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Subsurface runoff and recharge dynamics in a Mediterranean catchment based on StorAge Selection functions and end-member splitting analysis

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Investigations at the long-term experimental catchment Vallcebre in the Pyrenees revealed that rainfall-runoff dynamics are highly variable due to the Mediterranean climatic conditions affecting the storage and release of water in the subsurface[1]. In a changing climate, to the consequences of which could lead to more variations in catchment wetness due to an increase in both droughts and high intensity rainfalls, there is a strong need to better understand subsurface storage and runoff processes.

While our previous isotope studies (using ^{2}H and ^{18}O) demonstrated a pronounced heterogeneity of water flow in the unsaturated zone at the plot scale[2], we also observed that the contributions of young waters to catchment runoff are highly dependent on the catchments wetness[3]. These analyses provided a basis from which we present new insights into the relationship between subsurface runoff and storage dynamics applying StorAge Selection functions[4] and end-member splitting analysis[5]. Thus, we combined modeling and data-driven approaches to disentangle the partitioning of subsurface waters into storage and runoff based on water age dynamics.

We gathered an extensive isotope data set with >550 rainfall samples and >980 stream samples taken at high temporal resolution (30 minutes to one week), with highest frequencies during high discharge to improve the coverage of rainfall-runoff events. Using this high-frequency isotope data set, we calibrated the StorAge Selection functions and put special emphasis on the representation of the isotopic response during high flow rainfall-runoff periods. We further tested if time-variant representations of StorAge Selection functions dependent on varying wetness improves the stream water isotope simulations and the ways in which isotope data from different compartments (groundwater and tree water) can assist in constraining the parameter space. Furthermore, end-member splitting analysis provided an independent view into the flow dynamics based on these long-term isotope data sets. As such, the analysis allowed us to derive estimates of the dynamics of rainfall partitioning into runoff and evapotranspiration. Therefore, the combination of the modeling and data-driven approaches enabled an assessment of the dynamics of subsurface runoff at the catchment scale underlining the relevance of heterogeneous flow pattern that were observed on the plot scale.

References