RC1 Response

1. The use of a 500km radius to crop TC related precipitation in the article does not fully demonstrate the applicability of this radius in the GMR region.

We acknowledge that the use of a search radius is a simplification. Reviewer 2 (point 1) raises a similar question concerning the use of the 500km search radius when quantifying the TC related precipitation, and we therefore discuss the implications of using the 500km radius fully in that response (below).

2. Table 1 only considers three variables (precipitation, soil moisture, slope), ignoring possible important factors such as land use, reservoir regulation, and previous rainfall. Suggest explaining the possible impacts of these potential factors in the discussion.

Thank you for these useful comments. Whilst these other factors (especially land use and antecedent rainfall) are potentially important, the role that they play in controlling flow generation is largely manifest through their impacts on soil moisture. We have updated the following text in the manuscript to make this clearer for the reader (L200-L214):

> *"Our results also indicate that the key factor driving excess stream flow is excess soil saturation and slope-soil saturation interactions. Such excess soil saturation evidently arises due to wetting in the monsoonal months (May to September) prior to the cyclone season (June to November), in addition to wetting from TC-linked precipitation. Thus the wet season creates ideal conditions for maximum rainfall runoff impact from TC-linked precipitation. Any future climate where TC-linked precipitation occurs with greater intensity, after a monsoon season, will increasingly impact populations located in the 1 in 100 year coastal zone.*
>
> *We use soil moisture as a proxy here for a range of contributing soil-related sub-processes in the GMR, such as extent of soil saturation, soil type, or land use type. We make the assumption that low soil moisture content indicates soils that are capable of detaining rainfall runoff, and a high soil moisture value indicates the soil is nearing its maximum capacity to hold onto water. Once exceeded (increasingly possible in the future GMR), TC-linked rainfall would afterwards directly runoff instead of being absorbed and mitigated, effecting downstream communities. Saturated soils might also presage higher landslip risk, if other conditions allow. In finding that soil moisture is a controlling factor in our study area, the next phase of research might reasonably be to examine the role of sub-factors, such as soil types and class, aquifer proximity/capacity, degree of urbanisation, role of vegetation and tree cover (and associated evapotranspiration), and how land use has contributed."*

We also write in the conclusion section that other factors such as antecedent conditions, land use, and soil type, would all be appealing areas for future study.

3. The author points out that the reliability of data in the 1970s and 1980s was low, but does not evaluate the specific impact on trend analysis.

(*This response is also applicable for Reviewer 2, Point 5, below*).

Thank you for this comment. Indeed ERA5 precipitation reanalysis data prior to the 1980s is recognised to be less accurate, as it relied on fewer ground weather stations, radiosondes, and satellite retrievals for pressure, humidity and temperature (Bell et al., 2021[1]). To respond to this comment the authors explored the impact of incorporating pre-satellite era data in the trend analysis, by estimating, and then comparing, the Mann Kendall (*S*) trend signal for highest (95th percentile) river discharges, for the periods 1971-1984 (Fig RC1 below), and 1985-2019 (Fig RC2 below), relative to the full 1971-2019 dataset we used in the manuscript (Fig 4 in the manuscript = Fig RC3 below). In all figures, the panels show the trend direction With- (panel a), and Without- (panel b), TC-linked precipitation. Panel c shows the influence of TC-linked precipitation in those trends.

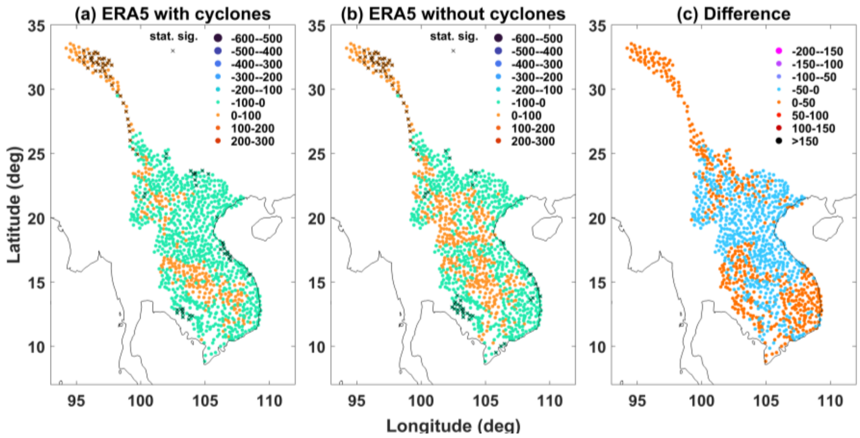

*Figure RC1 - Trends **1971-1984**: Mann Kendall (S), on 95th percentile flows, with significance.*

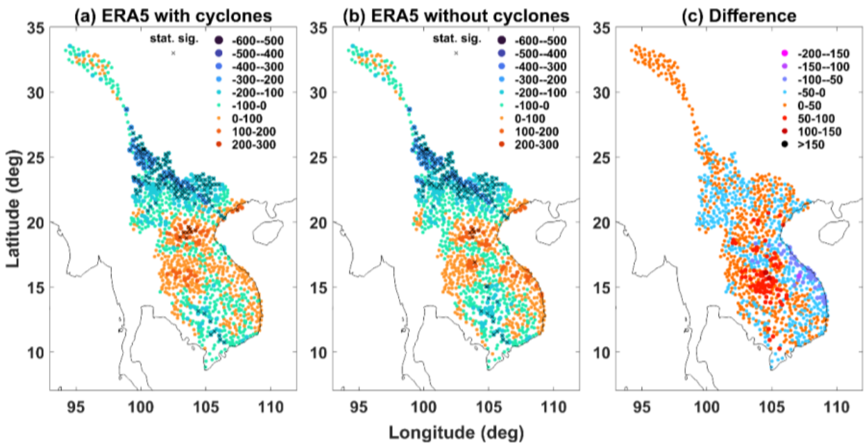

*Figure RC2 - Trends **1985-2019**: Mann Kendall (S), on 95th percentile flows, with significance*

[1] Bell, B., Hersbach, H., Simmons, A., Berrisford, P., Dahlgren, P., Horányi, A., Muñoz-Sabater, J., Nicolas, J., Radu, R., Schepers, D., Soci, C., Villaume, S., Bidlot, J.-R., Haimberger, L., Woollen, J., Buontempo, C., & Thépaut, J.-N. (2021). The ERA5 global reanalysis: Preliminary extension to 1950. *Quarterly Journal of the Royal Meteorological Society*, *147*(741), 4186–4227. https://doi.org/10.1002/qj.4174

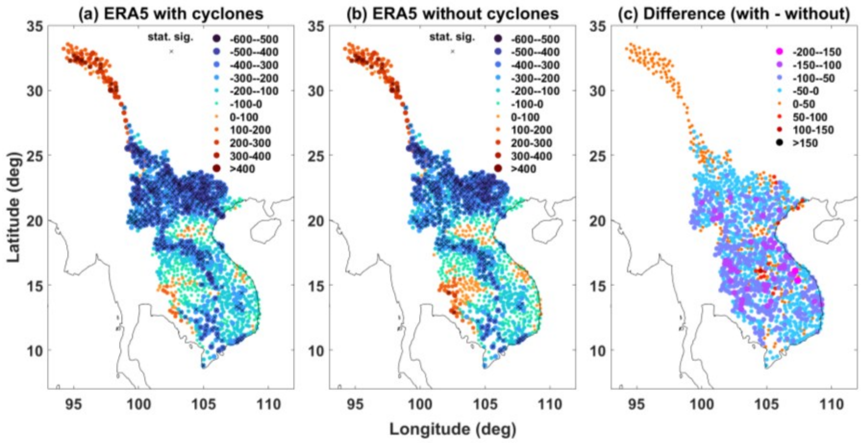

*Figure RC3 - Trends **1971-2019**: Mann Kendall (S), on 95th percentile flows, with significance*

These era-divided trend plots have also been added to Supplementary Material 4 ('S' statistic for mean and 95th percentile flows in the GMR: Figs S4.3-S4.6) for reference, and we refer to the issue in the manuscript L156-L162.

We find that using only data for 1985-2019 subtly alters the trend analysis results in a couple of ways. Firstly, river discharge trends at many sub-catchments in the Mekong/Red River headwaters within China (i.e. above 26° N), show a switch from small positive-*statistically-significant* in all data (Fig. RC3 panels a,b), to small negative-*not significant* trend in the post 1985 years only data (Fig. RC2 panels a,b). Here, TC-linked precipitation has consistently trended positive (panel c), therefore factors unrelated to TC-precipitation could be influencing this declining behaviour in discharge extremes at this location. The cause, if it is not related to the ERA5 data quality prior to 1985, could possibly be the impact of dam installation (which the GM-HYPE model does incorporate) in this region which occurred in the 1980s onwards.

Secondly, overall, in smaller headwater sub-catchments beyond the main channels, many *statistically significant* discharge trends are more positive in the 1985+ era data compared with the original dataset. There are modest new positive trends in highest river flows, both inland (upper Laos, Thailand) and in the steep coastal sub-catchments around Vietnam's northern and central coastlines. The upward trend is only *statistically significant* north of Vientiane, Laos (~19° N), where highest flows inland tracks with an uptick in TC-linked precipitation inland post 1985 (Fig 2c). Nevertheless, the (not *statistically significant*) upward trend around the coastline cannot be similarly ascribed to TC-linked precipitation, because in this area this is shown to be decreasing over the same timescale. One possible explanation of positive *statistically significant (*and *not-statistically significant*) trends here is that TC-linked rainfall distribution has been changing in the last decades: future climate projections for this region suggest TC events are slightly reducing in frequency, but becoming more intense (and thus travelling further inland). These ERA5 linked model results may possibly show an early signal of this behaviour.

Thirdly, whilst many locations described above appear to show a small positive trend in river flows in the post-1985 data, relative to the prior 1971-1984 years data, this is not the case for main channels of the Red and Mekong Rivers: in these headwaters (21° N - 25° N), and around the Mekong River sub-catchments upstream and downstream of Tonle Sap Lake in Cambodia, there is a negative *statistically significant* trend. This is consistent with the all-years dataset. A negative *statistically significant* trends occur for the Saigon River, Vietnam (11° N - 13°N), upstream of Ho Chi Minh City also. These negative *statistically significant* trends in post 1985 sub-catchment extremes are unlikely to be linked to TC activity, as a high proportion of these locations have increased TC-linked discharges over that time period (Fig R2, panel c). Again, these negative trends may be anthropogenic in origin, give the locations.

The findings outlined above highlight there is some sensitivity of the GM-HYPE model outputs to the choice of ERA5 period. ERA5 data before 1985 does appear to be slightly under-representing precipitation, potentially reducing flows in the model for that period. However, we do not have up-to-date river gauge measurements throughout the GMR to corroborate our assumptions as to the source of these differences. Abstraction, dams, and reservoir installation in the GMR could be an alternative plausible explanation. On balance, the authors believe that trends from ~50 years of data may be more reliable than trends obtained from ~35 years of data. The statistically significant trends observed in 1971-2019 data still closely match those found for the 1985-2019 period. Therefore the authors have not modified the data years used in the study. Instead we have updated the manuscript to highlight again that there is potential tendency for pre-satellite data to be less reliable (e.g. L127-L129, L156-L162), and point to the new figures in Supplementary Materials 4.

4. Figure 5 shows future changes, but does not provide confidence intervals or inter model differences (such as multi model sets).

We thank you for this comment. The authors have clarified the nature of our study to avoid misunderstandings; we are not able to provide confidence intervals or inter model differences for future changes because our study employs just a single HYPE model. In our discussion section we contemplate what mean and highest river discharges in the future GMR might look like due to a changing climate, given what we discovered for the past/present climate. Figure 5 illustrates findings for highest river discharges when our GM-HYPE model is forced with the Roberts et al. (2019) Global Climate Model data results (SSP5-8.5 scenario). Modelling the future flows GMR was never an objective of the study, so this paragraph is merely for discussion. We hope that our changes to this section of the manuscript makes this clearer.

5. The abstract should succinctly summarize the research objectives, methods, key findings, and conclusions. I suggest reducing background information in the abstract and focusing more on the study's highlights and outcomes.

Thank you for this recommendation. We have reworked the abstract to reduce the background information and to add extra lines of text to draw the focus more towards the study's objectives, key findings, and simple conclusions.

6. Some newest research work related with this paper can be added in the introduction. Diffusion evolution rules of grouting slurry in mining-induced cracks in overlying strata. Water injection softening modeling of hard roof and application in Buertai coal mine.

Thank you for this comment. This research does indeed look to be valuable, however given the limited scope of this study, the authors don't feel that this additional material is needed within the current outline. It could, however, be usefully employed in a future study, which extends our work, perhaps going into more detail of the impact of groundwater influences, soil type, and land use within the GMR.

7. The conclusion mentions "useful for planners and managers", but does not provide specific recommendations (such as which areas should prioritize strengthening flood control facilities). The authors should provide a summary of their main findings, the limitations of the study, and recommendations for future research in the conclusion.

Thank you for these constructive comments, the authors have updated and amended the conclusion section as suggested. For specific impacts we inserted:

> *"Our findings on historic extreme river flow trends will be of interest to urban planners, flood specialists, and river catchment managers throughout the GMR, and particularly in the smaller coastal sub-catchments south of the Red River delta where soil saturation appears to be driving an upwards trend in highest river flows."*

And there is new text which outlines a limitation of our study:

> *"…hydrological models do not provide insights of river hydraulics and flooding mechanisms, and as such this study is limited to mapping sub-regional river flow excess and trends, which we hope will form a basis for more detailed examination in future work.."*

In addition to this text which relates to opportunities / areas to consider for potential future research :

> *"We hope our findings will contribute to the understanding of the nature of contemporary flood hazard from rainfall runoff, and to the discussions around future proofing river flood defences. Further research work could focus on refining assumptions of a 500km radius to represent TC-linked precipitation within the GMR, or on the soil-related aspects driving the observed upward trend in parts of the GMR – e.g. whether soil saturation in these locations is linked to soil type, land use, vegetation or even soil-groundwater interactions. Alternatively, it would be interesting research to explore in more depth the TC-linked rainfall runoff risk in a future warming climate, using ensembles to better represent the uncertainty of projected TC activity in this region"*

8. There are several grammar mistakes in the paper, please revise and double-check throughout the whole manuscript. The language could benefit from further editing and polishing.

Thank you for these comments. We have checked the manuscript carefully and taken the opportunity to try and improve the readability of our manuscript.