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Reply on RC2

Luca Guillaumot et al.

Author comment on "Frequency domain water table fluctuations reveal impacts of intense rainfall and vadose zone thickness on groundwater recharge" by Luca Guillaumot et al., Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2022-201-AC2, 2022

Dear reviewer,

thank you for your interest in our manuscript. We answered below to the main comments. The revised manuscript will address all these points as well as minor comments.

Sincerely.

Luca Guillaumot, on behalf of all co-authors.

From the fitting results in Fig. 6 it appears that the parameter identifiability would benefit from replacing the aquifer length as a fitting parameter by the characteristic time, but this is not discussed or explored in the paper.

The model contains three parameters (transmissivity, porosity and length). These parameters have a physical meaning and can be compared to values from the field. Once we inverted parameters, indeed we chose to highlight the characteristic time (a combination of the three parameters) as we found it is well constrained by observed groundwater level fluctuations and it has also a physical meaning, allowing to summarize the behavior of the aquifer (line 111-112). One of the reasons explaining that we did not replace aquifer length by characteristic time during parameter inversion is that characteristic time ranges over more than five orders of magnitude given the plausible ranges of the three parameters. Finally, the aquifer length can not be removed from the analytical model (equation 2) or this would require either to fix the aquifer length or to introduce additional parameter combinations as a parameter. As suggested, we will discuss this point.

A considerable weakness of the paper is that the model is calibrated for both aquifers, but not validated, making it difficult to assess the model performance.

Indeed, we did not split observations for calibration and validation periods. Note we highlighted in Supplementary the impact of the size of the study period on storage coefficient estimates. This shows that the studied period should be as long as possible when estimating parameters. However, following your remark, we run the calibration over half the period from 1996 to 2004, instead of from 1996 to 2012, for borehole F19 located on the Ploemeur site. Results are illustrated by the figures in attachment comparing parameter estimates and simulated water table fluctuations. They will be included in the

revised Supplementary. Estimated parameters appear very similar when obtained over the first half of the period or over the whole period. Consequently similar water table fluctuations are obtained. To complete, results in term of parameters could be slightly altered in function of the studied time windows.

Our approach aims to estimate the informative content of the water table time-fluctuations in terms of parameters and recharge rather than to provide predictions. Our approach shows that water table fluctuations recorded in different boreholes contain the same aquifer-scale properties in spite of the aquifer heterogeneity. Moreover, we tested all possible combinations of parameters within extended ranges of potential parameter values with the finest systematic sampling of the parameter space. Thus, for these models we will not find any other better simulations than those we obtained. We argue that the more data we have the less equifinality issues occur.

Overall, the line of thought is a bit hard to follow some times because individual sections are not as focused as they can be. Throughout the paper, the clarity can be improved by thinking about what exactly the authors wish to convey to the reader and how to do so clearly. In the detailed comments I indicate where I got completely lost. I hope this will lead to a more structured, coherent paper.

Thank you for your remark. First, following your detailed comments, the revised manuscript will clarify several points of the methodology and more details will be provided regarding the development of the analytical model, including more sub-steps and references in Appendix 1 describing model geometry, boundary conditions and analytical resolution.

Sections 5, 6, and 7 are disappointing. They lack focus and structure and do not convey the main strengths of the study. That does not mean these strengths are not there. I very much like the modelling approach and the intended use. The Results and Discussion sections need to bring that out more strongly though.

Thanks for your comment. We understood that this main comment relates to several detailed comments (mainly the two comments below):

- Section 5.3 uses terminology with which I am too unfamiliar to understand what points are being made. Throughout the paper, the English is a bit off, but here it somehow becomes so much so that I can no longer decipher the meaning of several sentences. This section needs to be thoroughly rewritten to be accessible to readers outside the immediate field of this paper, and the English needs substantial improvement.
- Sections 6 and 7 require over five pages of text. That is rather long. They also introduce a large number of new references, which indicates that the paper is not well organized. The Introduction and the Methods sections should cover most of the literature needed in the paper.

The whole section 5 describes results about recharge estimates. Section 6 hosts discussion, while section 7 constitutes the conclusion.

Section 5.3 is very important, as underlined by reviewer 1, the revised manuscript will make it more accessible. We chose to analyze recharge fluctuations in frequency domain to highlight the different behaviours of recharge from soil models and obtained from groundwater levels in function of the time scale. The main advantage is to summarize the recharge signals for each frequency rather than comparing each recharge event individually and at different timesteps. As you suggested, we will revise our sentences carefully in this part.

The first part of Section 6 (section 6.1.1) contains additional references mainly in order to

compare estimated parameters with the literature. They are very specific to the studied site and they do not need to be presented before.

We will take into account your remarks in order to reduce sections 6 and 7 and make them more fluuid for the readers. See below the main modifications that will appear in the revised manuscript :

- We acknowledge that section 6.1.3 'Limitations' is long (25% of section 6) and will be reduced a lot in order to avoid losing readers. Indeed, this part introduces new references.

- While section 6.1 discusses methodology, sections 6.2 and 6.3 deals with processes understanding in Ploemeur and Guidel. In particular, the transformation of infiltration into recharge through the unsaturated zone and the impact of pumping. Indeed, the beginning of section 6.2 (line 499-502) is not appropriate here. We will modify it with a better explanation in section 6.2.1. Following your minor comments, we agree that section 6.2.1 repeats too much results from section 5.3. One part of section 6.2.1 will move to section 2.6 (Methods) and will help to clarify the method. Then, we will gather sections 6.2.1 and sections 6.2.2.

- Finally, the first part of the conclusion (lines 551 to 555) will be reduced. As suggested, we will also take care to avoid summarising too much in conclusion.

We hope that this will help to clarify the manuscript.

The title is informative but a bit long.

We will propose : "Frequency domain water table fluctuations reveal impacts of intense rainfall and vadose zone thickness on recharge".

Please also note the supplement to this comment:
https://hess.copernicus.org/preprints/hess-2022-201/hess-2022-201-AC2-supplement.pdf