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Eulerian and Lagrangian perspectives on a Foehn event in the Alpine region

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Foehn-related research has a long-standing tradition in mountain meteorology. In this context, the reason for Foehn air warming and the factors determining the descent of the air into the valleys have gained particular interest. Here, we readdress those research questions by combining a COSMO model hindcast at 1 km horizontal and 10 min temporal resolution with air parcel trajectories for a South Foehn case study in November 2016. The sub-synoptic situation in the model is studied using horizonal cross sections at different levels. Vertical cross sections in the Po valley and along the axes of major Foehn valleys complement the Eulerian analysis.

The selected event is characterized by its long duration, a far northern extent and exceptionally strong gusts. A low-level jet is discernible west of the Alps and a pronounced north-south pressure gradient develops. A striking feature is the strong tilt of the isentropes downstream of the Alpine crest. Trajectories reveal the versatile pathways of air parcels over major Alpine passes before they descend into the Foehn valleys. Differences with respect to upstream ascent and descent are observed for the different valleys. By tracing meteorological variables along the trajectories, the relative importance of adiabatic and diabatic processes for the Foehn air warming is quantified. The properties of air parcels that descend into the valleys or stay at higher levels are contrasted in order to identify factors that determine the descent.

The case study will set the scene for a forthcoming detailed analysis of Foehn flows based on online trajectories that make use of the wind fields at every model time step. The analysis will be extended to a number of cases representing the different South Foehn varieties. We will trace the temperature tendencies due to all diabatic processes (cloud processes, radiation, turbulence) along the trajectories in order to quantify their respective importance for Foehn air warming. First results in this extended framework will be presented.