Reply to the Editor

Dear authors,

many thanks for handing in the revised version of your manuscript on flood hazard maps for Europe. The paper has now been seen by two referees which only raise a few final comments, which should be addressed before the paper can be accepted for publication.

Especially the points of Referee #3, regarding key assumptions of the analysis should be considered since they directly affect the quantitative aspects of the presented data-product.

We thank the Editor for this additional review effort. Please find below a detailed reply of the points raised by Referee #3. Furthermore we have amended the manuscript as suggested by Referee #4.

Reply to Referee #3

General remarks:

I thank the authors for addressing my comments on the previous version of this manuscript. While I think that most of my comments have been satisfactorily addressed, I would like to insist on two points I find insufficiently addressed despite their importance.

Major points:

1. Distribution choice: Applying a goodness-of-fit test to the distribution used in a frequency analysis is essential. Using a 2-parameter distribution instead of a 3-parameter distribution for parsimony considerations is ok but only if the 2-parameter distribution captures the distribution of the observed floods. I still miss such a goodness-of-fit assessment in the revised version of the manuscript. The single fact that someone else has used a certain distribution for a specific application before does not necessarily make it a good choise for a specific data set.

We have added a dedicated section in the Appendix (B2) to evaluate and discuss the goodness-of-fit of the Gumbel distribution. We have also included the findings of this additional analysis in the discussion of the validation exercise (lines 425-426, 465-466, 605-606).

Appendix B2: "Here we evaluate the performance of the Gumbel distribution in fitting the available reference discharge values (26 annual maxima calculated for all the grid points of the LISFLOOD long-term run). Specifically, we compare the empirical and fitted distributions of streamflow annual maxima using the Cramer-von Mises test (Anderson, 1962), and we calculate the average differences between reference and fitted discharge values. Table B2 summarizes the resulting p-values over the study area. Figure B2 compares empirical and fitted distributions in two locations of the rivers Rhine and Danube. (…) P-values reported in Table B2 suggest a low skill of the fitted Gumbel distributions; however, the resulting *uncertainty in the estimates of discharge maxima is generally below 25%, as shown in the examples in Figure B2. This is considered acceptable because the reference discharge maxima are modelled and not observed values. Due to limited sample size, it is not possible to evaluate the extrapolation error for peak flows beyond the available sample; however, previous studies suggested the suitability of the Gumbel distribution. Cunnane (1989) stated that the Gumbel distribution is effective for small sample sizes, whereas the Generalized Extreme Value (GEV) distribution shows a better overall performance if the size is greater than 50. More recently, Papalexiou and Koutsoyiannis (2013) found similar results for extreme precipitation values. In particular, they demonstrated that short record lengths affects the estimation the GEV shape parameter, and thus the choice between a two-parameter (Gumbel) and a three-parameter GEV. Di Baldassarre et al. (2009) observed that the Gumbel distribution might estimate flood extremes with high return periods (e.g. 100-year) with smaller errors than other distributions, if the available sample size is small. Further research could use longer observed streamflow series to compare different extreme value distributions across European regions, similarly to what done by Villarini and Smith (2010) for the eastern United States and Rahman et al. (2013) for Australia."*

2. Design hydrograph construction: The assumption of a triangular hydrograph where the peak occurs in the centre of the hydrograph seems unrealistic as we know that flood hydrographs are asymmetric (more something like 1/3 vs. 2/3 instead of ½ vs. ½). Using a more realistic assumption for the temporal evolution of the event is highly recommended.

We apologize with the Reviewer the imprecise description provided here. We constructed the design hydrographs following the Chicago Hyetograph methodology, as proposed by Maione et al. (2003)". According to this approach, the hydrograph peak QT is placed in the centre of the hydrograph, while the other values for Qi are sorted alternatively. The resulting hydrograph shape is not symmetric or triangular. Instead, it is fully consistent with all the empirical values of the flow duration curve, taken with a daily step. We revised the text in lines 166-173 accordingly.

Additional References

Anderson, T. W. (1962). "On the Distribution of the Two-Sample Cramer–von Mises Criterion" (PDF). Annals of Mathematical Statistics. Institute of Mathematical Statistics. 33 (3): 1148–1159. doi:10.1214/aoms/1177704477. ISSN 0003-4851.

Cunnane, C. (1989). "Statistical Distributions For Flood Frequency Analysis". Operational Hydrology Report no. 33, World Meteorological Organization

Di Baldassarre, G., Laio, F., Montanari, A., 2008. Design flood estimation using model selection criteria. Physics and Chemistry of the Earth 34, 606–611.

Maione, U., Mignosa, P., & Tomirotti, M. (2003). Regional estimation of synthetic design hydrographs. International Journal of River Basin Management, 1(2), 151-163.

Papalexiou, S. M., and D. Koutsoyiannis (2013), Battle of extreme value distributions: A global survey on extreme daily rainfall, Water Resour. Res.,49, doi:10.1029/2012WR012557

Rahman, A. S., Rahman, A., Zaman, M.A., Haddad, K., Ahsan, A., Imteaz, M., A study on selection of probability distributions for at-site flood frequency analysis in Australia. Nat. Hazards (2013) 69:1803–1813 , doi:10.1007/s11069-013-0775-y

Villarini, G., and J. A. Smith (2010), Flood peak distributions for the eastern United States, Water Resour. Res., 46, W06504, doi:10.1029/2009WR008395.