Response to the interactive comments to the manuscript **hess-2020-600**

# "Characteristics and process controls of statistical flood moments in Europe – a data based"

by D. Lun, A. Viglione, M. Bertola, J. Komma, J. Parajka, P. Valent and G. Blöschl

Here we reproduce all comments of the Referee in *italic characters*, followed by our answers

## Kolbjorn Engeland (Referee)

*The paper provides a comprehensive analysis of a dataset of annual maximum floods covering all Europe and aims to discuss how process controls can explain the spatial patterns of mean annual floods and the coefficient of variation (CV) of floods. The paper comes in a line of papers analysing floods at a European scale (Blöschl et al., 2017; Hall and Blöschl, 2018; Blöschl et al., 2019 and Blöschl et al., 2020). Whereas the previous papers have investigated trends in time, this paper has a clear focus on the spatial patterns. This provides therefore new knowledge and is complementary to the previous papers. The paper is well written and could in my opinion be published after some minor revisions.*

> We thank Kolbjorn Engeland for the time he spent on our manuscript and for the useful and constructive comments that will help improve the quality of the manuscript. All his comments are reproduced and addressed in the following paragraphs.

*Lines 38:48: This is because a large basin is less likely to be fully covered by a thunderstorm than a small basin which tends to reduce the variance of extreme catchment average precipitation and thus the MAF (Viglione et al., 2010a, b).*

*I would suggest to add one sentence discussion that there is a transition from convective thunderstorms to long duration stratiform precipitation as catchment size increases (see e.g. Figure 13 in Merz and Blöschl, 2003). This phenomena is also well studied in literature on area reduction factors for extreme precipitation.*

> We plan to add the following sentence:
>
> Convective events, limited in duration and spatial extent, are most relevant for producing floods in small catchments with fast response times (Gaál et al., 2015), whereas long duration stratiform precipitation becomes more relevant as catchment size increases (Merz and Blöschl, 2009).

*Section 2.1 Data: Some more sentences could be added about the data. 1: Are the data from natural catchments not influenced by river regulations ? Do all flood data represent floods caused by rain and/or snow melt, or are there other types of floods like ice jam floods in this dataset ?*

> The data has been described in Blöschl, Hall et al. (2019) and more extensively in Hall, et al. (2015). A sentence will be added, citing these studies and addressing the referee's comment:

The time series were manually checked for strong human modifications such as reservoirs (Blöschl, Hall et al., 2019 and Hall et al., 2015) and include both rain floods and snowmelt floods (Kemter et al., 2020).

*Figure 1: You could discuss more if and how your choice of regions influenced the results. I guess that if the aim as to have the best possible predictions of mean annual flood in ungauged basins, you would investigate more in detail how Europe should be divided into sub-regions.*

This is a very good point. We plan to add the following sentence to section 2.2:

The aim of the partitioning was to represent a small number of contiguous regions that are to some extent hydro-climatologically homogeneous, without considering their effect on predicting flood moments.

We also plan to add the following sentence to section 4.3:

The results depend on the regional partitioning of Europe and will look different for different regions. If the aim of the study was optimal predictive performance of the regional models, the partitioning could be derived based on the data, for example via cluster analysis or regression trees (see e.g. Laaha and Blöschl, 2006).

*Line 143: Please specify units of Qi and catchment area.*

Units will be added in the text.

*Equation 5: Since you use multi-letter symbols for variables, it is difficult to see where the multiplication sign is located. Either you should use only single-letter symbols, possibly combined with subscripts, or use the multiplication symbol to make the equation easier to read.*

Thank you for pointing this out. We feel that using the three-letter abbreviations for the variables makes it easier to follow, so multiplication symbols will be added.

*Lines 167-169: What is the equation for calculating the radius ?*

We plan to add the following text:

It is calculated as the Euclidean distance between the origin and the mean flood date (mean of the sine and cosine of flood dates in polar coordinates), for more details see e.g. Burn (1997). The point (0,1) on the unit circle refers to January 1st, with clockwise rotation representing progress of the year, therefore polar coordinates as described in Breinl et al. (2020) were used.

*Line 180-181 Could you be more specific on which variables were log-transformed and why ?*

A sentence like the following will be added explaining which variables were log-transformed and motivating the choice:

MAF, CV, A and P95 were log-transformed, as their distributions were skewed.

*Line 206-207: Probably better to use past tense here.*

We will use past tense here.

*Table 2: The regional cv is listed in the table, but not commented in the text. I suggest that you add some comments in the text.*

We plan to add the following comment to the text:

The regional coefficients of variation in Table 2 (every other column) reflect the within-region variability of the observed flood moments. They are generally higher for MAF and $MAF_{\alpha}$ than for CV, both within individual regions and for all of Europe.

*Line 225: 'however' could be removed here*

We will remove 'however' from the sentence.

*254: is k the same as the radius defined on lines 167-169 ('The length of the vector from the origin is a measure of the variability of the date of occurrence, ranging from 0 (uniformly distributed across the year) to 1 (all events on the same day).' ? Then maybe k could be defined in the method section.*

Yes. A reference on how the radius was calculated will be added to the methods section, where the radius will be introduced as k.

*Kemter et al (2020) is missing in the reference list.*

Thank you very much for pointing this out. The reference will be added.

*Line 313: 'which may mask causal relationship'. Do you think that also spurious correlations might be a challenge?*

Yes, we think spurious correlations also are a challenge when interpreting correlations between flood moments and their process controls. Spurious correlations that are not meaningful and probably occur purely by chance could be the correlations for soil texture (Stex), because they are inconsistent with the existing literature. Alternative covariates, that are representative of the runoff generation processes, such as the HOST classification in the UK (Lilly et al., 1998), could provide a remedy for this. Spurious correlations that arise due to an indirect relationship between attributes are for example those between the fraction of forested area (LUF) and MAF, given that densely forested areas tend to be high elevation regions with higher rainfall depths (Lines 603-609). We believe we have already addressed these issues in the paper.

*Figure 5: Maybe one extra point to add: The sign of the correlations listed in Figure 5 might depend on the domain you investigate, and the sign might change between sub-regions of Europe. E.g in the Scandinavian countries, it is a negative correlation between elevation and LUF.*

We have analyzed the correlations among attributes also for all regions separately and indeed they vary between regions. However, we have chosen not to add them for space reasons.

## References:


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