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Hydrology and Earth System Sciences Discussions

Interactive comment on "Uncertainty in the determination of soil hydraulic parameters and its influence on the performance of two hydrological models of different complexity" *by* G. Baroni et al.

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A synthesis of the paper results

The paper deals essentially with: i) a comparison between a model based on the Richards equation and a simpler conceptual model based on a reservoir cascade scheme; ii) a comparison between different set of measured/estimated hydraulic properties to be used as input in both models. Comparisons were based on evapotranspiration and soil water content data measured on a 120 days interval.

The following main conclusions were drawn:

i) the simulated evapotranspiration from both models fit quite satisfactorily the measurements. This seems to be independent on the set of hydraulic properties selected as input;

ii) to the contrary, for a given set of hydraulic properties, the simulated water content evolution in the root zone from the two models is appreciably different; iii) these differences becomes even larger if, for a given model, different sets of hydraulic properties are used as input;

iv) simulations carried out using hydraulic properties estimated by pedotransfer functions (PTF) fit the measured soil water contents better then the lab/field measured hydraulic properties.

General comments

Based on my reading of the manuscript, the paper is well structured overall. The introduction of the paper illustrates clearly the rationale and the objectives of the work. It provides an extensive literature review covering the major topics related to the selection of hydraulic properties to be used in water flow models. To me, some deficiencies are especially related to the discussion about the strengths and weaknesses of the different models they consider and the reasons why the models give different results. The measurements and experimental conditions are well explained even if I keep some serious doubts if lab/field data are really correct. Tables and the figures effectively summarize the results. Overall, I think the paper is significant, even if the approach is not novel, the objectives very clear and in general effectively supported.

Anyway, I have some doubts about measured properties which can affect all the four results summarized above. The following arguments are necessary to make clear these doubts.

1. Having a look to the figure 2 and postponing the discussion about the PTFs effectiveness to the following point, it can be observed that the water retention and hydraulic

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conductivity measured in the field are higher then those from the laboratory method. This is frequently true in the pressure head range 0-100 cm. It is the first time I see something like that. As shown in Pachepsky et al. (2004 - figure 10), if one consider the UNSODA data base (Leij et al., 1996), at the same pressure heads, field water contents are almost always markedly less than the laboratory values. Actually, what is generally observed is that the field retention curves are significantly lower than laboratory ones. Basile et al. (2003, 2006) provide a review and a discussion on the physical reasons for this. Furthermore, laboratory hydraulic conductivities at h=0, Ks, are generally observed to be different from those measured in the field. Several researchers (Eching et al., 1994; Rockold et al., 1996, Pachepsky et al., 2004, among others) showed that the laboratory determined Ks can be one or more orders of magnitude greater than those measured in the field. Sometimes, in presence of macropores (this is the case of the paper under revision), larger values of the field hydraulic conductivity might well be attributed to preferential flows. Nevertheless, saturated water content much larger in the field then in the laboratory cannot be explained.

2. Whereas PTFs seems fairly adequate for estimating the soil water retention function for pressure heads (absolute values) higher then 100cm, the same however does not apply for the unsaturated hydraulic conductivity. The estimated values by PTFs differ from those the estimated by Mualem's model of 1-2 orders magnitude. Loague (1992) used textural-based saturated hydraulic conductivity estimates in a rainfall-runoff hydrologic model in a small catchment and concluded that texture was not a substitute for actual hydraulic conductivity field data. Sobieraj et al. (2001) compared the performance of nine different PTFs for estimating saturated hydraulic conductivity, Ks, in modeling the storm flow generated in a rainforest catchment. Overall they concluded that the PTFs underestimated the measured Ks, thus inadequately predicting hydrograph attributes and grossly overestimating total runoff and peak runoff for almost all their examined events. A likely reason for this failure is that saturated hydraulic conductivity depends largely on soil structure (Tuller and Or, 2002), whereas the currently available PTFs, and those used by the authors, fail to account for this soil characteristic.

3. The sensitivity to each of the parameters of hydraulic functions is strongly process-dependent. This should be always considered when a comparison between estimated and measured hydraulic properties is carried out in terms of functional properties, as in the paper under revision. It is known (see for example Coppola et al., 2008) that the relative importance of the water retention parameters (static parameters) increases during drying (draining and evaporation) while that of the hydraulic conductivity parameters (dynamic parameters) increases during infiltration. The sensitivity of the model to each parameter depends on the flow process being observed.

In the context of the paper being revised, the points above can be synthesized as follows:

1. The satisfactory fitting of the simulated evapotranspiration to the measured data is expected due to the fact that this process depends largely on the water retention parameters which are quite well predicted, especially for the higher (absolute value) pressure heads;

2. The same cannot be said for the simulated water contents evolution in the root zone. This is because the soil water content evolution largely depends on infiltration processes during which the sensitivity to the hydraulic conductivity increases considerably;

3. the paradox of the better results provided by the PTFs compared to the measured hydraulic properties may well be attributed to some uncertainties (either in the measurement or in the interpretation) of the latter. If this is true, the statement (page 4080 lines 17-19) “The poor performance is probably due to the presence of soil crusting and macroporosity, which were observed in the field but not accounted for in the two models” makes no longer sense. The poor performance could well be attributed to the “strange” measured hydraulic properties, while it is only expected in the case of PTFs.

Some minor remarks

- Page 4069 line 22. "…. be taken…";

- Page 4071 line 4. Please, specify "….saturated hydraulic conductivity";

- Over all the text Van Genuchten should be van Genuchten;

- Page 4074 lines 14-15. To my knowledge and experience, hanging water column method allows measurements up to 400-500 cm;

- Page 4075 line 18. The authors are using in the PTFs for hydraulic properties bulk density values which in turn are estimated by one more PTF.

- Page 4076 line 10. …..Readily….

- Page 4078 lines 12-14. Jhorar et al. used evapotranspiration fluxes to inversely identify soil hydraulic parameters under deep water table conditions and significant moisture stress. Under drying conditions, the hydraulic conductivity parameters (L but even Ks) have only minor weight on the process (drainage or evapotranspiration). The process is much more sensitive to the retention parameters. The hydraulic conductivity parameters (both L and Ks) contribution increases drastically during infiltration processes (see Coppola et al., 2008).

- Page 4079 lines 15-16. From figure 2 it seems that the field Ks is higher then the lab one;

- In the table 5 it should be useful to distinguish between parameters from lab and field methods;

- In figure 2 it is not so simple to distinguish the curves.

The Authors should discuss the issue of the measured hydraulic properties. They should justify the unexpected differences observed. It will increase the significance of the contribution of their paper.

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