RESPONSE TO REVIEW #2

We highly appreciate and are very thankful for the time and effort that was invested in reviewing our manuscript. Thank you for initiating this fruitful discussion. After carefully studying the constructive queries and comments, and following lengthy discussions among the co-authors, we have thoroughly revised our manuscript in an attempt to refine our key motivation and messages: to derive a simple but reliable methodology for localizing urban inundation hotspots by means of a numerical model, which makes best use of open access (geo) data, and a new and easy-to-apply flood severity index. Please find our responses (blue) and revised text blocks *(blue, italic)* below each review comment (**black, bold**).

General comments:

Part I:

The paper demonstrated how to process and applying open-access data to an urban surface run-off model. The authors also combined flood depth and duration into a so-called normalized flood severity index (NFSI) to identify urban inundation hotspots. Overall, this paper might be useful in demonstrating how open access data can be processed into hydrological model. However, the methodology to achieve this need to be more systematically presented.

We are very pleased to learn that Referee #2 agrees with our core idea and the usefulness of our approach in demonstrating how open-access data can be processed and incorporated into a hydrological model. Thank you for making us aware that the presented methodology is not always perfectly clear to the reader. The first step to remedy this was to add additional processing steps to the work flow presented in Figure 1 (e.g. validation/calibration, simplification of model inputs). Furthermore, more attention was given to the derivation of bathymetric data. In order to improve this aspect, we discussed adding a figure to Section 2.1.2 to better illustrate this process and/or to Section 2.2.2 that visualizes the derivation of the tidal boundary condition.

Part II:

Whether this methodology can be considered novel or not is unclear as the process seemed quite intuitive. Besides, the applicability of the research is thin. Vulnerability assessment is being conducted in cities to identify the areas that need response measures. Moreover, the application of the flood severity index is rather thin. As mentioned above, inundation hotspots can be identified through vulnerability assessment.

The thresholds for the NFSI were not mentioned. What insights or new implications can be extracted from using the NFSI?

We agree that the model set-up, data processing and boundary condition implementation seem intuitive. This, however, does not influence the overarching goal of this manuscript, which is to investigate the usability and reliability of hydro-numerical models that are built exclusively on open-access data. These models have the potential to offer preliminary, low-cost and low-effort flood hazard assessment in any flood risk analysis, especially in urban agglomerations in the developing world, where data is scarce and modeling expertise may be limited. Moreover, we are convinced that one needs to differentiate between a hazard and a vulnerability assessment, the latter of which requires gathering a substantial amount of socio-economic data and inputs. These inputs are not directly part of a numerical model and a flood hazard assessment. Our proposed methodology works to determine flood hazard, for which we combined two major components (flood depth and flood duration) through the proposed NFSI to better pinpoint areas where the level of hazard, in contrast to (socio-economic) vulnerability, is at its highest. Our discussed methodology does indeed not substitute but rather complement a vulnerability assessment and can be seen as a valuable contribution to flood risk assessment. This is achieved by identifying the locations or districts that are particularly exposed to flood hazard. This, in turn, allows vulnerability researchers to quickly identify areas of high concern, where more focused attention, awareness raising or training programs are required. The major advantage of the proposed methodology is its applicability and replicability since it does not rely on locally sourced and processed data. Nevertheless, we have revised the manuscript to include this explanation and thereby reduce any uncertainty in regards to the added value of flood hazard assessment through the NFSI.

Part III:

How can the data processing method be applied to other megacities? Why the authors selected HCMC for model validation? Why not different locations around the planet?

This question is praiseworthy as it aligns very well with our overarching goals. Ultimately, the practical objective of the presented methodology is to allow researchers to build low-cost, low-effort and fully transparent hydro-numerical models for any parts of the globe, especially for those locations where data accessibility, availability or both is lacking. Our methodology is unique and easily applicable on other coastal megacities that are particularly at risk from increasing flood severity due to climate change, relative SLR or other drivers and processes. Furthermore, a pronounced focus was laid on the relative changes of flood hazard due to climate change in the revised manuscript, which should also alleviate calibration and validation concerns, given that the relative changes are of interest. The case of HCMC was chosen since this city epitomizes the complex interplay of the aforementioned disaster risk components (see e.g. Kreibich et al, 2022) in an environment where accessibility to official data is limited.

Specific comments:

1- **Line 24: adaptation to what, increasing precipitation? Sea level rise? Usually, adaptation refers to responses to changing risk. I don't think it is applicable to this manuscript. In this case it is more like responding to floods.**

We thank Reviewer #2 for this comment. Ultimately, there are three main factors that control severity and extent of urban floods in regards to HCMC, namely extreme river discharge, heavy precipitation and storm surges. These drivers already pose a great problem for the inhabitants of Ho Chi Minh City, especially the combination of heavy rain and high tidal water levels that hampers the effectiveness of drainage, which will require adaptation in the near future. Besides the major threat of high intensity, low frequency floods that cause significant material and human damage, additional attention needs to be given to more frequent floods (with lower intensity) that cause significant socio-economic disruptions (ADB, 2010). This problem is projected to increase in the future due to changing hydro-meteorological conditions that are particularly troublesome for a flat, low-lying area such as HCMC. Even though precipitation is not projected to increase in intensity, relative sea level rise (combination of secular sea level rise and land subsidence) will make such precipitation more problematic due to an increase in the backwater effects, rendering stormwater drainage systems in the city useless. Through the proposed NFSI, critical flooding hotspots, that are controlled and dependent on the flood drivers can be identified. A more focused numerical investigation of the effectiveness of such future adaptation options can be found in Scheiber et al. (Preprint).

2- **Line 55 – 59: why there is a need for the complete surface runoff model while vulnerability assessment is being conducted? What is the application of the proposed flood severity index?**

As outlined in a previous response, risk is composed of three factors according to the IPCC (SREX, 2012; SROCC, 2019) namely a combination of hazard, exposure and vulnerability. The investigation of hazard is therefore one of three equivalent contributions when quantifying risk. It is true that some studies rely on topographic data alone to determine whether certain areas will be flooded in the future due to sea level rise, but such analysis does not capture the complex dynamics of flooding which can only be done through the use of hydro-numerical models. The proposed NFSI helps in giving a clearer, more concentrated picture of the spatial distribution of hazard and its local hotspots by combining two critical components, the flood depth and the flood duration.

3- **Line 66: how about flood frequency? Why is flood frequency excluded from this index?**

An integration of the frequency of exceedance of a certain flood level is definitely needed when quantifying flood damage and losses. Nevertheless, our hydro-numerical model provides an estimated distribution of flood depths and its associated duration due to set boundary conditions, i.e. hydro-meteorological time series. The frequency of occurrence of these boundary conditions is defined by their return period which was set to 1 year our study. It is certainly interesting to combine different events with different return periods and investigate the ensuing losses. This, however, would go beyond the scope of this particular paper since our main objective is to elucidate the level of hazard and extent of exposure in certain urban areas through the NFSI.

4- **Table 1: this table can be improved by incorporating errors or each DEM, and how these errors can be addressed.**

We find this comment very valuable and revised the table so that these errors are now included.

5- **Figure 2: if my understanding is right, it should be: subtract (c) from (b) rather than add (b) to (c).**

Thank you very much for revealing this mistake of ours. We appreciate the alertness and corrected the graph accordingly.

6- **Line 172 – 174: how about natural waterways inside HCMC? There is informal settlement encroaching on natural waterways inside HCMC, which also get flooded frequently during high tides and heavy rains (ex. Tran Xuan Soan street).**

Thank you for this valuable comment. There are indeed both natural and man-made waterways inside Ho Chi Minh City and both of them were considered in our model. We edited the text to make this clearer to our readers.

7- **Line 231: why not using data from Phu An station?**

We intensely discussed this question among the co-authors. In summary, there are two reasons for not using data from Phu An. First of all, we chose to build an expanded model of the HCMC area with a southern boundary at Nha Be. As a consequence, the tidal boundary condition needs to be applied at that location, which only allows the use of the Nha Be tidal levels. The second reason is the apparent lack of open-access data for the Phu An station, which makes it impossible to determine the water levels there using our methodology.

8- **Line 244: why an eight-day time series?**

An eight-day time series was chosen for two purposes. First of all, a certain run-up time needs to be considered in the hydro-numerical model in order to allow the stabilization of water levels. Furthermore, adequate time needs to be given after precipitation occurs in order for rain runoff to properly route and concentrate within the model. Thanks to your comment, we have added these details to our text for better clarity.

9- **Line 261: why only a 2-year flood selected? How about 5-year, 10-year floods?**

The 1-year event was adopted here in order to highlight the substantial divergence in the literature in regards to the calculation of the precipitation depth. Furthermore, our focus was on lower intensity, higher frequency rain events that regularly cause sustained socio-economic disruption in the city (ADB, 2010), for which the model was calibrated and validated. Lower frequency events with certainly larger flood extents and depths could also be easily simulated, but these scenarios of flooding would go beyond the scope of our study.

10- **Comment for the 2.2. section: How about reservoirs and groundwater? Why are these excluded from the model?**

The impact of reservoirs and groundwater is indeed a considerable aspect of hydrological modeling. However, for the present setting, we have assumed that groundwater is saturated during the rainy season, and thus no infiltration occurs, which particularly holds true when considering the significant percentage of impermeable surfaces in the urban areas of HCMC. In regards to the upstream reservoirs, no positive effect on their potential in reducing inundation depth was considered, which aligns with a conservative engineering approach.

11- Method section: there should be one graph summarize the proposed methodology. So far, these are scatter over different section of each type of date, which is difficult to grasp the bif picture of the proposed methodology. Besides, methodology for processing each element should be presented in equation form rather than figures (i.e., figure 2 and figure 7).

Thank you for this comment. We made sure that additional processing steps are integrated in Figure 1 to make the whole process more accessible to a wide audience. It is true that equations could be used instead of Figure 2 and 7, but we would prefer to visualize the results of the processing and include the equations in the illustration, as it allows the reader to intuitively grasp what happens at each step of the work-flow.

12- Line 335: what do the authors mean by the threshold of the NFSI is at its maximum? Maximum of what? How are the factors of changing climate considered? Why did the authors give equal weights to flood depth and duration? How about flood frequency?

We would like to clarify that it is not the threshold of the NFSI that is at its maximum but rather the combination of flood depth and duration over the threshold of 10 cm are at their maximum. For climate change considerations, the NFSI needs to be computed for that particular case and then normalized according to the base case where no climate change effects are considered. Regarding the equal weight, this was done in order to ensure that the results are not biased, especially considering the lack of additional data that are necessary to determine whether flood depth or duration play a bigger role in damage for a particular location. This weighting can be different depending on the case and the local composition of flood damage. Future users are, of course, free to change the weighting and adapt it to a specific use case. Flood frequency can surely be considered when changing the boundary conditions of the model depending on the investigated return period. To that end, the IDF curves presented in Fig. 4 offer a valuable starting point to estimate precipitation depth for HCMC.

References:

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Kreibich, H., Van Loon, A. F., Schröter, K., Ward, P. J., Mazzoleni, M., Sairam, N., ... & Di Baldassarre, G. (2022). The challenge of unprecedented floods and droughts in risk management. *Nature*, *608*(7921), 80-86.

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