Interactive comment on "Global warming increases the frequency of river floods in Europe" by L. Alfieri et al.

L. Alfieri et al.

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We thank the reviewer for this positive evaluation of our paper and thoughtful comments. We have modified the manuscript accordingly, and detailed corrections are listed below. In the following each reviewer's comment is answered after the label "Reply:".

General The paper is very well written and presents a detailed analysis of changes in flood risk for Europe using state of the art datasets and analysis methods. By using a grid-based return flow analysis in combination with a consistency check using the covariance between models, the authors really well present the projected changes and their related uncertainties for the whole of Europe. Although the results are not very

unexpected it is good to see that the projected changes obtained by earlier studies are confirmed by this study based on downscaled model runs of the latest IPCC report. Overall this paper lies within the scope of HESS and is after minor revisions ready for publication.

Specific comments - Section 3, line 2: The authors refer to 1990 as the baseline climate and 2020 as a future climate, while 2020 is much closer to today. For more practical applications, changes compared to 1990 are of limited relevance. Why were these years chosen and can you say something about the implications of choosing 1990 as reference iso of today.

Reply: EURO-CORDEX scenarios are produced by running all climate models till 2005 with historical emission levels. From 2006 onwards, different scenarios are run, corresponding to different RCP, by forcing the atmosphere with specific concentration pathways (in the chosen setup RCP 8.5). For this reason the baseline scenario (i.e., "1990") corresponds to the 30-year time span ending in 2005 (i.e., 1976-2005), while the future climate (2006-2100) has been divided into three 30-year windows spanning 2006-2035 (referred to as "2020"), 2036-2065 (i.e., "2050") and 2066-2095 (i.e., "2080"). Note that the names of the four time slices (i.e., 1990, 2020, 2050, 2080) simply corresponds to the median year of the corresponding range of years. To clarify this, Sect. 2.1 will be adapted in the new article version to stress that only years after 2006 can be referred to as future scenarios with RCP 8.5, while years prior to 2006 are historical scenarios forced by past climatic emissions. Also, in Sect. 3, we clarified that the names of the four time slices are taken from the median year of each 30-year periods, meaning that "1990" refers to the time window 1976-2005 and similarly for the other three time windows.

- Is equation 1 correct? It seems that for larger changes, higher $x_{f,I}$, the CV values will be higher – this could be the case for ensemble consistent projected discharge decreases in southern Europe. Should it be the differences / variation between the $x_{f,I}$ values obtained for the different scenarios?

Reply: We thank the reviewer for spotting the mistake in how the equation was written. Indeed the root mean square error of the relative change was erroneously shown as numerator in Eq. 1, instead of the standard deviation. We have corrected it in the new article version. We care to stress that this was only a mistake in the formula written in the article, while all analyses performed and shown were already done with the correct formulation.

- In section 3.4 the authors introduce the use of peak flows with return period of 2 years. Is for the analysis of the future discharges the historical / base discharge value of the 2 year return period used as well?

Reply: Yes, indeed the results shown in Sect. 4.3 refers to peak discharge values extracted by the historical and future time series, taking only discharge values exceeding the 2-year frequency values from the corresponding historical runs (i.e., Q2).

- Figure 3 is said to display the warming since pre-industrial conditions. Why do you refer to pre-industrial conditions. I do not believe that in 1970 the LSAT warming was zero compared to pre-industrial conditions.

Reply: In Sect. 4 of the revised version we will clarify that "the warming refers to pre-industrial conditions for consistency with IPCC studies". The value of a specific year (e.g., 1970) can be around zero or even lower, due to interannual climate variability, but a long term average around 1970 would probably show higher values. This is not shown as years before 1970 were not considered in our study. Note that temperature values were not processed but are simply those of the original EURO-CORDEX scenarios.

- Section 4.3: what is meant with country aggregated estimates of f100 ? How was this calculated?

Reply: In the revised version we will specify that "Values are obtained by counting the average frequency of occurrence in all grid points of the river network within each

country." This is done to increase the sample size of events and in turn the robustness of the frequency estimates.

- Discussion, second page, line 3: the authors state ' the region subject to decrease in Q100 looks shifted'. Is there an explanation for this in the precipitation fields?

Reply: Following the reviewer's comment, we will clarify that this shift southward is referred to the analysis by Rojas et al. (2012), which was made with a different set of climate projections (SRES scenarios). Hence, we prefer not to speculate on the cause of this shift, given that for the presented work we have only dealt with EURO-CORDEX climate projections.

- Discussion, third page, line 6: 'model consistent climatologies can provide a bias correction effect'. What is meant here? I do not agree that one can state that showing consistency results in bias-correction.

Reply: We will modify this sentence to stress that this finding is related to previous applications in flood early warning and not from this work. Also, we replaced "bias correction" with "calibration" as it's the word specifically used for such applications. We have also added another recent reference by Diomede et al. (2014) to support this statement.

Technical corrections: - Page 2 line 8 should read implications of iso implications between - Figure title Figure 1 replace text by main text or manuscript. - Section 4.1 second page, line 28: 7 scenarios have a 'significant' decrease - Table 2 what does Ne stand for and what is its unit? Reply: Corrections will be amended as suggested. Note that Ne in Table 2 is the number of simulated historical events above 100-year return period. This will be clarified by modifying a sentence in Sect. 4.3.