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# How does the spatiotemporal variability of isotopic signatures affect the results of hillslope runoff separation?

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Tracer-based hydrograph separation techniques are widely used to construct conceptual models of runoff processes at both hillslope and catchment scale. These techniques allow splitting of runoff into two temporal components – pre-event "old" and event "new" water contributions. However, several fundamental assumptions have to be met to perform the tracer-based hydrograph separation. In this context, stable water isotopes are widely used as naturally occurring tracers. The spatiotemporal variability of isotopic content in soil pore water and in rainfall represents a serious complication in the application of hydrograph separation techniques. In this study, the effects of variable isotopic signatures and hydrodynamic mixing were analyzed by a two-dimensional model of flow and transport in a hillslope segment and two-component mass balance approach. The similarity of the pre-event and event isotopic contents precluded the partitioning of the hillslope discharge into pre-event and event water components for two thirds of the selected rainfall–runoff episodes when natural isotopic signatures were used in the mass balance calculations. Additional numerical experiments were performed with synthetic isotopic signals, instead of observed signals. The simulation scenarios involving enhanced mechanical dispersion resulted in the increased estimate of the pre-event water contribution to hillslope discharge. The incremental weighting technique was found to be an appropriate method to account for the temporal variability of the isotope content in rainfall. The modeling results also highlight the role of the initial hillslope storage and its spatial distribution as well as the isotope partitioning between the soil matrix and preferential pathways prior to the rainfall event. It was demonstrated that the spatially and temporally variable exchange of isotope between the soil matrix and preferential pathways played an important role in the estimation of the temporal origin of water in the hillslope runoff.