The Cryosphere Discuss., 6, C2150–C2153, 2012
www.the-cryosphere-discuss.net/6/C2150/2012/

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.

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Replies to referee #1

1. Reviewer comment: 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.

Reply: The analysis of individual realizations provides almost the same conclusions. The SCE trend for observations is -3.4±1.1 % per decade. For ensemble mean simulations we obtain -1.3±0.8 % per decade. For individual realizations we obtain the same

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average value (-1.3). The simulated SCE trend exceeds the observed trends for only 2 simulations (out of 113 realizations), and it is weaker than -3,4+1,1=-2,3 % per decade for only 14 simulations (out of 113). These results confirm that the observed trends are clearly inconsistent with the model simulations. We propose to add this information in a revised version.

2. Reviewer comment: 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.

Reply: This is true. We will mention this, but, as the reviewer rightly states, the numbers concerning the sensitivity of snow cover to boreal land temperature variations are subject to large uncertainties. Moreover, we think that the boreal spring (March-April) temperature trends (0.66°C/decade observed and 0.38°C/decade modelled) are a more pertinent variable than the annual mean temperature trend given in the first submitted version, because snow melt will react to the spring temperatures, not to the annual mean temperatures, and we note that for spring, the difference between the simulated and observed trends is even larger (see also Wallace et al., PNAS 2012).

3. Reviewer comment: 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.

Reply: Over the boreal continents, there are many missing values in the CRUTEM4 temperature data for this longer 1922-2005 period. Moreover, the period before 1922-1979 is not dominated by anthropogenic warming and the amplitude of temperature

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variations is therefore weaker. This means that 1) the value for 1922-2005 would be dominated by what happens in the latter period and 2) the earlier period would essentially add noise to this.

4. Reviewer comment: 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 to model improvement or different observational data sets, or both?

Reply: In fact, the conclusions of Roesch (2006) have been discussed and challenged by Brown and Frei (2007), as reviewer 2 rightly remarks. So the difference is not necessarily due to model improvement, but possibly to an erroneous method used by Roesch for estimating snow pack density as a function of snow depth. We will therefore not refer to the Roesch (2006) paper.

5. Reviewer comment: 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?

Reply: Indeed, it is well known that snowfall measurements are very delicate, in particular in the high latitudes. So the observational value is definitely subject to a large uncertainty. However, overestimation of boreal extratropical precipitation rates in current-generation climate models seems to be a robust feature reported before (e.g., Dai, Journal of Climate, 2006).

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

Reply: The decrease obtained for individual realizations exceeds the observed trends for only 2 simulations out of 113. We will state this in a revised version.

7. Reviewer comment: P3325, L20 and later. Are the uncertainty estimates after the +/-

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signs standard errors, 5-95% confidence ranges, or something else? Please specify.

Reply: The uncertainty estimates are standard errors. This will be specified in the "Methods" section.

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

Reply: OK, we will correct this.

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

Reply: This was a typesetting error.

10. Reviewer comment: 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).

Reply: OK. Descriptive titles will be added in multi-panel figures (Figs 3, 5 and 6).

Please also note the supplement to this comment:
http://www.the-cryosphere-discuss.net/6/C2150/2012/tcd-6-C2150-2012-supplement.pdf

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