

Authors' Response to second round of comments September 2026

Changes in groundwater-surface water interactions following two centuries of irrigation practices and groundwater use in the Upper Ganges-Yamuna interfluvium, North India.

Original comment

AR: Authors' response (blue italic)

Editor

Dear authors,

Thank you for carefully addressing the comments of the reviewers.

To get the manuscript ready for publication in HESS, Reviewer #1 has a few additional minor comments. Please also consider the comments below:

AR: Dear Fanny Sarrazin, we want to thank you for your comments, please see below our responses. We revised the manuscript to include improvements based on your comments and reviewer #1 comments.

- Water quality: Regarding the reply to RC2-SC4, both point source contamination from wastewater and diffuse agricultural contamination (that can contaminate the groundwater through percolation from the soil) occur. Depending on the relative importance and the seasonality of the point and diffuse point sources, the seasonal changes in river water infiltration may impact water quality. This is a complex problem that would require further in-depth investigations in future studies. Reviewer #1 also indicates that the discussion on water quality in the manuscript would need to be more cautious. Where possible, please add references to past studies to support your statements.

AR: We agree that the potential implications for water quality are complex and strong statements require further investigation at finer spatial and temporal scales, supported by additional field observations. We have therefore revised the relevant statements in the manuscript to be more cautious and have added additional references to support the discussion of potential water-quality implications.

- In Figures 4 and 6, why showing the simulation obtained using the initial ("default") parameter set instead of the mean ensemble from the Monte Carlo simulations?

AR: The initial parameter set uses a multiplication factor of 1.0 for each recharge and abstraction component and represents our best estimate based on the available literature and data, as described in Appendix A. We therefore consider it more transparent and interpretable to use these initial estimates in Figures 4 and 6. The mean would not be appropriate because the multiplication factors are sampled from log-uniform distributions and would therefore be biased towards values above 1. However we considered using the posterior median, as the median would give appropriate values close to 1 for several components, including canal leakage, irrigation return flow, municipal return flow, and municipal and industrial abstractions, but would result in lower estimates for rainfall recharge and irrigation abstraction, as can be seen in Figure 3. Furthermore, a model run with the component-wise medians does not necessarily correspond to the median of the resulting groundwater response of Figures 7 and 9 etc. We have

kept the initial estimates to provide a direct representation of the underlying recharge and abstraction estimates described in Appendix A.

- Figures 8 and 10, it is not clear to what extent the increase and decrease over time compensate. It would be valuable to see the differences between the natural situation and the current situation map beyond the differences between the intermediate periods. In addition, please clarify what is shown in the figures (mean simulation ensemble?).

AR: Thank you for this suggestion. We agree that showing the difference between the current and pre-canal ("natural") conditions provides useful additional context. We have therefore added a panel showing the difference between the current period (2000–2016) and the pre-canal period (<1830).

The figures show the mean simulated groundwater table depth for each period, calculated across the posterior ensemble. The panels below show the difference between consecutive periods, calculated as the mean groundwater table depth of the later period minus that of the preceding period. We have clarified this in the figure captions.

- L389 "This may underestimate hindcast uncertainty, though median ensemble behaviour remains robust.": this sentence would require clarification. Would not the term "variability" be more appropriate than uncertainty? What does "robust" mean?

AR: Thank you for this comment. We agree that "variability" is more appropriate than "uncertainty" in this context. We have therefore revised the sentence accordingly. We have also replaced "robust" with "largely unaffected" to clarify that, although the variability may be underestimated, we do not expect the median ensemble behaviour to differ substantially.

- L409 "forcing variability": I think "uncertainty" would be more appropriate than "variability". It would be clearer to report here that forcing refers to recharge and abstraction.

AR: Thank you for the comment. We agree that "uncertainty" is more appropriate than "variability" in this context. We have also clarified that the forcing uncertainties considered in the Monte Carlo analysis refer specifically to recharge and abstraction components.

- Figures A.1 to A.7 should be grouped into a multi-panel figure.

AR: We agree that grouping Figures A.1–A.7 into a single multi-panel figure improves the presentation and reduces the space required. We have therefore combined these figures into one multi-panel figure.

- Minor edits:

Caption of Figure 10: replace "panals" by "panels" and specify what is shown.

L387: replace "at 1900" by "in 1900"

AR: Thank you for the suggested edits, we adjusted the text accordingly

Best regards,
Fanny Sarrazin

Reviewer #1

Thank you for addressing all the reviewers comments. The manuscript is much improved. I still think it would be helpful to be more transparent with the data you have used to validate the model.

AR: Dear Reviewer #1, thank you for your valuable comments and for recognizing the improvements made to the manuscript. We respond to your remaining comments below.

It would be good to show some of the analysis of groundwater level data you have added into the appendix in the main body of the text instead. I think this is needed for the reader to really evaluate your model. Could you combine figures B1 to B3 into a sub-panel plot and present it in the main text?

AR: We agree that comparison between observed and simulated groundwater levels is important for evaluating the model. However, we do not think that combining Figures B1–B3 into a single multi-panel figure would provide a sufficiently clear presentation, as Figures B1 and B3 contain substantial detail that would be difficult to retain if the figures were reduced in size. We considered moving Figure B1 to the main text, as it provides a direct comparison between observed and simulated groundwater heads, while retaining Figures B2 and B3 in Appendix B. However, we ultimately decided to keep all three figures together in Appendix B so that the different aspects of model performance can be considered together. To nevertheless highlight the model and observation comparison in the main text, we have included a short summary of the main findings from this analysis. Moving all three figures to the main text would also substantially increase the amount of space devoted to model evaluation, given that the manuscript already contains 11 figures, several of which are multi-panel figures. We therefore consider keeping Figures B1–B3 together in Appendix B, while summarizing their main findings in the main text, to provide a detailed evaluation without making the main text unnecessarily long.

Can you add the location of the observation wells on Figure 1?

AR: Yes, we have added the observation well locations to Figure 1. Although we have not included individual well IDs as labels because the nearly one hundred observation well labels would clutter the figure and reduce its readability.

I also think discussion of groundwater quality (including extensive discussion of wastewater discharge) can be misleading as you haven't directly assessed this. I would further temper your language about this, particularly in the implications section (around line 450 - 460).

AR: We agree that the potential groundwater and surface water quality implications are not directly assessed in this study. Our analysis focuses on the quantitative changes in groundwater levels, recharge, abstraction, and groundwater–surface water exchange, which may have implications for water quality. However, these implications depend also on additional processes that are not explicitly represented in our model. We have therefore revised the relevant statements in the implications and conclusions sections to use more cautious language.