

Manuscript review of resubmission

Original review: April 20, 2015

Resubmission review: July 25, 2015

The Cryosphere

Review of resubmission of Shi and Wang, "21st century changes in snow water equivalent over Northern Hemisphere landmasses due to increasing temperature, projected with the CMIP5 models"

GENERAL COMMENTS

Shi and Wang address a topic that is of great interest to the readership of The Cryosphere. I believe that the revised manuscript is improved, but that sufficient problems remain with the clarity of explanations that the manuscript should be revised again prior to acceptance in The Cryosphere.

MAJOR COMMENTS

1. The first major comment that I have brings in to question a number of the results and conclusions in the manuscript. Figure 5 shows observed and modeled mean SWE integrated over NH land areas (excluding Greenland) for the reference period. According to this figure, mean SWE peaks during spring at ~60kg/m², and reaches minimum values during August and September at ~20kg/m² (with models showing slightly lower numbers). The timing of the seasonal cycle seems realistic, but the magnitude of annual minimum SWE seems unrealistically high in comparison to the annual maximum. Previous analyses of observations and model results indicate that during the annual minimum the total snow covered area, and the total SWE, integrated over NH land areas is a much smaller fraction of the spring maximum (i.e. Takala et al. 2011 https://www.wmo.int/pages/prog/www/OSY/Meetings/GCW-IM1/Globsnow_Article.pdf; Frei et al. 2005, J. Hydrometeorology, V6, p. 681-695). It seems unlikely that integrated SWE over NH land areas (excluding Greenland) during August/September is near ~30% of the spring maximum (either in observations or models). The authors should explain clearly exactly what they are calculating and why it is realistic.

2. The second major comment is related to the first one. The authors do not provide any literature review of previous studies that evaluated GCM snow simulations. It seems that such a review would be important in a general sense. In a more specific sense, perhaps such a review would allow the authors to explain how their calculations of NH SWE (discussed in comment #1 above) relate to results of other studies.

MINOR COMMENTS / CLARIFICATIONS

1. Abstract: "...after May the reduction in SWE is controlled primarily by the decrease in accumulated snowfall. In summary, our results show a trend towards decreasing SWE, and the decreases in solid precipitation and accumulated

snowfall strongly affect the change in SWE before and after May, respectively.” This last part of the abstract needs clarification. First, summer temperatures are too high for significant snow even during the current climate, so their statement may be correct but seems to confuse the issue. The last sentence should be broken into two sentences to clarify.

2. P. 3 line 25 – statement that snow depth reflects the amount of precipitation, but not temperature, requires explanation because the temperature affects the density, and therefore the depth, of snow.
3. P. 6 lines 8-10 (datasets section). Explain why they use only the first ensemble members of each model experiment, and explain whether the mention of “aerosols” refers to greenhouse gasses only or other aerosol effects.
4. P. 7 lines 19-22. Explain the use of Pbar, and the meaning of line 22.
5. P. 8, top paragraph. Provide appropriate reference for the Taylor diagram, and explain how it is used here, and how conclusions are drawn from it.
6. p. 10 lines 26-27. Should the sentence state that the changes INCREASE, not decline, with time and increased emissions?
7. p. 11 lines 1-3. Why will decreasing SWE lead to an acceleration of the hydrologic cycle?
8. p. 11 lines 4-12. Please clarify the first sentence. Also, how meaningful are the results for the land area north of 70N, since there is very little land there?
9. p. 11 lines 13-27, and table 2. Please provide more clear explanation of these regression results. What are the independent and dependent variables? Are they “change in SWE” and “change in temperature” at all grid points in each zonal band? What are the units of the slope? How many data points are included in each regression?
10. p. 11 line 30. Please clarify “SWE decreases in response to a specific temperatures range.”
11. p. 12 lines 4-6 “The present results support these findings, suggesting that the most significant changes in SWE will occur at mid to high latitudes during winter and spring (not shown).” Why not show a figure, and explain, what you claim are the most significant changes? Since you use the same models as AR4, isn’t it obvious that you should get the same results?
12. p. 14 lines 2-4. “On a seasonal scale, the extent and magnitude of the SWE increase in winter is larger than in spring, but the range and magnitude of the SWE decrease is significantly smaller than in spring.” Please clarify this statement. Do you mean that during both seasons there are some areas with SWE increasing, and

some with SWE decreasing; but that when integrated over the NH the total SWE decreases more in spring than in winter?

13. p. 14 lines 8-10, and figure 7. In figure 7 the ranges of uncertainty for different scenarios are not visible.
14. p. 14 line 29 – page 15 line 1. “During the EP, total precipitation shows an increase in all months, but snowfall decreases in all months. This indicates that changes in total precipitation and snowfall have competing effects and lead to an increase and decrease in SWE, respectively.” The authors seem to imply that an increase in total precipitation leads to an increase in SWE, but that is not the case when temperatures are changing. Please clarify.
15. p. 16 lines 23-25. This last sentence of the paragraph seems trivial - if there is almost no snow to begin with, a small absolute change results in a large relative change. It seems that many of the results for summer need to be put in context of the fact that there is very little snow to begin with, as well as in context of the values shown in figure 5 (see Major Comment #1 above).
16. p. 17 lines 1-4. “... we note that while atmospheric warming occurs primarily during the winter half-year, coincident with the greater increase in precipitation, greater precipitation cannot compensate for increased snowmelt due to rising temperatures.” Greater precipitation would not be expected to have a compensatory effect, not only because of increased snow melt, but because there will be more liquid precipitation, except over Siberia.
17. p. 17 lines 11-14. “...However, the correlation between mean annual SWE and temperature suggests that a threshold in the relationship between the SWE and temperature would mitigate the persistent decrease in SWE with increasing temperature” This statement requires clarification. Are the authors referring here to the non-linearity associated with the freezing point of water, which should be obvious and should be discussed earlier in the manuscript.