Foehn air warming in six Alpine valleys: Lagrangian heat budget analysis and relation to airstreams

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Foehn air parcels are typically associated with a pronounced warming within lee-side valleys. While the physical mechanism of this warming has been disputed for over a century, recent studies emphasize the key role of both adiabatic descent (isentropic drawdown), but also turbulent mixing and upstream latent heating in clouds, depending on the Foehn case and the region. This study aims to attribute the warming to adiabatic descent and key diabatic processes for six major Alpine Foehn valleys in Switzerland and Austria. To this end, a mesoscale model simulation including online trajectories is combined with a Lagrangian heat budget to investigate how relevant the different processes are for an intense and long-lasting South Foehn event in November 2016.

In agreement with earlier findings for the Alpine Foehn, adiabatic descent constitutes the most important process for the majority (57%) of air parcels arriving within the six Foehn valleys. Nonetheless, upstream latent heating in clouds is more important for a considerable number (35%) of air parcels. On the one hand, the Lagrangian analysis reveals a clear difference between western and eastern Alpine valleys, as adiabatic warming gradually becomes more important for the eastern valleys. On the other hand, a distinct temporal evolution is identified, where diabatic processes emerge as the main warming mechanism for the western valleys during the central phase of the Foehn event.

As the contribution for diabatic heating varies strongly for the different Foehn valleys, it is used to subdivide the Foehn trajectories into three different airstreams. Air parcels associated with intense diabatic heating are typically advected within a low-level easterly barrier jet in the Po Valley before traversing the Alps. Diabatically cooled air parcels, on the other hand, originate at higher levels and are quasi-horizontally advected from the south towards the Alpine crest. Hence, the varying intensity of the contributing airstreams dictates the dominating warming mechanism. The results prevent a clear separation into ‘Swiss Foehn’ and ‘Austrian Foehn’, as, in our case study, both varieties either simultaneously occur in the different valleys, or distinct time periods of the Foehn within a valley are more or less dominated by either or the other airstream.