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How does subsurface retain and release stored water? An explicit estimation of young water fraction and mean transit time

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The stable isotopes of water have served science well as hydrological tracers which have demonstrated that there is often a large component of “old” water in stream runoff. It has been more problematic to define the full transit time distribution of that stream water. Non-linear mixing of previous precipitation signals that is stored for extended periods and slowly travel through the subsurface before reaching the stream results in a large range of possible transit times. It difficult to find tracers can represent this, especially if all that one has is data on the precipitation input and the stream runoff. In this paper, we explicitly characterize this "old water" displacement using a novel quasi-steady physically-based flow and transport model in the well-studied S-Transect hillslope in Sweden where the concentration of hydrological tracers in the subsurface and stream has been measured. We explore how subsurface conductivity profile impacts the characteristics of old water displacement, and then test these scenarios against the observed dynamics of conservative hydrological tracers in both the stream and subsurface. This work explores the efficiency of convolution-based approaches in the estimation of stream "young water" fraction and time-variant mean transit times. We also suggest how celerity and velocity differ with landscape structure