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A review of: Multiresponse modeling of an unsaturated zone isotope tracer experiment at the Landscape Evolution Observatory, by Scudeler et al.

Overview

The manuscript describes in detail efforts to fit a variably-saturated flow and convection-dispersion transport models to a very highly controlled field-scale experiment in a 1:1 physical analog of a hillslope. The physical models and numerical approximations are described in mathematical terminology (e.g. zero Neumann for no flow boundary condition etc.) yet readable for a wide community of hydrologists. The beauty of the paper is in the clear description of the need to increase the complexity of the model in the process of fitting first the integrated flow response (in which unique transient observations of seepage face flow-rate, and total storage of water are available in this experimental system) than the integrated transport response, than further complexity is needed to fit point observations of water content and concentrations. The model does not go very far with complexity, it starts in uniform hydraulic properties, moving to different properties near the seepage face and layered porous medium but does not go further to variability within layers, or mobile immobile formulations etc.. Hence, the well-known, good fit of the macro phenomenon relatively to poorer fits to point observations is described very clearly.

Recommendation

I am not sure there is completely new modeling knowledge here, nevertheless, the paper has “educational quality” for hydrological modelers as well as very unique experimental data (although not in focus in the manuscript), and therefore, I warmly recommend publication in HESS, following the authors pay their attention to the comments herein.

Major Comments

1) Title – The hillslope problem as well as the model used here and the results of the experiment, are variably saturated rather than unsaturated (saturation at 85 cm for significant duration of the experiment in most locations, Figure 11). Suggest to change to*: Multiresponse modeling of variably saturated flow and isotope tracer transport in a hillslope experiment at the Landscape Evolution Observatory*
2) Discussion - In line with the previous comment. I don’t understand why the authors do not discuss the more specific setup of a hillslope that was studied here, rather than concentrating on general unsaturated flow. The hillslope case has significant differences than the general unsaturated zone (variably saturated, lateral flow component dominant, relations with evaporation and runoff etc.).

Many simulation studies of hillslopes can be discussed (e.g. Fiori and Russo, 2008 WRR).

3) List of symbols – There are many symbols in equations and within the text. For example, it took me too long to find what does the nee in line 27 page 7 stands for. I suggest adding a list of symbols at the beginning of the paper.
4) Use of the term heterogeneity – is misleading. Changing a homogenous model deterministically to have lower Ks near the seepage face, or different hydraulic properties at different layers doesn't make it a heterogeneous model (a term now used for a medium in which the properties vary from pixel to pixel randomly usually constrained to a PDF and a spatial correlation function). I suggest describing this type of additional complexity with different (more explicit) terms (e.g. low Ks at seepage face, layered n(vg) etc.), throughout the text, tables and figures.
5) Fractionation? - in water isotopes during evaporation. The term fractionation is brought up late in the methods section (page 8) as if it is totally trivial. I suggest to add a paragraph on fractionation of water isotopes during evaporation in the introduction to introduce the topic before jumping into the details of dealing with modeling it in the methods section.
6) Van Genuchten (1985) - should be van Genuchten (1980). It would have been a specific comment for any other paper in hydrology (p. 6, l. 15 and in reference list).

Specific Comments

1) P. 4, Figure 1. a) Lowest pane (delta2H) – zoom into the interval of interests in the vertical axis (< 53); b) say something on the high readings at the beginning before tracer introduction, and just before the third rain pulse. Or looking at Figure 4 there seems to be a shift of the data to the left? Solve the problem, explain.
2) P. 5, l. 14, Eq. 2. I suggest to add the sink\source term – f(c) to the 2H transport equation here as well, rather than only elaborating on it in table 2 and related text.
3) P. 7, l. 27. Shouldn't the left hand side of the equation be n (or theta)*v*nee, rather than only v*nee (porous medium approximation of ratio of flux and velocity).
4) P. 10 l. 5-8. Excellent lines – don't touch, makes it so much easier to follow the long descriptions after.
5) P. 11, l. 11. The evaporation rates – were they calculated from the water balance and the load cell data? Or how? Please elaborate.
6) P. 15 Figure 4. A) Say something on the early breakthrough during the heavy isotope injection. B) Elaborate in the text why was the high disprsivity simulation so much biased upwards in the mass of tracer exiting the system (earlier arrival times are expected in high dispersity but also late ones. What were the left-in-storage or evaporated components of the mass balance in the high dispersity run?
7) P. 16, Figure 6 and related text: solute is not a proper term for 2H.