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RADON GAS, LOW ENERGY GAMMA RAYS AND NEUTRONS MEASURES DURING 2018 PERIOD IN SOUTH ATLANTIC ANOMALY REGION

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Abstract

During the month of January 2018 to end of September 2018, the region of south Atlantic Magnetic Anomaly nearSão José dos Campos, SP, Brazil, was affected by climate change. Very few rainfalls of much less number compared from the historical average was 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 level suffered remarquable variations. In the same place was measured every minute the neutrons intensity variations. The dynamics of the measured gamma rays, radon gas andneutron radiationincluding rainfall intensity during the period are analysed in this paper. According to these measurements in2018 and supposed phenomena involved in this correlation radon gas, gamma ray, and neutronwere discussed in this work.

Keywords: *rainfall, gamma radiation, neutron measurement, radon gas.*

I. INTRODUCTION

In the ground level interface of the Earth's atmosphere, ionizing radiation is mainly results from radon gas, the telluric radiation from the ground of Earth and the primary and secondary cosmic radiation produced in low atmosphere interface [1]. However, it is difficult to separate over time the intensity of ionizing radiation of each component including particles and photons coming from South Atlantic Magnetic Anomaly "SAMA" 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 ^{222}Rnare 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 coming from those regions which interacts 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, hadronic and electromagnetic components that propagate to the Earth's surface in the same region. The low energy neutrons up to 10, 0 MeV present in ground level mostly by cosmic rays and (α, n) reactions with surface earth's elements. 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 is 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 specific and small areas.

II. MATERIAL AND 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 aluminium foil and coupled with a PM (photomultiplier) with

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source power circuit settled in 1500 VDC and with data acquisition system provided by the company (Aware Electronics-Inc., USA) [8]. The neutron-monitoring detector consist of two identical tubes of proportional counts He-3 with power supply of 1500 VDC.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 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. 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, 11]. The rain detector is placed on the outside on top of the room with electrical and electronic interface white 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.

Fig. 1 – Aerial and ground view of the tower ACA/ITA and his environmental field region

This tower it employed to observe lightning's in the region since 2000 year.
It is a clean place with trees without major man-made electromagnetic interference.This tower is used for research in geosciences and monitoring of ionizing radiation near the ground level.

III. RESULTS AND DISCUSSION

The measures of environmental ionizing radiation, gamma rays and neutrons were made during each minute at 25 meters high inside the room localized in tower region of Figure1. The gamma-rays measures range from (0.200 to 10.0) MeV. The neutrons measurements range of (0, 002 to 10, 0) MeV for the period of Januaryto September26, 2018.In the long series of measurements showed Figure 2, only one peak of gamma radiation appears at this time indicating no intense rains that period in the region.

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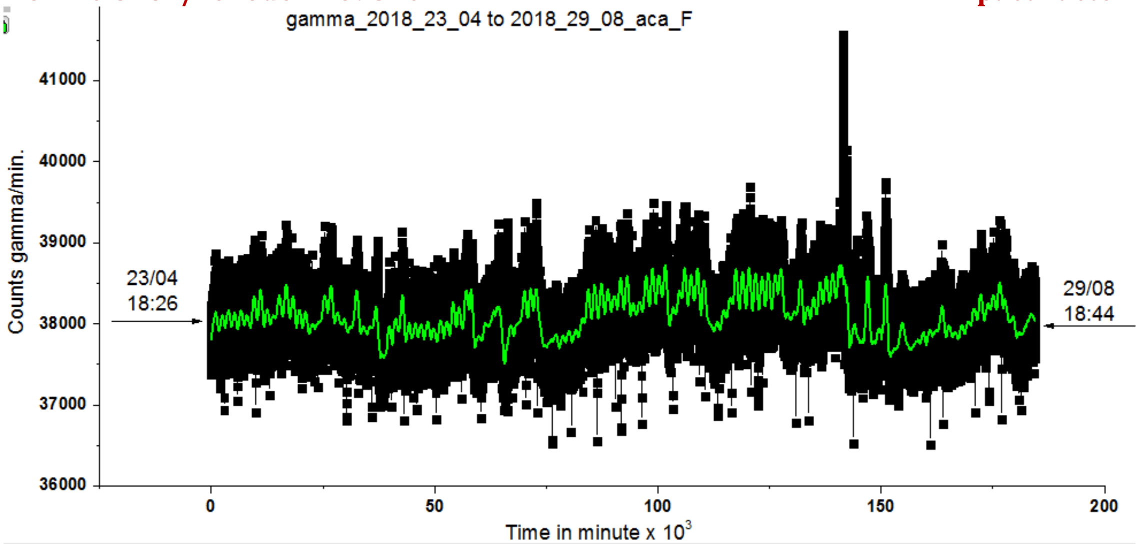

Fig. 2: Gamma ray counts rate from 23/04 to 29/08 with 1 day smooth showed green line.

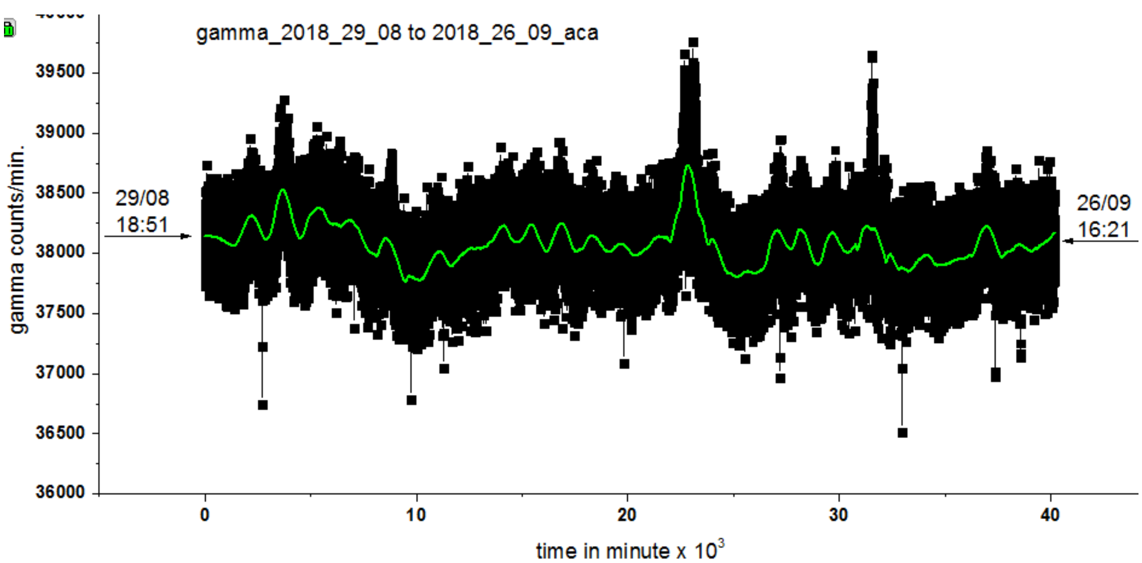

Fig. 3: Gamma ray counts rate from 29/08 to 26/09, 2018 with 1-day smooth showed green line

During the period of measures showed in Figure 3 of gamma radiation it is possible to observe tree peaks of that radiation due to the rains influence. However, these rains were of low intensities causing little increase of the gamma radiation in the place. The smoothing shown by the green curve and both figures indicate periodicities of a day. When there are clouds of sky cover, fogs, or mists in the region this periodicity disappear.

Figure 4 shows the long series of measurements of neutron intensity in the energy interval (0.002 to 10, 0 MeV) observed intensity variations between 06/08 to 26/09, 2018. The peaks with increased neutron intensity shown in Figure 4 may be due to wet soil by the rains or very hot soil surface on clear days withno clouds in the sky.In Figure 5 the hourly measurements of the radon gas emanating from the local land surface were placed in the period from 05/05 to 06/11, 2018.

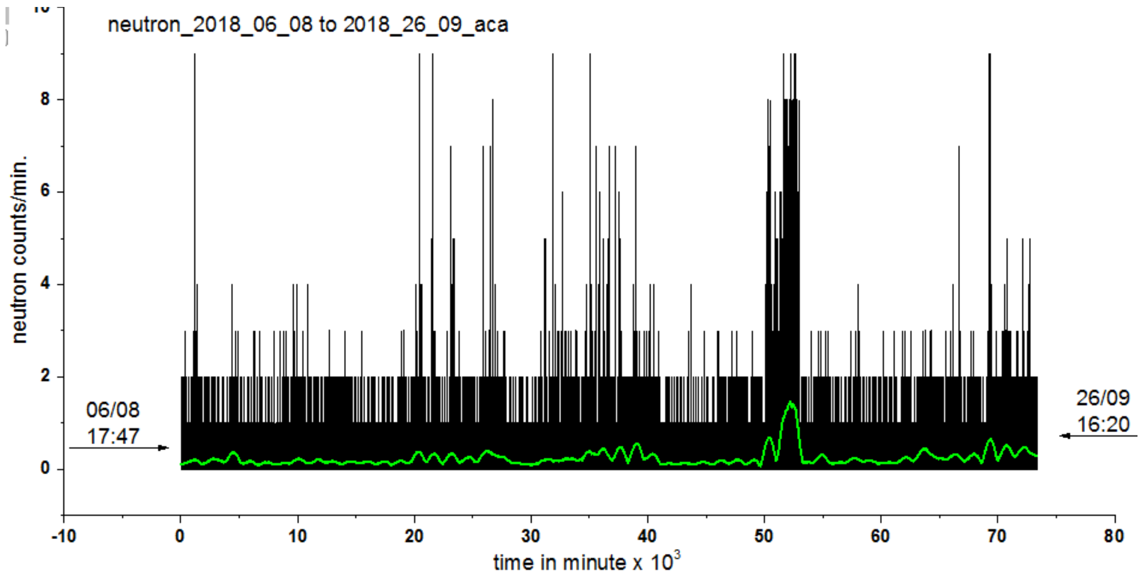

Fig. 4 Monitoring of neutrons from 06/08 to 26/09 in 2018.

In Figure 5 the hourly measurements of the radon gas emanating from the local land surface were placed in the period from 05/05 to 06/11, 2018. Red line curve indicate one day smooth value.

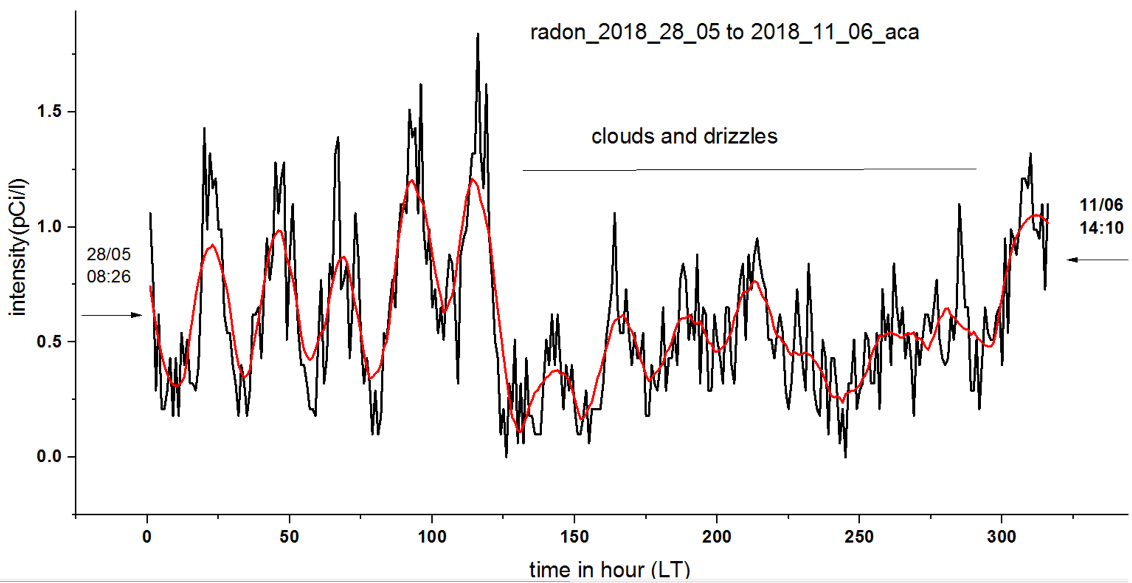

Fig. 5 Observation of intensity of radon gas emanating from the soil in the period 28/05 to 11/06, 2018.

Figure 6 shows the graph of variation of the radon gas in the period from August 31 to September 24, 2018. In this interval of measurements, three rains and warmer temperatures made variations in the intensities of the radon gas. The smoothed red curve of one-day show the dynamic of radon gas per day in that region and period of measurements. Measurements of radon gas during periods of drizzle or even in the presence of low-altitude clouds in the sky decrease the intensity of radon gas in the region. This effect were perceived as shown in Figure 5.As it is observed in Figure 6 in this period of small rains and heat the variation of the radon gas is quite dependent on the

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local soil temperature and the presence of low clouds. It was not clear whether the presence of cold fronts from the south greatly altered the intensity of this gas on the land surface of the region.

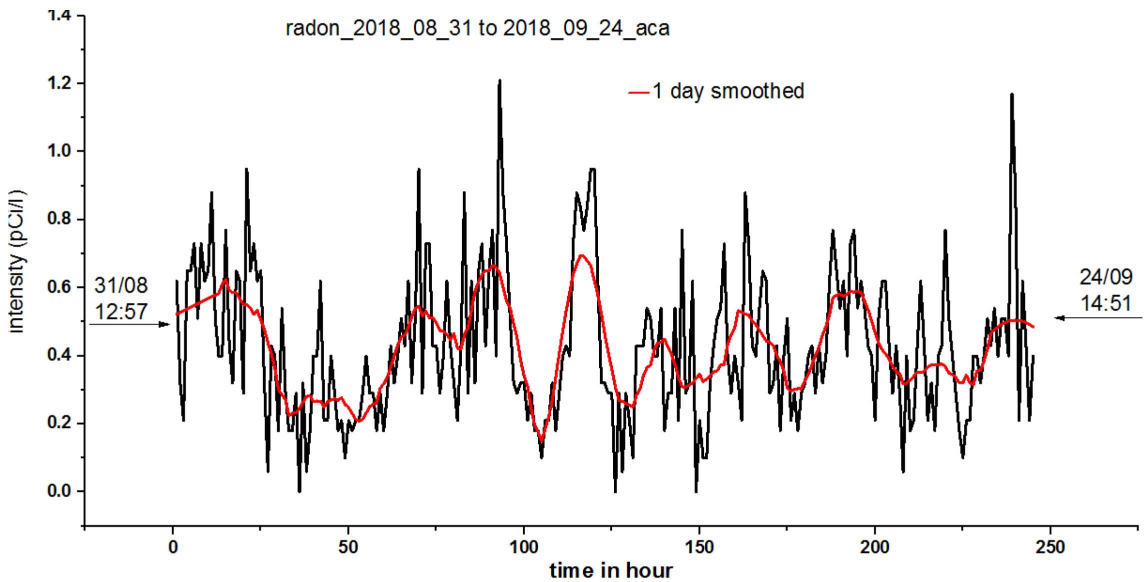

Fig. 6 Radon gas measurements from 31/08 to 24/09, 2018.

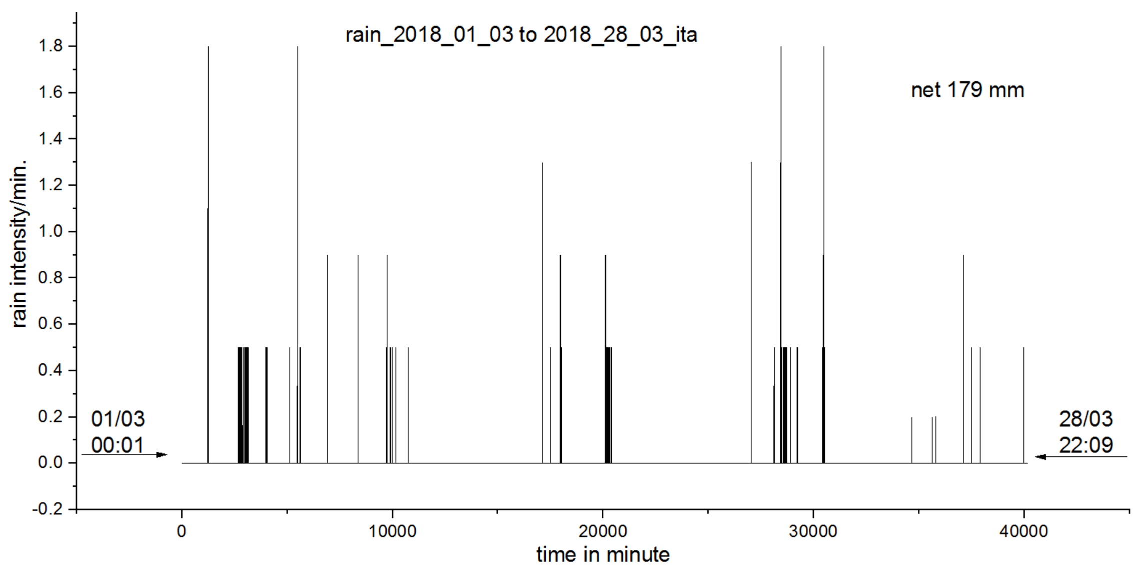

Fig. 7 Rain intensity display by minutes in March 2018 in the region.

During the period of March 2018, there was much rain in the region with a net of 179 mm. In the months of January and February of 2018, the rainfall intensity was well below the normal value for the period. The same happened for the period from Jun to September 2018 as indicated in Figure 8.In the period from April to May 2018 there were also moderate and weak rains in the historical average of the region of the order of 80 mm per month. The month of March 2018 was very rainy as shown in Figure 7, with a total for the month of 179 mm. For the period from January to the end of September 2018 the region experienced the presence of strong and weak rains, which allowed to correlate with presence and variations of gamma rays, neutrons and radon gas.

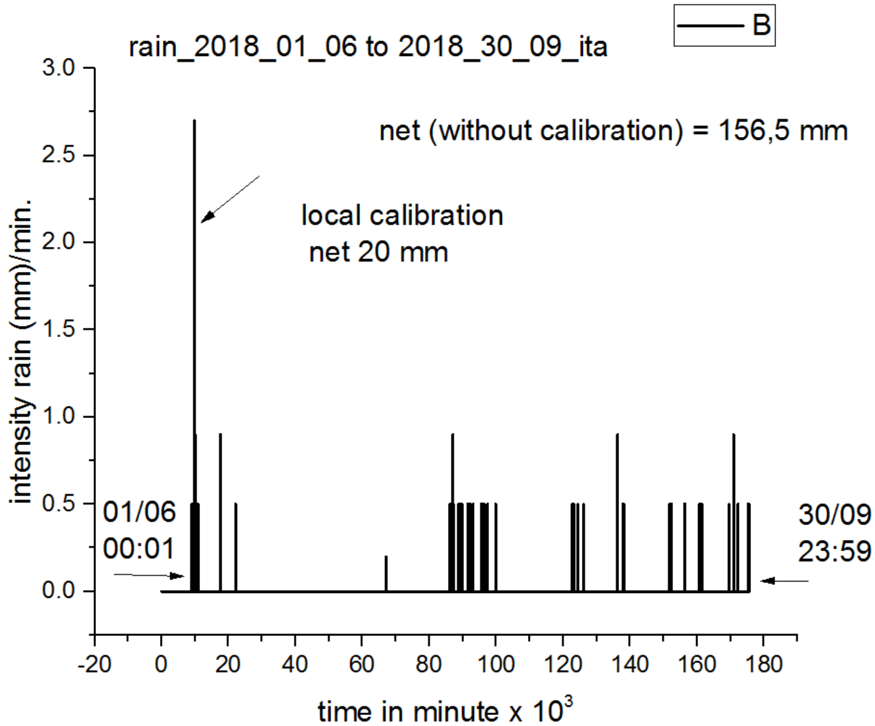

Fig. 8 Rain intensity display by minutes from Jun to September 2018 in the region

IV. CONCLUSION

During all monitoring timefrom January to September, 30of 2018, there were varied periods of dry and rainy weather. The uninterrupted continuous measurements of gamma, neutrons radiation every minute throughout 2018 clearly show the variation of gamma radiation and neutron withrainfalls in the region. Monitoring of both neutron and gamma radiation fluxes was able to show these variations using measurements made during the net period in the region. It is found that neutrons up to 10.0 MeV are more sensitive to precipitations (rainfall intensity) in the region. Also the gamma radiation is correlatedwith intensity of local rains but less sensitivity to the intensive rains. In the drier periods both 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, whose children during decay produce gamma rays and alpha particles in the soil/atmosphere interface, that should be responsible to produce neutrons near ground level.

V. ACKNOWLEDGEMENTS

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