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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.

Anonymous Referee #1

Received and published: 5 June 2014

This paper is a solid and original contribution that tests the ability of a model to replicate observed terminus position over cs. 150 years and investigates the possible controls upon the terminus position. In this respect, it adds to our understanding of the performance of models over important timescales whilst at the same time providing insight into the controls on terminus position in the KNS region. Overall, I found this a useful and interesting manuscript which is well-written and has good quality figures. As outlined below, there are a few points which could help clarify the paper, the most significant of which is providing a little more information on the shape control exerted (or

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Summary of Comments on tcd-8-C862-2014_replies.pdf

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not exerted) by the fjord sides and bed.

We would benefit from seeing a more clearly defined set of aims and objectives at the end of section 1. The objectives are effectively there (present record, evaluate model, test sensitivities), but crystalising the aim would aid clarity.

At line 10 on page 2010, is there any quantified uncertainty associated with the HadISST data? If so, do you incorporate any uncertainty range in your SST time series?

At the start of section 3, it might be good to start with the indication of the kinds of data you will map from. Then go on to describe the LIA max and later terminus positions.

Around lines 10-20 on page 2011, were there any cases where multiple images were available for a single year, and if so, does that help you indicate the confidence with which you can say the terminus position from a particular year is robust and not subject to high variability within the summer months?

In the model description at the start of section 4: You could indicate that the model uses a stretched grid, enabling small adjustments in resolution which is one of the keys to robust grounding line tracking. Note that in table 2, you indicate grid size is ∼250 m, but of course this will shrink a little, so include the explanation in the text, and in the table you could call it 'initial grid size'. Also, how do you prescribe basal slip conditions? Although you have no seasonal sliding variability, does basal slip evolve in response to changing ice conditions (e.g. as a function of driving stress?).

In section 4.1, you introduce a new parameterization dwnew. Perhaps indicate, in a single sentence, why it is unrealistic to follow the Nick approach of having such a restriction. The answer is obvious, but it would help show your thinking.

At line 15 of page 2022, you state talk about topographically controlled retreat. Can you be more specific about what you mean by this? E.g. retreat from a lateral or a vertical pinning point? I think that in sections 7.1 and 7.2 you need to be clearer about the

Author: Administrator Subject: Highlight Date: 25/07/2014 12:35:57

Author: Administrator Subject: Sticky Note Date: 01/08/2014 17:33:33
Clarified at P3, L17-27

Author: Administrator Subject: Highlight Date: 25/07/2014 14:25:54

Author: Administrator Subject: Sticky Note Date: 25/07/2014 14:34:09
There are errors associated with the HadISST data, though we do not include these in our time series. The reason for this is that the record used has been validated against independent observations from southern Greenland (P4, L31-34) providing a high degree of confidence in the dataset. Also, attempts to account for these errors in the modelling would substantially increase the number of runs required to fully evaluate what (if any) sensitivity this error would have on results.

Author: Administrator Subject: Highlight Date: 25/07/2014 14:34:16

Author: Administrator Subject: Sticky Note Date: 28/07/2014 14:20:47
P5 L5-6 done.

Author: Administrator Subject: Highlight Date: 25/07/2014 14:42:29

Author: Administrator Subject: Sticky Note Date: 01/08/2014 17:35:16
Most years covered by the Landsat record had ≥2 images available for each year. However, given that we wanted to compare terminus position to climate and modelled position *after* each melt season, it made more sense to use single images for each year, acquired as close to the end of each melt season as possible (P5, L21-26)

Author: Administrator Subject: Highlight Date: 25/07/2014 14:59:01

Author: Administrator Subject: Sticky Note Date: 01/08/2014 17:36:08
P6 L21-22 done

Author: Administrator Subject: Highlight Date: 25/07/2014 14:59:25

Author: Administrator Subject: Sticky Note Date: 25/07/2014 14:59:41
Table 2 - done

Author: Administrator Subject: Highlight Date: 25/07/2014 15:11:28

Author: Administrator Subject: Sticky Note Date: 01/08/2014 17:37:01
P7 L29-32 now explained

Author: Administrator Subject: Highlight Date: 25/07/2014 15:11:51

Author: Administrator Subject: Sticky Note Date: 01/08/2014 17:37:39
P7 L27-32 The model uses an effective pressure sliding law that allows it to replicate the typical tidewater glacier velocity profile (i.e. accelerating towards its terminus as the effective pressure exerted by the glacier on its bed decreases)

Author: Administrator Subject: Highlight Date: 25/07/2014 15:22:41

Author: Administrator Subject: Sticky Note Date: 28/07/2014 14:21:56
P8 L9-10. done.

Author: Administrator Subject: Highlight Date: 28/07/2014 16:23:58

Author: Administrator Subject: Sticky Note Date: 01/08/2014 17:41:25
P16 L28 - clarified

Discussion of the effect of fjord topography also expanded to now include:
P14 24-32
P17 L3-14
P20 L4-7

Figure 3C also provides along fjord bed and width variability

Figures 5B and C now provide "observed" and modelled evolution of the bed and width at the terminus through time.

influence of topography on both the observed and the modeled retreat rates. It would be good to see a plot of fjord width and fjord depth next to your modeled terminus position graphs (Fig. 5). You could also plot what lateral and basal drag looks like when the model is at its LIA position as it would show where peaks in drag may occur and may exert relatively more or relatively less influence.

On line 19-20 on page 2024, I am not clear how ocean forcing (via SST) could dominate atmospheric forcing (via surface runoff). I.e. although the forward case makes sense, in the vice versa case, why would SST alter surface runoff? Perhaps I do not understand the sentence?

Line 17 on page 2025: You don't appear to state anywhere in the earlier parts of the paper how you define fjord width for the model input. You should state this somewhere.

It could be useful to have a figure showing the DEM (above and below sea level) so that we can see what the fjord bed looks like in conjunction with the fjord margins on land. This may aid the communication about the topographic control vs. the climate vs. ocean control.

Figure 1: I found it hard to tell which colored line is from which year in panel B. I would prefer to see a more specific legend rather than a graduated color scale.

On figure 5A, it would be useful to have dots at each point on the black line to indicate where you have a real data point.

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Author: Administrator Subject: Highlight Date: 25/07/2014 15:32:52

Author: Administrator Subject: Sticky Note Date: 01/08/2014 17:43:45

P18 L28 - P19 L10 Attempted to clarify. We were trying to say that since neither a1 or a3 are related, this on its own does not tell us which is exerting a dominant control on terminus dynamics. To conclude that atmospheric forcing is a dominant control, the value of a1 needs to be interrogated (P19 L2-10).

Author: Administrator Subject: Highlight Date: 25/07/2014 15:44:54

Author: Administrator Subject: Sticky Note Date: 28/07/2014 14:24:41

P6 L26-27 done.

Author: Administrator Subject: Highlight Date: 28/07/2014 13:13:10

Author: Administrator Subject: Sticky Note Date: 28/07/2014 13:14:22

Model flowline with colour coded bathymetry used now on figure 3a, while figure 3c shows bed and width variability in 'along-flow' form.

Author: Administrator Subject: Highlight Date: 25/07/2014 15:47:14

Author: Administrator Subject: Sticky Note Date: 29/07/2014 12:11:17

We did look into showing each terminus with a specific legend, though it required showing 21 lines. This proved to make the diagram appear even more cluttered, and required labels so small as to be barely legible. As a compromise, we now label four of the termini in their respective colours. Although this is far from ideal, we hope that these will provide reference points within the colour scale for the reader.

Author: Administrator Subject: Highlight Date: 28/07/2014 13:14:30

Author: Administrator Subject: Sticky Note Date: 28/07/2014 13:14:36

done