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Hydrology and Earth System Sciences
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Discussions

Interactive comment on "Climate change will increase potential hydropower production in six Arctic Council member countries based on probabilistic hydrological projections" *by* Elena Shevnina et al.

Anonymous Referee #3

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In this study, the authors used projected precipitation from 4 GCMs to estimate the likely future streamflow using MARCS model. They then used a simple PHP formula to discuss how the projected change of streamflow may affect potential hydropower production. They concluded that climate change will increase potential hydropower production in six Arctic Council member countries.

Overall, while there is interest to understand this topic, I don't think there are sufficient data and appropriate methods to support this assessment. My detailed concerns are provided below. Given the current state of this manuscript, I would regretfully recom-

mend decline this manuscript from further publication in HESS.

1. [Insufficient GCM Representation] If the focus is to identify the most credible projection of future water resources (for hydropower production and other uses), individual runs from 4 selected GCMs are obviously insufficient. During the period of 2020–2050, the main controlling factor is the interannual variability of precipitation (modeled by different GCMs, as well as the ensemble simulations modeled by one single GCM with a series of perturbed initial conditions). With the large interannual variability, a much larger set of GCM projections should be used to capture the uncertainty. As a matter of fact, given the simplicity of MARCS and the selected PHP approach, I see no reason why the authors couldn't and shouldn't use more (if not all) existing CMIP5 results to conduct their analysis and draw more defensible conclusion. With that said, currently I don't think there is sufficient GCM projections to support the assessment and findings of this study.

2. [Treatment of Precipitation] I think some gauges examined by the authors are too large for grid-based assessment (i.e., contributing watershed covering multiple GCM grids). In such cases, using a single grid precipitation to represent the total precipitation input to the watershed is inappropriate and biased. With the advance of GIS techniques and data in the recent decade, I believe the authors can use the watershed boundary of each selected site as a spatial filter to more appropriately summarize average precipitation into the watersheds. This can hopefully help reduce some erroneous Q>P cases (i.e., total volume of streamflow is greater than precipitation) reported by the authors in the current manuscript.

3. [Limitations of MARCS and the Overall Statistical Approach] While I see the value of MARCS to potentially support large ensemble assessment (given its simplicity), I suspect if it is a suitable approach to explore future water availability in the context of atmospheric warming and climate change. In essence, the current assessment used statistical approach to estimate the likely change of streamflow ONLY by the change of precipitation (projected by GCMs). This approach would neglect other temperature-

related nonlinear effects such as earlier snowmelt and enhanced evapotranspiration.

4. [Oversimplification of Hydropower Assessment] While hydropower was specifically called out in the title, the authors only used a very simplified model (PHP) to infer the likely influence of climate change on hydropower production only from water availability perspective. Yes, for the selected region, the overall runoff is likely to increase as the result of increasing precipitation suggested by many GCMs, but the increases are likely in forms of more severe hydrologic extremes. With the intensified hydrologic extreme events, will our current reservoirs have sufficient storage to accommodate these highly varied inflows and be able to operate in the same fashion? For run-of-river types of hydroelectric projects, they may end up spilling most of the increased runoff due to limited storage so won't see a corresponding increase in hydropower generation. These more pressing issues cannot be addressed through an over-simplified hydropower model selected by the authors.

5. [Bias-correction Method] The delta bias-correction approach has become an outdated method. The authors should at-least consider the quantile-based bias-correction approach that can better adjust the GCM biases.

6. [Regulated Streamflow] I suspected that many of the gauge data used by the authors are in-fact regulated by existing reservoirs. How will this affect your assessment?

Other minor concerns:

7. [Line 27] "Engineering hydrology" sounds awkward.

8. [Line 186] Are you referring the "University of Delaware Air Temperature & Precipitation"? If so, a proper reference and citation should be provided.

9. [Lines 212–213] I don't think the statement is true. In the U.S., the cumulative streamflow originated from inland is far more important than the near-coast water resources for the purpose of hydropower generation.

10. [Lines 216 and 217] Should be Figure 3d.

11. [Line 218] Should be Figure 3c.

12. [Line 236] Should be Table 3.

13. [Line 242] Should be Figure 4.

14. [Line 282] Typo – "ew".

15. [Table 3] The first CA should be NO? Also, please provide the unique CMIP5 ensemble number (e.g., r1p1i1) so that the authors may know which exact GCM runs were used.

16. [Figure 1] In the bottom left box, "protected" should be "projected"?

17. [Figure 2] It is very difficult to differentiate sites with overlapping ST, FR, or SRC.

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