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Investigating the value of regional water isotope data on transit time and SAS modelling

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High nutrient concentrations despite mitigation measures and reduced inputs are a common problem in anthropogenically impacted catchments. To investigate how water and solutes of different ages are mixed and released from catchment storage to the stream, catchment-scale models based on water transit time from StorAge Selection functions (SAS) are a promising tool. Tracking fluxes of environmental tracers, such as stable water isotopes, allows to calibrate and validate these models. However, this requires collection of water samples with an adequate temporal and spatial resolution, while sampling in catchments at the management scale is often limited by the high costs of the instruments, maintenance and chemical analysis. Therefore, temporal and spatial interpolation techniques are needed. This study demonstrates how to deal with sparse tracer data in space and time, and evaluates if these data are valuable to constrain the subsurface mixing dynamics and transit time with SAS modelling. We simulated water isotope data in diverse sub-basins of the Bode catchment (Germany) and calibrated the SAS function parameters against the measured streamflow isotope data. We tested four different combinations of spatial and temporal interpolation of the measured precipitation isotope data. In terms of temporal interpolation, monthly oxygen isotopes in precipitation ($\delta^{18}\text{O}_p$) collected between 2012 and 2015 were converted to a daily time step with a step function and sinusoidal interpolation. In terms of spatial interpolation, the model was tested with raw values of $\delta^{18}\text{O}_p$ collected at a specific sampling point and with $\delta^{18}\text{O}_p$ interpolated using kriging to gain the spatial pattern of precipitation. The effect of the spatial and temporal interpolation techniques on the modeled SAS functions was analyzed using different parameterizations of the SAS function (i.e., power law time-invariant, power law time-variant and beta law). The results show how tracer input data with different distribution in time and space affect the SAS parameterization and water transit time. Moreover, they reveal preference of the sub-basins to mobilize either younger or older water, which has implications on how water flows through a catchment and on the fate of solutes.