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Interactive comment on "Assessment of Snow, Sea Ice, and Related Climate Processes in Canada's Earth-System Model and Climate Prediction System" *by* Paul J. Kushner et al.

Anonymous Referee #2

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Review of Assessment of Snow, Sea Ice, and Related Climate processes in Canada's Earth-System Model and Climate Prediction System by Paul Kushner and coauthors.

General comments

This draft is a review of studies carried out by the network of researchers within the project CanSISE. It deals with the quality of land snow and sea ice simulations in the CanESM2 earth system models, as well as the predictive capabilities of CanSIPS in land snow and sea ice predictions, with a focus on Canada and Canadian sector of the Arctic Ocean.

The draft is well written, and addresses a number of scientific studies, as well as

methodological topics related to model assessment. It will be an interesting and very useful reference for the Canadian ESM and its predictive capacities. I recommend this draft for publication. However, I did not find it easy to read and review, and I would like to raise a few points that, according to me, would improve the manuscript.

(i) I find the paper a bit unbalanced, the 'snow' discussion being more developed than the 'sea ice' one. Both discussions are also mostly unrelated. To me, it could question the usefulness of having both snow and sea ice discussed in a single paper. I think the authors should make an effort in harmonizing the presentation. It is obvious that the same parameters drive both snow and sea ice biases in CanESM, but it should be clearer. Additionally, the paper would be a bit clearer if sections 3 and 4 were structured with subsection on sea ice and snow (3a, 3b, 3c...).

(ii) Like other review papers, there is a need to find the optimal level of details. To me, there is a lot of references to past studies in this draft, which sometimes is not self-explanatory. Although it really makes me want to read papers written by CanSISE's partners, I would find it useful to have more details in a reference paper as a 'one-stop shop'. For instance, provide more details on datasets included in the Blended-5 SWE; remind the readers on some technical details: the components of CanESM/CanCM, ensemble generation in the large ensemble, in CanSIPS, the definition of the assessment regions... Tables could be used. Another related point is that the paper contains a large number of figures, which are not always well-discussed in the main text, and possibly too much in the captions.

(iii) Finally, as a non-Canadian (nearly) anonymous reviewer, I find the paper a bit too Canadian-centered. I am not surprised since it is a review paper from a Canadian project, and I acknowledge the major contribution of the CanSISE network to the field of snow and sea ice predictions. Though, the authors may wish to refer more to others' works...

Minor comments

Title The title should reflect that the assessment is on land snow, but it is clear in the abstract.

The abstract is clear and well-written.

1. Introduction

P2, L12, 'leading earth system': this is true, but a bit subjective. I would stay neutral and write 'global' earth system.

P2, L16, 'this study': this paper is more a review than a study.

P3, L1, 'related climate parameters': these parameters should be defined once in the draft: surface temperature, snow precipitation, sea surface temperature. . .

P3, L5, 'a more complete a characterization': too many a's.

P3, L5, 'observational uncertainty'.

2. Models and data used

This section should be a bit re-written. I would start by a description of the component of the coupled atmosphere-ocean-sea ice-land model, then describe the Earth System Model (ie with Carbon cycle), and finally explain what is CanSIPS. It is more in line with the order used to discuss the results in sections 3 and 4. And it seems to me more logical to describe the components, before describing the initialization method...

P3, L11-12: Merryfield et al. (2013a) refer to the multi-system sea ice predictions combining CanSIPS and CFSR. The reference should be Merryfield et al (2013b). Although there is an inversion of both references in the main text. . . which is the impression I have after reading the full draft...

P3, L16: what is 'it'?

P3, L19: It is not clear to me what (3) does exactly. Is it about calibration? It could be interesting to have an example.

P3, L23-29: Is it possible to provide any reference on the benefit of having an ESM? Is there any impact (positive or negative) of carbon cycle components on the state of the physical components?

P4, L1: CanESM alone includes a prognostic carbon cycle, isn't it?

P4, L3-6: Could the authors provide a bit more details on the reasons of improvements in CanCM4 relative to CanCM3? Is there any change in the model physics? Resolution?

P4, L19: compared to many other CMIP5 models and operational seasonal prediction systems (e.g. MetOffice is 1/4°, MeteoFrance is 1°...).

P4, L19-23: it would be interesting to have somewhere information about the size of ensembles run for seasonal predictions.

P4, L24-25, 'much higher resolution': what resolution?

P5, L7: what perturbations are used to generate the ensemble?

To me, in this section 2, a discussion on 'methodology' is missing. What is the motivation behind using the 'Large ensemble'? Maybe the words 'detection and attribution' should be written somewhere. How do the authors define the regions over which the assessment will be conducted? It would be useful at this stage, and will enable a discussion on the resolution of the land-sea mask for instance...

3. CanESM2 climatology and trends

P5, L15: is 'temperature' surface temperature? 2m-air temperature?

P5, L16: see above about the differences between CanCM4 and CanESM.

P5, L24: what about the orography in the (low resolution) model?

P7, L34 and sq: shouldn't it be the same for sea ice? See comment (i).

P8, L25: in terms of climatology

4. Snow and sea ice related forecast performance and development of CanSIPS

P9, L7-8: what is 'recently'? The review paper by Guémas and coauthors (see below) is never cited and provides a useful state-of-the-art of seasonal prediction of the Arctic sea ice.

P9, L26 and sq: the paragraph deals with land surface initialization, while it starts with reference to 'process representation of land surface'.

P10, L27: referring to Guémas et al (2016) would be fine here too.

P11, L4: a reference to Chevallier and Salas-Mélia (2012) seems relevant here.

5. Conclusions

P12, L9-13: does it mean that future developments of CanESM/CanSIPS include increase of resolution of the global model?

P12, L23: reference to Lindsay et al. (2012) not in reference list... Is it really a viable solution?

P12, L33-34: references for LS3MIP and ESM-SnowMIP?

Figures

Figure 1: what is 'temperature'?

Figure 3: definition of the regions considered (if I don't want to download Mudryk et al...)?

Figure 8: information on ORCA1° (not defined: reference?) seems not relevant here, or should be discussed in the main text (e.g. while presenting the components or their possible evolutions).

References

Chevallier, M., and Salas Y Mélia, D., 2012. The role of sea ice thickness distribution in

the Arctic sea ice potential predictability: a diagnostic approach with a coupled GCM. Journal of Climate, 25, 3025-3038, doi:10.1175/JCLI-D-11-00209.1

Guémas, V., Blanchard-Wrigglesworth, E., Chevallier, M., Day, J., Déqué, M., Doblas-Reyes, F., Fuckar, N., Germe, A., Hawkins, E., Keeley, S., Koenigk, T., Salas y Mélia, D., Tietsche, S., 2016. A review on Arctic sea ice predictability and prediction on seasonal-to-decadal timescales. Quarterly Journal of the Royal Meteorological Society, 142, 546–561. doi:10.1002/qj.2401.

Van den Hurk, B., Kim, H., Krinner, G., Seneviratne, S. I., Derksen, C., Oki, T., ... Viovy, N. (2016). LS3MIP (v1. 0) contribution to CMIP6: the Land Surface, Snow and Soil moisture Model Intercomparison Project–aims, setup and expected outcome, Geosci. Model Dev., 9, 2809–2832.

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