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Quantifying macropore flow by X-ray tomography to improve model predictions of solute leaching in soil

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It has been known for decades that water does not flow uniformly through the soil unsaturated zone during rainfall. A large proportion of the rainwater can be channeled through macropores bypassing large parts of the biologically active and chemically reactive surface soil, which significantly increases contaminant leaching. To account for the effects of macropore flow on contaminant leaching, models have been developed that treat macropores and soil matrix as two interacting domains with different transport velocities. Until now it has been very difficult to test the concepts underlying these models, since some of the parameters are derived by calibration against measurements. X-ray tomography has been proven to be a useful tool to quantify and characterize macropore networks in undisturbed soil columns. Other phases in soil can also be determined by X-ray scanning including, for example, the distribution of water in unsaturated macropores. Dynamic X-ray scanning experiments using iodine as a tracer have been shown to be suitable to describe solute exchange between soil matrix and macropores.
In a recently started project, we are performing irrigation experiments using undisturbed soil columns inside an industrial X-ray scanner to study the effects of pore network continuity and connectivity on macropore flow. Different soil types with varying soil structure including surface and subsurface samples are included in the study. The spatial configuration of the water in the macropores during flow is quantified at different irrigation intensities, while tracer experiments carried out under near-saturated conditions reveal the conducting macroporosity. We are using this data to directly parameterize and test dual-permeability macropore flow models, with the goal to improve understanding of these dynamic processes. This could lead to more reliable predictive modelling of macropore flow in soil.