

Interactive comment on “ICESat laser altimetry over small mountain glaciers” by D. Treichler and A. Kääb

Anonymous Referee #1

Received and published: 8 March 2016

The manuscript of the Treichler and Kääb discusses elevation changes of the southern norwegian glaciers, based on differencing of DEM and ICESat data. Their main finding is that, after applying a number of corrections, this method results in credible elevation changes, but the accuracy is limited by uncertainties in the DEM reference data. Although the results and some of the input data (DEMS) are specific to this area, and the negative trend of the southern Norwegian glaciers has been reported elsewhere, I believe this manuscript deserves to be published, after a number of minor changes, as it provides a good road map for future studies using similar methods and that will run into the same limitations of the DEM reference data.

- The authors choose to estimate elevation changes using the DEM differencing approach. However, another, popular method to estimate dh/dt is the plane-fitting approach (Howat 2008 and the Moholdt papers). Please provide a motivation why you

C1

prefer the DEM-ICESat differencing approach for this study.

- The third research question, 'What is the minimum region size w.r.t. glacier density for ICESat GLAS data to ensure statistically significant results' isn't really answered. You do show that you can retrieve an elevation change signal for Myklebustbreen, but don't give a hard lower limit for the region size.

- when assessing elevation bias and spatial shifts between ICESat and the reference DEMs (page 6, section 3.2), did you take into account vertical uplift due to GIA? Uplift rates are in the order of 5 mm/yr in Norway, so over a period of ~40 years (1978-2016), this would result in about 20 cm difference.

- when determining the c_{glac} correction (page 6, line 31- ...) did you check that the temporal coverage by ICESat is sufficient? If a glacier has only been sampled by one ICESat overpass, it's still possible to compute a c_{glac} correction, but the resulting dh will be ~zero after applying the correction.

- page 13: the c_{glac} seems only to work if the DEM subset covering the glacier is based on data from one acquisition date (as you also point out on page 14 when discussing the Swiss Alps DEMs). It's worthwhile to point this out here.

- page 10, lines 28-33: do to the increasing cumulative uncertainty in the in-situ mass balance measurements, it's hard to verify this claim. It would be helpful to include a 'mean' in-situ mass balance curve (after applying some weighting to ensure this 'mean' is representative).

- page 11, lines 1-4 + figure 4: the upward jump in the 2009 campaign data is probably an artifact of poor sampling, but what does the in-situ data tell about this year?

- page 13, lines 7: The trends for winter ice samples are indeed more negative, but the uncertainty is much larger, due to the interannual variability in accumulation, and differences with the autumn trends are non-significant. This should be pointed out.

- page 13. lines 14-19: Whether or not the derived trends for such small glaciers are

C2

to be trusted depends to a large extent on the spatial sampling of the glacier. Samples across the entire elevation range are required, with a sampling density resembling the hypsometry distribution of the glacier. Without a further analysis it's impossible to tell what the 0.47 ± 0.11 m/yr trend represents. Please discuss this in the manuscript.

- figure 7: the uncertainties for '05 are huge. Did something go wrong during plotting, or are these real (if so, it deserves to be discussed in the manuscript).

Technical/minor comments:

Page 1, lines 15-22: I would move this part of the abstract to line 13 (after, "rather than ICESat uncertainty"). Right now you're first discussing the DEM biases, then the ICESat elevation changes and then move back to the DEM biases.

Page 2 line 10: Slobbe 2008 discusses the Greenland Ice Sheet, bot ice caps, so technically, it doesn't belong in this list.

Page 2 lines 20-34: I suggest to use bullet points here to present the list of research questions.

Page 4, line 14: include references for previous ICESat studies

page 5, line 30: start a new paragraph after "... removing footprints on clouds (false positive dh).".

Figure 2: the dotted line is really hard to distinguish (both on screen and print copy)

page 8, line 2: what's the number of ice samples in the autumn 2003 campaign?

Page 9 line: on average

page 16, line 4: change 'volume loss' to 'elevation change' (or convert the $-0.34/-0.27$ m/yr height changes to volume changes)

Interactive comment on The Cryosphere Discuss., doi:10.5194/tc-2015-234, 2016.