

Hydrol. Earth Syst. Sci. Discuss., author comment AC2
<https://doi.org/10.5194/hess-2021-321-AC2>, 2021
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Reply on RC2

Rosanna A. Lane et al.

Author comment on "A large-sample investigation into uncertain climate change impacts on high flows across Great Britain" by Rosanna A. Lane et al., Hydrol. Earth Syst. Sci. Discuss., <https://doi.org/10.5194/hess-2021-321-AC2>, 2021

Response to Reviewer 2. Review comments have been included in **bold**, with our responses to each comment below.

RC: I reviewed the manuscript "A large-sample investigation into uncertain climate change impacts on high flows across Great Britain" by Lane et al. The main goal of this work is to present climate change impact projections on high flows for GB including climate model and hydrological model parameter uncertainties. There is nothing substantially new in this study: national scale studies already exist, studies with more options considered for each step of the modelling chain exist, and studies with a more thorough evaluation of the uncertainties exist. Overall, the study has some potential. Unfortunately, some methodological choices are questionable and do not reflect the state-of-the-art. Namely, the fact that one RCP only is used, one GCM only is used, that periods are not 30-year long and the reference period overlaps the "future" of RCPs is disturbing. Some figures are not properly introduced (I am not sure I understood well what is presented based on the captions). To summarize, I must say I failed to learn new insight neither on a methodological point of view nor on the future of GB floods (as one GCM and one RCP are used only). In addition, I second all comments from reviewer 1. Below are my major remarks, as well as miscellaneous minor or moderate points to tackle.

Response: Thank you for taking the time to review our paper and for your feedback, we have responded to all of the comments below. We disagree that we do not present anything substantially new. This study provides the first spatially consistent GB projections including both climate ensembles and hydrological model parameter uncertainties.

RC: A single GCM is used. I was very surprised to discover that the authors made the choice of using a single GCM. That's a rather unusual set up for this analysis: GCMs account for a large part of uncertainties in hydrological projections! The justification that comes at lines 145-147 (I understand it as the will to only sample the warmer range of possible climate outputs) is not convincing to me: another GCM, with a rather similar temperature pattern, might result in a very different precipitation evolution in the future - not all GCMs will result in intensified precipitation with similar spatial patterns, intensity and seasonality. As a consequence, the use of this single GCM might be interesting to estimate the warmer range of future temperature, but not at all to estimate the future

range of hydrological variables!

Response:

We defer to the same responses we provided to Reviewer 1.

The aim of this study was to explore hydrological model parameter uncertainties within a national climate impact study. We selected the UKCP18 climate projections to help us meet this aim as they have many advantages over other products, including 1) they were the nationally recognised highest resolution RCM climate model outputs available for a continuous run period over GB, 2) they were specifically developed for the UK and previous UKCP products have formed the basis of UK climate policy (Murphy et al. 2018), 3) they include a measure of climate uncertainty through the use of an RCM ensemble, 4) as RCM projections they are high resolution (12km) and have full spatial and temporal coherence which is needed for a spatially distributed hydrological model, 5) they are the newest national climate projections for GB, including the latest developments in climate modelling capability and scientific understanding, and have not yet been comprehensively analysed in other studies.

The UKCP18 projections only included RCM simulations for a single GCM, but still explored some climate uncertainties through the use of an RCM ensemble. This approach was also used for the UKCP09 climate projections which have been used in many UK climate impact studies (e.g. Prudhomme et al. 2013, Bell et al. 2016, Kay et al. 2018). The RCM ensemble was considered sufficient for our aim of assessing the hydrological model uncertainties within a national climate impact study. Importantly, we also found that minor differences between the RCM runs resulted in a huge variation of hydrological implications, showing that the RCM parameterisations which may be expected to be less influential were crucial after all. We are aware that the use of a different GCM would produce differing results, and we mentioned this in our discussion (lines 445-452). In response to all reviewers commenting on the use of a single GCM, we will clarify why the UKCP18 product was chosen in section 2.3. We will also make the limitations of this clearer in the discussion, adding that other GCMs may result in different precipitation trends into the future.

UKCP18 also only included RCM projections for the RCP8.5 scenario. We considered this the most important scenario to look at for two reasons: 1) it shows the 'worst case' and so will most likely show the largest expected changes, 2) the emissions in RCP8.5 are in close agreement with historical total cumulative CO2 emissions and more and more are looking like a plausible future (Schwalm et al. 2020). But again we recognise that our results would have been different if an alternative scenario had been used, and we acknowledge that it is best to use multiple scenarios if the information is available. In response to reviewer comments, we will 1) add a sentence to section 2.3 emphasizing that the RCP8.5 was the only available scenario and gives a 'worst case', 2) expand on the discussion of missing uncertainty sources to include emissions scenario and the impact this might have.

RC: Choice of the study periods. The authors state that "changes in flow metrics between the baseline (1985 –2010) and future (2050 –2075) periods were evaluated.". Why these choices? These are quite unusual for several reasons:

- the baseline contains 5 years with "future" GHG emission trajectories (2006-2010)**

- the periods do not cover the classical 30-year period used to estimate climatology (WMO recommendation)**

In addition, nowadays many studies assess the impact of climate change over the whole future period, using moving windows, which is a clear step forward as it allows to identify emergence times and trends.

Warmup period: Line 233: I find this justification rather disappointing. There are

many ways to avoid throwing 5 years of climate data during the pre-RCP period (i.e. < 2005):

- using RCM data < 1981 for warmup (but I understand that it was not made available by Met Office, which is very surprising as most climate models usually start in 1950 or 1970 at least)**
- using observed climate data from <1981 for warmup**
- recycling RCM data from 1981-1985 for obtaining 1981 initial states**

Response:

The 25-year baseline and future periods were selected to allow the maximum distance between the baseline and future.

The choice of a 1985-2010 baseline was due to 1) the need for a long model spin-up period as this is required for some catchments in the south-east of England, 2) the choice to have baseline and future periods that were at least 25 years long.

Thank you for your suggestions on how to reduce the need for a long model spin-up, we will consider these options for future work and of course would have used RCM data pre-1981 if it had been available. You are correct that the 2006-2010 climate data does include an element of predictive information, but 1981-2010 is the standard baseline of the WMO and is offered as an alternative baseline for users of the UKCP18 products (Murphy et al. 2018).

We agree that moving window analysis enables an interesting analysis of trends, and will consider this for future work. However, our aim was to present a national overview of potential changes using a spatial model, and this is easiest to visualise using baseline and future time-slices.

RC: Partially wrong assertions: Line 331: This assertion is partially erroneous for me. The sources of uncertainties depend a lot on the indicator that is studied. This is not necessarily true for low flows, as shown in more recent studies as those cited by the authors.

Response: Thank you for highlighting this and for your suggested references, we agree with your comment. We will amend this sentence to "RCM parameters were a larger source of uncertainty in median and high flow changes than hydrological model parameters (see Figure 6). This finding agrees with previous studies that have investigated high flows, which generally find climate models to be the largest source of uncertainty in hydrological climate impact assessments (Addor et al., 2014; Bosshard et al., 2013; Kay et al., 2009)."

RC: In addition, RCPs also represent an important source of uncertainty that is not considered in this study.

Response: See our response to the 'A single GCM is used' comment above.

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