

Answers to comments by Referee #2

Future projections of High Atlas snowpack and runoff under climate change

November 18, 2021

Dear reviewer,

We would like to thank you again for your detailed and constructive comments. We hope our replies and modifications will satisfy your remaining concerns.

Best regards,

The authors

Comment 1 *Line 28: Not sure if 'however' fits here? At least I had to stop when I was reading it. Maybe something like 'Previous investigation indicate...' is better?*

Answer: You are right; we changed the sentence accordingly: "*Previous studies indicate that the High Atlas snowpack may be particularly vulnerable to climate change.*"

Comment 2 *Fig 1: Include overview map? Not sure whether everyone knows where the Atlas and Morocco (country borders) is. Is it possible to include the information on what the red dotted line and black lines are into the legend directly? Then the reader would not have to search for it in the figure caption.*

Answer: Good suggestions, thanks. Please see the updated figure.

Comment 3 *Line 83: 'variability' of the seasonal snow cover?*

Answer: That's correct. We made it explicit in the revised version: "*Inter-annual variability of snow cover is substantial...*"

Comment 4 *Line 103: 'runoff will be modeled' Maybe be a bit more specific here? For a moment, I thought (again) you actually run a hydrological model for this.*

Answer: To avoid this misunderstanding, we suggest simply replacing "modeled" by "analysed".

Comment 5 *Line 158: 'MRCM output must be bias-corrected' You do this in this study or was this done by T20b already? Please specify. As T20a, T20b and this study are so interlinked, is it possible to add this information into the scheme Fig. 4?*

Answer: We apologise if the formulation was not clear. We do indeed bias-correct MRCM output in the present study, as detailed in the rest of the paragraph. The bias-correction step is already detailed in Figure 4 (we list the datasets used as targets for the bias-correction). We modified the beginning of section 3.2.1 as follows: "*6-hourly wind speed, specific humidity, air temperature, precipitation, and downward longwave and shortwave are extracted from the MRCM output over our domain, at the 12km MRCM resolution. We then bias-correct MRCM output when reliable observations are available, and downscale it to the MODIS 1km resolution at which we run the snow model.*"

Comment 6 *Line 174: What about temperatures? You do not downscale temperature?*

Answer: We do but indirectly through the bias-correction with the 1km MODIS data (so we directly obtain 1km data with no need to explicitly downscale the data). We added the following sentence at the end of section 3.2.1 to make it explicit: "*No additional downscaling for temperature data is required since the downscaling is embedded into the bias-correction step. The target MODIS LST-derived air temperature data in the bias-correction is indeed already at the required 1km resolution.*"

Comment 7 *Line 174: What lapse-rate do you use to downscale $\mu = ?$*

Answer: As in T20a we use an empirically-determined lapse-rate μ estimated at each time step from the MRCM simulations.

Comment 8 *Line 183: SWE usually used for snow water equivalent not snow water content. Please consider changing.*

Answer: This was a typo – SWE indeed stands for snow water equivalent in this sentence. We changed in accordingly.

Comment 9 *Line 190: Where is this formula coming from? Why do you use this? Why 0.85 and not 0.9?*

Answer: This formula comes from T20a (and was also used by Boudhar et al. 2011). The reason why we choose 0.85 is that it corresponds in practice to the maximum value of MODIS gridded snow fraction in our domain. MODIS snow cover values above that threshold are extremely rare, which probably reflects the strong small-scale variability of snow cover in the High Atlas at high altitudes (Baba et al., 2019). We added this information in the revised manuscript when introducing the equation.

Comment 10 *Line 198: Do the parameters differ a lot between the ERA and GCM calibrations? Maybe a small table with the resulting parameters?*

Answer: We can have it as a supplementary table indeed. Please see revised Table A2.

Comment 11 *Fig. 5: What time frame is shown here? Can you maybe add it to the figure caption?*

Answer: Good point. We added this information to the caption so that readers will not have to refer to the main text: "*Annual cycles of snow cover (in %) in the MODIS observations (2000-2011; black), ERA- Interim simulation (2000-2011; dashed red) and three GCM-driven historical simulations (1994-2005; solid blue: median; blue shading: 3-model range).*"

Comment 12 *Fig. 6 + 7 + A1: I find it hard to see the differences here. Maybe actually calculate the differences between the maps and show it?*

Answer: We can add a panel to Figure 7 to show the difference. Figures 6 and A1 are already quite big, so instead of adding new panels we suggest reducing the number of colors to make it more legible (please see the revised figures).

Comment 13 *Line 252-259: Move to discussion?*

Answer: Given that Figure 8 includes results as well, we would prefer to keep these sentences there.

Comment 14 *Line 416: What do you mean by 'peak snow cover' here? Maximum snow cover extent? What figure do you refer to here? I was not sure what those values represent...*

Answer: That's right, we did mean "maximum snow cover extent" – so we rephrased the sentence accordingly: "*Maximum snow cover extent is projected to go from 17% of the study area down to 9% under RCP4.5 and even 4% under RCP8.5 (Fig. 9-f).*"