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Large eddy simulation of foehn-cold pool interactions in the Inn Valley during PIANO IOP2

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Processes of cold-air pool (CAP) erosion in an Alpine valley during south foehn are investigated based on a real-case large eddy simulation (LES) using the Weather Research and Forecasting model with a horizontal grid spacing of $\Delta x = 40$ m. The event occurred on 4 and 5 November 2017 during the second Intensive Observation Period of the PIANO field experiment around Innsbruck. The goal is to clarify the role of advective versus turbulent heating, the latter often being misrepresented in mesoscale NWP models.

It was found that the LES outperforms a mesoscale simulation, is not yet perfect, but able to reproduce the CAP evolution and structure. The CAP exhibits strong heterogeneity in along-valley direction. It is shallower and weaker in the east than in the west of the city and exhibits a local depression above the city. This heterogeneity in the early phase of the foehn events results from different relative contributions and magnitudes of turbulent and advective heating/cooling, the former being important for faster CAP erosion in the east and the latter being important for CAP maintenance in the west of Innsbruck. The spatial heterogeneity in turbulent erosion is linked to splitting of foehn into two branches at the mountain range north of the city, the eastward deflected branch being generally stronger. Intensification of the western branch in a later stage of the foehn event leads to complete CAP erosion also in the west of Innsbruck. In the city centre, turbulent heating is strongest, and so is advective cooling by enhanced pre-foehn westerlies. These local winds are the result of CAP heterogeneity and gravity wave asymmetry. This study emphasizes the importance of shear flow instability for CAP erosion. It also highlights the large magnitudes of advective and turbulent heating compared to their net effect, what is even more pronounced for individual spatial components.