bridging the gap
BETWEEN ATMOSPHERIC SCALES

Numerical investigation of the PBL moisture content in the city of São Paulo using LES

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I. Motivation and objective

♦ Moisture content affects PBL directly by enhancing turbulent convection and indirectly by altering the energy balance at surface.

♦ The main objective here is to investigate the role played by moisture content on the PBL properties using Large-Eddy Simulation of a complete diurnal cycle. The model was developed by Moeng and Sullivan.

II. Initial conditions and surface forcings

♦ Initial PBL (180 m) and free atmosphere (180-2000 m) conditions correspond to mean (June/2004-2011) radiosonde profiles at 12 GMT [09:00 local time (LT)]. Surface heat fluxes are estimated from mean surface air temperature (June/1997-2011) and specific humidity (June/2009-2011) observations in SP.

♦ All simulations begin at 06:30 LT (June 15) and within the PBL the vertical structure was modified (by trial and error) to match the simulated structure to the observed mean profiles at 09:00 LT.

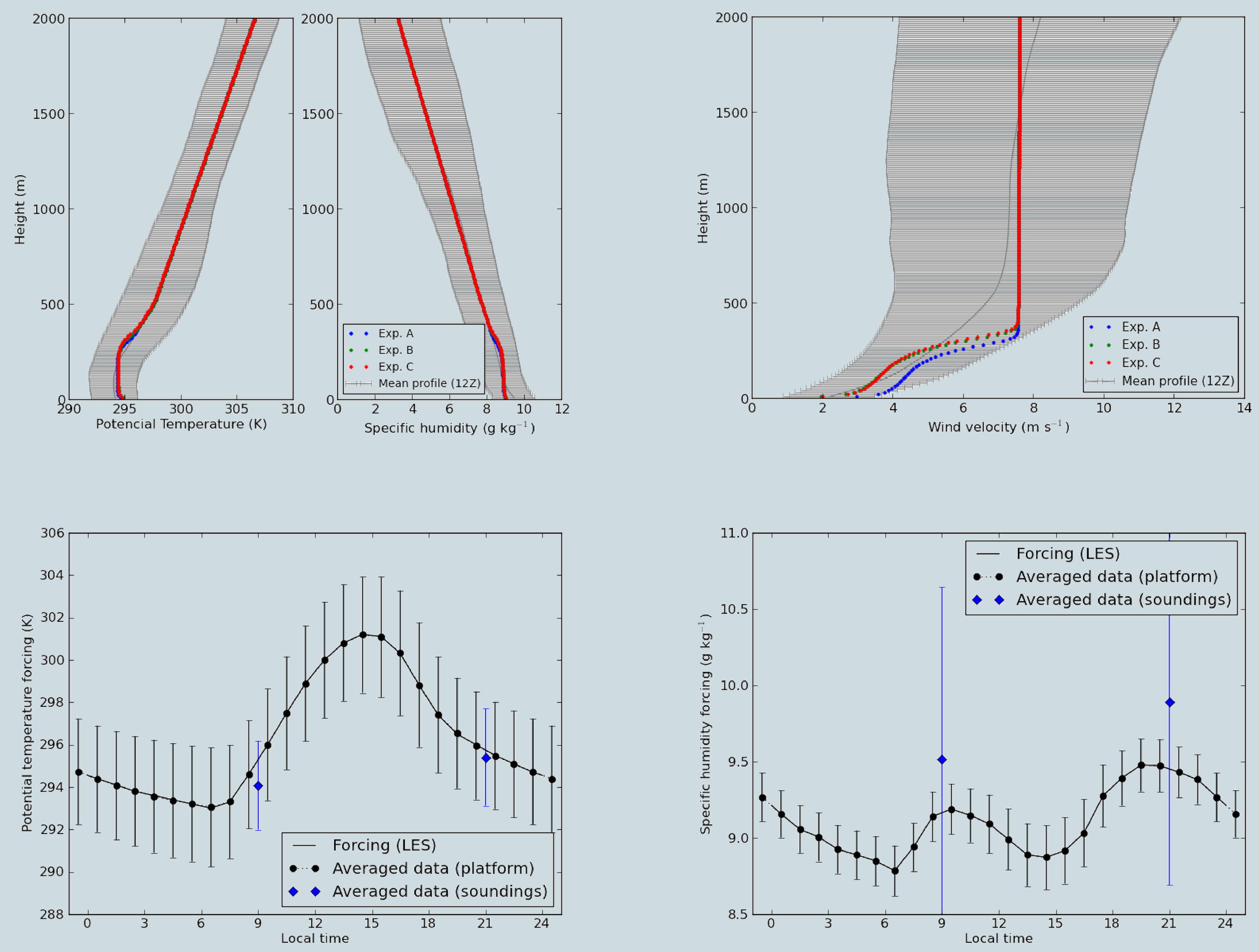

Figure 1: Monthly average potential temperature, specific humidity and wind velocity profiles at 09:00 local time (top) and hourly values of potential temperature and specific humidity at surface (bottom). Horizontal and vertical bars indicates standard error. Radiosondes were launched at Campo de Marte airport (23.50°S, 46.60°W, 722 m). Surface measurements were taken at the Micrometeorological Platform located in the University of São Paulo *campus* (23.40°S, 46.70°W, 742 m). Experiments **A**, **B** and **C** are described in section III.

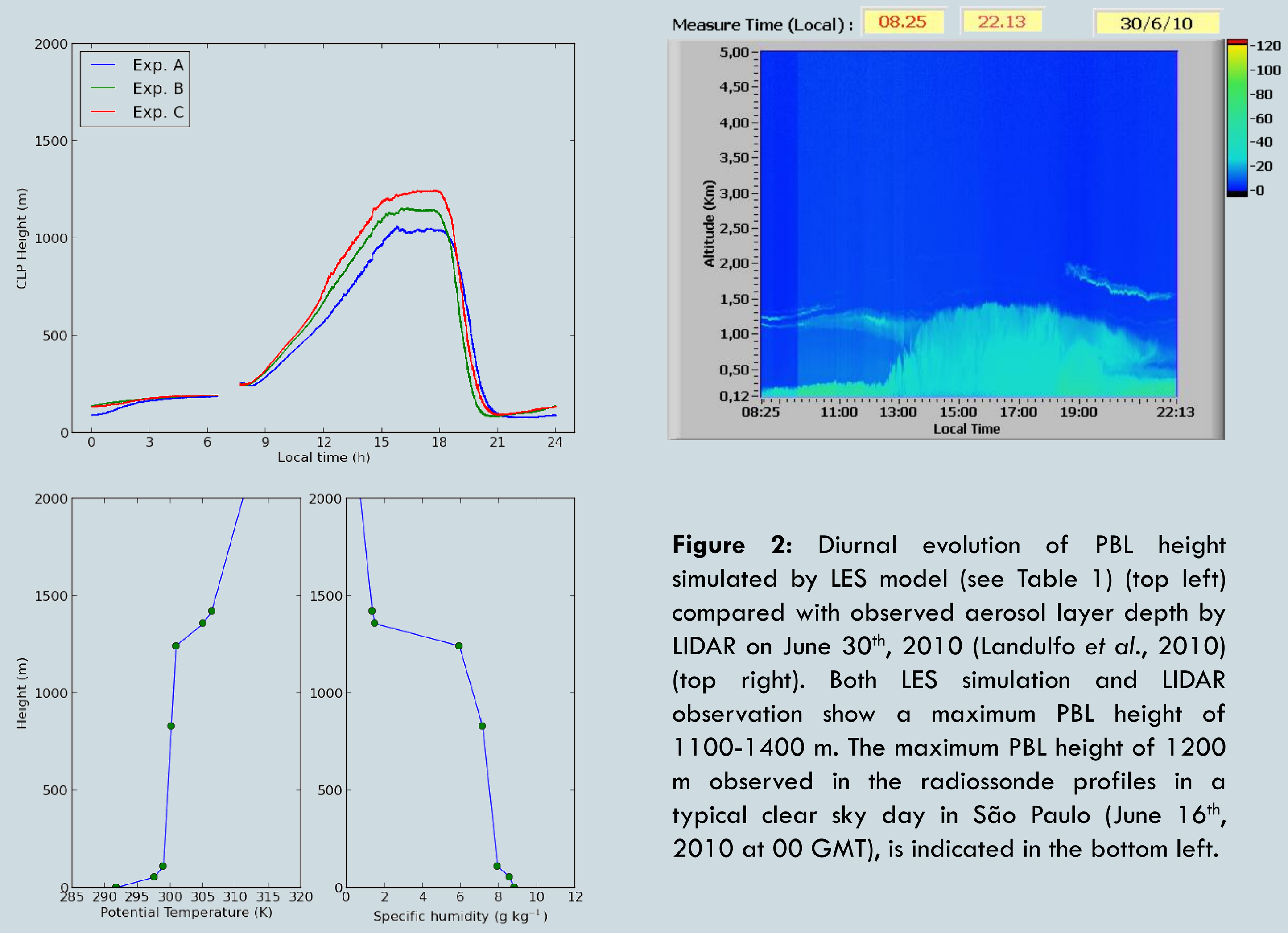

Figure 2: Diurnal evolution of PBL height simulated by LES model (see Table 1) (top left) compared with observed aerosol layer depth by LIDAR on June 30th, 2010 (Landulfo *et al.*, 2010) (top right). Both LES simulation and LIDAR observation show a maximum PBL height of 1100-1400 m. The maximum PBL height of 1200 m observed in the radiosonde profiles in a typical clear sky day in São Paulo (June 16th, 2010 at 00 GMT), is indicated in the bottom left.

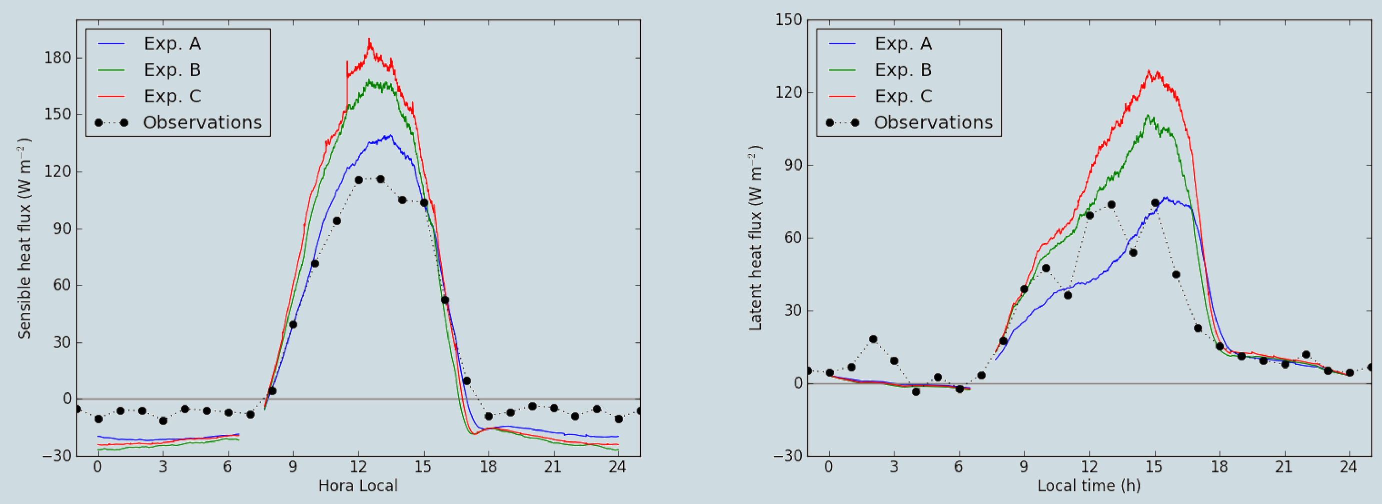

Figure 3: Diurnal evolution of **(a)** sensible heat flux and **(b)** latent heat flux during the three LES experiments (see Table 1), compared with hourly means for the month of June, 2010, taken at the micrometeorological platform of IAG/USP (Ferreira, 2010).

♦ Similarity expressions were obtained for variances and covariances involving specific humidity for free convection regime (Exp. **B**) :

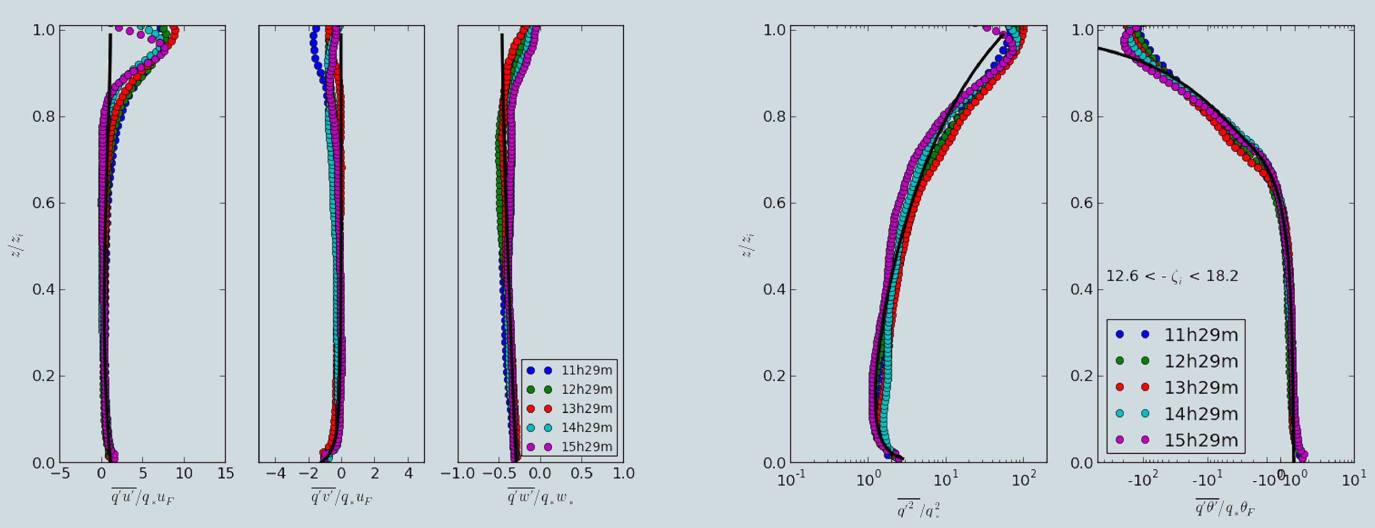

Figure 4: LES vertical profiles on free convective regime for **(a)** $\overline{q'u'}, \overline{q'v'}, \overline{q'w'}$, **(b)** $\overline{q'^2}$ and $\overline{q'\theta'}$ normalized by θ_F, u_F, w_* and q_*. These expressions where obtained considering just points in the first 80% portion of the mixed-layer.

III. LES experiments

♦ Three experiments, designated **A**, **B** and **C**, were performed with the same: grid domain (5,0² × 2,0 km³); grid points number (96² × 192); latitude (23°32'); geostrophic forcing (6.8, –3.4) m s⁻¹, and initial and boundary conditions, shown in Figure 1. Experiment **B** was used as comparison reference.

♦ Experiment **A** is compared with **B** to study the impact of different values of z_0.

♦ Experiment **C** is compared with **B** to study the relevance of using θ_v instead of θ.

Tabel 1: 24h LES experiments with initial and boundary conditions representative of the MRSP.

	z_0	Forcings	z_i máx.	z_i final
Experiment A	0.1 m	$\{\theta, q\}$	1063 m	185 m
Experiment B	0.5 m	$\{\theta, q\}$	1156 m	193 m
Experiment C	0.5 m	$\{\theta_v, q\}$	1245 m	192 m

♦ Turbulent fluxes at the surface (Fig. 3) are best represented by the smaller value of z_0, associated to smaller vertical wind gradients, even though observations indicate that z_0 = 0.5 m represents u_* and wind profiles more realistically.

♦ PBL is 8% higher and turbulent fluxes at surface are 15% larger when moisture is included explicitly in the simulation using θ_v instead of θ(Table 1, Figs. 3-4).

IV. Surface energy balance model

♦ Soil-vegetation-atmosphere transfer scheme (Oliveira, 2003; Bárbaro *et al.*, 2010):

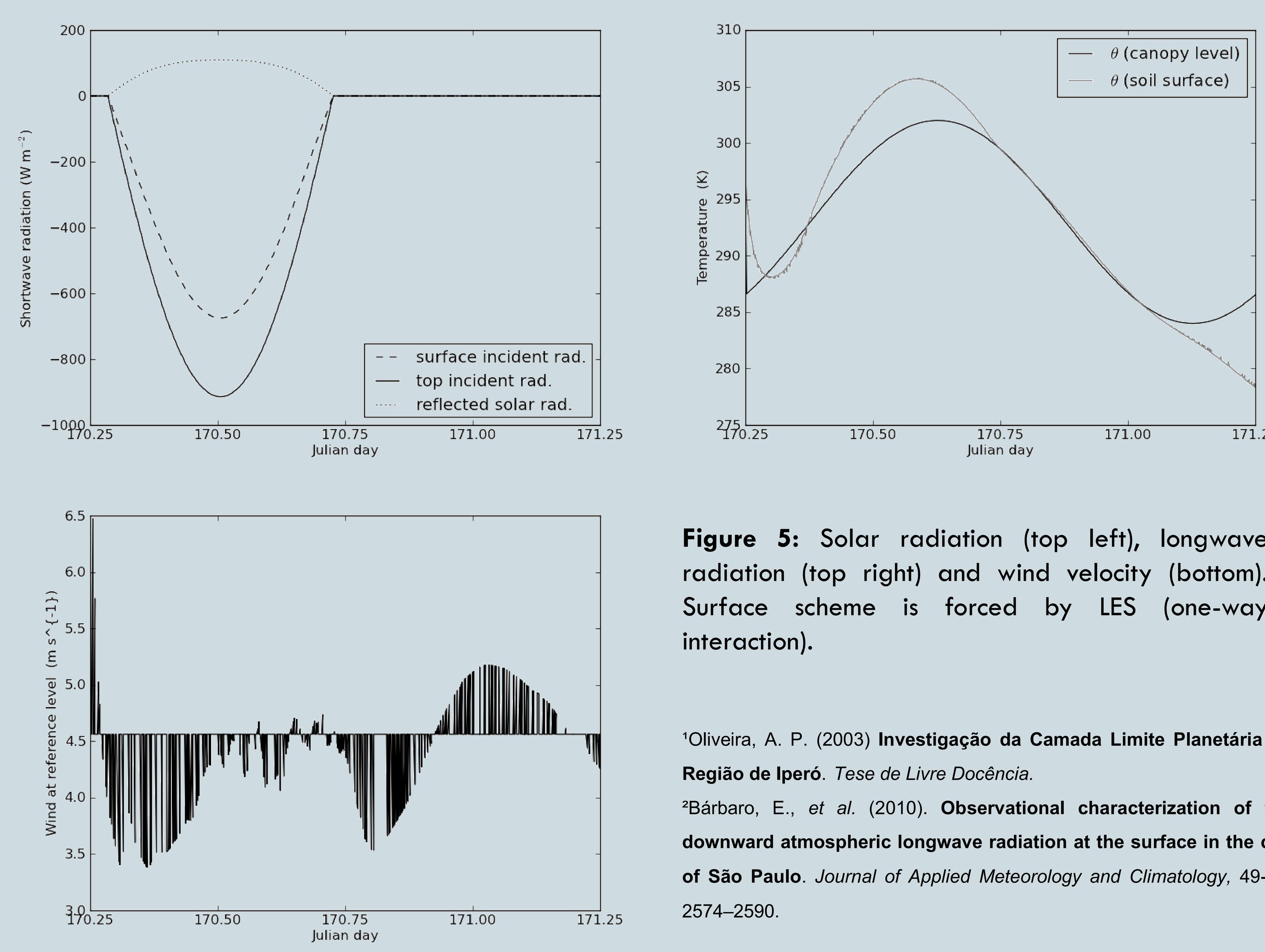

Figure 5: Solar radiation (top left), longwave radiation (top right) and wind velocity (bottom). Surface scheme is forced by LES (one-way interaction).

[1]Oliveira, A. P. (2003) **Investigação da Camada Limite Planetária na Região de Iperó**. *Tese de Livre Docência.*

[2]Bárbaro, E., *et al.* (2010). **Observational characterization of the downward atmospheric longwave radiation at the surface in the city of São Paulo**. *Journal of Applied Meteorology and Climatology,* 49-12, 2574–2590.

V. Aknowledgements

SENSE WAGENINGEN UNIVERSITY WAGENINGEN UR CAPES CNPq FAPESP