Tracking water pathways in steep hillslopes by δ18O depth profiles of soil water

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Assessing temporal variations in soil water flow is important, especially at the hillslope scale, to identify mechanisms of runoff and flood generation and pathways for nutrients and pollutants in soils. While surface processes are well considered and parameterized, the assessment of subsurface processes at the hillslope scale is still challenging since measurement of hydrological pathways is connected to high efforts in time, money and personnel work. The latter might not even be possible in alpine environments with harsh winter processes. Soil water stable isotope profiles may offer a time-integrating fingerprint of subsurface water pathways. In this study, we investigated the suitability of soil water stable isotope (delta O-18) depth profiles to identify water flow paths along two transects of steep subalpine hillslopes in the Swiss Alps. We applied a one-dimensional advection-dispersion model using delta O-18 values of precipitation (ranging from -24.7 to -2.9 parts per thousand) as input data to simulate the delta O-18 profiles of soil water. The variability of delta O-18 values with depth within each soil profile and a comparison of the simulated and measured delta O-18 profiles were used to infer information about subsurface hydrological pathways. The temporal pattern of delta O-18 in precipitation was found in several profiles, ranging from -14.5 to -4.0 parts per thousand. This suggests that vertical percolation plays an important role even at slope angles of up to 46 degrees. Lateral subsurface flow and/or mixing of soil water at lower slope angles might occur in deeper soil layers and at sites near a small stream. The difference between several observed and simulated delta O-18 profiles revealed spatially highly variable infiltration patterns during the snowmelt periods: The delta O-18 value of snow (-17.7 +/- 1.9 parts per thousand) was absent in several measured delta O-18 profiles but present in the respective simulated delta O-18 profiles. This indicated overland flow and/or preferential flow through the soil profile during the melt period. The applied methods proved to be a fast and promising tool to obtain time-integrated information on soil water flow paths at the hillslope scale in steep subalpine slopes.

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