Hydrol. Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/hess-2019-474-SC2, 2020

Hydrology and Earth System Sciences
Discussions

Interactive comment on "Ubiquitous increases in flood magnitude in the Columbia River Basin under climate change" *by* Laura E. Queen et al.

Laura Queen

queenl@oregonstate.edu

Received and published: 14 February 2020

We are grateful to Reviewer 3 for taking the time to perform this review and for noting the effort required to conduct this thorough assessment. We address below the reviewer's concerns.

"My first concern is the use of GCMs and not RCMs."

We have several responses to this concern.

1) Large ensembles of RCMs are rare. The 12-member NARCCAP ensemble (6 RCMs, 4 GCMs), completed a decade ago, remains the largest, but has a spatial resolution of only 50km. CORDEX North America now has a comparable-size ensemble, but mostly still at 50 km (some at 0.22°), and was not available in such large numbers

when we began our hydrologic simulations. At such spatial resolutions, RCMs would still have to be further downscaled and bias corrected to use in our hydrologic models (∼6km spatial resolution). Thus, RCMs are not necessarily a vastly better solution.

2) RCMs certainly have their place in such work and were used in some previous studies noted in our paper. But this dataset was developed in order to sample a larger climate space than is possible with RCMs, which must be driven by GCMs anyway and were too resource intensive to run to generate the 40 different climate scenarios used here.

3) Our ANOVA analysis (Figure 8) shows that the climate scenarios contribute a majority of the variation among results for most of the basin. Consequently, it is of great importance to sample the climate scenarios. Using RCMs would constrain us to a much smaller range of climate scenarios.

4) The flood events for the Snake and Columbia have a significant snowmelt component. As a result, the value of simulating hydrological processes well probably exceeds the additional value of RCMs in simulating daily rainfall compared to the MACA approach which links large-scale flow to local processes through a constructed analogs approach.

5) The mere fact that an alternative approach exists should not mean that the current approach, which has substantial backing in the literature, is rejected. Using RCMs would be an entirely different study, with (as noted above) its own weaknesses.

"My second concern is the use of an analogue based downscaling approach which may be compromised in its ability to represent unseen extremes"

The MACA dataset has been in wide use for nearly a decade while undergoing improvements since Abatzoglou and Brown (2011), and although other approaches exist, the most recent improvement on MACA (LOCA, the approach used in the most recent National Climate Assessment) also uses constructed analogs. In short, this approach

is still the benchmark. Points 4 and 5 above are relevant here too. Alder and Hostetler (2018) compared MACA and LOCA and found they gave similar results in hydrologic modeling.

"Alternately the authors must try to capture some novel question in their analysis that may shed light on processes elsewhere. For instance, a significant portion of the flow in the Columbia comes because of melt. Additionally, it is well known GCM simulations are not very reliable in the context of precipitation. Is there a research question in how one could downscale snow and rain using GCMs in a way snowpack dynamics for the current climate period are well represented? Additionally, how this downscaling would comapre [sic] with the higher spatial scale simulations from RCMs over the study region. There may be other questions too that could be of interest. Given the work the authors have already done, I urge them to identify such questions and change their presentation to addressing these instead of reporting overall changes in the basin."

The mechanisms of flooding in the upper Columbia and elsewhere are a key question arising from this work, and we agree with the reviewer that further investigation is merited. While beyond the scope of this paper, we have other papers in process that address some relevant questions: Chegwidden et al (in review) look at the processes that contribute to sensitivity of flood magnitude to changes in climate, and they assess how climate change will alter high streamflow events by both changing the prevalence of the flood generating process and the magnitude of differently generated floods. They present an analysis of changes in high streamflow events, classifying the events according to their underlying mechanisms, and compare how the different kinds of high flows respond to changes in climate at the annual scale. They find that snow will play a diminished role in generating high flows in the future. High flow events will switch to being caused by precipitation events, which they find are also more sensitive than snowmelt-driven events to increases in precipitation.

We contend that our approach is novel: the reviewer has not pointed us toward, nor could we find, a paper in the literature that uses such a large climate-hydrological en-

semble to comprehensively characterize the changes in flood magnitude over a basin, let alone while systematically presenting the dependence of results on climate scenario, location/hydrological characteristics, and other factors. Our ANOVA results, and plots distinguishing the variation across climate scenarios and hydrology scenarios, are all unique in the literature as far as we are aware. Moreover, the very purpose of this dataset – to inform international treaty negotiations – sets it apart from standard academic research. The reviewer's other suggestions to investigate snowpack dynamics or to use RCMs, are considerably beyond the scope of this paper.

In conclusion, we contend that our dataset and our approach are sufficiently state-of-the-science to merit publication, that HESS publishes papers of similar novelty and geographic focus, that RCMs are one (but not the only) acceptable tool for scientific studies such as ours, and that in the absence of similar work by others, which Reviewer 3 has not furnished, our work is novel.

References

Abatzoglou, J. T., & Brown, T. J. (2012). A comparison of statistical downscaling methods suited for wildfire applications. International Journal of Climatology, 32(5), 772-780.

Alder J R and Hostetler S W 2019 The Dependence of Hydroclimate Projections in Snow-Dominated Regions of the Western United States on the Choice of Statistically Downscaled Climate Data Water Resour. Res. 55 2279–300

Chegwidden, O., D. Rupp, and B. Nijssen, 2020: Upstream processes determine flood response to climate change. Environmental Research Letters, in review.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2019-474, 2019.