GMD paper on the junction model. Reviewer 1 (Katsutoshi Seki) plus reply

Below, the reviewer comments are in italics, and my replies in regular font.

General Comment

This paper presents a range of models for unsaturated soil hydraulic conductivity curves (UHCCs), differing in how they combine approaches across three conceptual domains. Building on the author's previous work (de Rooij, 2024a), the paper introduces a new model, JUV, alongside earlier models (ADV, AMV, GMV, HMV, KGV), as summarized in lines 399–404. The use of the RIAfitter and KRIAfitter programs for model comparison is commendable, and it is particularly valuable that all data, code, and results are openly provided. The full description of the fitting procedures enhances the reproducibility of the research.

For each model, five parameter fitting strategies were tested, as outlined in lines 370–374. Among these, methods 2 and 5 rely on SWRC parameters that have already been fitted from retention curve data, whereas methods 1, 3, and 4 re-fit all parameters, including those of the SWRC. This is somewhat confusing, given that line 188 states: "Before KRIAfitter 1.0 can be run to determine the values of the parameters of the chosen UHCC model for a particular soil, the parameters of the SWRC of Eqs. (1a–d) need to be fitted using RIAfitter 2.0." If SWRC parameters are already known, it is unclear why they are re-fitted during UHCC fitting. If these parameters change during the UHCC fitting, then the SWRC curve would no longer match the originally fitted SWRC. This raises the question of whether the SWRC parameters in the SWRC equations are treated as independent from those in the UHCC equations (e.g., is the "n" in SWRC distinct from the "n" in UHCC?). From a modeling standpoint, it would seem more logical to fix the SWRC parameters and only fit the additional UHCC parameters, as is done in methods 2 and 5.

Thank you for your thoughtful review.

This comment helped me identify the source of the confusion about the fitted SWRC and UHCC parameters. Before proposing a remedy, please allow me to offer some thoughts on the relevance of SWRC parameter values for the UHCC.

The predictive power of the fitted values for the SWRC for the values of the same parameters for the UHCC is often limited. As a general rule, I therefore do not recommend to assume that values of α, n, and h_{ae} fitted for the SWRC are necessarily valid for the UHCC as well. In principle, a code can be developed that allows one to fit all parameters on data from both curves, as RETC (van Genuchten's parameter fitting code) allowed for fitting van Genuchten's (1980) retention curve simultaneously with Mualem's (1976) conductivity curve. In all cases that I saw for which RETC was used with this option, the fits were not very good for either curve. I therefore did not implement this.

When using KRIAfitter, the user can choose the extent in which to use fitted values of SWRC parameters as fixed parameters for fitting the UHCC, as is illustrated by the various sets of fitting parameters, as the reviewer correctly notes.

Now, back to the point of the confusion about refitting parameters that were already fitted to the SWRC data points. To remove the source of confusion, I propose to give the parameters that appear in both the SWRC and the UHCC but can have different values different labels for the SWRC and the UHCC. The best way to so is probably adding the subscript θ to the

SWRC parameters, analogously to the distinction between $h_{j\theta}$ and h_j. I also propose to add the following to the start of Section 3 (Fitting the model parameters), together with additional minor edits in the text at the start of that section.

'The junction model (or any of the other UHCC model accommodated by KRIAfitter) does not require that the parameter values fitted for the SWRC are assumed to be valid for the UHCC as well. Nevertheless, physical consistency between the SWRC and the UHCC requires that θ_s and the matric potential at which liquid water is no longer present in the soil (calculated as $(1+c)h_d$ for the SWRC) are the same for both curves.'

The final sentence of the first paragraph of Section 3 can be revised as follows:

'Hence, θ_s is fixed at the SWRC value and h_d is calculated according to Eq. (2b) from SWRC parameters that are provided on input.'

Equation 2b will heave to be inserted in the text below Eq. (2) in Section 2.2, which has to be relabeled (2a). That proposed revision is:

Rewrite start

The intrinsic hydraulic conductivity of water in films is modeled according to Peters (2013).

$$K_a(h) = K_{s,a} \cdot \begin{cases} 0, & h \leq h_d \\ \left(\frac{h}{h_a}\right)^{-1.5}, & h_d < h \leq h_a \\ 1, & h > h_a \end{cases} \quad (2a)$$

$K_{s,a}$ (LT^{-1}) is the value of K_a when the domain with adsorbed water is completely filled, and h_a (L) is the matric potential at which this occurs. The value of the exponent is adopted from Peters (2013). Note that $K_a(h)$ abruptly drops to zero at h_d (the matric potential at oven-dryness, L), but K_a at that matric potential is so small that this will generally be insignificant for practical use. The need to carry over the correction of $h_{d\theta}$ in Eq. (1a) results in the following equality.

$$h_d = (1 + c)h_{d\theta} \quad (2b)$$

Rewrite end

Specific Comments

1. *Table 1: Based on RMSE, the most flexible parameter set (method 1) yields the best results in nine cases, while the second-most flexible (method 3) does so in one case. Since optimization aims to minimize RMSE, and method 1 likely encompasses the parameter space of method 3, it is unclear why method 3 would ever outperform method 1. If method 1 includes all of method 3's parameters, then the optimal set*

found by method 3 should also be attainable by method 1. This discrepancy could be due to method 1's parameter space not actually covering that of method 3, or because the fitting algorithm failed to locate the global optimum within the broader space of method 1.

I noted this too. Prof. Seki is correct in stating that the parameter space of set 3 is wholly contained in that of set 1. In other fits, I also saw that constraining the parameter space can occasionally give better results. Having dimensions in the parameter space that do not improve the minimum appear to let the search algorithm run astray, and reduce its ability to locate the minimum, even though the complexes in parameter spaces with more dimensions contain more points.

The code returns the number of reflection, contraction, and random points required to achieve convergence, and from this it became clear to me that reduced parameter spaces considerably improve efficiency. This is consistent with the observation that a reduced parameter space (i.e., with at least one parameter fixed) can give better fits if the parameter values at the location of the global minimum coincide with the value of at least one fixed parameter for the fit in the reduced parameter space.

2. *As mentioned in the general comment, I believe that fixing all SWRC parameters during UHCC fitting is a reasonable approach. In this context, method 2 fixes the SWRC parameter α, but only method 5 fixes all SWRC parameters. I would be interested in seeing more variations on this fixed-parameter approach—such as versions assuming Assouline's τ = 0.0 or Mualem's γ = 2.0—alongside method 5. The author's model in fact resembles the model proposed by Peters (2013), which originally used γ = 2.0. The equation involving γ and τ is specifically intended to describe the capillary range. If the focus is solely on the capillary range, as in this study, it may be sufficient to fix γ = 2.0, without fitting both γ and τ. This could be tested as a simplification, though it is ultimately up to the author whether to include such comparisons.*

   As I explained above, I think the quality of the fits of the UHCC will often improve if one does not fix the parameters that appear in the equations for both the SWRC and the UHCC are fixed to their values for the SWRC. Table 1 illustrates this by showing that that approach only gave the best fit (based on Akaike's Information Criterion) in a single case.

   Mualem's model fixes both γ and τ. When the SWRC parameters are also fixed, this leaves only $K_{s,c}$ (and $K_{s,a}$ for some UHCC models) as fitting parameter(s). I did some trial fits with this, when experimenting with different sets of fitting parameters, and found that the results were generally rather poor, so I discarded that option as one of the sets to be used in the test of the code.

   The five sets of fitting parameters all have a basis in the literature. GMD requires a test of the code in a model description paper such as this, which I provided through these five sets of fitting parameters.

   I hope that people will use the model and the code to carry out studies as the one proposed by Prof. Seki, but this paper is a model description paper, not a paper in which the model is used for a particular application, which GMD does not publish. Therefore, exploring the validity of fixing a set of model parameters if one is only interested in a specific range of the matric potential, as Prof. Seki proposes for the capillary range, is interesting, but beyond the scope of a model description paper in this journal.

The paper introduces a junction model with one branch for capillary flow, another for film flow, and a separate conductivity function for vapour flow. The work builds on a SWRC in which both capillary and adsorbed water are represented. I therefore do not understand the statement that this study focuses on the capillary range.

Technical Comment

1. *Equation 5a: Is the parameter "a" defined somewhere? Should this be "D_a"?*

Thank you for spotting this. The *D* dropped out when the Word file was converted to pdf before submitting the manuscript to the GMD website. This will be corrected (I hope to Word-to-pdf conversion will not corrupt it again).

References

- *Peters (2013): http://doi.org/10.1002/wrcr.20548*
- *Seki et al. (2023): https://doi.org/10.2478/johh-2022-0039*

The latter reference does not appear in the comment.