**Response to Reviewers**

We would like to thank both referees for taking the time to provide detailed feedback on our manuscript. We are pleased that both referees found our discovery that large simultaneous calving events in Porpoise Bay are driven by the break-up of multi-year sea-ice interesting and worth publishing. The referees were less positive about section 4.4 (reconstructing calving cycles) and reviewer 2 suggested this should be removed and that the paper could be considerably shortened.

In line with reviewer comments, we have decided to remove nearly all of the discussion of longer-term calving cycles from the manuscript and re-structure the paper, which does not impact on our main findings. Additionally, we have added further discussion on the 2016 calving event which has progressed further since our initial manuscript submission.

The revised manuscript is shorter and contains fewer figures. In short, the first half of the paper has remained similar, the section on reconstructing glacier calving has been removed, and a more in depth analysis on the drivers of the January 2007 and March 2016 sea-ice break-up has been added, as requested by the reviewers.

We include specific replies in blue to each reviewer and also attach a revised manuscript with changes highlighted in blue:

**Reviewer 1**

In “Simultaneous disintegration of outlet glaciers in Porpoise Bay (Wilkes Land), East Antarctica, and the long-term speed-up of Holmes Glacier,” Miles et al. present a study which investigates a few East Antarctic tidewater outlets. They document calving activity with a range of remotely sensed imagery and relate calving behavior to sea ice dynamics. Using sea ice concentration as a proxy, they infer recent glacier speedup of 50%. This is an interesting paper, expanding a known glacial (in)stability mechanism from the Arctic to East Antarctica. With some revisions, I certainly recommend it for C1 publication in The Cryosphere. -Allen Pope

We thank the reviewer for the positive comments regarding the manuscript.

Broad Comments: **The paper leads to some really interesting points, but some of these are let down by incomplete discussions. The paper would be improved and more useful if the discussion of (1) what could have led to increased glacier velocity and (2) what drove anomalously high melt / ponding were expanded. **Similarly, the conclusions are acceptable but do not place the results in a broader context, including the implications of the new knowledge described in the paper. **This paper includes a lot of figures which help demonstrate and illustrate the arguments in the paper. This is really helpful! However, the figures are often complex imagery – more annotation would help the reader quickly understand what they are supposed to glean from a particular figure. In addition, many figures’ brightness and contrast need to be reviewed for "readability" on screen and in print.

Specific Comments: L13: Indicate specific kinds of remote sensing data that were used.

Amended: we have removed the section on long-term calving cycles and glacier velocity so the first point raised is no longer an issue. We address the second point by adding lengthy discussion of the possible causes of the anomalously high melt. We have checked all figures and annotated them for greater clarity.

L25: Include a space between “March” and “2016”

Amended.

Abstract: The discussion includes mentions of warming, increased melting, etc. – including a sentence which nods to climate and larger implications may strengthen the abstract.

The abstract has been changed to reflect the revised manuscript and mentions the wider implications re: increased melting, climate change.

L93: The description of the method is VERY vague. What sort of automated mapping method? The goal should be reproducible science, so a fully described method should be included in the paper. At the very least, a citation which describes the method in depth should be included.

We have updated the description of the method. The description now details how method automatically classifies glaciers and sea-ice into polygons based on the pixel statistics of each image.

L126: 18 grid cells equals what area?

Amended, 18 grid cells equates to 11,250 $km^2$.

L131: Define ASI acronym

Amended.

~L133: You discuss multiple breakouts – why is only 2007 studied at higher resolutions, and are you sure the data sources are completely intercomparable?

The manuscript no longer discusses multiple breakouts and the longer term calving cycle. Thus, we focus primarily on the 2007 break-out, but have also added some discussion of a very recent event that may have initiated in 2016.

L138: I thought that the figure described a particular region where sea ice concentration was studied. When/why are you getting closer to termini?

Amended. This was an oversight; we now also include the region where the higher resolution sea-ice data was extracted (which is closer to the terminus) in Figure 1 and mention this in the text.

L141: At 27 km spatial resolution, how many points are you really sampling?

Amended.

L155-L157: A bit of a meandering sentence, it almost implies monotonic behavior, which is not the case.

Amended.

L159 & L167: It seems like Frost might not actually fit? More like a hybrid with Sandfjord?

All calving events which we observe in Porpoise Bay only occur after sea-ice has broken away from glacier termini. We clarify this is in section 4.4.

L200: Using anomalies rather than absolute concentrations or areas means that sea ice could be lower, but it doesn't actually provide proof that there is a breakup.

We appreciate that anomalies alone do not provide proof of complete break-up. However, when combined with imagery actually showing the break-up, the events would appear to be validated. We could show absolute concentrations instead, but these are very difficult to follow, especially over multiple years due to the strong seasonal variations.

L208: Are you really confident enough to use “cannot”, as opposed to the slightly more flexible “likely did not”?

Section removed in response to Reviewer 2 comments.

L211: Instead of “large,” how about “very large” or “largest”?

Section removed in response to Reviewer 2 comments.

Section 4.4: The first few paragraphs in this section seems more awkward and convoluted than previous sections. The sentence structure and tense seems overly complicated. It would benefit from a style edit so that it flows easier and therefore is more easily comprehended.

This section has been removed in response to Reviewer 2 comments.

L219: “has been” to “was”

Section removed in response to Reviewer 2 comments.

~L251-264: The language in this paragraph seems a bit belabored and the arguments (regarding sea ice) seem a bit circular. Streamline the writing to simplify and clarify. (On a side note: “thus” is repeated closely together, which is also awkward.)

Section removed in response to Reviewer 2 comments.

L291: Consider including inferred velocities for these time periods, too?

Section removed in response to Reviewer 2 comments.

L302: Insert space before open parenthesis

Section removed in response to Reviewer 2 comments.

L308: Okay, it may be the first time it is observed. So what?

We now state its wider importance. If future changes in climate result in a weaker persistence in landfast ice in porpoise bay, it may result in detrimental effects on glacier tongue stability.

L313: “suggest”, not “suggests”

Amended.

L316: Days/weeks is really the realm of weather not climate – clarify the difference between the two and really what the important processes are.

Amended. We now refer to days and weeks as synoptic conditions.

~L322: Temperature might not be driving melt, but something in the model clearly is driving melt. Look at other parameters to identify this. For example, is it wind that could be causing it? That would be logical, and really helpful to identify the driver of such an important process.

We now link melt events to atmospheric circulation anomalies (see section 5.2).

L332: It may be the first time this has been published explicitly – but it is also not surprising. There are a few papers that observe supraglacial lakes on East Antarctic outlets. So why is it important that this has been observed for the first time?

We now clarify the importance of surface melt on sea-ice. In the arctic, this has been linked to sea-ice break-up. Therefore, the fact that we observe ponding on the multi-year sea-ice prior to its fracturing and ultimate break-up suggests that surface melt could have been important.

~L347: Is it possible that the higher melt year saturated/refroze in the snowpack, which then allowed a lower melt year to be able to form melt ponds? I know that is the case on ice shelves, but I'm not sure if that is true in a sea ice context?

This is an interesting point. Studies in the Arctic suggest the trapped latent heat within the sea-ice as melt ponds refreeze may inhibit basal growth of the sea-ice (e.g. Flocco et al., 2015; JGR). We now include this point in the manuscript.

~L362: The sentences around here go in a couple circles about the processes and drivers that you think are most important for the reader to understand. I think it might help to clarify that, in this system, bathymetry and geometry seem to drive the location of calving events which sea ice drives the timing.

Section removed

L376: This is restating earlier conclusions. Maybe only need to say in one place?

Section removed

L380-389: This is really interesting and important glaciologically! The paper would be stronger if this were fleshed out and done so with more rigor. It can very much be a discussion of what is reasonable (not an in-depth analysis), but more should be included. For example, what might changed in accumulation do? Is it possible basal changes played a role? What else could be driving increased velocity?

Section removed

~L399: Yes, sea ice is related to climate – but Antarctic sea ice is very much dependent on more than temperature (which can be seen in regional expansion of Antarctic sea ice). More nuance needs to be brought to this sentence.

The conclusion has been modified to reflect the greater discussion on atmospheric circulation anomalies. However, we note that multi-year landfast ice may to respond to a different set of climatic drivers to sea-ice extent, which has been increasing.

L409: You specifically mention "warming" – but it would seem to be more appropriate to discussions in atmospheric or oceanic circulation?

We now discuss in detail the anomalous atmospheric circulation patterns.

L411: Okay – but where else might these processes be important? Expand this conclusion to be broader to have larger implications.

The conclusion has been expanded.

Table 2: No Landsat 8 OLI imagery used? This might be interesting for the recent breakup and data are available from 2013.

The 2016 event started in late March. Therefore, Landsat 8 only made a few passes before the polar night and most of the time it was cloudy.

Figure 1: **Include a small inset of the entire continent. **“Moscow University” should be “Moscow University Ice Shelf” **Scale bar in upper figure

We have removed figure 1a and added a small inset to Figure 1 (previously 1b).

Figure 2: **x-axis labels are a little too small **Caption should note the different vertical scales

Amended

Figure 3: **Blue is a bit hard to see **Show outline of this area in Figure 1? Don’t worry about it if too crowded. **Brighten figure so easier to view

Blue has been changed to yellow and the figure has been brightened.

Figure 4: **Consider tracing front in a 2nd color in each image to clarify the changes that you want to highlight between images? It is hard to see (as you admit) with the melt, etc. **You reference the total area calved. Maybe include a hatched area in the last image between the two terminus lines?

It is very difficult to digitize the front in each image because of the abundance of icebergs close to the terminus during the calving event.

Figure 6: Increase brightness and contrast to make more easily viewable.

Amended

Figure 7: Anomalies are interesting but is an absolute scale better to demonstrate what you want show?

An absolute scale is very difficult to follow due to the seasonal variations. Therefore, we have stuck with anomalies.

Figure 8: Include 2nd outline in lower image?

Figure removed

Figure 9: **Maybe darken a little so it prints better? **Include 2nd outline in lower image?

Figure removed

Figure 10: Increase contrast so more viewable. The edge of the 9 km advance isn’t very visible when printed.

Figure removed

Figure 11: Increase contrast in lower image.

Figure removed

Figure 12: Same comment as in text – include inferred velocities for these time periods, too?

This figure is now used to simply indicate the estimated terminus position of Holmes (West) Glacier, see section 4.6.

Figure 13: Add line for 7 Feb? Hatched area to indicate calved area?

Amended. Line added and figure updated with more recent imagery.

Figure 14: **Include annotation in each image and particularly at circle to help the reader **Increase contrast to make more viewable.

Further description has been added in the figure caption. Contrast has been increased.

Figure 16: Maybe just report January '14 melt total relative to 2007? I don't think that the timeseries is particularly helpful here.

Figure removed

Figure 17 & 18: Combine these into one figure? Figure 18: **Be consistent with date format **Double check permissions and copyright for using a Google Earth image in this publication.

Figure removed. See new figure 13

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**Reviewer 2**

This is an interesting but rather rambling study on the connection between the presence of fast ice and the timing of glacier calving, and its potential impact on glacier flow. The study uses MODIS image data and the record of sea ice concentration from SSM/I (mostly) to demonstrate that during the brief periods of sea-ice-free conditions in Porpoise Bay, significant calving occurs, implicating the fast ice as a stabilizing component. The study then continues to search backward in time for evidence of this relationship, to the earliest satellite data, and then forward in time to an event in early 2016.

We thank the reviewer for appreciating that our study is interesting.

It could be published as it is. . . it is not incoherent. But it does not offer a clear contribution beyond the initial worthwhile documentation that fast-ice break-up leads to rapid iceberg release; or, to say it conversely, the presence of fast ice inhibits calving and drift. The discussion of velocity change seems rather vague, since any speed-up is not able to be directly tied to fast ice break-out and increased calving. The link to surface melting is so tenuous as to be useless. Moreover, the writing style is not brisk and efficient. There is a lot of excess text.

We are pleased that that the reviewer suggests that despite some reservations our study could be published 'as it is'. We disagree that the link to surface melt is 'useless'. We agree that RACMO won't capture katabatic heating events, but we note that there are no weather stations within 100s km of Porpoise Bay, so it is arguably the best dataset available. We now present new imagery from early December 2005 and mid-January 2006, which shows the development of fractures in the landfast ice and link this larger scale atmospheric circulation anomalies. These same fractures eventually rupture initiating the sea-ice break-up in 2007. Therefore, the synoptic conditions throughout December 2005 are likely to have been important in driving the break-up of sea-ice and subsequent glacier calving in 2007, which we now discuss in more detail. During December 2005 we observe surface melt features on the landfast ice. Given that the RACMO model implies that the mean December 2005 melt was exceptional for the region, we suggest that surface melt (along with other associated processes) may have been important process in weakening the landfast ice prior to break-up. To our knowledge no other studies have considered surface melt in landfast ice break-up in Antarctica. We simply highlight that this could be an important process and is worth considering.

The central discovery of the study appears to be a major glacier calving event in late summer of 2007, during a period of extended sea ice retreat in Porpoise Bay. Images before, during and after the break-out of the sea ice show the disaggregation of the floating ice tongues in the region. Having found this, the authors extent the search, first backward in time through the sea ice record, and then back still further using the record of early Landsat and declassified Argon / Corona data.

There is another data set available, already processed, of MODIS data. See http://nsidc.org/data/iceshelves_images/index_modis.html This is a processed geolocated record of ∼monthly to weekly images going back to 2000. This shows other periods of low sea ice and partial fast ice break-up. Unfortunately, there is a one-year gap around 2001-2002 that could help narrow down the 2002 calving. If you request some additional images, we can add them for this time range.

This manuscript is very long, and could be much better focused. It is not necessary to show every data set that can say something about the 2007 event – the purpose is to document the event and the link with fast ice break-out, and then examine the extent to which glacier flow might change as a result. In particular, it is lengthy to read, first, the discovery of the 2007 event, then the inference of the 2002 and and 1986 events, and then the possibility that there was no calving between 1963 and 1973 (and that case is not well-made) and then that there was a recent event.

The paper should present what you've learned overall, not the step-by-step process by which you learned it.

I don't want to spend more time with the study. Nor do I want to berate the writers. So let me simply outline the paper they should write, if they wish to. Figure order is re-arranged. Any figure not listed is not needed.

Introduce the region (Figure 1b) Indicate the location of later figures here. Present the evidence for major break-ups in March 2016 and February 2007: (fig 13);(merge Figure 3-dates?- into Fig 4);(then, Fig2 extended through 2016). Fig6 might be retained, but it does not really help - regional sea ice is not low, yet there is a calving in austral autumn 2006.

Present the sea ice record from SSM/I+SMMR+EMSR for the areas in Fig 1b (using Figure 7) The major bay-wide calving and retreat is clearly timed by the loss of sea ice.

Earlier events large events at the Holmes Glacier front can also be linked, somewhat tentatively to extreme sea ice lows. MODIS data at NSIDC could help greatly here. An examination of this image series could document that the small iceberg pattern does / does not remain fixed (spreading or twisting of the arrangement of the bergs, but no 'individual' motion) during periods of continuous fast ice. Create a new figure from the MODIS data, summarizing what it shows about the small berg pattern evolution over time (this has a bit of Fig 14, but might be more extensive). Don't have to show every event in the 2000-2016 record – just the facts you extract from it.

With this record, i.e. ASAR, sea ice concentration, and MODIS, you have observations that can help you interpret the old record. Create a figure of the 1997, Nov 1973, Jan 1973, and Oct 1963 images, together. Given the field of small bergs trapped in fast ice in this series, make inferences about past calvings of Holmes, and of Frost (Figure 12). I would downplay the calvings of the other small glaciers, it is too confusing to follow it all.

From here, discuss synoptic patterns using reanalysis data that cause (or are associC3 TCD Interactive comment Printer-friendly version Discussion paper ated with) sea ice retreat from this region of Antarctica. I don't think surface melting helps much, and in any case RACMO is not likely to

capture katabatic heating events very well, which could be key in the immediate vicinity of the grounding line. I don't see how Fig 15, 16, 17 or 18 really helps.

This will be a new paper, that you would re-submit for review. It would be half as long. It would conclude things about calving and presence of fast ice, mostly focused on the the 2016, 2007, and 2002 events, but with a few statements about earlier events back to 1963. It would conclude things about berg motion within temporally continuous fast ice, and synoptic climate patterns that favor fast ice break-out and calving in this area.

The manuscript has been shortened and re-structured broadly along the lines the reviewer suggests, but also keeping in mind that Reviewer 1 specifically noted the helpfulness of the Figures and requested additional discussion. To summarise: we have removed the lengthy discussion on reconstructing the calving cycles and now focus on the drivers of sea-ice break-up in 2007 and 2016. We link the 2007 event to atmospheric circulation anomalies weakening the sea-ice in December 2005 prior to its break-up. In contrast, we find no link between atmospheric anomalies and the 2016 event sea-ice break-up. Instead, we link this event the terminus positon of Holmes (West) Glacier, pushing the multi-year sea-ice further into the open ocean. As noted in the revised conclusions, despite these different mechanisms, our manuscript clearly demonstrates the importance of landfast sea-ice on major calving events in East Antarctica.

We have reduced the number of Figures, but given that the satellite imagery are the primary source of data for this study, we feel it is very important to show these data on Figures. We also note that Reviewer 1 specifically praises this aspect of the manuscript "*This paper includes a lot of figures which help demonstrate and illustrate the arguments in the paper. This is really helpful!"*