Observational and Numerical Characterization of the Planetary Boundary Layer of the Urban Area of São Paulo - Brazil

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OBJECTIVES

A series of atmospheric soundings performed during the austral summer and winter taken at the Campo de Marte Airport (Fig. 1c), near the center of the city of São Paulo, as part of the MCITY project (Micrometeorological features of the urban climate of São Paulo CITY) are compared to the results of the WRF model. The time evolution of the PBL was analyzed.

SÃO PAULO CITY: Area: 1,530 km^2; Average altitude: 760 m; Population: 10,886,518 inhabitants; Vehicular fleet: 6,7 millions; Metropolitan area (Fig. 1c): 39 cities – 19 millions inhabitants

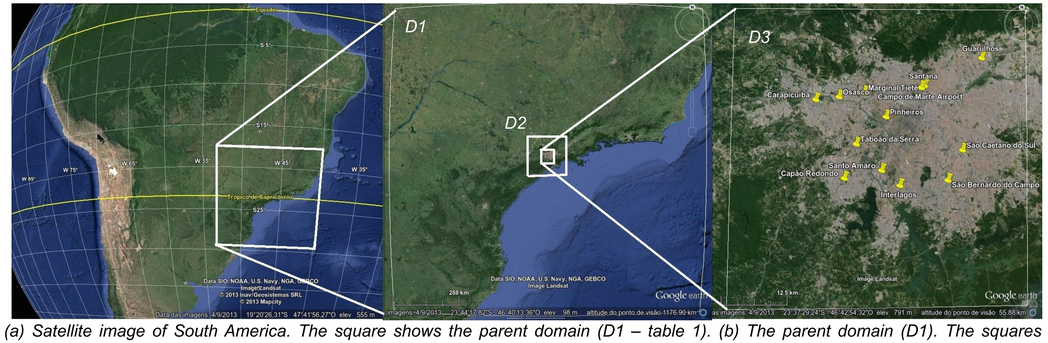

Figure 1: (a) Satellite image of South America. The square shows the parent domain (D1 – table 1). (b) The parent domain (D1). The squares show the children domains (D2 and D3). (c) D3 domain and the locations of the Campo de Marte Airport and the 12 Monitoring Stations of the Environmental Agency of São Paulo State (CETESB) – table 2.

METHODOLOGY

THE WRF MODEL: 3.5 version with 3 nested grids:

Domain	Horizontal Resolution	Horizontal Grid Points	Vertical Grid Points
D1	30 km	80	31
D2	10 km	25	31
D3	6 km	51	31

Initial and boundary conditions: GFS global model every 6 hours, spatial resolution of 1°. Parameterization schemes: a) microphisics - WSM-3; b) cumulus - Kain-Fritsch scheme; c) short and longwave radiation - RRTM/Dudhia; d) surface boundary layer - Monin-Obukhov; and e) surface - Noah.

Table 1: Resolution and grid points of the 3 domains used by the model simulation.

THE SOUNDINGS: From February 19th to February 28th of 2013 and from August 6th to August 16, a radiosonde sounding was launched every 3 hours, totalizing 80 vertical profiles of temperature, humidity and wind speed and direction for each campaign. They were taken at the Campo de Marte Airport (Fig. 1c).

VALIDATION OF THE MODEL: The hourly model results for the surface air temperature, relative humidity and wind velocity were compared to hourly averaged measurements taken at 12 Monitoring Stations of the Environmental Agency of São Paulo (CETESB) for the period of the summer campaign.

Monitoring Station (Fig. 1c)	Santana	S. Caetano do Sul	S. Bernardo do Campo	Santo Amaro	Osasco	Pinheiros	Carapicuíba	Interlagos	Guarulhos	Marginal Tietê	Taboão da Serra	Capão Redondo
Air Temperature (°C)	___	___	___	___	___	2,976	2,813	2,367	2,043	2,15	2,562	2,388
Relative Humidity (%)	___	___	___	___	___	___	14,2	12,9	11,4	14,4	15,1	12,9
Wind Velocity (m s-1)	2,625	2,178	2,612	2,059	1,837	2,163	1,75	1,762	2,169	1,668	___	1,98

Table 2: Root Mean Square Error (RMSE) of the model results compared to the measurements taken at the Environmental Agency of São Paulo State (CETESB) Monitoring Stations from 00LT 02/18/2013 to 00LT 02/28/2013.

RESULTS

Period	Maximum PBL Height	Day-Time	Minimum PBL Height	Day-Time	Occurrences of PBL Height < 200 m
Summer - Observation	1857	20 - 18LT	50	--	18
Modeled	1895,8	21 - 15LT	48	25 - 03LT	15
Winter - Observation	2068	10 - 15LT	50	--	14
Modeled	2512,5	13 - 15LT	29,3	13 - 06LT	14

Table 3: PBL maximum and minimum height during Summer and Winter campaign, estimated by the soundings and modeled by WRF.

RESULTS

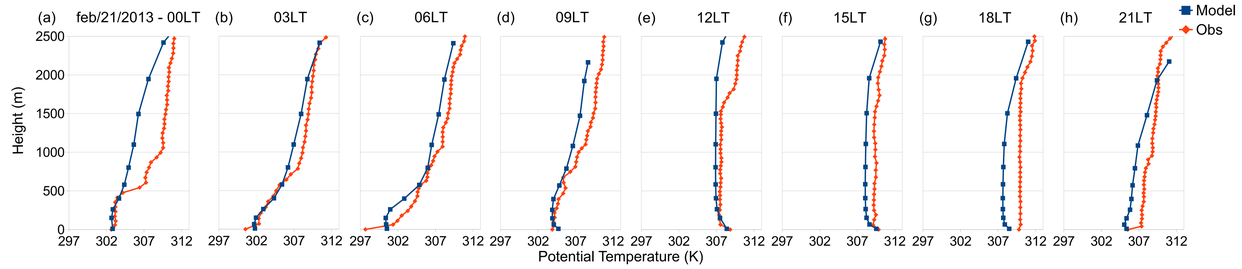

Figure 2: Vertical profile of potential temperature from the soundings (obs-orange line) and modeled (model-blue line) - Feb/21/2013 at (a) 00LT, (b) 03LT, (c) 06LT, (d) 09LT, (e) 12LT, (f) 15LT, (g) 18LT and (h) 21LT.

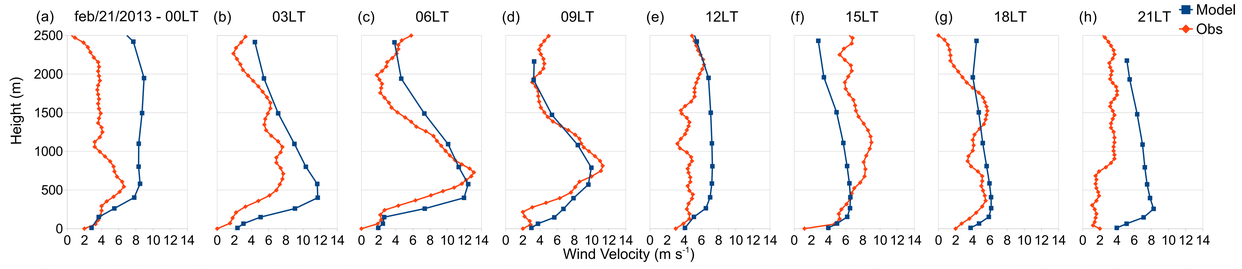

Figure 3: Vertical profile of wind velocity from the soundings (obs-orange line) and modeled (model-blue line) - Feb/21/2013 at (a) 00LT, (b) 03LT, (c) 06LT, (d) 09LT, (e) 12LT, (f) 15LT, (g) 18LT and (h) 21LT.

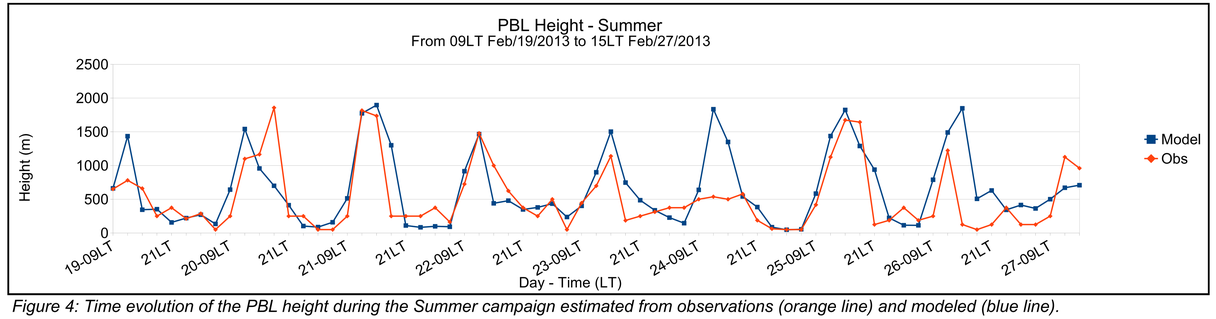

Figure 4: Time evolution of the PBL height during the Summer campaign estimated from observations (orange line) and modeled (blue line).

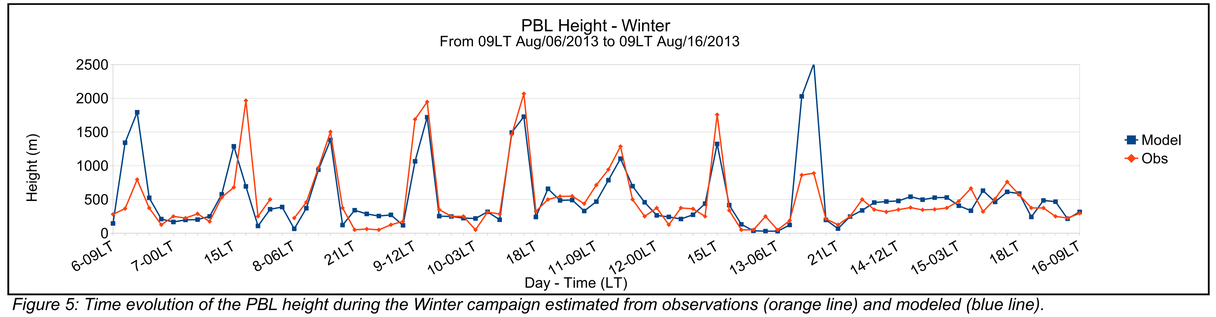

Figure 5: Time evolution of the PBL height during the Winter campaign estimated from observations (orange line) and modeled (blue line).

DISCUSSION AND CONCLUSION

The PBL evolution presented a similar behavior for the austral summer and winter periods, but the minimum and the maximum PBL height values were found during winter. The passages of cold fronts have an important impact on the PBL evolution. A low level jet is present during most of the nights. The model was able to represent important features of the PBL over the city of São Paulo, such as the PBL evolution and the low level jets. Future work will be to compare the direction of the wind and to determine the cause of the low level jets; to increase the vertical resolution of the model in order to improve the results near the surface and to test other parameterizations and study the performance of the model.

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