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RAMS sensitivity to mesh resolution in large eddy simulation of the neutral and convective atmospheric boundary layer

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Large Eddy Simulation (LES) is a computational fluid dynamic technique that has been extensively used to reproduce turbulence in the Atmospheric Boundary Layer (ABL). Most LES applications to ABL modelling deal with idealized regimes, particularly suited for the verification of simulation results and consisting in homogeneous surface properties, prescribed fluxes at the surface and periodic lateral boundary conditions. In recent years interest has grown around the possibility of using LES as a tool to study ABL turbulence in more realistic situations, i.e. avoiding periodic lateral boundary conditions and coupling LES with a land surface model that dynamically computes heat and moisture fluxes at the surface. One appealing alternative to periodic lateral boundary conditions seems to be grid nesting, that should make LES a suitable tool to reproduce real meteorological flows over complex terrain at the microscale. In this framework Numerical Weather Prediction Limited Area Models (NWP-LAMs) appear to be particularly suitable to perform LES of the ABL in realistic conditions because of both i) their capability of nesting, ii) the presence of one or more land surface model coupled with the equations of motion. The use of NWP-LAMs at the microscale is increasing, but the fact that NWP-LAMs are built to work at the mesoscale has to be taken into account. Consequently the evaluation of their performances at the microscale in idealized regimes should be the first step for their use in more complex simulations. The Regional Atmospheric Modelling System (RAMS) is one of the most popular and used NWP-LAMs, and its performances in LES of a ABL in both real and idealized conditions have been evaluated in several studies. This work aims at assessing the impact of mesh resolution on the performances of RAMS-LES in the two opposite idealized regimes of neutral and convective atmospheric boundary layer, for which the turbulent statistics and flow structures are well known. For both the considered regimes nine simulations are performed on a fixed computational domain, combining three different horizontal and vertical resolutions. Mesh resolution impact is assessed through the analysis of fundamental ABL turbulence statistics: mean vertical profiles of horizontal velocity, potential temperature, heat and momentum fluxes, turbulent kinetic energy and velocity variances. In addition velocity spectra and instantaneous flow fields are examined. The results reveal a different role between horizontal (Δx) and vertical (Δz) resolution, and in particular they show that the aspect ratio ($\Delta x/\Delta z$) of the mesh needs to be small enough to prevent the formation of noise in the simulated flow. But, at the same time, the best results are obtained when the aspect ratio is higher than a certain lower limit, that in our simulations is around 4 for the neutral case and 2 for the convective regime. In addition, the performed simulations demonstrate that RAMS-LES can be considered a suitable tool to study ABL phenomena if the requirement of a sufficiently fine horizontal resolution is matched, and the above said condition on the aspect ratio is satisfied.