Point by point reply to the comments of Referee #3

Flow dynamics in hyper-saline aquifers: hydro-geophysical monitoring and modelling

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by

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For the sake of clarity, the original comments are shown in *italic*, while our replies are **bold** Arial.

Anonymous Referee #3

The paper addressed the application of time-lapse crosshole ERT imaging to monitor the injection of freshwater into a hypersaline aquifer. In addition, a coupled numerical flow and transport simulation was performed to produce synthetic ERT data that were later compared with field data. The work is within the scope of HESS journal since the problem was dealt in a multi-disciplinary manner. Moreover, this study may contribute to understanding complex saline-freshwater interactions, specially in the context of freshwater storage within brackish or salty aquifers.

The overall presentation is very good, the language is fluent and easy to read. The used methodologies were correctly applied and authors demonstrated a deep knowledge about it. In fact, I consider that applied methodology is proper to this kind of problem. The title clearly reflects the contents of the paper and the abstract provide a complete summary of the study. In addition, the experiment is sufficiently described to allow reproduction. The methodology, results and discussion are supported by high quality bibliography. In general, the structure of the article is good but it seems that many results are included within the methodology. I suggest to move all the results to Results and Discussion section.

We thank Referee #3 for his/her comments and effort. We believe that thanks to these comments, the manuscript can be improved. We accepted nearly all suggestions. In particular we tried and moved all results in the Results and Discussion section.

Below, the part that should be moved
173-182: This is the result of a measurement. I suggest to move to result section.

We moved this part ito the section "ERT imaging results".

233-238: the results of sensitivity analysis should be moved to results. Also Figure 5. In addition, what electrode configuration (dipole-dipole, bipole-bipole) does sensitivity distribution refer to? (229-238)

The sensitivity analysis has its role in the inversion section. It refers to the whole, filtered dataset, including dipole-dipole and bipole-bipole. This is now stated clearly.

258-293: These are the results of time-lapse ERT imaging. Move to results. Moreover, to support the statements regarding the sensitivity of different electrode configuration, both (dipole-dipole and bipole-bipole) sensitivity analysis may be provided in figure 5.

The time-lapse imaging is already in the Results section. We computed the overall sensitivity of the entire configuration made of both dipole-dipole and bipole-bipole. We feel that going in more details with this would be out of scope for this paper.

288-289: Why resistivity background image does not "detect" the layer of finer sediments. Likely, the high water conductivity masks resistivity variations due to lithology. But this fact should be addressed.

The conjecture is correct – we now state it clearly, see also replies to Referee #1.

276-277: What is the explanation for "only a gradual change to higher resistivities in the upper part just below the water table can be seen"? Why the transition zone has this large thickness? Since the sediments above water table are mainly within sand fraction, the influence of capillary zone should be negligible. What is the water content of the unsaturated zone?

Probably this is also due to the smoothness-constraint characteristics of the inversion code. However, we see also a decrease of the electrical conductivity in the conductivity log in figure 2. We discuss it now explicitly at this point of the manuscript.

362: This sentence is part of the results.

This is a comparison between the simulated and real boundary conditions, so it is not quite a "result" of the study as a whole, but rather a demonstration of how the modelling exercise was set up.

371-387. These paragraphs, with their respective figures, should be moved to results.

This part has been moved to the results in the revised paper.

Some other comments:

369-371: How were the hydraulic conductivities of the different scenarios selected? Were they manually calibrated? Please, clarify.

Yes, they were manually calibrated. We have added a sentence to this effect in the revised version of the manuscript.

477-478: "Considering the extreme salinity observed at the site, this is not surprising". I'm not sure about the validity of this affirmation. In fact, Archie's law better describe electrical conductivity-salinity relationship in saline to hyper saline conditions. Perhaps, the choice of a unique formation factor (F) value is one of the reasons for the total mass underestimation by ERT field data.

The real issue is to what extent are these standard Archie's law parameters applicable in the case of hyper-saline aquifers, where even linearity of Ohm's law is at risk. We changed the sentence here, and made the consideration clearer.

Figures:

Fig. 2. The patterns in the lithology channel should be more contrasting. Please, make wide the line in the Fine fraction, porosity and electrical conductivity logs.

The figure has been changed.

Fig. 3. Please, change the symbols for different conductivity logs. The same for Fig. 13 Figs 7, 10, 11 and 13 should be enlarged.

The quality and size of the figures in the revised version of the manuscript have been improved.

Fig. 10: Why do x-coordinates for modeling results differ from those in figs. 7, 11 and 12? The coordinates should be the same? In relation to this, the 3D mesh in Fig 8 should include coordinates and the position of boreholes.

The difference depends on the different grids used in the simulations and in the ERT inversion. However the Referee is right that this is confusing. So we have used the same coordinate system for all figures in the revised paper.