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Evaluating travel time distributions of macroporous hillslope

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Residence and travel times of water in headwater catchments and hillslopes represent important descriptors of hydrological regime. In this study, travel time distributions were evaluated for a montane forest hillslope site using a two-dimensional dual-continuum model. The model was used to simulate the seasonal soil water regime and selected major rainfall–runoff events observed at the hillslope site. In particular, it was used to generate hillslope breakthrough curves of a fictitious conservative tracer applied at the hillslope surface in the form of the Dirac impulse. The simulated tracer breakthroughs allowed us to estimate the travel time distributions of soil water associated with the episodic subsurface stormflow, deep percolation and transpiration, yielding partial travel time distributions for the individual discharge processes. The travel time distributions determined for stormflow were dominated by the lateral component of preferential flow. The event-based stormflow median travel times ranged from 1 to 17 days. The estimated travel times were significantly affected by the temporal rainfall patterns and antecedent soil moisture distributions. The applied modeling methodology can be used for the evaluation of runoff dynamics at the hillslope and catchment scales as well as for the quantification of biogeochemical transformations of dissolved chemicals.