Understanding mixing and transport processes in the critical zone using stable isotopes of water

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Soils play a central role in water partitioning into evaporation, transpiration and recharge fluxes. I present how stable isotopes (\(\delta^2\text{H}\) and \(\delta^{18}\text{O}\)) of soil water can help to assessing soil evaporation dynamics, interpreting plant water uptake pattern, and inferring groundwater recharge fluxes.

On the one hand, the presented field observations of soil water isotopes under different environmental conditions allow direct interpretations of how water is mixed, stored, released to the atmosphere or percolating to the groundwater. The isotope data emphasizes how variable these processes in the subsurface are; both in space (e.g., soil depth) and time (e.g., seasonality). Such spatiotemporal variability has critical implications for plant water uptake estimates in ecohydrological studies.

On the other hand, the sampled soil water isotope data can be used for calibrating soil hydraulic models. Taking the isotopic tracer – in addition to hydrometric data (e.g., soil moisture) - into account allows to simulate in addition to the hydraulic response (e.g., change of soil moisture due to rainfall event, celerity) also the water transport (e.g., advection and dispersion of water, velocity). This way, we can trace water through the soil-plant-atmosphere continuum and determine travel times of evaporation, transpiration and recharge. Improving the assessment of the travel time variability in the critical zone will help understanding processes with regard to catchment hydrology and groundwater contamination.