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The Cryosphere Discussions
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Interactive comment on "Fluctuations of a Greenlandic tidewater glacier driven by changes in atmospheric forcing: observations and modelling of Kangiata Nunaata Sermia, 1859–present" *by* J. M. Lea et al.

S. Price (Referee)

sprice@lanl.gov

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Summary

In this paper a novel model validation exercise, with relevance to Greenland ice sheet outlet glaciers, is presented and discussed. The authors begin by motivating efforts for the validation of outlet glacier models on century to decadal timescales and by summarizing past studies that support an oceanic and atmospheric influence on controlling outlet glacier terminus position over time. They suggest that locations for which

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decadal to century-scale records of both climate (in this case, air and sea surface temperatures) and outlet glacier terminus position exist should provide good test cases for both validating numerical models and for better understanding relationships between outlet glacier terminus change and climate forcing. Kangiata Nunaata Sermia (KNS) glacier in SW Greenland, during the period 1859 to the present, is identified as one such location. A summary of the available climate and outlet glacier terminus position data is then provided, as is a description of the flowband model used and the methods for linking available climate records to dynamic changes within the model. A Monte Carlo approach for generating forward model runs (as a function of unknown model parameters) is presented, as is the procedure for identifying acceptable runs for further examination. From the discussion and conclusions sections that follow, the important findings from the work:

1) Periods of terminus retreat that are NOT topographically controlled generally coincide with periods of positive air and sea-surface temperature anomalies, provided that the air and sea-surface temperature records are averaged over suitably long time periods. It is suggested that records of climate and/or terminus position on the order of 2-5 years in duration will be too short (too noisy) to be relevant.

2) Care must be taken when looking for correlations between climate and outlet glacier terminus retreat because topographically controlled phases of retreat may or may not be in phase with air and sea-surface temperature anomalies.

3) When comparing observed terminus positions to model results, multi-annual time averages of positions should be used, in order to remove inherent noisiness due to the stochastic nature of calving.

4) For model runs in which terminus retreat is representative of observations, some combination of both oceanic and atmospheric forcing are necessary to induce the modeled terminus positions. While atmospheric forcing appears to be the more important of the two for KNS, some secondary link between atmospheric forcing and ocean forcing

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cannot be ruled out (e.g., changes in melting and runoff affecting fjord circulation).

Overall, this paper was well organized, well written, and easy to read. The science questions addressed are well within the scope of TC. The authors reach interesting and substantial conclusions, both with respect to demonstrating that their model can reasonably reproduce an observed outlet glacier retreat history and with respect to improving our understanding of (i) the relative importance of atmospheric vs. oceanic forcing in causing the observed retreat and (ii) the relevant time periods over which models and observations of outlet glacier terminus behavior should be compared over. The various datasets (the outlet glacier terminus position time series, the climate data time series) and new developments (metrics and weight for model evaluation) put into the study are a nice addition to the currently very small number of real-world, model validation exercises. They may prove useful to other modeling groups in the future (e.g., if some additional work were done to set this study up as a standard "validation" test case).

The paper doesn't require any major revisions, but I have a few minor suggestions (below) that might make the paper more clear and readable.

Minor Concerns

[Section or page number, line number(s): comment]

Abstract, 15-16: "... with changes in atmospheric forcing not needing to be offset by changes in oceanic forcing sensitivity." After reading the full paper, it is more clear what is meant by this statement, but as written it is not clear what is meant by this in the abstract.

2010, 8: "...used to good effect...". This is kind of vague. Can you clarify further if/how the papers referenced support the argument that SSTs are a good reference for oceanic forcing?

2010, 10-17: Clarify if/that the data you are referring to are reanalysis data.

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Interactive Comment

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Author: Administrator Subject: Highlight Date: 28/07/2014 14:04:10

Author: Administrator Subject: Sticky Note Date: 28/07/2014 14:05:29
P2 L8-10 clarified

Author: Administrator Subject: Highlight Date: 25/07/2014 16:07:38

Author: Administrator Subject: Sticky Note Date: 28/07/2014 14:06:15
P4 L25-27 "used to good effect" changed to "used previously to interrogate the role of oceanographic forcing on TWG stability". Studies mentioned have concluded that oceanographic forcing indicated by SSTs appear to exert a control on particular aspects TWG stability for their study regions.

Author: Administrator Subject: Highlight Date: 25/07/2014 16:19:41

Author: Administrator Subject: Sticky Note Date: 28/07/2014 14:06:44
P4 L32 These are not reanalysis data. Clarified in text.

2012, 17: A steady-in-time SMB relationship is used. It would be good to discuss whether or not the model output is sensitive to this, or at least present arguments for why it is not (especially since, from other sections, it sounds like there are time varying SMB fields that could be used to allow for an SMB that varies in time).

2013, 3-4: While it is certainly not necessary to repeat the entire init. cond. tuning procedure here, it would be nice if a short summary was given (so that the reader does not have to refer to Lea et al. (2014a) if they don't want to).

2013-2014: It would be nice to know how the value of B_base is determined. It sounds like it probably comes from the models mentioned in the next section, "definition of B_month", but that is not entirely clear.

2015: suggest elaborating on the title of the section "confluence with AS", to make it clear up front that you will also talk about how the ice flux is affected by this (e.g., "Confluence with AS: adjustments to d_w and ice flux").

2017, 12-19: From the description given, it is not entirely clear how the model parameters, which are varied according to the Monte Carlo procedure, are treated during the model initialization.

2018, 1-2: In general, the use of the "=" when describing a variable seems awkward (e.g. "n=terminus observation"). Perhaps it is just a stylistic preference, but it seems like it would be clearer to use something like "n represents a particular terminus observation, k represents the total number of terminus observations,", etc.

2018-2019: The section on the reconstruction of glacier terminus positions seems a bit oddly placed. Might it go better earlier on in the paper, before the model is discussed? Or, perhaps maybe even in a short appendix?

2023, 5-8: Put another way, the sign of advance or retreat taken from observations is likely to be a more robust indicator than the inferred rate of advance or retreat (?).

Conclusions: You might add something about whether or not this work could be ex-

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Author: Administrator Subject: Highlight Date: 25/07/2014 16:23:21

Author: Administrator Subject: Sticky Note Date: 28/07/2014 14:07:24
For KNS, over the timescales of interest, the glacier is not very sensitive to changes in the SMB field. This is mentioned on P7 L12-14, in reference to experiments conducted in Lea et al. (2014a). Time varying SMB fields do exist from RACMO for the period 1958-2007, though including these are likely to have extremely minimal impact on model results. The comparatively simple approach of using a single height vs SMB gradient was therefore taken for the modelling.

Author: Administrator Subject: Highlight Date: 25/07/2014 16:29:27

Author: Administrator Subject: Sticky Note Date: 01/08/2014 17:48:27
P7 L29-32 short summary of how basal roughness is prescribed now given in initial model description. More information regarding model initialisation is provided in section 4.5 where the model experiments are outlined.

Author: Administrator Subject: Highlight Date: 25/07/2014 16:36:26

Author: Administrator Subject: Sticky Note Date: 01/08/2014 17:50:28
this is defined later on, on P11 L32-33, though we now give a more generic description of Rbase on P8 L19-20 as "a baseline/long term average annual runoff value" which we hope clarifies things.

Author: Administrator Subject: Highlight Date: 25/07/2014 16:43:19

Author: Administrator Subject: Sticky Note Date: 25/07/2014 16:46:34
done

Author: Administrator Subject: Highlight Date: 25/07/2014 16:50:16

Author: Administrator Subject: Sticky Note Date: 01/08/2014 17:51:00
P11 L17-18 Description of how climate parameters are defined during initialisation now included.

Author: Administrator Subject: Highlight Date: 25/07/2014 16:51:33

Author: Administrator Subject: Sticky Note Date: 28/07/2014 14:08:50
Changed throughout.

Author: Administrator Subject: Highlight Date: 25/07/2014 16:53:10

Author: Administrator Subject: Sticky Note Date: 25/07/2014 17:15:14
We considered placing this section earlier in the paper, however it is in its current position to allow a distinction between the methods and results to be maintained. This also allows the reader to place the model results in the context of the observed variability without being interrupted by the model description in between. We also want to keep the observations in the main body of the paper rather than as an appendix as they provide a substantial amount of information in their own right that is relevant to the conclusions of the paper (especially the conclusions 1 and 2 highlighted at the start of the review).

Author: Administrator Subject: Highlight Date: 25/07/2014 17:15:26

Author: Administrator Subject: Sticky Note Date: 01/08/2014 17:51:57
Exactly. Clarified P17 L25-27.

Author: Administrator Subject: Highlight Date: 01/08/2014 17:53:15

Author: Administrator Subject: Sticky Note Date: 01/08/2014 17:54:12
Discussion of this possibility now included in P20 L17-20

panded into a standard test case for use in validating models that aim to simulate outlet glacier retreat and/or models that aim to simulate calving and its impact on outlet glacier dynamics.

Tables

Table 2: It would be nice to know the approx. temperature that the choice of the Glenn's law constant A(T) corresponds to (and how is was chosen).

Figures

Figure 3: In my printed version of this figure, the photograph is very dark and hard to see. It is not quite as bad in the digital version, but still not great. Perhaps the authors could play with the contrast / brightness of this image a bit to improve it?

Figure 5: It might be instructive to include a few "failed" runs on this plot for reference. And / or perhaps a run where retreat occurs but forcing is simply held constant in time. This would give the reader a general sense for how sensitive the model is to the time-dependent aspect of the climate forcing.

Editorial

A .pdf file, with some minor editorial suggestions, is attached. Note that one probably needs to use an Adobe product to see all of these (e.g. Mac Preview will show some, but not all of the suggested edits).

Please also note the supplement to this comment:
http://www.the-cryosphere-discuss.net/8/C955/2014/tcd-8-C955-2014-supplement.pdf

Interactive comment on The Cryosphere Discuss., 8, 2005, 2014.

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Author: Administrator Subject: Highlight Date: 28/07/2014 13:41:18

Author: Administrator Subject: Sticky Note Date: 28/07/2014 13:41:29
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Author: Administrator Subject: Highlight Date: 28/07/2014 13:41:29

Author: Administrator Subject: Sticky Note Date: 28/07/2014 13:47:02
unfortunately the copy of the photograph that we had was rather faded, so we have had to play about with the image to bring out the currently level of detail. We have had another go, and now present the image as a separate figure (3b) rather than an inset.

Author: Administrator Subject: Highlight Date: 25/07/2014 17:28:30

Author: Administrator Subject: Sticky Note Date: 25/07/2014 17:39:45
Figure 5 already has a lot of information, and has had to be expanded moreso to include width and bed information. Unfortunately, I think that adding the failed runs might lead to confusion/leave the reader unclear as to what is actually being shown