Interactive Discussion: Author Response to Referee #1

Brief Communication: Stay local or go global? On the construction of plausible counterfactual scenarios to assess flash flood hazards

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NHESS Discussions, doi:10.5194/nhess-2024-119

RC: ***Reviewer Comment***, AR: *Author Response*, ☐ Manuscript text

Dear Referee,

we are grateful for the time and effort you invested in this review, and for your critical and constructive comments. We really appreciate the concise and comprehensive synopsis on both PMP and SST, and we hope (and are confident) to find a way to adequately represent this information in our manuscript.

Please find our point-by-point responses to your comments below. These should be considered as preliminary (part of the interactive discussion). The actual revision of the manuscript, including another comprehensive response letter also depends on another referee report and the subsequent editorial decision.

Thanks again for your efforts!

Kind regards,
Paul Voit and Maik Heistermann

RC: ***In what I consider to be a failure of the literature review and peer review process, the present study and those previous ones neglect the century-long massive body of relevant research that in multiple respects is much more advanced what the authors present in terms of level of sophistication and importantly, real-world application. Namely, geographic transposition of storms to generate counterfactual flood scenarios has been a cornerstone of flood risk management in North America, Australia, and elsewhere (perhaps not in Europe) for about as long as flood risk management has been quantified. [...] Proper acknowledgement of the efforts of earlier researchers is certainly needed. Unfortunately, the scope for doing so in the case of the two already-published studies is limited. In order for the present study to be published in NHESS or any other publication, the authors would need to adequately review and cite existing research and practice, as well as carefully place their own work within this much broader 100+-year long body of work.***

AR: We were honestly astounded when receiving your comments, and have to admit that we did not come across these concepts during our previous research; neither had the topic of "stochastic storm transposition" (and the fact that this is a common concept in the USA and Australia) come up during numerous presentations at conferences and workshops, or discussions with fellow researchers and previous reviewers.

We certainly accept the responsibility for this, and it is kind of discouraging that, despite modern search engines, a mere difference in terminology ("storm transposition" versus "spatial counterfactuals") can lead to

overlooking significant aspects of previous research. Of course, such things have happened before, and our neglect maybe highlights a more general issue when scientific communities remain unaware of each other's work. All the more, we think that it is important to acknowledge the gap between research communities in Europe and the US, and to seek to close it. In fact, this paper could be an opportunity and a starting point to explicitly address this issue, and to contribute to unify research efforts.

In order to adequately (though still concisely) represent the previous research on PMP and SST in the context of our manuscript, we kindly ask the editor whether the format restrictions of the "Brief communication" can be slightly relaxed in order to use a bit more than 20 references. We would then provide a revised version of the manuscript subject to the comments of the second referee and the following editorial decision.

We suggest the following changes to the manuscript, all bearing in mind the important requirement of brevity in the context of a brief communication:

- in the introduction, we will briefly introduce the concepts of PMP and SST, based on the excellent references provided by the referee (particularly Wright et al., 2020) and put these into context with the recent studies on spatial counterfactuals in Germany.
- furthermore, we would like to pick up this issue in the conclusions, and to openly address the apparent gap between the US/Australia and namely Europe in order to provide a perspective on how to unify the efforts in research and specifically applications (or maybe, rather, to allow the European community to catch up on what has already been done in the US).

RC: ***Generally: there's no reason why this approach needs to be restricted to flash floods.***

AR: This is true, and the recent studies of Merz et al. (2024) and Vorogushyn et al. (2024) have demonstrated this. However, the focus of our work (referring to Voit and Heistermann (2024)) is on the application of this concept to catchments that are prone to flash floods: the rare coincidence of extreme precipitation with basins that are capable of producing flash flood, together with the data scarcity in such catchments, especially calls for a spatial counterfactual (or PMP/SST) approach, as the lack of historical experience may result in low risk awareness.

The focus on flash floods requires specific considerations with regard to the temporal and spatial resolution of precipitation observations, the robustness, parsimoniousness and computational efficiency of the hydrological model, and the resolution (or incremental distance) at which precipitation fields are transposed across a catchment of interest in order to actually find counterfactual scenarios that effectuate maximum peak flows. Applying this at the national scale (here: Germany-wide) implies a very large number of counterfactual scenarios and hence large computational expense: e.g., for our previous study (Voit and Heistermann, 2024), we modelled close to a billion hydrographs, stemming from 23.000 counterfactual scenarios.

RC: ***Given the major criticism above, it would be appropriate to adopt existing language (e.g., "transposing" instead of "shifting")***

AR: We agree and will change "shift" to "transpose". We will also use the term "transposition domain". After reading the references you provided we noticed that we, at least and by chance, also came up with the commonly used term "Catchment of interest".

RC: ***L15: the meaning of "small-scale observational records" is unclear.***

AR: We changed it to:

> However, the local rarity and the lack of long-term observational records, especially for small basins, challenges conventional FFA.

RC: ***Should the language be clarified to make clear that it is an observed heavy precipitation event that is transposed?***

AR: We suggest to clarify this as follows:

> In the context of flood hazard assessment, one option for counterfactual scenario design is to spatially transpose the location of an observed heavy precipitation event in order to assess the impact that it could have effectuated elsewhere.

RC: ***Figures 2 and 3: these figures did not render properly in the PDF I downloaded, using two different widely-used PDF viewers on a Mac. Given that, I can't properly assess these figures.***

AR: We are sorry for this. We do not know why the figures did not render properly, and have not yet heard about any such issue, yet. In any case, we enclose the figures at the end of this response letter for your perusal, and hope that the issue can be resolved in the course of the revision process together with Copernicus' editorial office.

References

Merz, B., Nguyen, V. D., Guse, B., Han, L., Guan, X., Rakovec, O., Samaniego, L., Ahrens, B., and Vorogushyn, S.: Spatial counterfactuals to explore disastrous flooding, Environmental Research Letters, 10.5194/nhess-2024-11910.1088/1748-9326/ad22b9, 2024.

Voit, P. and Heistermann, M.: A downward counterfactual analysis of flash floods in Germany, Natural Hazards and Earth System Sciences Discussions, 2024, 1–23, 10.5194/nhess-2024-11910.5194/nhess-2023-224, 2024.

Vorogushyn, S., Han, L., Apel, H., Nguyen, V. D., Guse, B., Guan, X., Rakovec, O., Najafi, H., Samaniego, L., and Merz, B.: It could have been much worse: spatial counterfactuals of the July 2021 flood in the Ahr valley, Germany, Natural Hazards and Earth System Sciences Discussions, 2024, 1–39, 10.5194/nhess-2024-11910.5194/nhess-2024-97, 2024.

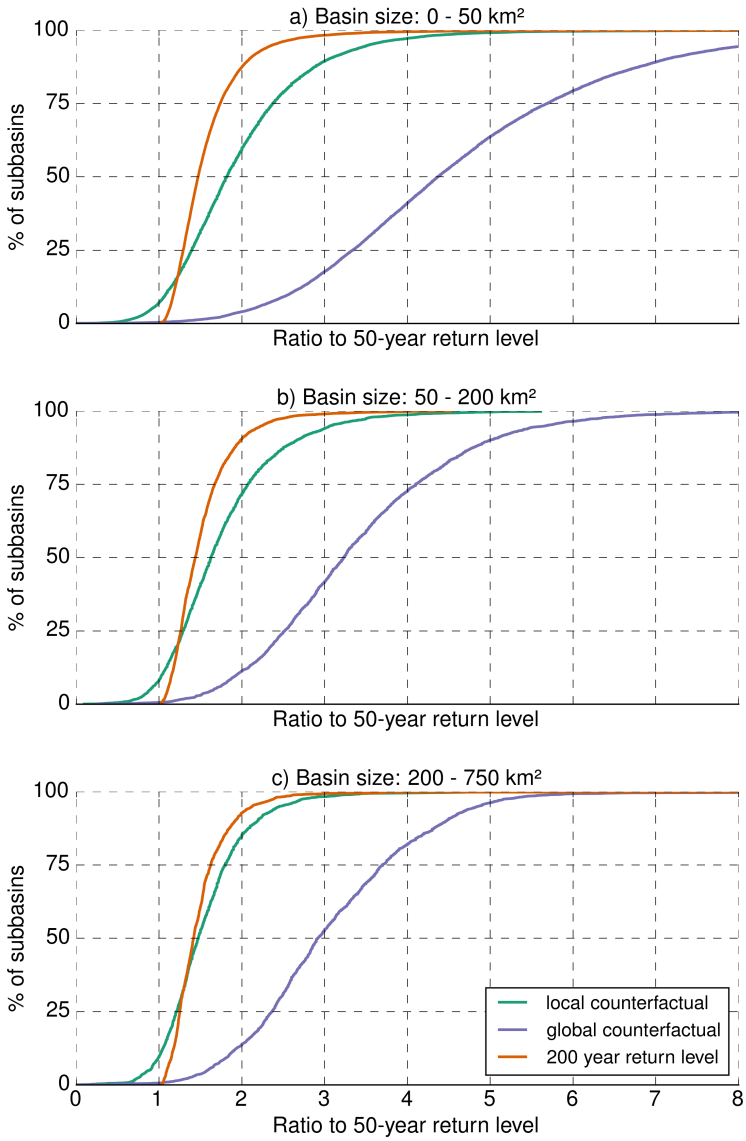

Figure 1: The cumulative density distributions show, for different subbasin sizes [a) <50 km^2, b) 50-200 km^2, c) 200-750 km^2], the ratio between three different discharge estimates and the 50-year return level: (1) the local counterfactual peak discharge (green), (2) the global counterfactual peak discharge (purple), (3) the 200-year return level (orange).

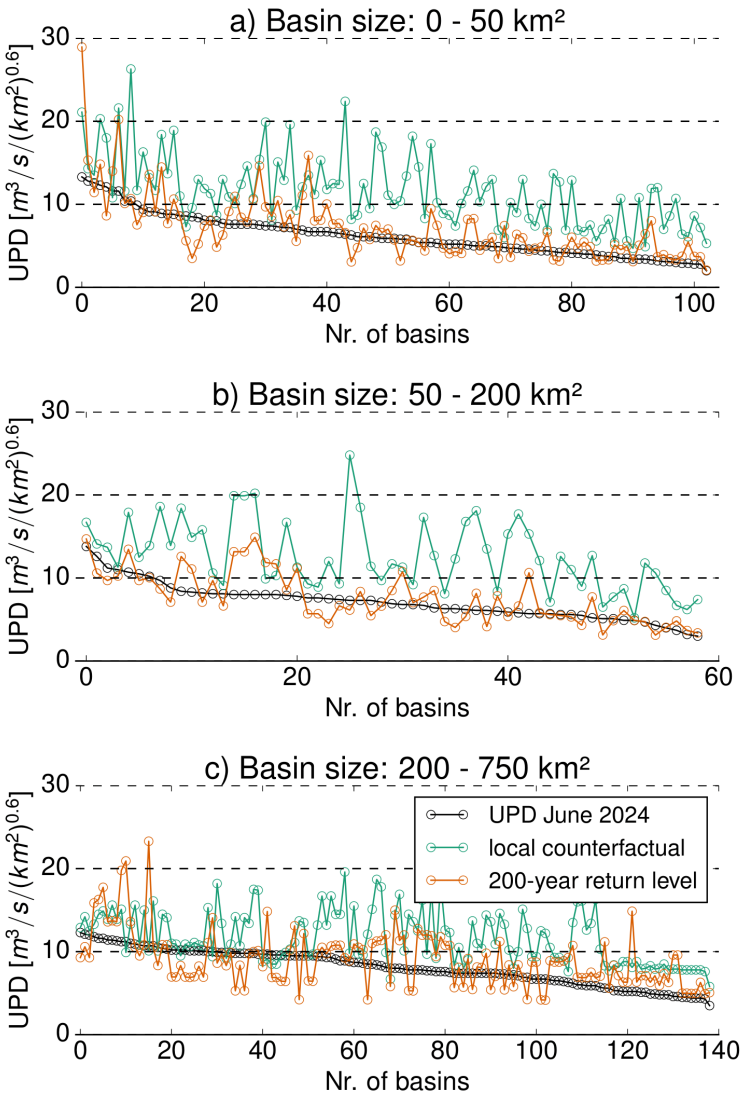

Figure 2: Case study of the recent heavy precipitation event from May 30 to June 4, 2024: the black lines show the simulated unit peak discharge (UPD) of the event for all subbasins within the Danube catchment with a return period > 20 years; for comparison, the green lines show the local counterfactual UPD and the orange lines the 200-year return level estimated from simulations between 2001 and 2022.