Reply to Referee 1

Answers to the comments in blue

Herzog et al. Study the longitudinal, vertical, and lateral connectivity of GW and SW in the Dreisam valley. The study is nicely done, generally well described and scientifically interesting. Mainly, I suggest adding some more explanation and discussion to better guide the reader and thus better help her to understand the storyline presented. I generally like the study and have no major comments beyond the constructive suggestions made below.

We thank referee 1 for the positive feedback and the constructive comments below.

[1] There are a few editorial changes needed regarding the English. An example from the abstract: “This raises the question on” should be “question of”. Or “By reason of the physically-based” would better read as “Due to the phy…”. Please have another read through the document for these instances.

The manuscript will be revised with respect to the English language

[2] In the abstract, “model reality” should probably be “model realism” to be more in line with the language used in other papers (e.g. Gharari et al. 2014 HESS; Hrachowitz et al. 2014 WRR; Wagener 2003 HP).

Will be revised accordingly.

[3] I like the abstract, but could you quantify terms a bit more. E.g. what is a short time scale in the context of this study? How many measurement locations did you consider? Etc. This is all discussed in the manuscript but might make the contributions of the study clearer right away if mentioned in the abstract.

The term "short timescales" mainly relates to the model simulation time period (2014-2022). Therefore, it is not possible to assess long-term changes in GW dynamics due to GW withdrawals, which already took place before 2014. We will replace the term “short timescales” by the term “short time periods”.

Regarding the measurement locations, the model is evaluated based on zero water level measurements at 20 locations in the Dreisam valley. However, for the evaluation of the relationship of longitudinal and vertical connectivity, a prerequisite is that locations experience both, ZWL days and zero leakage (7 locations). This is explained in the text (l. 273-275). These details will be revised in the abstract.

[4] It might be interesting to connect the metrics discussed, developed, and estimated in this study to the metrics (often called signatures) used in other studies. E.g. the recent study on reservoir impact in the UK by Salwey et al. (2023, WRR).

On the one hand, the approach to develop signatures and describe changes in these signatures due to water uses, (for example for water reservoirs in Salwey et al.) is somewhat similar. However, as in most other existing studies, these signatures/metrics are defined based on streamflow data only, which is similar to other classical approaches, such as the Hydrological Alterations approach. Such approaches help to identify changes in the streamflow regime and

dynamics but these approaches only consider longitudinal connectivity. In distinction, the objective in this study was to propose metrics, which include information on vertical connectivity as well to better understand the drying dynamics. The metrics consider dry phases (ZWL days) and connectivity changes (zero leakage, i.e. vertical connectivity). Thus, the signatures in Salwey et al. and the metrics used in this study are not comparable. We suggest that we will incorporate a more detailed discussion on the differences of our approach and existing signatures in the discussion section.

[5] The authors state in lines 69ff: "While such parameter uncertainties are relevant when it comes to obtaining the best model results, they are less relevant if the focus is on process understanding." I do not agree with this statement. Understanding which parameter dominate system responses, and what preferred values they take when they do so, has long been part of assessing models regarding their physical realism (e.g. Reusser et al., 2009, HESS). So dismissing parameter uncertainty as a simple problem of model performance is really understating the problem. I therefore would expect a discussion of the potential influence of parameter uncertainty on the study outcomes in the conclusions or discussions sections. Even if a more detailed analysis is not feasible in this study.

We agree that the sentence is too simplified and will expand our discussion on parameter uncertainty.

Late in the paper, the authors stated "The third research question addressed the sensitivities and changes of modelled connectivities in response to the applied stress test scenarios." Is this question really completely unrelated to parameter uncertainty? I can accept if the authors cannot add this element to this study, but a basic discussion of the potential influence would be good.

We agree that this research question is not completely unrelated to parameter uncertainty because the parameter uncertainty affects modelled ZWL days and connectivities. However, in this analysis we focus on the potential of model stress-tests and did not perform a sensitivity analysis in the way this term is often used in modelling terminology, i.e. sensitivity to varying parameter values. Responding to the comment, we suggest to weigh the potentials and limits of the approach in more detail and discuss how parameter uncertainty might affect stress-test findings.

[6] I am afraid that I am a bit lost when looking at Figure 5. The super short caption is hardly helping me to understand what I am looking at here. The text discusses gaining and loosing conditions. Maybe making those explicit in the figure would be a start? More info please.

The caption text will be adapted to be more explicit to express, that we are looking at examples of measurement locations which experience a direction change from gaining conditions (-1) to zero leakage (0).

[7] A general comment after looking at the next figure. Can you please make the captions more extensive. It is a bit annoying to have to go through much of the paper to look for abbreviations, variable names, location details etc. to understand figures. Please make the captions much more detailed so that the reader does not have to go through the text to understand the figure content. Or at least tell the reader exactly where to find the info needed to interpret the figure.

Captions (or where possible preferably the legends) will be expanded and improved.

[8] Regarding the conclusions. I understand that the authors discuss what they specifically learn about their study region. However, it might be nice to add a short paragraph on what innovations, understanding or questions might be transferrable to other studies. What outcomes are general?

Thanks for pointing this out. In the revised version we will work out transferrable knowledge gain such as

- the introduction and usability of connectivity metrics in different hydrogeological context and for different seasonality of the drying
- the potential to distinguish between climatic and human impacts on streambed drying using model stress test approaches
- the limitations of model approaches to simulate specific aspects of groundwater-surface water interaction

[9] As future work, the authors might want to consider a broader sensitivity analysis which could include both the stress test to the system as well as uncertainty in parameters or other model inputs. That would create a generic framework for analyses of the type presented here.

Thanks for this comment. Indeed, this would be the ideal follow up and we can add this to the outlook on future work.