Replies to Reviewer's Comments

We thank the reviewer for the valuable comments and suggestions. We have revised the paper substantially and have carefully made corrections according to the reviewer's comments. Our detailed point-by-point response to the reviewer's comments is given below.

1. P2140, lines 14-20. How are spatial correlations calculated? These values are very sensitive to autocorrelation in the residuals, which is undoubtably a problem in the snow cover field. Also, in the statement "by comparison", it is not clear what is being compared, and why or how the results are different. P2146 lines 1-5 the authors discuss correlations and partial correlations. Are these performed on detrended time series? How do the trends affect these results, and do they result in autocorrelation in the residuals which contradicts one of the assumptions of regression analysis? Also, throughout the manuscript the authors focus on absolute rather than relative changes in SWE, but never explain the advantages/disadvantages of evaluating relative versus absolute changes. By choosing to evaluate absolute changes, one skews results to areas with much more snow.

Answer: Thank you for your suggestion. We ordered all simulation grids and observations in sequence, and then calculated the spatial correlations. The term "by comparison" indicates the comparison of the correlation and standard deviation ratios across space and time, and we have deleted this in the revised manuscript to avoid confusion. The time series were not detrended for the correlation and partial correlation calculations. In the revised manuscript, the spatial, zonal, and monthly changes in SWE are analyzed in terms of the relative change (Figure 3, 4, 5).

2. P2145, lines 8-9, "the reduction in SWE during the winter half-year exceeds that in the summer half-year, in keeping with the results shown in Fig. 3." Since there is so much more snow in winter than summer, is this a trivial statement? Also, winter half-years and summer half-years are never defined. P2145, lines 26-27, the result

“This pattern implies that decreasing SWE is attributable to increasing temperature and the minor increase in precipitation” requires explanation. Another example is the recurring mention of a threshold value at which the rate of SWE reduction decreases over time throughout the 21st century: no explanation is provided, in terms of whether this local or global, based on the freezing point of water, or based on some other physical principal.

Answer: Thank you for your suggestion. Lines 8–9 have been deleted in the revised manuscript. The winter half-year ranges from December to May, and the summer half-year is from June to November.

In lines 26–27, we state that both temperature and precipitation show an increasing trend. A temperature increase leads to a reduction in SWE, and a precipitation increase causes SWE to increase. However, warming will also result in a decrease in winter snowfall and more efficient snowmelt. Therefore, the change in SWE is related to increasing temperature and precipitation. This is clearly explained in the revised manuscript (page 11, L4-12).

The threshold refers to the relationship between SWE and temperature. According to the response sensitivity of SWE to temperature during the three periods of the 21st century, a threshold may exist in the SWE–temperature relationship.

3. Throughout the manuscript one finds confusing references to CMIP experiments and IPCC experiments. The discussion sometimes refers to CMIP and sometimes to the IPCC AR number. For example, P2144 line 14 says that their results are different than AR5 (Stocker et al., 2013). Aren’t the authors using the same models as Stocker et al.? if so, how can the results be different? This requires clarification, and further explanation. Also, p. 2145 line 15 “which is consistent with the results in AR5.” If this is just a repeat of what has already been done for AR5, why is it of interest?

Answer: Thank you for your suggestion. In AR5, the results are based on reanalysis over the Northern Hemisphere during 1922–2012. By comparison, we suggest that the correlation between snow and temperature during different periods of the 21st century is stronger than that during 1922–2012. P. 2145 line 15 in the revised manuscript has

been deleted.

4. Clarity of presentation is a problem even in the introduction. First, in defining the questions asked in this manuscript (P. 2139, lines 6-7). How is question 2 different than question 1? Also, the phrasing of question 2 is entirely vague ("How about the link: : :"). Second, the authors must clarify (for example on p. 2139, lines 9-16) how this study complements previous studies of CMIP5 snow simulations.

Answer: Thank you for your suggestion. Problem 1 mainly focuses on the change in SWE on different spatial and temporal scales. Problem 2 refers to the relationships between SWE and temperature, and between SWE and precipitation during the 21st century. The "link" indicates the relationship between SWE and temperature. Furthermore, previous studies that employed CMIP5 snow simulations are discussed in the revised manuscript (page 4, L7-15). We want to analyze the mechanisms that underlie the change in SWE according to the contribution of total precipitation, the fraction of solid precipitation, and the fraction of accumulated snowfall (page 16, L2-15).

SPECIFIC COMMENTS

1. Abstract, p2136, lines 10-13. Run-on sentence, should be split into two sentences

Answer: Thank you for your suggestion. We have revised this point in the manuscript (page 2, L1-6).

2. p. 2137, lines 15-18. Define what is meant by snow cover.

Answer: Thank you for your suggestion. Snow cover represents a spatially and temporally integrated response to snowfall events, and exhibits a more direct relationship to temperature (page 3, L23-25).

3. p. 2137, line 27, "shown" should be "show"

Answer: Thank you for your suggestion. We have revised this in the manuscript.

4. p. 2138, line 16, should "except" be changed to "in addition to"? "Topography"

should not be capitalized.

Answer: Thank you for your suggestion. This section has been deleted in the revised manuscript.

5. p. 2138, line 20. What is meant by "simulated SWE actually increase with altitude"? the discussion is about rates of change, and the relevance of this statement is unclear.

Answer: Thank you for your suggestion. We have rewritten the introduction and this section has been deleted in the revised manuscript.

6. p. 2141, line 15. Define "relative-error ratio".

Answer: Thank you for your suggestion. The "Relative-error ratio" is actually the relative change, calculated by the equation $\frac{S_i - O_i}{O_i} \times 100\%$, where S_i and O_i are the simulation results and observations, respectively, we have added the equation in the revised manuscript(page 7, L10-12).

7. p. 2141, line 23-24, what is meant by "the extent of increased springtime SWE"?

Answer: Thank you for your suggestion. The extent of increased springtime SWE is the area of positive relative change (RE>0) (page 9, L15).

8. P. 2143, lines 9-11. Regarding the unique difficulty of simulating snow over the Tibetan plateau, this requires further explanation and some reference to the literature on this issue.

Answer: Thank you for your suggestion. This has been deleted because the annual maximum SWE is not discussed in the revised manuscript.

9. 2145, line 6, what is meant by "integration cumulative errors"?

Answer: Thank you for your suggestion. Due to the difference in physical processes and the algorithm, cumulative errors will be greater later in the 21st century. However, this has been deleted in the revised manuscript.

10. p. 2146, line 14. “form” should be “from”

Answer: Thank you for your suggestion. We have deleted this in the revised manuscript.

11. p. 2146, lines 14-19. Does this paragraph, which says that the sensitivity of SWE to temperature gradually increases during the 21st century, contradict previous statements?

Answer: Thank you for your suggestion. This does not contradict the previous statement. Table 2 shows that the sensitivity of SWE to temperature gradually increases from south to north at mid–high latitudes. This trend indicates that the most significant absolute change in SWE occurs at high latitudes, where the temperature increase is also significant.

12. p. 2147 line 27 – p. 2148 line 2. This is unclear and confusing.

Answer: Thank you for your suggestion. The spatial changes in SWE show that the magnitude and extent of the negative SWE trend are more significant in spring than in winter. However, positive changes in spring are less significant than in winter, which leads to a more significant reduction in spring than in winter. We have rewritten the manuscript to clarify this result (page 14, L18-23).

13. p. 2150, lines 21-24 (last sentence of manuscript). The meaning and relevant of integration truncation and intermodal differences is not explained, was not previously mentioned, and is therefore confusing.

Answer: Thank you for your suggestion. Physical processes and the algorithm (i.e., intermodal differences) may result in uncertainty. Here we only want to state that the uncertainty does not affect the overall conclusions of this study.

14. Figure 1, explain the axes, figure 2 specify which months are included.

Answer: Thank you for your suggestion. In Figure 1, the vertical axis indicates the standard deviation ratios, and the numbers along the arc are the spatial correlation. Figure 2 shows the winter (DJF) mean SWE. We have revised in the manuscript to clarify these figures.

15. Figure 6, 7. For what region is this? I assumed the entire Northern Hemisphere.

Answer: Thank you for your suggestion. The region is the Northern Hemisphere landmass where snow exists.

16. Figure 8. Cannot see range of results for all three scenarios.

Answer: Thank you for your suggestion. Due to model uncertainty, the simulated error gradually increases later in the 21st century, especially under higher-emission scenarios. Therefore, the ranges in model results for lower-emission scenarios are covered by the higher emission.