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comment

Interactive comment on "Unrepresented model errors – effect on estimated soil hydraulic material properties" *by* Stefan Jaumann and Kurt Roth

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This paper deals with the use of inverse modelling of soil water content and soil pressure measurements for estimating effective hydraulic parameters. Data are obtained from the ASSESS test site, which is an advanced experimental facility with well-known but complex soil layering and well-controlled boundary conditions. In particular, the effect of unrepresented model errors is investigated, and more importantly procedures are proposed to account for these model errors within the inversion process. The representation errors that are considered include uncertain sensor positions, uncertainty in boundary conditions, local heterogeneity, and dimensionality of the model (here: 1D vs. 2D). For the selected boundary condition (multi-step drainage and imbibition from below), it is found that small representation errors in sensor position can significantly

affect the inverted material properties. I am strongly supportive of the idea of this study. Many studies typically stop after a single inverse modelling run. Sometimes the residuals are inspected, but very rarely the results of inverse modelling are used to improve the model concept or the system representation. This study explores several representation errors, and the results seem to indicate that reasonably small changes in system representation can significantly improve the data fit and the properties of the residuals. However, I have a few general concerns and specific comments that I would like to see addressed. Addressing these comments likely involves moderate to major revisions. In addition, grammar and spelling should be improved in the revised version.
Reply: We thank the reviewer for the constructive comments and suggestions. The manuscript was revised accordingly, hence we refer to the revised manuscript.

General Comments

1. The introduction is rather unambitious and does do full justice to the content of the manuscript. The authors decided to include a second introduction in section 4.3 where the structural error analysis is introduced. I strongly encourage bringing the idea of structural error analysis in the beginning of the manuscript to better prepare the reader for what is coming. The general stance of this extended introduction could be: Analysis of inverse modelling results to improve models. As already indicated above, I think there are too few studies that pursue this idea.
Reply: We agree and revised the introduction accordingly.

2. A general concern with the chosen approach is that the same data are used for inverse modelling and evaluation of the results. Would it not be much stronger when the inversely estimated parameters are tested on an independent dataset? Are such independent datasets available for the ASSESS test site? In the current manuscript, improvements in data fit are reported, but this is fully expected because the amount of parameters was increased at the same time.

Reply: Independent datasets can either be achieved by changing the measurement method or the experiment setup. The former leads different model errors, e.g., due to different measurement volumes of different instruments, and the latter leads to a different sensitivity of the data on the estimated parameters. Hence, we decided to analyze datasets of different instruments separately and to compare the results. Please also note the reply to comment 5 of SC1.

The improvements are reported so that the readers can judge whether the size of improvement is worth the associated additional effort.

3. A short discussion about the transferability of the results to other soil types would also be useful for the readers. Of course, gradients in water content are steep in ASSESS and this may significantly impact the importance of accurate sensor positioning. Would the same insights be obtained when the ASSESS test would have consisted of different loam soils? Please comment.

Reply: We agree, that this is an interesting question. Beyond general comments, we cannot answer it with the given data of the presented case study.

4. The authors decided to not take the classical structure of Introduction, Materials and Methods, Results and Discussion, Conclusions. For me, the alternative structure is not really working. For example, part of the results are presented in section 4.3 where the used methods have not yet been clearly explained. Although I may be purist in this matter, I would say that this paper would benefit from an organization following the classical scheme.

Reply: We revised the structure of the manuscript, bringing it closer to the classical scheme.

Specific Comments

Page 1, Line 1. Abstract should be a single paragraph. In addition, it is customary

to provide the scope of the manuscript with an opening statement. Here, the authors immediately jump to the aims of the study.
Reply: We revised the abstract and added an introductory sentence.

Page 1, Line 19. Is direct determination really expensive? I would prefer time-consuming here.
Reply: We changed the wording here.

Page 2, Line 19. Huisman et al. (2010) considered a soil layer on top of the dike material.
Reply: We checked the paper again and found that the dike consists of the investigated material (Fig. 2, 4, 6, 9, and 10).

Page 2, Line 21. I would like to see more information about the TDR system that was used. Did the authors rely on automatic waveform analysis, or was this done manually to obtain more accurate results?
Reply: We added this information in Sect. 2.1 (Page 3, Line 20), Sect. 2.2.4 (Page 6, Line 2), and Sect. A1.3 (Page 23, Line 7).

Page 2, footnotes. I find it very unusual that the authors use footnotes. Is this possible and common in HESS? In any case, it seemed to me that much of the information provided in the footnotes could have easily been integrated in the main text. Please reduce the amount of footnotes to a minimum.
Reply: We integrated the footnotes in the text.

Page 4, Line 14. One-sentence paragraphs should be avoided.
Reply: We improved the section, such that the one-sentence paragraph is avoided.

Page 6, Line 19. I am not so convinced that a separate section on the implementation is a good idea. In particular, I do not really like the three very short subsections that now follow. It makes the text unpleasant to read.

Reply: We decided to separate the more general theory from the case dependent implementation such that the readers can skip or flip through the more general theory and just read the details on the implementation and do not have to do the sorting themselves. The three short subsections were introduced for precise referencing.

Page 9, Line 5. I could not follow your implementation of small-scale heterogeneity. Are you using heterogeneous parameters fields throughout the domain, or is this heterogeneity only introduced locally? Please clarify.

Reply: We clarified the Sect. A1.4 (Page 24, Line 6).

Page 10, line 12. I know this as global-local approach.

Reply: We updated the description of the 1D setup (Sect. 2.4.1) and don't use the wording anymore.

Page 10, line 21. Not sure that standard deviation is appropriate here? Is this not the expected standard deviation of the residuals (e.g. measurement error).

Reply: We made the sentence more precise (Sect. 2.3.1, Page 8, Line 14).

Figure 7. This figure did not make things clearer for me. Consider deleting.

Reply: We still think that graphically representing the flow of information is useful.

Page 12, Line 5. The start of this section seems out of place. For me, this clearly

belongs to the general introduction (see general comments).
Reply: We revised the introduction accordingly.

Page 13, Line 20-32. Perhaps I am a purist, but for me this is a result and this is not a good position in the paper to discuss a result. I would bring this later.
Reply: This is intended as an example to show that the method works. It is thus a methods piece, not a result.

Figure 9. It would be good to show measured and modelled data in at least one figure. Here, a third column could be added to the left in addition to the residuals.
Reply: We added the results of the *miller and position* setup from the 2D case study to the data in Fig. 4.

Page 15, Line 5. Avoid repetitions. This has already been described four lines ago.
Reply: This comment is unclear to us. We rechecked the paragraph and could not identify any repetition.

Figure 10. This figure is too complicated. I am not sure how to read it. I am particularly unsure about the green.
Reply: We removed the indication of the setups in order to simplify the figure.

Page 19, Line 32. It is not so clear how you reached this conclusion. Perhaps this needs to be emphasized better when discussing the results.
Reply: We separated the Sect. 3 in subsections and clarified the analysis in Sect. 3.1.3.

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