Study of surface energy balance at the Brazilian Antarctic Station in summer conditions using the WRF model

Caio Jorge Ruman, Jacyra Soares, Amauri P. de Oliveira, Georgia Codato

Micrometeorology Group, Atmospheric Science Department , USP, Brazil.

Introduction

Surface energy balance over different surfaces are important for diagnostic and prognostic climate change and environment monitoring studies. The primary objective of this work is to investigate the observational and numerical surface energy balance at the Brazilian Antarctic Station, located at the Keller Peninsula, Admiral Bay, King George Island, South Shetlands archipelago, Antarctic Peninsula (62°05' S, 58°23' W), set 20m above sea level (figure 1). King George Island is situated 130km from the Antarctic Peninsula and 849km from the southernmost point of the American Continent.

WRF specifications

The model Weather Research and Forecasting (WRF) and its Polar version (PWRF), version 3.5.1, were used to study the energy balance at King Georg Island, Antarctic.

Table 1: Grid Points, Spatial Resolution, Domain Size and Temporal Resolution used in the numeric experiments.

	Grid Points	Spatial Resolution	Domain size	Temporal Resolution
Domain 1	74 x 61	9km	666 x 549 km	60s
Domain 2	64 x 64	3km	192 x 192 km	30s
Domain 3	79 x 64	1km	79 x 64 km	10s

- 60 vertical levels, 10 bellow 800m;
- Topography: RAMP DEM v2;
- Model top at 10hPa;
- Model initialization and lateral boundary conditions: ERA-Interim;
- Four simulations of 5 days: from 00Z 20 Feb – 00Z to 25 Feb 2012 with 3 days of model spin-up

Parameterizations were selected based on a series of 3 days simulations – 20 to 23 Feb 2012.

Table 2: Parameterization used in the numeric experiments

Physical Process	Parameterization Scheme
Microphysics	MYDM (Conf. 1) WSM6 (Conf. 2)
Shortwave Radiation	RRTMG
Longwave Radiation	RRTMG
Surface Layer	Eta similarity
Planetary boundary layer	Mellor-Yamada-Janjic (MYJ)
Land Surface	RUC
Cumulus (d01 and d02 only)	Kain-Fritsch

Modifications were made on domain d03 to account for non-glaciated areas: change of the albedo and terrain type.

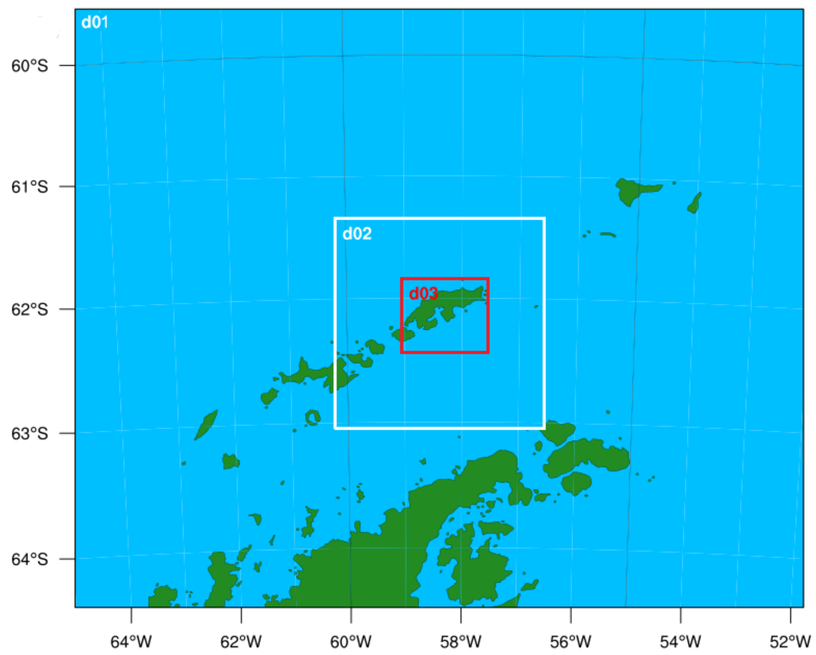

Figure 1: Domain configuration used, with 3 nested domains. Domain d01 centered at 62°05'S, 58°23'W.

Model Validation

WRF was validated using data collected *in situ* at the Brazilian Antarctic Station for the project ETA (Study of the Antarctic Turbulence): air temperature at 2m, soil temperature at 5cm depth, surface pressure, net shortwave radiation, wind velocity, downward longwave radiation and specific humidity at 2m. The sensible and latent heat were estimated using the flux-profile method.

The observed and numerical values were statistically compared using Root Mean Square Error (RMSE), Mean-Bias Error (MBE) and its correlation.

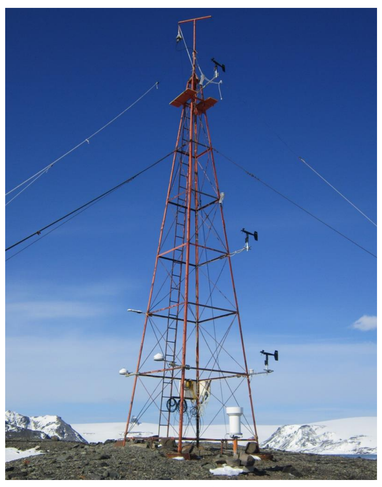

Figure 2: East view of the 12 meter instrumented South Tower.

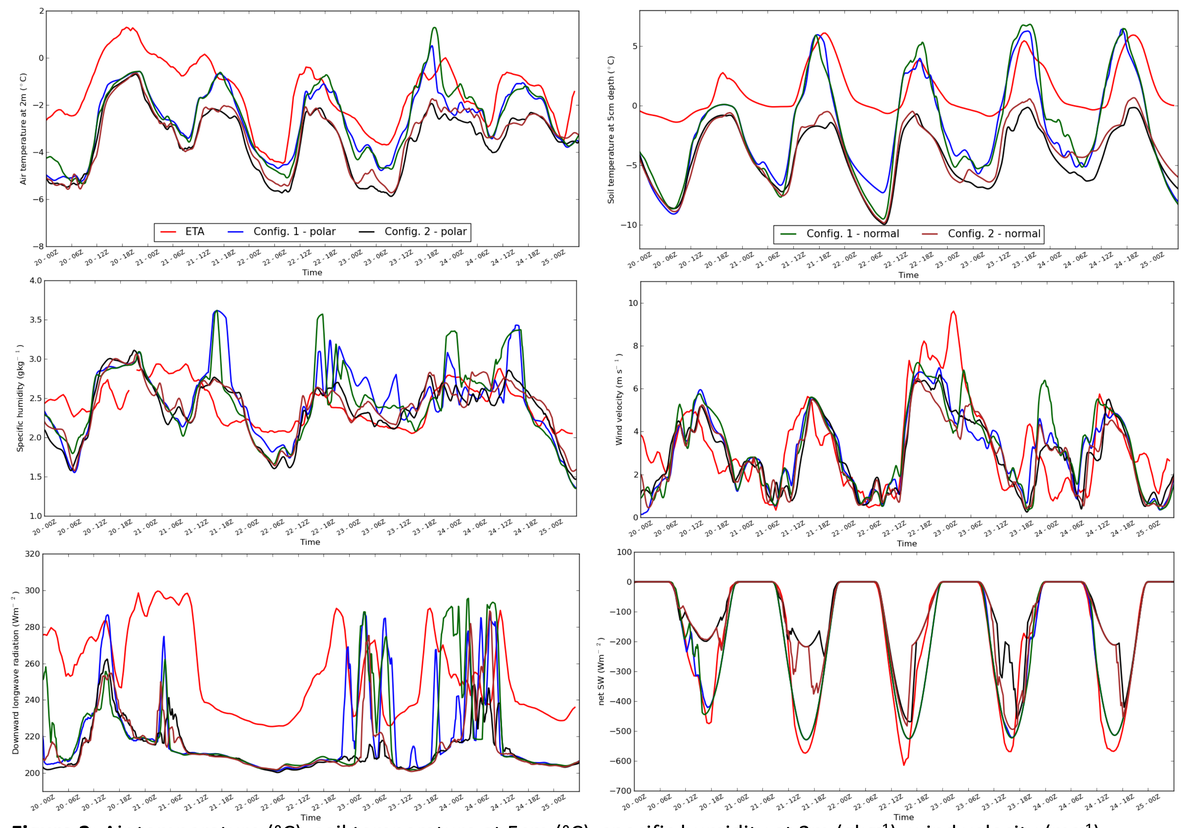

Figure 3: Air temperature (°C), soil temperature at 5cm (°C), specific humidity at 2m (gkg^{-1}), wind velocity (ms^{-1}), downward longwave radiation (Wm^{-2}), net showrtwave radiation (Wm^{-2}) for 20 to 25 Feb 2012 .ETA Project (red), WRF config. 1 (green), WRF config. 2 (brown), PWRF config. 1 (blue) and PWRF config. 2 (black).

Results

The energy fluxes are positive when oriented upward.

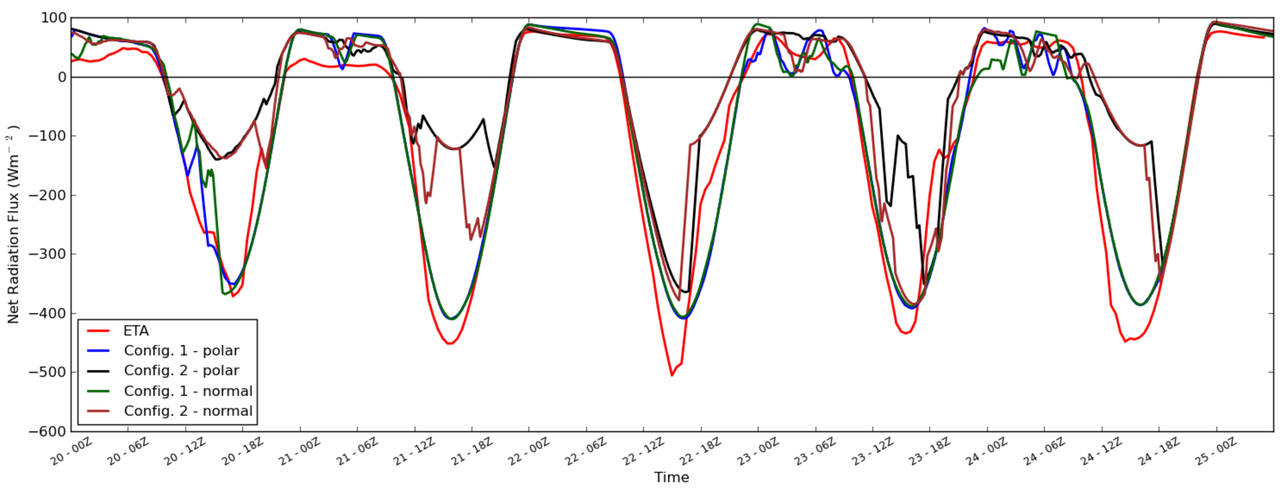

Figure 4: Net Radiation (Wm^{-2}) for 20 to 25 Feb 2012. ETA Project (red), WRF config. 1 (green), WRF config. 2 (brown), PWRF config. 1 (blue) and PWRF config. 2 (black).

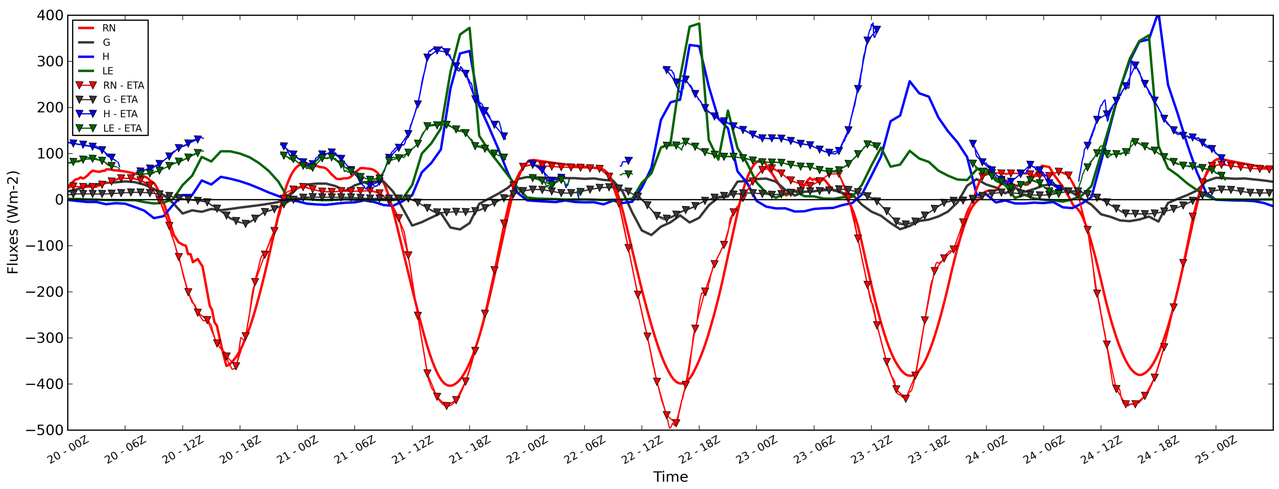

Figure 5: Energy balance components for 20 to 25 Feb 2012 for the ETA project (symbols) and the WRF config. 1 (lines). Net radiation (red) and soil heat flux (gray) observed values. Sensible heat (blue) and latent heat (green) calculated using the flux-profile method.

Discussion

- MYDM microphysics scheme simulated the region better then WSM6 scheme;
- Minimal difference between WRF and PWRF for the region studied. WRF is marginally better;
- Air temperature, wind velocity and pressure were well simulated, with low RMSE, high correlation values and a positive bias for pressure and a negative bias for air temperature and wind velocity;
- Days with less clouds were better represented. WRF underestimated downward longwave radiation;
- Sensible heat and soil heat flux was in accordance with the estimated values in daytime. Latent heat were overestimated by WRF due to the cloud representation;

The next step is to measure the sensible and latent heat fluxes using the direct method, as the high frequency instruments will be installed this November.

Acknowledgements: The first author Caio Jorge Ruman thanks CNPq scholarship 131881/2013-2. All authors thanks CNPq (ETA 407137/2013-0) and INCT-APA.
This work integrates the National Institute of Science and Technology Antarctic Environmental Research (INCT-APA) that receives scientific and financial support from the National Council for Research and Development (CNPq process: n° 574018/2008-5) and Carlos Chagas Research Support Foundation of the State of Rio de Janeiro (FAPERJ n° E-16/170.023/2008). The authors also acknowledge the support of the Brazilian Ministries of Science, Technology and Innovation (MCTI), of Environment (MMA) and Inter-Ministry Commission for Sea Resources (CIRM).