

Interactive comment on “Use of an ultra-long-range terrestrial laser scanner to monitor the mass balance of very small glaciers in the Swiss Alps” by M. Fischer et al.

Anonymous Referee #3

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General comments _____

This is a thorough assessment of the mass balance of five small glaciers in Switzerland using terrestrial laser scanning and direct glaciological measurements. The authors describe the methods, perform uncertainty assessments and give in general sufficient details on the study. In the title and throughout the term ‘very small glaciers’ is used. This term could be discussed in light of the literature. See also detailed comments for further comments and some suggestions for clarifications.

Detailed comments _____

P1, L3: the sentence starting Since . . . does not read well.

C1

P1, L4, are->have been. He sentence

P1, L9: and ->for

P1, L12: remove carefully

P1, L13: remove remarkably

P1, L15: remove very

P1, L22: remove always

P1, L21-22: on hence belong to the size class of very small glaciers (Huss, 2010).

text would flow better by defining small glaciers. Explain what is used in the literature and explain your definition. In this paper we define small glaciers as . . . (reference). Could refer to that there are different definitions, eg another paper in the cryosphere Bahr and Radic (2012) uses 1 km² etc. The mass balance glossary does not define very small glaciers, but define Glacieret as ‘A very small glacier, typically less than 0.25 km² in extent, with no marked flow pattern visible at the surface’ (Cogley et al, 2011) ’

P2, L4-5: since most -> in)

P2, L19: This seems like a conclusion, but next sentence it is said that it is highly promising, rewrite.

P2, L25: Add e.g. before Zemp, as several authors have pointed this out, also earlier refs.

P3, L7: It is, however, -> Validation is needed to assess the quality . . . Note that in order is redundant, can replace throughout in the paper or at least in most Places

P3, L13: remove very

P3, L15: remove or reformulate last sentence.

P4, fig. 1: could add box around (d). I prefer a legend instead of having the explanation

C2

of crosses and triangles etc. in the figure text. It is room for it in fig a above d. If text is kept, then Red numbers -> Numbers 1-5 Red triangles -> Triangles.

P5, L3-4: Just start with 'To better understand..' (remove words before)

P5, L5: since a couple of years is vague

P5, L6: delete 'for these previously unmeasured sites': later you talk about area and volume studies.

P5, L21. Retreated back to one third -> lost 2/3 of its area.

P5, L24. According to first insights: Rather state when measurements began.

P5, L27: glaciers. Mean in general or this glacier, clarify by writing 'of this glacier' if so.

P6, L21: But you do field work on some of these glaciers, would it not be interesting to compare with dGPS measurements?

P7, L1: unclear what is meant by 'this' and 'to an important extent', be specific.

P7, L7: add commas after interest and after dust.

P7, L11: What does manual course registration mean? Could remove course?

P7, L19: could add reference as for RISCAN PRO, which edition was used?

P9, Table 2: What is the source, add manual reference.

P8, L4: Is three and four significant digits in the percentages justified? Would round it.

P8, L8-9: neither nor, -> assumes constancy of the density profile

P9, L1: could add that in the past other values have also been used, typically 900 kg/m³.

P9, L2: Based on the numerous ...here -> Based on information collected in field (supplementary Tab. 2), approach (3) was applied here.

C3

P9, L12: Please add some more details on how the zones were mapped prior to the 2013 surveys. Does this yield all 5 sites as one of them not measured and some began in 2012 and 2013 according to section 3.2.1?

P9, L14: Be specific on the displacement, e.g. <xx m/a

P9, L27: The information on the startup of the programmes could have been added in section 2.

P9, L28. Mostly -> Usually

P10, L14: Could add short details on the stations with reference to the data (e.g. MeteoSwiss?) Use 'and' or 'or' not 'and/or'. Do you mean that you use their results or their methodology, a bit unclear.

These results would be interesting to compare with the spatial pattern found from the annual/biannual geodetic surveys, has this been compared?

P11, Table 3: Text. Divide sentence, is very long and hard to read.

P12, are not snow patches masked out?

P15, L22: can remove 'very small'

P15, L24.: Give results first, before interpreting them for better flow.

P15, L 25: why not give estimate for geodetic for allentive?

P20, L7: This can be explained by the higher point density and more complete coverage than for most other glaciers (...)

P20, L10: Remove With comparatively low uncertainty.

P20, L11-L12. May remove the inserted clause, which we uses ..., for better flow.

P20, L14. Be specific on what you recommend here, specify your methodological approach.

C4

P20, L20: Simplify by starting: Significant amounts of fresh snow or remaining firn on the glacier results is more error-prone . . .

P20, L24: over the last years, which years?

P20, L25: Delete applying our approach.

P20, 28: Instead of 'Following' . . . Start sentence 'A disadvantage of using the TLS is the . . .' and refer to reference in parentheses.

P21, L2: . . .very small glaciers, here defined as (<0.5 km²) . . .

P21, L13,L23: very dense -> dense

P21, L28-32: Unclear sentences and ending, be specific.

References: —————

Bahr, D. B. and Radić, V.: Significant contribution to total mass from very small glaciers, *The Cryosphere*, 6, 763-770, doi:10.5194/tc-6-763-2012, 2012.

Cogley, J.G., R. Hock, L.A. Rasmussen, A.A. Arendt, A. Bauder, R.J. Braithwaite, P. Jansson, G. Kaser, M. Möller, L. Nicholson and M. Zemp: Glossary of glacier mass balance and related terms, IHP-VII technical documents in hydrology No. 86, IACS Contribution No. 2., 2011.

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