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Improving hydrologic model realism by using stable water isotopes

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The last century of hydrological research has led to significant improvements in representing different hydrological processes in rainfall-runoff models. With widely available streamflow data, such models are typically calibrated against this reference time series, which can limit their predictive power. One option to improve the realism of rainfall-runoff models is by incorporating environmental tracers such as stable isotopes of water, water temperature and electrical conductivity within the modeling setup. Conventionally, stable water isotopes have been used to learn more about the dominant hydrological processes that occur within a given catchment, which generally helps improve the hydrologic model structure, but often at the cost of increased model complexity to simulate the tracer concentration along with streamflow.

In this study, we develop a framework to incorporate stable water isotopes in continuous hydrological modeling, without significantly increasing model complexity. In the first step, stable water isotopes are used along with streamflow recession analysis to initialize the model state variables. After that, a Bayesian mixing model is used to infer the proportion of slow vs fast subsurface flow, and the results are used as additional constraints during the model calibration. This framework is extensively tested in a snow-dominated experimental catchment called Vallon de Nant, located in the Southwestern Swiss Alps (1189-3051 m. a.s.l.). During the presentation, we will discuss the advantages and limitations of such a modeling approach and how it can be extended to other experimental catchments.