Response to Referee Argha Banerjee

We would like to thank Argha Banerjee for the careful review and constructive comments that helped improve the manuscript. We responded to all comments raised by the referee point by point in blue italic font.

General changes

In February 2021, we resubmitted data to the World Glacier Monitoring Service (WGMS) for the Fluctuations of Glaciers (FoG) database. The data included mass balance data for the annual and seasonal mass balance 2016/17 of Yala Glacier which we corrected due to a shift in the elevation records. Additionally, we submitted seasonal mass balance data for Yala Glacier. The updated FoG database is scheduled to be published in the coming weeks and until then the respective data can be requested from the WGMS. All related values have been corrected in the manuscript.

Besides responding to the referees' comments, the sections "3 Data and methods" and "4 Results have been reorganised". Section "5 Discussion" has been restructured and streamlined, the section "6 Conclusions" has been revised and a section "7 Recommendations" has been added.

In the Supplement, we added a section "S1 A brief description of summer-accumulation type glaciers and related mass balance measurements". Inspired by a comment by referee 2. We briefly describe summer-accumulation type glaciers, the related accumulation and ablation seasons, how it affects the mass-balance measurements and how the measurements are performed.

In section S3 we present Figures showing the mass balances and uncertainties for elevation bands at Yala and Rikha Samba glaciers, based on suggestions of referee Argha Banerjee.

In section S4 we added Figures and Tables to illustrate issues related to the representation of steep slopes in DEMs. Steep slopes and ice cliffs occur on Yala Glacier but we could neither quantify the mass balance, nor the relevance of steep slopes in terms of area in the DEM.

Comments Referee Argha Banerjee

Stumm and coauthors present and analyse glaciological mass balance and other related data measured at Yala and Rikha Samba (RS) glaciers. These data sets spanning seven balance years may be invaluable contributions towards a better understanding of the high-Himalayan glaciers and climate. However, there are a few points listed below where I believe there are some scope for improvements.

Major comments

1. I am concerned about the two very different strategies employed to extrapolate the winter/annual balance over the upper reaches of the accumulation zones of RS and Yala glaciers: An elevation-independent constant accumulation rate on RS, and a constant elevation-gradient based interpolation on Yala. While some discussions are presented with reference to Yala, a more detailed discussion of the rationale behind adopting these the two methods, and a quantitative analysis of the corresponding uncertainties may be necessary.

As far as I can tell looking at the fig 2 (left most panel), the balance measured at the upper few stakes/pits may be better described with a constant elevation-independent balance rate. (Let me mention here that I am not sure if the present choice of horizontal range for the left-most panel of fig 2, which seriously compromises the readability, is a good one. I request you to please restrict the horizontal range to something reasonable, like [-1,1] m w.e.)

The two different strategies to extrapolate the annual mass balance are now addressed in more detail in section "3 Data and methods", and in section "5 Discussion" (revised text below).

The uncertainties have been calculated for all elevation bands of 50 m intervals (eq. 3) for the annual mass balance and can be retrieved from the WGMS Fluctuations of Glaciers (FoG) database. For visualisation, the mass balance for each elevation band has now been plotted together with the uncertainties in the Supplement (Fig S3, S4, S5, S6). As described in the manuscript, the uncertainties are larger in the accumulation area.

Figure 2 has been revised. The design of Figure 2 follows the format used by the WGMS in the Global Glacier Change Bulletin (GGCB), in section "3 Detailed information". The GGCB is freely accessible from www.wgms.ch/ggcb. In the GGCB data related to the FoG database is published.

In section 3 the subsection "3.1.1 Point and glacier-wide mass balance" the revised text now reads: "For Yala Glacier, characteristic gradients for the ablation area were identified, and separately analysed for the annual and seasonal mass balances, with the winter and summer season starting in November and May or June, respectively. In the accumulation area, there are fewer measurements with large uncertainties because of the challenging measurement conditions described earlier and in Supplement section S1. This inhibited not only to identify characteristic gradients in the accumulation area, but also to define a fixed mass balance that could be applied in the accumulation area from a defined elevation. As consequence, a single gradient was used for the glacier-wide mass balance. The interpolation approach is simple and introduces a systematic error for the mass balance in the accumulation area. The part of the accumulation area without measurements for the respective elevations bands makes up 15 % of the glacier area for an elevation range of about 160 m (~5500 m to 5662 m a.s.l.).
For Rikha Samba Glacier two characteristic annual gradients were identified, with a large gradient in the lower ablation area and a medium gradient in the transition between ablation and accumulation area. Based on the assumption that the mass-balance gradients remain very similar in different mass-balance years, gradients were reconstructed for Rikha Samba Glacier for years with limited point measurements (2011/12, 2013/14, and 2014/15). The intersection points of the lower (large) and upper (medium) gradients were identified and reconstructed based on a regression line for sections

without measurements. For the accumulation area, no characteristic gradients could be identified because only few measurements were available. The elevation range without measurements is about 650 m (~5900 m to 6545 m a.s.l.) and makes up 36 % of the glacier area. At about 6000 m, the topography steepens (Fig 1). Using the upper gradient to interpolate the mass balance to the accumulation area would have resulted in much overestimated positive mass balances. Instead we considered it plausible to assume a fixed mass balance at high elevations, based on the steep slopes and the typically small gradient in accumulation areas. We assumed the lower elevation for a fixed mass-balance value between 5850 m and 5950 m a.s.l., guided by the upper gradient."

In section 5 the subsection "5.6 Extrapolation of in situ measurements to the accumulation area" has been added and now reads:
"In the ablation area of Yala and Rikha Samba glaciers sufficient in situ measurements largely allowed the interpolation of the data by using elevation dependent mass-balance gradient. In the accumulation area, measurements were often challenging and associated with higher uncertainties. The main issues were difficult access, and cumulative ablation that temporarily exceeded the cumulative accumulation (Supplement section S1). On one hand this ablation removed the marked reference surfaces for the accumulation measurements, and on the other hand the uncertainty is increase for ablation measured with stakes installed in an unstable firn and snow underground. Additionally, no accumulation data could be collected at the highest elevations.
To extrapolate the mass balance to higher elevations, we made a few considerations: the glacier mass-balance programmes were running only within the first decade, and a re-evaluation and possible correction of the glacier-wide mass balance with help of other methods is likely in the future (Zemp et al., 2013; Cullen et al., 2016; Wagnon et al., 2020). Therefore, we chose simple extrapolation approaches.
At Yala Glacier, extrapolating the ablation gradient to the accumulation area introduced a systematic error for a small glacier area (15 % of the total area) with a small elevation range (~160 m). The largest errors are expected in the highest elevation bands, where accumulation is overestimated (Fig. S3 and S4). At the steep south-west-oriented slopes of Yala Glacier, the ablation is likely increased and underestimated in the glacier-wide mass balance. At Rikha Samba Glacier, using the same extrapolation method like at Yala Glacier would have very much overestimated the accumulation in a large area (36 % of the total area) with a large elevation range (~650 m). Instead, we estimated a fixed value for the accumulation area, which introduced a random error. Consequently, complementing independent methods to assess the glacier mass balance for the same time interval help reducing uncertainties and should be part of any comprehensive glacier mass-balance programme following the international glacier monitoring strategy (WGMS, 2020b; Haeberli et al., 2000)."

2. I think the paper may benefit from a more careful presentation of the geodetic analysis in general.

While I am not that familiar with intricacies of geodetic techniques involved, I wonder if obtaining horizontal (vertical) location of the GCPs from Landsat (SRTM) products having a relatively lower resolution (and vertical accuracy) may seriously compromise the accuracy of the generated GeoEye-1 DEM that has nominal horizontal resolution of 2-5 m. In general, the rationale behind switching between SRTM1 and SRTM3 for various pieces of analysis done needs to be made clear. Also, why not use SRTM1 here?

Could you not check the accuracy of the DEM making use of any GNSS data from the stable terrain that may be available? A comparison between your May 2012 GNSS elevation profile, and the same extracted from Jan 2012 DEM could be very useful here. I missed such a plot in the present manuscript. In fact, it appears that you do not make much use the highly accurate elevation profile from GNSS survey, apart from comparing it with 2000 SRTM3 data.

It may be useful to plot the distribution of differences between DEM2000 and DEM2012 on the off-glacier stable terrain.

We agree with the suggestions to make best use of dGNSS data and use up to date data, as far as constraints allow. In winter 2011/12 we ordered GeoEye-1 stereo images covering the area of Yala Glacier. We intended to have stereo images at an early stage of the glacier monitoring programme to generate a DEM and to analyse the geodetic mass balance. In February 2014 under the guidance of Tobias Bolch, Tino Pieczonka and Nicolai Holzer we were able to calculate the geodetic mass balance of Yala Glacier between 2000 and 2012. However, in early 2014 we did not have sufficient dGNSS data to georeference the GeoEye-1 images, and used the GCPs based on Landsat images and STRM-3 as instructed.

When we ordered the GeoEye-1 images, we chose a restricted rectangle around Yala Glacier because of the costs. When generating the DEM, we learnt that a larger area would have allowed for better comparison of stable terrain data and selection of GCPs. However, at that time we couldn't acquire larger GeoEye-1 images anymore.

For Yala Glacier we analysed the geodetic mass balance in 2014 when only SRTM-3 was available. Later we did not have the capacity to recalculate the DEM and geodetic mass balance with SRTM-1. For Rikha Samba Glacier we recalculated the glaciological mass balance in 2017 and used the newer SRTM-1.

For the future, there is a need to reanalyse the glaciological mass balance as recommended by Zemp et al. (2013) and done e.g. by Wagnon et al. (2020) for Mera Glacier. New geodetic mass balance analyses will be necessary to cover the same time interval as the glaciological measurements. In this process the repeated surface profile lines from 2009 (Sugiyama et al. 2013), 2012, 2014 and 2017 will be supporting data generated with an independent method. Here we present the data currently available.

3. You have invoked subtropical jet stream which operates on a planetary scale to explain strong winds on certain glaciers during the winter season while referring to Ding & Sikka (2000) and Wagnon et al. (2013). You have not discussed this issue in depth, but I find it hard to imagine how a planetary-scale system influences two glaciers from the same region in a diffemt manner.

It seems that the connection between jet stream and winds speed on glacier scale that Wagnon et al. (2013) make is entirely based on observation at a single glacier/location. Also, the authors didn't discuss this issue in that detail. Unfortunately I could not access the article that they referred to or Ding & Sikka (2000) that you refer to, so not sure if these references talk about some relevant mechanism in the context of Himalayan glaciers.

To me your data from Yala may instead be a pointer that local effects can have a strong impact on spatiotemporal variability of winds. I believe a one-to-one correspondence between local scale and planetary scale winds will always be tricky - more so with the complex Himalayan topography.

I suggest that you please revise your discussions on the effects of the jet stream on local winds. Please provide sufficient arguments about the corresponding mechanism and/or cite relevant references.

The paragraph in the section "2.2 Climate" was revised and is based on the study by Shea et al. (2015b) and Fujita et al. (2001). Shea et al. (2015b) measured, described and compared the winds at Rikha Samba, Yala and Mera Glacier. The entire section "5 Discussion" has been revised and restructured and the sentence formerly referring to the jet stream has been edited. The study of the winds was not the focus; however, the winds play a role for the glacier mass balance and have been discussed accordingly. The reference Ding & Sikka (2006) has been delete.

The revised paragraph in section "2.2 Climate" reads now: "The wind directions at the Yala Base Camp station show a dominance of bimodal valley winds (Shea et al., 2015b). The Rikha Samba station is additionally exposed to synoptic-scale flows. Throughout the year, the wind velocities at Rikha Samba

Glacier are higher and with a larger variability than at Yala Glacier. The highest wind speeds are recorded in winter from October to May, with strong wind events with >8 ms^{-1} (Fujita et al., 2001). Winter wind velocities measured at Rikha Samba Glacier are very high and result from the channelling of synoptic-scale winds (Shea et al., 2015b). The winter wind speeds at Yala Glacier are much smaller, probably because Yala Glacier is better sheltered by surrounding high mountains. During monsoon from June to September the wind speeds at both glaciers are lower with a smaller variability."

The revised sentence in the discussion subsection "5.3 Comparison of in situ glacier mass balances in the Himalaya" now reads: "Wagnon et al. (2013) address the high wind speeds from westerly winds at Mera Glacier (5360 m a.s.l on glacier station) in winter, which causes in combination with sublimation a substantial part of the winter ablation."

4. If I am not mistaken, the paper refers to more detailed data from the two glaciers than that can be accessed from FoG database (for example, stake displacements, winter balance, digital elevation models etc.). It would be a great if all such data used in the study can be made accessible to the community.

In the abstract the available data has been further specified: "The data of the annual and seasonal mass balances, point mass balance, geodetic mass balance and length changes are accessible from WGMS (2021): Fluctuations of Glaciers Database, World Glacier Monitoring Service, Zurich, Switzerland, http://dx.doi.org/10.5904/wgms-fog-2021-xx"

The Fluctuations of Glaciers (FoG) Database of the World Glacier Monitoring Service is open access and the data can be freely downloaded also from: https://wgms.ch/data_databaseversions/.

The guidelines for the reported attributes are documented in "General Guidelines for Data Submission and Notes on the Completion of Data Sheets" and can be freely downloaded from: http://wgms.ch/downloads/WGMS_AttributeDescription.pdf

The FoG database uses a standardized format for specified data. The mass balance data for this article has been made available in the respective datasheets. Some of the data has been submitted as early as in 2012. Additional data as well as corrected data for the annual and summer balance in 2017 has been submitted to the WGMS in February 2021. This data is scheduled to be published in spring 2021. The revised manuscript refers to this updated database for data up to 2017. More recent mass balance data is part of other studies. The updated data can be requested by reviewers from the WGMS until the data is ingested into the database and freely available from the website.

In the FoG database, general information can be found in the sheets A and B. Length changes and geodetic mass balances are provided in the sheets C and D, respectively. Data related to the glaciologically measured mass balances can be found in sheet E, the glacier wide mass balance and mass balance for elevation bands are documented in sheet EE, and point mass balance data in sheet EEE. Other data such as digital elevation models or stake displacement data are outside the scope of the FoG database and may be requested from co-authors working at ICIMOD.

Minor comments:

* You have discussed the difficulties in identifying the lower boundary of the annual accumulation of snow in L513 and also in section 5.1. This an important issue that has implications for the data collected in the past on Himalayan glaciers, and may help improve similar measurements in the future. Therefore this point may be highlighted with the corresponding discussions moved to a dedicated subsection within the Discussions section.

In section "3 Data and methods", subsection "3.1.1 In situ mass balance" the text has been revised, and the described issue is further elaborated in the Supplement section 1. The described issue mainly occurs at sites with strong winds or close to the ELA but not necessarily everywhere. It is also difficult to improve the measurements. Instead, complementing geodetic measurements for the same time interval are important and a practical approach to correct this bias.

In section "5 Discussion", the importance of complementing geodetic mass balance analyses for the same timeframe are emphasised, as well as the need for a later re-evaluation of the glacier-wide mass balance to address uncertainties and biases such as related to the accumulation measurements.

The revised text in subsection "3.1.1 In situ mass balance" now reads: "The in situ mass balance was measured following Kaser et al. (2003), taking into consideration aspects in the ablation and accumulation area specific to summer-accumulation type glaciers (for details see Supplement, section S1). […] In the accumulation area, snow pits are dug or cores taken, and the snow profile, depth and density recorded. Additionally, several snow probing measurements are taken. Bamboo stakes mainly mark the measurements sites, but in absence of snow pit data they are also used for the mass-balance calculation, in particular in the case of a negative mass balance. The snow pit measurements are only reliable if the previous measurement surface can be clearly identified, e.g. when marked with a sawdust layer. Difficulties arise in the accumulation area, if the cumulative ablation temporarily exceeds the cumulative accumulation during the measurement period (Fig. S2). The exceeding ablation is not represented in a snow pit measurement and likely impacts the sawdust layer. Stake readings are less reliable because the underlying snow and firn layers compact over time and may push or pull the stake up or down."

* I request a carefully revision the manuscript to edit the language. Please identify and replace/rephrase sentences that are either difficult to understand and/or do not conform to standard English usage. I have tried to point out a few such instances, but there may be a few more.

The language of the manuscript has been revised and suggestions accepted as indicated in the response to the comments. Sentences and paragraphs have been revised as indicated in the manuscript with track changes. As guideline British English was used and the Oxford Dictionary of English.

* Please improve the readability of figure 1. Often the contour lines are all but invisible (particularly for RS). Elevation labels are generally hard to read as the text overlays cannot be distinguished from the background. Please explain the part the boundary marked with dashed lines in the caption. Please indicate the locations of the snow pits in this figure.

The maps and caption of Fig. 1 were revised, and following changes were made:

Both glacier maps:

- *Contour lines and elevation labels visibility improved*
- *Legends: Labelled "measurement sites" instead "stakes" because also snow measurements were taken if snow was present.*
- *Maps: Measurements sites labelled.*

Yala Glacier:

- *The adjacent glaciers from the ICIMOD glacier inventory (modified) were added to give the context of Yala Glacier and the dashed line is removed.*

Overview map:

- *The Himalayan range, rivers and glacier area are shown, including the investigated glaciers and other glaciers mentioned in the discussion as requested by referee 2. Country boundaries are removed to adhere to the journal's guidelines.*

Caption revised: "Figure 1: The study sites Rikha Samba and Yala glaciers showing the measurement sites and their location in the Himalayas. At all measurements sites stakes were installed. Snow pits were dug at the top stakes and at selected lower stakes provided snow was present. (a) For Rikha Samba Glacier RapidEye orthoimages from April 2010 were used for the background image and glacier outlines. The contour lines are derived from the SRTM-3 DEM. (b) For Yala Glacier GeoEye-1 orthoimages from January 2012 were used for the background image and in combination with dGNSS data for the glacier outlines. The contour lines are derived from the DEM2012 generated from the

GeoEye-1 stereo images. (c) The overview map shows the location of the two investigated glaciers and other glaciers mentioned in the discussion section. The glacier inventory is from ICIMOD (Bajracharya et al., 2014)."

* Table 1: Please include slope information. *→ Slope information added in Table 1*

* L115 Please expand the sentence with some more details if possible, and if necessary split it into multiple sentences. *→ Sentence deleted; literature review already provided in the introduction.*

* sect 2.2: Is it possible to include plots showing observed precipitation, wind, radiation time series for at least one of the years where there are some data?

Shea et al. (2015) published such data. Sentences were added referring to this source in the section "2.2 Climate": "Meteorological data from Rikha Samba Glacier, Yala Glacier and other automatic weather stations (AWS) in the Langtang and Dudh Koshi catchments were compared by Shea et al. (2015b). They analysed temperature, precipitation, incoming radiation, wind and other parameters from December 2012 to December 2013, as far as data were available."

* L220 Can the corresponding uncertainty be quantified?

We assessed the uncertainty of the point measurements individually, estimating the errors according to eq. 1. The resulting uncertainties of the point measurements are larger in the accumulation area than in the ablation area. Consequently, the uncertainties of the mass balances for the elevation bands (eq. 3) is also larger in the accumulation area.

The uncertainties of the point measurements and the elevation bands is documented in the WGMS FoG database in sheets EE and EEE (WGMS-FoG-2020-08-EE-MASS-BALANCE.csv and WGMS-FoG-2020-08-EEE-MASS-BALANCE-POINT.csv; Please see also the response to major comment #4.

The uncertainty of some type of errors can be relatively easily quantified (e.g. density). Other types of error are difficult to quantify and additional measurements with other methods would be required, which is sometimes not practical. The standard approach to address such uncertainties in glaciological measurements is to use geodetic mass-balance analyses to correct the overall annual mass balance series as done by Wagnon et al., 2020 (see also Zemp et al. 2013).

* L230 Can the bias be quantified using geodetic data?

With high resolution geodetic mass balance data for time intervals of only a few years e.g. based on lidar data (Joerg and Zemp, 2014), the ablation at the ice cliffs can probably be quantified. However, we don't have this data to estimate the bias.

* L231 The stakes don't seem to be following a flowline as far as I can tell from fig 1.

Corrected: "On Rikha Samba Glacier, eight stakes are installed along the approximate glacier centre line with some deviation, which follow roughly the stake setup of the Japanese researchers (Fujita et al., 2001).:

* L235 Is the corresponding contribution to the uncertainty of mass balance quantified?

Please see the uncertainties in the WGMS FoG database sheets EE and EEE. We quantified the uncertainties based on our data, knowledge and experience (eq. 1), and discussed the uncertainty assessment with M. Huss. Please see also the response to major comment #4 and comment L220.

* L238 Unclear

The paragraph has been deleted here. The revised paragraph is mentioned in section "4 Results": in subsection "4.1 Mass balances, ELA, AAR and gradients.

The revised paragraph now reads: "At Yala Glacier, the measured average densities with standard deviation for snow and firn were 336 kg m^{-3} (±81 kg m^{-3}) and 562 kg m^{-3} (±128 kg m^{-3}). However, harder firn layers were difficult to measure. Dependent on the site and firn conditions, and based on snow pit *profiles and field observations we estimated firn density between 550 kg m^{-3} and 700 kg m^{-3}. At Rikha Samba Glacier, the average snow density measured was 399 kg m^{-3} with a standard deviation of ±70 kg m^{-3}. For ice we assumed a density of 900 kg m^{-3} (Cogley et al., 2011)."*

* L 245 How are the hand-held 'GPS' data is combined with RTK data - their accuracies are quite different? In fact it is not clear if you actually use 'GPS' data anywhere. Also, please be careful about using GPS as opposed to GNSS.

We revised the entire manuscript and wrote "GNSS" instead of "GPS". In case of differential GNSS we used the abbreviation dGNSS. Now, we use the term "GPS" only for the handheld Garmin GPS unit.

We revised the sentence regarding the RTK mode: "The devices were dual frequency dGNSS units from Topcon and Magellan ProMark 3, and used in real time kinematic (RTK) mode."

* L253 Where do you discuss this data?

The results from the profile line survey at Yala Glacier is presented in the results section, and discussed in the section "5 Discussion". The revised text in subsection "5.1.1 Annual mass-balances rates" now reads: "Yala Glacier's annual geodetic mass-balance rate is -0.74 ±0.53 m w.e. a^{-1} from 2000–2012 (Table 6). The thinning rate along the profile line is with -1.1 ±0.13 m a^{-1} higher but within the uncertainty range of the DEM thinning rate, most likely because accumulation above 5571 m a.s.l. is excluded from the calculation."

* L255 Why not from all 'DGPS' data?

In the two mass-balance programmes, the new stakes are installed at the original coordinates rather than at the melt-out location of old stakes. To measure velocities, the same stakes must be surveyed. However, no stake lasted from 2014 to 2017.

* 266 "to do other tasks" — please specify what other tasks you are referring to.

"to do other tasks" deleted

* L269 Do you have access to multiple image-pairs?

Sentence deleted.

Background: We ordered a commercial GeoEye image for winter 2011/12. During this period, we received offers with preview images to select suitable stereo images within a restricted timeframe. We also evaluated Hexagon and Aster stereo-images, but they were unsuitable for the small area of Yala Glacier.

* L270 Why not use SRTM1 for both the glaciers?

The geodetic mass balance of Yala Glacier we analysed in February 2014 when only the SRTM-3 DEM was available. The data we submitted to the WGMS in early 2015. Due to limited resources at a later stage we didn't recalculated the geodetic mass balance with SRTM-1.

For the glacier mass balance analysis, it is better to have a more up to date DEM if available. In case of Yala Glacier, the DEM generated from the GeoEye-1 images was from 2012, and has a higher accuracy than the SRTM-1 DEM.

* L285 Why not used GNSS surveyed points to georeference or at least to validate the DEM?

We had one benchmark site that was established earlier by Japanese researchers, which wasn't enough for georeferencing or validation of the DEM. Up to February 2014 (generation of DEM with help of T. Bolch and colleagues), we only had limited access to dGNSS devices, and only limited time to conduct such surveys besides the mass balance measurements and trainings of about 25 participants. Initially the dGNSS data from May 2012 had a post-processing error, which could be corrected only later, and did not include GCPs.

* L289-294 This part may be a bit redundant as it appears from L292-293 that you have not really used any of the data from ICIMOD inventory in the end. Also, is there any reason for not doing the same analysis for RS?

Sentence adjusted and later sentence about the inventory outline data deleted. The geodetic mass balance of Rikha Samba Glacier has also been calculated and is part of a different study. The revised sentence now reads: "We used a Landsat 7 Enhanced Thematic Mapper (ETM+) image from 2000 to identify the outlines of Yala Glacier for the geodetic mass balance and frontal variation analyses."

* L295 Are you talking about one image or you have access to multiple images? Please rephrase the sentence accordingly.

Sentence rephrased: "A Hexagon KH-9 image from November 1974 was used for a frontal variation analysis of Yala Glacier. Other Hexagon images were found…"

* L302 The central meridians are 81E and 87E (https://epsg.io/32644)

Sentence clarified: "We used the local projection system called Modified Transverse Mercator,…"

* L 336 It is unclear what are you doing here and how.

Deleted, context now clarified in section "3.1.1 In situ mass balance"

* L342 I might have missed it, but I did not see the values you assigned for the various uncertainty contributions on the right-hand side of eq 1. A table containing the values used may be included (in the supplementary if you wish).

The error of each individual point measurement was assessed by analysing each error in eq. 1, provided it was relevant. The final error for the point measurement is reported in the WGMS FoG database sheet EEE (WGMS-FoG-2020-08-EE-MASS-BALANCE.csv).

* L345 Do you use the error estimated for each elevation band (eq 2)? Are they considered in the fits shown in Figs 2 & 3. It would be good to show the error bars in Figs 2 &3 at least for some representative years.

You probably did not define the elevation bands up to this point.

Also, why not simply plot individual stake data available for a period with elevation and do the regression? What necessitates the binning of data from individual stakes into elevation bands? Or, is it that the the summation in eq 2 is over the old and new stakes at the same location, and not really over all the stakes in an elevation band?

For clarity, the text has been slightly restructured and eq. 2 and 3 have been swapped. Equation 3 (now: error of the point measurements for a specific elevation band σ_{point_elevb}) is needed is to calculate equation 2 (now: overall error σ_{final} for the mass balance for elevation bands and glacier-wide mass balance).

In the WGMS FoG database sheet EE (WGMS-FoG-2020-08-EE-MASS-BALANCE.csv), the mass balance and uncertainty for the annual glacier-wide mass balance is reported, as well as for the elevation bands with the upper and lower limits. For both glaciers the elevation bands are 50 m for the entire glacier except for the elevation bands at the lowest and highest glacier elevations. The uncertainties have been assessed for each point measurements, elevation band, as well as for every year. There can be considerable variations dependent on the conditions of the glacier at the time of the measurements.

The uncertainties for all annual balance are documented in Table 2 and 3, and for the elevation bands and point measurements in the FoG database. Figure 2 and 3 don't show the uncertainties of the point measurements or elevation bands to maintain the readability of the Figures. The uncertainties of the mass balance of the elevation band for all six years are now plotted in the Supplement in Fig. S3, S4, S5 and S6.

The revised text in subsection "3.4 Analysis of glacier changes and uncertainties" now reads:

"To assess the error of the mass balance for the entire glacier and elevation bands of 50 m, the errors of the point measurements σ_{point_elevb} and interpolation method σ_{int} were analysed. […]

The overall error σ_{final} for the mass balance for the glacier-wide balance and elevation bands was calculated:

$$\sigma_{final} = \sqrt{\sigma^2_{point\_elevb} + \sigma^2_{int}} \quad (2).$$

The error of the point measurements for a specific elevation band σ_{point_elevb} was calculated by considering n point measurements in the respective elevation band:

$$\sigma_{point\_elevb} = \sqrt{\sum_{point=1}^{n} \sigma^2_{point}} / \sqrt{n} \quad (3).$$

To calculate the systematic error caused by the interpolation method σ_{int}, we estimated […]"

* L348 It is unclear what do you mean when you say mass-balance gradients "were applied to the DEMs".

Sentence rephrased: "The mass-balance gradients were derived from the linear regression lines of the point measurements. The elevations of the DEMs of Yala and Rikha Samba glaciers were applied to the regression equations to calculate the glacier-wide mass balance."

* L357 rephrase (You mean to say that above 5850 m balance was assumed to be elevation independent?)

The rephrased sentences now read: "[…] Instead we considered it plausible to assume a fixed mass balance at high elevations, based on the steep slopes and the typically small gradient in accumulation areas. We assumed the lower elevation for a fixed mass-balance value between 5850 m and 5950 m a.s.l., guided by the upper gradient."

For context please also note the response to major comment #1.

* L364 This may be addressed by analysing random subsets of the data where some stakes have been removed.

The subset of stake data in a year is not big enough to do that.

* eq 3: To compute sigma_final which value of sigma_point_elevb is used? I would expect sigma_point_elevb to vary between years or between elevation bands.

Yes, the uncertainties vary between years and elevation bands and are documented in FoG sheet EE. The value of σ_{point_elevb} is not a fixed value and depends on σ_{point}, which is documented in FoG sheet EEE. Please also see response for Line 345.

* L490 Not sure about your use of the word 'consistent'. Are you referring to a relatively low interannual variability of the balance gradient? If so, you may rephrase the sentence accordingly. However, please note that the corresponding coefficient of variation is about 2.5 times larger on RS than on Yala - so the two glaciers are not really that similar here.

The sentences have been revised: "For Yala and Rikha Samba glaciers, the mean mass-balance gradient at the ELA are 1.04 m and 0.36 m w.e. $(100\ m)^{-1}$, respectively (Table 2 and 3). The gradients show a relatively low interannual variability with standard deviations of 0.12 m and 0.9 m w.e. $(100\ m)^{-1}$, respectively."

* Sect. 5.1

I do not find the opening paragraph that relevant. I suggest that you either remove this paragraph or save it for later.

I don’t understand what is rationale of including Chota Shigri glacier, which is from a different region with distinctly different climate setting, in your discussion/table etc.

In this subsection, two separate topics are being discussed: 1. a comparison of the net balance of Yala with those of some nearby glaciers, and 2. a comparison with past data on Yala. It may be better organise these two topics into two different subsections. Also, if possible, please include some related discussions on RS (or point the reader to relevant references).

The section “5 Discussion” has been reorganised and streamlined. The opening paragraph has been shortened and is used later. The comparison of the mass balances of Yala and other glaciers is now in the subsection “5.3 Comparison of in situ glacier mass balances in the Himalaya” and subsection “5.4 Bias by small low-lying glaciers”. The comparison of past data from Yala Glacier is now discussed in subsection “5.5 Interannual variability of winter precipitation and long-term trends of accumulation”.

We agree, Chhota Shigi Glacier is from a different region and climatic setting in the Western Himalayas. We added Chhota Shigri Glacier because it is one of very few glaciers with a longer series of in situ mass-balance data from the Himalayas and also under the influence of the Indian summer monsoon although at higher latitude and more influenced by westerly disturbances. Inspired by section “2 Regional Information” in the WGMS Global Glacier Change Bulletin we considered it reasonable to include Chhota Shigri as a Himalayan glacier in the comparison. Based on the suggestion of referee 2 we added Chhota Shigi also in Fig 13. with the cumulative mass balance.

There is a large range of studies for Langtang but only few studies for Rikha Samba Glacier. Hence, the related discussion for Rikha Samba is much shorter.

* L743 I am not familiar with the usage "the 70ies" and so on. I am not entirely sure about it, but "the ’70s" may be a more common usage.

The entire manuscript has been revised, to consistently use 1960s, 1970s, 1980s, 1990s.

* L 755 I see that the "Conclusions" section contains both conclusions based on the rest of the paper, and future plans/recommendations that are not really based on things that are discussed in the rest of the paper. For example, the points about the need for homogenized climate data. While this is surely an important point, I wonder if moving this to the ’Discussions’ section might have been better.

The section “6 Conclusions” has been revised and the structure improved. In the section “5 Discussion”, subsection “5.3 Yala and Rikha Samba glaciers in a Nepalese and Himalayan context”, climatic aspects influencing the mass balance have been addressed. A sentence has been added: “To better understand the relationship between the climate and the mass balance of Yala an Rikha Samba glaciers, the analysis of homogenised climate data from nearby weather stations or reanalysis data would be useful.”

In the new section “7 Recommendations”, sentences have been added: “The comparison of mass balance data with climate data is needed to better understand the climate signal of the mass-balance data. Homogenised data from AWSs or reanalysis climate data could be used for that purpose.”

* L794 Rephrase the sentence.

The rephrased sentence now reads: “Geodetic mass-balance analyses overlapping the time interval of the glaciological measurements of Yala and Rikha Samba glaciers are needed (Zemp et al., 2013).”