Reviewer#3, Alex S. Gardner

Summary

Reviewer 1 and 2 have already provided very thoughtful evaluations of this work so I will try to keep my comments as brief as possible. Firstly, I think this is excellent work that adds greatly to our knowledge of recent glacier changes in the PKH, a subject that is somewhat controversial. The authors are very knowledgeable in both the methods and the study region. The work directly builds on, and greatly compliments, their previous work and is of good quality and of significant interest to The Cryosphere readership.

I do, however, see some room for improvement. In particular I agree with many of the more substantive comments of Reviewer 2. Having skimmed the article a month ago before finally finding time to complete my review, I identified most of the same points of concern as identified by Reviewer 2. I also found the quality of the writing a bit lacking, which I attribute to the native language of the author not being English. I would recommend that the first author work closely with his co-authors to improve the writing, particularly the abstract and introduction.

> Although they are more experienced at writing papers, co-authors are not necessarily better than the first author for writing and, in fact, all authors already worked closely on the MS before submission. We have now included all stylistic comments from G. Cogley and we also tried to improve the abstract and the introduction. If the editor or one of the reviewers thinks that the writing is still too weak and that it alters the readability/understanding of our MS, we will make sure it is proof-read by a native speaker. Also, all papers accepted for TC are subject to professional copyediting before publication.

General

See general comments by Reviewer 2.

I would only add that the calculation of uncertainties should be revisited.

> See General answer 0.4 to see how the calculation of uncertainties was modified.

Specific

Units: my personal preference if for SI units of kg m^{-2} yr^{-1} over m yr^{-1} w.e. but it ultimately boils down to personal choice.

> m w.e. yr^{-1} is used everywhere.

P976 – 15-17: Provide more context for this sentence.

> The sentence about contribution to water resource is now deleted from the abstract.

P976 - 4-7: The wording of this sentence could be improved
P976 – 20-23: I bit difficult to follow with all the directional references
P976 - 10-12: The wording of this sentence could be improved

P976-16 to P979-1: Three numbered lists in a row. Try to rework some of the lists into full paragraphs.

The introduction is now much more focused and considerably revised.

P977 –20: add "SLE" and provide area covered by study Done
P977 – 26 "shrinking rates" -> "rates of retreat " Done
P978 – 10: delete "obvious" Done
P978 – 14: replace "point-wise elevation" and with altimetry Done
P978 – (ii) provide a reason why the geodetic method is a good alternative.. It's obvious to me but may not be for other readers. Section reworked
P978 – i to iv: could better describe each method and their respective strengths and weaknesses This section has been reworked and we hope that it now clarifies the advantage/disadvantage of each method.
P978 – What about repeat gravimetry (GRACE)? Gravimetric method now added
P978 – include assessment of interannual variability, probably the more valuable measure that you can get from the in situ records. Inter-annual variability from glaciological record is now provided at the start of the discussion.
P980 – 6: How do you "extrapolate"? Linear interpolation? We assign to the unmeasured glacier area of a subregion the mass balance measured over the corresponding study site.
P980 – 23: "melt water" -> "meltwater".. can change throughout Done
P980 – 23: what about the basins on the northern sides of the mountain ranges? The PKH, as defined in this study, is not hydrologically connected to the basins of the Tibetan Plateau except for the northern part of the Karakoram which flows into the Tarim basin. This is illustrated in fig.1, which displays the outline of the major basins. Tarim is not added to the list of the basins.
P982 – 12: In general, the writing for the intro could use some improving. Deeply rewritten and hopefully, improved.
P982 – 17: "comes along with" -> "is provided with" Done.
P983 – 1: what method was used to resample the SRTM? Bilinear, now specified.
P983 – 5: delete "over the whole study site (Hengduan Shan, Everest and West Nepal), the"
P983 – 13: Can you make these outlines publically available either through GLIMS or RGI? We are already in contact with Bruce Raup and Anthony Arendt to share those outlines. They are also available upon request to the corresponding author.
P983 – "(before the Scan Line Corrector failure in 2003, which used to compensate for the forward motion of the Landsat 7 satellite, and results in a _ 20% data loss within a scene after 2003) -> "(prior to the failure of the Scan Line Corrector of the ETM+ sensor onboard Landsat 7 that resulted in image striping)" Done
P984 – (ii) does this cause error in the "relative elevation" as the image geometry is incorrect when doing the bundle adjustment? Not clear to us what the reviewer means here by "relative elevation".
P985 – 11: I would not use the word "value" as the "value" does change… maybe "does not impact the utility of validity of the correction. We just kept "validity"
P985 – (iv): For reasons already articulated by Reviewer 2 this section could use some more work. See response to Rev #2, our general responses and revised text, section 3.5.
P985 – (v): Why not use Kaab's estimates of seasonal elevation change? I agree with Reviewer 2, this correction could be improved or maybe just add it to the uncertainty. See general response 0.2. We already allowed for a conservative uncertainty for this correction.

P986 -20-22: Why would they bias your results? You are binning by elevation. It would (very slightly because they cover a very small percentage of the total glacier area in each site) bias the final mass balance of the study site if only their ablation/accumulation areas were sampled. It is now explained in the revised MS.
P986 – I don't know about the separation of surge type glaciers, as long as you have regionally proportional sampling then it should all average out. Do you anticipate surge-type glaciers to exhibit a regionally averaged dh/dt that differs from non-surge-type glaciers? When binning by elevation and 3-sigma filtering of outlier, we assume dh/dt to be homogeneous within each elevation bin. This assumption no longer holds when surge type glaciers are included in the binning process because they exhibit different dh/dt than other glaciers. If we did not separate them, their real dh/dt would be excluding when applying our 3-sigma filtering technique (Figure R1).

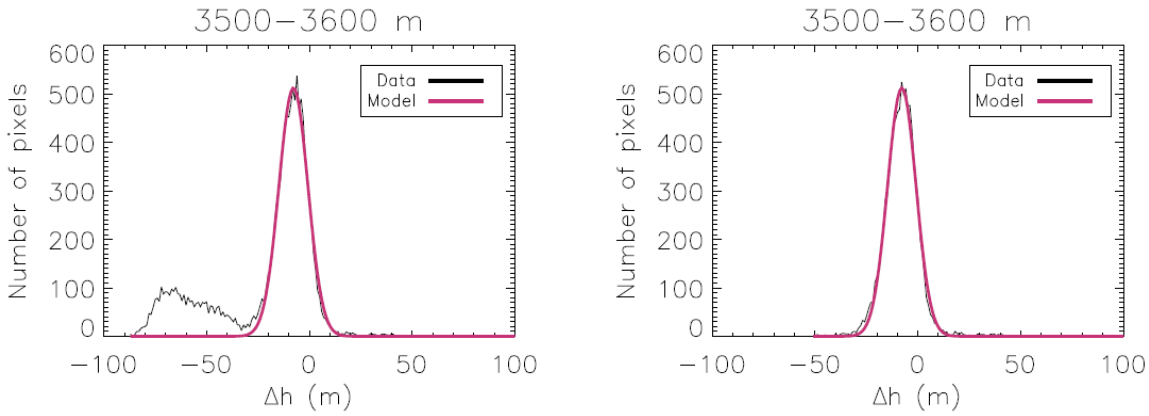

Figure R1 : distribution of elevation changes for the 3500-3600 m a.s.l. elevation band in the Karakoram West study site. On the left panel, surge-type glaciers are included, on the right panel, they were excluded. The "model" curve correspond to a Gaussian fit to the data.

P987 – 8: Flip figure order. The sentence was removed
P988 – are all stated errors for a 90% confidence interval? Maybe I missed this. Error levels correspond to one standard error. This is now specified in the revised MS.
P989 – 13: Gardner et al. 2013 used a correlation length of 50 km. Here we decided not to refer to previous estimate of the correlation length and thus removed reference to Berthier et al. and Bolch et al. The correlation length is proper to each dataset and thus comparison between the values from different studies is only relevant if the same data is used.
P989 – 14-17: This is a correlated bias… so should not be reduced with increasing study area. I believe this will substantially increase uncertainty bounds. SRTM penetration correction is now treated as a systematic error. It is now the main source of error for our mass balances. In fact, this was already the case in the submitted paper because the standard deviation of the elevation difference between SRTM C-band and X-band was high and led thus to large errors.
P989 18-21: Again, maybe this can be better constrained using the Kaab et al dataset. See General response 0.2
P989 – 22-23: I can't quite follow what you've done here. We have now improved the text, and hopefully it is now clear how the errors were computed.
P990 – 15% error seems way too large when I look at Table 1. Did you average % error or did you sum all regional areas then determine the % difference? I think the later is probably the best approach. In the submitted MS, we averaged % error, but we agree that an area-

average would be more appropriate (see also Nuimura comment). But as suggested by T. Bolch, we assigned different uncertainties for each sub-region, given that the RGI have varying quality.
P990 – what about the largest source of uncertainty, the uncertainty introduce from extrapolation of mass changes to regions without measurements? By extrapolating mass changes to unmeasured areas for each sub-region, we assumed homogeneous changes throughout that sub-region. This is partly supported by (i) the very similar mass balance for the two Karakoram study site and (ii) the fact that the new mass balance for the Hindu Kush is rather close to the one previously assumed by computing the mean of the two nearest sites. This is also supported by the relatively smooth pattern of mass balance changes throughout the region as mapped by Kääb et al. (2012, their figure 1). New, we compute now the ICESat trends for the entire regions, based on the data and methods of Kääb et al. (2012) and compared these results to the equivalent results of 3°x3° cells around the study cites only. The according spatial variations turn out to be small and are now taken into account in our revised error estimate (see MS section 3.5).

P990 – would you be able to show figure 2 with and without ice-free ground masked out? It would be valuable to see how much noise there is in the dh/dt over non-ice surfaces. Map of elevation changes off glaciers now shown in a supplementary file and also a histogram showing the elevation difference off glaciers is added as inset in each figure of the main article.

P991 – 21: The uncertainty in the SRTM penetration is at best 1.1 m or 0.14m/yr so a total mass budget uncertainty 0.11 m/yr is much too small. I would revisit the estimation and propagation of errors. We now provide the full equation used to compute our errors bars. The error on our estimate of SRTM penetration is now assumed to systematic and equals to 1.5 m. It is actually the main source of error and explains why the error bars are generally just slightly higher than 1.5 m *0.85 / ~10 years = ~0.13 m w.e. yr^{-1}

P992 – 12: mass change to discharge equivalent? Are these not the same. ?? Indeed, this is simply a unit conversion

P992 – If you mention proglacial lakes then you should also mention evaporation, ground water storage, and lake expansion, all of which make the glacier mass balance a maximum estimate. This paragraph has been moved in the method section because it was not related to the hydrology.

P992-993 – I find the analysis of surge glaciers not all the helpful.. maybe just group all glaciers together. You'll get the same result. We think it is interesting to see that the surges (displacing large amount of ice toward low elevation where ablation is high and fracturing the glacier) do not have influence the glacier mass balance. It may have been expected by the reviewer but, still our dataset provides an opportunity to verify this. See also above why, for the sake of mass balance calculation, surge-type glaciers have to be processed separately, because their presence does not guaranty a proper Gaussian distribution of elevation changes within elevation bins.

P993 – 5.1: should this be in results? Also see Reviewer 2's general comments. We did not want to create a very short sub-section in the Results section of our paper and thus we kept this part in the discussion. The comparison to previous estimates of the penetration is clearly relevant for the discussion.

P996 – 7: Your results are not significantly different. Correct, also noticed by T. Bolch in his Short Comment. Sentence modified.

P996 – 16 "dynamically little active" -> " slow flowing"? Corrected
P996 – 22: "took" -> "take" Done
P997 – 4-6: maybe ref Nuth et al., 2010 and Gardner et al., 2013 Ref added.
P997 – 9: This provides no evidence for a gradual speed up.. We are just pointing out that the equilibrate or slightly positive mass balance of Baltoro Glacier is compatible with the gradual speed up mentioned by Quincey et al. (2009).
P997 - 1-14: all much budgets are not significantly different from zero.. This supports that glaciers are near equilibrium not that they are gaining mass. Ok, reword to "equilibrate mass balance". Text has been modified.

P997 – 20: It would be better to assign an absolute error, unless you expect your error to scale with the measured mass budget.
The mass balance in the Hindu Kush is now calculated using a DEM derived from a pair of stereoscopic images acquired by SPOT5-HRG in 2008. The error on the mass balance in the Hindu Kush is thus now computed in the same way as for the other study sites.

P997 – 23 "yr" -> "years" Done

P989 – 5: "However, this" -> "The" Done

P998 5-19: This discussion is a bit weak. We think it is important to discuss these differences with the previous study by (Heid and Kääb, 2012). This part of the discussion is thus retained.

P998 – 25: estimates are not significantly different.. This will become even more apparent if the calculation of uncertainties is revisited. Our error bars are now modified and, as foreseen by the reviewer, are now larger. Estimate overlap within their error bars.

P998 27 to P999 -2: This is speculation. Both gravimetry and altimetry have the strengths and weaknesses. Jacob et al. 2012 provide adequate error bounds to account for the limitations of their methods. Reworded and speculation removed.

P999 18: "On the opposite" -> "On the contrary". Section removed.

P999 – 24: "is negative" -> "is slightly negative" could also say "nearly in balance". Changed

P101 5.5 See reviewer 2's comment.. I fully agree with his/her assessment. We disagree. See General response 0.5

Figure 1: Maybe change Study site outlines to red of green? I found it a little difficult to distinguish between all of the dark lines. Changed to brighter red

Figure 2-3, A1-6: Would be helpful if yo include a hill shade or Landsat base image to provide spatial context for the glacier changes. Could also include drainage divides and lake. Can't see glacier outlines or surge/quiescent markers (maybe increase size and change color to green or magenta?). Suggested changes have been performed.