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Assessment of large-eddy simulations of the atmospheric boundary layer in a steep and narrow Alpine valley

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Little is known about the turbulence field over highly complex terrain. It cannot be taken for granted that classical scaling schemes and similarity relationships hold in such an environment. Nevertheless, most numerical weather and climate prediction models use subgrid-scale parameterisation schemes which are based on similarity relations from ideal terrain. This may have a major effect on the accuracy and performance of these models. High resolution large-eddy simulations (LES) are a powerful tool to investigate this problem by providing a more detailed picture of the turbulence structure. We have been working collaboratively to apply a three-dimensional, non-hydrostatic and compressible LES code, the Advanced Regional Prediction System (ARPS), over the highly complex and steep terrain of the Riviera Valley in southern Switzerland. First, we have created a grid nesting and data assimilation context for the application of ARPS to the Riviera Valley. Second, we have used the data from the MAP-Riviera field campaign, carried out in summer/autumn 1999 in the Riviera Valley, to assess the performance of the code and our simulation context. This paper focuses on the second facet of our work. One clear-sky day of the measurement campaign (25 August 1999) has been chosen to be simulated with ARPS. After initialising with ECMWF data and radio soundings, and after four (one-way) nesting steps, the code is run at a horizontal grid-resolution of 350m [with a minimum vertical resolution of 40m] and the output compared to observations. The thermal structure of the atmosphere and the evolution of the boundary layer are very well reproduced. As in the observations, a pronounced valley-wind system with a distinct circulation pattern can be seen. However, in the simulations the thermal up-valley wind starts with a sig-

nificant delay. The onset and magnitude of the up-valley wind are highly sensitive to moisture and radiation processes in areas which are well outside the high-resolution domain. These processes are inadequately resolved on the coarser grid of the previous nesting level, and directly influence the flow structure in the high-resolution domain via its lateral boundary conditions. This leads to a discussion of the principal limitations of, but also the prospects for such a scheme over very complex terrain.