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Water flow in soils related to local-scale heterogeneities: modeling and validation experiments

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Soils often exhibit a variety of small-scale heterogeneities such as cracks, inter-aggregate macropores and voids which partition flow into separate regions. In this paper some approaches are discussed for characterizing the hydrological behavior of heterogeneous soils, in the presence of structural inter-aggregate macropores or even shrinkage cracks. Accordingly, special emphasis is given to the effect of micro-heterogeneity and soil structure on water flow processes at local scale. The discussion is limited to a review of mechanistic approaches, known to be based on physical concepts and laws. Theoretical discussion and experimental evidence of the structural effects on the hydrological behavior of some Italian soils are provided: firstly, a physically based simulation model of infiltration through swelling and shrinking soils is discussed in which Richards' equation for describing flow through the matrix is coupled with the description of the shrinkage and related flow of water along the shrinkage cracks. Infiltration experiments carried out on large undisturbed shrinking clay soil columns and at different inflow rates were specifically designed to calibrate the model. Relevant results are also presented. Subsequently, flexible retention relations in describing the retention data of aggregated soils are then evaluated, with the principal aim of assessing their predictive capability for estimating the hydraulic conductivity function and for describing flow in a composite porosity framework. Their predictive capability is independently tested by using a set of unsaturated conductivity observations determined through the crust method. The results enable a detailed discussion on

model parameterization and related parameter uncertainty to be made.