

Interactive comment on “Driving Forces of Circum-Antarctic Glacier and Ice Shelf Front Retreat over the Last Two Decades” by Celia A. Baumhoer et al.

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General Comments

This paper describes the production of a calving front change dataset which will surely be of significant interest to the Antarctic glaciological community. In addition to manually correcting and adjusting previously published coastline datasets this work has also produced a more recent Antarctic coastline using Sentinel-1 imagery (from 2018) and CNN techniques. The resulting terminus position change data will be invaluable to many studies investigating ice shelf and glacier tongue behaviour. Furthermore, the novel use of recently produced reanalysis (ERA5) outputs, in con-

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junction with other environmental data, has allowed a unique investigation into the key environmental drivers that have influenced ice shelf and glacier calving front behaviour.

I have some concerns with wording and sentence/paragraph structure used within the Discussion, as environmental parameters have been singled out to be the sole driver of calving events, and hence frontal retreat, with a complete neglect of the glaciological forcings involved. However, I think with careful rewording and strengthening of key arguments some really robust and significant findings can be presented here. I urge the authors not to be discouraged by the length of my review (particularly the technical comments) as the comments are intended mainly to help with grammar that will hopefully help improve the manuscript.

Specific Comments

The placement of Figure 1 is unusual, though it is referred to within the introductory text it contains results from the analysis performed in this work. Therefore, I suggest that this figure may be better suited to the Results section.

I find the term ‘the long term mean (1982-1996)’ to be confusing. How was this mean derived and how is it long term? Shouldn’t the long term mean be from 1982-2018 rather than referring to a previous epoch (1982-1996)? Using different terminology instead of ‘long term mean’ will likely remove this confusion.

The first few sentences of the Zonal wind Results section (line 280), that introduce SAM, read more like they would be better suited to the Zonal wind section of Section 2.2. In addition, the results for SAM (Figure 9) are included in the Discussion. I strongly suggest moving the SAM section from the Discussion to the Results section following the zonal wind results, as this will clarify the linkage between zonal winds

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and trends in the SAM.

It is imperative that there is careful wording used (particularly in sections of the Discussion) regarding the correlation between changes in the environmental variables and the pattern of calving front retreat, as is correctly mentioned at the start of the Discussion; correlation does not necessarily mean causation. The abstract uses appropriate language, e.g. 'enabling factors' which suggests that the environmental variables may be involved in destabilising ice shelves prior to calving, such as enhancing surface melt rates or driving ice shelf thinning, but they are not necessarily acting alone, as there are likely to be glaciological factors involved in the calving events. However, many of the paragraphs in the Discussion become misleading given paragraph structure, the words used and the lack of consideration of glaciological processes (particularly rift development). The impact of neglecting glaciological factors becomes clear in the argument regarding air temperature and calving front retreat (lines 329-332). Suggesting that the air temperature parameter is not a key environmental driver because there is a retreat of EAIS ice shelves under cooler air temperatures is very misleading. It allows neglect of the very important relationship between air temperature driven surface melt and hydrofracture, that has been found to be a part of disintegration style calving events elsewhere in Antarctica. Another key example is regarding the Amery Ice Shelf (lines 453 – 457), the wording and sentence structure implies that surface melt was involved in the recent calving event of 2019, '...the part affected by increased surface melt broke off in 2019...'. This is a very misleading sentence as it completely ignores that rift propagation was the driving factor involved in this calving event.

I suggest restructuring the paragraphs in the Discussion that focus on individual ice shelves or particular calving styles, to begin with mention of the complex interactions between the glaciological forcings and the environmental forcings that previous studies

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have identified to be involved in the calving events. Then follow this with the supporting evidence from the work performed here for the involvement of the environmental forcings in the observed frontal retreat. Including mention of the specific glaciological forcings as well as referencing studies that have looked at the glaciological drivers of calving will reduce confusion surrounding the key drivers, strengthen the arguments regarding the important influence of the environmental forcings and allow key environmental variables to be identified for future change analysis.

Technical Comments

Line 1. As only environmental drivers were evaluated with regard to calving front retreat I suggest the title should be amended to reflect this, e.g. 'Environmental Drivers of Circum-Antarctic...'

Line 11. Replace 'being' with 'that are'.

Line 14. Antarctic ice sheet should be capitalised so it is Antarctic Ice Sheet, this needs to be amended throughout the manuscript.

Line 15. Try to avoid informal language throughout the manuscript; such as shrank (replace with decreased by), comes along (replace with occurs in conjunction, line 17), actually (remove, line 170), hotspots (amend, line 199), slightly (replace with specific values, line 213).

Line 26. 'Shelfs' should be 'shelves', suggest restructuring this sentence so that it reads '...the fronts of ice shelves and glaciers...' also check the rest of the manuscript for this plural issue.

Line 30. Calving front retreat will only increase ice discharge if ice that has high buttressing values is removed, so it would be beneficial to clarify this point and add references.

Line 32. Is it supposed to be a single decade or several decades? If several, please add the number.

Line 34. Suggest creating a new sentence at 'Since' and rewording e.g. 'Since the

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1990s altimetry measurements have shown a small gain...’.

Line 35. Restructure e.g. ‘However, a strong mass loss trend of $-47\pm$ Gt/yr (1989-2017) is calculated using the mass budget method (Rignot et al., 2019)’.

Line 37. Watch out for the use of ‘at’ instead of ‘in’ or ‘of’ throughout the manuscript, it should read the ice shelves of or in a region depending on the context.

Line 39. Make ‘Glacier’ a plural and add ‘the’ before ‘atmosphere’ and before ‘ocean’. Also add ‘are’ following ‘hence’.

Line 41. ‘natural cycle of decay and growth’. This is a key point as it relates to the glaciological forcings that I mentioned in the Specific Comments. I suggest expanding what you mean by the decay and growth cycle and how glaciological parameters fit into this. That way this paragraph can introduce the relationship between the glaciological parameters and the environmental forcings.

Line 44. Replace ‘to’ with ‘with’ before ‘atmospheric warming’.

Line 45. Is ocean forcing the main driver or one of the key drivers involved?

Line 48. The upwelling doesn’t specifically increase ocean temperatures, but rather allows the warmer ocean waters to reach the base of the ice shelves, so I suggest restructuring this sentence.

Line 50. Avoid using ‘Especially’ throughout the manuscript, particularly when starting a sentence, and restructure this sentence e.g. ‘Basal melt, when combined with a retrograde bed (refs), has lead to a retreat of the grounding line followed by increased ice discharge (refs).’ Maybe add for which ice shelves/glaciers this has occurred.

Line 52-53. ‘In contrast...Miles et al 2016’. This sentences needs better incorporation into the paragraph and explanation of what sea ice days are is also needed. I also suggest possibly making a new paragraph here as the existing one is very large.

Line 84. Re-analysis vs reanalysis on line 87, check for consistency throughout the manuscript, the same applies for in-situ and in situ as well as snowmelt and snow melt, ERA-5 and ERA5.

Line 89. Sentence ending ‘...former ERA-Interim product’, suggest adding references.

Line 103. Sentence ending ‘especially during summer’, suggest adding references.

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Line 105. Sentence beginning ‘Overall, the mean absolute...’ ending is incomplete, suggest adding ‘in zonal wind speed is achieved’ after ‘variability’.

Line 113. ‘sea ice months April through to October,’ how have you chosen these months? Suggest adding clarification. Are you referring to fast ice or pack ice or both?

Line 119. Add ‘than’ in between ‘higher’ and ‘15 %’.

Line 127. ‘Oct-Mar’, watch out for consistency when writing the months, choose either abbreviated or in full and apply throughout the manuscript.

Line 186. Suggest replacing ‘composes’ with ‘is derived from’ and adding ‘the’ in between ‘for’ and ‘two’ on Line 187.

Line 191. Suggest replacing ‘visualized’ with ‘shown’, also on line 251.

Line 195-196. Suggest changing this sentence to be ‘Between 1997 and 2008, the large disintegration events of the Larsen B, Wilkins and Wordie ice shelves resulted in a 37 % higher calving amount from the Antarctic Peninsula, as compared to the amount calved from this region between 2009 and 2018.’

Line 205. Best to avoid starting a sentence with 75%, suggest changing the sentence structure. Also I’m not sure what you mean by Ross West and Ross East, I don’t think this is a common naming convention and I’m wondering if the Ross West is the McMurdo Ice Shelf? In addition, Figure 2 shows two Ross West labels.

Line 206. When you have multiple ice shelves it is common to capitalise the name and then have ice shelves in lower case. For example, it would be ‘...the Ross and Ronne ice shelves’. Also it is common when identifying particular ice shelves in the text to refer to them using ‘the’ e.g. ‘the Amery and Filchner ice shelves’. I suggest applying these changes throughout the manuscript.

Line 224. Suggest replacing ‘But’ with ‘However’,

Line 228. Replace ‘Ice Sheet’ with ‘ice shelves’.

Line 280. Suggest adding ‘the’ in between ‘In’ and ‘case’.