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Hydrology and Earth System Sciences Discussions

Interactive comment on "Do effective properties for unsaturated weakly layered porous media exist? An experimental study." *by* A. Bayer et al.

Anonymous Referee #1

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CONTENT

The paper analyzes a multi-step outflow experiment, performed on a laboratory column, uniformly packed with medium sand. Assuming uniform effective properties, i.e., a perfectly homogeneous column, the outflow of water out of the column can be almost perfectly fitted. A test of the homogeneity assumption is performed by scanning the water content distribution in the column during the hydrostatic equilibrium stages of the experiment by X-ray attenuation. The scanning revealed internal structured heterogeneity in the column, leading to a depth-dependent layering of bulk density, water contents, and hydraulic properties. Reconstruction of that heterogeneity in a layered numerical model and simulation of the outflow experiment yields an equally good fit of the outflow behavior, but a much better agreement between simulated depth-dependent water contents and measurements. Simulation of an identical multi-step experiment with the

same structured medium, but turned upside down, yields a different outflow behavior and thus different effective hydraulic properties. This leads to the conclusion that "objective" effective hydraulic properties do not exist for this layered structured porous medium. Since internal heterogeneity of this type is not revealed by a classic outflow experiment, the authors recommend to perform outflow experiments in two directions, to be able to judge on whether the implicit REV assumption holds in a given case.

MAYOR COMMENTS

The papers addresses one of the most central questions in the modeling of vadose zone hydrology processes, namely the question on which scales effective hydraulic properties exist and whether and how they are identifiable. Despite some contributions to this in the recent scientific literature, not too much work has been published on this issue, and this paper sheds light on some important aspects. The objective, the methods (with one single exception, see below) and the results are all presented in a clear manner. Tables and figures are clear and necessary. The conclusions are well based on the experimental findings. Alltogether, the paper is well written and marks a small, but significant scientific contribution.

I like to address a point, which may be considered by the authors in a potential revision. A careful notation is of utmost importance with respect to the terms "identifiable", "unique", and "objective" hydraulic properties. The authors chose to use the term "objective" to express the existence of unique effective properties. To me, "objective" means that no "subjective" component plays a role. Hydraulic properties are objective, if different investigators of a given data set come to the same result. Therefore, I tend to use "unique effective hydraulic properties" to express this (having in mind that the term "unique" is historically used for the uniqueness of the identification in a single experiment). The authors themselves write in the last paragraph of the results section (p. 1096, line 19): "Obviously, no unique hydraulic description can be obtained...". This hits exactly the point.

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Therefore, we (the scientific community) have to think about the appropriate concise terminology for the following:

- is the outcome of an experiment at all describable by a model that assumes homogeneous constitutive relationships?

- are the coefficients of the constitutive relationships uniquely identifiable?

- will experiments with different initial and boundary conditions lead to the same effective properties?

SPECIFIC COMMENTS

Abstract:

It is not recommendable to use "layered material model" and "heterogeneous model" to express the same model.

It is not recommendable to use "internal behaviour" of the column to express the "internal water contents" (the first expression encompasses also the local fluid dynamics, which is actually not measured)

Introduction:

page 1088, line 10: "Naturally"? -> better use "necessarily"

page 1088, line 13: "represent"? -> better use "lump"

page 1088,line 20: "To this end"? -jargon?

page 1088, line 21: "relaxation experiments" - this terminology is a bit unusual in vadose zone hydrology. To me, the experiments involve a series of perturbations AND relaxations, and the system response is upon both. page 1088, line 23: "the measured outflow is inverted" - is indeed the outflow inverted? (I understand the flow model is inverted, and the outflow data are used in the object function for the inversion).

Material and Methods:

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page 1089, line 6: The "matric potential" is defined in a wrong way: We use "matric potential" to express the energy difference between actual and reference state for soil water, and it is negative in unsaturated porous media. "Matric head" is the potential in units of length. The authors use the "matric head" throughout the paper in the sense of the tension, i.e., positive for unsaturated conditions. This is contradictory, e.g. to the (correct) expression of the boundary condition in Fig. 2. Note that, if this is corrected, it also effects the definition on page 1094, line 3, and the caption of Fig. 3.

page 1092, line 17: "... with respect to porosity" - with respect to volume fraction?

Results and Discussion:

page 1093, line 17: "stationary states" -> hydrostatic states! page 1094, lines 5 to 9: "Corresponding to the eight steps of the MSO experiment we obtained... ...to account for the structure in the measured profiles". I do not understand this part. Please try to specify it in a clearer manner.

page 1094, line 10 and Fig. 4: The depth distribution of the third fitted parameter, the residual water content, is missing in Fig. 4.

Conclusions:

page 1096, line 26: "huge discrepancies" -> "significant discrepancies"?

References:

I do not understand the numbers (1088, 1093, etc.) at the end of each of the references.

Fig. 3:

" ... changes in the sample surface" -> "...changes near the sample surface"? "... unreal water content values" -> "unrealistic water content values"?

Fig. 4:

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Theta_r is missing.

Interactive comment on Hydrology and Earth System Sciences Discussions, 2, 1087, 2005.