Review of: Dynamic changes in outlet glaciers in northern Greenland from 1948 to 2015

General comments:

This paper brings together data on glacier terminus position, speed, fjord geometry, and other metrics to examine glacier behavior across northern Greenland over 1948-2015. This is useful data to publish and results are in line with established ideas on glacier dynamics, influence of fjord geometry, and behavior of glaciers with or without floating ice tongues. Several tables figures are particularly useful for visualizing the results (e.g, Table 2 and Figure 6) and the paper adds new information about several glaciers and is quite thorough in addressing all marine-terminate northern glaciers.

Despite the strengths of the paper, there are fairly substantial areas for improvement:

In an attempt to pull climate and ocean conditions into the analysis, the authors include air temperature data from two weather stations and sea ice concentration from passive microwave (Section 2.4 and results in Section 3.5). The value of including these data seems extremely limited. On the air temperature side, only two weather stations are available, at the southern edges of the study area on the east and west coast. These data are used for a basic determination of changes in air temperature trend. For sea ice, the 25km resolution precludes analysis in narrow fjords or near the ice edge. It is well established that these data do poorly in capturing sea ice concentration at glacier termini in Greenland. Thus both the air and ocean data is severely lacking in detail compared to the other datasets the authors are working with. The authors even note themselves that they are focusing on ice dynamics and not air/ocean forcing (page 7, lines 3-5). I suggest that the authors reconsider the utility of these data and inclusion in the paper. They may instead choose to refer to data already published on Greenland air temperature and sea ice trends. The other analysis in the paper is of more interest and better quality.

At no point do the authors discuss some of the fundamental differences expected in glaciers with grounded termini versus floating ice tongues. I expected some acknowledgement that the former would have small, more continuous calving events and the latter would experience calving of large tabular icebergs. Since this is exactly what the authors observe, they need to provide some information and context for the behavior. This can also include a discussion of why smaller dynamic changes might be expected for glaciers with floating ice tongues. Without some of these notes, the results and discussion feel as though they have been pulled out of context from the greater body of glaciological literature.

The paper does suffer some overly complex sentences, wordy phrasing, and occasional poor organization. These items can be taken care of with mindful editing. Joshua Schimel's book Writing Science is an excellent reference for techniques and ideas.

Specific comments by page/line number:

1/12. 'remains unknown' is an overstatement and needs changing

1/23. This sentence is long and the wording at the end is overly complicated. Requires editing.

2/4. Moon et al. 2012 is a paper about ice speed and does not discuss thinning or retreat. This paper is incorrectly referenced in several places in the manuscript (e.g., also 14/32). An appropriate reference for thinning is: Csatho, B. M., A. F. Schenk, C. J. van der Veen, G. Babonis, K. Duncan, S. Rezvanbehbahani, M. R. van den Broeke, S. B. Simonsen, S. Nagarajan, and J. H. Van Angelen (2014), Laser altimetry reveals complex pattern of Greenland Ice Sheet dynamics, *Proceedings of the National Academy of Sciences*, *111*(52), 18478–18483, doi:10.1073/pnas.1411680112.

2/19-26. This paragraph would be better ordered: Sentence 2, sentence 1, sentence 3.

4/15-19. Another section that could be simplified/shortened. For example: 'Presence of sea ice and highly fractured termini made terminus picking at Steensby, CH Ostenfeld, and NGIS glaciers more difficult (Refs). Re-digitising all 1999-2015 Landsat terminus positions yielded additional errors of $\pm$13% for these glaciers.'

5/3. It's not clear what range you are referring to – include the numbers here instead of 'this'.

5/3-5. This is confusing and I do not clearly understand the process from this description. Please revise.

5/11. It is better to refer to 'earlier' and 'later' instead of 'first' and 'second'.

5/12. Please specify what you are using to estimate average errors in velocity. This is more clear for other methods descriptions.

5/29-30. Why use only the difference between 1995/96 and 2015/16 velocity data to calculate change when you have so many years of data between these years. Seems that finding a trend across all years of data would provide a more accurate picture of change.

6/9-11. The same comment as above, but for the surface elevation change. Why use just two periods when you have more data in between? As a separate note, please reconsider using 'SEC'. This is not a commonly used acronym and the more you can avoid acronyms the easier it is to read.

6/30-31. It is not clear what using 'a flow accumulation threshold of 500 to calculate stream threshold' means. Please clarify.

7/30 and throughout manuscript. Remove 'clear'. This word is used widely throughout the paper and is superfluous. Recommend removing it in all cases.

8/8. Remove '1948-1975' from the first mention, and put these years in the second half of the sentence when you call out that the earliest epoch is 27 years long.

9/21-31. This description is poorly organized. I want a sense of what is happening at each glacier. Separate them out and talk about each with greater specificity. Describe how advance/retreat phases were more/less consistent and then changed (or not). How has the character of terminus change varied? I understand the urge to create something of a laundry list of information, and the difficulty into crafting fairly dry information into something that is easy to follow and structured across the paragraph. It is, however, important to work towards this goal. An good example of an organized, engaging description is page 12, lines 27-32.

10/22. ‘Loss of their floating ice tongues’ is incorrect for Petermann – instead just refer to ‘retreat’ or similar.

10/27. Something is not ‘synchronous’ with events in the following decade. Reword.

10/30-11/1. It’s not clear if you mean changes in speed after large calving events or only after complete ice tongue removal. Please clarify.

12/2-15. ‘Dramatic’ appears several times in this paragraph – it’s not a particularly useful or quantitative descriptor and I recommend revising/deleting. (‘Clear’ also appears several times in this paragraph).

13/19-14/2. Another paragraph in need of reorganization.

14/5 and 8. It is incorrect to refer to a single year (1995) as a change point because you are considering longer epochs. Refer to changes before/during/after those epochs rather than at specific years.

14/10. Clarify that ‘These changes’ is not referring to air temperatures.

14/15. This paragraph needs an introductory sentence and work on organization and flow.

14/26. The second half of this sentence is irrelevant to the discussion.

15/2-3 (and following paragraph). Acknowledge the role of other ocean processes, like ice front melt, in this sentence/section, followed by the more thorough discussion in the next paragraph. These references (or information within them) may be useful:
Wilson, N. J., and F. Straneo (2015), Water exchange between the continental shelf and the cavity beneath Nioghalvfjerdsbræ (79 North Glacier), *Geophys Res Lett*, *42*(18), 7648–7654, doi:10.1002/2015gl064944.
Choi, Y., M. Morlighem, E. Rignot, J. Mouginot, and M. Wood (2017), Modeling the Response of Nioghalvfjerdsfjorden and Zachariae Isstrøm Glaciers, Greenland, to Ocean Forcing Over the Next Century, *Geophys Res Lett*, *44*(21), 11,071–11,079, doi:10.1002/2017GL075174.

16/2. Write these in an order than makes more sense for the actual process, either thinning-retreat-speedup or retreat-speedup-thinning (use this latter one if you want the focus on dynamic thinning due to speedup).

16/15-19. It would be useful for the authors to comment on why they think these differences occur among the glaciers they mention. For example, how does scale of event and force balance based on glacier characteristics enter into the discussion. Also, it’s not entirely clear whether the authors are consistently referring only to velocity changes on the grounded ice portion of these glaciers.

17/4. Another paper just out on this topic: Millan, R., E. Rignot, J. Mouginot, M. Wood, A. A. Bjork, and M. Morlighem (2018), Vulnerability of Southeast Greenland glaciers to warm Atlantic Water from Operation IceBridge and Ocean Melting Greenland data, *Geophys Res Lett*, 1–23, doi:10.1002/2017GL076561.

18/4 and 11. What do the authors mean by ‘strongly attached to’? How has that been quantified, in this study or others?

19/18-19. A few more words are needed on this, and whether or not it is likely these are surge glaciers. Did you look at different data than these other studies? Can you definitely confirm there was no surge in periods where it was previously detected because you have better data or similar?

19/20. 'controlled by external forcing' is too vague. Say specifically what mechanisms might be at play and whether there is evidence for it, or what data would be needed.

19/30. Another incorrect reference to Moon et al. 2012. This would be a good place to reference Howat and Eddy 2010 (already listed in the references).

20/2. A variety of ocean data is available for northern Greenland. It is not, however, being used or analysed in this paper (which is just fine). But please remove this incorrect statement.

20/24. I understand the urge to end on 'could soon contribute an important component to sea level rise', but this is a vague statement and is not well connected to the paper analysis (which does not discuss sea level). Suggest rewording with a stronger concluding statement that is more specific and tied to the main idea of the paper.

27/3. This caption would benefit from more precise language throughout. The use of 'calculated by subtracting 1948 and 2015 positions' is one example.

Table 1. Consider the various order in which glaciers in each category could be listed and choose the one that makes the most sense for the reader or message.

Figure 1. The caption includes a lot of information on methods, which seems misplaced.

Figure 2. The legend should have lines rather than boxes.

Figure 4. Please reword for improved clarity and brevity.

Figures 7-9. It is very difficult to see the lines/colors in the legend and in the plots. Distinguishing among the surface elevation change lines to understand their progress is only possible in a broad green or blue sense. Understanding the detailed progress is impossible with the current color map.

Figure 8. Remove the odd floating ice in 8h, which does not appear to be connected to the glacier.

Figure 9. Is there no data for showing terminus position in 9c?

Figure 10. Instead of 'inland' and 'terminus' give a number for actual location/distance.

Figure 11. It's quite odd to stack the warmer temperatures below the colder temperatures in these plots. You also mention 'ocean' in the caption data, which is not included in the plots.

Technical corrections by line number:

2/5. Delete 'across the ice sheet' – unnecessary.

2/30. Delete 'objectively' – unnecessary.

7/30. Delete 'eventual'

10/8. Delete ‘It was also clear that’. I’m not going to note anymore of the instances of ‘clear’, but just repeat that they should all be removed.

11/19. Thickening or thinning?

11/21. Delete ‘then’

15/7. ‘concentrations’ instead of ‘conditions’

15/9. Remove quotes around calving season.

15/11. Remove ‘,’

17/19. ‘importantly influence’ is very awkward – reword

18/24. Should be ‘accompanied by acceleration’

19/17. ‘overriding’ is poor word choice – please change

35/5. Replace ‘Current’ with ‘2016’

Figure 12. Delete ‘except for the first…position changes’