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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Diagnosis of future changes in hydrology for a Canadian Rocky Mountain headwater basin" *by* Xing Fang and John W. Pomeroy

Xing Fang and John W. Pomeroy

xing.fang@usask.ca

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General comments I do mostly agree with referee #1. The paper is a very valuable contribution to the understanding of climate change effects on the hydrology of small high mountain catchments. Its strength are the modelling tools that were used to provide a physically and process based analysis, and the clear and well-structured text of the paper. Very well done. Likewise, I am no native speaker, but there is an issue with the use of articles all through the text. See my supplement. I would also suggest to always add "ecozone" after its name. Other things that would improve the overall value of the paper: - a brief explanation of how the ecozones were derived - some

more words about the generation of the PGW simulation (particularly extending "The climate perturbation was derived from 19-model ensemble mean change from the fifth phase of the Coupled Model Intercomparison Project (CMIP5; Taylor et al., 2012) under a "business as usual" forcing scenario: representative concentration pathway 8.5 (RCP8.5; van Vuuren et al., 2011).") - a map of the HRUs Everything else: see supplementary comments. Congratulations, a very nice paper, very interesting, and fun to read. Good work!

Response to general comments: Thanks to referee #2 for general comments about the manuscript. We added a brief explanation of the ecozones generation along with a map of the HRUs, because they are connected: ecozone were derived from the same land-cover type of the HRUs. We also added a few more words for PGW simulation. Last, we added some missing articles as suggested in the detailed supplementary comments, and we also added "ecozone" after its name. We also revised the manuscript to improve its structure, readability and flow.

Supplementary comments

Supplementary comment 1: Page 1 - 6: skip comma - 9: "Rocky Mountains" - 16: "during a current period (. . .) and a future period (. . .)" - 17: what does "PGW" stand for (comes on page 3)? - 22: "as well as a shorter snow season": repetition; "in the alpine"

Response 1: We keep the comma for readability although the comma can be skipped. The sentence would be quite long when skipping comma. Yes, we changed to use ". . .Canadian Rockies". Yes, we added the missing articles "a". Yes, we used ". . .a current period (2005-2013) and a future pseudo global warming period (PGW, 2091-2099)" to replace ". . .current period (CTRL, 2005-2013) and future period (PGW, 2091-2099). Also, an appendix for abbrevations is added, which is suggested by the referee #1. We rephrased to "The alpine snow season will be shortened by almost one and half month, but at some lower elevations there will be large decreases in peak snowpack

(∼45%) in addition to a shorter snow season."; this is to convey the message "besides a shorter snow season, large decreases in peak snowpack occurred at some lower elevations".

Supplementary comment 2: Page 3 - 3: "Empirical snow modelling methods . . . have great difficulty": reformulate, because it is not the method having a difficulty but we ourselves in interpreting its results with respect to a certain research question

Response 2: Yes, we rephrased to "Empirical snowmelt modelling methods that use temperature-index techniques are inappropriate in cold mountain regions. . .".

Supplementary comment 3: Page 4 - 32: correct "gird" to "grid"

Response 3: Yes, we made correction.

Supplementary comment 4: Page 5 - 9: "the systematic bias" - 19: "to force the hydrological simulations"

Response 4: Yes, we made the changes as suggested.

Supplementary comment 5: Page 6 - 15: "for the current period" - 16: "for the future period" - 17 and 18: "in the CTRL period" - 20: "calculated by the equations"

Response 5: Yes, we made the changes as suggested.

Supplementary comment 6: Page 7 - 1: better "linearly distributed" than "linear distribution" - 16/17: "the simulation had large differences with the observations": find better formulation - 29: "suggesting that the model had some"

Response 6: Yes, we made the changes as suggested.

Supplementary comment 7: Page 8 - 22: "112 mm" - 30: "the entire basin" - in general: always add "ecozone" to its name (everywhere)

Response 7: Yes, we made the changes as suggested.

Supplementary comment 8: Page 10 - 10: "for the basin" - 27: explain "dam3" - 32:

delete "Whilst", or connect sentence with previous one (". . . in May, whilst monthly . . .")

Response 8: Yes, we added the missing article "the". dam3 stands for cubic decametre, equal to 1000m3. It is one of the SI units, and according to journal's house standards, units do not need to be defined in text. Yes, we changed it to ". . .in May. In contrast, monthly. . .".

Supplementary comment 9: Page 11: - 1: "and had a very similar low value" - 7: "onset of the spring freshet" - 9: delete "While", or connect sentence with previous one (". . . (Fig. 11a), while the largest . . .") - 11: "ranging from 0.3 mm" - 13: "from the forest clearing" - 19: "and the entire basin"

Response 9: Yes, we made the changes as suggested.

Supplementary comment 10: Page 12 - 11: "these . . . simulations require" (not "requires", it is plural) - 9-13: evtl. add Warscher et al. 2019, same (and very recent) discussion - 18: "in the Rocky Mountains region" . . . and probably better skip "in this region" - 19: "One study suggests . . ." - 20: "while others reported" - 23: "gradients" - 27: "in the PGW period" - 30: you may even add "for other sites with different climates" - 31: "of the snowcover"

Response 10: Yes, we made the changes as suggested and added Warscher et al. 2019 to the discussion.

Supplementary comment 11: Page 13 - 5: "in the PGW period" - 12: "for the upper forest ecozone" - 31/32: evtl. add Strasser et al. 2019

Response 11: Yes, we made the changes as suggested and added Strasser et al. 2019 to the discussion.

Supplementary comment 12: Page 14 - 2: "for a more comprehensive" - 15: "large elevational gradients" or "a large elevational gradient"

Response 12: Yes, we made the changes as suggested.

Supplementary comment 13: Fig 1 - "Hydrometeorological Stations“ should be "Hydrometeorological Station“ (Singular) - "WRF Grid“ should be "WRF Grid centroid“, and the latter should be explained in the caption. The "and“ before it should be removed

Response 13: Yes, we made the changes as suggested.

Supplementary comment 14: Fig. 2 - caption: ". . . that the best linear fit is a straight line . . .“

Response 14: In the new Fig. 3, we removed the best linear fit as suggested by the referee #1.

Supplementary comment 15: Fig. 3 - caption: Comparison without -s (better singular). Add what belongs to where in the caption.

Response 15: Yes, we changed it to “Comparison of the. . .”.

Supplementary comment 16: Fig. 5 - caption: "Note that the total water year precipitation is presented here, and the average water year value is presented for the other variables.“

Response 16: We made change: “. . .Note that the accumulation over the water year is used for precipitation, and the average value over the water year is presented for the other variables.”.

Supplementary comment 17: Fig. 6 - caption: ". . . (FCCSF) and lower forest . . .“

Response 17: Yes, we made the change as suggested.

Supplementary comment 18: Fig. 7 - caption: better "mean annual“; "The line . . .“

Response 18: Yes, we made the change as suggested.

Supplementary comment 19: Fig. 9 - caption: "The line . . .“

Response 19: Yes, we made the change as suggested.

Supplementary comment 20: Fig. 10 - caption: "for the eight- water year period between . . .“

Response 20: Yes, we made the change as suggested. Now “Figure 11. Change between WRF CTRL and PGW periods in the simulated mean Marmot Creek monthly streamflow discharges during March to October for the eight-water years.”

Supplementary comment 21: Fig. 11 - caption: "The line . . .“

Response 21: Yes, we made the change as suggested.

Supplementary comment 22: Fig. 12 - caption: "The line . . .“

Response 22: Yes, we made the change as suggested.

Supplementary comment 23: Fig. 13 - caption: "Mean rainfall ration and runoff . . . ecozones and the entire Marmot Creek basin“

Response 23: Yes, we made the change as suggested.

Supplementary comment 24: Table 4 - caption: better "mean daily“ Response 24: The evaluation is for the time-series of daily mean streamflow value (i.e. daily discharge) from the simulation. We think daily mean is better one to use.

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