Author response to reviewer #1 comments for HESS manuscript "Modelling the effects of climate and landcover change on the hydrologic regime of a snowmelt-dominated montane catchment " [Paper #: hess-2023-248]

Dear Reviewer,

We would like to thank you for your thoughtful review of the original manuscript submission. You raised several important issues that will certainly result in a stronger manuscript. Please find below a list of responses to your comments. We hope our responses satisfy the spirit and intent of your remarks.

Sincerely,

Russell Smith

Reviewer #1 comments

General Comments

I think that this contribution tackles a very important question, i.e. what is the join influence of climate and landcover change on hydrological signatures. However, similarly to the existing literature on the topic, it does not go beyond a case study. While the case study is carefully done and changes in different streamflow signature explained in detail for the one watershed under consideration, the generalizability of results is limited given that existing studies showcase the large variability of hydrologic responses to both climate and landcover changes and their interplay. In addition to not being generalizable to other regions, the results are also quite predictable given the existing literature: they point to earlier snowmelt, earlier flood peaks and an increasing influence of precipitation as we move into the future. While I do not see how the current study advances our knowledge related to future changes in streamflow signatures and the interplay between climate and landcover influences beyond the study region, I acknowledge the detailed and well-presented results for the case study watershed.

- We acknowledge that the manuscript presents a case study for a specific physiography, and that certain elements of the findings are predictable (examples you identified). We believe the results can be generalized to other snowmelt-dominated montane catchments having variable slope aspects and substantial elevation relief, and are particularly valuable to catchments with forest cover disturbance (harvesting or wildfire) and a managed water supply. There are many manuscripts addressing influences of climate change, and many others evaluating landcover;

however, the amount of literature investigating both mechanisms in detail is quite limited. Moreover, our manuscript addresses complexity in three dimensions: climate scenarios, land cover conditions, and several hydrological indicators (i.e., not strictly one or two indicators). The indicators include influences on snowpack accumulation and melt; runoff timing, magnitude, and frequency for peak flows, low flows, and annual discharge; and typical (i.e., average) and extreme events. The study examines different distributions of landcover disturbance, as well as forest regrowth. Approaching the topic in this manner revealed some predictable findings, but also findings that could only be revealed through such a holistic investigation. We will revise the abstract and introduction to highlight these points.

Other major comments

1. I find the methods descriptions detailed but rather superficial. That is, while the most important steps of the modeling framework are named, many methodological specificities remain unclear. A few examples:

What is the temporal resolution of the streamflow data used for the analysis? (p.4, l. 98)

- Daily data were used. This point will be clarified in the text.

Do the percentage changes in forest cover refer to the entire catchment area or just the forested catchment area (the latter would be more logical in my opinion)? (p.7, l.124-125)

- They refer to the entire catchment area. This point will be clarified in the text.
- We believe that expressing the percentage change with respect to the entire catchment more precisely relates to the proportional impact on the catchment water balance.

How were precipitation and temperature interpolated from station data to areal data? (p.7, l. 141)

- They were interpolated from the P1 weather station using lapse rates constrained by P1 and weather data from Penticton Airport near the watershed outlet. These points will be clarified in the text.

Which algorithm was used to estimate the full snowpack energy balance? (p.7, l.144)

- The snowpack balance incorporated coupled mass and energy balance equations. The full snowpack energy balance was represented using algorithms that estimate energy fluxes using daily precipitation, and daily minimum and maximum air temperature (Quick 1995). It accounted for cloud cover, short-wave radiation, long-wave radiation, and turbulent flux (Quick, 1995; Dingman, 2002). These details will be provided in the supplementary.
- Quick, M., 1995. Computer models of watershed hydrology. Water Resources Publications, Highlands Ranch, Colorado. chapter The UBC Watershed Model. pp. 233–280.
- Dingman, S., 2002. Physical Hydrology. Waveland Press Inc.

How was the historical streamflow record adjusted for storage changes in Greyback Lake? (p.8, l.152)

- Greyback Lake is a controlled reservoir (p.4, l.100). Storage in Greyback Lake was "naturalized" so-to-speak. Bathymetric data and lake level data were combined to generate a time series of daily storage change. Increasing storage was added to the discharge for the catchment outlet (and vice versa for decreasing storage), assuming an instantaneous transfer to the catchment outlet. We deem this assumption reasonable with running the model at a daily time-step, as the actual transit time during high flow periods would be ~1 hour, and the rate of storage change during low flow periods would be very low. These details will be clarified in the text, and incorporated in the discussion of uncertainty.

2. The climate impact assessment relies on one climate scenario (i.e. GCM and emission scenario combination) only, neglecting uncertainties related to emission scenario and GCM choice. While this limitation is acknowledged in the discussion section, I find that it could be overcome relatively easily by running the model for a few more climate scenarios. Furthermore, the model used for the analysis should be better contextualized within the sample of existing models (see Section 4.4.) by comparing its temperature and precipitation changes to those of other existing models.

- We acknowledge that simulating multiple climate scenarios is frequently used for projecting climate change impacts. Because of budget limitations, we had to choose between complexity of climate scenarios, land cover conditions, and hydrologic indicators. We decided to limit the climate scenarios by choosing one that had a severe climate change. Our rationale is that the scenario we chose would indicate how much hydrology may change and, thus, pose the greatest challenge to management. In doing so, we retained complexity in land cover because it's something forest and land managers can influence. We retained complexity in the hydrological indicators because of their importance to human values. However, we plan to address your concern by running four additional climate scenarios. We will provide additional tabular and/or graphical outputs in the manuscript as a sensitivity analysis, and incorporate these results in the discussion.

3. The authors use a weather generator on the climate simulations to increase sample size (Section 2.2.2.3), which is per-se a good thing. However, it is unclear why these simulations are limited to 100-years given that the focus is among other variables on extreme events, which requires larger sample sizes to separate signal from noise.

- One hundred years of data are sufficient to estimate a 1 in 100 year event (widely considered to be an extreme event) and infer most probability distributions. Moreover, we question the validity in us generating much more than 100 years of synthetic data from 32 years of observed weather data (p.8, l.182). Any historical or climate change projection on the impact of events is limited by the historical and projected climate records. Addressing extremes that are outside of these records is an area of cutting edge research (e.g., Fischer et al. 2023, Storylines for unprecedented heatwaves based on ensemble boosting, Nature Communications, https://doi.org/10.1038/s41467-023-40112-4; Zeder et al. 2023, The effect of a short observational record on the statistics of temperature extremes, Geophysical Research Letters, https://doi.org/10.1029/2023GL104090). It requires many hundreds of projections to produce an extreme outside of the regular climatology. This research is yet to provide guidelines and datasets for the practitioner. We will note in the discussion of uncertainty that there could be events outside the boundaries of our simulation.

Minor comments

Use superscripts for units such as km2 and m3/s

- Thank you for noticing. We will make that change.

The discussion talks quite a bit about risk (Section 4.3). However, the authors do just look at changes in hazard while changes in vulnerability and exposure are not assessed. To avoid confusion, I would therefore use more specific terminology.

- Good point. We will outline in the text that our discussion of increasing or decreasing risk relates specifically to changing hazard.