Response to reviewers' comments

"The dynamics of peak head responses at Dutch canal dikes and the impact of climate change" https://doi.org/10.5194/egusphere-2024-1495 submitted to Natural Hazards and Earth System Sciences

We thank the reviewer for her/his thorough, insightful and valuable feedback, both on a general and more detailed level.

Below, we reply to the reviewer's comments and explain how we will address them. The reviewer's comments are shown in *Italicized text in gray*, our responses are shown in blue. We provide detailed responses to the major comments, along with specific **actions** to improve the manuscript. For minor comments, we offer brief responses, as we will incorporate these suggestions to enhance clarity and refine terminology throughout the text.

Anonymous Referee #2

This manuscript outlines an application of time series models using impulse response functions to model the hydraulic heads observed with dike systems in the Netherlands. Different model structures are tested to simulate the heads, with a nonlinear-threshold model (TARSO) found to perform the best. This is an interesting result, that could teach us something about how the heads in dike systems respond to precipitation and potential evaporation. The study attempts to relate model characteristics to various physical characteristics of the dike systems, with moderate success. I generally found the manuscript well written and the figure quality appropriate. The topic fits the scope of the journal. I have a couple of major comments that should be addressed, and some minor technical comments at the bottom.

Thank you for your constructive feedback; we appreciate your insights and will carefully address your comments.

- *One thing I was missing in the manuscript is an explanation and interpretation of why the threshold nonlinear model structure (TARSO) works best for the hydraulic heads in Dikes in the Netherlands. This is a surprising outcome to me, that deserves more thought and might be informative for future attempts to model the heads in dikes. This model was designed for a different type of system (groundwater levels in polders, influenced by ditches falling dry and being activated). Perhaps there is topping-off of the heads in dikes. These types of models are commonly used to gain understanding of how groundwater systems function, and why. A discussion of this type is currently missing from the manuscript but would be a welcome addition.*

  The strong performance of the TARSO model in modeling hydraulic heads in Dutch canal dikes can be explained by the non-linear characteristics of the head response in these dikes. The manuscript gives some suggestions in line 330 – 332: "*This non-linear behaviour can be the result of various soil layers in the dike body, each with distinct hydraulic properties, and changes in infiltration rates or nonconstant storage capacities of the unsaturated zone during the dry season*" The suggestion that there may be a "topping-off" effect in dike heads is an interesting perspective that aligns with the need to account for non-linear responses.

Action: We will expand on this discussion in the revised manuscript, providing a more extensive interpretation of why the TARSO model performs well for dikes. However, as these explanations remain hypotheses at this stage, we will also emphasize that further research is needed to verify these mechanisms.

- *Looking at Figure 6, I was very surprised by the simulated behavior of the FlexModel given that all models share the same input and not be that far off from each other. I made a quick script to model the data using the Pastas default values to better understand the result but got an average of R2=0.68 for the FlexModel, much higher than the reported value of 0.32. I suspect some suboptimal choices were made for that model. Perhaps the Authors can revisit the scripts and double-check this, or explain this result in more detail.*

  Thank you for this remark. It is unclear how the reviewer obtained an average R^2 of 0.68 for the FlexModel. When we apply the FlexModel using default values, we obtain a significantly lower average R^2. We have experimented with different initial parameter settings but were unable to achieve a substantial improvement in model performance.

  If the reviewer is willing to share their script, this would be very helpful for comparison and to better understand the differences in our findings. Additionally, this relates to the subsequent comment regarding the reproducibility of results, which we address separately.

- *I assessed the manuscript for its reproducibility. I appreciate the authors providing the original head, precipitation, and evaporation data is provided. This data provides a unique dataset on head measurement in dike systems, which might be worth highlighting in the manuscript. I note here that none of the data underlying the results shown in the figures and tables are shared, nor are the scripts that lead to the results. This makes it difficult to verify the results and/or build upon this work. I would recommend the authors to share the scripts and output data on a FAIR repository to improve the reproducibility of this study.*

  Thank you for assessing the reproducibility of our study and for highlighting the uniqueness of the dataset. We appreciate the importance of making research more transparent and reproducible.

  Action: We will emphasize the uniqueness of the dataset in the manuscript. Additionally, we will share the scripts and output data on 4TU.ResearchData, ensuring alignment with FAIR principles to improve the reproducibility and accessibility of our work.

Minor technical suggestions:

L84: Potential evaporation Correct; will be revised

L195: Figure 4 and 5 appear to be the same. I am not sure if another figure is meant to be here. Otherwise Figure 5 can be removed. Correct; we will remove Fig. 5.

L192: How well does GeoTop actually work for dikes? I can imagine that these are not related at all, given that dikes are built by humans with specific materials. This may influence the results later on relating outcomes to the soil types, i.e., would the relationship with the soil type improve if the GeoTop data is left out? Some consideration about this would be good here.

This is a good suggestion; We will check this and write down the findings in the revised paper.

L238: I think Sm is substituted by R, not the other way around. Correct; will be revised

L276: simulate "the heads". Good suggestion, will be revised

L288: How was this threshold of 0.7 determined? How sensitive are the result to changing this threshold. We will elaborate on the sensitivity of this threshold.

L302: Analyses Will be revised

L303: every "…"? We will rewrite this sentence: "of every" will be deleted.

L327: r2 was previously referred to as R2, check throughout Will be checked and corrected in the manuscript

L329: The FlexModel is a nonlinear recharge model, the other three models are not. I think the TARSO model is meant here, which still computes recharge using a linear equation.

In literature, tha TARSO-model is often referred to as a nonlinear model, since it accounts to some extent for the nonconstant relationship between precipitation excess and water table depth caused, in contrast to linear model (Knotters en Gooijer, 1999)

L342: replace by "in the summer of 2019" Will be revised

L343: disturbances Will be revised

L345: scatter plot in Figure XX. Sentence will be rewritten.

L366: I don't understand what "peak block" is, please clarify. This is explained in lines 347-349.

L496: Apparently, the head time series were filtered using some reliability criteria in this study. This should be mentioned in the section describing the data. What reliability criteria were used?

This is discussed in section 3.1.3 – Model calibration and selection. Lines 287-294 describes the reliability criteria used

L501: Remove "explicitly". Uncertainty was not considered, as I understood from the manuscript.

We believe you mean line 511: we will remove "explicitly".

Knotters, M., & De Gooijer, J. G. (1999). TARSO modeling of water table depths. Water Resources Research, 35(3), 695-705.