Fluvial Flood Inundation and Humanitarian Impact Model Based On Open Data

Authors' Response

To Referee Comment (RC) 1

Lukas Riedel on behalf of the authors

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1 Comments

Referee Comment (RC) Firstly, I want to express my gratitude for giving me the opportunity to review this excellent piece of work. I must admit that as I am not a risk modeler, I may not be able to provide detailed commentary on the models integrated into this paper. Overall, I found the paper to be well-structured and thoughtfully presented. However, I do have a few suggestions for modifications that I believe could enhance clarity and readability. These suggestions are outlined below.

Author Response (AR) Thank you for a positive and thorough review. We appreciate the added interdisciplinary perspective and we feel confident that it strongly improved the paper. For additional context, see our detailed responses below.

RC In the introduction but more importantly in the title, the word "humanitarian" in this context might be misleading. While floods can indeed have significant humanitarian impacts, the term "humanitarian" typically refers to actions or interventions aimed at alleviating human suffering, particularly in emergency situations. I will highly recommend revising the introduction to better convey the challenges faced by communities affected by floods.

AR Thank you for this correction. It was difficult to find an umbrella term for the impacts our model could consider. We wanted to clearly distinguish the socio-economic impact model from the physical flood inundation model, and to indicate that the model can be calibrated to other types of impacts as well (if suitable data is available). After reconsideration, we decided to rename the manuscript title to "Fluvial Flood Inundation and Socio-Economic Impact Model Based on Open Data".

RC The second paragraph of the introduction refers to the Sendai Framework for Disaster Risk Reduction. The correct footnote should cite UNDRR instead of UNISDR.

AR We corrected the reference to (UNDRR, 2015).

RC It would also be beneficial to define displacement in the introduction, particularly in the context of flooding, such as during monsoon seasons. This is important because individuals may experience multiple waves of flooding, resulting in repeated displacement.

AR We added a definition of disaster displacement to the introduction.

RC I would suggest merging sections 2) "Data" and 3) "Flood Model" into one section. The rationale behind this suggestion is that the data section currently contains a significant amount of information on various flood modeling techniques. I recommend using the data section as an introductory section instead. Later in the document, this data could then be utilized to present empirical evidence from past events from multiple sources.

AR We merged the "Data" section (previously sec. 2) into the "Flood Model" section (sec. 2), renaming it to "Input Data" (sec. 2.1).

RC Section 3 flood model: I would suggest revising the 1st sentence:
"To compute a flood inundation footprint from gridded, geo-located river discharge data, said data is related to the historical 85 discharge time series via an extreme value analysis, and the corresponding return period is used to look up flood depths in flood hazard maps."

AR This sentence was indeed hard to grasp. We simplified the introduction to "Flood Model" (sec. 2, previously sec. 3).

RC In Section 4, Implementation, I suggest refraining from using the term 'natural,' especially when discussing exposure. You can explore the 'no natural disasters' campaign, which emphasizes that while some hazards are inherent in nature and unavoidable, the resulting disasters are often influenced by human actions and decisions. `https://www.nonaturaldisasters.com/`

AR Thank you for raising awareness of this topic. We concur and removed any mention of "natural disaster" or "natural catastrophe" throughout the document.

RC Regarding section 5.3 on historical times series. Have you reach out to the Pakistan government to explore further historical trends? I think data are available only since 2017 `https://pdma.punjab.gov.pk/`

AR The data provided in the situational reports by PDMA Sindh and Punjab are typically in PDF format, and sometimes only in image data formats. These formats make it difficult to machine-read the data, which heavily complicates parsing larger amounts of data to establish historical trends. We reached out to PDMA Sindh to possibly receive machine-readable tabular data of their situational reports, but have not received a response. The data provided by the IDMC and OCHA databases therefore were our only sources of historical trends.

RC I highly recommend adding a section on Vulnerability to explain how it is defined for flood displacement as an impact function. We can find some information in section 6.2 where you mention that vulnerability is determined by calibrating impact functions to impact data from past events. It would be beneficial to expand on this further. How many events were assessed? What were the dates and magnitudes? Additionally, the choice of the step function for simplicity may require additional information.

AR We expanded the explanation of the vulnerability in a new subsection "Impact Model and Calibration Setup" (sec. 4.2.1), and added a table listing the extracted PDMA displacement data in Appendix B. For means of the calibration, the displacement during the 2022 floods was considered a single event, whose flood footprint was the maximum flood extent and inundation between 01 July and 30 September 2022.

RC Later, you mention in your calibration process that you decided to use 0.5m as a threshold for Pakistan. Having this information centralized in one section would make it easier to understand. It appears that you calibrated to 0.5m for Pakistan. Do you have any measurements that can corroborate this hypothesis? Additionally, it could be interesting to explain in the conclusion how, as you aim to develop a global impact forecasting system, parameters may be adjusted depending on the context.

AR We updated the impact model discussion (sec. 5.2, previously sec. 6.2) to clarify that we do not set a threshold of 0.5m ourselves, but that Kam et al. (2021) chose a threshold of 0.5m for calculating displacement risk due to river floods in a pessimistic scenario. We further clarify that the medians of the inundation thresholds calibrated with our model (No Protection: 0.58m. FLOPROS: 0.52m) are close to this value. To make the distinction clearer, we also revised the paragraph on using the model in situations where no calibration data is available. We now exemplify using a threshold of 0.2m to indicate population at risk of flooding, to further differentiate from our previous model setup.

RC At around line 390, I would recommend changing the wording from "historical time series of displacement" to "historical trends". The reason for this change is that each displacement has a duration that can vary from hours to days, months, or years. The term "time series" typically refers to situations where we have multiple snapshots of information over time. Regarding

the flooding events of 2022, there are still more than 1.1 million people living in displacement situations in Sindh province. They were not able to return home due to many obstacles.

AR Indeed, it was not clear enough what the model reports. In terms of the Global Internal Displacment Database (IDMC, 2023), it reports "Internal Displacements" for each month, and not "Internally displaced people (IDPs)" over time. It also assumes full recovery after each month.
We removed any mention of "historical time series" and instead refer to "monthly displaced population" and "historical (flood) displacement". We changed the subsection title from "Historical Time Series" (previously sec. 5.3) to "Historical Flood Displacement" (sec. 4.3). We further added the caveat on the model assumption of full recovery after one month to this section and placed it more prominently in the caption of fig. 6.

RC In the conclusion I personally welcome the suggestion of a range of people at risk of displacement between the worst case and best-case scenarios.

AR Unfortunately, we cannot state a general range of people at risk in best- and worst-case scenarios. We slightly updated the conclusion, trying to further clarify this issue. Referring to "Impact-based Forecasts" (sec. 4.4, previously sec. 5.4) and fig. 7a in particular, we find that estimated impacts between the two models ("No Protection", "FLOPROS") may differ a lot. But the uncertainty within each model is also considerable. Recommending a specific workflow to determine reasonable best- and worst-case scenarios indeed warrants further research. The uncertainty and sensitivity analysis in sec. 4.4 (previously sec. 5.4) exemplifies this.

2 References

IDMC: Global Internal Displacement Database, Internal Displacement Monitoring Centre (IDMC), URL `https://www.internal-displacement.org/database/`, 2023.

Kam, P. M., Aznar-Siguan, G., Schewe, J., Milano, L., Ginnetti, J., Willner, S., McCaughey, J. W., and Bresch, D. N.: Global warming and population change both heighten future risk of human displacement due to river floods, Environmental Research Letters, 16, 044 026, https://doi.org/10.1088/1748-9326/abd26c, 2021.

UNDRR: Sendai Framework for Disaster Risk Reduction 2015 - 2030, United Nations Office for Disaster Risk Reduction (UNDRR), URL `https://www.undrr.org/quick/11409`, 2015.