Response to anonymous referee #2

We would like to thank referee 2 for the careful and detailed 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 anonymous referee #2

First of all, I would like to congratulate the authors for their efforts in establishing the new glaciological mass-balance programmes at two glaciers in Nepal. Direct measurements are still scarce in the entire Himalayas, and as also written by the authors in their paper, there is an urgent need for such key data for climate monitoring but also for applications such as water resources or hazard management. Moreover, such data are indispensable for model calibration and hence for projections of future developments in this regard. The presentation and discussion of direct glaciological measurements at Yala and Rikha Samba glaciers are the centerpiece of the presented paper (this focus could actually be emphasized even more explicitly in the paper). The data are complemented by other relevant glaciological information such as geodetic mass-balance data, glacier length changes, and glacier velocities. This very nicely fits to the scope of "Earth System Science Data" and I recommend the paper to be published after addressing the following comments and suggestions.

Overall, the description of data and methods is very detailed and applied methods are sound. Some clarifications and specifications might be needed at some instances, see detailed comments below. Although the presented series of glacier mass balance are still rather short, results are plausible and in line with other studies (using other methods). This is also confirmed by the mass-balance gradients observed in this study, which are consistent over the entire observation years. Regarding the mass-balance gradients, I was though wondering about the different approach to estimate the gradient at high elevations (Yala vs. Rikha Samba glaciers, Figure 3). Although the authors give some indications in the paper and refer to other studies, too, it is not fully clear why there are two different approaches chosen. I suggest that the authors address this point in the Discussion section. Or, if the effect is neglectable for the overall mass balances, it would be useful to have some quantification about the effect.

Regarding the data, I was wondering why the data are presented until 2017 only. The authors refer to the "Global Glacier Change Bulletin No. 3" by WGMS, where we can find the data up to the balance year 2016/17. On the other hand, the authors also refer to the latest version of the "Fluctuations of Glaciers" database by WGMS from August 2020, which includes data until 2018, also Figure 4 includes some data until 2018. This might cause some confusion. Regarding the available datasets, it should also be specified which data are actually available from the WGMS. If I am right, only the glaciological mass-balances are included, but the geodetic data are not (yet?) included and for instance velocity data are currently not stored by the WGMS.

The paper is very nicely structured and clearly presented. As mentioned above, the description is very detailed, which is useful for readers that are looking for comprehensive information about mass-balance programmes (almost in the sense of a review). On the other hand, I am still wondering whether the paper can be shortened and streamlined, such as the Data section and in particular the Discussion as well as the Conclusions sections. The discussion is very comprehensive and includes many interesting aspects (e.g., climatic influence such as monsoon and jet stream, local weather conditions), which however call for further answers that are not provided in the paper (and which are not in the scope of the paper). I therefore strongly recommend to limit and streamline the discussion to facts that are directly linked and most relevant to the data of the present paper, and to clearly highlight the importance and the value of the presented mass-balance series. In turn, the Conclusions should concisely focus on the key points from the Discussion.

Regarding the approaches chosen to extrapolate in situ mass balance data to high elevations, a subsection "5.6 Extrapolation of in situ measurements to the accumulation area" has been added in the section "5 Discussion". Additionally, the approaches are described in more detail in the subsection "3.4.1 Point and glacier-wide mass balance".

Data up to 2017 is presented in this manuscript. Mass balance data from 2017/18 onwards are part of other studies and are not presented here. The data entry for 2017/18 in the manuscript has been

deleted. In the abstract and in the last paragraph of the introduction, the data submitted to the FoG is now specified. The authors submitted glacier data to the WGMS since 2012, including geodetic and glaciological mass balance data and glacier length change data, which are integrated in the newest version of the FoG database.

Parts of the section "3 Data and methods" have been shortened, few have been extended in order to address the referees' comments. The sections "5 Discussion" and "6 Conclusions" have been restructured and streamlined. In the study region the data basis (e.g. DEMs, maps, survey base stations) has varying quality and the environmental setting is challenging. Some of the resulting issues and challenges have been addressed in the manuscript because they impact the monitoring programmes and data collection. The mass balance is directly influenced by the climate and we considered it relevant to address how the weather and climate may impact the mass balance.

More specific comments and suggestions are as follows:

Line 9: Should be formulated more precisely, because "essential variable" might be associated with the ECV Glacier according to GCOS/WMO terminology. Moreover, I would separate between the climate aspects (sensitive response of glaciers to climate change) and applications of the data, such as for runoff modelling.

"essential" replaced by "important"

Sentence rephrased: "The glacier mass balance is an important variable to describe the climate system, and is used for various applications like water resource management or runoff modelling. The direct or glaciological and the geodetic method are the standard methods to quantify glacier mass changes, and both methods are an integral part of international glacier monitoring strategies."

Line 11: This sentence could be deleted as you anyway state at the end of the abstract that the data are available from the WGMS. One might also ask if the main purpose was the ingestion of the data into the WGMS database (which is of course important but probably not the main motivation).

Statement deleted about WGMS database, sentence rephrased and connected with following sentence: "Here we present the methods and data for glacier length changes and the directly measured annual mass balances for the first six mass-balance years for both glaciers."

Line 14: It is not fully clear which series refers to the glaciological method and which one to the geodetic method. General comment regarding the dates: although it becomes mostly clear from the context, it could be helpful to specify the balance years for the glaciological measurements (e.g. 2011/12 to 2016/17). Otherwise the year could refer either to the start of the measurements or to the moment when the observation period is finished.

Previous sentences rephrased and methods clarified: "Here we present the methods and data for glacier length changes and the directly measured annual mass balances for the first six mass-balance years for both glaciers. For Yala Glacier we additionally present the directly measured seasonal mass balance, and the mass balance from 2000 to 2012 analysed with the geodetic method."

Mass balance years have been changed to the format using the start and end year. The original notation using only a single year is based on the definition of "year" by Cogely et al., 2011, p 99: "… The practice when brevity is desirable, regardless of hemisphere, is to identify the hydrological year, mass-balance year or measurement year by the calendar year in which it ends. For example the mass-balance year 2000 began in calendar year 1999 and ended in calendar year 2000." The WGMS uses this notation in the FoG database.

Line 15: cumulative mass loss → *corrected*

Line 16: missing verb → *corrected*

Line 18: logically not clear, the mass balance of Yala is compared to the mass balance of another glacier. The same also applies to line 19.

Sentence revised: "Compared to regional mean geodetic mass-balances rates in the Nepalese Himalaya, the mean mass-balance rate of Rikha Samba Glacier is in a similar range, and the mean mass-balance rate of Yala Glacier is more negative because of the small and low-lying accumulation area. During the study period, a change of Yala Glacier's surface topography has been observed with glacier thinning and downwasting."

Lines 18-20: Was this really investigated in the present paper? Some aspects are discussed but there are many other aspects that could be considered, and given the fact that there are only very few other glaciological mass-balance series available, I would be careful with such general or relative statements (such as "mostly because of. . ." or attribution to "low-lying" areas etc.).

The sentence has been revised (see comment above). Yes, in the discussion the mass balances of Yala and Rikha Samba Glacier have been compared to regional geodetic mass balances. In the restructured section "5 Discussion", subsection "5.4 Bias by small low-lying glaciers" addresses now the role of Yala glaciers low-lying and small accumulation area and related bias compared to mean geodetic mass-balance rates in the region.

Line 23: Specify that the glaciological mass-balance datasets are available.

Available data specified: "The data of the annual and seasonal mass balances, point mass balance, geodetic mass balance and length changes are accessible from WGMS (2021)"

For clarification, besides general information (sheets A, B) and glaciologically measured mass balances (sheets E and EE), also point mass balance (sheet EEE), length changes (sheet C) and geodetic balance (sheet D) have been submitted. In February 2021, additionally the seasonal mass balance (EE, EEE) as well as the corrected mass balance from 2017 (shifted elevations and resulting mass balances corrected) have been submitted.

Lines 28/29: This is a bit too simplified and could be further explained: the glaciological method is indeed a key in international monitoring strategies and is needed for model calibration etc., but for global sea-level rise, the largest ice masses measured by satellite remote sensing are contributing most. Moreover, you could specify what kind of local hazards you refer to.

Sentence clarified and reworded: "The glacier mass balance is one of the seven headline indicators for global climate monitoring (Trewin et al., 2021) and one of the products of the ECV glacier, besides area and glacier thickness changes (GCOS, 2016). Mass-balance monitoring with the glaciological method is an integral part of international glacier monitoring strategies (Haeberli et al., 2007; Trewin et al. 2021). The glacier mass balance is relevant in various regards, such as climate indicator, for glacier process understanding, the hydrological cycle and modelling, hazards and contribution to sea level rise."

Line 30: input variable → *"input" replaces "important"*

Line 30: water availability and the change in its availability

Sentence revised: "As an input variable the mass balance is used to model the water availability and its change, and runoff scenarios for glacierized catchments and downstream livelihoods and ecosystems (Huss and Hock, 2018; Immerzeel et al., 2012; Kaser et al., 2010)."

Line 34: or: "in support of the United Nations Framework. . ." → *adjusted*

Lines 32-35: 1-2 key references should be given here

References added: "IGOS, 2007; WGMS, 2020b"

Line 37: still involve → *corrected*

Line 44: Some studies have focused (?) → *corrected*

Line 45: Not fully clear, did these studies only address the lower parts of the glaciers (where there is debris cover)?

Sentence clarified: "Some studies focused on ablation and runoff on a high spatial and temporal resolution on clean and debris covered glaciers (Litt et al., 2019; Pratap et al., 2019; Pratap et al., 2015; Immerzeel et al., 2014; Fujita and Sakai, 2014), but rarely measured precipitation and snow accumulation in high altitudes due to challenges such as harsh conditions for precipitation measurements or difficult access to the accumulation zone."

Line 51: the longest series . . . is found (?) → *verb corrected "is found" instead "are found"*

Line 51/52: with measurements since 2002 → *corrected*

Line 52: why partly?

Rephrased, "partly with ongoing monitoring" deleted: "Other investigated glaciers in the Indian Himalaya are for example Dokriani, Gara, Gor Garang, Naradu, Neh Nar, Shaune Garang and Tipra Bank (Dobhal et al., 2008; Vincent et al., 2013; Pratap et al., 2015; Azam et al. 2018; WGMS, 2020a)."

Background: Uncertain status regarding continuation of monitoring programmes. Dokriani Glacier likely continuation, for other listed programmes no evidence for continuation found.

Line 55: are glaciological mass-balance records available for both periods?

Sentence revised: "In the Chinese Himalaya, geodetic mass-balance data measured with differential global navigation satellite system (dGNSS) surveys are available from 1991 to 1993 and 2007 to 2010 for Kangwure Glacier, north of Mt Shisha Pangma and Langtang Valley, and from 2006 to 2010 on Naimona 'Nyi Glacier, in an upper tributary of the Ganges (Liu et al. 1996; Tian et al., 2014; WGMS, 2020a). Additionally, glaciological mass-balance data are available for Kangwure Glacier from 1991 to 1993, and Naimona 'Nyi Glacier from 2006 to 2010."

The term dGPS has been replaced by dGNSS in the entire manuscript. The term dGNSS is mentioned here the first time and the abbreviation is written out. For readability, the above-underlined phrase was used instead of "…the differential global navigation satellite system (dGNSS) mass balance data…".

Line 57: What do you mean with in situ geodetic mass balance measurements?

Sentence revised: "Glaciological and dGNSS mass balance measurements ..."

The geodetic method is used to determine the volume balance of a glacier based on glacier surface elevation changes (Cogley et al., 2011). Currently, dGNSS is the most common method to measure the glacier surface elevation in situ.

Line 60: rather point mass-balance measurements than index measurements → *corrected*

Line 62: check tense: have these measurements been continued until today?

Measurements continue, e.g. Yala in 2009, 2012, on Rikha Samba approx. in 2010, 2019.

Line 63: 1970s, 1980s → *corrected, entire manuscript checked and corrected*

Line 65: I suggest writing Pokhalde and Changri Nup Glaciers (in plural), to make clear that you refer to two different glaciers. The same spelling should be used throughout the entire paper, incl. Yala and Rikha Samba Glaciers – I leave it to the authors what they prefer. → *done*

Line 67: you could specify what they calibrated against. Geodetic mass-balance data?

Sentence rephrased and information specified: "Wagnon et al. (2020) reanalysed the mass-balance data of Mera Glacier by using geodetic mass balances to calibrate the glaciological measurements from 2007 to 2019."

Line 68: what do you mean with in situ surface surveys?

«or in situ surface surveys» deleted

Currently, dGNSS surveys are the most common method to survey a surface in situ.

Line 69: where exactly was this applied?

"or in situ surface surveys" deleted

Fujita and Nuimura (2011) conducted in situ surface surveys with theodolite and dGNSS zigzag lines on Rikha Samba, Yala and AX010 glaciers. In Bhutan, Tshering and Fujita (2016) used dGNSS to repeatedly surveyed the surface of Gangju La Glacier with a dense zigzag pattern. Other researchers conducted repeated surveys along profile lines and transects (e.g. Wagnon et al., 2020).

Line 78: What was the glacier selected for? → *Specified: "for the Himalayan Glacier Boring Project"*

Line 79: or: it offered / enabled easy access

corrected "offered" instead "had"

Sentence revised: "Yala Glacier was selected for the Himalayan Glacier Boring Project based on a GEN reconnaissance flight in Langtang Valley because it was the only one without debris cover and offered easy access to the glacier and the accumulation area (Watanabe et al., 1984)."

Line 80: what do you mean with glacier processes?

Sentence revised: "Comprehensive studies were carried out with a wide range of measurements in the field of glaciology, meteorology and geomorphology (e.g. Murakami et al., 1989; Ono, 1985; Yokohama, 1984)."

Background: Japanese scientists and partners conducted research in various parts of Nepal, including the Langtang Valley and the Hidden Valley. Many articles are published on glaciological and related research. The research is comprehensive and on a wide range of topics and for Yala and Rikha Samba Glacier dozens of articles are available. The literature review here aims at giving a glimpse of the work done with a focus on the two glaciers. Work by Japanese researchers relevant for this manuscript are discussed in more detail at other places (totally >30 articles by Japanese scientists cited).

Line 82: delete the comma (last character in line) → *corrected*

Line 87: documented → *"document" replaced by "assessed"*

Line 87: "for Langtang valley": did they also observe other glaciers in the valley?

Yes. Sentence revised: "Various studies assessed historic and recent glacier fluctuations at Yala Glacier and in the Langtang Valley" (e.g. Shiraiwa and Watanabe, 1991; Ono, 1985; Yamada et al., 1992; Kappenberger et al., 1993).

Line 90/91: "highlights the importance of. . .": you could elaborate a bit more on this very important aspect.

The precipitation seasonality is addressed in the section "2.2 Climate" and further discussed in the section "5 Discussion", subsection "5.5 Interannual variability of winter precipitation and long-term trends of accumulation"

Line 92: Cogley et al. 2011?

The reference is correctly cited: Cogley et al. Tracking the source of glacier misinformation, Science, 327(5965), 522, https://doi.org/10.1126/science.327.5965.522-a, 2010.

Lines 93ff: Here I am wondering about the structure: after a rather long introduction, the motivation of the present study is given here again (compare with second paragraph of the Introduction), which leads to some redundancy. Moreover, you refer to the motivation of establishing a sustainable and long-term mass balance programme. This is a very important aspect; however, the paper is about the mass-balance data themselves and not about the monitoring strategy behind. This should be clarified

here. In the same paragraph, you mention the training of students and professional; another key aspect in maintaining the monitoring programme on the long-term, however, the paper does not deal with this aspect either. These aspects could be given at the end of the Conclusions in the sense of an outlook.

The paragraph has been reworded and restructured. To eliminate redundancy, the first two sentences or the original paragraph were shifted to the second paragraph of the "Introduction" section, and the third and fourth sentence were deleted. The paragraph on the motivation to establish long-term mass-balance programmes has been revised and the background and context for the glacier monitoring programmes is given instead. The glacier monitoring programmes of Yala and Rikha Samba glaciers are influenced by strategic decisions for the benefit of long-term sustainable measurements. The measurements on Yala Glacier were an integral part of the training activities. The field campaigns had to accommodate with the training requirements, which had an impact on glacier monitoring. From 2011 to 2017 about 50 trainees from various cultural backgrounds and countries participated in 9 trainings in an extreme high-altitude environment. Glacier monitoring campaigns with main focus on scientific measurements can be managed more efficiently and flexible regarding measurements. E.g. the extent of measurement, or the dates of the data collection are partly influenced by the trainings (section "3.1 Data collection": in autumn expeditions starts approx. 1 week after the last festival finished).

The restructured and revised paragraph now reads: "In 2011 the HKH-Cryosphere Monitoring Project was initiated in Nepal by ICIMOD, and its partners the Department of Hydrology and Meteorology of the Government of Nepal, Kathmandu University and Tribhuvan University. The project goal was to improve the knowledge and understanding of the cryosphere in relation to climate change and impact on water resources in the HKH region and capacity building. Within this framework mass-balance monitoring programmes were established on Yala and Rikha Samba glaciers. An integral part of the project were trainings every year on the easily accessible Yala Glacier for a few dozens of students and professionals from the Himalayan countries, on one hand to build capacity for sustainable and consistent measurements, and on the other hand to promote the development of further mass-balance programmes in other parts of the HKH Region. Students from Kathmandu University utilized preliminary mass-balance data for their Master theses (Baral et al., 2014; Gurung et al., 2016; Acharya and Kayastha, 2019)."

Line 96: Add break and start new paragraph with the main objective.

Obsolete after revisions, see comments for 93ff.

Line 102: Master theses → *corrected*

Line 104: The focus is not only on Yala glacier.

Rephrased: "Here we focus on the mass balance of Yala and Rikha Samba glaciers".

Line 104: seasonal? Bi-annual could be interpreted ambiguously (twice a year or every two years).

Sentence rephrased: "At Yala Glacier we measured the mass balance twice a year in the field from 2011 to 2017, with remote sensing from 2000 to 2017, and assessed glacier length changes from 1974 to 2016."

Line 107: For general clarification, I would just refer to the latest version of the database.

Sentence revised: "The methods are documented for these measurements and data submitted to the WGMS Fluctuations of Glaciers (FoG) database (WGMS, 2021), and other supporting data beyond the scope of the WGMS FoG database."

Line 109: The questions is also whether the experiences are applicable to other remote areas, too. A short notice in the Discussion or as an outlook at the end could be useful. → *Sentence deleted*

Line 112: Altitude range of Yala glacier?

This is an introductory paragraph. More details including the altitude range are provided in section "2.2 Yala and Rikha Samba glaciers", and in Table 1.

Line 114/115: What kind of data is already available for Yala glacier, and what do you mean with long gaps?

Sentence deleted; brief literature review already provided in the introduction. Statement about "long gaps" is irrelevant for mass balance research.

Line 116: mass-balance monitoring programmes?

Sentence modified and integrated in section "Introduction"

Line 120, Figure 1: In the overview map, include the name Nepal. As you refer to the different rivers in the text, it could be useful to show them also in the map (I leave this up to the authors how much effort they want to put into the overview map). Regarding the glacier maps, I am though wondering whether the stake locations also include snow pits? For Yala glacier, I am also wondering why there are no stakes in the upper part of the glacier (i.e. in the northern half of the glacier). Is the area too steep or inaccessible? Are the contour lines from the DEM from 2012 for both glaciers? The hill-shaded DEM seems to apply to Yala, the background for Rikha Samba is an ortho image?

The maps and caption were revised:

Both glacier maps:

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

Yala Glacier:

- *The adjacent glaciers from the ICIMOD glacier inventory (modified) were added to give the context of Yala Glacier (please also see comment for Line 142).*
- *In the northern part of Yala Glacier no stakes were installed because the area is inaccessible due to ice cliffs and steep slopes, which has been clarified in the text (comment Line 225).*

Overview map:

- *The Himalayan range, rivers and glacier area are shown, including the investigated glaciers and other glaciers mentioned in the discussion. 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: Order of characteristics? Glacier locations could be placed first; glacier type information rather below

Table reorganized: "Mass balance information", "ELA_0" and "AAR_0" shifted to the end. "Average slope" added. "Glacier type" mentioned after "Climate" because it's directly related. In the caption added: "The balanced-budget equilibrium line altitude and accumulation area ration are denoted as ELA_0 and AAR_0." (cf. Cogley et al., 2011)

Line 142: not clear: if the glacier extents further to north-west, why is this area not included in the analyses? Also, not clear: how can the glacier be separated along the flowline? What do you mean exactly?

Sentence rephrased to clarify terrain, please also note the revised Figure 1: "The ice body extends further to north-west on a similar elevation range, with steep slopes, ice cliffs and rockfall areas. For the mass-balance analyses, Yala Glacier's drainage basin was separated from the adjacent ice body along the flowline."

In subsection "3.4.2 Glacier area and length" the methods is briefly explained: "On the north-west side, the glacier's drainage basin has been separated from the adjacent ice body along the flowline, using flow vectors drawn perpendicular to the contour lines derived from the DEM2012 (Cuffey and Paterson, 2010)."

Reference added: Cuffey, K. M. and Paterson, W. S. B.: The Physics of Glaciers, 4th ed. Butterworth-Heinemann/Elsevier, Oxford, 2010.

Line 144: Do the 5% of the area also include the ice cliffs or only the steep slopes? What is the influence of the ice cliffs? (it is addressed in the Discussion, maybe add make a short separate section there, because it is a special feature).

Sentence revised: "The glacier faces mainly southwest and the average slope is 25°. Numerous ice cliffs and steep slopes are distributed over the glacier area, but mainly in the northern part of the glacier."

The influence of the ice cliffs and steep slopes is now addressed in the section "5 Discussion", subsection "5.1.4 Steep slopes and ice cliffs". Knowledge about the influence of ice cliffs on the mass balance of clean glaciers is limited, mainly to glaciers from low and high latitudes (e.g. Kilimanjaro, Antarctica). The influence of ice cliffs has been studied in the Himalayas on debris covered glaciers, which is less meaningful for clean glaciers.

We analysed the slope angles and slope heights that can be represented by DEMs of various resolutions. We found that with a DEM of 30 m resolution, slopes can only be represented if steep slopes have a defined minimum slope height. The original statement that "slopes steeper than 50° only cover 5 % of the glacier area" is only valid for slope heights larger than 35 m. Smaller and steeper slopes are not represented in a DEM of 30 m resolution. Therefore, the statement has been deleted. In the Supplement section S4, the issue related to the representation of steep slopes in DEMs are addressed.

Line 146: based on radar or other measurements?

Revised: "measured by ground penetrating radar (GPR)" added

Line 148: if rockfall covered parts of the glacier, why is it outside the defined outlines?

Sentence revised: "In the 2015 Nepal earthquake, rockfall covered parts of the ice body, which are next to the defined outlines of Yala Glacier."

The revised Figure 1 and first paragraph contribute to the clarification of this sentence (please see comment L 142).

Line 148/149: this transition zone from debris-covered ice to buried ice (dead ice?) and permafrost ground with ice should be shown on the map. And, how is a clear delineation of the glacier margin possible? Does this situation influence the massbalance observations?

Sentences revised: "In the 2015 Nepal earthquake, rockfall covered parts of the ice body, which is next to the defined outlines of Yala Glacier. In these parts we find a transition from debris-covered glacier to possible permafrost with refrozen meltwater and buried ice."

Background: In a large area, in the vicinity of Yala Glacier a lot of ice of various appearance was observed between big boulders and debris. There is a transition of ice from obviously debris-covered glacier, glacier ice buried by rockfall and refrozen meltwater. However, in large parts the genesis of the ice is unclear. The occurrence of permafrost is very likely. Mapping such a transition zone (e.g. with geoelectrical measurements) was outside the scope our work.

Consequently, in the transition zone it is impossible to clearly delineated the glacier margin, which is a common problem. However, the adjacent terminus of Yala Glacier is not affected and the transition zone does not influence the glacier mass balance in this study because the area is outside of Yala Glacier's outlines.

Such ice transition zones can be observed near many other glaciers, and new ones will form with the continuous glacier retreat. The ice transition zone explain some of the difficulties to map the glacier area in the vicinity of Yala Glacier. At some locations this will influence the glacier mass balance, and in particular geodetic mass balance calculations that rely on glacier inventories. These are relevant aspects and the reason to mention the transition zone in this article, although there is no influence on our mass balance calculations of Yala Glacier.

Line 149: Add a break and start new paragraph. → *corrected*

Line 150: Earth's → *deleted*

Line 150: the largest landslide so far documented (?)

corrected: "Yala Glacier sits on a gneiss bedrock shelf, which forms part of the base from which a large landslide slipped (Weidinger et al., 2002, Takagi et al., 2007)."

Line 152: ka → *corrected*

Line 153: What do you mean with high glaciation? Glaciation during the ice age(s) or glacier coverage until today. → *"recent high glaciation" corrected to "recent glaciation"*

Line 155: why possibly? From your own field experience, you can maybe directly assess the local meteorological conditions?

Revised: "possibly" replaced by "probably" (see also next comment)

Based on the topography and personal observations the statement is a reasonable assumption. To limited degree meteorological measurements are available between 4000 m and 5500 m a.s.l., but not from above 6500 m a.s.l. on top of the mountain ranges.

Lines 154-162: Move the aspects about the climate to the next section.

Sentence rephrased and part of the information shifted to section "2.2 Climate": "The landslide left behind an open topography, with Yala Glacier located within and sheltered by the surrounding high mountains of the Langtang range (>6500 m a.s.l.)."

Line 162: compared to Yala glacier? → *sentence deleted*

Line 169: is sparse → *corrected*

Line 173: "received": check tense → *past tense, referring to reanalysis data from 1957–2002*

Line 175: the meteo stations you refer to could be added to the map

AWSs at Yala Glacier are shown in Fig. 1. Other stations are outside the map boundaries.

Line 177: rather mean annual precipitation (also line 181) → *corrected*

Line 178: start new paragraph for Rikha Samba glacier

In this section, the topics of the paragraphs are the general setting, precipitation, temperature, cloudiness, and wind. The paragraphs were kept as they were.

Line 189/190: not clear: what do you mean here? How is it indicated? From the observed radiation?

Sentence revised: "The sky in the Nepal Himalaya is generally clear in the post-monsoon and winter season (Fujita et al., 2001)." "as indicated by the incoming solar radiation" deleted.

Lines 189-200 and entire sub-chapter 2: Regarding the overall structure, I suggest to bring first the more general facts about the setting incl. climate, and then specifically address the two glaciers.

The structure of the section "2.2 Climate" is the general setting, precipitation, temperature, cloudiness, and wind. Each paragraph is introduced by indicating the climatic parameter addressed. The paragraph on precipitation has been improved by adding a better introductory sentence: "Precipitation has been analysed for the Langtang Valley and Rikha Samba Glacier based on reanalysis data and field measurements (Immerzeel et al., 2012; Racoviteanu et al., 2013; Fujita et al., 2001)."

Line 199/200: does this apply in general or especially at Yala glacier?

Sentence revised: "During monsoon from June to September the wind speeds at both glaciers are lower with a smaller variability."

Line 200: wind speeds → *corrected*

Line 202: was monitored → *corrected*

Line 202: rather write "from autumn 2011 to. . ."

This is an introductory paragraph for the following sections and the sentence is kept as it is. Details about the measurements follow below.

Line 206: avoid abbreviation and "biannually"

"HKH-CMP" deleted; the project is now introduced in the section "1 Introduction"

"Biannually" replaced by "twice a year"

Line 207: measurements → *corrected*

Line 218: stakes → *corrected*

Line 219/220: unclear, should be further explained. Also, in line 221/222 you refer to ablation and accumulation occurring during the same time. For a better general understanding of the seasonal mass-balance evolution at the glaciers, it would be useful to have (1) a general statement about potential accumulation/ablation seasons and (2) how this affects the mass-balance measurements (and (3) how mass-balance measurements are performed in practice).

In the section "Study area and climatic setting" in Table 1, it is stated that Yala and Rikha Samba glaciers are summer-accumulation type glaciers in a monsoon climate. In the introductory paragraph about the study area, sentences have now been added specifying the main characteristics of summer-accumulation type glaciers, mentioning the main accumulation and ablation seasons. The first paragraph in section "3.1.1 In situ mass balance measurements" has been modified. Many readers might be unfamiliar with summer-accumulation type glaciers and the related measurements. A brief description of summer-accumulation type glaciers, how it affects the mass balance measurements and how measurements are performed in practice is now provided in section S1 of the Supplement.

The introductory sentence about the study area now reads: "Both glaciers are summer-accumulation type glaciers (Ageta and Higuchi, 1984), which are characterized by an overlapping main accumulation and ablation season during the monsoon season (Fig. S1). A brief description of summer-accumulation type glaciers and mass-balance measurements is provided in the Supplement (section S1)."

The introductory paragraph for 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 ablation area, the mass balance is measured with bamboo stakes. If snow is present, its depth is usually measured at each measurement site, and at selected stakes the snow density and profile are also recorded. 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. "

Line 221: can be clearly identified → *corrected*

Line 225: why is the network stretched along one line? See also my comment regarding Figure 1.

The Paragraph has been rephrased to clarify why no measurements were taken in some parts of the glacier: "On Yala Glacier, the measurements stretch along a line established in the past by Japanese researchers (Fujita et al., 1998). In the lower part a few stakes were initially added in a transect. Since the glacier has been shrinking, a second row of stakes was installed parallel to the original line in November 2016, in an attempt to maintain measurements also in future when the glacier retreats beyond the current stake locations. In the northern and highest parts of the glacier no measurements were taken because steep terrain, crevasses and ice cliffs make access difficult."

Line 229/230: The effect of the ice cliffs and steep slopes should be placed in the Discussion.

The sentence has been deleted and is addressed in the discussion.

Line 234: Snow depths and snow pits incl. snow density. . .

Sentence rephrased: "Snow depth was probed, and the density measured in snow pits, but sawdust was spread only during few occasions and found only once, making accumulation measurements challenging."

Line 238: kg m^{-3} → *corrected (paragraph deleted here but kept and corrected in section "4 Results")*

Line 240ff: This section is very detailed (too detailed). You could just directly refer to Table S1.

The section has been shortened. It is common to provide technical details about dGNSS surveys (e.g. Wagnon et al., 2020; Tshering and Fujita, 2016).

Line 245: at best? → *"at worst" deleted*

Line 255: What are the velocity measurements used for?

Glacier velocity data is supporting information for the interpretation of glacier data. It can give an indication about glacier dynamics and flow direction. As stated in the discussion chapter, the lowering ice velocities of Yala Glacier give an indication about the glacier's downwasting.

Line 258: Explain that "Schneider" is a particular map name (Arbeitsgemeinschaft für vergleichende Hochgebirgsforschung?)

Sentence revised: "The maps include the Survey of India, the so-called Schneider and the Nepal topographical maps published in 1965,…" Additional information about the map is provided in Table S2.

Background: In Nepal, the "Alpenvereinskarte Langthang Himal Ost" is known as the "Schneider map". The map was published within the framework of the Alpenvereinskartographie by the Oesterreichischer Alpenverein (Austrian Alpine Club) in 1990. The "Arbeitsgemeinschaft für vergleichende Hochgebirgsforschung" was not involved, and published different maps.

Section 3.2 is interesting to read but very detailed. Maybe some of the information could be placed in a table instead to shorten the section.

The section has been revised and shortened, sentences have been deleted, or statements are expressed more concisely. The Tables S2 and S3 in the Supplement provide more detailed information about maps and satellites. The shortened section now reads:

"For Yala Glacier, various maps were compared and evaluated for their suitability for area, volume and frontal change analysis. The maps include the Survey of India, the so-called Schneider and the Nepal topographical maps published in 1965, 1990 and 1995, the map by the Japanese Glaciological Expedition Nepal (GEN) map (Yokoyama, 1984) and glacier outlines from the ICIMOD glacier inventory of Nepal (Bajracharya et al., 2014; Table S2). The GEN map and glacier inventory data were used; however, despite good quality no other maps could be used because of transformation issues and inconsistencies. The GEN map is based on a ground photogrammetric field survey in 1981 (Yokoyama, 1984). The photo point was about 2 km from the glacier terminus in 1981 on a lower location; consequently, the exposing axis is almost parallel to the glacier surface. We found a distortion and mismatches at the ridge and at the south-east and north-west side of the glacier. We georeferenced the map with the GeoEye-1 orthoimage from 2012 to calculate the frontal variations but did not use it for area or geodetic mass-balance analyses.

Satellite images were used to delineate glacier outlines and termini of both glaciers, and to calculate the geodetic mass balance of Yala Glacier (Table S3). The SRTM-3 DEM (SRTM-3) is the third version of the DEM from the Shuttle Radar Topography Mission (SRTM) and is generated based on data from 2000. The spatial resolution is about 90 m, with an absolute vertical accuracy of ±16 m and a vertical reference to the WGS 84 EGM96 geoid (Rabus et al., 2003). The penetration of the SRTM C-band beam in snow, firn and glacier ice is an issue that results in a lower accuracy especially in the accumulation area (Kääb et al., 2012, Berthier et al., 2006). SRTM-3 was resampled to 30 m for the geodetic mass-balance calculation of Yala Glacier. The SRTM-1 DEM was used for the mass-balance analysis of Rikha Samba Glacier. It is based on the SRTM-3 data from 2000 but was released with an improved resolution of about 30 m.

The GeoEye-1 is a commercial high-resolution stereo satellite image with 0.5 m spatial and 8 bits per pixel radiometry resolutions. The stereoscopic images from 15 January 2012 were used to generate a DEM (DEM2012) for Yala Glacier to calculate the glacier-wide geodetic mass balance, and the orthoimage was used to delineate the outlines.

We used Landsat images for various purposes. A Landsat 8 image acquired on 18 November 2013 was used to collect horizontal reference (x, y) and the SRTM-3 for the vertical reference (z) for ground control points (GCP) to georeferenced the GeoEye-1 images, and tie points for DEM generation for Yala Glacier. A Landsat 7 Enhanced Thematic Mapper (ETM+) image from 2000 helped to identify the outlines of Yala Glacier for the geodetic mass balance and to analyse frontal variations. We analysed terminus changes of Rikha Samba Glacier using a Landsat 4, Landsat 7 ETM+ and two Landsat 5 Thematic Mapper (TM) images from the years 1989, 2001, 2006 and 2011, respectively. RapidEye images from 25 and 27 April 2010 were used to delineate the outlines of Rikha Samba Glacier.

A Hexagon KH-9 image from November 1974 was used for a frontal variation analysis of Yala Glacier. Other Hexagon images were found unsuitable for area and volume analysis because of void areas, or cloud and snow cover in the images at other times of the year. Additionally, it was difficult to delineate

the glacier at the north-west and south-east side without contour lines to derive the flowlines at that time.
For this study, we adopt the projection system WGS 1984, UTM Zone 44N and 45N for Rikha Samba and Yala glaciers, respectively. We used the local projection system called Modified Transverse Mercator, with false easting 500,000 m and scale factor of 0.9999 at the central meridian 84° E and 87° E for Rikha Samba and Yala glaciers, respectively."

Line 305: not clear, rewrite the last sentence

Sentence revised: "The DEM was used for to analyse the mass balance analysis of Yala Glacier with the geodetic and glaciological method."

Line 332: Abbreviations should be written out when they appear for the first time.

Corrected and Table 1 adjusted: "The glacier-wide mass balances, the equilibrium line altitude (ELA) and accumulation area ratio (AAR) were calculated based on the interpolated mass balance gradient derived from the point measurements following a similar method used by Wagnon et al. (2013)."

Line 358: based on the measurements by whom? According to Figure 3, there are no data.

Context changed and sentence rephrased: "For the accumulation area, no characteristic gradients could be identified because only few measurements were available."

Line 358: balance year 1998/99? → *corrected*

Line 360ff: Are there large changes in the area over the observation period? If not, the difference between conventional and reference-surface balance is small and a corresponding note should be added in the text.

We did not analyse area changes of Yala and Rikha Samba glaciers between 2011 and 2017.

Background: As documented in section "3.2 Maps, satellite images and DEMs" and Table S2, for Yala Glacier we made efforts to assess various maps and satellite images with the goal to analyse the geodetic mass balance or area changes. However, as mentioned we faced a range of issues such as snow cover, transformation and scale problems. While accurate maps and DEMs with high resolution and regular updates are a standard e.g. in Europe or North America, this is not possible in Nepal because of its extreme environment. In our work we faced repeatedly challenges such as distorted maps or inaccurate elevations, which made it hard to georeferenced satellite images for areas as small as Yala Glacier.

Line 375/376: not fully clear what you mean with regression lines caused by outlying points

Sentence rephrased:" The accuracy of the ELA and AAR were estimated by shifting the regression lines based on point measurements deviating from the initial regression line."

Line 380: not clear: what has been separated? Why based on the contour line method? It is not evident from Figure 1 (map).

Sentence revised: "On the north-west side, the glacier's drainage basin has been separated from the adjacent ice body along the flowline, using flow vectors drawn perpendicular to the contour lines derived from the DEM2012 (Cuffey and Paterson, 2010)."

Line 402: Not clear: earlier in the text you state that the ELA is derived from the mass balance gradient; is it also observable in the field? "balanced ELA": write ELA0 as in other occasions in the paper and state at some point that ELA0 (AAR0) is the balanced ELA (AAR).

Sentence revised and the term "balanced ELA" doesn't appear in the manuscript anymore: "The accumulation and ablation areas were separated by an estimated ELA of 5350 m a.s.l."

Background: for the calculation of the geodetic mass balance the process required the ELA to be estimated for the respective time period. This ELA differs from the one calculated from the annual mass balance gradient data and the ELA_0.

Line 410: What is/was the purpose of this additional profile line? Was it used to calibrate the geodetic data? Was there a correction applied? Or was there any benefit for the in situ glaciological measurements?

The profile line has been addressed in subsection "3.1.2 GNSS surveys", and the revised paragraph now reads: "The glacier surface profiles of Yala and Rikha Samba glaciers were repeatedly surveyed with dGNSS, along a longitudinal profile and three and two cross-profiles, respectively, but only data from May 2012 from Yala Glacier are presented here. Already Sugiyama et al., (2013) surveyed the profile line in 2009. The repeated measurements provide the opportunity to further analyse the mass balance with an independent complementing method (Wagnon et al., 2013, 2020)."

Line 434: climate stations? → *Corrected: "…however, AWSs on and near…"*

Line 445: gradient for Yala Glacier from 2011/12 to 2016/17. Delete row with "1999" → *corrected*

Line 450: Not clear whether there was actually a measurement at Rikha Samba in 1999 or if this should be 2011. However, if the latter applies, the caption should read 2010 to 2017, or better 2010/11 to 2016/17.

Caption revised: "Table 3: Mass balance (B) measured with the glaciological method, ELA, AAR and the lower and upper mass-balance gradient for Rikha Samba Glacier for the mass-balance years 1998/99, and from 2011/12 to 2016/17. We did not calculate the ELA and AAR for Rikha Samba Glacier for 2011/12, 2013/14 and 2014/15 due to the very few data points. For the mass-balance year 1998/99, the point measurements collected by Fujita et al. (2001) were used."

In the subsection "3.4.1 Point and glacier-wide mass balance", it is mentioned that data from Fujita et al. (2001) was used to calculate the glacier-wide mass balance for the mass balance year 1998/99. For clarification it is now also mentioned in the caption of Table 3.

Line 463: The differences between seasonal and annual balances should be further explained (in the Discussion).

In the section "5 Discussion" in subsection "5.1.2 Seasonal mass balance" the differences in annual and cumulative seasonal balance in 2011/12 and 2014/15 are now addressed.

Lines 474-477: Repetition of what has previously been stated.

Lines deleted in the "Data and Methods" section, but kept in the "Results" section.

Line 486: m a.s.l. → *corrected*

Line 488: linear regression? → *corrected*

Line 493: seasonal and annual balances The consistent gradient for the glacier: an interesting finding that should be mentioned in the abstract.

The sentences have been revised to better explain in words what can be seen in Figure 2. The described gradients show a common pattern, especially considering that the lack of sufficient data in the accumulation area prevented identifying a characteristic gradient in the accumulation area. The findings are not unusual and there is no need to describe them in the abstract. Examples of common mass balance gradients can be found in the Global Glacier Change Bulletins of the WGMS.

The revised sentences now read: "Figure 2 shows the characteristic gradients for the annual and seasonal balances of Yala Glacier that remain relatively constant over the investigated time period. However, additional measurements in higher elevations would have allowed to identify a gradient in the accumulation area for the annual and the summer balance."

Line 499: Your statements here raise the question of why there are no measurements in the higher areas of the glacier(s). Are these areas too high? Too steep? Too dangerous? This should be specified and clarified at some point.

In subsection "3.1.1 In situ mass balance", sentence revised: "In the northern and highest parts of the glacier no measurements were taken because steep terrain, crevasses and ice cliffs make access difficult."

Lines 500-509: move this paragraph to the Discussion → *paragraph shifted*

Line 528: The thinning rate along the profile line is not clear (-1.1 m a-1); is it the mean along the line? Would a mean even make sense? What is the purpose of this profile line?

The revised sentence is: "The mean thinning rate along the profile line is -1.1 ±0.13 m a^{-1}."

In the section "5 Discussion", subsection "5.1.1 Annual mass-balance rates" sentences have been added discussing the purpose of the mass balance of the profile lines: "The profile line has been surveyed repeatedly, the first time by Sugiyama et al. (2013) in 2009 and in subsequent years by our team. The future analysis of the geodetic mass balances along the profile lines and transects is planned as supporting and independent method for the analysis of the mass balance (Wagnon et al., 2020, 2013)."

For such a long time period, only the mean makes sense. Along profile line Line 529: m a.s.l.

→ *corrected*

Line 538: Table 4 should be moved to the Discussion. → *done*

Line 540: In Table 4, you refer to WGMS (2019). The reference is missing and anyway the question is what the original source is. In the table, I would explicitly write "glaciological method".

"direct measurements" replaced by "glaciological method"

The initial compilation of some of the data is based on the FoG dataversion 10.5904/wgms-fog-2019-12, when the most up to date data was only available from the FoG database. The FoG reference has been updated short before submitting the manuscript in early September 2020. In the meantime, new references have been published and are updated in the Table 6 according to best knowledge. These are:

- *Wagnon et al., 2020, including supplementary information*
- *Mandal et al., 2020*

Please note, for the geodetic mass balance calculation for Yala and Rikha Samba glaciers 2000–2016, the paper by Brun et al., (2017) has been provided for the description of the data. The actual values for the two glaciers have been retrieved from WGMS (2020a), no other source could be accessed.

Lines 545-552: should be moved to the Discussion → *done*

Line 550: Maybe also add Chhota Shigri glacier (cf. Discussion) → *Chhota Shigri Glacier added*

Line 551: regarding Mera and Pokalde glaciers: where are these glaciers exactly located? They could/should be added to the overview map.

The glaciers have been added in the overview map in Figure 1.

Line 558/559: The comparison of the retreat rates of both glaciers is relative because the glaciers are different in size and form. For Yala glacier, it might also be more straightforward to assess area changes instead of length changes (?). Or to add area changes in addition to the length changes.

The revised sentence now reads: "For Rikha Samba Glacier, between 1989 and 2013 the average retreat rate and total retreat was -18.0 m a^{-1}, and -431 m, respectively."

In this section, the results of the glacier length changes are presented, which have been reported for the FoG database in 2015. We discuss length changes in section "5 Discussion", subsection "5.1.3 Glacier length changes, flow and downwasting" and put them into context of past records. We are aware that glacier length changes depend on the topography, that their climate signal is delayed and indirect and depend on the glaciers' individual response times. The ECV product "glacier length" (Haeberli et al., 2007) has been changed to "glacier area" (GCOS, 2016) only in recent years and therefore we initially put priority on reporting glacier length changes. If it was easy, we would have also analysed area changes. It wasn't easy. As already stated in section "3.2 Maps, satellite images and DEMs", we assessed satellite images and maps but found them unsuitable for area analysis.

Line 579: Figure 12 should be moved to the Discussion. → *Done*

Line 583: The displacement of the stakes is interesting and allows the link to the velocity measurements. → *Yes, thanks*

Line 585: why is the profile line from Sugiyama et al. added? And is this the same profile line as mentioned before?

Profile line has been removed from the Figure because it is not relevant here. And yes, it is the same profile line that we surveyed repeatedly for further comparison.

Line 595: All glaciers and benchmarks as used in the Discussion could be shown in the overview map. For clarification, it should also explicitly be stated

In Figure 1, the overview map (c) has been revised, showing the investigated glaciers and the glaciers mentioned in the Discussion. In the Discussion, references to Fig. 1 is made.

Line 614: The paragraph here as well as the subsequent ones refer always to geodetic mass balances; this should be clearly stated or structed in a clear way so that both observations types are not mixed up.

The section Discussion has been restructured. Geodetic and in situ data are now explicitly mentioned.

Line 637ff: What does this mean for assessing glacier mass balances over the entire Himalaya? Is it possible from the available data to draw general conclusions? The authors might elaborate a bit more on this question, which also allows to place the mass-balance data from Yala and Rikha Samba into a larger context and to streamline the Discussion (cf. my general comment above about the Discussion).

The section Discussion has been restructured. The mass-balance data of Yala and Rikha Samba Glacier have been put into a larger context in the "5 Discussion", subsection "5.3 Comparison of in situ glacier mass balances in the Himalaya".

In the subsection "5.4 Bias by low-lying glaciers" the closing sentences have been reorganised and now read: "The bias introduced by low-lying glaciers result in the overestimation of negative mass balances in the region (Gardner et al., 2013). It highlights the importance of investigating large glacier elevation ranges, measuring mass balances in the accumulation areas and precipitation data in high altitudes."

Line 640: Such a bias → *corrected*

Line 641: here the term mass budget is used, at other occasions the term mass balance is used. You may check for a consistent use throughout the paper. The same applies to the term net balance (e.g. in line 649 or Figure 14), which should be avoided (cf. the mass-balance glossary by Cogley et al., UNESCO, 2011).

The terms "budget" has been replaced by "balance", and "net" has been replaced with a suitable term in the manuscript, except for "balanced-budget equilibrium line altitude (ELA_0) and balanced-budget accumulation area ration (AAR_0)" and "net accumulation", where the terms are used according to Cogley et al. (2011).

Line 651/652: delete sentence → *deleted*

Line 660/661: 1980s, 1990s (see also line 680 and other occasions) Paragraph from line 649: It should be better worked out why this context is important for the discussion of the measurements presented in this study.

Regarding 1980s, 1990s etc.: entire manuscript checked and corrected

The context is now addressed in the restructured section "5 Discussion", subsection "5.5 Interannual variability of winter precipitation and long-term trends of accumulation".

Line 686: If you specifically address particular stakes with names, then these should also be labelled in the map. → *done in revised Figure 1*

Line 700: There is a break and hence a new paragraph should be started here.

Obsolete after restructuring the section "5 Discussion"

Line 701: why are the measurements on Yala glacier representative? Could you explain that a bit more in detail? → *sentence deleted*

Line 707: The general character of Yala (and Rikha Samba) glacier(s) should be stated at the beginning of the paper (it also relates to my previous comment regarding the ablation/accumulation season, see lines 219/220). In line 708, there is now a contradiction to the what has just been stated before. This should also be clarified.

The discussion has been restructured and rephrased. The introductory sentence repeating the character of Yala Glacier and results has been deleted. Please also see response to comment 219/220.

Line 715: during favorable conditions → *corrected: "in" deleted*

Line 723: Is this statement really needed for the discussion? → *Statement deleted*

Line 738ff: rather results, can be deleted here or just refer to Figure 11, but then also an explicit link to the mass-balance data should be made. On the other hand, the Little Ice Age extent is mentioned here for the first time, however, the location is not shown on the length change plot (either add or delete entirely).

The discussion has been restructured and the frontal variations of the two glaciers are now discussed separately. LIA is now written out as Little Ice Age.

Please note, in the section "5 Discussion" we put our own results into the context of measurements from earlier years, based on studies conducted by Ono (1985), Yamada et al. (1992), Kappenberger et al. (1993), Fujita et al. (1998) and Fujita et al. (2001). In the section "Introduction" we refer to some of the respective work. Their results are not displayed in Fig. 9 and 10 (in section "results"; previously Fig. 10 and 11) but surely would have been interesting to see. The former glacier extents and data on moraines were not available to us in a georeferenced digital format. As addressed in the responses for comment "Section 3.2" and "Line 360ff", there are in general problems to georeferenced maps because of transformation issues. However, the respective references provided maps and photos. In the section "results", Table 4 (previously 5) has been corrected and the three entries with "Source: Fujita et al. 2001" have been deleted because these are not our results.

We submitted frontal variation data (former ECV products) to the FoG database and hence found them relevant to be discussed. The mass balances data are a direct climate signal and the glacier length changes are the delayed response to the mass changes. However, the glacier dynamics of Yala Glacier is "disturbed" because of the downwasting, which makes it problematic to use the response time equation by Jóhannesson et al. (1989). The response time of Rikha Samba Glacier is according to Jóhannesson et al. (1989) approximately 43 years. We do not have mass balance data from several decades to draw conclusions about the observed glacier length changes.*

**Jóhannesson, T., Raymond, C., and Waddington, E. (1989). Time-scale for adjustment of glaciers to changes in mass balance. Journal of Glaciology, 35(121):355–369.*

Line 756: the mass-balance data shown only cover a few years, so it is probably more appropriate to write about an overall retreating. Or can you exclude that there were more balanced (or maybe even positive) years over the last couple of decades?

Sentence revised: "Both Yala and Rikha Samba glaciers shrank and retreated in the last couple of decades. The geodetic mass balance of Yala Glacier showed a mass loss of -10.49 ±7.41 m w. e. from 2000 to 2012, at an annual rate of -0.74 ±0.53 m w.e. a^{-1}. The cumulative in situ mass balances for Yala and Rikha Samba Glacier were -4.80 ±0.69 m w.e. and 2.34 ±0.79 m w.e., and the annual mass-balance rates -0.80 ±0.28 m w.e. a^{-1} and -0.39 ±0.32 m w.e. a^{-1}, respectively. From 1974 to 2016, Yala Glacier retreated 346 m, and from 1989 to 2013 Rikha Samba Glacier retreated 431 m."

Line 760/line 770: Avoid new references or rather move to Discussion

Conclusions revised and reference now also mentioned in the discussion

Lines 764ff: Does this refer to Yala and/or Rikha Samba? → *statement deleted*

Line 772: m a.s.l. → *corrected*

Line 773: This aspect is not mentioned in the Discussion, isn't it? It is an important aspect because it also influences the glacier's mass balance (and there is also another comment above about conventional vs. reference-surface mass balance), therefore I would discuss it before and draw one conclusion that is then presented here at the end.

The downwasting is addressed in "5 Discussion" and has been revised in the new subsection "5.1.3 Frontal variations, glacier flow and downwasting". Area changes were not assessed.

In the section "6 Conclusion" the revised statement now reads: "Yala Glacier experienced downwasting, indicated by the observed changing surface topography between 2011 and 2017 and decreasing ice flow velocities. Over the course of the years, most of the stakes could not be reinstalled at the original coordinates, either because of new crevasses, or significant changes of the surface features at the original site. The downwasting and small accumulation area at low elevation compromise the long-term monitoring of Yala Glacier."

Line 784: Can you give a time horizon regarding the survival of the glacier? Or are there any projections for the region?

A sentence is added addressing the expected survival of the glaciers: "Under the recent climate it can be expected that Yala Glacier will disappear over time but not Rikha Samba Glacier (Fujita and Nuimura, 2011)."

Lines 786-793: In my view, these sentences can be deleted. → *deleted*

Lines 794ff: In fact, the inclusion of geodetic mass-balance data is an integral part of the monitoring strategy within the Global Terrestrial Network for Glaciers (GTN-G), to compare and eventually calibrate both glaciological and geodetic time series (which is not the case for Yala glacier). This should be clearly stated here. In turn, I would rather conclude how in your case the geodetic method helped to interpret the glaciological mass-balance measurements (and will eventually help to calibrate the series at a later stage).

The "6 Conclusions" have been revised and a section "7 Recommendations" has been added. In the "6 Conclusion" we now state: "The glacier mass-balance programmes for the two glaciers have been designed using a comprehensive monitoring strategy following the international glacier monitoring strategy within GTN-G (WGMS, 2020b; Haeberli et al., 2000)." In "7 Recommendations" we now state: "Geodetic mass-balance analyses overlapping the timeframe of the glaciological measurements of Yala and Rikha Samba glaciers are needed. The complementing approaches assure keeping the annual signal of the glaciological measurements, and reduce the uncertainty introduced for example by unmeasured parts of the accumulation area or glacier steep slopes."

Line 803/804: are available and are published

Revised: "The data are available from the Fluctuations of Glaciers Database http://dx.doi.org/10.5904/wgms-fog-2021-xx (WGMS, 2021)."

Line 805: delete "World Glacier Monitoring Service, Zurich, Switzerland" → *corrected*

Line 810: mass balance data → *corrected*