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Pore network modeling of infiltration

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Current network model approaches to infiltration are usually static in nature and thus provide no information about the transient movement of the invading fluid front. On the other hand, fully dynamic approaches suffer from extensive computational demand prohibitive for many applications. We are developing a quasi-dynamic approach that uses local velocity information to derive the pore filling sequence assuming simple piston-like advance. The defending fluid (air) is entrapped at places where no continuous path to an outlet exists. First results suggest that the rule-based algorithm permits a rough approximation of the transient infiltration process. This approximation should improve with the frequency of numerical updates of the pressure field, which will be investigated in a next step.

Another aspect concerns the role of continuous (macro-) pores. Minkowski functions, such as pore size distribution, surface area density, and topology (Euler characteristic), may be used to characterize soil pore structure. It has been previously shown that these functions, when properly matched in the grid of a pore network model, may provide realistic predictions of the water retention and relative hydraulic conductivity functions of some soils. However, the full complexity of the pore network, as e.g. obtained using X-ray-micro-tomography of soil samples, cannot be preserved in this approach. The corresponding loss of information appears to be unproblematic in case of more or less homogeneous, isotropic materials. However, we show that the loss of information can be critical for soil pore networks characterized by continuous (macro-) pores. A statistical measure of the continuity of flow paths is the local percolation probability. We compared two empirical methods added to the grid setup: varying the probability of pore cluster formation vs. varying the pore length. The latter approach significantly improved the representation of local percolation probability in the network model for most of the pore size range. Moreover, it resulted in a better prediction of measured soil hydraulic and transport properties.