Physical Pedotransfer Functions To Compute Saturated Hydraulic Conductivity From Bimodal Characteristic Curves For A Range Of New Zealand Soils

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RESPONSE TO REFEREE 2

Dear Reviewer 2,

We would like to express, our gratitude for your efforts for your review of our article: *Saturated hydraulic conductivity model computed from bimodal water retention characteristic curves for a range of New Zealand soils*. We understand that you have concerns about the manuscript and we hope that we have addressed them.

The intent of this paper is not very clear. On closer examination, even the title of the paper is problematic to me.

We modified the title of the paper as suggested by reviewers 1 & 3 since they argue that the developed K_s model is not a pedotransfer function but a functional model so therefore we changed the title to:

Saturated hydraulic conductivity model computed from bimodal water retention characteristic curves for a range of New Zealand soils

1. It is true that soil moisture release curve, $\theta(h)$, is still being measured in the laboratory despite being time-consuming. The hydraulic conductivity function $K(h)$ is too expensive and time– consuming to measure and is typically reconstructed from the saturated hydraulic conductivity K_s and $\theta(h)$. Therefore what the authors seem to suggest in the paper is to use a bimodal $\theta(h)$ to compute K_s. The error involved will be too huge. In fact, it is common knowledge that an accurate $K(h)$ can be obtained by measuring K_s and $\theta(h)$ rather than by estimating $K(h)$ directly from $\theta(h)$. In fact, this is one C1 of the recommendations for future work in the paper. 2. Saturated K_s is not more time-consuming to measure compared to $\theta(h)$.

The reviewer raises an important issue. In some cases, $\theta(h)$ can be easier to measure, but our collective field and laboratory experience over many years is that the components of measurement required to estimate K_s are more expensive to measure accurately, given the great variability we commonly expect for this property in New Zealand soils. We believe that this is due to the relatively young geomorphic development of the soils in this country. The purpose of this paper is to test one approach for modelling the $K(h)$ curve, which is an established valid approach in the scientific literature. You are correct that there are alternative approaches, which we will test in time as part of the S-map programme in NZ, but it is not the purpose of this paper to test these other options.

For clarification, among our *recommendations for future work* is a task to collect more accurate information on $\theta(h)$ and $K(\theta)$ to improve the development of K_s models, which are required for the predictions of $K(\theta)$ *to* be fed into the S-map data base (https://smap.landcareresearch.co.nz/).

3. The approach chosen to determine Ks is strange as Ks depends on the voids in the soil. I can understand if one chooses the particle size distribution as providing the key parameters in a pedotransfer function to estimate Ks. Using $\theta(h)$ is an indirect process of getting the pore-size distribution but due to the time-consuming nature of the test, it is less suitable to be used as a proxy for pore-size distribution.

As mentioned above, the purpose of this paper is to test one approach for modelling the $K(h)$ curve, which is an established valid approach in the scientific literature. You are correct that there are alternative approaches, which we will test in time as part of the S-map programme in NZ, but it is not the purpose of this paper to test these other options.

Thanks for providing us with new insight in the development of K_s model based on the particle size distribution. Nevertheless, the current S-map database does not have accurate particle size distribution, nevertheless we have good data on $\theta(h)$ and this is why we decided to use $\theta(h)$ to infer the pore size distribution based on Eq. 1. It will be interesting to compare K_s models based on $\theta(h)$ and models based on particle size distribution for which, to my best of knowledge, a comparison has not yet been published.

For instance, Arya and Paris (1981) showed that there is a strong relationship between pore-size distribution and the particle-size distribution and therefore adding soil texture information should not improve the model.

4. Even when using $\theta(h)$, it is expected that the matrix (micro) pores are the ones governing Ks but this is not evident from the paper.

The percentage of pores contributing to macropores as discussed in the paper depends largely on θ_s - θ_{s_mac}.

5. The error for Ks shown in Figures 3 and 4, is about +/- one order. The errors in the measurement of Ks should be less despite the problems mentioned in Section 4.1.3.

This may suggest that the model is performing more accurately than the measured data! As mentioned in the paper high variability in Ks is widely recognised in the literature, which is why we are suggesting in the paper that future work use larger sample volumes (which is also shown in the literature to reduce measurement variability).

6. Based on the above assessment, most of the equations presented in the paper have little value. In addition, none of the equations presented is a pedotransfer function in the traditional sense.

As mentioned above, the purpose of this paper is to test one approach for modelling the *K(h)* curve, which is an established valid approach in the scientific literature. As discussed, we changed the title of the paper to reflect our agreement that our K_s model does not fit in the category of pedotransfer function but in the category of a model which is derived from principles of soil physics.

It is important to remember that the ultimate purpose of this paper is to derive K_s from $\theta(h)$ data which is available in S-map, which is the national soil database of New Zealand. S-map addresses key issues that are important to New Zealand soils, although the methodology could in principle be applied elsewhere, and therefore the developed equations are useful to a greater or lesser extent outside New Zealand, depending on the soil information available other countries.

7. More relevant literature on estimating of saturated hydraulic conductivities should be cited e.g.

Many thanks for proposing literature to enrich our paper we included them in our paper. We found the following references to be highly relevant to this topic:

Chapuis, R.P. (2004) Predicting the saturated hydraulic conductivity of sand and gravel using effective diameter and void ratio. Canadian Geotechnical Journal, 2004, 41:787-795, 10.1139/t04-022

Mbonimpa, M., Aubertin, M., Chapuis, R.P. (2002) Practical pedotransfer functions for estimating the saturated hydraulic conductivity. Geotechnical and Geological Engineering (2002) 20: 235. doi:10.1023/A:1016046214724