GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

# INTERACTIVE INFOGRAPHIC TO UNDERSTAND DYNAMICS ENVIRONMENTAL RADIATION DURING 2017 WINTER IN SOUTHEAST OF BRAZIL

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## ABSTRACT

In this article we present a didactic way to discuss the day and night dynamics of environmental ionizing radiation during winter in southeast of Brazil. We developed a simulator made in HTML5. The origin of the ionizing radiation data was by varying the intensity of gamma radiation integrated between 200 keV and 10.0 MeV, from June 28 to September 25, 2017. These measurements were performed at one-minute intervals at an altitude of 25 meters high of soil in a tower in São José dos Campos, SP, Brazil. In the end of August, there was a week with low and moderate rains totaling 27 mm net. There was very cold and during the day the high temperature reaching up to 32ºC, reproducing a desert-like climate. It was possible to monitor the arrival of cold fronts in southeast Brazil and (day / night) cycles using the presence of radon gas in the region. The dynamics of gamma radiation measurements indicate in a simple way the variation of the meteorological parameters very important for the environmental studies

**Keywords:** *Ionizing Radiation, Infographic, Environment.*

## I. INTRODUCTION

At the ground / atmosphere interface of the Earth's, ionizing radiation is composed mainly of radon gas, the earth's telluric radiation and the radiation of the primary and secondary cosmic rays. 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 $^{238}U$, $^{235}U$, $^{40}K$, $^{232}Th$ and it is constant for each region [1]. The radon gas coming from the disintegration of $^{238}U$ from the Earth's crust [2] to Ra-226 and Rn-222 arriving at the isotopes $^{214}Pb$, $^{214}Po$ and $^{214}Bi$ giving α particles and gamma radiation. The primary cosmic radiation consists mainly of galactic and extragalactic protons and the Sun with very high energy, that interacts with Earth's atmosphere producing the EAS (Extensive Air Showers) [3]. The efficiency of this interaction is maximal when it occurs at altitudes between 15 and 17 km in the tropics that form secondary cosmic rays with muonic, mesonic and neutronic components that reach the surface of the Earth in the region [4]. These radiations cause health problems for the crew and passengers of civil aviation and are present at the beginning of the stratosphere called Pfotzer's 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 produced by electrical discharges between earth-clouds, clouds-earth and clouds-clouds. X-rays, gamma rays, neutrons and beta particles are all formed by the the cone of lightning [5]. Other sources of ionizing radiation are those produced in industrial, medical, dental and hospital clinics, but these radiations are mainly controlled in small areas. To help to understand the environmental radiation in southeast of Brazil during the winter we made an interactive infographic with all data acquired and some weather systems free source at internet.

## II. DEVELOPMENT

The gamma ray detector for using in the energy range of 200 keV to 10.0 MeV consists of a 3-by-3-inch (3-by-3-inch) Thallium-doped 3-by-3-inch Sodium Iodide scintillator crystal. This crystal is directly coupled to a photomultiplier (PM), which records the pulses coming from the scintillator and with amplification and an analogue digital converter (ADC) where these scanned signals are recorded by a computer [6]. This experimental set is seen in Figure 1 located in the inner room of a tower 25 meters high in relation to the ground (ACA tower) belonging to the Institute of Aeronautics and Space (IAE) in São José dos Campos, SP, Brazil.

ISSN 2348 – 8034
Impact Factor- 5.070


*Fig 1. View of scintillator detector with associated electronics and computer laptop on top tower*

The scintillator coupled to photomultiplier is closed in a thin layer of aluminum to make it portable. The set (scintillator + associated electronics + data acquisition) only depends on a laptop with a charged battery to measure the radiation for up to 5 continuous hours. However for series of long measurements it uses electrical network or photovoltaic energy. The scintillator and associated electronics were calibrated in terms of energy and counting intensity per minute at the experimental teaching physics laboratory of ITA using radioactive sources and a spectral analyzer of counts versus energy in the range of 0.2 to 10 MeV (Million Electron Volt) [7,8].

**Infographic**

Infographics are digital content developed to help sales. The possibility to merge data visualization, videos, graphs and other contents to understand a message, make infographic a possible tool for education.

Furthermore, infographics are useful tools to represent some information in a compact way. In their study of how readers understand environmental health risks in the news, [9] researchers reported that readers benefited from reading infographics that combined texts and graphics.

The main focus is to synthesize information. In addition, infographics are creative, and are easily shareable. They can be a great tool for students to understand complex theory as radiation.

To help comprehend the radiation dynamics an infographic was developed in HTML5 called "Radiation Infographic – Brazilian environmental radiation during 2017 winter".

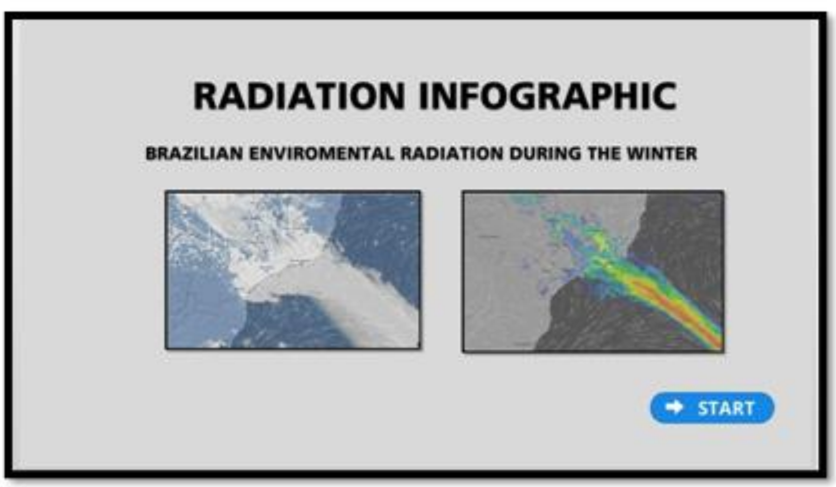


*Fig. 2 – Radiation Infographic*

## III. EXPERIMENTAL RESULTS

Gamma radiation measurements were performed from June 28 to September 25 of 2017 in the inner room above the tower seen in Figure 3. The pluviometer was operating on the roof of the tower, reporting the intensity of rainfall in (mm / min), during the above described time interval

*Fig. 3 – Exterior view of the tower showing the room 25 meters high*

Figure 4 show gamma radiation intensity acquired from June to September of 2017. The monitoring was done with no interruptions minute by minute

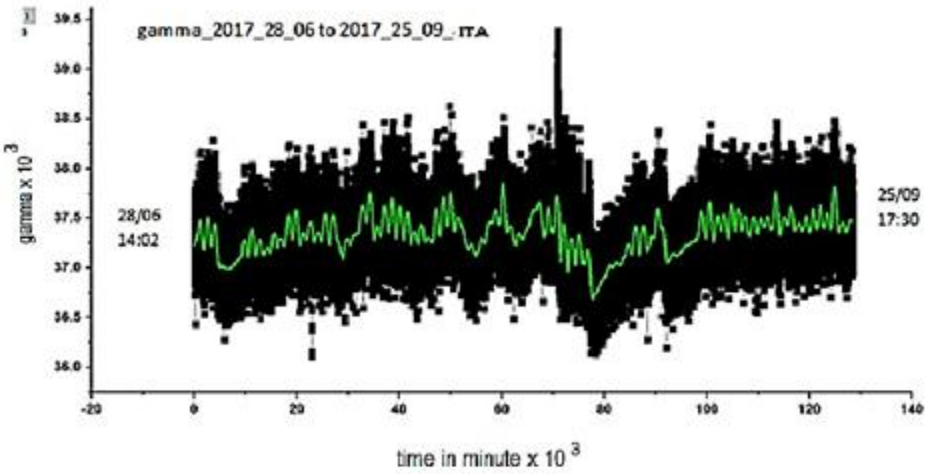


*Fig. 4 – Monitoring of gamma radiation in the room at the top of the tower. Green line show smoothed values of 1 day*
**Source: Project Atmosrad 2017**

Analyzing the dynamics of the radiation measurements, there are 3 large variations occurring in the whole period analyzed. Between the beginning of monitoring and close to 70 x $10^3$ minutes, the mean intensity of the measured radiation was 37.5 x $10^3$ counts / minute. It presents in this analyzed time also small variations indicating passages of cold fronts but without rain. See this dynamic in this period expanded in Figure 5, taken from the graph in Figure 4.

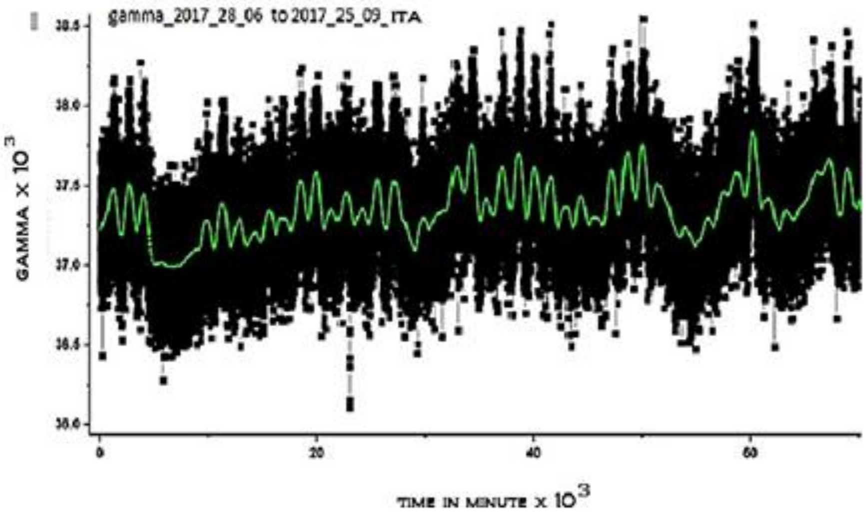


***Fig. 5 - Monitoring of gamma radiation between start and time 70 x 10³ minutes. Green line show smoothed values of 1 day.***
**Source: Project Atmosrad 2017**

Figure 5 shows the radiation monitoring between 70 to 80 x $10^3$ minutes after the start of the measures. It was a rainy week with intensities varying according to Figure 8.

In the same period, we can see that a huge mass of cold air comes from south to north in Brazil, as shows Figures 6a and 6b. Also, we can notice that there was no rain in this period as shows Figure7.

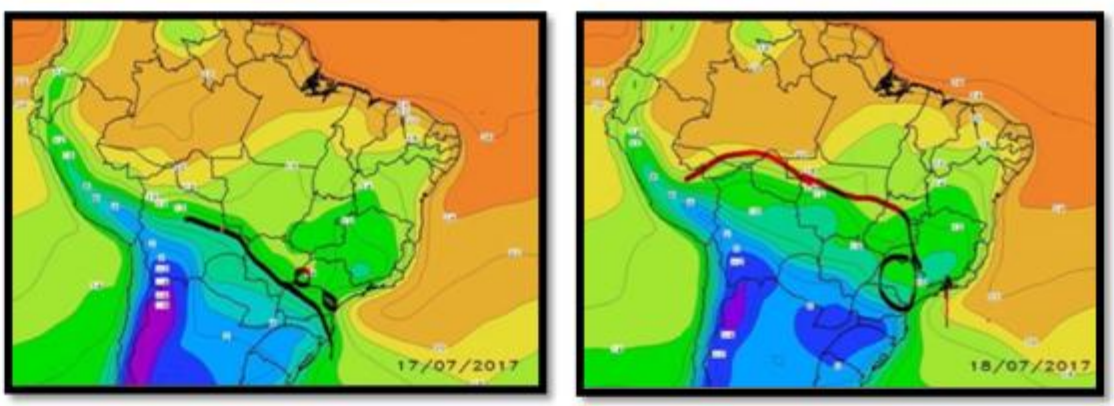


***Fig 6 a – Cold mass coming from South of Brazil in middle of July. 6b – Cold mass getcloser to southeast of Brazil***
**Source:Climatempo**

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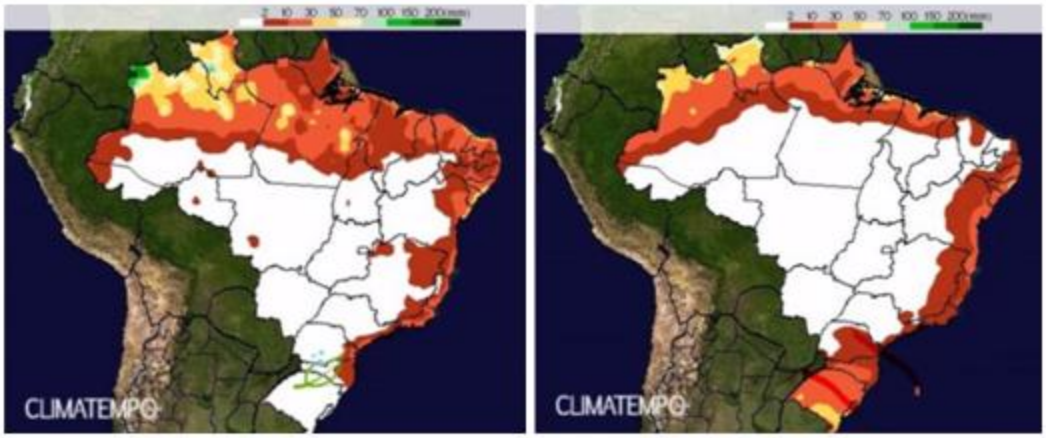


*Fig.7 a – Rain accumulated in beginning of July. 7b – Rain accumulated in end of July.*
**Source: Climatempo**

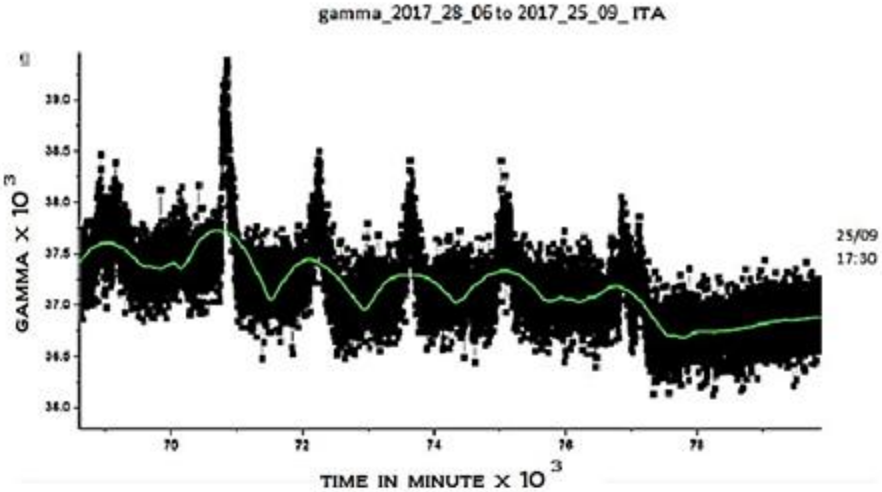


*Fig. 8 – Radiation during a rainy week. Green line show smoothed values of 1 day.*
**Source: Project Atmosrad 2017**

In the beginning between 70 and 71 x $10^3$ minutes, there was an intense rain, where the level of radiation count reached the order of 40 x $10^3$ counts / min. Then, on the other days there was always less intense rains, but always in the afternoon between 14 and 15 local time during that week, as shown by the radiation peaks caused by the rains. In Figure 6, taken during the measurement time of 80 to 100 x $10^3$ minutes, there are variations in the dynamics of the radiation with passages of two cold fronts in the region, but without causing rains. However, the terrestrial surface was wet and with very little exhalation of radon gas. The arrival of the front causes an increase of the radiation due to the accumulation of radon gas that arrives with the cold front. This rain can be observed in Figure 9. This data was obtained with apluviometer

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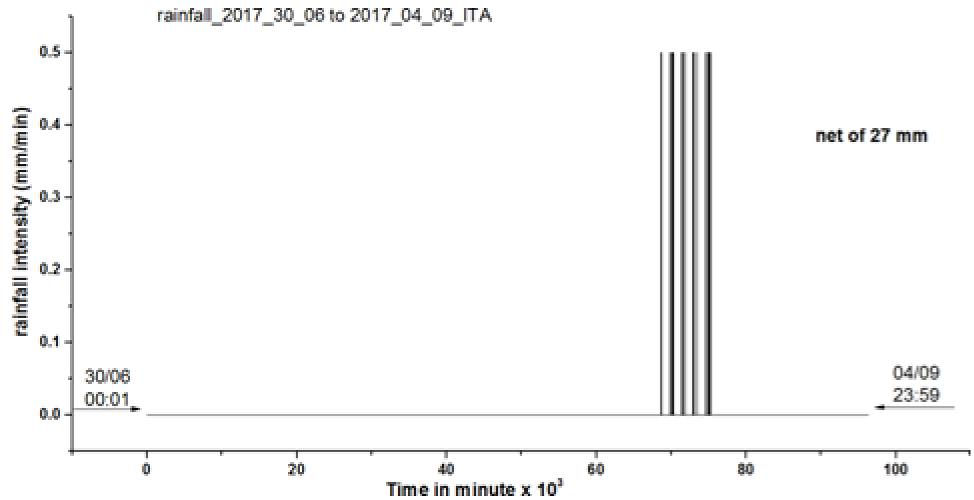


*Fig. 9 – Spectrum of rainfalls that occurred in the region during the period of measurements*
**Source: Project Atmosrad 2017**

In 2017, the region of São José dos Campos, SP, Brazil was severely punished by one of the longest droughts ever, due to climate change. There were many occurrences of large fires causing damage to agriculture, fauna and local flora. The net of rain statistic for the period is 170mm

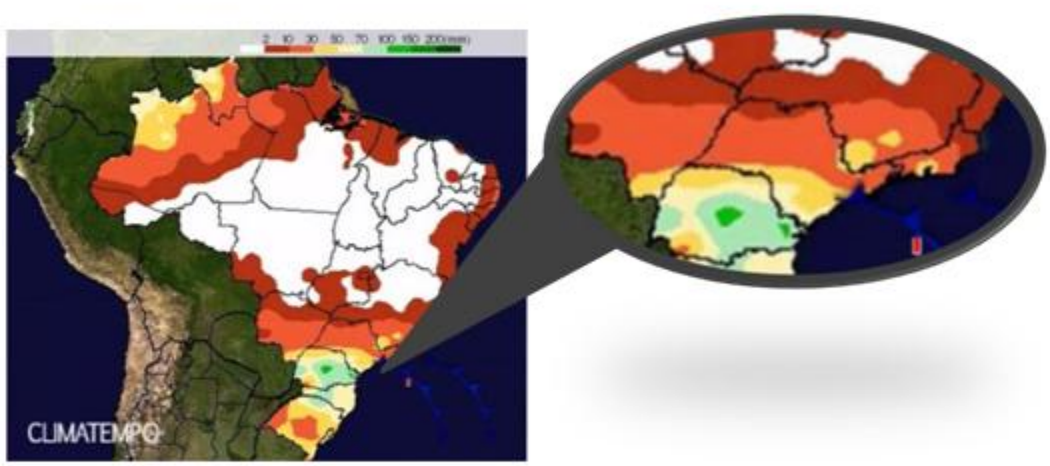


*Fig.10 – Rain accumulated in middle August of 2017*
**Source: Climatempo**

Figure 10 shows the accumulated rain in southeast region of Brazil. In this period, as showed also in Figure 9, the rain value was 27 mm. This can be view in the light brown area in the state of Sao Paulo, as shows the zoom from figure 10

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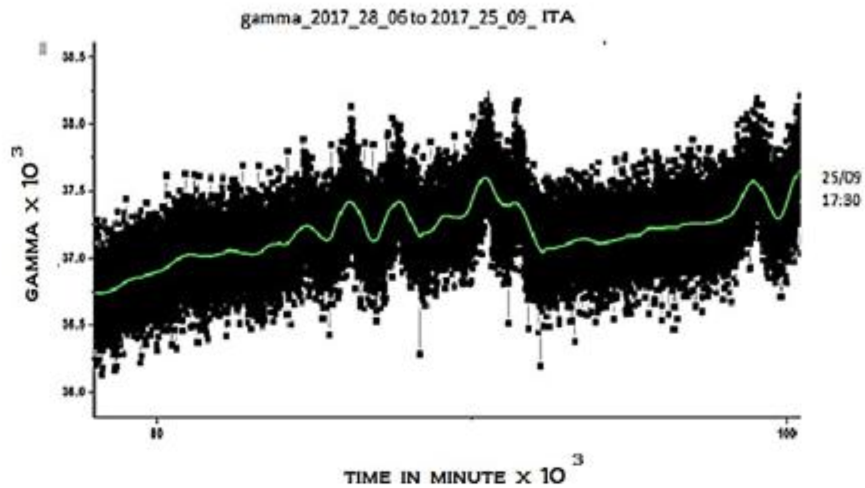


***Fig. 11 – Monitoring of radiation during two cold air mass passages in the region with very dry soil. Green line show smoothed values of 1 day***
**Source: Project Atmosrad 2017**

In Figure 11, taken during the measurement time of 80 to 100 x $10^3$ minutes, there are variations in the dynamics of the radiation with passages of two cold fronts in the region, but without causing rains. However, the terrestrial surface was wet and with very little exhalation of radon gas. The arrival of the front causes an increase of the radiation due to the accumulation of radon gas that arrives with the cold front.

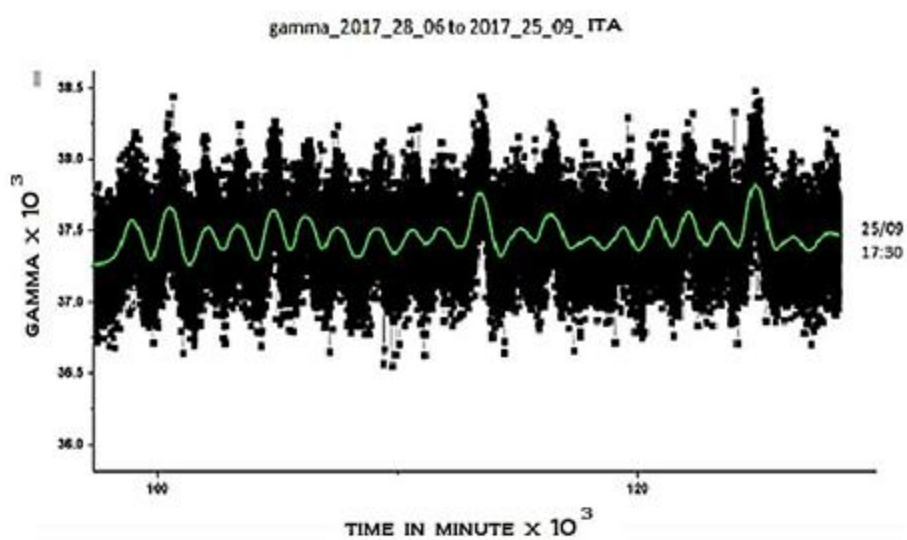


***Fig. 12 - Radiation monitoring on dry soil hot by day and cold at night. Green line show smoothed values of 1 day***
**Source: Project Atmosrad 2017**

In Figure 12, the monitoring between the times of 100 to 130 x $10^3$ minutes with average intensity of 37.3 x $10^3$ counts / min. undergoes an influence of high pressure in the region with very dry soil. This occurs in the afternoon where the temperature varied between 25 to 30 ° C and the night between 12 to 20 ° C. This dynamics in temperature during this period facilitates greater and lesser exhalation of the radon gas. The two largest radiation peaks, shown in Figure 12, are provoked by heavy fog in the morning of thosedays

## IV. RADIATION INFOGRAPHIC

After all the experimental data acquisition and analysis we develop an Infographic.

The main screens are shown in figure 13.

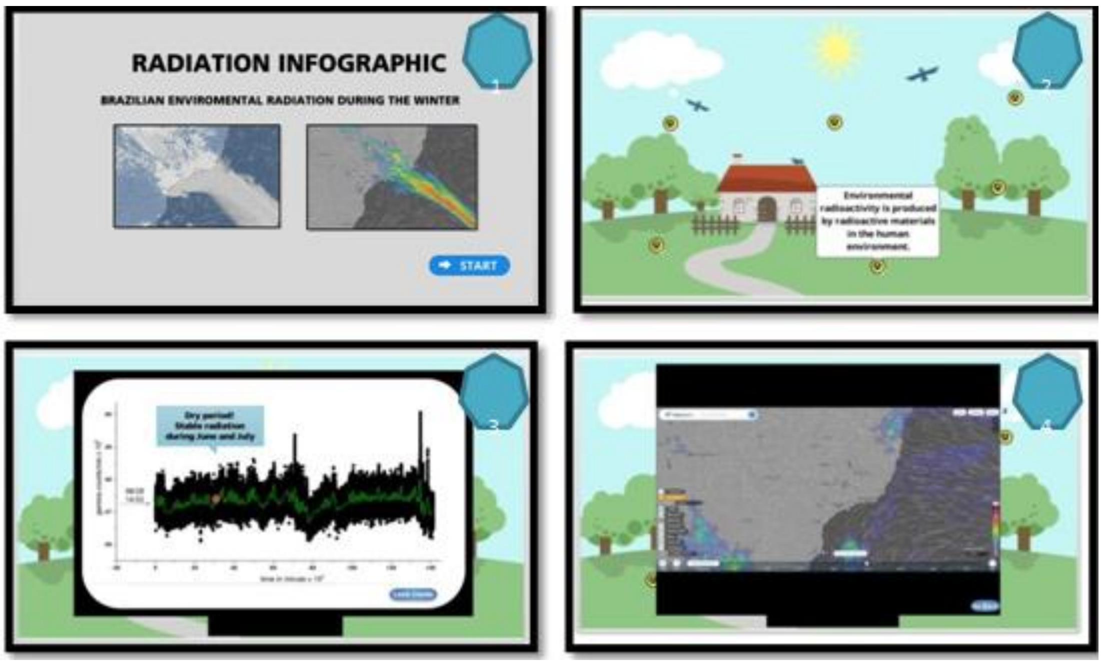


***Fig 13 – Main screens of radiation infographic. It can be accessed in***
http://161.24.5.141:8081/weblab/documentos/radiacao/index.html

The infographic have a start screen (screen 1). Then we show an interactive screen about environmental radiation information in (screen 2). Also, it presents animated graphic to show dry period, day and night radiation oscillation and stability during winter (screen 3). To show the real monitoring, we make a screen capture from Ventusky [10] to confirm our data, and also, our theory that radiation peaks comes in rainy days (screen 4).

We believe that these kinds of digital objects help students to understand complex topics as radiation and particle physics. Also, researches shows that mental maps and interactive content provides learning development [11]

## V. CONCLUSION

In the period of August and September of 2017, the intensity of rains was monitored every minute and in the same place and at the same time the intensity of neutrons was measured every minute. The analysis shows that during the single week of moderate and weak rains, there was a noticeable increase in the intensity of neutrons. The total rainfall in the period was 27 mm scattered in time, Figure 3 shows the differencecaused by the rains in the measurement of neutrons. Also in this work, the perfect oscillation of the neutrons (day / night) in the dry period is evidenced, without cloud, fog or lightning. This oscillation it is provoked by the exhalation of radon gas (Rn-222) in the region and is larger during the local solar zenith. The alpha particles of the gas interact with the metallic materials of the local terrestrial surface generating the measured gammas.

The Interactive Infographic "Radiation Infographic – Brazilian environmental radiation during 2017 winter" showed in a didactic way the correlations of environmental radiation in day and night. Furthermore, some videos help to understand how the radon gas is transmitted from soil to air, and a screen capture from Ventusky.

## VI. ACKNOWLEDGMENT

Thanks to CNPq (National Counsel of Technological and Scientific Development) and CAPES (Coordination for the Improvement of Higher Education Personnel) by the fellowships grants support to the group's researchers. Thanks to INCT-FNA-ITA (National Institute of Science and Technology – Applied Nuclear Physics – Institute Technologic) to provide funds for ATMOSRAD. Thanks to IAE and ITA - Division of Fundamental Sciences for supporting this research.

Finally, thanks for Climatempo that provides climate analysis free

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