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Discussions

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

Anonymous Referee #2

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This paper reports on a new study of the effects of climate change on flood risk in a mountainous river basin that builds substantially on previous published work in the field.

There are several advances in this study over previous work that make it an important contribution to the growing understanding of this problem. In particular, compared to earlier papers, this study uses 1) more recent global climate model simulations, 2) a new statistical downscaling method that better represents daily variability, 3) a suite of hydrologic models to better represent uncertainties. Overall, results are consistent with the previous understanding of flood risk changes in river basins where flooding is snow-melt driven, rain driven, or transitional. Some important difference are seen, however, particularly in the trend for increased flood risk in all regimes, where earlier studies

found decreased risk in some basins. Also, the use of multiple hydrologic models and multiple climate modes provides important insights into the relative importance of uncertainty in climatic and hydrologic processes in different domains.

As with all papers on regional climate change, the paper focuses on a single geographical region. However, the general principles are universal to understanding climate change in regions of complex topography and so, like any regional climate study, is helpful to scientists studying climate change in many other regions worldwide.

Based on these consideration, I find the paper to be a substantive contribution and well deserving of publication subject to revisions outlined below.

I find no major errors in the paper and the relevant literature is properly cited. There are a few issues raised in the paper that I felt were left unresolved. I raise these more as a matter of discussion than as mandatory revisions.

On Page 7, l 193, the authors describe the behavior on the Snake as surprising. I would argue rather that is is the upper Columbia that is surprising. The increase in flood ratio along the Snake is consistent with the shift of snow-dominant to transient basins described in Hamlet and Lettenmaier (2010) and so forth. I found the large flood ratios found in the coldest parts of the Columbia surprising, and this is partly where this study diverges from Tohver et al (2014). I'd like to see more explanation of the Upper Columbia; it's hard to see how the effect of temperature alone could explain this, and there must be an increase in the snowpack at the head waters. The effects of temperature and precipitation could potentially be discerned by comparing changes in discharge timing and intensity (Fig 9) – if intensity changes with out a change in timing, precipitation changes are likely the cause. Results at TDA suggest a longer less abrupt melt season in the future in contrast to CRNIC.

I'd like to see some comparison in the results section to Tohver at al (2014) rather than leave it for the conclusions. Their fig 5 (flipped on y-axis) is essentially the same as your fig 3. Results are essentially the same for rain basins, but you find more consistent increases for transient and snow basins. Pointing this out here helps show the continuity and newness of these results.

p 8: This section brings a lot of fresh insight, and I'd like to see a little more. In particular, given the interesting result of high flood rations in the Upper Columbia, it would be interesting to understand what's different about models like cnrm-cm5 and canesm2 that show the strongest result.

l232: Also, for the snow dominant basins, much of the uncertainty depends on how much snowpack is simulated for the future and how it melts, which are related to temperature and precipitation. Putting it into the river is relatively easy.

Minor quibble: At l232 you say "the role of climate grows more important and the role of hydrologic variability less important." The word "role" suggests that in the real world, changes in climate and hydrology have differing effects. Really, it's just the uncertainty in modeling these that map onto uncertainty in the results differently depending on location. So

In the conclusions, you make comparisons to Salathé et al (2014), and attribute a lot of the difference to the single scenario used there. Another factor is that the RCM is going to have a lot shorter spatial coherence (ie lack of temporal correlation across small distances) in the precipitation. So, whether it is snow or rain, for a single realization, there will be a few stations that buck the larger (deterministic) trend by chance. A large ensemble would reduce that effect.

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