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The impact of horizontal model grid resolution on the boundary layer structure over an idealized valley

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The role of horizontal model grid resolution on the development of the daytime boundary layer over mountainous terrain is studied. A simple idealized valley topography with a cross-valley width of 20∼km, a valley depth of 1.5∼km and a constant surface heat flux forcing is used to generate upslope flows in a warming valley boundary layer. The goal of this study is to investigate differences in the upslope flow and boundary layer structure of the valley when its topography is either fully resolved, smoothed or not resolved by the numerical model. This is done by performing both large-eddy (LES) and kilometer-scale simulations with mesh sizes of 50, 1000, 2000, 4000, 5000 and 10000∼m. In LES mode a valley inversion layer develops, which separates two vertically stacked circulation cells in an upper and lower boundary layer. These structures weaken with decreasing horizontal model grid resolution and change to a convective boundary layer similar to the one over an elevated flat plain when the valley is no longer resolved. Mean profiles of the LES run, which are obtained by horizontal averaging over the valley show a three-layer thermal structure and a secondary heat flux maximum at ridge height. Strong smoothing of the valley topography prevents the development of a valley inversion layer with stacked circulation cells and leads to higher valley temperatures due to smaller valley volumes. This investigation shows that a parameterization is needed in coarse resolution models to capture exchange processes over mountainous terrain.