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Water distribution in and between soil aggregates: X-ray tomography and modeling

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Soils are almost never homogeneous, but are generally characterized by heterogeneities and structures (e.g. aggregates). The resulting pore geometry generates non-uniform movements of water and solutes, which are critical to be predicted and may lead to hazardous consequences. Recent advances in image techniques can shed a new light on the relations between soil structures and hydraulic properties.

We studied a typical structured state of top soils: an aggregate packing. We used neutron radiography to image the water redistribution through series of aggregates. We observed that the contacts between aggregates control the water flow: they can be either conductive or bottle-necks for the water flow. Also, the transition between these two limiting cases is abrupt. In order to understand this hydraulic process, we performed synchrotron based X-ray tomography of aggregate pairs at equilibrium in wet conditions (matric head h=-2.5 cm) and drier conditions (h=-140 cm). Water, air and solid phase could be distinguished at a resolution of a few microns. Subsequently, we used a morphological pore-network model to calculate the distribution of water in the contact region at varying matric heads. We found that large voids in the contact region become rapidly drained. As a consequence the flow cross-section and the conductivity of the contacts drop as the matric head decreases.

This study identified the discontinuities between soil aggregates and quantified the effects on the unsaturated water flow in aggregated media. Also, the area and the saturation degree of the contacts are important for the mechanical behavior of such media. The results were obtained by combining neutron and X-ray tomography. Neutrons are optimal to monitor in real time water movements, i.e. the effect of heterogeneities. X-ray tomography yields the pore geometry, i.e. the presence and extent of hetero-

geneities.