

Interactive comment on “Overview of areal changes of the ice shelves on the Antarctic Peninsula over the past 50 years” by A. J. Cook and D. G. Vaughan

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General comments:

Point-1 Comparison to earlier area estimates

We accept that the paper does not provide a comparison with previously published numbers or explain the differences with new figures we have determined, and we have made some corrections in the paper to address this. However, there are two main reasons why we have not made any direct comparisons of areas between different studies:

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Interactive Discussion

Discussion Paper



1. The numbers in the earlier studies follow no set rule about listing area changes. The purpose of this study is to provide this first consistent approach to calculating and displaying areas of the ice shelves in a comprehensive way, using the same approach for each ice shelf. And thus, to provide comparisons between the areas of different ice shelves and in different decades. The reviewer suggests extracting more areas from the existing studies and putting them into a similar table format as Table 3. We do not believe that this is practical: most of the key figures have been extracted already; some papers only list area changes (not the areas themselves); some are not clear about dates and some list many areas from within one decade. Table 1 was intended as a summary of what research had been done before in which overall change between first and last available dates was measured, which we believe is adequate for the aim of the paper. Also, we feel that there is little gain in displaying all area numbers from all papers as this may only serve to confuse the reader.

2. Furthermore, we do not believe it is possible to make direct comparisons and discuss differences with previous studies for each ice shelf as there are too many factors causing differences in area calculations. For example: measurements may have been made from images of different dates, resolution and positional accuracy, different grounding line positions and ice shelf delineation and digitising errors. However, greater than these may be the map projection on which the areas were calculated. In most previous studies it is not clear how the measurements have been made. In this study, the lines were digitised onto images in Polar Stereographic projection, then re-projected onto Lambert Azimuthal Equal Area projection (with the Latitude of Origin close to the centre of the ice shelf) for the most accurate area measurements. This is a well recognised and reliable method for calculating areas. If areas are calculated on a different projection it can produce significant differences. For example, Wilkins Ice Shelf in July 2008 was 11,488 km² on LAEA projection, yet on Polar Stereographic projection it gives an area of 12,175 km². In some cases it can result in differences of over 1000 km². There are studies that quote figures for the areas of an ice shelf but without explaining the methodology in attaining this number (e.g. Humbert (2007) lists

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Interactive
Comment

the area of George VI Ice Shelf as being 22,019 km² but it is not clear how this number was reached). We cannot discuss why there are differences if there is no description of the methods used in the original paper.

In summary, we have not discussed differences between new figures and previously published figures for each individual ice shelf, but we have added an explanation in the introduction to the descriptions about why there are differences. We have also taken note of the reviewer's point that it is not clear which area numbers quoted in this paper are new and which are old and have hopefully clarified this by only stating numbers that are ones calculated for this study, unless they appear with a reference. Also, as this is an overview paper, we have kept our own calculations to one per decade and refer the reader to other studies that list more detailed area changes. We have been as complete as we feel we were able in Table 1 with listing previously quoted areas of ice shelves. The table was based on publications prior to 2008, when our study began, which is why it did not include more recent area calculations made in other studies, but we have updated the table with the study by Braun et al. (2009) and made minor corrections.

Point 2 – is this “new work” or a “review”?

The review raises the question of whether this is a review paper or a piece of new work, and whether it is appropriate for publication in The Cryosphere. This is a fair question, we certainly intended this to be a “Research Article” as described in the guidelines to authors, and we present new datasets and histories of ice-shelf change, that we hope give greater insight into the recent events on the Antarctic Peninsula. However, we certainly accept that we have tried to review the salient processes that have been hypothesised and described on each ice shelf. We would take the advice of the Editor, if we have strayed too far towards a “Review Article”, and would offer to make the changes required to fit into that category of TC submission if required.

Specific comment:

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Interactive
Comment

P. 581, line 13-18: clarification inserted

Line 25: this reference was helpful, however Suyetova found that the increase in area of Antarctic ice shelves between 1961 and 1984 turned out to be as a result of corrections to the positions of their boundaries on the maps. I have cited this paper in the caption for Table 1 for completion.

P.584, line3: correction made

Line 8: The ‘original’ area does not mean the area measured in previous studies, but the first year measured for the current study (in this case, the first measured year for Larsen C is 1963 – see table 2). The explanation inserted into the introductory comments will hopefully clarify this.

Line 9-17: The paragraph in the discussion which deals with the influence of the oceans has been expanded to respond to this point. We believe that this is the best place in the text for this addition.

P.585, line19: The word ‘fast’ has been removed

Line 20: corrected

P. 586, line 1-2: We have added Domack et al (1992) reference (Antarctic Journal of the US, 27 (5),71)

p. 587, line 6: Here we are quoting conclusions made by Fox and Vaughan (2005), with, we believe, adequate citations. Amongst their conclusions they stated that comparison of the retreat of the east and west portions supports modelling studies such as Doake et al., 1998.

Line 10: the ice thickness (surface elevation) across Jones Ice Shelf were measured and presented in Fox and Vaughan (2005). We did not feel it was worth repeating these here.

Line 9: we have clarified that it was an ice rise that created the pinning point.

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Line 19: corrected with the addition of the word 'observed'

Line 20-21: we fail to see how this is contradictory, but have changed 'given' to 'yielded' in case of confusion.

p.588, line 5: We understand that the reviewer is happy with the use of the word 'rapid' here.

p.589, line 22: Citation to Humbert (2007) added.

Line 23-25: the problem arose when using the Landsat image from 1974 due to difficulty in interpreting the ice front as a result of sea-ice and large ice bergs at the time the image was taken. This also occurred when interpreting from TMA and RARE aerial photographs in the northern George VI Sound, but wasn't so much of a problem in recent images. Measuring from altimetry data wouldn't be necessary for the purposes of this study, but may be valuable for future work.

p. 590, line 6-10: we have inserted the point that the reviewer suggests.

p. 591, line 12: we have added the reference to the start of this section as suggested.

Line 14: sentence has been corrected accordingly

Line 16: corrected

Line 19: we have removed our numbers that differ from the studies mentioned by the reviewer. There are several reasons as to why they differ, as already outlined (including projections, image dates, resolution, digitising methods etc.). It is not clear how the measurements have been made in previous studies. As this is an overview paper, we do not feel that it is significant to discuss the differences between new figures and those measured as part of more detailed studies, so we have removed them.

Line 22 and 23: Fig 4e shows the 2009 ice front as it was in April. The ice front is changing frequently and this was the most up-to-date position when we were writing the paper. The purpose of the paper is to show the position of the ice shelves, showing

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one from each decade, and one from 2008/9. It is not intended to give the most recent positions. We have re-worded the paragraph to refer the reader to the more detailed studies of Wilkins Ice Shelf and have explained more clearly the 5434 km² figure.

Lines 26: "Interior" added to make this clear.

Line 27: We believe that 200 ma⁻¹ is a representative velocity for George VI Ice Shelf, we take this from the model output presented by Humbert (2007), and generally supported by early measurements (Pearson, M. R., and I. H. Rose; 1983, Br. Antarct. Surv. Bull., 52, 205-220.). The source paper suggested by the reviewer (Rignot, E.; 2006, Phil. Trans. Roy. Soc. Lond. A., 364(1844), 1637-1655.) does include a map of "measured" ice velocities for the entire AP, but this only shows the George VI IS at low-resolution, and this map appears to show velocities in excess of 1000 ma⁻¹ over much of the George VI IS, without corroborative evidence, we believe these velocities may be incorrect.

P.592, line 6: We believe that 'brine-soaked to sea-level' is correct and that it should not say 'below' sea-level

Line 17-20: correction – it now says Braun et al (2009)

P.595, line 13 and 18: corrected

p.596, line 1: Larsen Inlet is not regarded as a separate ice shelf in this study but it is a section of Larsen A Ice Shelf (until the late 1980s they were one body and so separate area calculations could not be made). It is not listed separately as one of the 12 ice shelves on the AP so probably should not go in the title to this section.

Line 7: done

Line 14-18: done

Line 19 and 14: edited as suggested

P.597, Line 16: We believe we are correct in citing MacAyeal (2003) as all of the pro-

cesses were described in this paper. We are unable to identify any relevant MacAyeal 2009 paper.

p.598, Line 28: corrected

p. 602, line 6: We leave it to the Editor to decide if this is appropriate use of non-SI unit, but if the Editor requests it we will be happy to replace the rate of temperature change, 3.7 °C(century)–1 etc, with the SI equivalent.

p.604, line 18-19: we have corrected the sentence to read: “fluctuations in the position of”. Although the southern ice front is mentioned in other articles (e.g. Humbert (2007)) we cannot find a reference that describes in detail how the position has changed. We believe the reference mentioned by the reviewer, Humbert (2008) was intended as Humbert (2007), as we are unable to find a relevant Humbert (2008) paper.

line 17 onwards: we have edited this paragraph accordingly

Table 1: It is not possible to edit this table to match Table 3, as discussed above. We have edited the Table caption to clarify the purpose and content of the table and with references to other papers showing area figures. The relevant missing references have been added as suggested.

Interactive comment on The Cryosphere Discuss., 3, 579, 2009.

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