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The Cryosphere Discussions

Interactive comment on "Use of an Unmanned Aerial Vehicle to assess recent surface elevation change of Storbreen in Norway" *by* Walter Immerzeel et al.

Anonymous Referee #1

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general comments The article 'Use of an UAV to assess recent surface elevation change of Storbreen in Norway' by Immerzeel et al. describes the results of one UAV campaign and the technical aspect of DEM and orthoimage processing. The author furthermore compare the derived DEM with an independent source (LIDAR) and derive volume changes. They compare the volume changes with the glaciologically derived surface mass balance using a rough density conversion method. The Article is well written and shows the potential of high-resolution and low-cost DEMs and is methodologically sound. The climatic interpretation is largely missing and the comparison with the glaciological method is rather crude and contains a major source for misinterpretation. The value of the article is thus primarily of methodological nature and as such it

deserves publication in TC after applying some major revisions. A way to improve the comparison significantly would be a point-wise assessment of glaciological balance vs geodetic balance. Furthermore, decadal mass changes of other areas/studies could be compared in more detail. There is room for shortening it significantly, both in number of figures, and by adding a table. Some English formulations may be improved.

specific comments and technical corrections L19: 'routinely . . . monitoring' sounds weird to me. The first sentence of the abstract could be deleted without losing info. L26: remove: under the yielding conditions? L27: LIDAR-DEM? L28-29: see below, but I fear that the agreement is actually worse than that if you consider the glaciological b applied for the entire glacier vs the geodetic for 77% (i.e. the more negative part of the glacier). This likely would make the geodetic balance of the entire glacier less negative and would increase the difference of geodetic vs glaciologic more. L31: Is that a strong mass loss and retreat? The retreat seems very moderate, the mass loss significant but not very strong either? L34: are glaciers characterized. . .? Reformulate? L37: what is meant by 'likely play a major role'? L34-41: condense to 1 sentence? L74: supraglacial? L79: why 'largely'? L86: typo: monitor L93: . . .of UAVs for mass balance monitoring L96-99 can this be combined to one sentence? Section 3.1.: could the info be included/condensed into Tab1, i.e. include LIDAR survey date, resolution, point density, GCPs, etc? Then the text could be reduced significantly. L142: Why haven't the corners of the bag been measured? I guess it is too late but this could maybe yielded to a higher precision? L156: The title is misleading as it does not include meteorological surveys here, right? I guess snow is in this case part of the glaciological survey. Later you use some AWS data. It may be worthwhile presenting it here. L162: is that justified? When I look at Fig 2 and Fig 7 I am not sure if the strong gradient just below the center of the fig is not an artefact simply because of the one point that lies in ca 1650 at the Eastern lobe (2B)

Section 3.3.: I am not sure if I understand method (1): if used as GCPs in the DEM Generation shouldn't it then be 100% the same as the DEM/orthophoto is fitted through

them? And as for (2) how do you account for antenna height over surface? I guess when moving this can vary quite a bit, say +-0.3 m? L195: what do you mean by trail here? The tracks in the snow? Specify. L225: Typo: upper part L230: post-processed? L234: why 2m grid? L238: Why dows Fig7 appear here? Be consistent in Figure labelling, f. ex. Compare L239 with L250 L241: was corrected L242: I would add the methodological part of the density conversion here. L250: a.s.l. L251: really ablation measurements? Or at the time of the summer balance survey? L264+: here starts again a methodology section that fits better to 3.3. The paper would benefit if the methodology part would be combined and shortened and the climatic interpretation (incl climate data, weather patterns, reanalysis data, etc.) L267: reference to Fig. inconsistent, see above. L271: see previous comment of section 3.3. L280: using the GNSS between XX and XXX? L282-283, I am surprised, that the RMSE is that much higher here than for the GCPs. Any idea? L295: Delete sentence starting with However,...? L298: automated weather station?; m a.s.l. L299: negative temperatures? L300: confusing with varying units. mm w.e.? L311: are varied L312: 'impact' instead of bearing? L318: glacier L319: even though there are only half as many markers? L324: lowered over the entire area surveyed with more thinning near the snout. – and remove the next sentence? L325: reference to fig 7 here? L325-326: overuse of word 'lower' L333: was used L336: consider removing one sign digit L336-349: should appear in methods. L339: (e.g., Zemp et al. 2016) L350-351: out of place, remove? L357-368: This part is problematic as stated above and I recommend a stake-by-stake intercomparison. Then of course you open up for new issues, such as emergence velocity. If it is left as it is, the statement that they fit together reasonably (abstract L28) has to be weakened. L359: reveals L360: terminus L362: consistent significant digits. L367: The area change does not appear very high; suggest adding a literature review of recent mountain glacier change and put into context Reference to Fig 8? L399: seems to provide or better: provides L406: OBIA? Explain abbreviation L408-409: Appears without being mentioned before.

Figures: Figure 1: should be removed. The only extra info is the map of Norway. That

fits into 2B Figure 2A: Add coordinate grid Figure 2B, 3A: scale bar: remove comma in 1,000 Figure 3A and 3B could be merged by adding contour lines to A. I don't get much more info from 3B. m a.s.l. Remove resolution from caption. This appears in text and can not be seen in image anyway. Figure 4 caption: (a,b) or A,B? I don't understand why c does not use the same points ad D, i.e. n=150? Explain in text Figure 7: Adjust scale: i.e. -15 until -3 or so. See comment about kriging. Add snow measurements from 2B in this figure?

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