

Dr Bethan Davies
Institute for Geography and Earth Sciences
Aberystwyth University
Aberystwyth SY23 3DB

Professor Hilmar Gudmundsson
Scientific Editor
The Cryosphere

Re: Manuscript No, tc-2011-102

"A new glacier inventory for 2009 reveals spatial and temporal variability in glacier response to atmospheric warming in the northern Antarctic Peninsula, 1988-2009".

Dear Professor Gudmundsson,

Please find attached replies to comments by an anonymous referee.

We have worked hard to distil and condense the information conveyed, and have reduced the manuscript by 600 words to 8400. We have removed detail from the manuscript to better convey the principle findings. We have also merged the supplementary methods into the main text, and condensed the methods. We have also attended to all of the specific comments raised by the referee.

Please note that the reviewer criticises that the manuscript includes a lot of inventory data in figures and tables. We note that the manuscript has two aims: firstly, to inventory the glaciers of the Antarctic Peninsula, and secondly, to analyse glacier change. It is therefore important to retain these important inventory data, and not to focus entirely on the glacier change results, as this reviewer suggests. These inventory data (total numbers and areas of glacier types, rose diagrams of aspects, min and max and mean elevations, ELA etc) are important to related research and are included in all inventories.

Below we have responded more directly to each point raised below (*italic font*).

Yours sincerely,

Bethan Davies

The paper provides a detailed mapping of the Trinity Peninsula, Vega Island and James Ross Island glaciated regions, with a breakdown of several glaciological parameters (area, length, hypsometry, slope, aspect, and ELA).

I found the paper to be overloaded with detail and short on analysis of what the details might mean. Components of the paper that are really just hashes of data to be given to the glacier inventories should be culled, keeping those aspects that provide some insight into change and causes of change.

The many important inventory parameters provided by the manuscript are an important part of the results, as noted by the other reviewers. For example, regarding these inventory data, Matt King states, "This represents a significant body of work which will be of great value to the community." It is important to publish inventory data such as this, and not to leave it unremarked upon, for example in the GLIMS database, because, as we state in the introduction, glacier inventory mapping and data

is an important prerequisite for regional mass balance studies, numerical modelling studies and predictions of future glacier behaviour.

We feel that the detail in the manuscript, with factual observations and data, is a strength of the manuscript. However, in the results section, as have condensed the manuscript to remove some of the detail.

For example, I don't think there any merit to telling the TC audience that ELA estimates based solely on altitude ratios of 50 versus 60 per cent correlate highly. Nor do I think that near-zero correlations of the many parameters that don't do so are worth the space or the effort to understand them. If you propose a hypothesis (or a few hypotheses) of what leads to glacier changes in the region, you can examine the data you have in an organized fashion, and eliminate parts that don't have much to say.

The strength of the correlation of these parameters is part of the basis for including or removing ELA estimations from the results and discussion, and it is therefore necessary to include these correlations.

I recommend that the paper be significantly reduced, and extensively rewritten, presenting the valuable map of Figure 1 in as high a resolution as is reasonable; accompanied by a well-organized summary table of the glacier parameters.

We have shortened the manuscript throughout. Summaries of glacier parameters are already provided in Tables 4, 6 and 7, and Figures 1,3, 4, and 5. These are an important part of the manuscript.

Table 5 should be shortened to the meaningful relationships. *It is as important a result that there is no correlation as that there is, and this table shows important results.*

Table 6 and 7 are fine, but should replace parts of Fig 4 (cut Fig 4). *Fig. 4 shows important data that is not presented in tables, and in addition to Tables 6 and 7, shows regional distributions of aspect, ELA, hypsometry etc., which is not given in the tables. It therefore complements the tables well. Equally important are the changes E, F and G, which demonstrate the regional variations in aspect, hypsometry and glacier long profiles, which are a significant influence on their behaviour.*

Tables 8, 9 are of value.

Figures 2, 3, 4CDE FG, 6, and 7 mean very little, except to show that lots of things don't matter.

Figure 2 is important as it not only demonstrates examples of the route taken for glacier length mapping (important for demonstrating that the methods are robust and replicable) but also illustrates the glaciological structural mapping used in ice divide mapping.

Figure 3 provides important, standard, inventory data, and is an important part of the results of this paper, which has two aims: firstly, to inventory the glaciers of the Antarctic Peninsula, and secondly, to analyse glacier change.

Figure 4, as noted above, also provides important information on the regional distribution of glaciological parameters.

Figures 6 and 7 show important information regarding terrestrial and tide-water glaciers respectively. The difference in behaviour of these glaciers is an important finding and needs to be explored.

Abstract

The abstract has been rewritten.

3452 L14-16 - this sentence essentially repeats the preceding one. *Sentence deleted*

L18-19 -this JRI retreat rate is very small, the sentence is a bit awkwardly put. You are saying that losses have essentially stopped on JRI glaciers. *Sentence deleted*

L19-20 - These are retreats; non-steady behaviour. The orographic temp and precip differences have always been there. You need to re-think this statement. (The strength of the differences may be changing – you need to explore that as an explanation). *We believe that the glaciers are retreating in response to overall warming, but that the precipitation starved glaciers on the eastern Peninsula are more vulnerable. We have strengthened and clarified this statement.*

L20-11 - suggest change to: 'Large variations in rates of retreat of adjacent tidewater glaciers in the area may result from ...' *Amended to read, "Large variations in rates of area loss of nearby tidewater glaciers may result from the influence of glacier length, altitude, slope and hypsometry on glacier mass balance"*

L22-23 - High snowfall: you can't make this statement in this paper without a lot more work. - Increased- snowfall -may- be stabilizing the western-side glaciers. Yes, that is likely to be true. But you don't know without a look through time at past extents, calving, ocean temperature and circulation, past accumulation rates. etc. *Rewritten in line with other reviewers to state, "Reduced shrinkage on the western Peninsula may be a result of higher snowfall."*

L23-25 Similar comment here - you need qualifiers, you have not begun to introduce the possible causes of retreat or the current slowdown in retreat rate. It may be due to retreat into the fjords, to cooler (or flat) climate, cooler (or flat) ocean temps at depth...*Rewritten to: "Rates of area loss on the eastern side of Trinity Peninsula are slowing, which may be because as the floating ice tongues retreat into the fjords, the glaciers reach a new dynamic equilibrium."*

Intro

3453 L18-19 - this reference is not appropriate here - use a Grace-based result such as Ivins and others 2010. Hock et al. have no validation data in the southern hemisphere, the number is very tenuous, and it is not clear if they considered Trinity or other areas of the main Ant ice cap. *I cannot find this citation. We have the reference Ivin and others, 2011, JGR, and removed Hock et al 2009.*

Page 3455 L10-15 - rewrite, this is just too approximate to be useful. Bellingshausen - not 'warm', it has more to do with the absence of sea ice (you say this later); and the western Ant Peninsula climate is dominated by orographic uplift of polar marine air masses, not just Bell Sea. West Ap is warmer than East AP at the same latitude by 7deg. *Rewritten to, "The western Antarctic Peninsula therefore has a polar maritime climate, dominated by the relatively warm and ice-free Bellingshausen Sea, whilst the eastern Antarctic Peninsula and James Ross Island have a polar continental climate, dominated by the Weddell Sea, which is ice-bound for much of the year (Martin et al. 1978; Vaughan et al. 2003, King et al. 2003)."*

5 Glacier change results:

Condense this to the important, well-mapped, and scientifically pertinent data you extracted. Let the tables do the work they were designed to do: restrict the text discussion to the interesting cases. *This section has been shortened. Interesting glaciers are provided as case studies.*

6.4 Changes in ELA

If the only data is altitude, then I think you should remove most of the discussion of ELA from the paper. You have no data on the real ELA. The Hess method does not seem to work for this region. *ELA data is an important and necessary part of glacier inventories, and as a first estimate, it is important to explore how these glaciers would continue to behave in a changing climate (see comments from reviewers Bolch and King).*

You don't have sufficient imagery to accurately assess ELA from satellite. -If- you wanted to do this, you could use MODIS data to get a reasonable ELA from the 12 years of available data, although the resolution would be low (it would be more accurate than averaging the elevation from top to bottom, though). *This would not only be beyond the bounds of the study, it would also not provide any more accurate information on ELAs in this region, as we have shown that the TSL method is not applicable in these polar regions. This is, in itself, an important result of this work.*

6.5 Ocean T

You don't measure anything related to ocean temperature. If you were to attempt to relate any of the retreat rates to geographical parameters potentially related to ocean T at depth or on the surface (west coast, east coast, AAR, ice front width) than you might have room to discuss this. As it is, Section 6.5 is just a discussion of literature and not really a part of your study.

It is important to situate the work within and relate the work to the wider published literature and observed changes. We have measured ice front width but noted that it was not related to glacier change; this point highlights the fact that even the inventory parameters that are shown to be insignificant are an important finding.

7Conclusions

Some of these are not conclusions of the paper. e.g., opening lines -but overall this is a reasonable summary of the paper's important results. *It is important to note the context for the glacier changes in this manuscript.*

Table 1: Landsat 4 TM - TM does not have a Pan band. Bands 1234 are 28.5 m resolution. *Thank you for noting this; amended*

Table 3: Of the methods listed, I think you should eliminate ELA-median; it is a complete guess. *ELA Median, as we have stated in the text, is the median altitude of the glacier and has been shown to correlate well with the ELA (See methods section). This is a standard technique in glacier inventories.*

I don't understand ELA-thar. *Toe to headwall ratio (THAR) is used in many glacier inventories (cf. Carrivick and Brewer 2004).*

Table 5: Why are you bothering with the several pairs that have essentially no correlation? These could be listed in the text. *It is briefer to note these in the table.*

The ELA correlations - unless something other than hypsometry is involved the high correlation is meaningless. So the first ELA correlation of 0.95 is of no use? *This demonstrates that ELA_Hess and ELA_TSL are not useful parameters.*

Figure 1: useful and informative, if accurate. I see there are some questions about Vega Island. *We have attended to these in response to Marinsek's comments.*

Figure 2: some of the length lines don't appear to begin at the highest contour, e.g. GIJR124, GIJR115, GIJR97? *The length lines begin at the ice divide.*

Figure 3: for the scatterplots, include R² value either in the graph or the caption. Side note, it is not science to compare numbers and examine meaningless relationships. I would cull the graphs here based on those that provide insight into glacier stability. *R² value is now only in the graph or Table 5. Captions shortened. As we have stated above, these graphs are an important part of the inventory data that this study has provided.*

Figure 5: Caption: A 2 C warming could result in a an average ELA rise of 345 m.(don't mention 2040, it is irrelevant) *Amended*

Figure 6: check caption, 'and-terminating glaciers'. *Caption shortened and this deleted.*