The Cryosphere Discuss., 9, C314–C321, 2015
www.the-cryosphere-discuss.net/9/C314/2015/

The Cryosphere
Discussions
Open Access

Interactive comment on "Area, elevation and mass changes of the two southernmost ice caps of the Canadian Arctic Archipelago between 1952 and 2014" *by* C. Papasodoro et al.

R. Way (Referee)

rway024@uottawa.ca

Received and published: 3 April 2015

Reviewer comments on 'Area, elevation and mass changes of the two southernmost ice caps of the Canadian Arctic Archipelago between 1952 and 2014' by Papasodoro et al.

General remarks: This is an interesting study investigating glacier change for two glaciers on the Meta Incognita Peninsula of southern Baffin Island. I believe it provides new insight and uses a wide swath of available data sources which present a consistent picture of the evolution of Grinnell and Terra Nivea ice caps over the past half-century. Although the paper is certainly not brief, I believe that the lack of existing literature for these particular ice caps warrants the fuller discussion provided by the authors in the introductory material. Overall the science is well-implemented and the results are consistent other recent studies examining the eastern Canadian Arctic. The additional information provided by in situ surveys along portions of Grinnell Glacier represent a very important contribution in that the results have been validated using both field and remote sensing-based methods. The use of a Pléiades-derived DEM for ground control on photogrammetry-based DEMs is also a novel methodological approach and hopefully its widespread application for other, more topographically complex environments is investigated in more detail in future works. Overall, this contribution warrants publication although I believe some of the Figures could be presented in a clearer fashion.

Detailed comments on manuscript:

P1668L23-25 Two of the references for the currently observed Arctic warming section refer to paleoclimatic reconstructions, which although very interesting, may not be necessarily the best studies to cite with respect to the Arctic being currently warming rapidly. I would suggest Comiso and Hall (2014) or Cowtan and Way (2014) as perhaps being more appropriate in these cases, particularly in that they show the regional distributions of warming trends over the recent periods from satellite and surface temperature records.

Study Area Section: P1670-1671 Lenaerts et al (2013) modelled the surface mass balance for the ice caps to be strongly negative - this point might be useful to add to this section. The authors note several of the major results suggested by previous work in the area but not the the recent results of the complimentary study by Way (2015) mentioned at the end of the introduction. Given the overlap in some aspects of the areal change analysis it may be worthwhile to note the major findings of that study in the same brief manner that it was done for the other studies in the Study Area section. Notably that areal decline has accelerated, that ice thinning appears to be occurring and that recent increases summer melt intensity were linked to this decline.

In my view, this is a nice tie-in to the current study because Way (2015) qualitatively suggested that ice cap thinning was ongoing (Nunatak exposure) but did not present a quantitative assessment like this study does.

Data Section: P1672L2-5 Although it is true that in some late-summer images there appears to be very little winter snow accumulated (even at high elevations), there is a high degree of volatility in summer snow cover for these ice caps. A casual glance at Landsat imagery over the past two decades reveals both years where there is very little late-season snow cover and where it is more widespread therefore it may not be safe to assume that the absence of winter snow cover is an annual occurrence.

P1672L10-20 Using aerial photography in high snow accumulation environments can be very difficult, particularly when using 1950s-era black and white photography from the Canadian Arctic. The authors note that the photos are much higher quality than the photos used to derive the CDED data in terms of scale but how accurate was the delineation between snow cover and ice for these particular images. The manuscript currently has a number of figures so I will leave it up to the editor and the authors to determine if they feel this is a worthwhile suggestion but given the exceptional nature of the photographs and the lack of field photographs of the region, would it perhaps be useful to have a two-panel figure which shows a portion of the ice cap in the aerial photography from 1952 and then again in 2014 in the satellite imagery so that readers can cross-compare and also evaluate the quality of each image source.

P1673L1-4 Was this comparison done for the region and if so what was the average elevation difference in this area?

P1673L20-23 Was the vertical precision spatially or more importantly altitudinally influenced?

Meteorological data: Is this data from the Adjusted and Homogenized Canadian Historical Climate Data or just the raw measurement from the online database. The reason I ask is because eastern Canada was impacted by the time of observation bias when the climatological day was redefined in 1961 and this appears to have had an observed impact on minimum temperatures for Iqaluit's station based on Vincent et al's (2009) analysis.

Methods: P1680L13-19 Although I believe that the approach used for calculating uncertainties in the respective DEMs is undoubtedly valid, I would suggest that an additional caveat be added to the discussion given that the uncertainty in DEMs derived from aerial photography and ASTER would possibly have larger errors at high elevations for the ice caps relative to at the same elevations for unglaciated terrain because of the difficulty in pixel matching. This point would be mitigated if each of the DEMs were collected in years without substantial high elevation snow cover (like the Pléiades DEM) but that is unlikely to be the case for all the imagery used.

P1681L5-8 The 3% uncertainty seems to be appropriate for the most recent imagery where a detailed evaluation could be made but I believe this estimate may be a little optimistic for the earlier aerial photography where it can be more difficult to interpret between late-season snow and ice. This perhaps should be noted.

Results: P1681L19-26 These results should be also in Table 2.

Discussion: P1684 Section 6.1 The Pléiades DEM being used for photogrammetric ground control is interesting and is a very worthwhile contribution. The authors may note that multiple Pléiades acquisitions subsequent DEMs over the same area could be useful to increase the confidence in its use for ground control.

P1685 Section 6.2 Although the mass change results are placed in the context of the surrounding ice caps and glaciers the area change results are not. It may be worthwhile to add a few brief comments on this to the discussion, for example there were area changes noted on the small glaciers to the northeast on Baffin (Paul and Kaab, 2005/Paul and Svoboda, 2010/Svoboda and Paul, 2010), on northern Baffin (Anderson et al. 2008) and the south in the Torngats (Brown et al. 2012/Way et al. 2014), not to mention many of the other nearby ice caps.

P1687L13-20 Although I can certainly see the importance of evaluating the sum of positive degree days there are limitations to its applicability in this case. A modest increase in the length of the melt season can be inferred from the results but its importance for the strongly negative elevation change rates is probably less than the importance of the melt season intensity. For instance, the meteorological analysis presented by Way (2015) suggests that although the melt season duration has modestly changed the melt intensity has substantially increased in the region. As a result, the ratio of warm-season cumulative thawing degree days relative to cumulative freezing degree days has nearly doubled over the past decade (Way, 2015; Figure 5C). It would perhaps be more effective if the authors either referenced this finding or calculated melt-season thawing degree days which could be added to Figure 8 Panel A instead of the positive degree day sum. I think it might also be worthwhile to mention that there is no particular trend in cold-season precipitation for the region (strengthening the result that mass changes are melt-driven).

Conclusion: P1688L24-26 "…regional warming is linked to strong near-surface warming possibly caused by summer sea ice losses."

Comments on Figures:

Figure 2: I believe that Panel C distracts from the focus of this figure, particularly given that there are so many outlines on the two images and also because it overlaps portions of both ice caps. A nearly duplicate figure to that of Panel C is also shown in Figure 8 Panel D. I would suggest that the areal changes provided in Figure 8 Panel D should remain (albeit in an altered form – see comments below) but that Figure 2 Panel C should be added to the Table 2 which could be slightly reconfigured to have both mass balance and area change.

Figure 4: The organization of the legend and line graph should be arranged in a more consistent manner as currently they appear to be disorganized.

Figure 5: Captions b and c need to be rearranged. From my perspective I do not

believe that Figure 5 Panel A is needed or that it adds a particular amount of insight that could not be gleaned from Figure 5 Panel D currently. We can see from Figure 5 B and Figure 5 C that elevation changes have accelerated and Panel D emphasizes that. Considering the uncertainties in ASTER DEMs I also find the area of elevation gain near the interior of the ice cap to be curious because upper elevations are more likely to be snow covered and therefore be more uncertain in the matching process of DEM generation. Do the icesat validation results for the ASTER DEM used by the authors suggest that accuracy is high at these upper elevations?

Figure 6: Top panel appears to have a portion of the graph cut off on the left.

Figure 8: I do not particularly like that Figure 8 Panel A has been inverted. I understand the point in that it is inverted to show a similar scale to the other three graphs but I believe that it is more intuitive to flip the scale to make sense (e.g. an increase in positive degree days).

Figure 8 Panels B and C show very similar results and perhaps should be combined – this would allow for panel A, B (combined) and C to be enlarged which is necessary for Panel D to be interpreted more easily.

As noted in the discussion of Figure 2, I believe that Panel D in Figure 8 duplicates the results to some degree from that earlier figure. I suggested that Figure 2 Panel C be removed and information be added to Table 2 but that Figure 8 D is retained.

I do not necessarily believe that the dots from this study on Figure 8 D be connected by lines as that suggests that the results of this study and those of Way (2015) conflict whereas I believe they are very complimentary. These ice caps undoubtedly show large year to year variations in the amount of late-season snow cover which is why Way (2015) used multiple images for each average. Therefore it is not unexpected that deviations from the best fit lines would occur. The lines also suggest that substantial ice losses would have occurred between the 1950s and the mid-1970 results from Way (2015) whereas I believe that this is somewhat at odds with what is presented in that analysis. I suggest that the dots (all) are connected by a dotted line and that error bars are shown for the area estimates. The enlargement of the figure suggested above would facilitate this to be done and would enable a more useful figure.

References: Anderson, R. K., Miller, G. H., Briner, J. P., Lifton, N. A., & DeVogel, S. B. (2008). A millennial perspective on Arctic warming from 14C in quartz and plants emerging from beneath ice caps. Geophysical Research Letters, 35(1).

Brown, B. R., Lemay, M., Allard, M., Barrand, N. E., Barrette, C., Bégin, Y., ... & Way, R. (2012). Climate variability and change in the Canadian Eastern Subarctic IRIS region (Nunavik and Nunatsiavut). Brown BR, Lemay M, Allard M, Barrand NE, Barrette C, Bégin Y, Bell T, Bernier M, Bleau S, Chau-mont D, Dibike Y, Frigon A, Leblanc P, Paquin D, Sharp MJ, Way R, Allard M, Nunavik LM, Nunatsiavut: From science to policy (eds) An Integrated Regional Impact Study (IRIS) of climate change and modernization. ArcticNet Inc., Quebec City, 57-93.

Comiso, J. C., & Hall, D. K. (2014). Climate trends in the Arctic as observed from space. Wiley Interdisciplinary Reviews: Climate Change, 5(3), 389-409.

Cowtan, K., & Way, R. G. (2014). Coverage bias in the HadCRUT4 temperature series and its impact on recent temperature trends. Quarterly Journal of the Royal Meteorological Society, 140(683), 1935-1944.

Lenaerts, J., Angelen, J. H., Broeke, M. R., Gardner, A. S., Wouters, B., & Meijgaard, E. (2013). Irreversible mass loss of Canadian Arctic Archipelago glaciers. Geophysical Research Letters, 40(5), 870-874.

Paul, F., & Kääb, A. (2005). Perspectives on the production of a glacier inventory from multispectral satellite data in Arctic Canada: Cumberland Peninsula, Baffin Island. Annals of Glaciology, 42(1), 59-66.

Paul, F., & Svoboda, F. (2010). A new glacier inventory on southern Baffin Island, Canada, from ASTER data: II. Data analysis, glacier change and applications. Annals of Glaciology, 50(53), 22-31.

Svoboda, F., & Paul, F. (2010). A new glacier inventory on southern Baffin Island, Canada, from ASTER data: I. Applied methods, challenges and solutions. Annals of Glaciology, 50(53), 11-21.

Vincent, L. A., Milewska, E. J., Hopkinson, R., & Malone, L. (2009). Bias in minimum temperature introduced by a redefinition of the climatological day at the Canadian synoptic stations. Journal of Applied Meteorology and Climatology, 48(10), 2160-2168.

Way, R. G., Bell, T., & Barrand, N. E. (2014). An inventory and topographic analysis of glaciers in the Torngat Mountains, northern Labrador, Canada. Journal of Glaciology, 60(223), 945-956.

Way, R. G. (2015). Multidecadal Recession of Grinnell and Terra Nivea Ice Caps, Baffin Island, Canada. ARCTIC, 68(1), 45-53.

Interactive comment on The Cryosphere Discuss., 9, 1667, 2015.