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Transit times of water particles in the vadose zone across catchment states and catchments functional units

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Understanding the water movement in the vadose zone and its associated transport of solutes are of major interest to reduce nutrient leaching, pollution transport or other risks to water quality. Soil physical models are widely used to asses such transport processes, while the site specific parameterization of these models remains challenging. Inverse modeling is a common method to adjust the soil physical parameters in a way that the observed water movement or soil water dynamics are reproduced by the simulation. We have shown that the pore water stable isotope concentration can serve as an additional fitting target to simulate the solute transport and water balance in the unsaturated zone. In the presented study, the Mualem- van Genuchten parameters for the Richards equation and diffusivity parameter for the convection-dispersion equation have been parameterized using the inverse model approach with Hydrus-1D for 46 experimental sites of different land use, topography, pedology and geology in the Attert basin in Luxembourg. With the best parameter set we simulated the transport of a conservative solute that was introduced via a pulse input at different points in time. Thus, the transit times in the upper 2 m of the soil for different catchment states could be inferred for each location. It has been shown that the time a particle needs to pass the -2 m depth plane highly varies from the systems state and the systems forcing during and after infiltration of that particle. Differences in transit times among the study sites within the Attert basin were investigated with regards to its governing factors to test the concept of functional units. The study shows the potential of pore water stable isotope concentration for residence times and transport analyses in the unsaturated zone leading to a better understanding of the time variable subsurface processes across the catchment.