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Identifying solute transport scale in an unsaturated stony soil by spectral analysis and scale dependence of transport variance

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Solute transport parameters are known to be scale-dependent due mainly to the increasing scale of heterogeneities with transport distance and with the lateral extent of the transport field examined. Based on a transect solute transport experiment, in this paper we studied this scale dependence by distinguishing three different scales with different homogeneity degrees of the porous medium: the observation scale, transport scale and transect scale. The main objective was to extend the approach proposed by van Wesenbeeck and Kachanoski to evaluating the role of textural heterogeneities on the transition from the observation scale to the transport scale. The approach is based on the scale dependence of transport moments estimated from solute concentrations distributions. In our study, these moments were calculated starting from time normalized resident concentrations measured by Time Domain Reflectometry (TDR) probes at three depths in 37 soil sites 1m apart along a transect during a steady state transport experiment. The Generalized Transfer Function (GTF) was used to describe the evolution of apparent solute spreading along the soil profile at each observation site by analyzing the propagation of the moments of the concentration distributions. Spectral analysis was used to quantify the relationship between the solid phase heterogeneities (namely, texture and stones) and the scale dependence of the solute transport parameters. Coupling the two approaches allowed us to identify two different transport scales (around 4-5 m and 20 m, respectively) mainly induced by the spatial pattern of soil textural properties. The analysis showed that the larger transport scale is mainly determined by the skeleton pattern of variability. Our analysis showed that the organization in hierarchical levels of soil variability may have major effects on the differences between solute transport behaviour at transport scale and transect scale, as the transect scale parameters will include information from different scales of heterogeneities.