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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Observed and model simulated 20th century Arctic temperature variability: Canadian Earth System Model CanESM2" *by* P. Chylek et al.

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This reviewer's suggestions are very helpful. We appreciate the help, however, we note that some of the suggestions have been already done and published, some of the comments are beyond the scope of our paper and address tasks faced by the broad climate research community, and others will be a subject of future research. Reviewer's basic comments are in quotation marks with our response following.

". . ..a simple intercomparison of the single temperature time series in models and observations does not bring us any further in understanding Arctic climate change or model performance."

The mean temperature variability is generally accepted as a basic parameter characterizing the changing climate (global and regional) and in the IPCC 2007 report a considerable attention has been devoted to temperature trends and their model simulations. While it is true that the comparison of observed and model simulated temperature itself does not lead to improvements of models, it clearly separates models that can and those that cannot reproduce the past mean temperature. The entire climate community finds mean temperatures as a useful indicator to guide further research and needed improvements in climate models.

"It may rather lead to confusion because, for example, some other models of CMIP3 ensemble already simulate the recent Arctic warming very well (see Wang et al. 2007) without having interactive carbon cycle/land vegetation or improved stratospheric representation."

We have shown that the major improvement occurred between the CanCM3 and CanCM4 that are both just atmosphere-ocean coupled general circulation models without carbon cycle or land vegetation. Thus it is clear that the vegetation cycle is not essential for the major improvement shown by Canadian models.

As pointed out by the reviewer, Muin Wang (one of co-authors of the submitted paper) did show (Wang et al 2007) that some CMIP3 models simulated the Arctic temperature better than others. However, Wang et al 2007 used only a limited number of relatively weak metrics to classify the models. Here we use an additional important indicator: the 20th century Arctic temperature trend. We find that the two considered CMIP5 Canadian models reproduce the trend reasonably well while the CMIP3 version Canadian model and the CCSM3 model (which were classified among better models by Wang et al 2007) overestimates the trend by a factor of two to three.

"I recommend addressing the following issues in the revised manuscript. 1) If the new models have an interactive carbon cycle, what are the atmospheric GHG concentrations? How do they compare to the 20C3M forcing data?"

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The CanESM2 carbon cycle only modifies the vegetation response to changing CO2 concentration and corresponding change of albedo. In these simulations land-atmosphere or ocean-atmosphere exchange of CO2 doesn't change atmospheric CO2 concentration. The forcing data used in these simulations is thus exactly same as for the 20C3M simulations. However, with the interactive terrestrial carbon cycle in place, vegetation responds to inter-annual climate variability and consideration of historical land use change means that the crop area increases over the 1850-2005 period. The model does not modify the CO2 concentration itself, which is exactly equal to the 20C3M forcing. Detailed description is in Arora, V. K., J. F. Scinocca, G. J. Boer, J. R. Christian, K. L. Denman, G. M. Flato, V. V. Kharin, W. G. Lee, and W. J. Merryfield (2011), Carbon emission limits required to satisfy future representative concentration pathways of greenhouse gases, Geophys. Res. Lett.. 38, L05805, doi:10.1029/2010GL046270. This explanation and citation will be included in the revised manuscript.

2) "If the indirect aerosol forcing is involved, one may consider cloudiness and vertical temperature profiles for getting an insight on the impact."

The indirect aerosol effect on cloudiness and associated atmospheric changes are described in Ma et al, ACP, 10 9851-9861, 2010. Additional details of aerosol scheme are also provided in Peng et al, ACPD 11, 26477-26520, 2011. These references will be included in the revised manuscript.

3) "Was the effect of interactive vegetation visible in albedo, soil properties or snow cover?"

The land surface albedo is calculated by the scheme called CLASS, in which the land albedo is determined by bare soil, vegetation-covered soil, and snow-covered soil. So far the interaction between vegetation growth and surface albedo has not been considered. However this is an interesting and complex topic that will require a separate publication. We hope to do this investigation and report later. The CLASS is described

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in: D. L. Verseghy, CLASS: The Canadian land surface scheme (CLASS): Its history and future, Atmosphere Ocean, 2000, 38, 1-13. A brief explanation and the CLASS reference will be incorporated in the revised manuscript.

4) "Is the improvement of the model performance in the Arctic accompanied by better simulated global/hemispheric trends?"

Yes, the global and hemispherical temperature trends were improved as is described in Arora et al, Geophys. Res. Lett., 2011. The statement and reference will be included in the revision.

5) "The patterns of the temperature changes/trends (in and between the different models for the ECW and recent period) could also give an indication of underlying mechanisms."

The Canadian CMIP5 models (CanCM4 and CanESM2) show better simulated global/hemispheric temperature trends compared to the CanCM3 model. This is described in the paper Scinocca, J. F., N. A. McFarlane, M. Lazare, J. Li, and D. Plummer: The CCCma third generation AGCM and its extension into the middle atmosphere. Atmos. Chem. and Phys., 8, 7883-7930, 2008. The CMIP5 models provide a superior simulations of individual time epochs of the 20th century (1900-1940, 1940-1970, 1970-2000) compared to the CMIP3 models. To find out if the improvement is due to aerosols will require extensive and expensive new runs (with and without a direct, and with and without an indirect aerosol effect) of the 20th century simulations, which hopefully will be accomplished within the next few years. A comments and references will be included in the revision.

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 22893, 2011.