Original Research Article

Outdoor radon measurements during 2018 in São José dos Campos, Brazil

Abstract

During 2018 the intensity and its variation in time were monitored, every hour the presence of the radon gas in two distinct points 2 kilometers away each other in São José dos Campos, Brazil. One point was 25 meters high (ACA tower) and the other 3 meters high (ITA laboratory). Two identical RadonEye RD200 (ionization chamber) detectors were used, calibrated in pico Curie/liter (pCi/l) or Bequerel/cubic meters (Bq / m^3). These measurements indicate that there is always a day/night variation in the intensity of the local radon gas. With dry and hot periods there is a more increase in radon gas intensity. Intense rains and short period of time there is also increased presence of the radon gas in that place. Fine and continuous rains decrease the presence of radon gas present. Comparisons between radon gas intensities per hour and gamma and neutron changes between (0-10) MeVof total energy at the same time interval were observed.

Introduction

The interest of monitoring the radon gas of a region as a function of time lies in the fact that it is a tracer of the local tropospheric air movement. The local radon gas is also attributed the highest number of deaths observed in each year as shown in Figure 1 below (Radon-related lung cancer deaths compared to other select cancers).

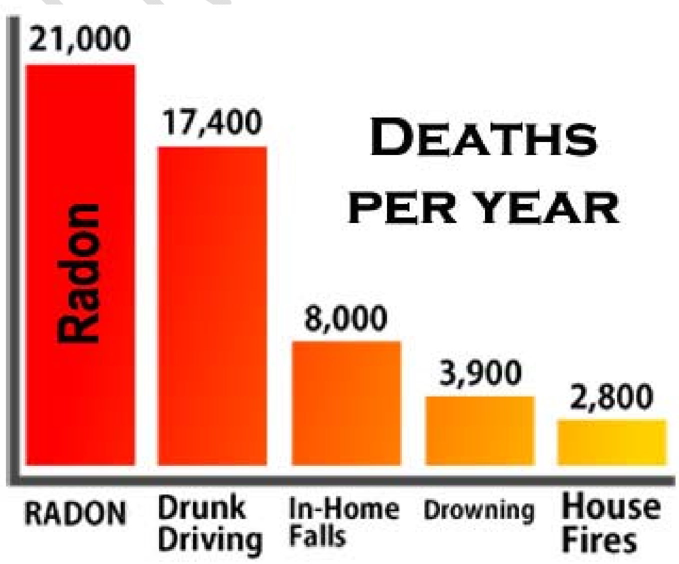

Fig. 1 - Number of deaths per year caused by radon gas compared to other causes credit Ref.[1] -(https://www.epa.gov/radon/health-risk-radon).

Radon is a natural gas formed by disintegration of Radium ^{226}Ra an element coming from the Uranium ^{238}U decay series. Emanating naturally from the Earth crust and accumulating in indoor environments in near ground level in every place. From ^{226}Ra decay in 3,82 day the radon gas^{222}Rn appeared emitting alpha particles of energy E_{α} = 5,49 MeV and others non-gaseous daughter products Polonium, Bismuth (^{218}Po ,^{214}Po and ^{214}Bi) that produces near 50% of equivalent dose of natural ionizing radiation near earth surfaces.In the ground level interface of the earth's atmosphere, ionizing radiation is mainly resulting from radon gas, the telluric radiation from the ground of earth and the primary and secondary cosmic radiation produced in low atmosphere interface [2]. However, it is difficult to separate over time the intensity of ionizing radiation of each component including particles and photons coming to São José dos Campos, as the energies overlap. The telluric radiation is constituted by ^{238}U, ^{235}U, ^{40}K, ^{232}Th series decay products, and it is constant in each specific region [3]. Isotopes ^{214}Pb, ^{214}Po and ^{214}Bi originating from the uranium decay in the earth's crust [4] measure radon gas ^{226}Ra and ^{222}Rn. The primary cosmic radiation consisting mainly of high energy galactic and extragalactic protons and those coming from regions which interacts with the earth's atmosphere produces the EAS (Extensive Air Showers) [5]. The intensity of this radiation is maximal at altitudes between 13 km and 17 km call (Pfotzer maximum) in the tropics forming secondary cosmic rays' flux with muonic, 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 coming by cosmic rays with (α, n) reactions with surface earth's elements. These radiations cause health problems [6]for the populations on Earth surface and crew more passengers of civil and military aviation. 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 [7,8,9,10]. 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.

Materials and Methods

Fig. 2– Aerial and ground view of the tower ACA and his environmental field region in São José dos Campos, SP, Brazil (23° 12'45" S, 45° 52'00" W).

Figure 2 shows the location where the measurements of the radon gas were carried out below / above the tower of 25 meters of altitude.

This place is free from any human interference. The radon gas detector is a portable ionization chamber as shown in Figure 3. It is powered with 110 or 220 V. It can measure hourly counts between 0.00 and 10000.00.

These counts can be transformed into (pCi/l) or by (Bq/m³) directly by the FTLab application software that is acquired jointly the detector. To acquire the data or Android Smart appliances. This application can generate files on each download and can be saved in txt. All instructions are given on reference [11].

Fig 3 – Top view of Radon Eye RD200 ionization chamber used for monitoring radon gas [11]

The variation can be seen in Figures 4 and 5 occurred in the measurements of the ITA made in 12/5/2018. These measures are shown here giving insight into how easy the RD200 is about obtaining and storing and manipulating data.

In figure 5 below is shown the RadonEye RD200 measuring on a table in open space in ITA and ACA Tower. The view count of 0.43 (pCi / l) represents the value at the last hour that the ionization chamber made measurements. InITunes software installed on an IPhone, you get the data that is already plotted on the screen of the IPhone as indicated by figures 4 and 5.

A maximum time of measurements for the Radon Eye RD200 can be considered up to three months in hourly sequence as shown in Figure 4 obtained in ITA and ACA tower via IPhone on 12/05/2018. For periods longer than 3 months, both the acquisition data and download of measures are very slow in time.

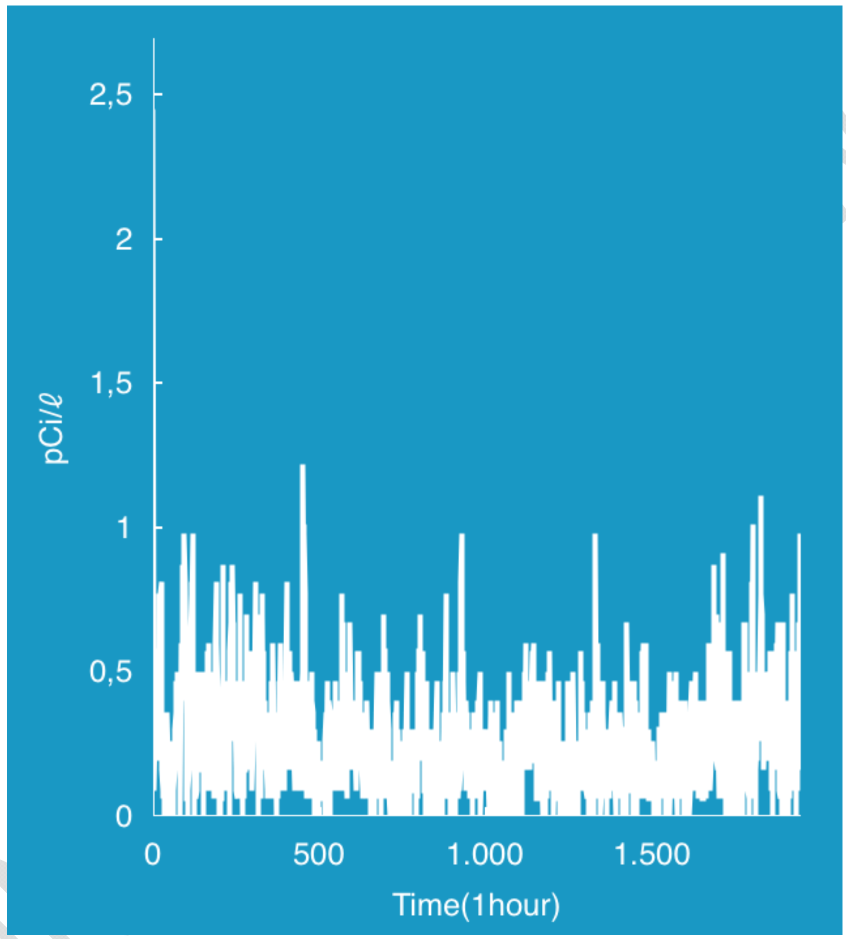

Fig. 4 – Monitoring of 1943-hourseries from RD200 in ITA using (pCi/l) unit.

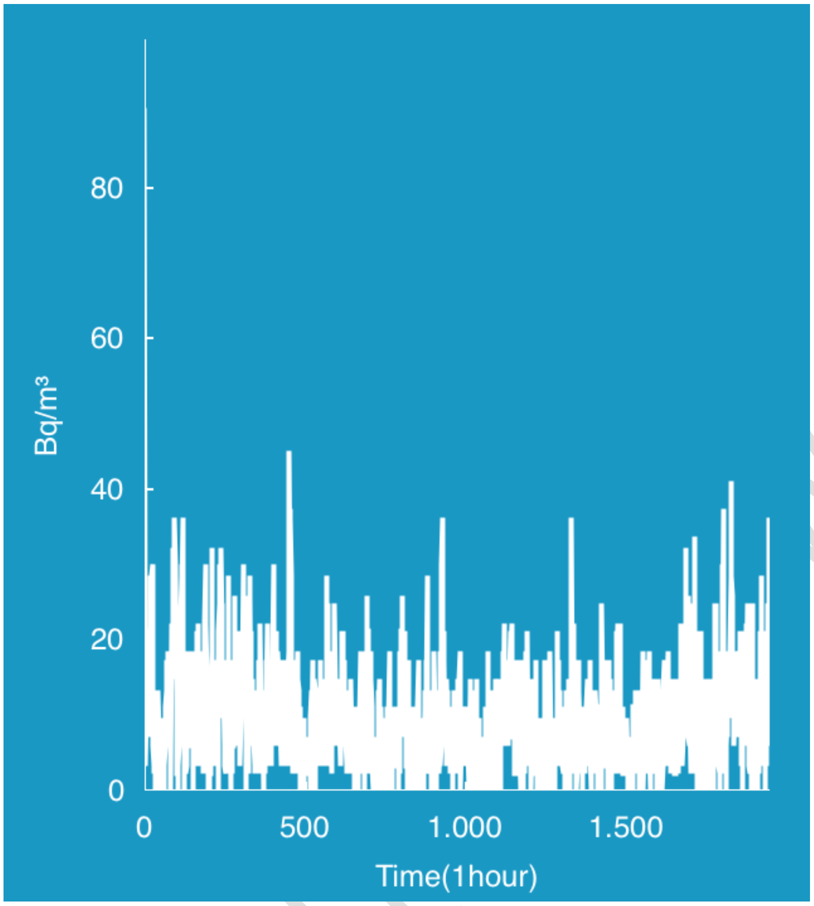

Fig. 5 – Monitoring of 1943-hour series from RD200 in ITA using (Bq/m³) unit.

Results and Discussions

Throughout 2018 the presence of radon gas close to the ground (ITA) and 25 meters high in the Tower (ACA) was measured. Figure 6 shows the measurements performed between April 24 and May 28, 2018. During this period, the maximum peak of radon gas reached 2.0 pCi / l and an average of 0.5 pCi / l. It was also clearly observed the 24 hours smoothed evidence of day / night changes in the presence of the radon gas.

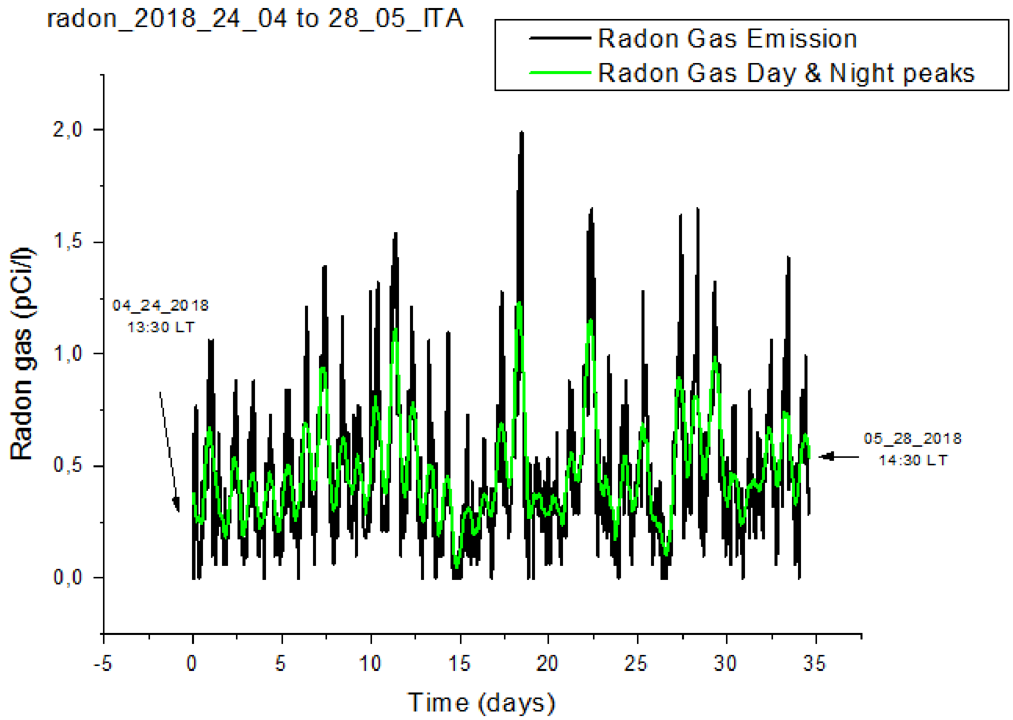

Fig. 6 – Radon gas measured in ITA during 04/24/2018 to 05/28/2018 with green line showing smoothed curve of 24 hours.

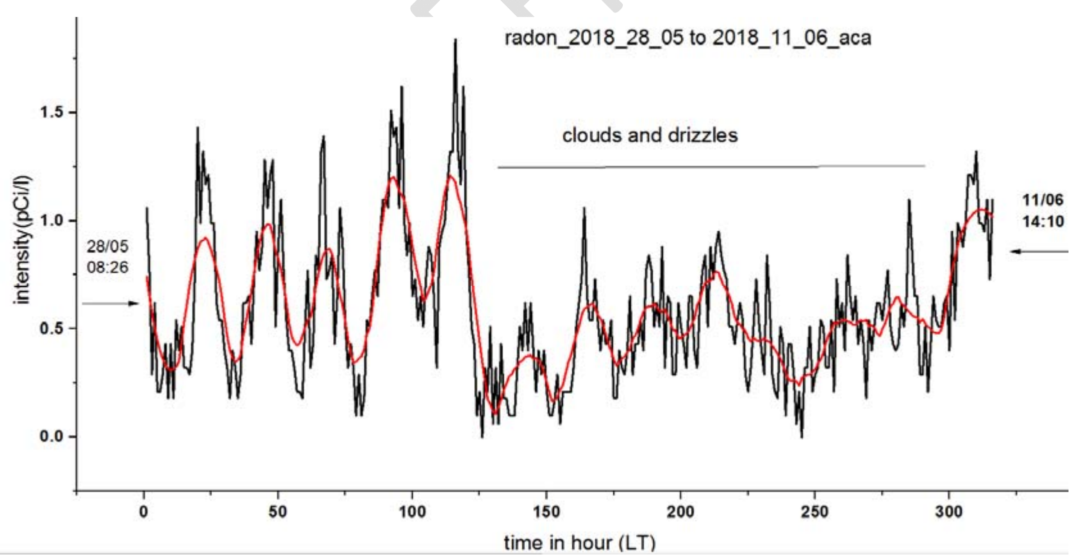

Fig. 7 - Observation of intensity of radon gas emanating from the soil in ACA Tower in the period 28/05 to 11/06, 2018. The red line show smoothed curve of 24 hours.

It can be observed in Figure 7 that there was an appreciable change in the intensity of radon gas during the long period of rains and drizzles in the region of São José dos Campos. This phenomenon is much more visible in the measurements made at 25 meters of altitude (ACA).

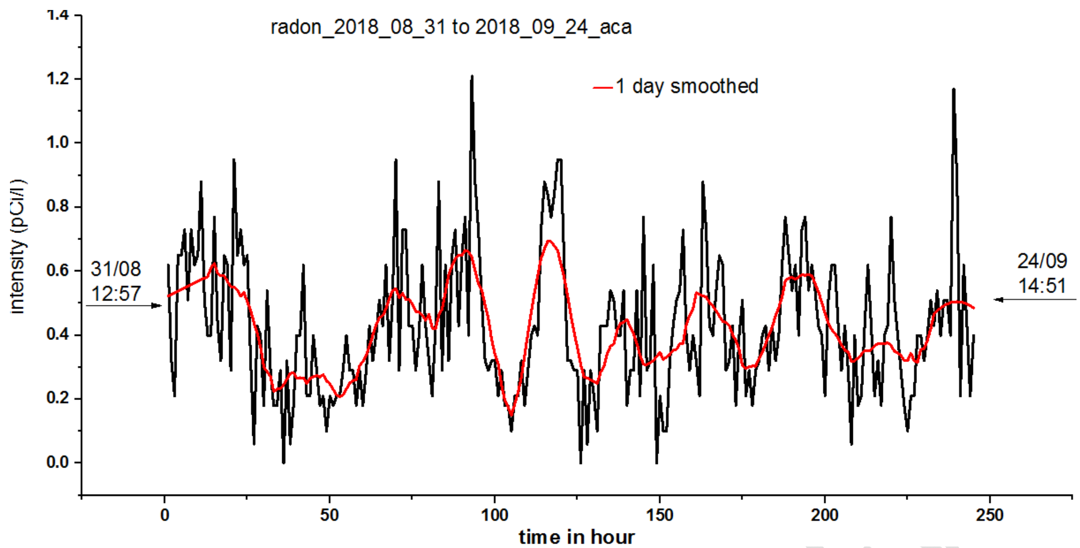

Fig. 8 - Radon gas measurements in ACA Towerfrom 31/08 to 24/09/2018.

In the months of August and September 2018 with very few showers and clear ceilings the intensity of radon gas varies very little. Even the day-night variation as indicated by the smoothed red curve of a day in Figure 8, does not show very clear variation.In the months of October, November and December of 2018 the rains have been more frequent in the region.

Between the end of September and the end of November 2018 the sky remained very cloudy in the region. However, in the beginning of December until 2019/02/01the weather was very hot, insolation and heavy rains during this period. These meteorological phenomena were perceived as shown in Figure 9, in the measurements of radon gas intensity.

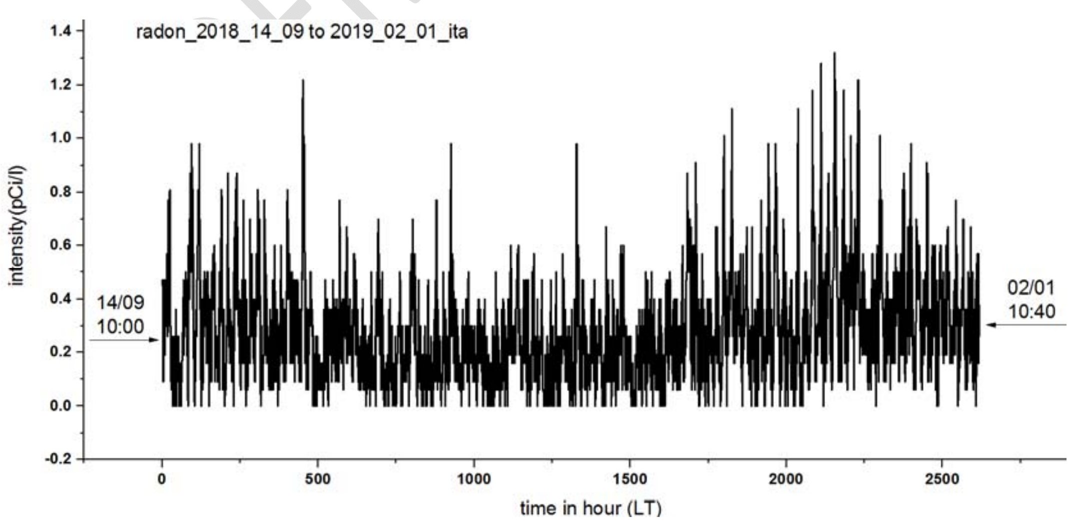

Fig. 9 – Radon gas measurements near ground level (ITA) during 14/09 to 02/01 in 2018 and 2019.

Comparing the twomonitoring profiles of Figures 9 and 10, they have approximately the same intensities between 0.2 to 0.6 pCi /l in (mean value). However, in the 25-meter altitude (ACA) the variation profile is more regular then near ground level as a function of time.

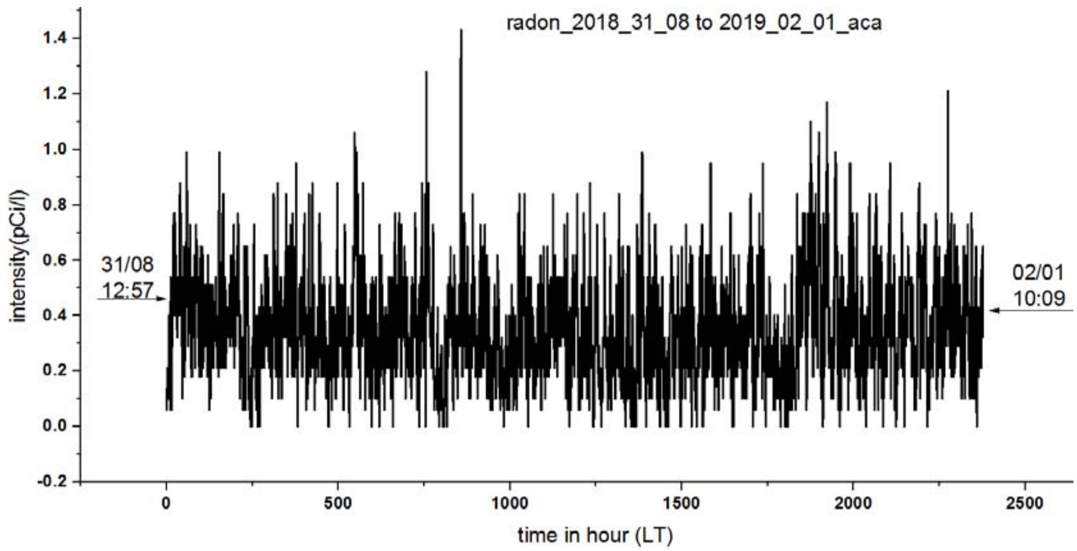

Fig. 10 – Radon gas measurements at 25 meters high level (ACA) during 31/08 to 02/01 in 2018 and 2019.

During December 2018, due to the greater intensity of heat (32°C) and higher rainfall intensity in the region, there is a tendency to increase the intensity of radon gas. It is noted in Figures 9 and 10 that in the month of December 2018 due to frequent rains and even intense sun every day an increase in radon gas intensity appeared.

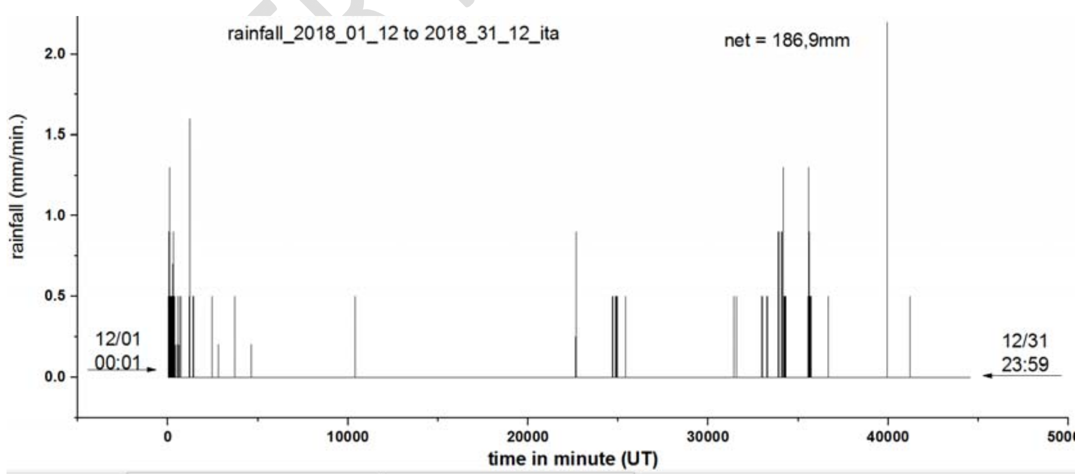

Fig. 11 - Heavy rain that occurred between 01 and 31 December 2018 at the ACA Tower site.

During the entire radon gas measurement period in 2018, the RD200 RadonEye detector described in (Materials and Methods), was used. Both on the surface of the Earth and in the Tower at a height of 25 meters, the monitoring every hour was perfect indicating variations (day/night), and (dry/wet)weather period.

Conclusions

Throughout 2018 and early 2019, uninterrupted monitoringof radon gas were performed at both ITA and ACA sites. Next to the soil (ITA) the measurements show better indices of variations of this gas regarding dry weather and wet weather. The day / night variation and the presence of heavy rains and drizzles also clearly affected the presence of radon gas in the region.

The same type of variation happens in 25 meters of altitude (ACA) but with less sharpness and intensity of the gas. It is suggested that the presence of shear winds at the height of 25 meters provokes this interference of intensity of local radon gas.

However, during all year 2018 the intensity was always below 100 Bq/m^3 as shown by the measurements made in this region.

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