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Lagrangian analysis of foehn air warming in a dry and a moist event over the Swiss Alps

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High temperatures in foehn valleys is one very prominent manifestation of foehn flows. The explaining physical mechanisms are an issue since the early days of foehn research, but are still not well constrained and understood. By performing Lagrangian investigations of two foehn events in the Swiss Alps with a focus on the Rhine valley, we gain new insight in this topic. To this end we performed simulations with the high-resolution numerical weather prediction model COSMO with a online trajectory tool and a two-moment microphysical scheme. The high resolution trajectories illustrate the complexity of the source regions for air parcels arriving in the foehn valley. A budget analysis of potential temperature changes along the trajectories shows that the warming is to the first order determined by adiabatic descent, but in addition there are significant diabatic processes leading to a net cooling and heating of up to 6 Kelvin. These diabatic temperature changes can be attributed to turbulent mixing with other air masses on both sides of the Alps and microphysical processes. The budget analysis of the latent heating due to phase changes of water substance along the trajectories reveals a significant cooling due melting of ice. Besides shedding new light on the temperature changes involved in foehn air warming and the driving physical mechanisms, this study illustrates the added value of the Lagrangian perspective and the use of trajectory data at very high temporal and spatial resolution for understanding flow over complex terrain.