Geophysical Research Abstracts,
Vol. 10, EGU2008-A-05516, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-05516
EGU General Assembly 2008

Numerical modelling of Beerkan infiltration tests and related estimation of unsaturated soil hydraulic properties

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While processes in the vadose zone layer are integrated on length scales of meters or tens of meters, processes in soils are integrated at length scales of pore size or centimetres. The appropriate measurement strategy for soil water status and soil hydraulic properties in conjunction with global transfer experiments must recognize these length scales and account for spatial variability of soil transfer processes and soil water conditions. A specific protocol was developed to accurately determine the soil water retention curve h(θ) and hydraulic conductivity curve K(θ) using in situ measurement techniques: the Beerkan method. It is based on the specific parameter estimation algorithm (BEST) that relies on analysis of a simple ring infiltration experiment and easily collected soil texture and soil structure data. The analysis used in BEST relies on the formulations of 3D cumulative infiltration developed by Haverkamp et al. (1994). They postulate that the cumulative infiltration in 3D correspond to the infiltration in 1D plus one term proportional to time, the proportionality coefficient being a function of a shape coefficient γ. Cumulative infiltration in 1D is a function of time and another shape coefficient, β. These coefficients are supposed to be constants and usually taken as β=0.6 γ=0.75. The goals of this paper are (1) to validate the values of the shape parameters γgnd β for different soil types and (2) to estimate the errors in the estimations of the hydraulic curves h(θ) and K(θ) by the consideration of their usual values. HYDRUS 3D was used to model the infiltration experiments under 1D and 3D, for several initial conditions and for the specific case of a sand, a loam, a silt and a siltyclay. Nu-

merically optimized values for γ and β are then proposed depending upon soil type. Optimal values for γ and β were implemented in BEST algorithm to propose a new version for BEST. The results prove that the analytic formulations of Haverkamp et al (1994) are clearly adequate to model both 1D and 3D numerical infiltrations for either different soils or conditions. The values for γ and β could be optimised to improve the fitting of numerical data. Optimal values differ from usual values and depend upon the soil type. Moreover, their implementation in BEST improves BEST estimations results. To conclude, the proposed study shows the importance of the choice in the value for both parameters γ and β in regards to modelling 1D and 3D water infiltration using the Beerkan method, which appears to be a convenient tool for analyzing soil physical processes, complementary to short periods of the intensive measurements.

Haverkamp, R., P.J. Ross, K.R.J. Smetten, and J.-Y. Parlange. 1994. Three-dimensional analysis of infiltration from the disc infiltrometer. 2. Physically based infiltration equation. Water Resour. Res. 30:2931–2935