The stably-stratified PBL generated by LES

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1. Introduction

In the last decades both the theoretical and experimental progress has improved our understanding of the physics of the spatial and temporal evolution of the Stable Boundary Layer (SBL). In the SBL, the buoyancy is able to suppress the turbulent eddies that become smaller in dimension and independent of the distance from the surface. This fact prevents the easy getting of a representative scale (Sorbjan, 1986). Other restrictions as the intermittent regime of the turbulence, gravity waves interaction and inertial oscillation can difficult the development of a complete framework (Mahrt, 1999). In this study the Large-eddy Simulation (LES) model is used to investigate some characteristics of the SBL under moderate condition that occurs during transition periods. One of the major difficult in simulating the SBL with LES is the need of a significant resolution and computational facilities (Beare *et al.*, 2006).

2. The computational set up

To generate a SBL we followed the methodology proposed by Saiki *et al.* (2000) and Kosovic and Curry (2000). The numerical domain was defined 1 km in each coordinate direction, and a set of 128^3 evenly spaced grid points. The initial condition consisted of a convective boundary layer mean structure with a prescribed geostrophic wind equal to $\left(U_g, V_g\right) = (15.0, 0)\,\mathrm{ms}^{-1}$, and a positive kinematic heat flux of $\left(w'\theta'\right)_0 = 0.05\,\mathrm{mKs}^{-1}$. A strong capping inversion was established at 500m to limit the growth of the boundary layer. After one hour of physical time, the kinematic heat flux was reset to zero and a neutral PBL was simulated for the next hour. This was followed by a gradual cooling the boundary layer over a time period of 8 hours, with a variable surface cooling rate. The statistic analysis was done over the last two hours of the simulation.

3. Results

The SBL simulated presents a friction velocity nearly constant of $u_* = 0.38\,\mathrm{ms}^{-1}$ that is associated to the stability parameter z_r/L equal to 0.23, were L is the Monin-Obukhov length scale and $z_r = 15\,\mathrm{m}$ is the second vertical level of the grid. In the Figure 1 presents the low-level jet generated by inertial oscillation with a supergeostrophic mean wind velocity of $21.6\,\mathrm{ms}^{-1}$.

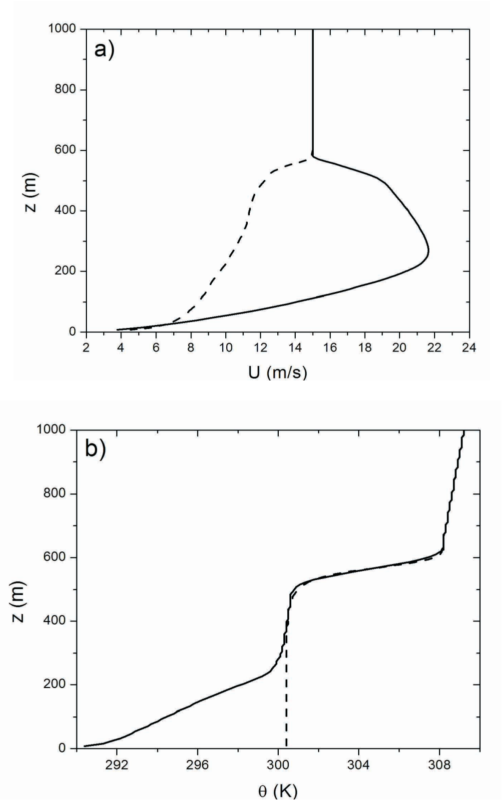

Figure 1. Vertical profiles of mean wind velocity (a) and potential temperature (b). The dashed line represents the initial time and solid line the last 2 hrs of the simulation.

The potential temperature profile (Fig. 1) showed the development of an extensive inversion layer on the surface. The total cooling of the surface layer during the simulation was approximately 10 K.

Figure 2 presents the horizontal and vertical wind velocity spectra. The spectra at the top there is evidence of peaks in the low frequency range. This fact probably indicates the presence of gravity waves. Near to the surface, in the inertial subrange, the spectral line is more inclined in relation to the expected, likely it can be associated to the difficult in maintain the resolved small turbulent scales of the eddies in the SBL with the larger dissipation provided by the LES subgrid model.

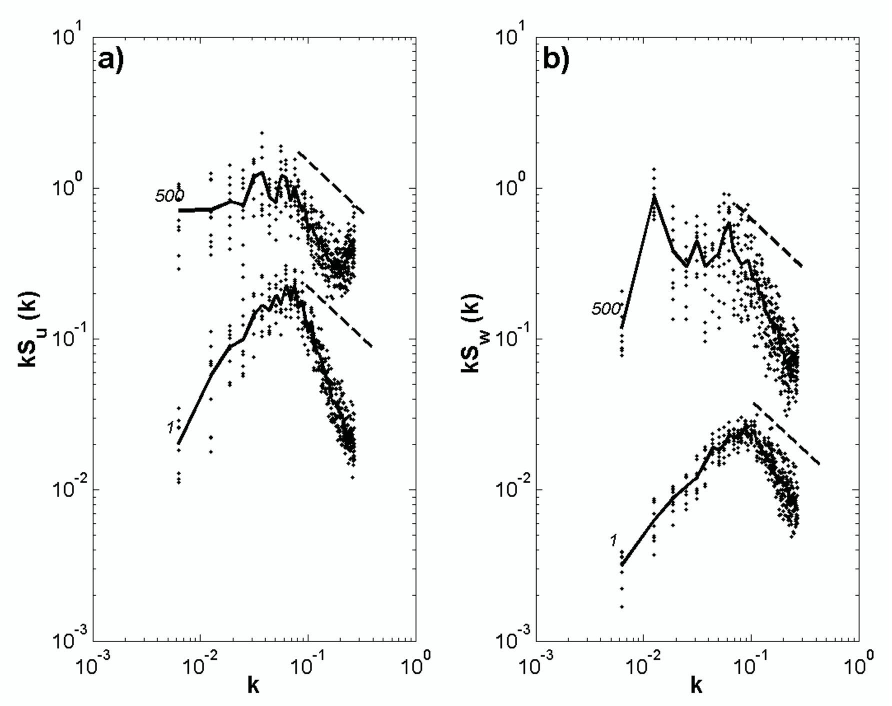

Figure 2. Spectral wind velocity components: a) horizontal; b) vertical. The dashed line represents the $k^{-2/3}$ and solid line represent the mean values in the layers $z \leq 80\,\mathrm{m}$ (lower) and $230 \leq z \leq 300\,\mathrm{m}$ (upper), multiplied by 500 for visualization.

4. References

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