The Cryosphere Discuss., 8, C2066–C2072, 2014
www.the-cryosphere-discuss.net/8/C2066/2014/

The Cryosphere
Discussions
Open Access

Interactive comment on "Surface elevation and mass changes of all Swiss glaciers 1980–2010" *by* M. Fischer et al.

Anonymous Referee #3

Received and published: 14 October 2014

This study assesses glacier-specific changes in surface elevation, volume and mass balance of all Swiss glaciers for the reference period 1980 to 2010. To scale measurements of different periods to the 30 year reference period, a homogenization approach is applied. Following an accuracy assessment, the observations are interpreted, not only qualitatively, but also by using variables that quantify the glacier geometry.

The study is solid overall. Most comments are minor and given below in the "Specific comments" section. The accuracy assessment has the most room for improvement, although it is extensive already. At this point, it calculates the DEM uncertainties in two different ways, by using the DEM accuracies provided by swisstopo, and by conducting an independent DEM comparison over unglacierized terrain. While this is good, the study applies two extreme approaches for determining uncertainties (resulting in a

'nominal' and a 'stochastic' uncertainty, assuming either fully correlated or completely uncorrelated errors). The study does not apply a third approach, which quantifies spatial correlation in the difference grid through variograms. This approach has been used in recent work and should be implemented here as well. See Truessel and others (2013, J.Glac, 59 , p.153) and references therein (Motyka and others, 2010, Rolstad and others, 2009) for more information.

Specific comments:

P. 4582:

Abstract: You compare your geodetic mass changes to geometrical indices such as slope, aspect, etc., which is an important part of the study. Please indicate that in the Abstract.

P. 4584:

'within only some few' –> in only a few

P. 4585

L. 15. Figure 6 indicates that there is some glacierized area below 2000 m asl. What DEM is used there, which technique, and which date?

L. 22. Mention why: Because the errors are not systematic, they get reduced when averaging over an entire glacier. This finding should be considered in your error assessment.

P. 4586

L. 1. There is some DEM data from the 60s. A 1960 DEM in conjunction with the smaller 1970 mask will underestimate the volume loss. Or were areas and mass balances stable between the 1960s and 1970s?

L. 20 'Due to' –> Thanks to

P. 4587

L. 18. 850 +-60: add something like “according to Huss (2013)”

P. 4588

L. 1 – 11. Add a sentence of justification for this approach. Why is this approach valid? –> If the mountain range balance has a positive anomaly, then glacier A is also likely to have a positive anomaly. In general, this paragraph reads less well than other parts of the paper. Rephrase/add information so that the reader grasps the idea more quickly. Possibly add another equation: B_norm = sum B_i,g from i = 1980 to 2010 divided by 30

L. 20. simplify to ‘which can explain this variability to a certain extent.’

P. 4589

Equation 4: Add reference. For example (Etzelmueller, 2000: “On the quantification of surface changes using grid-based Digital Elevation Models”). What does it stand for? –> Standard propagation of random errors What does it yield? –> The combined per pixel uncertainty. Note that there are other (better) ways to obtain delta sigma z, using variograms (e.g., applied in Motyka and others, 2010).

L. 24 What do the vertical accuracies provided by swisstopo (2000) stand for? (one sigma?)

P. 4590

L. 7. “multiplying with the initial glacier area” . A simple multiplication would mean that the per pixel uncertainties are correlated across the glacier area, which is probably not the case given your statement on p. 4585, Line 22 (i.e., your error bounds would be too high). On the other hand, treating the per pixel uncertainties as random would yield errors that are probably too low (as shown in your Eq. 8). The recommended intermediate approach would be that applied by Motyka and others (2010).

Equation 5: How do you justify that the sigmas are not just summed up? Assuming that the measurements of individual glaciers are uncorrelated? Add a reference if this equation was used in previous work.

Equation 6: May be more readable if you combine factors 1 and 2 as well as 3 and 4 into (F1*F2)ˆ2 + (F3*F4) ˆ2

Line 16: make clear that the uncertainty comes from Huss (2013).

P. 4591

Equation 7: Again, clearly justify why the numerator is not just summed up.

L. 9. ”over stable terrain” How much terrain did you consider (how many km2, is the area evenly distributed among the aspect categories? Etc.).

L. 11. Show the corresponding distribution in addition to Figure 4. Examples are given in Larsen and others (2007) and Truessel and others (2013). Also, state that you did not correct for this systematic shift.

L. 15. “. . .literature-based uncertainty estimates.” I assume you mean the values assigned by swisstopo (2000). If so, state this.

Equation 8. You calculate the stochastic uncertainty without explaining your motivation for doing so. Also you don’t discuss why you refrain from using the stochastic uncertainty for your final error estimates. In fact, the stochastic error is likely too low, because the elevation changes of individual pixels are correlated to some extent. Again, the approach applied in Truessel (2013) and Motyka (2010) would yield error estimates that lie somewhere between the two extreme cases calculated in your work.

L. 23. Discuss reasons for this increase with elevation. I would have assumed that this is due to the more rugged terrain (i.e., steeper slopes), but you rule that out in the next sentence. Other reasons?

P. 4592

L. 8. Elaborate on the Nuth and Kaeaeb approach: Did the approach suggest any shift, etc.

Figure 4. The slopes to the NW of Griesgletscher appear to have a systematic shift while the slopes to the SE do not (admitting that the slopes in the SE sections are flatter, implying that the same shift may show up as smaller elevation difference). Nevertheless, this begs the question whether the shifts are systematic over large areas or systematic only on a “local scale”. The latter case would not be corrected with the approach of Nuth and Kaeaeb, I think (in general, such errors would be difficult to correct properly). Also, Fig. 4 indicates that an additional buffer around the 1970 outlines would have been appropriate, as the terrain is particularly unstable in recently deglacierized areas.

L. 20. ‘considerably’ rather than ‘significantly’

L. 22. It would help if error bars were integrated into Fig. 5. This would indicate how reasonable your error estimates are.

L. 26. ‘same order of magnitude’. Is this something you assume based on Figure 5? If so, you should add a ‘likely’. Or do you have additional analyses that would support this statement?

L. 27. Delete ‘for instance, by photogrammetric techniques.’

P. 4593

L. 8. ‘whereof’ –> of which

L. 11. ‘lowermost elevations’. Maybe mention that you have this typical ‘knee’ in the curve, with max. elevation changes above the lowermost elevation, due to the glacier retreat.

L. 16. “state of disequilibrium”. Elaborate a little more on this. What are the reasons for the elevation changes above 3500 m asl (Surface mass balance? influence of flow

dynamics?)

P. 4594

L. 24. ‘is a good example to explain’–> ‘illustrates the influence of ’

P. 4595

L. 8. What does significant mean here? Did you test for significance or does it stand rather for ‘considerable’? In general, make sure to calculate significance levels and be careful with interpreting non-significant relationships.

L. 9. Elaborate how you obtained the correlations for the aspects. Did you fit a straight line into the points, previously sorted by eight aspect bins? Or did you actually use the sine and cosine components as done in previous work (Evans and Cox, 2005)?

L. 10. ‘a good one’ –> the strongest one. An $r = 0.42$ indicates that about 18% of the variability can be explained with the slope variable. Also, state why you used the slope of the lowermost 25%? Huss (2012) used the slope of the lowermost 10%.

L. 13. ‘5-% quantiles’. Explain how you obtained them (I assume sorted by the respective variable and then filled into the 5% bins by number).

L. 15. Did you conduct a correlation analysis for those binned values? Are the fits significant? What are the corresponding correlation coefficients?

L. 17. ‘longer response times’ implying that they are ‘more out of equilibrium’ or ‘lag behind the climatic forcing ’. State that here.

P. 4596

L. 17. ‘the same methods as ’ –> our method for

L. 18. ‘-0.65’ add error

L. 23 ‘-0.39’ add error

P. 4597

L. 5. Combine the two paragraphs.

L. 7. significantly –> considerably

P. 4598

L. 6 What percentage is due to outline quality and what percentage due to DEM quality?

Figures specifically:

Fig. 3: add t_1 and t_2 to the plot replace “measured period” with “observation period”, “measured” with “observed”

Fig. 4.: Discussed above. Add an additional figure with error distribution. Is there a small polygon in Griesgletscher that should not be in there? (the one intersecting the 2700 m contour)?

Fig. 5.: Discussed above. Add bars with uncertainties.

Fig. 7.: No need to show all of Switzerland. Crop the left side and the top and so that you can show the glacierized areas larger.

Fig. 8. and 9. Is there a way to add uncertainties for each or selected glacier(s), which would allow the reader to better interpret the results?

Fig. 10.: Hard to read as is. Increase thickness of box plots, increase point size. d) Does a linear correlation coefficient make sense for aspect categories? What do the whiskers stand for? 1.5 IQR?

Interactive comment on The Cryosphere Discuss., 8, 4581, 2014.