Geophysical Research Abstracts, Vol. 7, 07542, 2005
SRef-ID: 1607-7962/gra/EGU05-A-07542

Identification of the Hydraulic Response of Layered Soils by Inverse Analysis of Laboratory Evaporation Experiments

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Inverse modeling is frequently used in vadose zone hydrology for determining selected unknown parameters of the soil water retention and hydraulic conductivity functions, which describe unsaturated flow processes. Various investigations on uniform soils have reported successful applications of the inverse modeling approach through laboratory or in-situ transient flow experiments. However, the application of this approach to layered soils is more problematic, as in this case interpretation of the inverse results can be rather ambiguous and questions arise on the nature of the equivalent system in terms of reproducibility of the hydraulic behavior of the soil investigated. This information is crucial for correctly interpreting routine hydraulic tests, such as the classic laboratory evaporation experiment, in the presence of layered soils. At larger scales, such as hillslopes or small catchments, the equivalent hydraulic response of a soil profile is of major interest, particularly for the uppermost soil horizons whose properties and locations undoubtedly play a key role in the partitioning of rainfall in infiltration and runoff. The hydraulic characterization of layered soils through inverse modeling is investigated in this work with reference to the laboratory evaporation method. Synthetic evaporation tests were reproduced for a 2-layer soil system obtained by combining five different soils of different thickness, each subjected to two different evaporation rates. For each test, the inverse analysis is performed as described by Romano & Santini (WRR, 1999, 35:3343-3359), with the input matric head data from 4 tensiometers in the objective functions and by imposing the observed evaporative flux. In this study, vapor flow was neglected and the flow process is assumed to be governed by the Richards equation, benefiting from the numerical algorithm of Romano et al.

(AdWR, 1998, 21:315-324) that is particularly suited in case of layered soils. This numerical exercise enables to evaluate the different weights of the factors affecting the equivalent optimized parameters, especially those linked to the characteristics of the layers. Outcomes of this research would also contribute to investigations that are under way on the identification of suitable equivalent parameters to synthesize the nonlinear hydraulic response of soil at the scale of interest.