Cover Letter

Dear Hongkai Gao,

here we present the revised manuscript. We addressed all further reviewer comments and provide below the point-by-point replies.

Regarding the file validation remark on using colorblind friendly color scales: We generally use color palettes that are perceptually uniform and respect color vision deficiencies, and are possibly even print-safe, such as https://www.fabiocrameri.ch/colourmaps/, https://colorbrewer2.org/, or viridis. The only figure that might not respect this, is Figure 3 (and some similar figures in the supplement). However, in these cases, the different colored lines should only give an impression of variability, and it's not necessarily needed to follow every line to understand the message (which might be challenging for people with vision deficiencies, but partly also for people without deficiencies).

Best regards,

Michael Matiu, also on behalf of the co-author, Florian Hanzer

Reply to Referee #1

You made good responses to reviewers' comments. The added descriptions about datasets, validation, and discussions that improved the manuscript.

Comment 1:
Figure 2a, 2b, and 2c is not well organized. It is suggested to provide a overall title for figure 2, and to show the links among figure 2a, 2b, and 2c.

Thank you for the evaluation and the comment. We improved figure 2 as suggested. We added titles to parts a, b, and c, and provide the links between the overall summary (a) and detailed sub-steps (b) and (c).

Reply to Referee #2

It seems the author have put a lot of effort in the revised version of the manuscript – this is very appreciated. I think particularly the methodology section was much improved, which enhances the comprehensibility and potential reproducibility of the novel approaches described in the manuscript. Most of my comments are of minor but there is one larger issue that should be addressed/resolved. The page and line number refer to manuscript version 2.

Thank you for the positive feedback.

Major comment
I'm puzzled by the sometimes very different elevation gradients in projected (absolute) snow cover change, which result from raw RCM data, bias adjustment and downscaling. E.g. in Figure S8, you show that for RCP8.5, largest absolute reduction in snow cover fractions are expected for elevations ~1000 – 2000 m, depending on the RCM-GCM combination, season and processing method (raw or different bias adjustments). In contrast, Figure 6 (rightmost panels) shows that absolute reduction in snow cover fraction generally increase with elevation. Both figures show bias adjusted data (without downscaling) – so I guess one of them must be wrong.

The difference in the elevation gradients that you mention is because Figure 6 shows annual values, while Figure S8 shows seasonal values, but not for all seasons (only winter and spring).

We added two additional figures in the supplement (S18 and S19 in the new version). An annual version of Figure S8, which should now resemble better what is seen in Figure 6. And a seasonal variant of Figure 6, which should be then more similar to Figure S8.

Additionally we added "seasonal" or "annual" to all figure legends and figure axes in the main manuscript and supplement. We hope this helps in reducing confusion and assures you that the figures are correct.

Minor comments
L91: I'm not sure if really all biases are constant in time. I suggest to rephrase this sentence to: " these systematic biases seem to be predominantly constant across time, …"

Done.

L98: “limitations of both approaches.” à limitations of the high-resolution snow model are not discussed, I would thus rephrase it to “limitations of the presented method.”

True, corrected.

L161: I’m not sure if I understand this sentence correctly – with “future change estimates” you mean relative values, right?

Yes, relative, but also absolute values. To be clearer, we rephrased to the following:

> Consequently, also for the future maps, SCD cannot be compared between high and low resolutions without introducing the same errors from scale issues. This holds for the absolute number of SCD, i.e., how many days with snow cover are there at a specific location/elevation. However, it’s still possible to compare future absolute and relative change estimates, i.e., how many less or more days with snow cover are there. These change estimates should be unbiased, since subtracting past from future values also subtracts the biases introduced by scale mismatches.

L187: I would rephrase (or entirely remove) the sentence with “unavoidable” because you just propose in the following sentence how the imbalance could be resolved.

Done.

L196: “future meteorology” à “projected meteorological data”

Done.

L281: I’m confused by the term “non-strictly” because a “strictly monotonic relationship” would also guarantee a unique solution (as you show in the reply to referee 2). Maybe the term “monotonically non-decreasing function” would be less ambiguous in this context?

In mathematical terms, non-strictly monotonic encompasses also strictly monotonic (but not vice-versa), so non-strictly is a less strong assumption than strictly, which also includes it. But since it’s too confusing, we removed “non-strictly” and only talk about monotonic relationships.

L294-L298: I was not able to fully understand what you mean by these lines.

We are sorry for not being clear. Our intent with the sentences was to motivate the Wasserstein distance. The lines now read:

> We expect two grid cells to be similar, if the two distributions of pixel elevations within the respective grid cells are similar. The Wasserstein distance is especially designed for comparing distributions: If the two distributions are thought of as earth piles, it calculates how much and how far “earth” has to be moved, such that the two distributions agree. Other distance metrics, such as Euclidean, would in this case require to have a pairing of all values (pixel elevations) between the two grid cells, and are not well suited to compare distributions.

L472: The ordering of the subsections 4.x is a bit odd. Normally, the evaluation/validation of the results is shown first before one discusses e.g. future projections (to underline the robustness of the results). This ordering is however almost reversed in your manuscript. You could consider reordering the subsections.

Thank you for the suggestion. We moved the validation of the downscaling from 4.4 to 4.2 after bias adjustment, but before the results of downscaling.

Figure 2: This figure is very helpful to understand the methodology. Could you increase the axis (tick) labels in panel (b) a bit – they are rather hard to read.

Done.

Figure S2: I'm not sure what you mean by "SCD summaries by elevation." Maybe you could rephrase that. Besides, I was quite confused by the x-axis labelling of panel (b) "pixels/grid cells". I first read it as "pixels per grid cells" but I think you mean "pixels or grid cells".

By "SCD summaries" we meant SCD averaged by elevation. We modified the legend accordingly. Thanks for pointing out the ambiguity of panel (b). We modified the x-axis label to "pixels or grid cells".