Review of “Strong ELA increase causes fast mass loss of glaciers in central Spitsbergen” by J. Małecki.

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Overview

This short paper analyzes decadal scale glacier change in Dickson Land, a small area of Svalbard near the former mining town of Pyramiden, using older and newer map products. The paper recapitulates some of the analysis described in Nuth et al (2011), i.e. it deals with length and area changes, but it does so in slightly more detail, and uses a newer higher-quality dataset covering the latest period. The latter allows the possibility to study elevation changes between 1990 and 2009/11.

The study is valuable for validating this and other previous earlier larger-scale, coarser resolution regional wide studies. However, the language needs improvement throughout, and the paper will need to be rewritten extensively before it can be accepted for publication. I have not given more than a cursory look at the language, since there are some other issues that need to be addressed first.

First, the sensational title needs to be changed. The “strong ELA” change of the title is not mentioned until late in the paper; and there is no description or figures showing how these changes are derived. A change in ELA of 100s of m over these decadal time scales is not realistic, measured ELA trends are much smaller. For the two small glaciers in Ny-Ålesund with long records, for example, ELA increases by less than 1 m/yr over the 50 years of measurements.

In any case, as best I can tell, you are not actually measuring an ELA change through time. You compare two estimates, made at different times; these show that the later estimate is higher than the earlier one. Ultimately you are comparing apples and oranges. It is fine to estimate the rough ELA (what you call “tELA”) using a fixed AAR. However this cannot be compared to other ELA estimates, such as those from in situ mass balance measurements.

Furthermore, the “geodetic equilibrium line”, the elevation at which dH/dt is zero, is not related to the traditional stake-derived ELA, except possibly over very short time intervals, in an otherwise stable climate. Consider a glacier in balance: it has a certain ELA, yet the GEL is not defined, because dH/dt is zero everywhere. If the ELA rises to some new value, in one step, the glacier will lose mass all along its length, by a decreasing amount, until a new value is attained. Now dH/dt is negative everywhere, and the GEL is again, not defined.

Since the change in the elevation of the GEL is the entire basis for your claim of a “strong change” in ELA, then significant changes to the paper’s title and discussion are in order.

Otherwise, I have comments about the data used for the analysis and their sources. The “Glacier geometry data” section jumps around too much; consider dividing it into two sections to describe the sources for the glacier outlines and DEMs, as they are accessed in different ways, even if they are ultimately based on the same data source: NPI (Norwegian Polar Institute) aerial photographs.

Glacier outlines:

1960s: The older NPI S100 maps are used to redigitize the outlines for the 1960s; I was surprised that the precision of these glacier boundaries in our NPI glacier database (Nuth et al 2011) was insufficient for your purposes, since the boundaries are obtained from precisely the same maps. After examining the shapefiles from our database, however, it was clear that our older boundaries do have coarser resolution than, for example, the newest data available (the 2009-2011 S100 coverage cited). However, this increase in boundary resolution may be illusory for the purposes at hand. After all, the intent is to map changes, which are occurring chiefly at the front.

In Nuth et al 2011 we smoothed slightly the original digitized outlines, which likely resembled those that you redigitized. We removed detail around the glacier outlines using modern imagery to decide whether extraneous boundary convolutions were related to gullies or snow patches rather than to the "true" glacier geometry. Recall that the outlines in the 1966 maps may themselves be imprecise, having been made by cartographers rather than glaciologists. We can digitize every convolution of these old glacier outlines in great detail and still be no more accurate in our estimate of the glacier area. In other words, the outlines in our database are not necessarily imprecise.

To map area and length changes the most important things are i) to be consistent with the criteria along the glacier sides, by not modifying them unless there have been real and significant changes, and ii) to do a good job at digitizing the front. In many glaciers the latter is straightforward, but is more challenging when the tongue is debris-covered.

In any case, all this motivates me to see about updating and upgrading the NPI glacier database, and illustrates the value of such a detailed exercise. I did compare area and length on a few glaciers chosen from the two different datasets and find slightly different, although ultimately comparable, values.

1990s: You cite the NPI database (Norwegian Polar Institute, 2014b) as the source for the 1990 outlines, but this reference only contains the newest (2009 and 2011) outlines for the Dickson Land area. The 1990 outlines and centerline data are currently available in the NPI glacier database (Nuth et al 2011, König et al 2013).

DEMs

1990: This DEM is no longer available at the cited source. Also, as noted below, you should show the extents of the 1990 DEM, in Figure 1 for example.

Specific comments

1) P6159, L10: I think you mean to say that "On glaciers with multiple outlets (e.g. Jotunfonna), more than one centerline must be used to determine the representative lengths and retreat rates." Also, properly speaking, each flow line should be considered separately, as is done in the NPI glacier database.

2) P6159, L25. I do not understand your distinction between $\overline{\mathrm{d}h}$ and d*H*. The text implies that this is a pixel- or element-wise calculation, so that *h* is the elevation at each pixel, and that the overbar indicates spatial averaging over the entire surface.
3) P6160, L3. Equation (2) is wrong. The correct expression should be:

$$\mathrm{d}H = \frac{2\,\mathrm{d}V}{(A_{1990} + A_{20xx})}.$$

4) P6160, L14. d*H*/d*t* when integrated over the glacier is the geodetic mass balance, whatever units you choose.
5) P6162,L4: This is not the place to suddenly tell the reader that the 1990 DEM is incomplete, and outline the steps for patching in some other data; that should come in the data section. Furthermore, given the care with which you otherwise devote to the analysis, it doesn't make sense to use d*H*/d*t* values based on similar AARs, since the relation between your tELA and d*H*/d*t* still has a fair amount of scatter. It would be better to restrict the analysis to the areas where you have the data.
6) P6164L18: The main "driver" for d*H*/d*t* is not elevation, it is the regional climate. What you mean to say is that d*H*/d*t* is correlated with the glacier mean elevation, as shown in Fig. 7a. Actually Fig. 6a shows the relation between dH(z)/dt nicely, once one accounts for the fact that d*H*/d*t* values taper off to zero toward the earlier epoch due to the wedge profile of the glacier tongue.
7) P6164L23: Similarly, *A* doesn't "control" *L*, the two are related; see papers on glacier scaling relations by David Bahr.
8) P6166L10: I guess this is the source of the title. Again, the elevation of the GEL is not equivalent to the ELA.
9) P6166L21: What geometrical analysis?
10) P6167L12: Nuth et al (2013) find decrease in area loss rates after 1990 for southern Spitzbergen (N2013 p 1617), while there is much scatter for all of Svalbard (N2013 Fig 7b).
11) P6167L22: You really can't make this claim; Nuth et al (2010) reports a number of glaciers which have comparably negative specific mass balance rates (N2010: Table 2). See also abstract.
12) P6168L12: I wouldn't try to sell DL as a particularly important region for the overall mass balance of Svalbard. All regions are important, but we don't have access to high-quality data in all regions. We can, however, look at glacier change in limited areas, which have either better logistical access or better data sources, and then we can use these high-quality data to, for example, calibrate Svalbard-wide mass balance models.