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Analyzing hillslope hydrographs using synthetic and natural isotope signature

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Stable isotopes of water naturally occurring in rainwater have the potential to reveal principal transport mechanisms at multiple scales – from soil profile to hillslope and catchment scale. In this contribution, we study transport processes at the hillslope scale by combining field observations of hillslope discharge and the associated oxygen-18 contents with detailed process-based numerical modeling. One-dimensional dual-continuum vertical flow and transport model (based on Richards and advection-dispersion equations) coupled with one-dimensional single-continuum lateral flow and transport model (based on diffusion wave equation for saturated subsurface flow and advection-dispersion equation for isotope transport) were used to simulate the subsurface processes during observed rainfall-runoff episodes. The observed subsurface runoff and its oxygen-18 composition were compared with the model predictions. In addition, contributions of pre-event and event water to hillslope runoff during major rainfall-runoff episodes were evaluated by means of numerical experiments involving synthetic oxygen-18 rainfall signatures. Although preferential flow played an important role in the hillslope runoff formation, pre-event water was found to be the significant runoff component in most events. Simulation results confirmed the hypothesis of substantial mixing between infiltrating rainwater and water stored in the hillslope soil profile (i.e. the oxygen-18 rainfall signatures were not transformed into the hillslope discharge signatures in a simple and intuitively predictable way). The simulated hillslope responses showed a reasonable agreement with the experimental data in terms of subsurface runoff and oxygen-18 transport dynamics. The applied modeling approach seems to describe adequately both vertical and lateral mixing of water and oxygen-18 in the hillslope segment.