Geophysical Research Abstracts,
Vol. 11, EGU2009-12960, 2009
EGU General Assembly 2009

Influence of soil structure on water potential and fluxes in the upper part of the unsaturated zone

A. Kuhlmann (1), I. Neuweiler (2), and S.E.A.T.M. van der Zee (3)

(1) Institute of Hydraulic Engineering, University of Stuttgart, Germany (anna.kuhlmann@iws.uni-stuttgart.de), (2) Institute of Fluid Mechanics and Environmental Physics in Civil Engineering, University of Hannover, Germany, (3) Institute of Soil physics, Ecohydrology and Groundwater Management, University of Wageningen, Netherlands

As the unsaturated zone is the interface between the subsurface and the atmosphere, it plays an important role in climate modeling. The water budget and fluxes of the unsaturated zone are determined by infiltration, evaporation, redistribution of water and transpiration by plants. The exchange of water with the atmosphere and the uptake of water by plants are highly dynamic processes. To gain a more detailed understanding of the soil water dynamics is of great importance behind the background of climate change which leads to more frequent and extreme weather events.

In general unsaturated flow is calculated according to the Richards equation and the exchange of water with the atmosphere is captured by the boundary conditions. Heterogeneity is supposed to have a large impact on the interactions of soil water budget, root uptake and atmosphere. A challenge is that predictions of the water budget are needed for large scales but soil is highly heterogeneous on small scales, which cannot be resolved. Modeling of water fluxes with the resolution of soil heterogeneity would be computationally too demanding and would require knowledge about the soil parameter distribution, which is usually not available. It is a major goal to gain a general understanding of the relationship of heterogeneous structure of soil parameters and large-scale flow processes in the soil. One problem when dealing with heterogeneity is the scarcity of measurements and a corresponding uncertainty about the detailed distribution of soil parameters. Therefore a stochastic approach is often used in which heterogeneity of soil is described by a parameter field with multi-Gaussian distribution. As nature is not Gaussian it is important to look at fields with more realistic structure, such as structures with connected pathways of extreme parameter values. A comparison of flow processes in multi-Gaussian fields with processes in fields with more realistic structure could improve our understanding of the applicability and the limitations of methods, which are based on a multi-Gaussian model, such as second order perturbation approximations.

The presentation deals with the relationship between soil heterogeneity and water fluxes on a lab scale, considering dynamic systems i.e. timely varying boundary conditions and sink term. The influence of simple soil structures in one dimension as layered or column media and more complex structure as Gaussian and Non-Gaussian fields is observed under consideration of root uptake and infiltration for steady state and dynamic processes. Steady state and dynamic processes will be compared regarding the influence of the structure using the numerical model MUFTE-UG where infiltration and root uptake is implemented in the following way. Infiltration due to rainfall is modeled as a top boundary condition of Neumann (flux) type. This implementation does not always describe inflow into heterogeneous media sufficiently since ponding might occur if low conductive lenses are located close to the surface. To ensure that rainwater naturally distributes, a conductive layer on top of the domain is added. Transpiration is accounted for in a macroscopic way as a sink term which is proportional to the potential transpiration, a root density distribution and with restricted uptake due to water and oxygen scarcity (Feddes-Function). Rainfall and transpiration are timely varying according to periodic cycles with a shift in time since root uptake is supposed to be limited when leaves are covered with rain.

Different settings are applied to find the interrelation of spatial structure and dynamic processes. Variable parameters are rainfall events with changing frequencies and different kinds of soil structures (Gaussian fields, fields with connected extreme values and fields with root-resembling structures). To compare the scenarios, depth profiles (mean values and variance of potential, and sink term versus depth) and the change of total potential and total transpiration over time as well as fluxes are analyzed. Based on these simulations it is tested, which scenarios are influenced by soil heterogeneity and when the approximation of multi-Gaussian parameter fields can be applied.