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A Scalable Lagrangian Approach to Model Soil Water Dynamics in Structured Soils

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Many experiments and studies have shown, that soil water movement follows preferential paths - across scales, across flow domains and across conditions. At the same time different flow domains are widely noticed in several model abstractions (stochastic stream tubes, double domain approaches, explicit structure definitions, and others). Both aspects cumulate in the question of interaction of domains - again across scales and conditions.

We propose a Lagrangian approach, treating water directly as particles, in an abstract unified representative macropore-matrix-domain. The model is driven exclusively by observable parameters. The approach is fully scalable from a single soil column to the lower mesoscale.

The domain is a 1.5D representation of a macropore and adjoined matrix. Depth is explicitly resolved as first dimension. Relative distance from the macropore-edge forms the lateral dimension based on observations of macropore density and diameter distribution over depth. Soil matrix characteristics (data from standard physical soil analysis) are respected for diffusive water particle movement dissipating pressure gradients. Fluid properties and macropore configuration (data from sprinkler experiments) are treated explicitly as reference of advective transport.

Through this we open up a link of porescale physics to preferential macroscale fingerprints without effective parameterisation or mixing assumptions. Moreover, solute transport, energy balance aspects and lateral heterogeneity in soil moisture distribution are intrinsically captured.