

Hydrol. Earth Syst. Sci. Discuss., referee comment RC2
<https://doi.org/10.5194/hess-2022-243-RC2>, 2022
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Comment on hess-2022-243

Lina Stein (Referee)

Referee comment on "Widespread flooding dynamics under climate change: characterising floods using grid-based hydrological modelling and regional climate projections" by Adam Griffin et al., Hydrol. Earth Syst. Sci. Discuss.,
<https://doi.org/10.5194/hess-2022-243-RC2>, 2022

Widespread flooding dynamics changing under climate change: characterising floods using UKCP18

The authors present a study on flood changes under climate change in the UK. The focus lies specifically on changes in modelled flood return periods based on an ensemble climate projection. The main point of analysis is the changes in widespread flooding. The authors find that there is more widespread flooding in winter and less in summer in the future projected climate. Further analysis included changes in return period, area covered and duration of events between current and future climate.

Overall, I like that the article focuses specifically on simultaneously occurring flood events under climate change. The analysis and results presented here show thorough, good work. I would have wished for a bit more focus on how the uncertainty of the climate ensemble translates into the results and more discussion of the results regarding potential drivers of change. While I have lots of comments and open questions, all of them are minor and should be quick to address.

Introduction:

Since a large part of your results section talks about spatial dependence, can you motivate this analysis in the introduction? Especially since several people have already written about flood coherence/synchrony (Brunner et al. 2020) including results for the UK (Berghuijs et al. 2019).

Methodology:

Can you elaborate on why you chose the Grid-to-Grid model for this analysis and how well it performs in streamflow/flood prediction under the current climate? This would allow some estimate how reliable future projections might be.

I like that you thoroughly elaborate on your choice of thresholds regarding POT and inundation extend. Can you supplement this with a sentence along the lines of "Widespread events are defined as...".

Can you elaborate more on the method chosen for asymptotic dependence and, more importantly, elaborate on what that means? I have not encountered this method before, nor did I understand by the end of the paper, what it actually tells me. If you are interested in using an established method, I can refer you again to the papers by Brunner et al, (2020) or Berghuijs et al. (2019). Their results should also be discussed in line 254 since it relates to your proposed further work.

Results:

There seems to be a mix between results and discussion in the results section (e.g. lines 184-190 are discussion, not results). You could either call the results section "Results and Discussion" or move any discussion from the results section to "Discussion and Conclusion". Generally, the discussion could be more elaborate (see below).

You quite often talk about an "increase in the range", "little change", "less asymptotic dependence", "extend slightly". Can you support these statements with numbers?

Line 205: "On the right of some panels (future winter and autumn) is a set of events with a peak return period of at least 1000 years." From what I see, all panels have events up and over a return period of 1000 years.

Even though you use a climate ensemble as input data for the hydrological model, the presented results mostly do not give an overview of the uncertainty the different climate projections introduce. Can you please give an indication of how the ensemble spread

demonstrates uncertainty in the results? Especially since you state in the abstract: "Results were consistent across ensemble members, with none showing significant difference in distribution." Since the two main conclusions are about the seasonal shift and spatial dependence, the results in Figure 3 are not enough to support this statement across all findings.

Figure 2: Can you include in the caption what the percent inundation refers to? Is this percent grid cells or percent land area?

Figure 3: I would prefer if you would present a summary figure for the different model ensembles. After all, since the ensemble runs represent uncertainty, only presenting, comparing and analysing individual ensemble members does not make sense.

Figure 4: Since you are using ensemble results, can you include uncertainty bars into the event count? Secondly, the caption says that you take the sum of all ensemble results. I would think that the mean or median (and potentially even the range) is the more appropriate measure. This is the case for Figures 5 and 6 as well.

Figure 5+6: Is there a specific reason why you have return period once on the x-axis and once on the y-axis? If not, I would recommend choosing one or the other, not both.

Discussion:

Although the analysis itself does not focus on drivers of change, there have been several published articles on how hydrology and specifically floods are changing in the UK. I think the discussion would benefit from discussing the results of this study in the context of previous findings. For example, there is a projected increase in winter atmospheric rivers in the UK which are likely to bring widespread flooding (Lavers et al, 2013). Furthermore, floods in the UK are strongly associated with soil moisture timing (Blöschl et al, 2017). Do changes in the soil moisture influence in the increase/decrease of widespread flooding in the UK?

General comments:

There seems to be an issue with your referencing system. I found at least three references cited in the text to be missing in the reference list (Coles, 2001; Jiminéz Cisneros et al, 2014; and Paz et al, 2006). I did not check all of them, so there could be more. Furthermore, the reference list is not always sorted alphabetically (e.g. Robson et al and Rudd et al should be before Sayers et al) and some references do not start on a new line (e.g. Chen et al.).

Data availability: What is EIDC?

There are missing spaces in lines 201, 223, 225, and 227, and an "s" missing in asymptotic in line 218.

Line 181: There seems to be a word missing after "widespread".

References

Berghuijs, W. R., Allen, S. T., Harrigan, S., & Kirchner, J. W. (2019). Growing spatial scales of synchronous river flooding in Europe. *Geophysical Research Letters*, 46(3), 1423-1428.

Blöschl, G., Hall, J., Parajka, J., Perdigão, R. A., Merz, B., Arheimer, B., ... & Živković, N. (2017). Changing climate shifts timing of European floods. *Science*, 357(6351), 588-590.

Brunner, M. I., Gilleland, E., Wood, A., Swain, D. L., & Clark, M. (2020). Spatial dependence of floods shaped by spatiotemporal variations in meteorological and land-surface processes. *Geophysical Research Letters*, 47(13), e2020GL088000.

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