Interactive comment on "Sequential and joint hydrogeophysical inversion using a field-scale groundwater model with ERT and TDEM data" *by* D. Herckenrath et al.

Anonymous Referee #2

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This paper considers different inversion methods for model data synthesis of hydro-geophysical observations and ERT and TDEM data. This is a subject that is relevant to the readership of HESS-D, and an important topic to improve chracterization of the vadose zone.

I think that the paper is unnecessarily difficult to follow. This will really diminish impact. The description of the inversion methods is rather confusing, and reader might not be able to discern the differences between the three inversion methods that are summarized.

(1) Abstract is difficult to follow. Results are not easy to understand for an average reader. Obviously, this is a choice of the authors – I do believe however that a paper can have significantly more impact if it is written in such a way that someone that is not a domain expert can still follow the text and main findings.

(2) P:4658, Line 17 –> this work is not limited to single objective problems. For instance Huisman et al. (2010) shows how to use this methodology within a multiobjective framework,

(3) I think that the paper would benefit tremendously from a Figure that conceptually explains that differences between the three different inversion methods (JHI, CHI, and SHI) considered in this paper. The explanation of the different methods is unnecessarily difficult which poses lots of questions later on.

(4) P4662, L10; I suggest the authors to have a look at the work of Eric Laloy (WRR, 2012) and the group of Professor Linde that uses parallel MCMC methods to derive the two and three dimensional soil moisture distribution from geophysical data.

(5) P4663, L5: Remove "a" –> of ..

(6) Section 2.3. –> What about Coupled Hydrogeophysical Inversion (CHI). Why is this not used? Why not use all three different methods and then compare their results? Again, most readers will be stuck on the use of terminology. JHI versus CHI and SHI. What is their main difference. A simple schematic figure will really help to illustrate their differences. Always try to avoid to describe differences mathematically. Most readers will not understand. Just use simple words, and ideally a nice schematic. I do not understand why CHI is not used in the comparative analysis. Maybe I am missing something (highly likely), but why not benchmark the work performed herein against that of Hinnell et al (2010) using CHI??? With appropriate discussion of the actual search method used, parameters considered. A less technical description will increase readability.

(7) The theoretical part of the paper that describes the different inversion methods is really difficult to follow. This introduces confusion.

(8) I wonder what search methodology is actually being used to solve the different inversion methods? Some more details on this would make the paper easier to follow. Equally important, what likelihood (objective) function is used? How is uncertainty being treated, and how does model error affect the results.

(9) Section 3.5. –> Very difficult to follow. The paper might be presenting important findings but the methods and results are so difficult to follow (at least, according to my limited understanding) that this will really affect impact.

(10) P4682, L20: What does a std. of 10% mean? Rather strange unit. This depends on the choice of the prior distribution, actual search method used (classical linear intervals versus Bayesian (MCMC) intervals), so I would suggest to provide more details about the uncertainty. Coefficient of Variation (CV) is certainly not ideal (depends on scaling of mean), and thus why not just include a table with mean values of the parameters and their standard deviation. Note that the recent work done by Laloy et al, and Linde and coworkers on this topic explicitly confronts the issue of model parameter and soil moisture uncertainty using different dimensionality reduction methods. I would recommend the authors to have a look at this more recent work.

Altogether, I believe that a major revision is appropriate. With emphasis on rewording so that that a larger readership can understand what is done and why, and why CHI has not been included in the analysis (to my understanding). A detailed description of each method is warranted, including a Figure and some text that illustrates the main differences between the three different inversion approaches. Also it would be useful to have more information about the actual search method that is used to solve for the parameters.

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