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Quantifying mixing of water within catchments.

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In a catchment freshly fallen precipitation is mixed with groundwater and surface water. The degree of mixing within catchments determines the contribution of freshly fallen precipitation to catchment discharge, storage and evapotranspiration and thus controls the water quality of groundwater and surface waters. In this study we propose Exit Rate Distribution Functions (ERDF) to quantify the degree of mixing.
ERDFs are derived through a transformation of travel time distributions (TTD), which rescales the TTD with the volume of water stored inside a catchment and the absolute travel time of water parcels. ERDFs purely quantify the mixing process within a catchment and thus provide a scale independent method to compare distributions of flow paths between catchments. Such a catchment characteristic is crucial for understanding and simulating catchment-scale groundwater-surface water interactions and for explaining observed differences in water quality dynamics between catchments.
In our presentation we derive theoretical ERDFs for different types of hillslopes and numerically derive ERDFs for a lowland catchment using a transient particle tracking approach. We found that our lowland catchment has a strong preference for discharging and evaporating the youngest water from the catchment storage and thus exhibits strongly incomplete mixing. Via a simple conceptual model we demonstrate how incomplete mixing affects surface water nitrate concentrations, which we compare with measured nitrate concentrations. These results show that ERDFs effectively characterize catchment-scale mixing and that it might be possible to derive ERDFs directly from observed dynamics in surface water concentrations.