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Investigation of the surface-atmosphere interaction on the coastal region of the monazite sands of Meaípe, Guarapari (ES) - preliminary results

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RESUMO
O conhecimento do comportamento das variáveis meteorológicas pode ser importante para o mapeamento do deslocamento temporal e espacial da radiação natural ionizante presente na região costeira de Meaipe. Com esse objetivo estão sendo realizadas medidas observacionais simultâneas das variáveis atmosféricas de alta e baixa frequências e da intensidade da radioatividade local, radiação gama, na camada limite superficial da região. Resultados desta pesquisa científica proporcionarão um alicerce para estudo futuro sobre o efeito biológico das doses de radiação natural associadas às areias monazíticas. Pretende-se estabelecer, em Meaípe, uma base experimental permanente para estudos físicos e biológicos da radiação ionizante local.

ABSTRACT
The knowledge of the behavior of the meteorological variables may be important to map temporal and spatial displacement of the natural ionizing radiation present in the coastal region of Meaipe. With this objective, simultaneous observational measurements of the atmospheric variables of high and low frequencies and the intensity of the local radioactivity, gamma radiation, in the surface boundary layer of the region are being carried out. Results of this scientific research will provide a foundation for future study on the biological effect of natural radiation doses associated with monazite sands. It is intended to establish in Meaípe a permanent experimental basis for physical and biological studies of local ionizing radiation.

1. Introduction

The interaction between the surface (land and/or ocean) and adjacent atmosphere occurs in the atmospheric surface layer, characterized by vertically constant vertical turbulent fluxes. These fluxes quantify the exchange of energy, moisture, and momentum between the surface and atmosphere and, therefore, are crucial to determining the spatial-temporal variability of local weather. In addition, turbulent fluxes of sensible and latent heat are important components of the surface energy balance [1].

The specific objectives are to build a meteorological database unprecedented in the region to adequately represent surface-to-atmosphere interaction processes. The atmospheric measurements will be related to the observations of the concentration of the ionizing radiation. Atmospheric and oceanic coupled models will also be used, along with observational data, to map the temporal and spatial variation of gamma radiation on Meaípe beach.

2. Site and measurements

The atmospheric monitoring has been carried out using a tower installed around 33 m from the shoreline of Meaipe (Fig. 1) at Guarapari, ES (20°39'13"S, 40°30'07" W). The site of the tower is not ideal, with obstruction of the wind flow due to the buildings. However, it was the point with a combination of less obstruction and greater safety available for the tower installation. It is intended, in the near future, to put another tower in a more favourable place, with less obstruction, to carry out the measurements.

The observations shown here were gathered between November 2018 and April 2019, representing basically summer conditions. The data was obtained with a sampling frequency of 0.1 Hz and stored as 5-min averages by a CR5000 datalogger, Campbell Scientific Inc., UK. The local time (LT) was used as the standard time. The instruments of the tower were connected to a datalogger and linked to a laptop at the foot of the tower. The data were automatically transmitted to the Air-Sea Interaction Laboratory, at the University of São Paulo, Brazil (http://www.iag.usp.br/meteo/liam/data/MEA01/MEA01_RT.html). The data is available, upon request, to the scientific community.

Figure 1: Instrumented tower and the Meaipe beach.

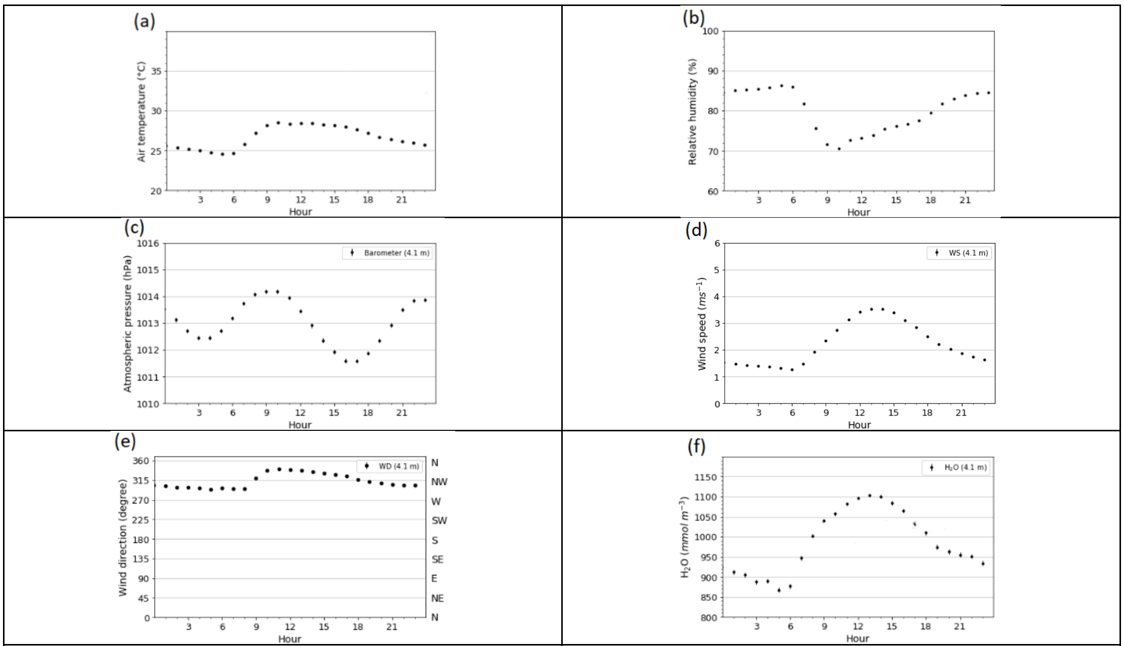
Measurements of low frequency of (i) air temperature, (ii) air humidity, (iii) wind speed and direction, (iv) shortwave radiation incident and reflected, (v) longwave radiation emitted by the atmosphere and surface, (vi) soil temperature and (v) soil heat flux were performed (Fig. 2). The high frequency instruments measured fluctuations of wind velocity and speed, air temperature, water wapor and CO2 (Fig. 2)

Hourly averages of the barometric pressure, air temperature, wind, air specific humidity, soil temperature and soil heat flux were estimated using 5-min average data. The hourly averages of the solar radiation components were obtained from the integrated 5-min average values throughout the day. The standard error (or statistical error) of the mean was calculated according to the [2].

Figure 2: Instrumented (a) atmospheric tower and (b) soil equipment.

3. Preliminary results

The diurnal averages of some meteorological variables are displayed in figure 3, for summer conditions. At 6 local time (LT) the air temperature starts to rise, and the relative humidity to decrease in value (Fig. 3a,b). The diurnal mean of the local atmospheric pressure presents a bimodal variation with peaks near 9 and 21 LT value (Fig. 3c). The wind direction at the sampling site is predominantly NW and N, with higher intensities occurring around 14 LT (Fig. 3d,e).



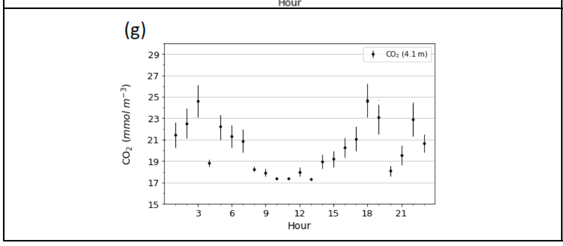


Figure 3: Average diurnal variation of (a) air temperature, (b) relative humidity, (c) atmospheric pressure (d) wind speed, (e) wind direction, (f) H2O flux and (g) CO2 flux. The vertical bars indicate the statistical error of the mean.

The diurnal variation of the vapor flux in the atmosphere (Fig. 3f) presents its highest value approximately in the same time of higher wind speed (Fig. 3d) and lower CO2 flux (Fig. 3g).

The diurnal average variation of the gamma radiation (Fig.4) shows higher values around the warmer time of the day (Fig. 3a) and the higher wind intensity values (Fig. 3d).

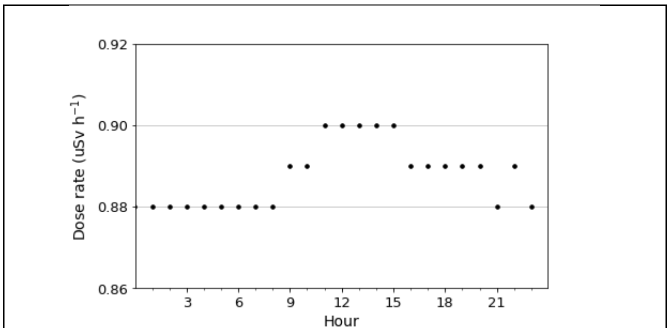


Figure 4: Average diurnal variation of dose rate of gamma radiation. Summer conditions.

The temperature at 5 cm inside the soil is displayed in Fig 5a and the soil heat flux, at same depth, is in Fig. 5b. The soil heat flux is the conduction of energy per unit area in response to a temperature gradient [3].

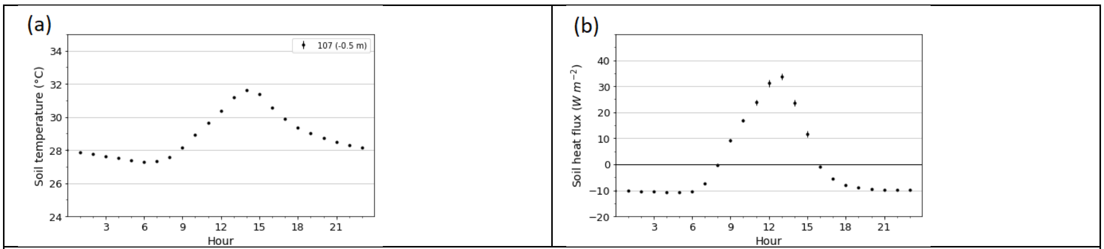
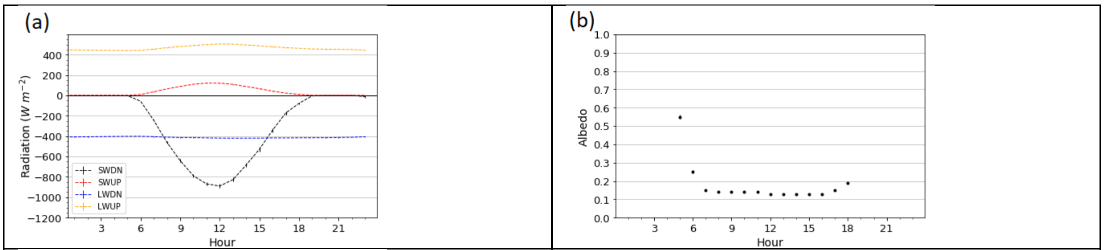


Figure 5: Average diurnal variation of (a) soil temperature and soil heat flux. The vertical bars indicate the statistical error of the mean.

Shortwave radiation incident on the surface is the most important energy for almost all geophysical processes. It is also the main determinant of the local climate [4]. Ultimately, the life of the planet depends on that energy.

The surface radiation balance or net radiation (Rn) is the difference between the incoming and outgoing fluxes of radiation: $Rn = SWDN + SWUP + LWDN + LWUP$. The SWDN and SWUP are, respectively, the incident and reflected shortwave radiations. LWDN and LWUP are the longwave radiation emitted, respectively, by the atmosphere and surface (Fig. 6). The signal convention used here considers positive the radiation when directed upward towards the atmosphere, in the vertical coordinate [5].



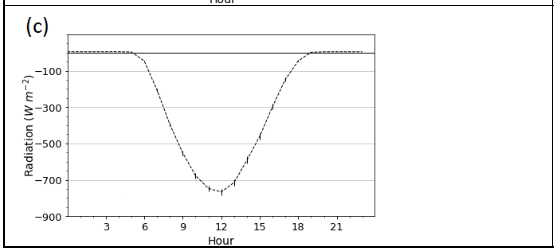


Figure 6: Average diurnal variation of (a) incident shortwave (SWDN, black), reflected shortwave (SWUP, red), downward (LWDN, blue) and upward (LWUP, yellow) longwave. (b) albedo and (c) net radiation (Rn). The vertical bars indicate the statistical error of the mean.

The surface albedo (a = SWUP/SWDN) is a fundamental property of the surface and has a cooling effect on global temperatures, sending energy back into space. The albedo is displayed in Fig. 6b and its average value is around 13%.

4. Discussion

Here meteorological measurements gathered on Meaipe beach, at Guarapari, ES, between November 2018 and April 2019 were presented, representing basically summer conditions.

The local atmospheric characteristics are related in small scale to the local features and in large scale to the synoptic systems acting over the region.

It is intended to establish in Meaípe a permanent experimental basis for physical and biological studies of local ionizing radiation.

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