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Hydrology and Earth System Sciences
Discussions

Interactive comment on "The role of flood wave superposition for the severity of large floods" *by* Björn Guse et al.

Björn Guse et al.

bjoern.guse@gfz-potsdam.de

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Comment 1 from Reviewer#1: This paper analyses flood wave superposition at 37 confluences in four large river basins across Germany and assesses its role in the severity of flood events. It concludes that flood wave superposition is not the driving factor in the severity of floods for most basins analysed in this study. Overall, I found the paper to be well-written, with a clear set of well-justified analyses supported by some nice figures. The work represents a useful contribution to better understanding the processes that shape the severity of floods across Germany and Austria and I am looking forward to the future work identified by the authors in the conclusions of their study (particularly in terms of different storm tracks which I think would add a lot to this study).

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Discussion paper

Reply 1 from the authors: We thank the reviewer for this positive summary of our work.

C2: I have some suggestions to improve the reproducibility of the study (so that other researchers could more easily apply the methodology to other regions) and strengthen the discussion section of the paper. I also noticed that there is no 'data availability' or 'code availability' sections at the bottom of the paper - the dataset could be a useful resource for other researchers, can you clarify whether the annual maximum flood series could be made available for each of the gauges or if they are available already?

R2: We agree with the reviewer that we should give some information on data and code availability in the manuscript. The discharge data is owned by the German authorities and their transfer is restricted. We are not allowed to make this data freely available without permission. The data is in principle available from authorities upon request or can be obtained from us if the permission from authorities is obtained. In contrast, we could add our code to derive the flood events as supplementary. In addition, we will add this information at the bottom of the revised version of our manuscript.

Main Comments

C3: Section 2.2 – there are a lot of methodological choices in this section that are not well justified/explained. For example, why choose 2% as a threshold for the tributary catchment size? How did you define 'a close distance' between the three gauges (Line 12-13) – did you set a threshold, what is the greatest distance you allowed? This needs to be better justified as these catchment choices affect your results and also affects the ability of other researchers to reproduce your methodology.

R3: In the revised version of the manuscript, we will improve the explanation of the methodological choices. The 2%-threshold was empirically tested. It was investigated which tributary catchment size influences the main river peak discharge. Too small tributaries have no relevant impact since the contributing flood volume is too small compared to the flood volume in the main river. We defined "close distance" in a way that the sum of the upstream and tributary catchment is at least 70% of the downstream

catchment. To make it clearer, we have restructured this paragraph (P.4).

C4: I had to re-read Section 3.1 quite a few times to understand exactly how you derived the flood peaks – it would be useful to include a figure which shows an example of event start point, end point and corresponding maximum flows for each of downstream, upstream and tributary gauges (perhaps you could add this to Figure 3?).

R4: We agree with the reviewer and will add an example in the revised version of this manuscript of how we have derived the events.

C5: While the results were well discussed in Section 4, there was almost no reference to the wider literature or discussion of the limitations. This needs to be strengthened for the paper to be published. In particular a. How does this work fit in with the previous flood wave superposition studies you address in the introduction? Does your analysis agree with theirs?

R5: We thank the reviewer for this comment. We will add a discussion of our approach and of differences and similarities to former studies presented in the literature in the revised version of the manuscript. However, one has to admit that to our knowledge this is a first study that analyses flood wave superposition for a large number of river confluences and tries to identify different superposition patterns. Previous studies mostly focused on the analysis of one or a few confluences and the superposition patterns over time at these specific locations or they looked at potential scenarios that would aggravate flood hazard.

C6: The paper needs a broader discussion of the use of daily data for the analysis and how the results could change with hourly data – this is mentioned a few times throughout the text but is not discussed in detail

R6: We have considered this point in the preparation of the article. We did the same analysis with hourly data for a set of triple points in smaller catchments, e.g. for the sub-catchments of the Mulde river. The obtained results basically support our main

outcomes based on the daily data. In this context, we would like to mention that daily data are available for a long period and a large set of catchments. In contrast, hourly data are only provided for shorter periods and fewer catchments. Thus, we have selected daily data to include the major floods of the last seventy years in order to be able to perform statistical analyses. We will add an explanation on the use of daily data in the revised manuscript.

C7: The applicability of the methodology to other regions – while I like the classifications, they seem to be quite subjective. Did you use any quantitative thresholds/rules to assign these classifications or were they based on expert judgement from the plots you produced?

R7: For us, it is not fully clear to which classification this comment refers to. We assume that it is related to the example of flood wave superposition presented in Figure 3. Here, we present four general possibilities of how flood timing and flood magnitude could impact flood wave superposition. We have selected this figure to introduce our methodological approach and to clarify our intention and facilitate the interpretation of the figures 5 to 7 that are presenting our results. The figures 3 and 4 cover all possible superposition patterns and we believe that they are independent.

C8: There is no recognition of the quality of the flow data or the discharge uncertainty in these results – the most severe flows can be heavily biased due to rating curve errors. It would be good to acknowledge this in the text as these impacts are gauge specific, vary significantly in time and could impact the results, particularly when ordering by event size.

R8: We agree with the reviewer that high flow data are uncertain. However, in using discharge data for the same gauge, we can assume that the uncertainty at one location is similar for different events. Thus, we do not expect that the ordering of events would change significantly when having “perfect” discharge data. Moreover, we do not expect a high impact on our study, since we discuss several events jointly and we are

more interested in overall patterns than in single event results. However, we will add a comment in the revised manuscript on data uncertainty and how it might affect (or not affect) our results.

Minor Comments

C9: P3 L14 – I was confused by the 'and data resampling', do you mean data resampling of the catchment elevation? How was it resampled?

R9: We will clarify this point in the revised version of the manuscript. As the background for the map (Fig. 1), we used an elevation map from the mHM model. For this application, the DEM was resampled to a suitable resolution for the model. This point is a graphical aspect and only refers to the map. It has no impact on our methodological approach.

C10: P12 L25. I think you should say here that 'Flood wave superposition is not the major driver for flood peak occurrence downstream of most confluences analysed in this study', as there may be other catchments where this is the case (and this is still a relatively small sample of gauges).

R10: Changed

C11: Figure 3 – It would be more useful to show 'real examples' from the flow time series for each of the four case studies rather than the stylised examples which are not overly clear.

R11: We have selected these stylised examples to present the four possible options of matching or mismatching of flood wave superposition in time and in magnitude. As said before, the intention of this figure is to present our idea. To make our intention clear, we prefer to keep the stylised examples.

C12: Figure 4 – can you add a legend denoting the colours for the different time lags, you state in the caption that grey corresponds to zero lag, but it is not clear what the blue and red colours relate to. Alternatively can you add to the figure caption that blue

means the tributary peak arrives earlier and red vice versa.

R12: We will add a legend to figure 4.

C13: Figures 6 and 7 – what are the units for discharge? These should be included in the axis labels.

R13: We will add units.

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