

## ***Interactive comment on “Sensitivity of geodetic glacier mass balance estimation to DEM void interpolation” by Robert McNabb et al.***

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Received and published: 2 October 2018

### Summary:

The authors provide a comprehensive assessment of the impact of void-filling routines on the calculation of glacier elevation and volume changes. This is an important work that has relevance for a wide variety of both local and regional scale glacier change studies utilising geodetic datasets. This is a timely study and a topic I've been interested in for some time. The manuscript is of high-quality, is very well written, largely free from errors, and suitable for publication in The Cryosphere. I would recommend acceptance following minor revisions, providing that the authors address the following minor comments. I'd like to congratulate the authors on an interesting study and an

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important addition to the growing body of knowledge on regional-scale glacier volume change estimation. This paper will be an excellent companion to the equally good Nuth & Kaab TC study of 2010.

### Minor comments:

- Title: There is an inconsistency between the use in the title of the term 'geodetic mass balance' and what is referred to elsewhere in the manuscript (and what is actually calculated) – which is volume change. I know why you have it up front in the title, as this is motivation for the study, but as you calculate only 'relative estimates of volume change' (4,23-24), the title is in fact incorrect. You do not assess the sensitivity of geodetic glacier mass balance in this work. The title therefore needs to be revised to 'volume change'. However, keep the geodetic mass balance mentions in the abstract and elsewhere, as they're used correctly there, and provide the important context to this work.
- page 1, line 18: can provide
- 1,21: has been calculated
- 1,24-25: this isn't quite right, though may just be a quirk of language. The geodetic method does not have to require extrapolation of sparse measurements, but it still can if measurements are sparse. Centreline elevation changes extrapolated to full width and differenced are still the 'geodetic method' (see, for example, Arendt references in your list). A couple of other studies, including one of mine, have directly compared mass balances calculated from full coverage DEMs and extrapolated centreline elevations (Barrand et al., 2010, J. Glaciol., 56, 199, doi:10.3189/002214310794457362).
- 2,4: not sure 'glacier water resources' is quite the phrase you're looking for as that gets into ice thickness / total water equivalent volume territory. Perhaps something like 'the scale of glacier change'?
- 2,35: I know you detail from where the DEMs are from later, but this sentence is

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fragmentary and would benefit from a very brief description of the source of the data.

- 3,1-2: this sentence is strange. So, you're measuring volume changes but we should not interpret these as mass balance estimates? Why would we, given the additional density correction step that is necessary to calculate mass change? Why not calculate volume changes only (and present these) and avoid any mention of mass balance entirely? Then you solve the problem of seasonal timing. This looks to be what you've done (from the following sentence). If the estimates presented here '...should not be interpreted as mass balance estimates..', then you need to change the title of the paper and the content of the abstract, to reflect this.
- 17,1: it's not clear to me why the elevation data in this figure should be presented in a categorised colour scale. I think it would be clearer to view and interpret if the background hillshade was slightly opaque, and the DEM data were presented in a continuous colour scale. The dark grey outlines are presumably the ice-covered land, though this is not specified in the figure itself or the caption. With a more opaque hillshade, the ice cover would then be more discernable.
- 3,9-14: I don't think there is, but is there any reason to believe that findings from a single DEMs scene from this region would differ from elsewhere in the world (perhaps regional differences between SRTM tiles?). Can you justify here why this study uses just a single difference DEM from this location, rather than multiple difference DEMs from elsewhere?
- 3.20: qualify here that SRTM is commonly used at regional-scales and over medium to long time periods as it is not exceptionally accurate and likely wouldn't be as much use for e.g. 2000-2001 mass balances.
- 3,24-30: due to these problems, would it not have been better to select a region for which two high-quality regional-scale DEM products exist? Say, Iceland?
- 4,11-12: what's the justification for this omission now that we know that these very

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small glaciers are quite important? (Bahr & Radic, 2012, Cryosphere, doi:10.5194/tc-6-763-2012).

- 5,1-2: specify 'most spaceborne stereo optical sensors'. Sensors onboard airborne platforms or historical aerial photographs will not have identical spectral range or resolution, and therefore may not be comparable with processing of ASTER scenes.
- 5,13: mean and median, or the mean or median? Which? See also 6,7-8.
- 5,20: if this is to be replicable then some more detail is required. Which surrounding pixels? Just those immediately proximal to the void? If so, this could be problematic as there may be inaccurate elevations just beyond the low correlation areas cutoffs. If not the very next pixel, then how many back from the void space? Provide enough detail of this method for another to reproduce your procedure exactly. See also 5,25
- 6,26: why 10%? What's your justification? 6,27: over what scales does spatial autocorrelation occur? I see this on the next page. But, why is it assumed to be 500 m (and why only 500 m given that it can occur on a range of scales simultaneously)?
- 18, Figure 2: Can you differentiate between the colour of the glacier outline and the ASTER correlation score mask? The middle panel all looks the same colour to me (except the red), even though I think its supposed to be dark grey outline and black mask.
- 19, Figure 3: Shaded grey around elevation changes refers to uncertainties? If so, please state in the caption.
- 7,9-10: why would you find the most voids occurring in the middle of the elevation range when from an optical image feature matching perspective (where the ASTER DEM gets its correlation score) you would expect fewer features and poorer correlation the higher up you go?
- 20, Figure 4: Background Landsat scene is a bit awkward to see as its so dark. Can you adjust the contrast, or similar to a previous comment, turn up the opacity to

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de-emphasise the background and emphasise the elevations changes? Looks like a graded colour scale, yet legend shows categories. Shouldn't the legend by a graded colour bar too? Likewise other figures.

- 7,18: by acquisition area, do you mean accumulation area? If you're going to list individual glacier names in the main text, these need to be listed or shown in the figure somehow. 7,24: I would say 'patterns' isn't quite the right word here. Some of the 'variability' perhaps?

- 7,25-26: is it therefore worthwhile to consider repeating this exercise at the local glacier (rather than regional) scale? And for simple vs complex perimeter glaciers?

- 23, Figure 7: Great figure, but for readability perhaps the 'RGI60.01.' part can be removed from each individual glacier on the y axis and be included in a single y axis label? Can you also indicate in the figure caption how the individual glaciers are sorted along the y axis? It doesn't appear to be by RGI ID number, or by volume change. Is it north-south, or by glacier area, or something else?

- 24, Figure 8: It would be interesting to see this analysis extended to smaller glaciers, or the entire sample, but I understand if this is too time-consuming and therefore not possible.

- 9,1-20: some very small paragraphs here (comprising just one sentence sometimes). Is this necessary? 9,18-20: can you add some value judgments between these best three, perhaps quantifying precisely how each do and therefore which performs best? Actually, nevermind that, I see it in the next paragraph.

- 11,8: please quantify rather than just stating 'performed well'. 11,20-25: please replace 'do well', 'does well' etc, with 'perform(s) well'.

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Interactive comment on The Cryosphere Discuss., <https://doi.org/10.5194/tc-2018-175>, 2018.