

## ***Interactive comment on “Future projections of the climate and surface mass balance of Svalbard with the regional climate model MAR” by C. Lang et al.***

### **Anonymous Referee #1**

Received and published: 28 January 2015

Future projections of the Climate and Surface Mass Balance of Svalbard with the Regional Climate Model MAR C. Lang, X. Fettweis, M. Erpicum

This manuscript describes the impact of projected climate change on the surface mass balance of Svalbard glaciers. Although several publications are available presenting the projected changes in Svalbard surface mass balance, this is the first to be based on a coupled atmosphere - snow-pack model. I found the manuscript interesting and reasonably well written.

I do have some comments, which are listed below.

One general comment is that I am a bit surprised by the choice of figures in the supplement. All supplement figures are referenced more than once in the manuscript which

C5

suggests to me that they belong in the manuscript and not in the supplement. Same holds for the table.

The fact that this is the first time a physically based snow model is used in combination with an atmosphere model to determine the surface mass budget of Svalbard may be stressed a bit more by the authors.

Abstract:

L7: Remove 'and the ice caps'. The ice caps are part of the Archipelago. L12: Replace 'strong' by 'stronger'. There already is a West-East temperature gradient. L17: The fact that the whole surface area is now net ablation area does not mean that the retreat is 'irreversible'. When climate changes again, the glaciers can grow again or come back. I suggest only to state the facts: that all glacier area is at the end of the century net ablation area and will, when this climate persists, result in an ice free Svalbard.

P116:

L21: Very long sentence. To improve readability rephrase or cut the sentence before 'Arctic glaciers'.

P117:

L3: Replace 'low' by 'small'.

P118:

I am missing a bit the bigger picture here. What are the changes in the components determining the mass budget: atmospheric flow patterns, sea ice cover, sea surface temperature? The description immediately focusses on mass budget, while these components are crucial in determining the mass budget.

P119:

L12: Replace 'driven by' by 'determined'

L13-16: Rephrase: I don't see this. The evolution in time for both regions (East compared to AV) is very similar, however, the absolute values differ resulting in a reasonably

C6

small difference in SMB.

L21: Refer to figure 3c.

L22-29: Rephrase: I don't see any trend in cloud cover for any of the areas. Cloud cover is rather variable and all regions show a decreasing trend in incoming radiation. The strong decrease in incoming radiation therefore cannot be explained by changes in cloud cover. It might be related to changes in type of clouds, but that is not shown here.

What I see is that the albedo in West decreases more than in East and AV and that the net absorbed short wave radiation increases more than East and AV. The fact that net radiation in West resembles East and AV more than South and BE can be explained by the on average higher cloud cover in West, but does not explain the trends.

P120:

L5: Where does 'larger acceleration' refer to?

L6: How is 'anomaly' defined? (explain also further in the manuscript).

L9: Why do you refer to m ice instead of w.e.? Since you do not consider ice flow these values do not refer to elevation change.

L13: Where does 'all permanent snow/ice' refer to? BE or Svalbard?

L13: On what calculation is this based? Do you know how much ice is on BE? Have you calculated how much time it will take to melt all that? Is all the ice at 0 K or do you have to warm it first? You have to explain where this statement is based on.

L22: The conclusion of contribution to sea level and following discussion is out of place here, since you have not discussed any of the uncertainties related to the assumptions in your calculations (fixed ice mask, fixed DEM). Furthermore, you do not discuss the impact of possible changes in calving rates at all.

L27: Explain the differences between this study and the sited studies.

P121:

L12: Replace 'should' by 'do'.

L24: Replace 'expect' by 'assume'.

C7

L25-29: In my opinion it is a guess that the net effect of these three uncertainties will cancel each other. You do not support it with any calculation or reference. Furthermore, Fettweis et al (2013) suggest an uncertainty of 5-10% for Greenland, which is not insignificant. They also state that it should be taken into account. Finally, Greenland is a rather different situation from Svalbard in size, topography, and likely sensitivity to changes. Which has to be taken into account when transferring results from Greenland to Svalbard.

P122:

L6: What about changes in calving rates due to climate changes? Especially for Austfonna an important factor.

L6-7: Does this sentence refer to the whole of Svalbard?

L7-8: Repeat of L30 previous page. Remove one of these statements.

L10: I do agree that the increase in JJA near surface temperature is small, but I do not agree that it is spatially homogeneous.

L11: TAS<sub>jja</sub> is already defined earlier. The use of TAS for JJA and DJF is a bit confusing.

L12: Remove 'much larger'.

L12: Start new sentence after '7a)' to improve readability.

L19: Replace 'normal' by 'to be expected' and explain why this is to be expected based on the representation of the scenarios.

P123:

L10: Replace 'start to not form' with 'retreat'.

L10-12: Rephrase: formulation is not correct. Sea water is always warmer.

L13: Replace 'where there is a possibility for more sea ice to decrease' by 'in areas where sea ice can decrease'.

L18: Replace 'altitude' by 'topography'.

L18: Reference to wrong figure. Fig. S3b?

L18: Replace 'only' by 'most dominant'.

C8

L20: Replace 'altitude gradient' by 'the effect of topography'.

L21: Replace 'should' by 'will'.

L22: Remove 'Finally'.

L27: Reference to non-existent figure. Fig. S4?

L28: Reference to model HadGEM1 when referring to work of Day et al. who are using HADRM3 (L25) is confusing. Rephrase.

P124:

What is the impact of the limitations/uncertainties introduced by the limited horizontal resolution of 10 km, and fact that you keep your mask and topography fixed, on the extent of the melt season?

L13: Replace 'at the same time as' with 'coincides with'.

L15: Move this line about precipitation to L20, where you discuss effect of precipitation.

LL25: To my knowledge, MAR does not include a routing scheme and is therefore not capable in showing a delay in runoff to the ocean. Although this delay will be there in reality, the timing difference in melt and runoff in the model as shown in the figure is not a result of that.

P125:

L13-15: Move this sentence to after introducing the surface energy balance equation.

L17: I find the use of SWD for the short wave radiation rather confusing. In general SW is used. Since D refers to downward it ignores the fact that there is also a reflected and therefore upward component.

L19-20: remove twice the word 'downward'.

P126:

L5-7: Explain better: I guess you manipulate the albedo and short wave radiation output. You did not do additional runs in which you kept the albedo or radiation constant.

L11: Add total amounts to the table. That is more informative than the percentages.

L16: 'Second largest' suggests large differences while SHF, LHF and LWnet are fairly similar in value, at least percentage wise.

C9

P127:

L6: Replace 'impact a lot on its' with 'have a large impact'.

L14: Replace 'should' with 'will' and 'contre' with 'counter'.

L17-19: This is the reason for the acceleration in melt. Why not state that as well?

L17: Replace 'through the' by 'by increasing'.

L19: Insert 'thus increasing the energy' between 'and' and 'available', and remove 'in the energy budget'.

L20-24: Rephrase, very long sentence.

L26: Replace 'should decrease' with 'also decreases'.

P128:

L1: See my comments on relation cloud cover and short wave radiation on page 119.

L7: Replace 'that' with 'the significant impact of' and replace 'impacts Svalbard a lot' with 'on Svalbard'.

L12: Replace 'should be' with 'is'.

L12: Add that the gradient is expected to reduce.

L14-16: Rephrase sentence, not clear what is meant.

L21: See my comments on the word 'irreversible' in the abstract.

L29: Replace 'should' with 'will'.

P129:

L1-2: Twice replace 'should' with 'will'.

L6: Replace 'could' with 'will'.

L7: Remove 'could'.

Figures:

Rephrase captions such that not for each panel the words 'same as' is used.

Figure 3: Explain the abbreviations in the axis description.

Figure 4: How is 'anomaly' defined?

Figure 8: Explain the lines in the figure.

S1: Why not add plots of runoff and precipitation to figure S1 in the supplement as

C10

well?

S2b: Is incoming short wave radiation, not net short wave radiation

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Interactive comment on The Cryosphere Discuss., 9, 115, 2015.