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Spatially Distributed Characterization of Soil Dynamics Using Travel-Time Distributions

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The description of storage and transport of both water and solved contaminants in catchments is very difficult due to the high heterogeneity of the subsurface properties that govern their fate. This heterogeneity, combined with a generally limited knowledge about the subsurface, results in high degrees of uncertainty. As a result, stochastic methods are increasingly applied, where the relevant processes are modeled as being random. Within these methods, quantities like the catchment travel or residence time of a water parcel are described using probability density functions (PDF). The derivation of these PDF's is typically done by using the water fluxes and states of the catchment. A successful application of such frameworks is therefore contingent on a good quantification of these fluxes and states across the different spatial scales.

The objective of this study is to use travel times for the characterization of an ca. 1000 square kilometer, humid catchment in Central Germany. To determine the states and fluxes, we apply the mesoscale Hydrological Model mHM, a spatially distributed hydrological model to the catchment. Using detailed data of precipitation, land cover, morphology and soil type as inputs, mHM is able to determine fluxes like recharge and evapotranspiration and states like soil moisture as outputs.

Using these data, we apply the above theoretical framework to our catchment. By virtue of the aforementioned properties of mHM, we are able to describe the storage and release of water with a high spatial resolution. This allows for a comprehensive description of the flow and transport dynamics taking place in the catchment. The spatial distribution of such dynamics is then compared with land cover and soil moisture maps as well as driving forces like precipitation and potential evapotranspiration to determine the most predictive factors. In addition, we investigate how non-local data like the age distribution of discharge flows are impacted by, and therefore allow to infer, local properties of the catchment.