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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.

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Lea et al (2014) provide a detailed presentation of the results of a simple flow-band numerical model for reconstructing glacier dynamics and the terminus behavior of Kangiata Sermia. They further compare the resulting terminus history to sea surface temperature and air temperature finding this glacier more sensitive to the latter. This model provides useful insights and the results here will be of considerable importance, in part because the glacier has a sill preventing sea water at depth from entering the fjord. The paper needs more attention to the fjord width variable to better quantify the importance

Summary of Comments on tcd-8-C595-2014_replies.pdf

This page contains no comments

and limitations of this parameters impact on terminus behavior.

Specific Comments:

2009-25: List a couple of example glaciers, where warm water incursion is important.

2010-3: Other glaciers with shallow sills in their fjords? Should have a better Figure 1 that illustrates the larger region and points out the sill location and other key features. this is a long and complicated fjord. This could replace Figure 3. The figure could be similar to Figure 1 from Lea and others (2014a) but showing the sill location too. Any bathymetry that can be added could be in this figure also.

2011-25: Example here from Lea et al (2014b) in the difference maybe Jakobshavn or Narssap Sermia.

2013-14: Explain crucial nature of the crevasse water depth variable.

2014-5: The model is not focused on the seasonal cycles as noted, but as a follow up to the runoff cycle, the velocity cycle should be mentioned in the next sentence. Ahlstrøm et al (2013) in their Figure 4 indicate the peak in velocity as the melt season begins and a decline and minimum in velocity as the melt season progresses.

2016-10: What is the upstream limit where rapid ice flow begins, identified by Joughin et al (2010) and modeled by Lea et al (2014a)? Does this agree with the velocity and depth profile in Thomas (2009)?

2019-26: Fjord width and pinning point importance. Given the nature of the model and lack of bathymetry it is not expected that this be fully quantified here, since pinning points can be width or depth based. Fjord orientation may also be involved, less so for Kangiata. However, it should be emphasized more. In Figure 1 and 3 it would appear that natural pinning points exist at the LIA maximum, the 1921-1936 terminus location and the 1979-1997 terminus position. It makes sense to have an along track fjord width figure, which would show how much control this factor play in short term slowing or accelerating the retreat. This could be one slice of Figure 4a, which would

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Author: Administrator Subject: Highlight Date: 25/07/2014 12:46:10

Author: Administrator Subject: Sticky Note Date: 01/08/2014 17:25:55

The section is a description of the field site, though references highlighting cases where warm water incursion may be important are included in the introduction (P3, L11-15)

Author: Administrator Subject: Highlight Date: 25/07/2014 13:07:53

Author: Administrator Subject: Sticky Note Date: 28/07/2014 14:11:59

P6, L8. Extra reference to Lea et al. (2014b) added. We are reluctant to include a specific example from this paper as it would require extra background information to explain a small (albeit important) point in the paper. We therefore feel that the extra reference is sufficient if any reader wishes to follow this up.

Author: Administrator Subject: Highlight Date: 25/07/2014 13:45:15

Author: Administrator Subject: Sticky Note Date: 28/07/2014 14:12:32

P8 L4-7: done

Author: Administrator Subject: Highlight Date: 25/07/2014 13:53:07

Author: Administrator Subject: Sticky Note Date: 01/08/2014 17:28:35

P7 L22-25: extra sentence included, and additional justification.

Author: Administrator Subject: Highlight Date: 25/07/2014 13:57:53

Author: Administrator Subject: Sticky Note Date: 01/08/2014 17:29:05

Section has been expanded to talk more about model setup (specifically basal sliding: P7 L22-31). Further information regarding model initialisation is given in section 4.5 now includes information relevant to this comment..

Author: Administrator Subject: Highlight Date: 28/07/2014 14:16:11

Author: Administrator Subject: Sticky Note Date: 01/08/2014 17:31:45

Discussion of fjord topography expanded to include:

P14 L23-32 Fjord topography (results)
P17 L3-14 Fjord topography (discussion)
P20 L4-7

Figure 3 now includes plot of fjord bed and width (3C)
Figure 5 now includes "observed" and modelled evolution of bed and width with respect to time. (5B and 5C)

show fjord width as a function of time not distance. Carr et al (2013 and 2014) provide a good description of the concept first outlined by John Mercer (1961). From Carr et al (2014).

"However, our data suggest that along-flow variations in fjord width are an important control, and we demonstrate a statistical relationship between fjord width variability and glacier retreat across the study region. We suggest that along-flow width variations may influence retreat rates via two mechanisms: (1) owing to the principle of mass conservation, widening of the fjord would mean that the glacier needs to thin and the surface slope needs to reduce in order to maintain the same ice flux, which would make the ice more vulnerable to thinning and eventually to flotation, thus increasing calving rates and promoting retreat; and (2) lateral resistive stresses tend to decrease with increasing width, which would reduce resistance to flow and promote further dynamics thinning and retreat."

2021-25: Need to provide an example Mbase value that the reader can better relate to, mean thickness of melt. What is the areal extent where submarine melting occurs, what is its variability in the model?

2023-8: This is the natural location to discuss fjord width role in changing retreat rates, if the model indicates it is a key factor at such points. If not that is key to point out to.

2025-7: Specify the centennial behavior referred to here.

2025-21: The fjord width as noted cannot be verified above the 2012 position, however, it can be stated whether your work suggests it increases and how far behind the current terminus there is a significant change. Is there an inflection in surface slope at some distance above the terminus suggesting a depth pinning point?

Ahlstrøm, A. P., et al: Seasonal velocities of eight major marine-terminating outlet glaciers of the Greenland ice sheet from continuous in situ GPS instruments, Earth Syst. Sci. Data, 5, 277-287, doi:10.5194/essd-5-277-2013, 2013.

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The width integration of the model means that SM is applied evenly across the entire fjord width. Due to the variability of fjord width, Mbase cannot therefore be simply translated to a linear melt rate (see appendix A of Lea et al. (2014a).

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P18 L12 - "centennial" deleted to avoid any confusion regarding timescales.

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We don't really have the evidence for, or would like to speculate about the location of potential pinning points upstream of the 2012 terminus position. This answer can only be given through improvements to bed topography estimates.

Carr, J.R., Stokes, C.R. and Vieli, A., in press. Recent retreat of major outlet glaciers on Novaya Zemlya, Russian Arctic, influenced by fjord geometry and sea-ice conditions. J. Glaciology, 60, doi: 10.3189/2014JoG13J122, 2014.

Carr, J.R., Vieli, A. and Stokes, C.R.: Climatic, oceanic and topographic controls on marine-terminating outlet glacier behavior in north-west Greenland at seasonal to interannual timescales. Journal of Geophysical Research, 118(3), 1210-1226, 2013.

Joughin, I., Smith, B. E., Howat, I. M., Scambos, T., and Moon, T.: Greenland flow variability from ice-sheet-wide velocity mapping, J. Glaciol., 56, 415–430, doi:10.3189/002214310792447734, 2010.

Mercer, J.H.: The Response of Fjord Glaciers to changes in the Firn Limit. J. Glaciology, 3(29), 850-858, 1961.

Thomas, R, Frederick, E, Krabill, W, Manizade, S, and Martin, C.: Recent changes on Greenland outlet glaciers. J Glaciology, 55(189, 147-162, 2009.

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

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