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Defining isotopic indicators for precipitation origin and recycling from a multi-year high-resolution climatology of Alpine moisture sources

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The water cycle of the Alps is vitally important for large parts of Central Europe. A number of aspects of the hydrological cycle in that region are however not fully understood, in particular with respect to the origin of precipitation water. Better knowledge of the processes of the Alpine water cycle is also key to the interpretation of numerous paleoclimate archives in the area, such as ice cores, peat bogs, and tree rings. This study relies on a climatology of the moisture source regions of the Alpine mountain range, and attempts to create a link between model results and routine observations of stable isotopes in precipitation.

A climatology of the Alpine moisture sources covering the years 1995-2002 was created, using a quantitative Lagrangian moisture source diagnostic based on backward trajectories, and ECMWF's ERA-40 reanalysis data. Calculations were performed on a 0.5° x 0.5° grid at 6-hourly time resolution. Monthly observational data of oxygen-18 and deuterium stable isotopes in precipitation were provided by the Swiss National Network for the Observation of Isotopes in the Water Cycle (NISOT).

The main moisture sources of the Alpine mountain range are the eastern North Atlantic, the western Mediterranean, and the central European land mass. However, a pronounced seasonal cycle is present in the moisture origin: winter precipitation has a strong contribution from long-range transport of moisture originating in the North Atlantic, while during summer precipitation sources are considerably more local, and indicate recycling over the European continent. Significant correlations between anomalies of Central European moisture contributions and deuterium excess from the Swiss network of stable isotope observations confirm that a recycling signal is present at several stations. In addition, deuterium excess from stations in the southern Swiss Alps shows influences from anomalous Mediterranean moisture contributions. A physical explanation for the observed correlations is proposed.