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Investigação da camada limite superficial na região Antártica. Parte I: observações meteorológicas

Surface boundary layer investigation in Antarctic region. Part I: meteorological observations

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Resumo

A coleta contínua de dados ambientais na região Antártica é vital para a validação dos modelos numéricos de previsão do tempo. No entanto, este lugar apresenta condições climáticas extremas, o que torna as campanhas de observação um desafio. Este trabalho propõe um estudo sobre os dados observacionais coletados na Estação Ferraz na Ilha Rei George, durante o mês de Janeiro de 2014. Cada variável meteorológica apresentada mostrou estar relacionada aos sistemas atmosféricos que ocorreram na região, sendo que estas variações acarretam variações nos fluxos turbulentos verticais de calor e momento horizontal, os quais são apresentados na Parte II deste trabalho.

Palavras-chave: *Dados ambientais, sistemas atmosféricos, Ilha Rei George.*

Abstract

Collect continuous environmental data in Antarctic region is vital for validation of numerical weather prediction models. However, this place offers severe climatic conditions that makes the observational campaigns as a challenging. This work proposes a study about the observational data collected in Ferraz Station in King George Island, during January 2014. Each meteorological variables showed to be related to atmospheric systems in the region, and these variations provide changes in vertical turbulent fluxes of heat and horizontal momentum, that is shown in the Part II of this work.

Keywords: *Environmental data, atmospheric systems, King George Island*

1 Introduction

The extreme climatic conditions of the Antarctica region make this place as one of the most inhospitable place in the Earth. Continuous observational data about the atmospheric conditions near the surface at this region is crucial for validation of numerical weather prediction models.

The Planetary Boundary Layer (PBL) is turbulent lower atmospheric layer. This layer is where the most activities human are comprehend and the surface interaction contributes with energy for the occurrence of atmospheric systems. Approximately ten percent of this layer is denominate as Surface Layer (SL), the region adjacent of surface, which the vertical turbulent fluxes are approximately constant (Stull, 1988).

The purpose of this study is present the observational data collected in Ferraz Station (EACF), the Brazilian Antarctic Station in King George Island, during January 2014, by the ETA Project (financial support by CNPq and INCT-APA). Part II of this work (Alves et al. 2015) l presents the estimative of vertical turbulent fluxes of heat and momentum through the profile method using the dataset described here.

2 Methodology

The observational data was obtained from instruments installed in the Antarctic Brazilian Station, located in King George Island, which is part of the South Shetland Islands in Antarctic Peninsula (62°05'07" S, 58°23'33" W, 20 m about mean sea level).

The data used in this study was collected *in situ* during January 2014. It was used observations of the wind velocity and direction, air temperature, and air relative humidity, in three different levels of height, installed in a micrometeorological tower of 12 m (Fig. 01). The sampling frequency was of 10 Hz stored as 5 min average by a datalogger (CR5000, Campbell Scientific Inc.) using the local time (-4 UTC) as standard time. Pressure values, at 1.35 m of height, were also used. The sensor specifications and respective height are described in Table 1.

Table 01: Sensor specifications.

Sensor	Variable	Range and (Accuracy)	Height (m)
RM Young 05103[1]	Wind vel.	0-100 ms^{-1} (±0.3 ms^{-1})	2.1-Level 1 5.15-Level 2 10.2-Level 3
	Wind dir.	0-360° (± 3°)	
Campbell CS215[2]	Air temp.	-40° to +70°C (±0.9°)	2.2-Level 1 5.25-Level 2
	Air rel. humidity	0% to 100% (±4%)	10.3-Level 3
Vaisala PTB110[3]	Pressure	Several ranges (±0.3 hPa at +20°C)	1.35

[1] available in: http://www.youngusa.com/products/7/5.html
[2] available in: https://www.campbellsci.com/cs215-specifications
[3] available in: http://www.vaisala.com/en/industrialmeasurements/products/barometricpressure/Pages/PTB110.aspx

The instruments, installed at the tower, are connected to a datalogger, connected to a laptop inside the Meteorology laboratory, which transmits the data instantly to the Air-Sea Interaction Laboratory in IAG/USP, as illustrated in Figure 01.

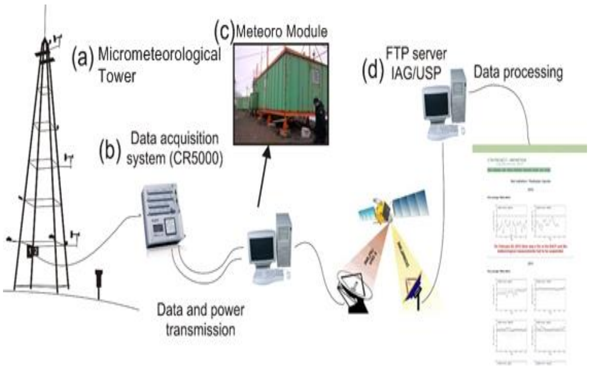

Figure 01. Acquisition data system of the ETA Project.

The Micrometeorological Tower was installed over a region with different surface characteristics. At the North of the tower there is the Stenhouse glacier; at South, the Admiralty Bay, comprehend by the Martel Inlet and some bare soil; at East side there is the Admiralty Bay and at West side there is bare soil, represented by hills (Fig. 02).

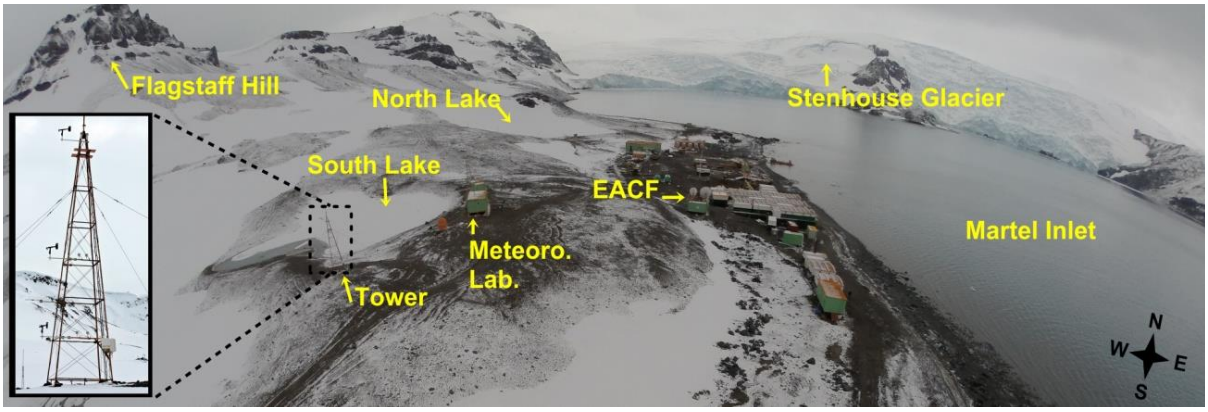

Figure 02. Aerial view from the Micrometeorological Tower (photography copyright Renato Torlay).

3 Results and discussion

During January 2014, the wind velocity reached its maximum value of 22.3 ms^{-1} at year day 12. The monthly averaged wind velocity was about 4.9 ms^{-1}. The highest value of atmospheric pressure was 1004.2 hPa during day 09 and the lowest value (976.4 hPa) during day 26 (Fig. 03a). It may be observed that during low-pressure conditions, the wind velocity is stronger than during the presence of high-pressure systems, and, there is no clear relationship between the wind direction and wind velocity (Fig. 03).

The high-pressure systems with wind direction from E-SE showed to be related with periods of the lowest values of temperature, which agrees with the result presented by Kejna (1993) apud Braun et al. (2004). Kejna (1993) studying synoptic maps, in the King George area, from 1986 to 1989 was able to distinguish 21 circulation types, using pressure centre type and air mass transport as major parameters of classification. According with his study, a high-pressure system acting on Antarctic Peninsula causes advection of cold air masses from E-SE due to the barrier winds. Besides that, an anticyclone centre over the northern Weddell Sea is the responsible for winds from N-NE, while winds from S are associated to anticyclones over the southern of the Antarctic Peninsula. When high-pressure systems are situated in the North of the King George Island, the mass transports are leading for winds coming from West quadrant (SW, W and NW). By the other hand, over low-pressure systems (in general, approaches its centre toward the West of the King George Island over the Bellingshausen Sea) it can be seen winds coming from N and NW, while cyclones over the Drake Passage are associated to winds from E and NE.

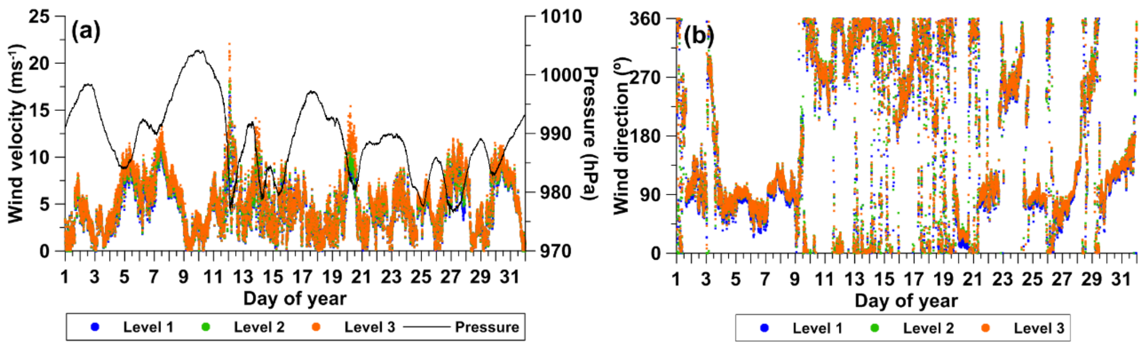

Figure 03. Temporal variation of (a) wind velocity (ms^{-1}) and atmospheric pressure (black line, in hPa) and (b) wind direction (degree), for January 2014. Blue, green and orange points represent the values obtained at level 1, 2 and 3, respectively.

The preferential wind direction for the investigated month was from East with high values of velocity between 10 and 20 ms^{-1} (Fig. 04). Easterly winds coming from Weddell Sea area are responsible for temperature drops in the King George Island region, as discussed by Parish (1983) and Schwerdtfeger (1984). Easterly winds are usually associated with westward-moving cold, stable air masses in the lowest 1,500 m of the atmosphere, reaching the mountain barrier of Antarctica Peninsula and deflected to the North (the barrier winds).

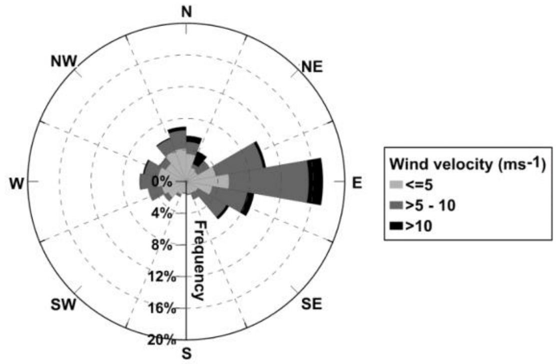

Figure 04. Distribution of wind velocity frequency related to the wind direction, measured at 10.2 m (third level) during January 2014.

The averaged diurnal variation of the wind velocity shows values around the monthly average, with three picks of velocity: the first one at 04 h, the second one between 12 and 15 h, and the last at 22h (Fig. 05a). Wind direction were preferentially from Northeast since from 0 to 10 h; after this period the wind direction was basically from East (Fig. 05b).

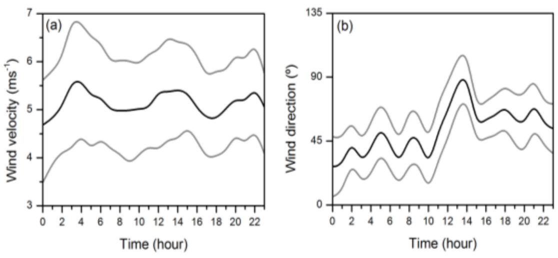

Figure 05. Mean diurnal variation of (a) wind velocity and (b) wind direction measured at 10.2 m level height. Black line represents the mean value while the grey lines show the interval of 95 confidence.

According to Jones and Simmonds (1993), low-pressure centres moving toward the east in the circumpolar west wind zone of Southern Hemisphere dominate the climatic conditions in King George Island. In addition, the geographical position of the Island leads to a polar maritime climate, especially for lower elevations as where EACF is located. The temperature is relatively warm (temperature rising above zero degree during summer), with a small variability in the mean annual temperatures, snowmelt starting usually in November and lasting until March (2/3 for the energy available for melt comes from the net radiation) (Bintanja 1995; Smith et al. 1996; and Wen et al. 1998).

Cold and dry air masses occasionally may be advected toward King George Island due to barrier winds along the east coast of the Antarctic Peninsula, which often persists for 1 day or more (Schwerdtfeger 1984). By the other hand, the passage of warm and humid air masses from the northerly directions, associated to cyclonic systems along the northern Antarctic Peninsula is responsible for melt events in the Island (Braun et al. 2001).

The lowest air temperature recorded near the surface (height of 2.1 m), during January was around -3.5 °C (with weak winds from the northern) during day 09 and the highest around 7.0 °C, during day 13 (over wind velocity around 10 ms^{-1} from North-West), as can be seen in Fig. 07a. The air temperature monthly averaged, near the surface, was about 0.6 °C, what agrees with previous studies. Rachlewicz (1997) and Rakusa-Suszczewski (1993) have shown that the average monthly air temperatures during summer periods reaches values above zero degree. It also can happen during winter periods, near the coast, due to the advection of warm humid air masses.

The air specific humidity presented its minimum value of 1.91 gkg^{-1} in 09 January and maximum of 5.26 gkg^{-1} during day 13 (Fig. 06b), with monthly average of 3.27 gkg^{-1}, which correspond respectively to the periods of lower and higher values of temperature. According to Bintanja (1995), during summer, it is usual to observe temperature values above 0 °C in the Brazilian Station due to the

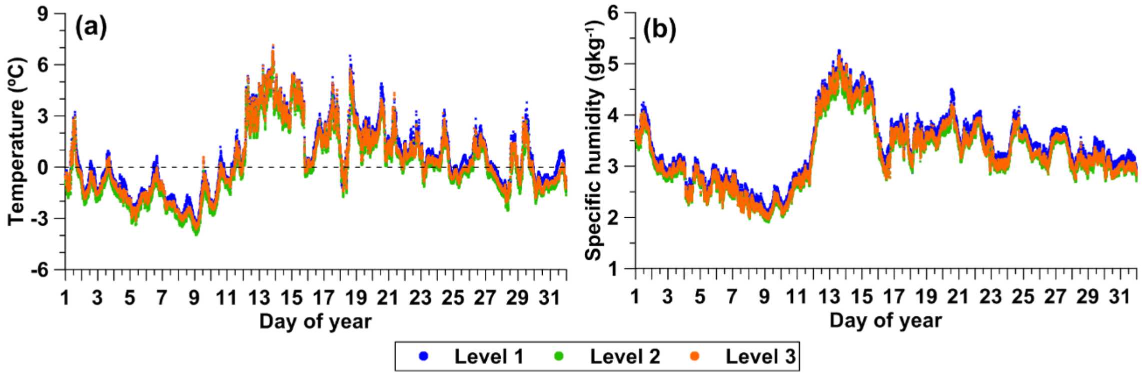

Figure 06. Temporal variation of (a) air temperature (C). The horizontal dashed line indicates 0 °C and (b) air specific humidity (gkg^{-1}) for January 2014. Blue, green and orange points represent the values obtained at level 1, 2 and 3, respectively.

occurrence of Föhn-type winds coming from the Northern side of the Station, which advect warm and dry air, rising the temperature in this region compared to the Northwest side (Martianov and Rakusa-Suszczewski 1989).

The mean diurnal variation of air temperature for this month shows the minimum at 05 h, with value around 0 °C, and the maximum at 16 h, with values around 1.3°C (Fig. 07a). The observed relative humidity diurnal variation is out of phase with the air temperature variation. During the day, the relative humidity values are lower than during night (Fig. 07b). The mean diurnal variation of air pressure presented values around 989.5 hPa with the minimum of magnitude during around 5 h (Fig.07c).

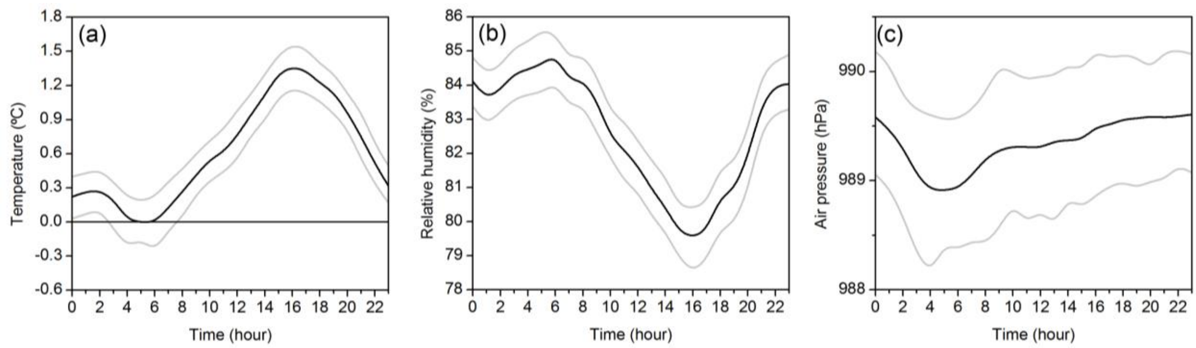

Figure 07. Mean diurnal variation of (a) temperature, (b) relative humidity, and (c) air pressure. Black line represents the mean value while the grey lines show the interval of 95 confidence.

4. Conclusions

This study showed how the meteorological variables are related with atmospheric systems over the King George Island. Consequently, this variation will be related with variances in vertical turbulent fluxes of heat and momentum in this region. These turbulent fluxes for this month in EACF are shown in Part II of this study (Alves et al. 2015).

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