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LES of Scalar transport in a turbulent katabatic flow along a curved slope in the context of stably stratified atmospheric boundary layer.

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The behaviour of the Atmospheric Boundary layer (ABL) along alpine valleys is strongly dependent on the day-night thermodynamic cycle and might impact meteorology and air pollution prediction. At night, the ABL is stably stratified and the radiative cooling of the surface yields the development of a katabatic flow. This flow consists of a downslope wall-jet which has the structure of both wall turbulence in the inner-layer zone and shear layer turbulence in the outer-layer zone and enhances a relative mixing eventhough stable stratification is considered. A full 3D description of such flow by mean of Large Eddy Simulation of turbulence (LES) has not yet been achieved, except recently on relatively simple slopes (Skyllingstad 2003, Fedorovith and Shapiro 2009) or including geostrophic wind forcing (Cuxart et al. 2006, Cuxart and Jimenez 2006). This is the purpose of the present study to accurately describe the ABL on a curved slope with stable stratification, including passive scalar transport. The numerical code used, Meso-NH, has been developed in CNRM/Meteo-France and Laboratoire d'Aérologie Toulouse, and consists of an anelastic non-hydrostatic model solving the pseudo-incompressible Navier-Stokes equations. About 5 million grid points are necessary to afford a relatively precise description of the flow in the vicinity of the ground surface, with a special refinement down to 1 m in the vertical direction to capture the wall-jet developing along the slope. The setting of initial and boundary conditions is crucial for the simulation of stable ABL. Initial conditions consist of air at rest following a stable temperature profile with a constant Brunt-Väisälä frequency $0.01<N<0.02$. A rough surface boundary condition with a roughness length of r=35 cm is applied as no-slip condition. A constant surface cooling -30 W/m2 < q_w < -10 W/m2 is applied on the stably stratified fluid initially at rest, which generates a katabatic downslope flow along the bottom surface due to gravity effect. After a transient of about two hours, a strong mean shear is observed in the external part of the ABL all along the slope which forms a shear layer with a thickness of about 10 m. Transition to turbulence occurs in the external shear layer zone due to Görtler instabilities which develop on the convex part of the slope. Consistently, the gradient Richardson number is about to reach values above the critical number $Ri_c=0.2$. Strong streamwise turbulent structures increase local mixing along the slope, a property of direct interest for scalar transport and which must be accurately described to allow for air quality prediction. Applications to more realistic terrains will be considered and the role of Görtler vortices will be discussed in such a context.