Response to the interactive comments to the manuscript **hess-2019-523**

"Flood trends in Europe: are changes in small and big floods different?"

by Miriam Bertola, Alberto Viglione, Julia Hall and Günter Blöschl

We reproduce in the following document all the comments of the Referees in *italic characters*, followed by our answers.

Referee #1: Dominik Paprotny

The manuscript "Flood trends in Europe: are changes in small and big floods different?" analysed changes in return periods of extreme river discharges between 1960 and 2010. The study is largely a follow-up to "Changing climate both increases and decreases European river floods" by Blöschl et al. (I will refer to it, for brevity, as the "Nature" paper). This doesn't compromise the novelty or importance of the submission, which is overall a well-written and important contribution. I have three major comments, and some very minor points.

> We want to thank the Referee Dominik Paprotny for the time he spent on our manuscript and for the useful and constructive comments. We have carefully considered and addressed all his comments in the following.

Major comments:

1. The analysis in section 3.2 includes the uncertainty ranges of the trends, but their ranges look in most cases proportional to the magnitude of the trend. I therefore find it not informative. It would be much more clear if instead of showing the uncertainty, to providing information whether the trends are statistically significant (at alpha of 0.1, or 0.05) by recolouring cells with insignificant trends grey. The text in section 3.2 could then be adjusted accordingly to the modified figures 5 & 6. The problem needs to be addressed as in the Nature paper as much as 72% of station trends were found to be insignificant. Also, in some areas the large uncertainty comes from the very limited number of stations. Though the stations are shown in Figure 1, a supplemental figure with the number of stations included in each 600 km box could be added, maybe even separately for large and small catchment sizes. This extra figure(s) is only a recommendation.

> We thank the Referee for raising this issue; we understand it deserves additional explanation and changes to the manuscript. In the Authors' opinion, it is more informative to show the uncertainty associated with the estimated regional flood trends (represented in figures 5 and 6 through the width of the 90% credible bounds), rather than discarding the statistically not significant trends. This is because, on the one hand, we are interested in showing the absence of the trend when it is associated with small uncertainties (i.e. cells where the estimated trend is close to zero and the credible bounds are narrow). In this case, the trend would result as statistically not significant from a trend test and the corresponding pixel would be shown in grey, as for those pixels where there is not enough information to reject the null hypothesis. In reality we have accurate information about the absence of the trend. On the other hand, when the estimated trend is statistically significant, but it is associated with very large uncertainties (e.g. in figure 5 in eastern Europe), we are interested in showing how much this estimate is uncertain (i.e. the width of the credible bounds). For these reasons we do not think that redrawing Figures 5 and 6 with grey pixels will improving them. However we will add to the text the number of pixels for which the 90% credible bounds do not include the value of zero trend, which is analogous to performing a trend test with alpha 0.1 (even though, strictly speaking, null-hypothesis significance testing is not a tool of Bayesian statistics). We will update section 3.2 accordingly.
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> As the Referee correctly says, there is a tendency of having larger uncertainties in the regions where the trend magnitude (in absolute value) is larger. The Authors believe that this is due to extrapolation of the trends to catchment sizes not well represented in these regions, which results in large flood trend magnitudes (in

absolute value) which are indeed very uncertain. According to the Referee's suggestion, we will add one extra figure showing the number of stations in each cell, with a distinction of catchment size.

Furthermore, thanks to this comment we understand that figures 5 and 6, as they are, drive the attention of the reader to the stronger trends only (represented by the darker colours), without giving the right weight to the uncertainties (represented by the white circles). We will try to produce an alternative representation of figures 5 and 6 that better balances between the importance of the two type of information, i.e., the estimated flood trends and their uncertainties.

2. The analysis in section 3.3 includes three manually derived regions, which creates several problems. For one thing, no proper explanation for the choice is given. The Nature paper is cited as the source, but that paper also gives no real explanation apart for the attempt for homogenic regions (elliptical and overlapping for some reason). The other cited reference, Kotlarski et al. (2014) shows very different regional divisions (and not "not dissimilar" – btw. please avoid double negation). The regions omit, according to Table 1, one-third of stations in Europe, including most of the Danube catchment and northern Europe. Further, for some reason, the number of stations in each region is different than in the Nature paper, despite the ellipses being the same and the total number of stations as well. In summation, the authors should make a new derivation of regions, preferably based on actual geographical divisions of Europe (Fennoscandia, East European Plain, etc.), Koeppen's climate zones or drainage divides. Alternatively, cluster analysis could be used for this purpose. This would provide better connection between climate, topography and observed trends.

In the Nature paper, the 3 elliptical regions were identified by visual inspection of the flood trend patterns and by the selection of large homogeneous regions in terms of changes in the mean annual flood discharges. In this study (which, as the Referee correctly says, is a follow-up of the Nature paper), the same regions are selected because of consistency with this previous publication. Section 3.3 shows, in fact, changes in flood quantiles and the effect of catchment area for the 3 elliptical regions, that were found to be homogeneous in terms of changes in the mean annual flood discharges. We will clarify this by better explaining the reason for this choice in section 2.3. Moreover, we will correct the sentence with the double negation at line 158-160.

We thank the Referee for noticing the difference in terms of number of stations in each region in table 1. We will correct the table and reproduce figure 7 with the correct number of stations. We will also follow the Referee's suggestion to repeat the analysis of section 3.3 with pre-defined climate zones and we will add this analysis to the manuscript, if meaningful outcomes are found.

3. Not really a comment on paper, but an important question to the authors nonetheless. The authors provided an online dataset, and I noticed that it was updated recently in order to fix the errors in station coordinates. I wonder whether those errors affected the paper's results and figures in any way, and whether they could account for the difference between the number of stations in Table 1 and the Nature paper. I suggest the authors check their data and code to ensure that there is no data-processing error present in their paper.

We thank the Referee for spotting this and allowing us to check. The correction of the released flood data did not affect our analysis, as we used the original data. This correction was about an error occurred while producing the csv file for the public release.

Minor comments:

Title: the study deals with floods understood as extreme river discharge, rather than floods as occurrence of losses. I know that's the hydrological vs natural hazards perspective issue, but even in HESS, the title could be more precise by mentioning "Flood discharge trends" rather than "Flood trends".

We understand the Referee's point of view; we will clarify and emphasize in the abstract the fact that this study analyses river flood discharges. However, we would like to keep the original title.

L4, L41, L128: the flood database is mentioned as "newly-available", but it has been compiled 4 years ago already. If it wasn't released publicly recently, the "newlyavailable" moniker should be removed.

In the manuscript (L41 and L128) we cite an article about the compilation of the flood database (i.e. Hall et al., 2015) which was, at that time, ongoing. The flood database was instead publicly released in August 2019.

L20-21: please correct this sentence, it's very ungrammatical.

We will rephrase the sentence.

L41-L44: when referring to the Nature paper, the names of regions from this submission are used instead of the Nature study. Especially the location of the "Atlantic" region, used throughout (including the abstract), is unclear until section 2.3.

We will revise the manuscript and the abstract, in order to make sure that the locations of these three regions are clear to the reader from the beginning. We will additionally change the naming "Atlantic region" into "North-western Europe".

Section 2.1: the similarity report noticed some overlaps in text with the author's other recent paper, which is not cited. Some comment in the section whether the presented methodology was used before or not would be beneficial.

The main similarity with the Author's other recent publication is in the description of the tool used (i.e. rstan). Thank you for noticing it; we will rephrase the sentences at lines 119-122.

L134-135: the authors repeat the explanation of station selection from the Nature paper, but given the methodological differences between the papers, I think the need for more even spatial distribution is much reduced here. Maybe some better explanation would do here.

Since this work is a follow-up of the Nature paper and complementary analyses are presented, we should be consistent with this previous study by analysing the same flood data, in order to produce comparable results. We will better explain it in section 2.2.

L216: "British-Irish Isles" should be replaced with "British Isles", as this term encompasses Ireland.

We will correct it.

L410: the reference to the Nature paper should be updated, as it is no longer "under review".

Thank you for spotting it. The reference has been updated.

I am looking forward to the authors' revision of their paper.

We want to thank the Referee for his comments that will help to improve the quality of the manuscript.

References:

Hall, J. *et al.* (2015) 'A European flood database: Facilitating comprehensive flood research beyond administrative boundaries', *IAHS-AISH Proceedings and Reports*, 370, pp. 89–95. doi: 10.5194/piahs-370-89-2015.