Hydrol. Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/hess-2020-514-RC1, 2020

Hydrology and Earth System Sciences
Discussions
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Interactive comment on "Assessing the dynamics of soil salinity with time-lapse inversion of electromagnetic data guided by hydrological modelling" *by* Mohammad Farzamian et al.

Anonymous Referee #1

Received and published: 11 December 2020

This manuscript addresses the use of soil water and solute modelling (HYDRUS 2D) for finetuning the inversion of electromagnetic induction (EMI) data in the context of soil salinity studies. A suitable dataset is available, consisting of detailed soil data for the soil water modelling exercise and time-lapse EMI data measured along transects that were treated with irrigation water of different salinity levels. The proposed methods are sound and appropriate. The manuscript is well written. Below some suggestions are provided that might be of use for tightening the focus and improve the structure of the manuscript. The focus should be on the EMI inversion, which is the relevant and novel part, not on the hydrological simulations nor on the field experiment. I can therefore recommend "minor revisions".

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General comments: 1. There has been a lot of talk about the use of hydrological modelling to optimize or constrain inversion of EMI data, but no clear framework to do so has been proposed so far. This manuscript contributes to the development of such a framework. Therefore, the topic is timely, relevant and novel, while also of interest to practitioners of inversion of electromagnetic induction data. 2. Overall, a rather qualitative approach is taken in this manuscript when it comes to interpretation of the results. This contrasts heavily with the strong quantitative approach taken to model soil water and solute transport and to invert the EMI data. Readers might expect o more quantitative evaluation of the results. 3. The focus of the manuscript should be tightened to make clear to the reader from the beginning what the authors want to achieve. As it stands, apparently more attention is dedicated to the soil water and solute transport modelling than to the inversion of the EMI data. This should be reverted by discussing first the chosen inversion approach and the details of the different parameters. From this analysis it should become clear why and how soil water and solute modelling can be used to optimize the inversion parameters. Also, the objectives need to be rewritten according to the chosen focus. The results and discussion should be reorganized accordingly. Redundant information (information that is not used further on or not relevant) on the field experiment and hydrological modelling should be omitted. 4. The reader should be informed why a synthetic study is necessary in this case. I can understand that a synthetic study can provide information for the inversion, beyond the specific conditions of the field experiments. The synthetic study should be clearly distinguished and justified within the structure of the manuscript. When going through the manuscript, the reader also wonders why not simulate also the field conditions for the dates on which the EMI surveys are performed so that the forward models can be compared with field-observed EMI measurements? The synthetic part could be a "proof of concept" while the analysis of the real-world field EMI measurements could be considered an application/demonstration.

Specific comments: L41 this should be "a few centimeters" L50 Define sigmab in L50 upon first use L79-86. Reformulate the objectives in order to tighten the focus of the

manuscript. The performance of a controlled irrigation experiment, sigmaa monitoring or numerical simulation with a hydrological model are not objectives here. These tasks are part of the methods to achieve the objectives. According to the title and the introduction, the main objective should be “Parameter optimization and/or constraining in time-lapse EMI inversion using soil water and solute modelling”, and more specific objectives should be strictly related with this main objective. L87 After the introduction the electromagnetic inversion methods should be first explained. This is the important and novel part of the methods section. Once this is done it becomes clear what is needed throughout the remainder of the manuscript: sigmaa measurements in the controlled field experiment and hydrological simulations which can be explained in subsequent sections. L89-140 This section can be substantially shortened. All information that is not used further on should be omitted. L110 Should this be Ko instead of Ks? L143-173. This description is confusing. Too many details are given so that it becomes difficult to see the wood for the trees. All irrelevant information should be omitted. The manuscript is not about the hydrological simulations but about how this information can be used to improve inversion of EMI data. L180-186. Start the section with this information. This is the novel and relevant part for this manuscript. Maybe a flowchart can be used to explain better what is actually done. L243-251 This section is very difficult to follow for non-specialists. Please rewrite this section so that also less experienced readers can understand what is done and what the meaning is of the different parameters and inversion variants. L253-256 This is confusing. If only one 12 dS/m scenario is used hereinafter it is not necessary to introduce all the available information in the preceding sections. Also, if only data from 4 dates are used do not provide information on 6 dates in the preceding sections. L258 It is unclear why a simulated bedrock needs to be used here if 4 of them were measured in the field experiment (Fig 1b). I understand that this is done to obtain more variability in the soil depth in order to see how this propagates through the hydrological model and the inversion. It this is the case, please state this clearly. Do not consider the hydrological simulation as a separate task but relate it to the inversion. L258-288. Shorten this section. Discuss what the relevance

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is of these patterns for optimizing inversion parameters. L266 Which profiles do you refer to here? L283-283 Avoid repeating information. L300 I assume that rho32 refers to one of the signals that the EMI sensor provides, but this should be clearly introduced and explained in the M&M section. L308-344. I would expect a more quantitative approach here. Statistical measures (e.g. correlation coefficient, RMSE, MAE,. . .) for the correspondence between the section shown in Fig.6d and those shown in Fig 8 can be calculated for different inversion parameters and plotted in a graph. The optimal combination of parameters should show the best statistics. Also, more sophisticated map comparison methods can be used. Or variograms could be used to compare the spatial structure of the obtained profiles. L346-381. Is there any information (soil data or simulated water and solute transport data) available to validate these profiles? How can you check whether these sigmab maps really represent salinity and not only soil water content? You could optimize the parameter set for each transect by producing first simulated soil water and solute patterns and using this information for forward modelling as done in the synthetic example. It is still unclear why a synthetic example is needed in this manuscript Why not applying directly the method to the 4 monitored profiles?

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