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Discussions

Interactive comment on "On the quest for a pan-European flood frequency distribution: effect of scale and climate" *by* J. L. Salinas et al.

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Response to F. Laio (Referee)

The authors are greatly thankful for the review the referee did, in particular for the very constructive criticism and suggestions made on the Monte Carlo simulations strategies. The proposed approach, and one additional one has been included in the corrected manuscript (see details below). Corrected manuscript(s) will be uploaded within the next days, including the changes cited below. The original referees comments will be formatted in *italics*, and the authors' response in **bold**.

1) The manuscripts contains two papers in one: the first 12 pages are mainly devoted to try to understand if the GEV distribution is a suitable model to represent floods in

Europe, while the remaining part of the manuscript focuses on the control of catchment size and precipitation on the flood distribution. In a time when "salami publications" are the standard, it is a very nice surprise to see that some researchers still try to build up robust and inclusive papers. But unfortunately this also carries some problems, including the fact that the two parts of the paper should be better linked one to the other, and the fact that some shortening could be useful, because there is an high risk that the reader loses attention in the final part. As for the linkage between the two parts of the paper, it is not clear why the Authors decided in the second part to concentrate their attention on a limited part of the database (Austria, Italy and Slovakia) only, instead of using the same data considered in the first part. If these were two different papers, nobody would have argued, because even the subset of the database used in the second part is a large one, but here the discrepancy is rather evident and requires some additional explanation.

Authors' response to 1)

Indeed, there are two differentiated parts in the manuscript. The overall topic is regional flood frequency distributions in Europe, but two different science questions are addressed that could be regarded as independent, as the reviewer has pointed out. Connected to point 3 (details below), a considerable amount of additional analysis has been performed on the "first part" of the paper, in particular a new set of Monte Carlo simulations taking into account, among others, the effect of sample length. Three new plots , two new tables and one subsection are included in the new corrected manuscript. Unfortunately, this substantial extension of the "first part" of the paper could cause, even more strongly, as the reviewer states, that Âńthe reader loses attention in the final partÂż. Mainly for this reason, the authors have decided to split the manuscript in two parts, which are more balanced in length and content: Regional parent flood frequency distributions in Europe – Part 1: Is the GEV distribution a suitable pan-European parent? Regional parent flood frequency distributions in Europe – Part 2: Cli-

mate and scale controls The authors think that now the two parts have even more differentiated and direct science questions with independent conclusions and take home messages. From the technical point of view (following instructions of Ms Topfer from the Copernicus editorial team), the HESSD discussion of the paper that is being reviewed now will continue, and as "post-referee review corrected manuscript", the two parts paper will be submitted. The final decision will be taken by the handling editor. On the choice of the 3 countries for the second database, it is due to the minimum requirements set when compiling the full European database, where only an agreement on sharing the L-moment-ratios was reached. This means that even the very basic catchment descriptors were not available for all the countries, at least for all the stations with L-moments provided. In the second part of the paper, the subset from the countries of the authors' core team is used, as they could provide, at least, MAP and area. A short explanation is added in the corrected manuscript.

2) I would like to see some more discussion about the "quest for a pan-European flood frequency distribution" (title of the manuscript): do we really need a unique probabilistic model to represent European floods? I understand trans-boundary discontinuities may be a problem, but I am also worried about attempts to standardize something which is highly uncertain and largely unknown, as also the present manuscript demonstrates. Maybe it would be also good to preserve some of the "biodiversity" in national procedures, which may be not only due to a lack of communication between scientists working in different countries, but also to an actual need to describe different processes and phenomena (e.g., flash floods in a small catchment in southern Italy versus one-week floods in the Danube river) with different tools, including the use of different probability distributions.

Authors' response to 2) **The authors fully agree with the reviewer. The title could be misleading, as the main outcome of the first part of the manuscript is to reject the GEV as a single pan-European frequency distribution. Also, some examples of**

this process "biodiversity" from the literature are already addressed in the conclusions, making clear that we do not necessarily need one single pan-European frequency distribution; this fact is now stated explicitly in the introduction in the corrected manuscript. The title of the Part 1 manuscript is also less ambiguous in this sense ("Regional parent flood frequency distributions in Europe – Part 1: Is the GEV distribution a suitable pan-European parent?")

3) I am not fully convinced by the simulation strategy adopted to construct Figure 1b (page 6329-6330). In fact, I find it not completely correct to mix together data from samples with highly different record lengths, because this tends to hide the fact that the sample variability is expected to be much larger in smaller samples. I try to explain my point with an example. Consider a set of catchments with L-cs values around 0.3 C2088(expected L-ck=0.2 for the GEV). Suppose to be in a rather extreme situation, where this subset of basins is made up of 100 catchments where the sample size is 10, and other 10 basins where the sample size is 100. The 100 shorter samples have been actually sampled from a GEV, and their observed L-ck will thus be distributed around the expected value 0.2, with a large variability because the sample size is small. The 10 longer samples have in contrast been extracted from another parent distribution, and have their L-ck values distributed around 0.33 with small variability. The simulation will likely not recognize that these 10 series have not been sampled from a GEV, because values of L-ck around 0.33 are included in the range of L-ck values typical of the smaller samples. The null hypothesis that the parent is a GEV would therefore be mistakenly accepted, while it would have been falsified rather easily by separating the samples based on their sample size; in this case, in fact, L-ck values around 0.33 would have been recognized as rather unlikely for GEV samples with L-cs=0.3 and size 100. As an alternative simulation strategy the Authors could consider the following: (i) take one catchment at a time, with its own sample length n, L-cs and L-ck; (ii) generate 50000 samples of size n from a GEV with the same L-cs as the considered sample; (iii) compare the observed L-ck with the distribution of the 50000 L-ck values obtained from the simulation, for example by finding z=P(L-ck), where P() is the empirical cumulative *distribution function of the L-ck obtained from the simulation; (iv) repeat this procedure for each available catchment to obtain a sample of 4015 z values, which could be tested for uniformity to verify the hypothesis that each and every sample has been extracted from a GEV. Different z samples could also be obtained by binning the data based on their L-cs value, as done in Figure 1b. This procedure has the problem that sample L-cs values are used as population values, but this is the same hypothesis adopted when applying the method of L-moments to estimate the GEV parameters, and it is thus well supported in the hydrological practice. Moreover, other ancillary hypotheses, as the choice of the distribution of the L-cs and of the sample size (page 6329, line 15-20), may be avoided with this procedure.*

Authors' response to 3)

a) The analysis requested by the referee, i.e. Âń(i) take one catchment at a time, with its own sample length n, L-cs and L-ck; (ii) generate 50000 samples of size n from a GEV with the same L-cs as the considered sample; (iii) compare the observed L-ck with the distribution of the 50000 L-ck values obtained from the simulation, for example by finding z=P(L-ck), where P() is the empirical cumulative distribution function of the L-ck obtained from the simulation; (iv) repeat this procedure for each available catchment to obtain a sample of 4015 z values, which could be tested for uniformity[...]Âż. These simulations try to test the hypothesis that all stations have been drawn from a GEV distribution, based on their local properties. Three new figures are added to show the results of this analysis. b) Following a similar approach as in the previous version of the manuscript, simulations for the regional behavior of Europe have been performed, but this time stratifying the database in series length classes (under 25yr, 25-50yr, 50-75yr, above 75yr) to clearly assess the the influence of sample length on the L-moment-ratio variability. These simulations investigate the L-Ck dispersion with varying sample lengths, as compared with the one present in the database. Figure 1b) is substituted by a similar one, with the simulation results stratified by length classes.

Both a) and b) lead to the overall same result, the rejection of the GEV as a single pan-

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European flood frequency distribution. For more details, see new text in the corrected manuscript.**The authors thankfully acknowledge the detailed comment of the reviewer on this very technical aspect of the paper. The important influence of the sample length on the sample L-moments dispersion was underestimated and somehow mistreated. Only on the estimation of the averaged L-moment-ratios, the series length was taking into account by weighting each value proportionally to the sample length. Additional Monte Carlo simulations have been carried out, in order to correctly address the effect of sample length in the analysis; two strategies have been applied:**

a) The analysis requested by the referee, i.e. Âń(i) take one catchment at a time, with its own sample length n, L-cs and L-ck; (ii) generate 50000 samples of size n from a GEV with the same L-cs as the considered sample; (iii) compare the observed L-ck with the distribution of the 50000 L-ck values obtained from the simulation, for example by finding z=P(L-ck), where P() is the empirical cumulative distribution function of the L-ck obtained from the simulation; (iv) repeat this procedure for each available catchment to obtain a sample of 4015 z values, which could be tested for uniformity[...]Âż. These simulations try to test the hypothesis that all stations have been drawn from a GEV distribution, based on their local properties. Three new figures are added to show the results of this analysis. b) Following a similar approach as in the previous version of the manuscript, simulations for the regional behavior of Europe have been performed, but this time stratifying the database in series length classes (under 25yr, 25-50yr, 50-75yr, above 75yr) to clearly assess the the influence of sample length on the L-moment-ratio variability. These simulations investigate the L-Ck dispersion with varying sample lengths, as compared with the one present in the database. Figure 1b) is substituted by a similar one, with the simulation results stratified by length classes.

Both a) and b) lead to the overall same result, the rejection of the GEV as a single

pan-European flood frequency distribution. For more details, see new text in the corrected manuscript.

4) In the part of the paper where the controls on the flood frequency curve are inves- tigated, I think some very relevant controls are still missing, in particular regarding the effect of basin elevation and temperature (through snow accumulation and melting) on flood formation. Some of the comments reported in the discussion, in particular re- garding small-size basins, do not seem to consider the fact that small basins are rather frequently situated at high elevation, and these high-elevation basins typically behave very differently of the low-elevation catchments with similar size. For example, the CV is typically smaller in mountain basins, due to the peak-attenuation effect of snow ac- cumulation and melting. Considering also the mean catchment elevation, along with the catchment area and mean annual precipitation, would help disentangle some of the relations between statistical and morpho-climatic descriptors obtained in Figures 4-7.

Authors' response to 4) The authors agree with the reviewer. There are many other significant controls on the flood regimes. In the time of the analysis, only the elemental catchment attributes mean annual precipitation (MAP) and catchment size were available, and actually goes exactly in line with the simplified nature of the approach. From the flood time series, only the L-Cv, L-Cs and L-Ck are available, not the data themselves. From the catchment descriptors, only MAP and area were available as they are more easily and more directly obtainable (results from the survey described in Section 2). Usually mean/median catchment elevation requires additional treatment of the DEM and are not always directly available. Nevertheless, it is true that the interrelationship between elevation, catchment size, temperature and snow effects will be very strong, particularly in the given database, where the presence of mountain catchments in significant. The inclusion of elevation, together with some parametrization of land-use

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will be very encouraging research direction in better understanding the relationships between the statistical properties of flood regimes and morpho-climatic characteristics. An explicit reference to this research outlook is included in the conclusion of the Part 2 manuscript.

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