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Unsaturated Water flow and Solute Transport in Field Soils: advances in measurements and data analysis.

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Water flow and solute transport in soils are invariably affected by heterogeneity and often by preferential flow, both typically occurring within 1 m^2. Paradoxically, we need to understand flow and transport at this small scale to quantify them at the field and regional scales. This paradox arises from the geometry of soils: the scale in the direction of the flow is orders of magnitude smaller than the scales perpendicular to it. Therefore, studying small-scale processes remains relevant in this time of national and continental hydrology. We present a package of observational and experimental tools to observe and analyze small-scale (0.1-1 m^2) water and solute fluxes.

Multicompartment samplers can measure small-scale water and solute movement in space and time, particularly in temperate climates. The latest generation of samplers allows repeated extraction of percolate samples *in situ* under controlled suction to minimize disturbance of the unsaturated flow field. After discussing the general principle of such samplers, a method will be presented to estimate the required total sampling area of a sampler from the degree of flow convergence in a soil (de Rooij et al., 2006).

In the past years, we improved our ability to analyze the data produced by multicompartment samplers. The spatial solute distribution curve as the spatial equivalent of the breakthrough curve was parameterized and physically interpreted. Both curves were unified in the leaching surface (de Rooij and Stagnitti, 2002), which has tremendous potential for detailed interpretation. Particularly the spatial solute distribution curve and the leaching surface can be of great help in determining the importance of prefer-

ential flow in a given soil.

To stress the importance of solute flux observations, we derived resident as well as flux concentrations from a numerical study of solute movement through a heterogeneous aquifer. We constructed leaching surfaces from both and will show how very erroneous the outcome can be if resident concentrations are used.

Multicompartment samplers can also help identify the nature of the solute transport process. Recently, the theory of solute dilution was made applicable to multicompartment sampler data (de Rooij et al., 2006). We will demonstrate how dilution theory can be used to determine the predominance of a convective-dispersive or a stochastic-convective transport regime during a tracer experiment.

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