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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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We acknowledge Antonio Coppola for the interesting observations, in particular about laboratory and field measurements. We will take advantage of his suggestions to improve in the revised paper the description of the experimental conditions and the goal of the manuscript as discussed below.

General comments

(0) 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.

As pointed out also by referee #2, we agree that the motivations of the model comparison can be expressed in an improved form in the manuscript. Therefore we will introduce a paragraph, with a short assessment of the advantages/disadvantages in using the two different modelling approaches as well as the added value of their comparison.

(1) I have some doubts about measured properties: the water retention and hydraulic 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. Actually, what is generally observed is that: the field retention curves are significantly lower than laboratory ones; the laboratory determined Ks can be one or more orders of magnitude greater than those measured in the field.

We agree with the Referee that the description of the field and laboratory parameter sets can be improved and some more details and explanations should be given to a better interpretation of the results. Therefore we will add in the revised paper more details on (i) the field procedure used in our case study and (ii) the effect of tillage on the field and laboratory measurements, as discussed below.

(i) About this first point, we have to underline that the field technique we used is not the instantaneous profile method used in other studies (e.g. Basile et al., 2006). Using the definitions reported in Basile et al. (2006) we can probably define our field method as the "field method with simplification", in particular "drawing field hydraulic variables partly from laboratory". In fact, as reported in the manuscript, in our study simultaneous field measurements of soil moisture by CS probes and of pressure head by tensiometers were collected in the experimental site at the depths of 20, 35 and 70 cm. The water retention function of Van Genuchten (1980) was fitted to the field measured theta-h values using the RETC code (van Genuchten et al., 1991). Anyway the CS probes were calibrated with undisturbed soil cores in the laboratory. In the op-

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timisation with the RETC code the porosity was fixed to the value obtained with these last experiments and not with the values obtained in the field. This is in our opinion the major reason for that the porosity in the field curves is not less then the porosity measured in the laboratory. Moreover this assumption changed the shapes of the retention curves also for the pressure head range 0 - 100 cm. Also the values of the residual water content was fixed to the calibrated values of the probes. On the other hand, the CS field measurements was used in the optimisation to estimate the shape parameters a and n (m was fixed to m = 1-1/n). In particular the water retention curve was obtained coupling the measurements of theta and h carried out at the same depth and time during the monitoring period. At higher suctions the representativeness of the two curves obtained with these values can be questioned, since the soil water content in the field was always relatively high during the monitoring period, particularly for the deeper layers due to the presence of the shallow groundwater table.

(ii) About the second point, i.e. the effect of tillage, we have to underline that the field and laboratory measurements was conducted in different periods as described below. First of all a trench was opened in the centre of the field on may 2006. The CS probes were installed at the different depth (5, 20, 35, 50, 70 cm) together with the tensiometers (20, 35, 70 cm). The undisturbed soil samples were taken for each horizon and sent to the hydraulic laboratory of soil hydraulics of the University of Naples (Prof. Nunzio Romano), where the measurements of the saturated hydraulic conductivities and of the retention curves were carried out. All the instruments in the experimental site were equipped with a data-logger and the first measurements were used to check their proper functioning. Before the sowing (on June 3, 2006), all the instruments of the first layers of the soil (until 50 cm) were taken away from the field. In this the mechanical operations were carried out uniformly in the whole field, including the area of the instruments. It is worth underlining that the soil hydraulic properties measured in the undisturbed soil samples for these first layers can be affected by the different soil tillage. The saturated hydraulic conductivity Ksat (cm h-1) was measured by the Guelph permeameter after the sowing at the same depths as the monitored theta - h values. Although we did not collect an extensive data set, our measurements confirm the observations of several authors (e.g. Strudley et al., 2008; Ndiaye et al., 2007), showing that the tillage has a significant effect on soil hydraulic properties. In particular, as pointed out also by the Referee, the saturated hydraulic conductivity can be strongly influenced by the modification of the soil structure. For instance the Ksat value we obtained by laboratory measurements is bigger than the field one in the 4th horizon, which was not affected by mechanical operations, while in the others layers, the laboratory values are smaller then field one.

As pointed out in Basile et al. (2006), also in our case "complications arise because in situ determined hydraulic properties disagree with those determined on undisturbed samples collected at the same site, in a way that field hydraulic properties cannot be straightforwardly drawn from laboratory ones". We realize that these are extremely important issues, which are not touched in our paper, and in the revised manuscript we will pay more attention in describing the way in which the field and laboratory parameter sets were obtained. In the same way we will use these specifics to a better interpretations of the output of the models.

(2) Overall they concluded that the PTFs underestimated the measured Ks

As underlined in the point (1) we used different procedures to estimate soil hydraulic parameters but, in our opinion, it is difficult to take advantage of these results as a direct comparison of the curves, in particular due to the effect of the tillage. Also if it was not our goal, the data collected suggested that the temporal variability of the soil hydraulic properties is an important issue in the agricultural field and the behaviour is not obvious because differences can achieved rapidly in space and time. As reported in Strudley et al. (2008) more researches should be done in this direction because "differences in temporal variability depend on spatial locations between rows, within field at different landscape positions, and between sites with different climates and dominant soil types. Most tillage practises have pronounced effects on soil hydraulic properties immediately following tillage application, but these effects can diminish rapidly. In this, new standards for experimental classification are essential for isolating and subsequently generalizing space-time response. Accordingly, enhanced methods of field measurements and data collection combined with explicit spatio-temporal modelling and parameter estimation should provide quantitative predictions of soil hydraulic behaviour due to tillage and related agricultural management." As a matter of fact, a better interpretation of the direct comparison of the curves could be arise if the procedure was done with more undisturbed samples, larger measurement ranges and more accurate measurement methods e.g. the undisturbed soil samples for the laboratory analysis done immediately after the field measurements (Basile et al., 2003). Some suggestions for the soil of the Padana Plain (Northern Italy) are carried out by Ungaro et al. (2001) but just for the retention curve. With respect to the saturated hydraulic conductivity we agree that more attention would be warranted.

(3) The sensitivity of the model to each parameter depends on the flow process being observed. 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.

We agree in general with the referee. Anyway in the particular case study we point out that the actual evapotranspiration rate was generally very close to the potential rate. In this specific situation the evapotranspiration rate is not affected by the soil hydraulic parameters, therefore the values obtained with the different parameter-sets are very similar (Fig. 3). In our opinion with these data we can not confirm the assumption reported by the referee.

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;

We agree with the referee and we think that this is an important message. In the

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revised manuscript we will underline that these processes are particular affected by the uncertainty in the determination of the hydraulic conductivity curve.

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.

As discussed with referee 1 (see point 3 of the reply to Ref.1), we have rather the impression that the evaporation process is not well simulated by both models, irrespective of the parameter set that is used. Indeed the different parameter sets gave similar simulation results in terms of evaporation and therefore, we think that the differences between simulated and measured values are due to other sources of uncertainty. Soil crusting and macroporosity were provided as examples of factors that could play a role in the differences, but we will try to improve the explanation of our viewpoint in the revised manuscript.

Minor remarks

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).

As reported in point 3, we agree with the referee and we think that this is an important message. In the revised manuscript we will underline in the discussion that the sensitivity of the model to each parameter depends on the flow process being observed.

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

It is true. The unsaturated conductivity based on field measurements are characterised just in the deeper layer by smaller values of Ksat in comparison with the curves obtained by the other methods. For the first layers field Ksat is similar or even higher as in the case of lab Ksat. As discussed in point (1) we think that this behaviour is due to the tillage and it will be pointed out in the revised manuscript.

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

We decided to show only the main statistics of the parameters in the table 5 because all of the methods used are affected by some uncertainty as discussed in the point above and no method, in our opinion, could be taken as reference. Moreover, as shown in figure 2, there is not a strict correspondence between the layer depths which would make the Table very complicated. As alternative, we intend to report all the data in the revised paper as suggested by the referee.

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

We will try to provide a clearer figure.

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