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Towards tracer-aided spatially distributed models of catchment storage and mixing to predict non-stationary hydrologic and biogeochemical response

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To develop a spatially distributed understanding of the linkages between storage dynamics, mixing processes and non-stationary watershed response we have used diverse, intensive data sets collected in a small montane catchment to both inform and test hydrological and water quality models. At the core of these efforts has been the use of ~6 years of daily isotope data in precipitation and stream flow to inform the calibration and testing of coupled flow-tracer models that constrain storage estimates, mixing processes and hydrologic fluxes in the dominant landscape units as well as simulating discharge and stream isotopes. LiDAR surveys have been used to extend this approach using a high resolution DTM to facilitate a Spatially distributed Tracer-Aided Rainfall-Runoff model (STARR). This provides a flexible, generic approach that allows us to track and visualise aggregated storage changes, mixing processes, and the fluxes and age distribution of water across spatio-temporal scales. The modelling framework provides a basis for assessing the effects of hydroclimatic variability on the non-stationary nature of catchment hydrological function by simulating the spatial variation in tracer composition of different source waters and flow paths. This is tested against extensive (over 120 sites) synoptic surveys of multiple-tracers in soil water, groundwater and stream water repeated under contrasting states of catchment storage when different flow paths are activated. The modelling approach can reproduce the major spatio-temporal differences in isotopes, dissolved organic (DOC) and alkalinity reasonably well and thus, has potential to be adapted for biogeochemical modelling. This potential is explored in relation to daily DOC simulations over prolonged (2 year) periods. The transferability of the modelling approach to other sites is also tested.