Climate of the Past Discussions

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Comment on cp-2021-160

Anonymous Referee #2

Referee comment on "Influence of warming and atmospheric circulation changes on multidecadal European flood variability" by Stefan Brönnimann et al., Clim. Past Discuss., https://doi.org/10.5194/cp-2021-160-RC2, 2022

The authors identify a “long-lasting conundrum” in the literature such as past flood-rich periods occurred mostly during cold conditions, while more floods are expected with the ongoing global warming. They develop an approach aiming to explore changes in the atmospheric conditions (dynamic versus thermodynamic processes) that could explain these distinct patterns in flood activity in Europe. The scientific question is highly relevant as e.g. flood projections still encompass large uncertainties, partly because how the climate change may regionally modify flood hazard is still unclear. The study is rather well designed and the paper well written. However, i) the “long-lasting conundrum” as presented here is not fully consistent, ii) the objectives and the way of proceeding for some treatment / analyses need clarifications and, most importantly, iii) the findings partly rely on visual analyses, limiting the robustness of the conclusions. These points are detailed in the comments below.

Main comments

1. The “long-lasting conundrum” (section Abstract and Introduction)

The authors introduce a “long-lasting conundrum” with the increased occurrence of floods during past cold periods and the expected increase of floods in the future with the climate change. This relies on the comparison between historical / paleodata and projections. However, the comparison is limited by differences in i) the time scales, ii) the studied catchments and iii) the return period considered. For instance, changes in flood activity from paleodata are mostly observed at longer timescales than those discussed here (centennial versus decadal). Paleodata also come from very small catchments (a few km²) compared to those studied here or those studied with historical data and projections (> 1000 km²). Floods discussed in historical and paleodata are characterized by high return periods (>10-100 years), while the authors discussed here annual flood events. All these differences may result in a large range of flood-prone hydrometeorological processes and, thereby, in various responses in flood variability to the same climate change. This may easily explain this "long-lasting conundrum". In addition, the authors only use 1 reference about flood projections (l.55), while many other studies have been published and show large differences even in the sign of the change (some of these references are used l.421-422). Thereby, selecting another one may also show a decrease in flood activity under warming conditions. The authors may more convincingly use the recent findings of Blöschl et al. (2020, Nature) to introduce this "conundrum" – indeed, they showed that past flood-rich periods occurred under cooler conditions, while the most recent one occurred under warm conditions with a more homogenous dataset.

2. Treatment / analyses that need further explanations and/or quantifications

Discharge data (l.72-74) - The authors apply many treatments to the discharge data without explaining the rationale behind. This needs clarification. I am also wondering why the authors do not use the raw data instead of this kind of index of "flood intensity", especially when this provides similar results as stated.

Precipitation data (l.88-90) - The authors chose 2 precipitation indexes (Rx5d and Rx20d). Again, there is neither a rationale nor reference to explain why the authors chose 5 and 20 days. The sizes of the studied catchment areas are very different and floods may be triggered by rainfall events of different durations. In addition, why a short and long duration? What do these two indexes represent here? This also needs clarification. At the end, only the Rx5d is used in the analyses.

Flood seasonality (Fig. S1 and l.93 and following) - The authors perform a selection to get a set of cold- and warm-season floods, assuming they mirror distinct, regional hydrometeorological processes. The considered seasons are here long of 6 months. Why 6 rather than 1 or 3 months needs to be explained. The authors also discard 5 flood series because their triggers may include e.g. snow processes (l116-117). However, much more series do not show a good correspondence between the highest values in the precipitation indexes and the highest occurrence of the annual peak streamflow (Fig. S1), suggesting that almost half of the series represent mostly floods triggered by a mix of processes in which precipitation is not a dominant driver. Or that the chosen precipitation indexes are not the most relevant. The selection process of the series is thereby questionable.

Correlation test (l.248 and following, Fig. 4) – A correlation test (but which one is not indicated) has been performed between peak streamflow and Rx5day (why not also with Rx20d?). Among the results shown (8 rivers among 43?), the values are rather low for most of them (< 0.35). First, results for the other results should also be shown in e.g. a table in Supplementary Material so that the reader can have an overview of its relevance. Second, the general low values suggest that precipitations explain only a small part of the variability, limiting the relevance of the following analyses to explain changes in flood variability. This point is not discussed. About the correlation between CONV5d and peak streamflow, it is only assessed visually, while it is a key link for the following analyses. Similarly, the respective contributions of the circulation change, water vapour change and interactions on changes in the annual peak streamflow is also based on visual "correlation" (l. 294 and following; Fig. 5). Therefore, the findings mainly rely on visual comparisons, strongly limiting their robustness. Instead, we expect that a correlation test as well as a significance test to be applied systematically to each correlation discussed and supporting the findings.

3. The relative contribution of atmospheric processes to changes in peak streamflow

The authors stated that periods with higher flood intensity prior to 1950 are mainly due to circulation changes, while the period with higher flood intensity after 1950 is more related to changes in water vapour changes. However, looking at Fig. 5b, the contribution of circulation changes is also increasing after 1950, better mirroring the increase of CONV5d than water vapour changes. Therefore, a quantification of the respective contributions of atmospheric processes to changes in CONV5d is really needed to objectively assess them. In addition, the authors state that this explains why flood-rich periods have been mostly observed during cold periods in the paleodata. However, large changes in temperature have also been reconstructed over the last millennia. So, we may also expect that changes in water vapour played a role further back in time?

Minor comments

L.117. The authors removed five series. They should name the series they removed.

- 173. Typo: "in order to"

l.180. Why 5 days? What this duration correspond to?

l.221. The authors may refer to Fig. S1 instead of S2?

l.227. Typo "such less pronounced peaks"

- 230. "1919-.. exhibit low values)". This is unclear.
- 248. "at 4-yr aggregation" again, why 4?

Fig. 4 and S4 are very similar. So, Fig S4 could replace Fig. 4.

Fig. 7. Why the 80 members are not shown here? What is the curve, the mean of the 80 members?

Fig. S1. The way the seasonality is identified is sometimes misleading since there is not always a correspondence between the six months of high precipition and high discharge. Thereby, for some series, months with the most frequent annual peak flow are not considered.

Fig. S3. Why these series are excluded from the analyses?

Fig. 1a. Why the numbering of the discharge series starts by #2 (instead of #1)?

SI Table 1: why the cluster column is empty? If so, it can be removed.