

## ***Interactive comment on “Modeling the response of Northwest Greenland to enhanced ocean thermal forcing and subglacial discharge” by Mathieu Morlighem et al.***

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This is an important and relevant paper as it extends previous efforts by the same group from a single outlet glacier to a regional view. It certainly deserves publication after some polishing of the text. While the science is sound, the writing is relatively poor and sloppy, with many typos and grammatical errors. It seems the manuscript was put together in a haste and would have benefited significantly from a round of proof reading before submission (see all my technical comments).

Cheers, Andy Aschwanden

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### Methods

The methods and data section needs polishing and clarification: Please explain more carefully how subglacial discharge and thermal forcing are applied, are these daily or monthly forcing, or annually averaged? Is the subglacial discharge averaged over a certain time period like the surface mass balance? What is the resolution and the time step of the model? Since it's an unstructured grid, please inform the reader of the minimum and maximum cell size.

Equation 2 uses ambiguous notation First, TF should not be used as a variable because it could mean  $TxF$ , how about something like  $T_h$ ?. I realize that this kind of sloppy notation has become more widespread in the glaciological literature over the past few years, and that the authors want to use the same notation as previous publications. Second, it took me several readings to understand that  $q_{sg} \times 1$  and TH  $+1^\circ C$  is a shorthand for anomalies. The problem with this is that it is unclear when the authors talk about the initial (present day) forcing, and when anomalies are meant. I think what the authors are doing is something like this

$$\dot{M} = (Ah(q_{sg}(x, y)q_a)^\alpha(t) + B)(T_h(x, y) + T_a(t))^\beta$$

, (1)

where  $q_a(t)$  and  $T_a(t)$  are multiplicative and additive time-dependent scalar anomalies, respectively. Use of a notation like this would improve clarity.

Regarding climate (surface mass balance) forcing: Why do you use the 1960-1991 average surface mass balance? This could possibly effect both the calibration and the projections. The 1960-1991 average was longer than today, thus to match the observed frontal retreat, your calibration procedure for the ocean forcing will have to compensate. Furthermore, use of the 1960-1991 average SMB for projections is questionable and

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as a consequence, one has little confidence in the sea-level contribution (Figure 5). As the focus of this paper is on glacier front retreat, I wonder if I'd be best to remove Figure 5 (and related text)? I do not think the manuscript would lose anything.

Detailed comments

p 1, l 8: Northwest -> northwest

p 1, l 13-14: "While these parametrizations are approximations..." this statement is almost universally true and I thus suggest to remove it from the abstract with any loss. How about "These parametrizations have shown to provide reliable estimates..."

p 1, l 17: include the year. The 50km retreat occurs from present day until year 2100, otherwise the reader might think the glacier retreats 50km over the course of 15 years.

p 2, l 9: remove comma. "...the rate of undercutting at the calving face..."

p 2, l 11-12. Rephrase "We don't...", this sentence does not make much sense to. Or leave the sentence out?

p 2, l 20-21: It remains unclear, however, to which extent glaciers of the...

p 2, l 30-31: "While a lot of progress has been made in terms of capturing ice flow through the development of new, higher-order stress balance solvers, ..." I respectfully disagree with this statement; significant progress was due to the availability of more accurate ice thickness instead. I'm not aware of a publication that demonstrates that higher-order stress balance solvers have greatly improved our ability to capture ice flow on a continental scale.

p 3, l 25: insert comma after equation

p 3, l 27-28: A lot of research is currently being dedicated to derive parametrizations for  $c$  and  $\dot{M}$ ; here we chose to recent parametrizations described below

p 5, l 4: insert comma after equation

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p 6, l 1 simplification, but -> simplification, but

p 6-7: "As we do not run a coupled model, we rely on the last year of constrained rate of undercutting (year 2016) and repeat it" This sentence does not make sense. As I understand it, you calculate undercutting from thermal forcing and subglacial discharge, what do you mean with "repeating"?

p 8, l 13: overestimates the retreat on the southern...

p 8, l 31: Kjer Gletscher exhibits almost the same...

p 8, l 33-34: I think it should read "up to 70km upstream to where the bed..." (not sure though)

p 8, l 34: add year: but continue to retreat another 17km by 2100 to reach...

p 9, l 1: the northern branch retreats 45km...

p 9, l 9: "has" is very colloquial. Use "shows" or "exhibits" instead.

p 9-10: "In our simulations, Cornell Gletscher shows some of the most stable behavior of all investigated glaciers: under all scenarios, it retreats roughly another kilometer upstream." Remove the "or so", this is too colloquial.

p 10, l 4: the model projects that...

p 10, l 6: ...no additional increase in TF

p 10, l 8: I think it should read "..., on the other hand, has retreated more..."

p 10, l 10: Our simulations suggest that the glacier may reach..."

p 10, l 11: clarify "by 4km or 11km", on what does this depend?

p 11, l 2: is multiplied by a factor of six

p 11, l 5: in the control experiment, in which we kept the ice front fixed.

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p. 11, l 11: Under these conditions, ...

p. 12, l 12: "(not shown here) -> this results is highlighted in the abstract, I thus think it needs to be shown here.

p. 12, l 24: move towards coupled ice-ocean-climate models

p. 12, l 33: "Among other limitations...". Clarify and rewrite. "the thermal forcing is dictated by the undercutting" ? Isn't it the other way round?

p 5, l 13-14 and 22: is there a contradiction? First you say you are using ECCO from 1992-2015 and further down it's 2007 until 2015? I understand that the simulations start in 2007, so what is the ECCO data prior to 2007 used for?

Figures: the figures are beautiful.

Figure 1: ..., and white crosses indicate the locations of CTD data from NASA's Oceans Melting Greenland campaign that were used to calibrate thermal forcing

Figure 3: add units to colorbars.

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