Hydrology and
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Discussions

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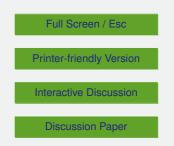
L. Alfieri et al.

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We thank the reviewer for his useful comments and the overall positive evaluation of the article. We have modified the manuscript accordingly, and point by point corrections are listed below. In the following each comment is answered after the label "Reply:".

General Alfieri et al. present a well-written manuscript, and as referee #1 has stated, it is state-of- the-art in terms of methods and data. Using Euro-CORDEX regional climate model data, a comprehensive view on flood risk in European catchments is presented assuming drastic climate change by the choice of RCP 8.5 scenario simulations. Although uncorrected climate scenarios are fed into the hydrological model, relative changes are likely represented well in this study. Projected changes are com-

pared to previous studies and especially the analysis of flood frequencies under climate change is more convincing compared to the analysis flood peaks given the uncertainties of today's climate models. In general this paper is written very professional and straight-forward. After some minor revisions this paper can be accepted for publication in HESS.

Major issues Chapter 2.1 – You need to reason why you have chosen RCP8.5 and why you chose this set of climate scenario runs!!!

Reply: We agree with the reviewer's comment that this point is worth some further words of clarification. In the Introduction of the revised version we will add that "Chosen climate projections are forced by Representative Concentration Pathways (RCP) 8.5 W m-2, to simulate the effect on the projected river streamflow of high-end emission scenarios corresponding to the exceedance of 4°C globally by the end of the current century (Stocker et al., 2013)." In addition, in Sect. 2.1 we will add that "The seven models were chosen among those available in mid 2014, giving priority to models with driving GCM with high ranking in the performance evaluation of CMIP5 models carried out by Perez et al. (2014)."

P 1123 line 23f – How was the model extended? What is the effect? Can you cite some description of this?

Reply: The sentence will be slightly modified to "The latest developments on the European setup. . ." as it was misleading. Indeed, the model code was not changed for this work. We used the same model but added some features already existing in the Lisflood model code, to enable a better representation of hydrological processes. For example, the lake routine is a standard option of Lisflood and it is well documented on its user manual cited in the article. For these simulations we collected information on a number of large European lakes to simulate more appropriately the inflow-outflow processes. Similar work was done for some large reservoirs and for water use.

P 1128 line 1f – You produced a lot of discharge maps, but why? Isn't this produced by

LISFLOOD? Why is this technical detail important here?

Reply: Lisflood produces output discharge maps but doesn't extract peaks over threshold. To my knowledge there is no standard routine that does it on a map stack as in this case. That's why we developed a specific routine which works spatially and is computationally efficient for large datasets as in this case. We thought it would be worth mentioning (although it's not pure science) because it's a novel application and the implementation was not trivial and took quite some time.

Figure 8 – The authors take some lines to explain the graphs and how exceedances can be extracted from this. Yet, to me this presentation of the main results of this paper is not intuitively readable. Hence, I propose to change the diagrams to show exceedance probabilities instead of cumulative distribution functions for a better communication of the main results of this paper.

Reply: We acknowledge that the proposed graph type is not commonly used, and it can take some time to understand how to interpret the values shown. However, we have done different tests to plot such results and we believe that this representation is the most suitable for our purpose, mainly for two reasons: 1- The use of cumulative distributions enables the cumulation of small values and differences through the probability (and return period) range, making it possible to overlay and compare different time slices on the same graph. Other visualization methods not based on cumulative frequencies made the comparison very difficult, particularly for our case where ensembles (polygons) are shown instead of deterministic (lines) projections. The alternative option to improve the visualization, in case exceedance probabilities are shown, is to plot the frequencies on the y axis in logarithmic scale, but then values become difficult to read, particularly when they are not on labelled lines on the y-axis. 2- The current visualization style allows the reader to assess the distribution of events above the 2-year flood by breaking it down into the corresponding components of low and high probability events, and to compare the behavior of curves for different time slices. Currently the description of this graph and how to interpret the results is shown on about 2 pages

in Sect 4.3, therefore we prefer not to add extensive parts to this description. However, following the reviewer's suggestion, in the revised version we will adapt the text by adding some examples of interpreting the graph's values, trying to make the graph interpretation more easily understandable.

Minor issues P 1120 line 24 – Please give some citation for your statement "Yet, regional implications between ongoing global warming and future precipitation and runoff patterns are still under investigation, especially when extreme events are considered."

Reply: Relevant reference will be added as suggested.

P 1121 line 29 – change 'into' to 'fed into'

Reply: Amended

P 1121 line 29 – Please give citation for "the quality of bias corrected output scenarios strongly depends on that of the observational dataset used for correction."

Reply: This sentence was meant to comment on the resolution of bias-corrected datasets. In the revised version it will be deleted and this concept will be included in the subsequent sentence: "Further, a number of processed datasets are produced at spatial resolution coarser than the original one, to conform to the available gridded observations, thus limiting the range of applications at the small scale."

P 1126 line 22 – "it is commonly used in flood hazard estimation" - Where? Do you have some more sources than Hall et al. 2005 and your own paper?

Reply: To strengthen the statement above we have added reference to the works by Di Baldassarre et al., 2010 and by Merz et al., 2008, relative to flood hazard estimation in Austria and in England, respectively.

Figure 4 – You should reverse colours in the top row, because your colours are counterintuitive!

Reply: The colour scaling used follows closely what is used in a num-

ber of European and national hydro-meteorological centers. See for example the bimonthly bulletin of the European Flood Awareness System (https://www.efas.eu/utilities/efas-bulletins.html), the radar estimates of precipitation by MeteoSwiss (http://www.meteoswiss.admin.ch/home.html?tab=rain), by the American NOAA (http://radar.weather.gov/Conus/index_loop.php), and by the Catalan Weather Agency (http://www.meteo.cat/observacions/radar).

Figure 5 – I am quite surprised to see such high extremes in RCM generated data. Maybe a word on this would be great!

Reply: Following the reviewer's comment we will add in Sect. 4.1 the sentence "It is worth noting in Figure 5 how maximum point accumulations (in blue shades) give a measure of the models sharpness and of their ability to represent extreme values way larger than climatological averages, yet compatible with realistic observed past values (see e.g., WMO, 2009, Sect. 5.7)."

References

Di Baldassarre, G., Schumann, G., Bates, P. D., Freer, J. E. and Beven, K. J.: Floodplain mapping: A critical discussion of deterministic and probabilistic approaches, Hydrol. Sci. J., 55(3), 364–376, doi:10.1080/02626661003683389, 2010.

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Perez, J., Menendez, M., Mendez, F. J. and Losada, I. J.: Evaluating the performance of CMIP3 and CMIP5 global climate models over the north-east Atlantic region, Clim. Dyn., 1–18, doi:10.1007/s00382-014-2078-8, 2014.

WMO: Guide to Hydrological Practices, 6th edition, Volume 2, 2009.

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