Correlation between atmospheric physical factors and soil temperature of Keller Peninsula, King George Island, Antarctica

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Abstract
This study investigated what atmospheric physical factors (air temperature, precipitation, solar radiation, air moisture and wind) contribute to soil temperature in Keller Peninsula, King George Island, Antarctica. Temperature sensors were installed at three soil depths at two sites, near to the Antarctic Station Comandante Ferraz (Brazil). Data were collected every three hours during the period from March to December 2008 and were compared with atmospheric data from the meteorological station of the Instituto Nacional de Pesquisas Espaciais (INPE, Brazil). The air temperature was the factor that most influenced the soil temperature. Other factors such as precipitation and solar radiation had a significant contribution, however minor. The air humidity and wind affect respectively, the first 5 and 20 cm of soil. These results demonstrated the importance of monitoring the soil temperature as an indicator of climate change.

Key Words
Climate change, meteorology, cryosols, permafrost, active layer.

Introduction
The Maritime Antarctic region has the highest temperature and rainfall across the Antarctic continent which promotes primary production, soil genesis and biological activity in general. The increase in ice-free areas in the Antarctic, as a result of climate change, causes a series of local transformations that may affect the microclimate of the soil, causing greater melting of the permafrost and causing changes in the soil moisture (Francelino 2004). The study of soils in maritime Antarctica, considering the seasonal variation of the active layer and permafrost, is an efficient tool that highlights the effects of higher temperatures in the region, as the active layer and permafrost are both sensitive to climate change (Wu *et al.* 2005). In Antarctica, there is little information about the distribution, thickness, chemical, or physical properties of permafrost. This study was a comparison between the temperatures at different soil depths and atmospheric physical factors such as air temperature, humidity, precipitation, wind speed and solar radiation, in Keller Peninsula, located in King George Island, Antarctica Maritime.

Methods
Two sites were chosen (A and B) for monitoring the temperature of the soil, near to the Brazilian Antarctic Station Comandante Ferraz in the Keller peninsula (Figure 1). At each site three temperature sensors (Model 107 Temperature Probe) were installed at different soil depths and coupled to a storage device CR1000 data logger from Campbell Scientific. The system was programmed to perform reading of data every hour. Data on soil temperature, obtained from March to December 2008 were compared to data of precipitation (mm), air temperature (°C), relative humidity (%), solar radiation (W/m) and wind speed (m/s) in the same period, collected every 3 hours by the weather station of the National Institute for Space Research (INPE 2009), located next to EACF. For this comparison was calculated and tested - the 5% significance - the Pearson correlation coefficient (r) between the different variables, using the program STATISTICA 7.1 (StatSoft 2005). Data on soil temperature obtained by using the weather station at depths 0, 5, 10 and 20 cm, were used as a control. The data of radiation and moisture were processed to obtain a normal distribution, using the equation log(x +1).

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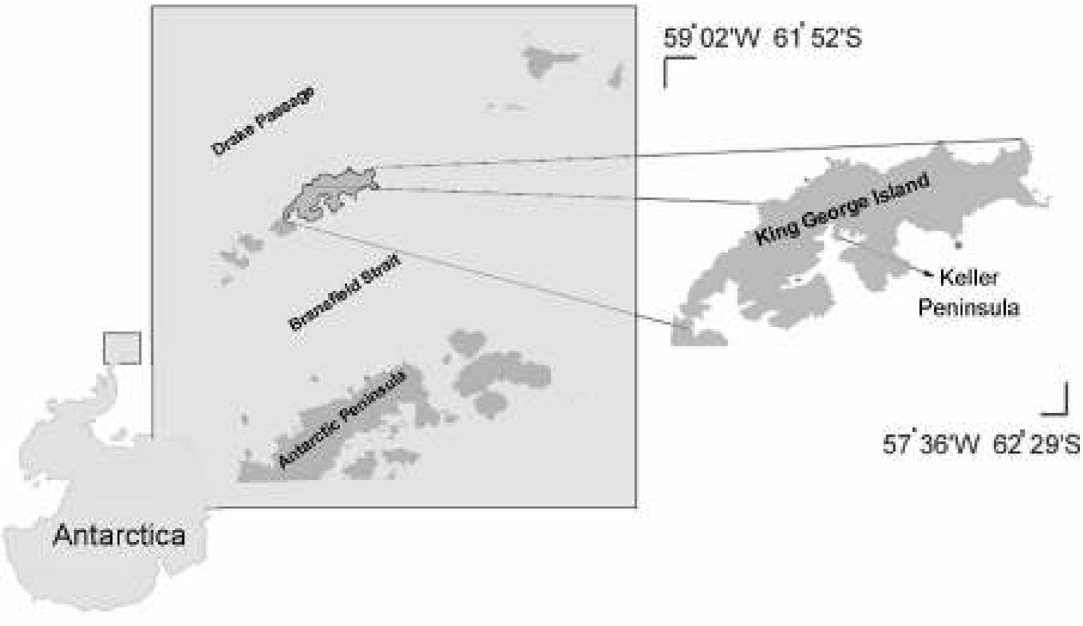

Figure 1. Location of Keller Peninsula in King George Island, Antarctica.

Results

There was a higher correlation between soil and air temperature than other factors studied (Table 1). However the correlation between soil and air temperature decreased with increasing the soil depth. This behavior was expected, (Francelino *et al.* 2004), since the air is in direct contact with the soil surface. Precipitation and solar radiation also contributed to soil temperature ($p < 0.05$), but at a lower intensity. The contributions of precipitation and solar radiation also decreased in the deeper layers. Air moisture had a negative correlation with soil temperature, being significant in the sensors of the meteorological station of INPE, where the moisture influenced the temperature of the soil to a depth of 5 cm. The wind affected the temperature of the soil to a depth of 20 cm.

Table 1. Correlations between atmospheric physical factors and soil temperature in the Keller Peninsula, Maritime Antarctica.

Site	Coordenate (UTM) E	N	Soil depth (cm)	Air temp.	Wind	Precip.	Moisture	Radiation
A	427137	3115583	10	0,61*	0,05*	0,10*	-0,04	0,31*
			44	0,43*	0,01	0,07*	-0,02	0,20*
			99	0,27*	-0,01	0,04*	0,02	0,08*
B	427053	3115790	10	0,70*	0,07*	0,12*	-0,03	0,36*
			51	0,53*	0,02	0,09*	-0,04	0,29*
			92	0,42*	-0,01	0,08*	-0,02	0,22*
INPE	427272	3115514	0	0,76*	0,12*	0,13*	-0,07*	0,45*
			5	0,76*	0,12*	0,14*	-0,04*	0,39*
			10	0,73*	0,11*	0,13*	-0,04	0,36*
			20	0,67*	0,09*	0,11*	-0,04	0,34*

Note: Temp.= temperature. Precip.= precipitation. * $p<0,05$.

The monthly mean soil and air temperatures obtained in the monitoring sites are shown in Figure 2. The air temperature was more similar to the surface soil temperature at site B. This is because site B was located at an elevation similar to the meteorological station, where they collected atmospheric data, which shows the change in microclimate that occurs in areas in close proximity of this region. It was observed that surface soil temperature in the depth of 10 cm is higher in summer compared to the deeper layers, a fact which is reversed in winter mainly due to the large amount of snow deposited on the soil surface in that period. There was also a slowing of the average temperature of soil in relation to the air. According to Setzer *et al.* (2004) this can be explained by the deepening slow-line freezing of the soil due to its constitutuents, i.e., a solid and porous materials, so that soil is not an efficient heat conductor.

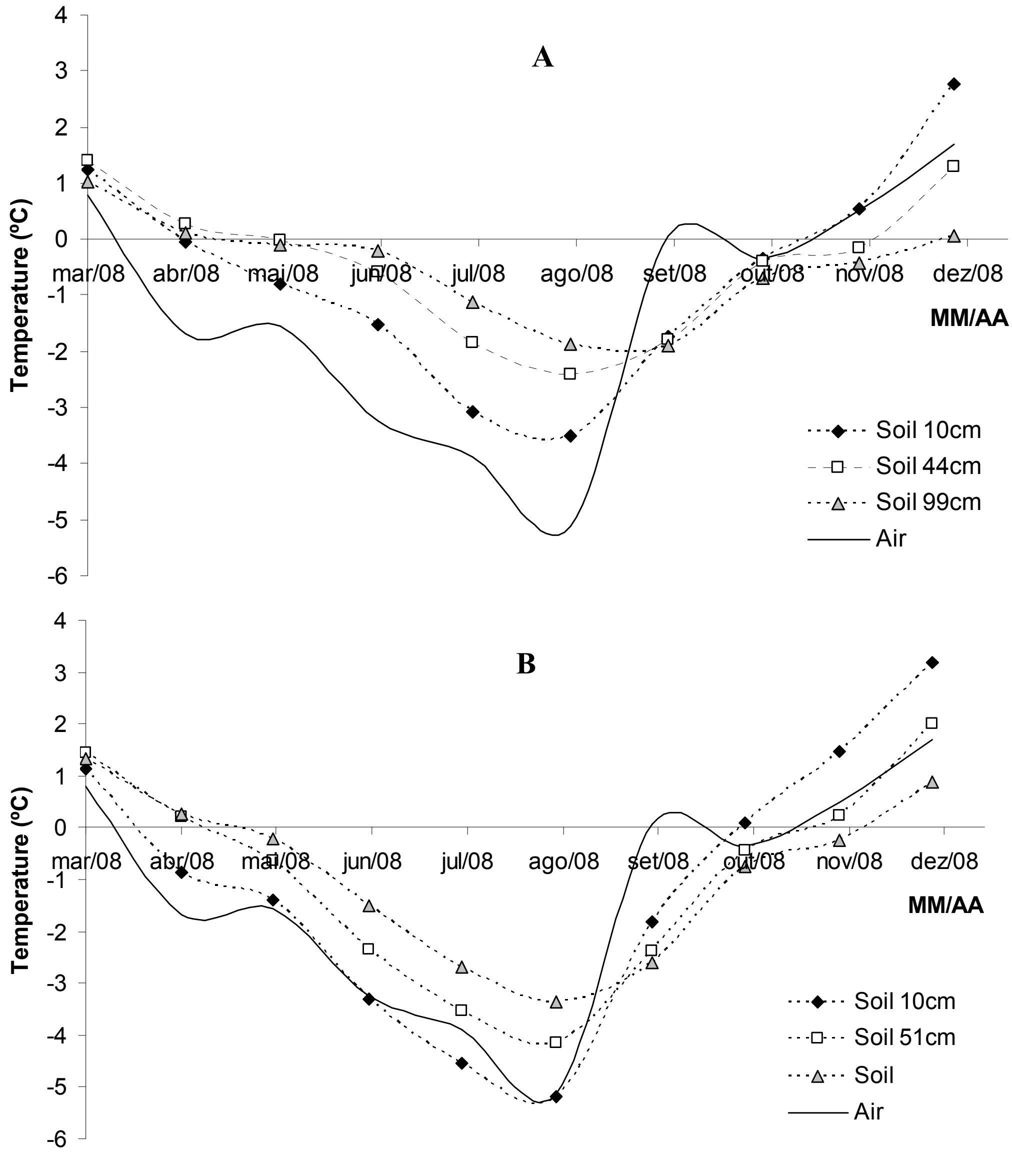

Figure 2. Soil and air temperature in A and B sites.

Conclusion

The air temperature was the atmospheric factor that had higher correlation with soil temperature. Precipitation and solar radiation also showed a significant correlation. The humidity and the winds seem to influence the soil temperature near the surface. A sampling of temperature and other physical factors in new areas may provide data for future environmental modeling of the region.

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