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The Cryosphere Discussions

Interactive comment on "An analysis of present and future seasonal Northern Hemisphere land snow cover simulated by CMIP5 coupled climate models" *by* C. Brutel-Vuilmet et al.

Anonymous Referee #1

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This paper represents an analysis of Northern Hemisphere land snow cover, its recent trends and 21st century changes in the new CMIP5 ensemble of climate model simulations. Although the CMIP5 models on the average reproduce the observed climatological snow cover extent very well, they underestimate (in accord to earlier results for the CMIP3 ensemble) the observed rapid decrease in March-April snow cover in 1979-2005. The authors attribute this, in part, to a too slow simulated warming in boreal land regions during this period. They also show that there is a close although model-dependent linear relationship between the simulated boreal warming and the decrease in spring snow cover, both in the 20th and 21st centuries.

The paper is clearly written and the results are important. Nevertheless, I do have a number of scientific and technical comments, as detailed below.

First, comments about the science (the three most important in the beginning):

1. When several realizations of the simulated climate evolution are available for the same model, the authors average the results. However, this is potentially misleading when comparing the simulated and observed trends of snow cover, because the averaging reduces unforced variability. To see whether the observed trends are clearly inconsistent with (i.e., outside the range of) the ensemble of model simulations, or whether the difference might be explained by internal variability amplifying the observed trend, it would be more informative to use individual realizations from the models in this comparison.

2. I agree with the authors that the underestimate in boreal warming (average in models: 0.31, observed 0.45 C / decade) in 1979-2005 very likely contributes to the underestimate in the rate of spring snow cover decrease. However, the difference in snow cover trends (average in models -1.3% / decade, observed -3.4% / decade, disregarding uncertainty) is too large to be explained by this factor alone. Another factor that apparently contributes is smaller than observed sensitivity of snow cover to boreal land temperature variations (observations: -4.2% / C, average for models -3.0% / C). Despite the large statistical uncertainty in these numbers, this difference deserves attention: in per cent terms, it is nearly as large as the underestimate in warming.

3. In 1979-2005, the models clearly underestimate the “boreal amplification” of global warming (beginning of P. 3329). Does this also hold for the longer period 1922-2005? If this is not the case, then the lower than observed snow cover sensitivity to the variations of the global mean temperature during this period (observations: -14.1 % / C, model average -5.6 % / C, P. 3328) would require another explanation.

4. P 3324, L19-21. “We do not observe a significantly delayed spring melt such as reported by Roesch (2006) for the CMIP3 models”. Do you think this difference is due

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6, C1391–C1393, 2012

to model improvement or different observational data sets, or both?

5. P3326, L26-27. The large difference between the observed and simulated (163 vs. 307 kg m-2 yr-1) snowfall rates is surprising considering the good agreement on snow cover extent. I wonder whether the observational estimate is properly corrected for gauge undercatch?

6. P3332, L. 21-23. Are there any individual realizations in the model ensemble in which the decrease exceeds the observed trend (cf. comment 1)?

Second, technical comments about the presentation:

7. P3325, L20 and later. Are the uncertainty estimates after the +/- signs standard errors, 5-95% confidence ranges, or something else? Please specify.

8. P3333, L1-2. This should be (Räisänen, 2008).

9. Table 1, last line. Why are NorESM1-M and NorESM1-ME on the same line?

10. In multi-panel plots, it would be reader-friendly to include descriptive titles in the figure panels themselves. In particular, this concerns Figs. 3 (insert 20%, 50% and 80% in the map headers), 5 (insert the texts “observations” and “models” on the top and “snow cover”, “temperature”, and “snowfall” on the left) and 6 (use x-labels “boreal land temperature change” and “global mean temperature change).

Interactive comment on The Cryosphere Discuss., 6, 3317, 2012.