

***Interactive comment on “The impact of a seasonally ice free Arctic Ocean on the climate and surface mass balance of Svalbard” by J. J. Day et al.***

**Anonymous Referee #1**

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**Review comments**

The impact of a seasonally ice free Arctic Ocean on the climate and surface mass balance of Svalbard J.J. Day, J.L. Bamber, P.J. Valdes and J. Kohler

This paper describes the impact the removal of sea ice and increase in sea surface temperature may have on the temperature and precipitation on Svalbard, and thus and on the surface mass balance of Svalbards glaciers. The authors describe scenario runs with a regional atmospheric climate model and discuss the different results in terms of atmospheric temperature, solid precipitation and mass budget of the Svalbard glaciers.

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The presented subject fits well in the general scope of the journal and the study itself is interesting.

My main concern with this paper is that the authors are sometimes a bit careless in their formulations, often do not explain the underlying processes and the manuscript generally lacks focus.

**General remarks**

- I am missing explanations of the processes, especially in the first part of the manuscript.
- The title is not to the point: The study does not discuss climate in general, but temperature and precipitation.  
From what I understand, surface mass balance of Svalbard is not discussed either, solid precipitation is discussed.
- For Regional climate models, 25 km resolution is not high resolution anymore. At present models are run on 2-5 km.  
Given the scale of the Svalbard glaciers, is 25 km enough to discuss changes in mass budget? Especially precipitation is very sensitive to chosen resolution.  
Also validation on these scales is questionable. The variable topography of Svalbard makes it hard to find an area large and homogeneous enough for a 25 by 25 km size grid box to be representable.

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## Specific remarks

### Abstract

- Not only models predict rapid decline sea ice extent, observations show it as well.
- explain what the underlying processes are resulting in the differences between sea ice covered, sea ice free, and sea ice free but with prescribed surface temp. Also explain what causes the difference in surface mass balance in the different tests.

### Introduction

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- 26: is 2-4% of the total significant?

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- 12: how does sea ice extent impact Svalbard glaciers? Explain.
- 14: Explain correlation.
- 19: Explain why, time scale of ice cores, when was the last time sea ice extent was similar?
- 21: Climate is a very broad term. Be more specific (throughout the manuscript).
- 25: Explain what causes the larger response in winter than summer in Deser et al 2010, also explain the accumulation changes in Singarayer et al 2006.

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- 10: Especially precipitation is very sensitive to model resolution and is a very important parameter in the surface mass budget of the glaciers. Is 25 km resolution enough?
- 23-27: Be more specific in your goal of this study.

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### Model setup and methods

- I am in general missing a description of how the model deals with the surface mass budget. Does it have an ice mask and snow/ice layers? Does it calculate subsurface processes such as refreezing? How does it handle melt and runoff?
- I am also missing technical details on how the model was forced. How often are the boundaries imposed on the model? Every 6 ours, or once per month? What is your model time step?
- What are you using for the analyses of the mass budget and climate, analyses of forecasts?

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- 5-10: Rephrase, not clear to me, what is the driving simulation?
- 13-16: Rephrase, not clear, be more specific and explain.
- 20-28: Have you tested the impact of the nesting procedure and the necessity of doing it? Note that the ratio of 10 is an arbitrary choice.

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- How is  $b_n$  determined in your model?
- Is figure 2 from Oerlemans et al. 2005 or your model calculations?
- Explanation of the methods is not clear, symbols are explained several paragraphs after first mentioning them.
- Assuming that Figure 2 is from Oerlemans et al. (not clear to me) you do not present such a figure from your own calculations, which would be very interesting.

### Comparison of model with observations

- I am not sure how much point there is in actual validation. I think it is better to discuss the modelled temperature and precipitation in general terms compared to observations and limitations of the model through the limited resolution than the detailed point vali-

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ation given here.

- Make clear that you validate only Temperature and precipitation, the parameters you are interested in when discussing the sensitivity to sea ice extent.
- Somewhere explain what is the impact and why sea surface temperature changes, sea ice extent changes impacts temperature and precipitation over Svalbard. Explain the underlying processes!
- I guess this is not the first time this model is used and validated against data. Is there more information on model performance, perhaps from other areas? Refer to those results.

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- check spelling of names of glaciers
- 8: remove the location information for Kongsvegen, is given in the table.
- 20: Refer to figure 5 c, showing the orography in the model, and perhaps if available the ice mask.
- 15: periods are quite different. How much does this influence the comparison with the reference period? You can use the Longyearbyen data to calculate averages over the different periods and see how they differ from the reference. That way you can say something about the impact different periods has on the found differences.
- 28: Check the references.

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- 5: explain the surface scheme MOSES
- 12: This paragraph suggests that the model does not calculate melt. Is that correct?
- 24-28: discuss differences in observed T and P between periods 60-90 and 2000-2008, before attributing the differences to model performance. Also keep in mind that the model resolution is limited.
- 24-28: quantify your statements when possible.

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- Note that in the Svalbard ice cores melt layers are present. This makes it more difficult to determine accumulation from ice core layers.

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- 17: I assume you only use precipitation from the RCM because melt is not calculated? The best comparison would be the mass balance, thus accumulation from ice cores and precipitation minus melt from the model.
- 21: I don't see the point in making such a detailed analyses of precipitation given the 25 km resolution of the model.

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- 1: change 'block' into 'step'.

### **the impact of changes in sea ice to the climate of Svalbard**

- You use the term climate often when you only discuss temperature and precipitation. Be specific.

- 10: 'many details of Svalbards climate' is a very general statement, be specific.

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- 1-2: I guess you mean turbulent fluxes of heat and moisture? Explain these fluxes and explain how they change when sea surface temperature and extent changes.

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- 17-20: Rephrase, not clear.

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- 28: Check reference to figure.

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- show the resulting SSC in a figure and discuss the results. How is bn calculated? Precipitation? explain.

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## Conclusions

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-1-2: Rephrase, be more specific, very general statement.

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- 22-28: You do not discuss the resulting SSC at all.

## Tables

Table 1: Where does the information from the ELA come from? Give reference.

Table 2: Are the RCM grid cells defined as ice? Or land surface? Does the model calculate surface fractions within a grid cell? Is the specific surface mass balance presented here a combination of melt and precipitation or only precipitation. If the latter, don't call it specific mass balance. At these elevations there can be significant melt.

Table 3: explain the abbreviations for the seasons (also in main text and figures).

## Figures

Most figures have very small axis labels please increase the size.

Figure 1: Does this figure include the ice mask as used in your model? Not very clear and also not much of Svalbard is covered by ice according to this figure. about 60% of Svalbard is presently covered by ice.

Figure 2: are these your results of from Oerlemans et al 2005? Oerlemans presents Austfonna and Kongsvegen, which one is this? Limit the y-axis to -0.10 to 0.05.

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Figure 5c: can be shown earlier plus the ice mask in the model.

Figure 6: nicely visible the impact of the warm ocean current, explain that in the text.

Figure 7: Are these the sea ice forcings downscaled with the RCM?

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Interactive comment on The Cryosphere Discuss., 5, 1887, 2011.

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