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Comment on hess-2021-500

Anonymous Referee #2

Referee comment on "Synopsis of the uncertainties introduced by bias-adjusted climate forcings in regional glacier surface mass balance evolution studies - A case study using a CORDEX chain envelope in western Norway" by Yongmei Gong et al., Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2021-500-RC2, 2022

The paper presents an analysis of glacierized catchments in Norway. The analysis consists in testing CORDEX outputs (with and without bias correction) in a snow and glacier modeling context for different catchments with variable climate conditions. The analysis focuses on a past/present period and aims at assessing the relevance of the CORDEX data compared to a high-resolution hindcast product. The paper concludes that bias-corrected CORDEX data might not be usable in such a study due to important remaining biases and errors in the data.

I'm sorry in advance, this is going to be a bit tough… I have several major issues with the paper (see below for more details). First, comparisons between climate model outputs (CORDEX) and reanalysis-driven model outputs (NORA10) should not be done by comparing the time series, as climate models are not forced to follow the observed climate. GCM/RCM outputs thus should only be compared in terms of statistics and not as time series. Moreover, it is nowadays best practice to use multiple GCM/RCM model chains and not a single one. Also, comparing RCP scenarios does not make sense for the past/present as the scenarios have not diverged at that stage. You show quite early by comparing the climate forcing that there are issues in the datasets considered and that the bias correction procedures seem to be unsatisfying. At this stage, it does not make much sense to go any further in my opinion... You then analyzed in detail the snow/glacier model outputs, also in terms of runoff, obtained from models that we have no way to assess the quality of their calibration (there is no metric for the calibration/validation of the runoff). Also, from these modeling outputs, you analyze patterns that could be retrieved from observations as well as some general well-known phenomena (e.g., runoff correlation with precipitation and glacierized catchments have a hydrological cycle with a late peak discharge). I am very sorry to say it, but excluding the elements above, I am not sure there is much left of the study or any conclusion of interest.

My major issues:

- Comparison of climate scenarios and observations: It is not clear how you compare the climate forcing with observations in 3.1, but it sounds like you're calculating the RMSE on the time series. However, this cannot be done as there is no correspondence between the dates: the climate projections are disconnected from the actual weather system evolution, and they cannot be compared in terms of time series even on the control period. Only overall statistics can be compared between the two. It is also the case for Fig. 8, where time series are plotted for CORDEX (climate projections) and NORA10 (reanalysis-driven).
- Comparison of RCP scenarios: It does not make much sense to compare RCP scenarios for the present, as the scenarios did not diverge for the past/present. They only diverge in the future. Thus, all analyses of the role of the RCP scenario (l.247-249, l.264-265, l.271-273, l.350, l.375-376, …) do not make sense.
- You used only one GCM-RCM chain. However, it is nowadays recognized as a best practice to not use a single model chain but to account for the uncertainty of the climate models by using several climate forcing chains. You state in 4.2 that "the first and foremost concern lies in the choice of future climate forcing from GCMs and RCMs". Well, you shouldn't pick only one in the first place… Using different bias correction methods is a good idea to account for the uncertainties related to the downscaling/correction, but it does not replace the consideration of the uncertainties from the climate modeling chain.
- You show that the bias-corrected CORDEX outputs still have a high bias. Thus, it seems that the bias correction was not optimal. It is not clear if you did the bias correction yourself or if you used an already bias-corrected product. The analysis of the climate forcing is then enough to identify that the data cannot be used directly in a climate impact study. There is no need to go all the way through the snow/glacier/hydro models. Maybe these errors you identified in the bias-corrected CORDEX can be related to how you computed the comparison, such as by directly comparing the time series (see above)
- You analyze spatial and temporal patterns from the model outputs, while this can (and should) be first retrieved from the data. Also, even when you used the benchmark model (reanalysis-based), you never compare the runoff outputs to observations. We have no way to assess what your model outputs are worth. The model results of the runoff are the basis of several analyses. However, there is no metric regarding the calibration/validation with reference to observed discharge (e.g., NSE, bias, …). Thus, we cannot know if these analyses rely on plausible results.
- I'm not so keen on the correlation analysis (4.1) based on the model outputs, with no comparison with observations. We retrieve the model behavior more than the natural system behavior. You infer several conclusions based on the model outputs, while we have no clue what they are worth.

Other elements:

- You state that "the ability of high-resolution modeling to accurately project glacial-hydrological changes into the future is hampered by keeping the glacier geometries fixed in time" (l. 453). You also suggest in your last sentence to consider "the evolution of the glacier geometries and extents". There is a whole bunch of literature on that topic. Approaches to account for a change in the glacier geometry exist.
- The unit used for the runoff is Gt/km2, which is quite uncommon in hydrology. A unit of mm/yr is much more common.
- The fact that glacierized catchments have a hydrological cycle with a peak discharge

later in the year is well established in the literature. References should be added, and Fig. 11 can be removed.

- 176-183: the original issue and your computation are not clearly explained. Please better explain the problem.
- In Fig 5b the axes are reversed, but you analyze the results as if it was not the case…
- 336-339 (Fig. 7): it is not clear how significant these trends are.
- Analyses of the peak discharge (4.1) are a bit out of scope here and somehow reinventing the wheel…

Figures:

- 1: Scales are difficult to read. Try to make them larger and white. The insert with the whole country is very small and of poor quality, we do not see much. You also mention in the caption the "Conrad's continentality index" with no explanation nor reference.
- 2: difficult to see as quite small.
- 3/4: it does not make much sense to compare the different RCPs for the past.
- 5: the maps are too small, we cannot see the patterns. For panel (b), the y-axes are reversed!
- 6: the maps are too small
- 8/9: analyzing the time series of climate model outputs does not make sense. Also, plotting outputs for 2 catchments in the same figure makes it impossible to read.
- 10: mm/d is more frequent than m/day.
- 11: should be removed.