

Response to reviews of the manuscript titled “Hydro-pedotransfer functions: A roadmap for future development” - egusphere-2023-1860 - by Weber et al.

Replies to Reviewer Comments 2 (RC2)

General comments: This article describes the state of the development of pedotransfer functions (PTF) development, including traditional methods of creating such models, limitations, and proposed improvements in their development. The article is well-organized, well-written, and relevant to the journal. I found the paper, especially the first half, to be thought-provoking and an easy read. The ease in readability decreased after section 3, but the remainder of the paper is still accessible to those who wish to learn more about this topic. I have only some moderate suggestions (listed below), and believe the article should be acceptable for publication once these are addressed.

Thank you very much for your time and effort to dedicate yourself to this extensive manuscript. Your work is very much appreciated.

Minor Comments

4. Line 34: revise to “spatial scales”

AGREE. Done

5. Line 42: Add period after Gilding et al. reference.

AGREE. Done

6. Line 51: Change period after Gerke et al (2002) to a comma

AGREE. Done

7. Line 52 and 212: “Land” should not be capitalized

AGREE. Done

8. Line 137: Revise to read: “...or by coupling RRE variations of the RRE...”

AGREE. Done

9. Line 145: change to “...as the point at which water loses...”

AGREE. Done

10. Line 164: Change to “... the significance of...”

AGREE. Done

11. Line 166 and many places from this point forward: There are often extra parentheses when in-text citations are given. Double-check that there are the proper number of parentheses throughout.

AGREE. Done

12. Line 210: Add period at end of sentence

AGREE. Done

13. Lines 253-264: The authors address the issue of varying taxonomic systems later in the paper, but this may be a good place to at least mention it.

DISAGREE. It is mentioned.

14. Line 266: Change to "...models applied in spatially explicit modeling..."

AGREE. Done

15. Line 303: Change to "...hydraulic properties in many tropical soils..."

AGREE. Done

16. Lines 344-346: If most models do not consider the litter/humus layer (as stated in the first sentence of this section), does it need to be modeled using the RRE, or would another method be more suitable? It seems the authors have limited themselves to a discussion of the RRE, which they admit themselves is likely not suitable for litter layers.

AGREE. We deleted the second but last sentence. Now it makes more sense. We now write at the end of this section. (Changes in italics):

"We think this is mostly related to the lack of experimental data as a consequence of highly demanding experimental methodology for materials with such little structural cohesion and temporal dynamics. A concerted effort is required to establish methods which can be applied to litter and humus layers and test if the theory underlying RRE is applicable in such contexts, which includes testing if other approaches than simulating with the RRE are more suitable."

17. Line 449: Something weird happening with Paschalis citation; also, change to "...PTF found that uncertainties..."

AGREE. Done

18. Line 451: "artifact" is misspelled

AGREE. Done

19. Line 509: While I applaud the authors for attempting to show some analysis of their own in this study, the provided figures do not necessarily support their statements made in this section. No explanation is given as to how the residual distributions explicitly show dependency on soil texture or sample size. There is variability shown across these categories, but that does not empirically prove dependence in the way the authors are implying. I recommend that the authors re-think their arguments here.

AGREE. In fact, the residual distribution could be a combined effect of methods used, soil texture, and sample size. We will look further into this in the revision and try to disentangle this better for the current manuscript. If that is not possible based on our current data, we will note the combined cause. It will not change the observations that standardization would help to improve the quality of PTFs.

20. Line 540: Remove “allowing”

AGREE. Done

21. Line 541: Change to “...sequence, allowing...”

AGREE. Done

22. Line 548: Change to “...obtained data from these methods are not directly compatible with one another...”

AGREE. Done

23. Line 549: This is the first use of “quasi-continuous data” and it would be helpful if a definition or example was given.

AGREE. Added “, *i.e. data with a high measurement resolution within minutes*”

24. Line 552: End sentence after “...quasi-continuous data.” And begin the next sentence with “While it is based on...”

AGREE. Done

25. Line 566: Change to “Furthermore, while x-ray tomography...”

AGREE. Done

26. Line 569-570: remove “who illustrated the huge sensitivity in image thresholding”- this was already stated.

AGREE. Done

27. Line 580: Some random non-English text here.

AGREE. Deleted

28. Line 584: Change “effect” to “affect”

AGREE. Done

29. Line 585: I recommend that the authors change all instances of “height” to “length,” because not all samples are collected vertically. Often, samples are collected horizontally by driving a sampling core into the wall of a soil pit. This assumption of vertical sampling also affects the authors’ interpretation of pore characteristics, so the authors should take care here.

DISAGREE. The reason we use the ubiquitously used “height” is not related to vertical/horizontal sampling but to the height of the cylindrical sample. We will leave this as is.

30. Line 610: What did Vanclooster find, exactly?

AGREE. This was misleading. The sentence now reads: “*With regard to the hydraulic conductivity of soils, the considerations regarding sample saturation remain valid. Javaux and Vanclooster (2006) demonstrated hydraulic conductivity estimates may be influenced by sample size.*”

31. Line 633-645: I applaud the authors for their ambitious goals, but these standards are unrealistic in practice. It would be good for the authors to better discuss the reality of the costs, including money and time, needed to meet their recommended strategy, especially given that in many cases funding for such projects is very difficult to get.

We DISAGREE that cost here is an important point to be made. On a different note, we reorganised the section by moving the paragraph “*Although the scale of measurement [...], and subsequently hydrologic fluxes.*” to the end of the paragraph.

32. Section 4.4: There seems to be a shift in the writing here, and “field soil surveys” are mentioned several times in this section, where previously the discussion was centered on samples collected. The authors of this section seem to be assuming that soil samples are collected primarily during these types of pedogenic surveys, which is often not the case. Many times samples are collected without any pedogenic data or profile descriptions.

AGREE. This is very pointed. Thanks!

33. Line 690: bimodal model of what? A specific parameter or something else? Please clarify.

AGREE. Added “SHP models”

34. Lines 693-699: This was already addressed in Section 3.3

AGREE. Moved to section 3.3

35. Line 702: change to “...soil pore structure...”

AGREE. Done

36. Section 4.5: This section is lacking a description of several keys methods of larger-scale in situ sensing that may provide very useful data for inclusion in PTFs. A few that come to mind are the use of electromagnetic induction (EMI) surveys for determination of clay content (e.g., Hedley et al., 2004), gamma ray spectroscopy for determination of field-scale bulk density (e.g., Reinhardt and Herrmann, 2019), and the novel use of cosmic ray neutron detectors for estimating fieldscale hydraulic properties using inverse modeling within the HYDRUS COSMIC module (e.g., Brunetti et al., 2019).

Hedley paper: <https://www.publish.csiro.au/SR/SR03149>

Reinhardt: <https://onlinelibrary.wiley.com/doi/full/10.1002/jpln.201700447>

Brunetti: <https://access.onlinelibrary.wiley.com/doi/full/10.2136/vzj2018.06.0123>

Note: None of these are my papers

AGREE: We agree that geophysical or hydrogeophysical methods applied at larger scale might be an important tool for PTF validation and development. We therefore added the following paragraph to the manuscript:

“At the landscape level one can also think about sensor technologies to estimate either soil properties such as soil texture by electromagnetic induction (EMI) (e.g., Hedley et al., 2004; Heil and Schmidhalter, 2012; Mertens et al., 2008), gamma ray spectroscopy or EMI for determination of field-scale bulk density (e.g., Reinhardt and Herrmann, 2019, Schmäck et al., 2021), or the use of either stationary or mobile cosmic ray neutron detectors for

estimating field scale water content dynamics and hydraulic properties using inverse modeling within the HYDRUS COSMIC module (e.g., Brunetti et al., 2019). While these are promising methods, they are still far from operational requiring still some fundamental research to integrate them into field-derived PTF development.”

References:

- Brunetti, G., Šimůnek, J., Boga, H., Baatz, R., Huisman, J.A., Dahlke, H. and Vereecken, H. (2019), On the Information Content of Cosmic-Ray Neutron Data in the Inverse Estimation of Soil Hydraulic Properties. *Vadose Zone Journal*, 18: 1-24 180123. <https://doi.org/10.2136/vzj2018.06.0123>
- Hedley C. B. , Yule I. J. , Eastwood C. R. , Shepherd T. G. Arnold G. (2004) Rapid identification of soil textural and management zones using electromagnetic induction sensing of soils. *Soil Research* 42, 389-400. <https://doi.org/10.1071/SR03149>,
- Heil, K., and Schmidhalter, U. (2012). Characterisation of soil texture variability using the apparent soil electrical conductivity at a highly variable site. *Computers & Geosciences*, 39, 98–110. <https://doi.org/10.1016/j.cageo.2011.06.017>
- Mertens, F. M., Pätzold, S., and Welp, G. (2008). Spatial heterogeneity of soil properties and its mapping with apparent electrical conductivity. *Journal of Plant Nutrition and Soil Science*, 171(2), 146–154. <https://doi.org/10.1002/jpln.200625130>
- Reinhardt, N. and Herrmann, L. (2019), Gamma-ray spectrometry as versatile tool in soil science: A critical review . *J. Plant Nutr. Soil Sci.*, 182: 9-27. <https://doi.org/10.1002/jpln.201700447>
- Schmäck, J., Weihermüller, L., Klotzsche, A., von Hebel, C., Pätzold, S., Welp, G., and Vereecken, H. 2021. Large-scale detection and quantification of harmful soil compaction in a post-mining landscape using multi-configuration electromagnetic induction." *Soil Use and Management*. <https://doi.org/10.1111/sum.12763>

37. Line 785: First mention of “parametric PTF.” Use consistent terminology. Done.

AGREE: We now added “Before building a parametric PTF, *i.e.* a PTF to predict SHP model parameters, the parameters of [...]“. We think this is necessary to enunciate.

38. Line 803: “We explicitly introduce it here...” What is “it” referring to? Be specific. AGREE. replaced “it” with “the Bayesian inference scheme”.

39. Line 814: What is meant by “This is mostly done...”? Do you mean that this is the most common method, or that the work is nearly completed?

AGREE. changed to “Most commonly...”

40. Line 833: Could the authors provide an example of the “clear empirical evidence” that they refer to here?

AGREE. Added from measurements, calculations, and physical theory.

41. Section 5.2/Line 803: Both sections describe physical constraints. Consider reorganizing to be more clear.

DISAGREE. The sections introduce a method (5.1.) and some physical constraints (5.3.). We carefully seek to identify and reduce redundancies.

42. Line 888: Change to “...loamy soils must have a higher length of evaporation L_c than sandier soils...”

AGREE. Done.

43. Figure 9: I really like this figure and think it provides a clear understanding of what the authors are describing.

Thanks! :D So does Reviewer 1.

44. Section 6.4: I found the vague description given of a standardized measurement method to be disappointing. I was expecting a detailed explanation that would allow for replication of the described methodology, but that description given here is very ethereal and non-specific.

PARTLY AGREE. As a roadmap paper, the suggestion for further experimentation has to remain at a higher level and provide direction. We think we are doing this. We are currently building such experiments and to thoroughly evaluate them in the described context. We have discussed a lot how far we can go in this paper and we would impose a heavy imbalance to the other aspects raised if we would give a detailed explanation. We actually hope that the proposed shift of the attention towards a) the pedon scale and b) experiments to measure a large proportion of the functional state-space can be understood.

PARTLY DISAGREE. Our suggested transfer of procedures from the lab into the field as standardized in-situ experiment is not a detailed explanation but it points out novel approaches which have high potential to advance the field. So far, no such experiments and no such sets of highly controlled boundary conditions exist. Hence we would not see the suggestion as “ethereal”.

Based on the comment, we will add the following sentence at the end of the paragraph: “So far, controlled boundary conditions (irrigation/wetting and drying cycles) and sensors for state dynamics in the soil profile (at least soil water content, matric potential and temperature) only exist as experimental setups without any standardization and with rare links to SHPs and PTFs. Similar to recent advances in lab standardization, the development of such a device has high potential to further the data foundation of PTF development, in particular, and soil system understanding, in general.”

45. Line 1038: How do the authors propose to actually carry out point #7? “Tackle the discrepancy” is very vague.

AGREE. it is vague. Therefore, we have added: “tackle the discrepancy between the scale of derivation and the scale of application, *by considering functional evaluation at the scale of application and using physical and functional constraint-based simulation during the building and evaluation of PTFs*”

46. Line 1040: Change to “...evaluate PTFs functionally...”

AGREE. Done.

47. Lines 1041-1042: Point #10 contains a typographical error and does not currently make sense.

AGREE. This sentence is gibberish, but was rescued and now reads: “ *rethink field experiments with the aim to gain data with a high information content and use easy to set up, standardisable, and ideally low-cost methods.*”