

## ***Interactive comment on* “Surface mass balance model intercomparison for the Greenland ice sheet” by C. L. Vernon et al.**

### **Anonymous Referee #2**

Received and published: 18 February 2013

#### General comments

This manuscript describes an intercomparison study of 4 different methods of downscaling the ERA-40 reanalysis product for Greenland, 3 are applying regional climate models, Polar MM5, RACMO and MAR, to dynamically downscale it and one down-scales the ERA-40 reanalysis product in two steps, first with bilinear interpolation from 1.125° to 0.5° grid and then lapse rate correcting the temperature and computing surface melt with a positive degree day model. All these products are on different grid resolution and are applying different ice sheet masks, which makes the comparison difficult, but authors regrid all model outputs to a common projection and a 5km grid resolution and state that this rearranging introduces only 1% changes from the native output. Analysis of the impact of mask variation is made and it is concluded that

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approximately a third of the inter-model SMB variation can be explained by the large mask variation at low altitude, much of the disagreement between the models is in the ablation area, outside the common mask area. After analysing this difference a series of comparisons between the 4 products is made, the SMB components (precipitation, runoff, melt and refreezing) are compared, the Equilibrium line altitude and regional and seasonal intercomparisons of the SMB components are made. Finally, a very brief comparison with observations is made. In the conclusions section of the paper the study is summarised, but no thorough discussion of the presented analysis or any real conclusions are drawn, apart from the fact that having models applying the same ice sheet mask and the same grid resolution would make the comparison between the model products more useful. Reader is left with many open questions, the most important ones are: what are the conclusions of this study? And what have we learned from this work?

There are fundamental differences in the models that are compared, for example in the representation of the albedo and how the refreezing processes are included – and possibly is the topography different between the models. These will have a large impact on the surface mass balance, but this fact is not at all addressed in this study. How large differences are there in the values of the albedo in the different models? how does that variation change regionally and seasonally? How large impact will that difference have on the simulated melt? A recent study by two of the co-authors emphasize the importance of the albedo feedback for the Greenland Ice Sheet mass balance (Box et al., 2012) and therefore some consideration of the albedo differences between the models would be appropriate in this study. Similarly, a large difference is presented in the amount of refreezing between the models, but no analysis or attempt to understand the impact that the difference in refreezing implementation between the models will have on the model results.

A very brief presentation of observations is made and even briefer comparison made with the models and noted that "model estimates differ from observations by a larger

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amount in the ablation area than the accumulation area“ What is the uncertainty in these observations? How reliable and representative are they? What can be learned from this comparison? Does this comparison increase the confidence in the models?

This intercomparison is clearly presented and a valuable analysis made on the difference between the selected models, but there is a lack of interpretation and discussion of the results (tables (e.g. 3 and 4) and figures (e.g. 5, 7, 8 and 9) are presented but not really discussed) and conclusions of this study are really missing. With clear conclusions and perhaps a recommendation for further work on improving the models and increasing the understanding of their shortcomings this paper would become a valuable contribution.

#### Specific comments

Page 4001 line 13 "runoff" here "melt" would be more appropriate as runoff includes rain that does not contribute to mass loss Line 26- line 2 on page 4002 This statement is not correct, there are a number of other reconstructions available (see for example in Rae et al. 2012)

Page 4002 line 20 typo in "coving" Line 22-23 not clear sentence, rewrite to make clearer, less satisfactory than what? Over which period?

Page 4003 line 1 "ERA-40 data" – ERA-40 is a reanalysis product based on data, suggest to be consistent throughout the paper (see also page 4003 line 20, page 4004 line 26, page 4006 line 14 and probably other places where it is called ERA-40 reanalysis data, ECMWF re-analysis ERA-40, ERA-40 respectively) and call the fields ERA-40 reanalysis product.

Page 4003 lines 1-3 very long and unclear sentence, suggest to break up and clarify Page 4003 lines 3-5 another long and unclear sentence, suggest to rewrite Page 4003 line 20 missing reference for the operational analysis data. Please explain better what reinitialising entails, is the snowpack reinitialised? What variables are reinitialised?

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Line 22 – not ideal for what? What kind of inhomogeneities? Line 24 errors in what? Explain better Line 25 Is the precipitation, one SMB component, modelled with an energy balance model?

Page 4004 line 27 missing reference for the operational analysis. Suggest to replace study area with model domain.

Page 4005 line 1 what does "open fraction" mean? How is it prescribed? Using what? Equation 5 there is inconsistency in the use of  $M$ , here it is used for melt energy, but in equation (4) it is the amount of melt, please be consistent with the terms.  $Q_H$  and  $Q_E$  are already defined. Line 23-26 This is not correct, in a paper that is reference in this study (Lucas-Picher et al, 2012) analysis of a 5km resolution run with HIRHAM5 is presented.

Page 4006 line 14 missing reference and explanation for ERA\_INTERIM Line 26 what fields?

Page 4007 line 1 suggest to add "up to" (is the error the same everywhere? How large variability?) Line 19 replace "runoff" with "ablation" area Line 21 suggest to turn sentence, the downscaled data is not independent from observations Line 23-27 this sentence should be somewhere else in the paper not in the description of the ECMWF downscaled product

Page 4008 line 3 (with fraction grid boxes rounded) what does this mean? Please clarify Lines 4-8 this sentence is not clear, please edit Line 16, what do you mean by stating that common mask is not more accurate?

Page 4009 line 1 what is "the sub-grid issue"? Line 6 replace "reconstruction" with comparison Line 12 what is meant by "fewer of this type" – please edit and clarify Line 15 do you mean each position? This sentence is not clear, suggest to rewrite and explain what filtering means here

Page 4010 line 26 do you mean larger negative SMB? Do you mean common points?

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(rather than masks)

Page 4011 line 13-15 – sentence is not clear, do you mean modelled mass balance (not observed)? Please edit and clarify. Lines 24-25 what is meant here, how is the effect of biases minimised?

Page 4012 lines 4-6 replace "from" with "in period" the sentence is not clear, please rewrite, what is SMB tracking?

The Note on refreeze is not useful here, some explanation of the different implementation of refreezing between the models would be helpful to present here

Page 4013 line 26 " A similar, but different pattern ..." what does that mean? Please rewrite

Page 4014 lines 7-9 What does this sentence mean? Is the comparison then not reliable when only total values are compared?

Page 4014 line 20 – and why is this difference? Can you give some explanation? Lines 24-25 why is this difference? Some analysis and discussion would be useful here

Page 4015 line 10-12 some analysis and discussion of this difference would be useful  
Section 4 Conclusion is really only a summary of the previous sections, there is missing thorough discussion of the presented intercomparison and conclusions from this study  
line 19 "reasonable agreement" what does that mean? Is it regional? Seasonal? Can you quantify? Line 20 What do you mean by "filtering"? add "between models" to the last part

Page 4016 line 1 – what was previously thought? Maybe some references could be added here? Line 24 what is meant by this sentence? It is not clear. Suggest to end the study with some conclusions that have been drawn from this intercomparison exercise.

Figure 10 what is a "rank order" – this could be explained better.

J.E. Box, X. Fettweis, J. C. Stroeve, M. Tedesco, D. K. Hall and K. Steffen, 2012,

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Greenland ice sheet albedo feedback: thermodynamics and atmospheric drivers. The Cryosphere, 6, 821-839, www.the-cryosphere.net/6/821/2012/doi:10.5194/tc-6-821-2012

J. G. L. Rae et al. 2012, Greenland ice sheet surface mass balance: evaluating simulations and making projections with regional climate models. The Cryosphere, 6, 1275-1294, www.the-cryosphere.net/6/1275/2012/doi:10.5194/tc-6-1275-2012

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Interactive comment on The Cryosphere Discuss., 6, 3999, 2012.

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