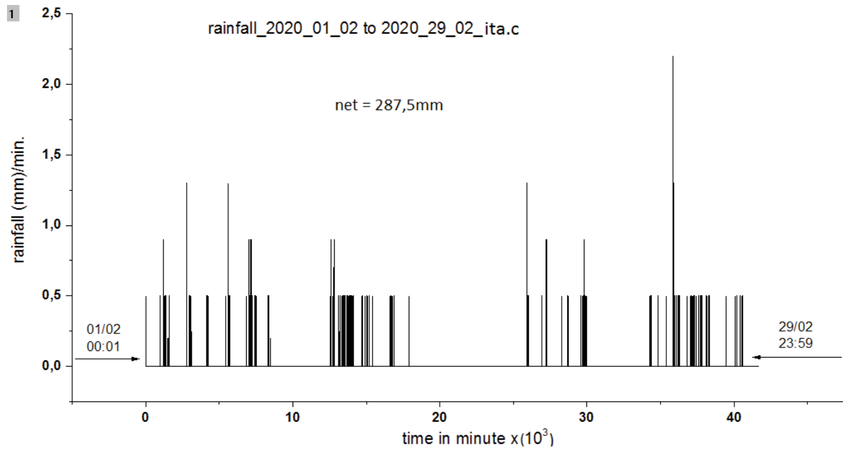

Figure 7: Rainfall intensity at each minute in the month of February 2020.

So with this low-cost, easy-to-operate experimental system, any group will be able to monitor the rain intensity of their home, school and even small towns using a simple gamma radiation detector in that energy range.

Conclusion

In February 2020, the variation in rainfall intensity and environmental ionizing radiation (photons and particles) in the city of São José dos Campos, a tropical region of Brazil, was monitored. February 2020 was chosen for this study because the net rainfall intensity in that month was twice the average of the last 30 years. Therefore, the comparison between the spectrum of radiation and rainfall over time with a minimum interval of one minute shows a positive correlation between rain and ionizing radiation. It is said that during periods of rain there is a washing of radon gas in air close to the Earth's surface and an possible increase in ionizing radiation at the site overcome with the surface dry for several days and an intense external rain coming in, there are always peaks of ionizing radiation well above normal, thus showing the presence of radon gas in the region with respect to the environmental radiation monitoring measures carried out in this work through Geiger, it was noted that only the Geiger with Russian tube was more sensitive to radiation variation as a function of time. However, the Geiger Chinese tube only measures the average level of the site, which is 0.25 μSv/h radiation dose.

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