HESS-2022-173 Reviewer 1

The reviewer comments are in *italics*, the reply in regular font.

Great thanks for the author's efforts in deriving a closed-form SWRC with a logarithmic dry branch for addressing dry-range data issues. This is particularly helpful when the SWRC is parameterized (within a physical range) for soils in arid and semi-arid areas, for which the numerical solution of Richards equations can easily crash. This reviewer is very interested by the proposed model, and had tried out the code with the example input and obs data as provided. Although this reviewer recommended the acceptance of this manuscript, there are a few technical comments for the author's considerations as below:

Thank you for the positive appraisal of the paper, and for testing the parameter fitting code.

1. The model seems not working well for soil C2 and C4 soils. This reviewer is wondering if the author could help explain or hypothesize the relevant potential physical mechanisms behind it?

The paper does not elaborate on this because, that is correct. The explanation is that the unimodal version of the SWRC has three segments: a vertical segment for matric potential between zero and the air-entry value, a sigmoidal segment that can simplify to a power-law segment for matric potentials between the air-entry value and the junction point, and a logarithmic branch (linear on the semi-log scale) for matric potentials between the junction point and oven-dryness. Some of the clay-rich soils of C2 and C4 exhibit multimodality (soils 1180, 1181, and 1182), which does not fit the three-segment mold. Others have a very small number of data points in the dry range (soils 1122, 1123, and 1135), so the code has little to go on. Given the unreliability of the dry-range data points, with the degree non-equilibrium exacerbated by the low hydraulic conductivity of clayey soils, the fits for the soils with limited dry-range data are not that bad, lending credibility to the paper's suggestion to fix h_d for such cases.

2. This reviewer appreciates very much the author for sharing his data/code/manual. And it is very well documented as well. Just a trial to make the applications easier for various users, and for their understanding, perhaps it would be nice to indicate a few places (in the code) to which equations (as numbered in the manuscript) the code are corresponding.

Thank you for mentioning the quality of the documentation. It is an integral part of this publication and I made an effort to make it clear and comprehensive.

I was planning to do so in the manual if and when this paper is published, but doing so in the code is a good idea. Thanks for the suggestion. I am clarifying some of the other comments in the code and making it a bit more efficient in a few locations, so I will include this in the work flow for version 1.1. However, I can only do so after the paper has been accepted because I have to be sure I refer to the equations numbers as they appear in the published version, and I also want to include a reference to the final published version.

Some minor technical adjustments are attached. Please also note the supplement to this comment: https://hess.copernicus.org/preprints/hess-2022-173/hess-2022-173-RC1-supplement.pdf

Response to the minor comments of Reviewer 1.

p. 4

Typo corrected, thanks.

Plausible combinations of alpha and n are not easily depicted in Fig. 1 (even if the software I used would allow it) because in combination with hj they all coalesce in a very narrow band bordering the blacked-out region. That is what Fig. 2 illustrates, which is a cross-section of Fig. 1 for $n = 1.4$. I propose the following addition to the text: '...where h_j is very close to its maximum allowed value, i.e. very close to the blacked-out region in Fig. 1.'

I am not sure if I can show this band in the figure because the software will not allow it, but I will try to find a solution.

p. 7

Typo corrected.

p. 16

I believe that the only way to better fit the multimodal SWRCs of some of the C2 and C4 soils is to fit the multimodal version of the SWRC. This is outside the scope of this paper for reasons explained in my reply to Reviewer 2.