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Lagrangian investigation of high-frequency variations in stable isotope composition of atmospheric boundary layer water vapour

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Process-based investigations of the atmospheric water cycle using stable water isotopes have become possible lately at the time scales of significant weather events using novel laser spectroscopic measurement techniques. In this work, we analyse 6 months of stable water isotope measurements performed in the boundary layer water vapour at a prealpine measurement site at high temporal resolution (1 hour). Since the water isotopic composition of an air parcel is determined by the integrated history of phase changes and mixing processes from evaporation to the point of measurement, we adopt a Lagrangian perspective to interpret the data. We apply a moisture source and source condition identification algorithm from 3D kinematic backward trajectories based on atmospheric analysis data. This technique gives us a good estimate of the properties of the advected air masses. The moisture source properties of these air masses can be used to predict the deuterium excess ($d = \delta^2$H-8δ^{18}O) at the measurement site. Generally good correlations are found between the deuterium excess at the measurement site and moisture source relative humidity and temperature. However, especially in summer, local processes linked to turbulent mixing in the boundary layer and evapotranspiration at the local scale are very important and not well represented by the chosen Lagrangian moisture source identification method. A simple box model approach has thus been chosen to better characterise these local effects and to complement the Lagrangian perspective of large-scale moisture advection. The relative importance of the local dynamics of the water cycle in contrast to remote phase changes can thus be quantified.