

Interactive comment on “Interannual snow accumulation variability on glaciers derived from repeat, spatially extensive ground-penetrating radar surveys” by Daniel McGrath et al.

Anonymous Referee #1

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General Remarks

The study by McGrath et al. addresses the question of the temporal stability of patterns of snow accumulation on mountain glaciers. To my opinion, this is an excellently and clearly written study. The authors use a very comprehensive dataset, spanning five years and two glaciers. Furthermore, they provide insight on the implications of their findings for glacier mass balance measurements using the glaciological method.

As a general recommendation, I suggest that the authors provide an only slightly more detailed but more systematic overview to (i) the characteristics of the two glaciers and (ii) the measurements that have been carried out there 1966-2009 and 2009 to present.

C1

Furthermore, I believe that the last paragraph in Section 5.3 “Winter mass balance comparisons” warrants a few more details. It appears interesting that detailed measurements of winter mass balance seem to be able to reduce the agreement between geodetic and glaciological measurements. However, I believe clarity of the argumentation could benefit from adding a few more details.

Detailed Remarks

Lines 136: The reader does not know at which elevation the glacier is located. Hence, provide a reference (e.g. is this at the ELA, below the glacier tongue or at the top?). Only Figs. S3 and S4 would provide this information, but I recommend introducing the glaciers in a bit more detailed manner (e.g. max and min elevation, typical ELA).

Line 139: Maybe better “lower” instead of “low”, this is still a respectable amount of precipitation for many glaciers elsewhere.

Section 3.2: There are no snow probings in the accumulation zone? I fully understand that you do not apply probing in the accumulation area, but ask myself here whether there are any data from the accumulation area. Are the four locations where you dug snow pits located in the accumulation zone? Or some of them in the accumulation zone? I understand that they are visible on the plots but there is no information on the typical elevation of the ELA.

Lines 93: Just curious, why the irregular sampling interval?

Line 227: Maybe you could add a brief explanation of Sb. The following sentence is not clear to me. In particular, it is not fully clear to me whether lines 228 to 231 explain Sb or explain how it is calculated.

Section 3.5: This section is, to my opinion, not fully concise. It appears to me that the history of the measurements is insufficiently described. For example you mention that the measurements were sparse, but only later you write of a three-stake network. Have there been only three stakes 1966 to 2009, i.e. “sparse” refers to three measurements?

C2

Line 338: Remove second dot.

Lines 358: The gradients are a function of time. Maybe mention somewhere that they refer to the accumulation season.

Lines 587 to 589: True, but it might also be worth mentioning that glaciers preferably form where more snow accumulates than on average (e.g. Kotlyakov and Krenke, 1982). The smaller the glacier, the stronger this effect. Hence, while snow measurements on a glacier do minimize the risk of errors due to small scale effects, they might increase the risk of a systematic positive bias.

Line 596: Sounds almost a bit as if the data gaps are not safe to access on ground surveys :-). Maybe rearrange?

Line 600: Not sure, should there be a hyphen: "under-sampled"?

Lines 639-654: This paragraph makes a very interesting point. I believe it is worth providing a few more details (see suggestions below).

Line 641: This is somewhat difficult to understand, what do you mean with "stake solution"? Do you mean average annual (or winter?) mass balance calculated from the stake measurements? Over which time period?

Line 642: Unclear what is meant with -0.43 m w.e. a-1. Do you have to subtract 0.43 m w.e. from annual glaciological mass balance ("stake solution") to achieve a decadal mass balance in agreement with geodetic surveys?

Line 646: -1 m w.e. a-1 sounds quite extreme but is difficult to assess without more detailed insight into (i) how you interpolated annual mass balance based on the stake measurements, and (ii) over which time period you compare geodetic and glaciological mass balance. If I understand your interpretation correctly, it might be possible that the stake network captures winter accumulation reasonably well (and it appears likely that GPR surveys do this even better) while at the same time the stake network is not representative for measuring summer ablation?

C3

Line 873-875: This paper appears not to be cited in the main text. Remove from references or add citation.

References

Kotlyakov, V. M. & Krenke, A. N. (1982): Investigations of the hydrological conditions of alpine regions by glaciological methods, Symposium at Exeter 1982 – Hydrological aspects of alpine and high mountain areas, IAHS Press: Wallingford, 138, 31-42.

Interactive comment on The Cryosphere Discuss., <https://doi.org/10.5194/tc-2018-126>, 2018.

C4