Reviewer 2

- 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).
    - On line 39 we add the following: "… more frequent and severe. Spatial coherence of flooding events – whether flood timings at different locations have become more correlated – is of key interest to national-scale actions to mitigate the associated loss. The dependence structure of river flow has been analysed on a Europe-wide scape (Berghuijs et al., 2019) and focusing on the United States (Brunner et al., 2020), focusing on synchrony of events within a given range."

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.
    - We will add some further information to Section 3.1 about previous studies using Grid-to-Grid, which has been widely tested and applied to explore climate change impacts on river flows across GB, including for floods and droughts (Bell et al., 2009, 2012; Kay et al., 2018; Rudd et al., 2019, Kay 2021, Lane & Kay 2021), and which is also used by the Environment Agency for flood forecasting in England (Price et al., 2012).
- 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…".
    - Agreed. We add the following at line 95: "We define widespread events as timepoints for which a large number of locations experience very high flow (i.e. above the POT threshold) simultaneously."
- 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.

- The measures of asymptotic dependence are well established but often misunderstood. To alleviate this, we edit the text at line 136 to the following: "…are calculated between pairs of points. For two points i and j, $\chi_{ij} = \lim P[Q_i > x \mid Q_j > x]$ as $x \rightarrow \infty$. If $C^*(u,v) = 1 - u - v + C(u,v)$ for a copula between two points i and j, then $\chi^* = \lim 2 \log(1-u)/\log(C^*(u,u))$ as $u \rightarrow 1$. Chi describes the level of asymptotic dependence, if chi == 0 then the variables are asymptotically independent, otherwise they are asymptotically dependent. In the asymptotically independent case, chibar describes the dependence for large but not asymptotic values of flow. In the asymptotically dependent case, chibar == 1."
- To comment on both panels of Figure 7, we change the sentence on line 220 to: "The figure suggests that asymptotic dependence decreases as distance increases. In the asymptotically independent case (Figure 7b), we see a similar pattern in dependence for large values of flow, with high dependence at short distances, even if they are independent in the limit."
- On line 254, we add the following: "…event length determination. Brunner et al. (2020) make use of a spatial dependence function (F-madogram) and hierarchical clustering to determine events for which points are mutually dependent to a sufficient degree. This would be an interesting direction to go in to improve event identification. To highlight spatial dependence in a simpler way than χ, Berghuijs et al. (2019) use a metric of flood "synchrony", measuring how often extreme floods occur at the same time within a given radius of a target point. The gridded data set we have available here could be evaluated using this metric, or one like it."

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).
  - We will call it Results and Discussion.
- You quite often talk about an "increase in the range", "little change", "less asymptotic dependence", "extend slightly". Can you support these statements with numbers?
  - We will add percentage changes where appropriate throughout the results and the discussion, and add change in χ and χbar as well.
- 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.
  - We change this sentence to "We see that in all seasons are a small number of events with return periods exceeding 1000 years, particularly in winter and autumn."
- 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.
  - Aside from Figure 3 which is already split by ensemble member, we can easily include uncertainty bounds on Figure 4, and include some measure of variance in Figures 5, 6 and 7 through adjusting transparency (alpha), where low variance is shown by a stronger colour, and high variance by fainter colours. Including upper and lower bounds in addition would result in a lot of extra figures, or much more complex ones, at a cost to readability. At line 177 we replace the sentence "In the rest of this section, the event sets …" is replaced by "In

the rest of this section, ensemble members are treated as separate sources of equal weighting. Variance between ensemble members is indicated in figures by brightness, and the colour indicated the median value of the respective statistic amongst the ensemble members.

- Figure 2: Can you include in the caption what the percent inundation refers to? Is this percent grid cells or percent land area?
  - We add the following on line 160: "The percentages show refer to the percentage of the number of river grid cells, not a fraction of UK 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.
  - As mentioned above, we can add uncertainty bounds to Figure 4, and add levels of variance to figure 5-7. However, Figure 3 is important to highlight that we have not erroneously included ensemble members which differ significantly from the others. The specific statistics are covered more broadly in the subsequent figures, so we feel adding to this information-heavy figure would reduce readability.
- 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.
  - See above for our response on this
- 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.
  - This is a formatting choice. In Figure 5, duration is much narrower in range than return period, so the heat maps have a "vertically" stretched profile. Conversely, the key features in figure 6 vary more by return period, and so again, due to the number of panels, the order was chosen to keep the figures clear.

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?
  - We will add a couple of sentences to the discussion (at line 244) to provide some context for our results, in terms of projected changes in precipitation seasonality, soil moisture etc., referring to Kay et al. (2022) which discusses soil wetting dates

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.).
  - Understood and we will correct and check this at the typsetting stage.
- Data availability: What is EIDC?

- EIDC is “Environmental Informatics Data Centre”. We will edit this sentence.
- There are missing spaces in lines 201, 223, 225, and 227, and an “s” missing in asymptotic in line 218.
  - We will correct this.
- Line 181: There seems to be a word missing after “widespread”.
  - The missing word is “events” which we will correct.

References

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