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An isotopic comparison of waters obtained by destructive and non-destructive methods to evaluate mixing and runoff processes at the mini-hillslope scale

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Technical developments in recent years have fostered the application of stable water isotopes to measure, understand and predict water flow paths and different pools of subsurface water. Here we set up an outdoor mini-hillslope experiment to study mixing and runoff processes by means of stable water isotopes. To gain the isotopic information preserved in the soil, we applied non-destructive and destructive pore water sampling methods and intercompared their isotope results. We tested the null hypothesis that all extraction methods sample the same soil water pool. We followed the stable water isotope composition of precipitation – as a natural input function – over and through the soil profile. Our three hillslopes (0.63 m wide, 1.78 m long and 0.43 m deep; slope: 10°) were mounted on load cells and filled with volcanic crushed basalt rock of loamy sand texture sourced from the Biosphere 2 (University of Arizona). The slopes were equipped with soil moisture and temperature sensors, a bottom outflow and a surface runoff gauge for isotope sampling. To intercompare pore water sampling methods, one hillslope was instrumented with suction cup lysimeters. In the second hillslope, we installed sampling ports for direct in-situ measurements of soil water vapor isotopic composition. The third hillslope was sampled destructively via soil coring for applying the centrifugation and vapor equilibrium methods to evaluate the soil's isotopic composition. All hillslopes were sampled at four depths at three different downslope positions. ^{2}H and ^{18}O analyses were performed via laser spectroscopy (OA-ICOS, IWA-45EP Analyzer, Los Gatos Research Inc., US). Our results showed that the surface runoff followed the isotopic trend of the precipitation input and fell on the local meteoric water line. The isotope values of the baseflow plotted within a more narrow range. The applied pore water extraction method had a significant effect on the obtained isotopic composition. Results from the in-situ vapor port measurements showed the greatest standard deviations. The isotope results from centrifugation, the vapor equilibrium method and the suction cup lysimeters were almost identical, all falling on or slightly to the right of the local meteoric water line. Our isotope results suggest that with the extraction methods applied here, we most likely sampled the more mobile soil water pool. This water pool also seemed to generate the hillslope's runoff and therefore similar isotope results were obtained at the runoff gauge. We suggest that users of water extraction approaches choose a technique that is sampling the soil water pool of interest (mobile vs. tightly bounded water) to study dynamics and heterogeneous shallow subsurface and vadose zone processes.