Hydrology and Earth System Sciences Discussions

Hydrol. Earth Syst. Sci. Discuss., referee comment RC1
https://doi.org/10.5194/hess-2022-243-RC1, 2022

Comment on hess-2022-243

Rory Nathan (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-RC1, 2022

General Comments

The overall concept of this paper is neatly done: a 12-member ensemble of baseline and future climate (12 km resolution) is input to a grid-based hydrological model (1 km resolution) to characterise the impact of climate change on flood events. The strength of the paper is in its focus on areal flood events, where the joint interaction between the factors that cause floods over a range of temporal and spatial scales is implicitly accommodated by the use of a gridded daily continuous simulation model. All inferences about changes to flood risk are made using 30-year sequences of daily floods, as derived from the 12-member ensemble of climate projections. Differentiating impacts by the areal extent and duration of floods of varying severity is novel, as is the exploration of possible changes in their spatial dependency.

There are, however, some aspects to this work which are potentially problematic, and these need to be addressed by further explanation and/or revision.

Specific Comments

The key issues that I am struggling with are as follows:

- It is difficult for a dynamically downscaled rainfall products to reproduce rainfall quantiles over the temporal and spatial (meso-) scales relevant to catchment flooding, and I was surprised to read (lines 62-63) that "due to the focus on … extremes rather than the whole regime in general" that no bias correction was applied. Bias-correcting

projected extremes is as important, if not more important, than a central tendency measure. The rainfall-based simulation of floods is critically dependent on the correct representation of the frequency distribution of areal rainfalls, and I think it important to provide evidence that the frequency of areal rainfall extremes derived from the UKCP18 data compare reasonably well with observations. To this end, providing evidence that distributions fitted to n-day maxima extracted from UKCP18 (preferably for a range of areal extents relevant to the adopted spatial limits) are reasonably consistent with those based on observational data. I searched for any such evaluations in the Met Office documents (the citations provided for these need to be improved and corrected in the manuscript) but I could not find anything specifically relevant to the rainfall behaviour of most interest.

- On the basis of the information provided it is difficult to be comfortable with the reported probabilities of exceedance (PoE). In concept the approach of adopting a merged CDF on the basis of empirical and fitted distributions is fine, my difficulty is with the inferred annual PoEs. I suspect that there is a problem with the way that the Poisson approximation is applied, and I suggest that the authors compare (or replace) their analysis with the more straightforward approach based on fitting the GPA distribution to the POT2 series, where the annual quantiles are obtained by the simple expedient of factoring the exceedance probabilities by N/M, where N is the number of years in the record and M is the number of maxima extracted. The key reason for my discomfort with the PoEs reported is the severity of the identified events. For example, in Figure 2 it appears that 3 (possibly 4?) events with return periods of 1000 years have been observed in a single 30 year sequence. I appreciate the need to consider the influence of spatial dependency and the trading space for time issues here, but still, this number of extreme events is higher than expected (and higher than I suspect would be extrapolated by Tawn et al, 2019). A crude estimate of the likelihood of this could be obtained by estimating the notional number of largely independent catchments across the UK. If we adopt a spatial dependence limit of 120km (from line 220 in the paper) then the notional upper limit of the spatial extent of an event might be around 45000 km^2, which yields around 5 or so independent catchments (or "trials") in each year. Given that the likelihood of a 1 in 1000 event occurring in a 30-year period is 0.029 (from the Binomial distribution), then there is about a 13% chance you would see a single 1000-year event in one of the five independent catchments somewhere across the UK in a 30-year period. However, we would actually need to have around 50 independent catchments in the UK to see three 1000-year events occurring in a 30-year period with any likelihood, and this corresponds to an asymptotic dependence limit of only around 40km, which is very low given the information presented in Figure 7. The number of exceedances shown in Figure 5 is larger again, but this may be due to how the ensemble members are combined (discussed in the next point).
- If my understanding is correct (lines 175-177), the 12-member ensemble from UKCP18 has been lumped together and used in the preparation of the results as summarised in Figures 3 to 7. I think this approach confounds the absolute interpretation of the reported frequencies and return periods, and I suggest that it would be more useful to treat each ensemble member as a source of aleatory uncertainty over a 30-year period. Thus, rather than reporting, say, that there are 17 events larger than 1000-year event in DJF (Fig 5) under baseline conditions, it would be more useful to report on the average (or median) frequency/quantile across the 12-member ensemble, where the highest and lowest ensemble member provides an indication of the upper and lower bounds of the sampling uncertainty in each 30-year period.
- Lastly, no discussion is provided on how the asymptotic independence metric varies with distance (lower panel, Figure 7). I think the metrics used by Coles to explore asymptotic behaviour would benefit from additional explanation here as they are not intuitively obvious; specifically, the way in which the independence metric is defined is easily misinterpreted and without explanation it appears odd that the degree of independence is decreasing with increasing distance, which is exactly the opposite of what one would expect (and as shown in the dependency metric in the upper two

panels of Figure 7, which is consistent with intuition).

Rory Nathan
Department of Infrastructure Engineering
University of Melbourne