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Professor Hilmar Gudmundsson
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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,

We would like to thank Mauri Pelto for his thoughtful comments on our manuscript, and respond to each comment below (italic font).

We have worked hard to distil and condense the information conveyed, and have reduced the manuscript by 600 words to 8400.

Our main concern is that the use of transient snow lines in polar regions such as this with summer-accumulation type glaciers and year round snow fall is very limited. Even with large amounts of imagery, it is difficult to objectively select an image that shows 'typical' summer snow lines, as this depends simply on the date of the most recent snow fall. Although we welcome Mauri Pelto's suggestions re calculation of accumulation area ratios, we feel that unfortunately it is not appropriate for this study.

However, calculation of ELAs is a vital part of glacier inventories. Despite rigorously attempting several methods of ELA determination, including snow line altitudes, glacier shape and hypsometry, we found that considerable scatter in transient snowline mapping and the Hess method rendered them inappropriate in this instance. Again, we feel that this observation is important and should be included. Although the long-term ELA calculated from topographic data is limited, it provides a useful indication not only of a glacier's ELA, but also a glacier's likely response to a raise in air temperatures.

We welcome Mauri Pelto's observations on the recent recession of glaciers on Vega Island, and note that this would make an interesting follow-up report in several years' time. However, too little time has passed since the 2009 inventory to analyse this data.

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

Yours sincerely,

Bethan Davies

Davies et al (2011) provide a valuable inventory of glacier changes on the Trinity Peninsula, James Ross Island and Vega Island. The large changes in areal extent of the glaciers are spatially and

temporally documented, providing a valuable and comprehensive data set that can be easily extended in future resurveys. The largest changes are of the tidewater glaciers and these match other studies and current imagery. Comparison of changes for smaller land terminating glaciers in the northwest of Vega Island, indicate some problems. A secondary aspect of the paper is the ELA determination, five methods are used, but none give in my view useful verifiable results for the current situation. If possible AAR values would be a more robust indicator of mass balance.

3551-13 and 3354-12: Both AAR and ELA are vital as indicators of mass balance. The ELA is generally used to determine AAR, which in turn is equated to mass balance. Given the noted spatial patchiness of the snowline and the temporal variability, AAR would be a better measure of mass balance conditions for these glaciers. The ELA-Mean approach as noted below can provide a measure of the long term ELA that generated the glacier. However, given the large scale retreat, it is clear the long term ELA is not the same as the recent mean ELA. The imagery analysed in this project can provide a valuable measure of the AAR, if not the ELA-TSL. The ELA-Mean simply does not pass the verification test on Vega Island for assessing current ELA. The difference between ELA-Mean and recent ELA is also of value in terms of identifying the impact of the warming on glacier mass balance.

ELA-MEAN is determined from the 2006 SPIRIT DEM (all parameters apart from transient snow lines), and is therefore valid for that date. We have insufficient data to create a long-term ELA as this would need multiple detailed field seasons. Our ELA-MEAN is only intended to be used as a first estimate of the ELA.

The transient snow lines cannot be used to indicate AAR because of the reasons indicated in the manuscript, including large inter-image variability even during summer ablation months.

We have removed reference to the glacier on Vega Island because of differences in reconciling ice divides.

3554-18: I do not suggest that the following point be examined in detail as it goes beyond this inventory. However, somewhere in the discussion on this page reference should be made. The ELA-TSL does not provide a robust measure of the ELA for the reasons noted above. However, mapping the ELA-TSL does provide an accurate assessment of the AAR at the time of the imagery. Any one image is of limited value; however, several late ablation season images can define the typical AAR.

The TSL is of limited value even for determining the AAR because snow falls throughout the summer season in this region. The AAR would therefore be determined only by the date of the last snow fall. While this method may work well in winter-accumulation type glaciers such as in the European Alps, it does not provide accurate information on seasonal snowline altitudes in this location.

This typical AAR even if it is not the end of the season indicates the extent and duration of typical ablation conditions, which in turn is valuable for mass balance assessment (Dyugerov, 1996; Pelto, 2011). A plot of observed AAR values would be of considerably more value for mass balance assessment than ELA-mean values derived from hypsometry. The goal would not be to determine the mean AAR or even identify the end of the melt season AAR, simply plotting the observed typical AAR on these glaciers late in the ablation season. Given the better understanding of the AAR-Ba relationship this would be of greater value than determining the ELA five different ways and applying a method based on hypsometry that does not reflect the current climate conditions. This methods could be applied even to a limited subset.

Because of the reasons identified above, and because this is beyond the bounds of this study, we have decided that this would be inappropriate.

3555-11: The limited value of the ELA-Mean approach is indicated by the poor comparison with Bahia del Diablo (BDD). The ELA on BDD has been above 400 meters in 7 of 10 years from 2000-2009, and every year above 350 m (WGMS, 2011). Compared to the 245 m derived here. The ELA on the glaciers adjacent to BDD are comparable to these elevations. *As we have used different ice divides, we have removed the comparison to Glaciar Bahia Diablo (see response to Marinsek).*

3358-24: The base map makes it very difficult to identify the inventory numbering for Vega Island. Examining the material submitted to the GLIMS did not help. Only by going back to Rabassa et al, (1982) I was better able to determine the numbering scheme. *The glacier ID is available in the attribute data in the GIS files.*

Further it is stated that on Vega Island limited recession was apparent after 2001 on land terminating margins. Examination of 2006 Aster imagery and 2011 Landsat imagery suggests considerable recession was still occurring of land terminating glaciers in the northwest of Vega Island. In the inventory glaciers Vega Island 02-04 have shown recession and in several years have very little retained snowpack. Vega Island 28 also shows significant recession. *The comparison of 2006 Aster imagery and 2011 Landsat imagery is complicated, not only because of differences in resolution, but because recession may have occurred since 2009. It will be interesting to compare rates of recession from 2009 onwards, perhaps in a follow-up manuscript in 10 years time.*

The issues of glacier divides and margin conditions noted in Marinsek's comments also suggests further attention is needed here. *Please see response to Marinsek on this issue.*

Dyurgerov, M.: Substitution of long term mass balance data by measurements of one summer, Gletscherkd. Glazialgeol., 32, 177–184, 1996.

Pelto, M.S.: Utility of late summer transient snowline migration rate on Taku Glacier, Alaska. The Cryosphere, 5, 1127–1133, 2011.

Rabassa, J., Skvarca, P., Bertani, L., and Mazzoni, E.: Glacier inventory of James Ross and Vega Islands, Antarctic Peninsula, Ann. Glaciol., 3, 260–264, 1982.

WGMS: Glacier Mass Balance Bulletin No. 11 (2008–2009). Zemp, M., Nussbaumer, S. U., Gärtner-Roer, I., Hoelzle, M., Paul, F. and Haeberli, W. (eds.), ICSU(WDS)/IUGG(IACS)/UNEP/UNESCO/WMO, World Glacier Monitoring Service,