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Dual-continuum modeling of a natural tracer transport in a soil profile

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This study aims at evaluation of soil water dynamics in a shallow hillslope soil. The transport of stable oxygen isotope ^{18}O in a variably saturated soil profile is simulated by means of a one-dimensional dual-continuum model. The model is based on Richards' equation for the water flow and advection-dispersion equation for the isotope transport. The isotope plays the role of a natural tracer. The detailed observation of the isotope concentration has been carried out in a small headwater catchment Uhlirska (Czech Republic) The concentration of ^{18}O in soil water and subsurface stormflow is analyzed and further used for the comparison with the model results. Several vegetation seasons were analyzed with respect to both soil water fluxes and isotope concentration variations. The parameters of the dual-continuum model were taken from previous soil water flow studies. No additional parameter calibration, based on the observed isotope concentrations, was performed. In overall, close agreement with the observed variables was achieved. In particular, the measured subsurface stormflow is in a relatively good agreement with the simulated outflow from the preferential flow domain and the observed ^{18}O concentration in soil water correlates well with the simulated matrix domain concentration. Mixing processes in the soil profile caused the isotope dilution (even though the preferential transport was considered), i.e. no rapid (unmixed) event-driven ^{18}O outflow through the preferential pathways occurred. The study helped us to improve our understanding of the complex transport processes through the heterogeneous soil system. The results confirm that preferential flow is a relevant transport process in the studied soil profile.