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Discussions

Interactive comment on "Use of field and laboratory methods for estimating unsaturated hydraulic properties under different land-use" *by* S. Siltecho et al.

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We would like to thank the referee for the thorough reviewing of our manuscript. The Comments and criticisms have been taken into account and the questions answered here below :

Q: The current manuscript is concise, but difficult to assess at times. To fully appreciate the comparison, the reader currently needs to be an expert on the various approaches already, or needs to be willing to look up all of the references made to various methods and techniques. The conciseness also hampers the conclusion in my opinion; the com-

parison is done on a strictly statistical basis, on which the authors conclude no method out competes another, and therefore the low-cost Beerkan method is probably the best. Nonetheless, every measurement techniques has its pros and cons. The manuscript would benefit from mentioning such pros and cons in the technique description, and assessing these together with the statistical analysis. The scale dependency of the (unsaturated) hydraulic conductivity may justify discussion on the area/volume being assessed by each technique.

R: The pros and cons of each technique have been presented in the paper. The discussion about the scale dependency of unsaturated hydraulic conductivity and sample size has also been introduced into the text. For the Beerkan method the main advantage is the simplicity of the experimental set-up which doesn't need specific material nor specialized skills. Moreover the infiltration process is usually quite rapid (less than an hour) to reach the constant infiltration rate. On the other hand the exploitation of the data is more complicated the method is based on strong hypothesis about the unsaturated hydraulic properties, namely they are supposed to follow strictly van Genuchten's retention with Burdine conditions and Brooks and Corey hydraulic conductivity expressions. Though in most of the cases this assumption agrees well, some cases, like bimodal porous networks are not taken into account.

Disk infiltrometer is a very precise way to measure the infiltration rate and to derive hydraulic conductivity near saturation as the tension applied to the device allows for infiltration at specific matric potential values. The experiment is difficult to set up for it needs a perfect flat contact between the soil surface and the disc and is prone to many technical fails (leaks, etc ..). Moreover each experiment takes usually a very long time to reach constant infiltration rate (sometimes several hours for fine textured soils). Wooding's model used to derive saturated hydraulic conductivity from disc infiltration measurements assumes an exponential relationship between hydraulic conductivity and matric potential, that is quite different from the van Genuchten function.

Evaporation method is the only method for which the retention curve is actually measured without any a priori model. In this case the slow evaporation rate imposed at surface generated a very slight tension gradient inside the soil, with a uniform water content distribution. The draw backs of this method are the long time necessary for a soil sample to dry completely (up to two weeks) and therefore to complete the retention curve and the costly equipment (oven, computer, balance, micro-tensiometers, pressure gauge, data-logger).

The inverse modeling performed with Hydrus 1D, is an elegant method to determine the unsaturated soil properties from evaporation data where the data used to fit the van Genuchten's parameters directly. The drawback of this method are the same as those cited previously as the evaporation experiments in controlled conditions still have to be performed.

The pedotransfer function is an extremely easy method to derive the retention curve based only on particle size distribution. Arya and Paris relationship is physically based deriving the size of the voids between the grains assuming a packing model. Nevertheless as this model, unless Beerkan method, is exclusively governed by the PSD and the bulk density of the soil, little information about the soil structure is available in the computed retention curve.

Q: The limited amount of samples in all of the measurement techniques, and the different area/volume these techniques cover are compared with location variability of which not much more is written than the textural composition of the sites, and the land use. These issues need to be discussed to make the current concluding statements more convincing.

R: Considering the texture (mainly sandy) and especially the lack of structure of the soil in the different locations (except in the forest) the volume of the soil samples exceeds the Representative Elementary Volume, that can be estimated to 100 cm3 according to ccording to Anderson and Bouma (1973) and Bouma (1980) . Therefore despite not having been measured on strictly the same volumes or areas but still in the order of

magnitude (Beerkan 800 cm3, Disc infiltrometer 2000 cm3, Evaporation 1500 cm3) the results for the different methods should not be affected by the scale. The number of samples depended on two main criteria: the time and simplicity of the method, and the data finally exploitable after processing. The number of repetitions is therefore uneven and sometimes very low. In order to overcome this problem we used non parametric tests like Kruskal-Wallis aimed to deal with little and uneven sets of repetitions.

Q: Another difficulty in assessing the paper is the consistency of naming methods in the text and in the tables (including structure). Especially i) Wind's method/evaporation method/inverse method/associated inverse method and ii) pedotransfer function(PTF)/Arya and Paris method/Arya method. With careful reading this can be overcome, but could perhaps be prevented. R: The reviewer is completely right and the different names of the methods have been harmonized throughout the text: Beerkan, Disc infiltrometer, Evaporation, Inverse, and Arya.

Q: Some vagueness surrounds the hypothesis on page 6103 lines 19 to 23. If different land managements would change soil properties, are these changes for example a result of structural changes due to (mechanical) cultivation? Or the transgression from natural vegetation to pasture or plantation, leading to changes in root mass, and thus in soil structural changes? Can it be assumed such changes can be assessed by measuring the hydraulic properties of top soil? Or is the rationale for this study from the perspective of infiltration capacity and erosion risks? Please clarify.

R: It is assumed that the different land managements would affect structural properties of soil, due to different tillage methods, different root densities and sizes, and different biological activity of macro fauna. Therefore the hydraulic conductivity of the top soil will be affected and the infiltration capacity (more than the erosion risks) will be modified. In the context of tropical rain patterns with heavy rainfall followed by long dry periods, with these shallow soils, the infiltration capacity is an important factor in the soil water balance. The efficiency of the rainfall is highly depended on the infiltration capacity.

Q: On page 6105 and 6106 two models for estimating soil unsaturated hydraulic properties are described. What was the motivation for using these models, instead of others?

R: The two models describing the unsaturated soil properties namely van Genuchten's functions and Brooks and Corey's function have been chosen because they correspond to the parameters possibly usable with Hydrus water flow modeling software. Moreover they also correspond to the functions used in Beerkan method.

Q: Page 6107 For the disc infiltrometer: How many repetitions at each of the sites?

R: Six to seven replications were performed as for the Beerkan method. When the variation seemed high the number of replications was increased.

Q: For the evaporation method an inconsistency seems to occur between the M&M and result section: Page 6108 line 4 "Two undisturbed soil samples were collected at each location" versus Table 3 evaporation/inverse n=3 (or 2 for some of the sites).

R: Three soil samples were collected for each location.

Q: Which samples were used for the PTF method described in section 2.2.5?

R: The PSD determined on the soil samples for Beerkan method were also used for the deriving retention curve with the pedo-transfer function (Arya method in the text).

Q: Section 3.6: Since infiltration was strictly 1D in one of the distinctive groups, I would ex- pect a discussion here if the results of some of the measurements techniques suffered from lateral flow. This is not mentioned in the text discussing the measurement results, it could be that by applying the algorithms to analyse the data such possible errors are assessed, but since none are described very extensively it is hard to assess.

R: None of the measurement technique was affected by lateral flow as the slope of soil surface is very slight (3%). However a point that has to be mentioned in the text is that the interface between the sandy layer and the clayey layer has a steeper slope and therefore, when the perched water-table appears during the rainy season, water flows

along this slope in the sandy layer (Seltacho et al. 2013).

Q: The conclusions focus on differences between techniques only, and do not justify the first line in the conclusions, nor the first objective of the paper.

R: The first part of the conclusions focuses mainly on the difference between the locations, and points out the different hypothesis that possibly can explain them. However this part can be extended.

Q: Table 3 and 4 only show Ks while equation 3 and 4 seem to facilitate K(theta) as well. For unsaturated flow modelling the shape of K(theta) is important. Why did the authors only plot the scaled retention curve (Fig 3), but not K(theta)?

R: Indeed in table 3 and 4 only Ks is mentioned as it is one the prime parameters used in for water flow modeling, the scaled hydraulic conductivity curves are not as informative as the retention curve for all the curves are gathered and none really stands out.

References

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Seltacho, S., Sriboonlue, V., Suwanang, N., Wiriyakitnateekul, W., Hammecker C.: Quantification and modeling of water flow in sandy soils in Northeast Thailand, In Advances in Unsaturated Soils. Bernardo Caicedo, Carol Murillo, Laureano Hoyos Julio Esteban Colmenares and Ivan Rafael Berdugo Ed. CRC Press 2013: 573–577, 2013.

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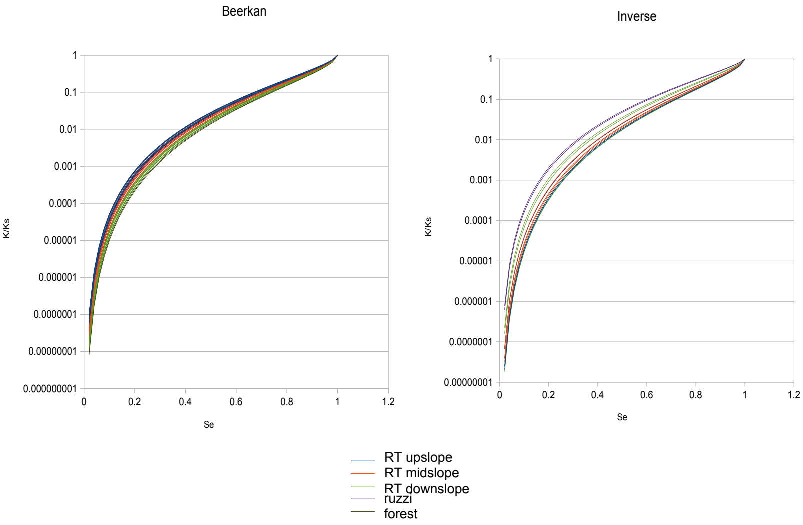

Fig. 1. reduced hydraulic conductivity versus effective saturation

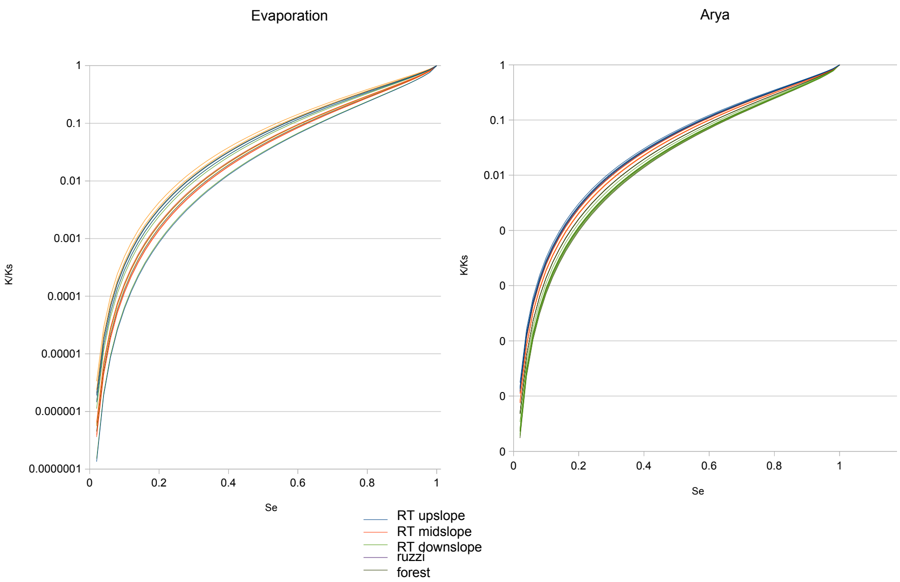

Fig. 2. reduced hydraulic conductivity versus effective saturation

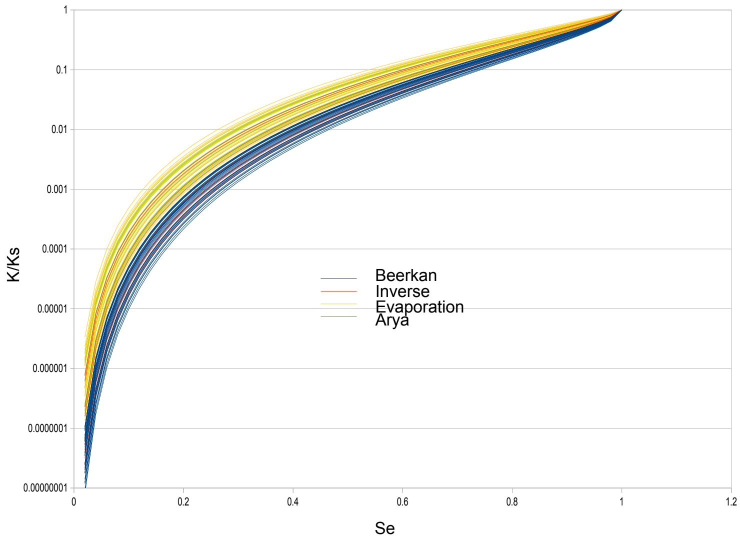

Fig. 3. reduced hydraulic conductivity versus effective saturation