The authors would like to sincerely thank the referee for the valuable, constructive and detailed comments which certainly helped to improve the manuscript. The corresponding changes and refinements have been made in the revised paper (track changes was used in order to be easily identified) and are also summarized in our reply below.

Reply to comments from anonymous referee #2

General comments:

This study describes the use of a novel long-range terrestrial laser scanner (TLS) dataset to calculate annual and summer mass balances and delineate accurate glacier boundary of Urumqi Glacier No.1 in eastern Tien Shan over two consecutive years (2015-17). After introduction of the data used and methodology applied, the authors showed TLS-derived surface elevation and geodetic mass changes. They then compared these results with the conventional glaciological method following the framework proposed by Zemp et al (2013) to validate the accuracy and relevance of the TLS to monitor glacier mass balance. At the end, they give a discussion about the quality of TLS data and DEM differencing, explain the possible causes about differences between the two methods and evaluate the potential of such long-range TLS to measure seasonal and annual glacier mass balance. The paper employs advanced instrument of glacier mass balance monitoring and can be seen as a deep-going study of a published paper (Xu et al., 2017, J. Glaciol., doi:10.1017/jog.2017.45). China contains the largest number of glaciers outside the polar regions, very few glaciers have discontinuous glaciological mass balance records, so we need alternative approaches that could complement glaciological method. The presented study is very interesting, which I think to be a valuable contribution to The Cryosphere. However, there are some comments and issues that the authors should be addressed.

1) The discussion about the potential of the long-range TLS to measure glacier mass balance is very weak, which undermines the paper. Please see detailed comments in "Specific"

Reply: The very weak discussion has been enriched as suggested; please see the revised version of our manuscript.

2) Uncertainty assessment of the glaciological methods: you have quantified various errors according to other similar studies, but I firmly believe that these values are really different, especially for errors in spatial extrapolation over the entire glacier. Just as you say relative smaller area and accompanying higher density of point measurements of UG1 than other glaciers decide the uncertainty is smaller. Could you compare specific net mass balance with in situ measured stake datasets of UG1 to determine the error of spatial interpolation?

Reply: Thanks for the good comments. We have compared glacier-wide mass balance with individual sites. We find that the differences between specific net mass balance at individual sites and in situ measured point mass balance at corresponding sites were in the range of 0-0.042 m w.e. with an average value of 0.01 m w.e., namely, the error of spatial interpolation in the measured area is small. Therefore the error mainly originates from unmeasured areas (e.g. accumulation areas), however, the lack of measured data in the accumulation areas limits us to quantify the error. We conservatively cite an empirical value from similar literature.

Now the paragraph was revised as:

The class (ii) errors originate from extrapolating observed values to unmeasured areas, insufficient spatial distribution of measured sites and the interpolation method. Hock and Jensen (1999) evaluated the error of the interpolation method at about ±0.1 m w.e. a-1 for mean specific mass balances. Huss et al. (2009) computed and compared mean specific net balance with randomly reduced annual stake datasets and found that the error was ±0.12 m w.e. a-1. For UG1, we find that the differences between specific net mass balance at individual sites and in situ measured point mass balance at corresponding sites were in the range of 0-0.042 m w.e. with an average value of 0.01 m w.e., namely, the error of spatial interpolation in the measured area is small. the firn basin and glacier tongue terrain of the WB are very steep and the upper eastern elevation of the EB is also precipitous, resulting in no in situ measurements are available in theses inaccessible areas. Therefore the error mainly originates from unmeasured areas (e.g. accumulation areas), however, the lack of measured data in the accumulation areas limits us to quantify the error. We conservatively assume that the corresponding uncertainty σ_extra was ±0.1 m w.e. a-1 (cf. Andreassen et al., 2016).

3) Some sentences should be written more clearly and precisely, including P2, L4; P2, L34; - P6, L26

Reply: Relevant sentences have been rewritten as suggested.

4) Figures: Figures need some improvements in terms of visibility of their content.

Reply: Done.

Specific comments:

0 Abstract

- P1, L10: Delete “typically”. To date the glaciological method is commonly used to measure seasonal and annual surface mass balance. So it is not necessary to emphasize the method using “typically”.

Reply: We fully agree and delete accordingly.

- P1, L10: Rephrase “seasonal surface mass balance”

Reply: Done.

- P1, L11: Replace “measuring networks” with “field networks”

Reply: Done.

- P1, L15: “scanner” instead of “scanning”

Reply: Done.

1 Introduction

- P2, L4: Add “are spare and discontinuous”. Please rephrase to be more accurate.

Reply: Now added accordingly.

- P2, L7: I would rather delete “entire”. It is not always possible to cover the entire glacier, such as ICESat.

Reply: We agree! Now deleted as suggested.

- P2, L12: Replace “spatiotemporal” by “time”. I know some images have high spatial resolution at present, e.g. Cartosat-1 (2.5 m), Pléiades (0.5 m), QuickBird(0.61 m), GeoEye(0.41-1.65 m) etc.

Reply: We agree and rephrase as suggested.

- P2, L28-29: Rephrase “…central and bottom elevations were detected due to the glacier area is relatively small.”

Reply: Here I think the glacier size is big, so the sentence was rewritten as “…only the central and bottom elevations were detected due to the glacier area is relatively big.”

- P2, L34: What the meaning of “best-monitored glacier”? I guess you mean Urumqi Glacier No.1 has the longest and most detailed surface mass balance measurements in China. Please rephrase the sentence to be clear.

Reply: Now this sentence is changed accordingly. “Urumqi Glacier No.1 (hereafter known as UG1) has the most detailed annual and seasonal surface mass balance measurements in China.”

- P2, L38-40: Rephrase “To date, comparison of glaciological and geodetic mass balances …for the period 1981-2009 at intervals of several years, geodetic reanalysis of seasonal and annual glaciological mass balance…”

Reply: Now replaced accordingly.

- P2, L40: You already have a publication about the reanalysis of glaciological and geodetic mass balances of UG1 (Xu et al., 2018, Cold Reg. Sci. Technol., doi: 10.1016/j.coldregions.2018.08.006), please write here.

Reply: We have written as suggested.

2 Study site

- P3, L23: Add “…a northeast-orientated small…”

Reply: Done.

- P3, L24: Replace “Fig” by “Figs”

Reply: Done.

- P3, L24 “and consists of two independent small glaciers: the east branch (EB) and the west branch (WB)” would be better at the end of this paragraph and then delete “and consists of two independent small glaciers”

Reply: We have changed accordingly.

- P3, L27 “long-term measurements”? I think you may mean something like glacier mass balance?
Reply: Yes! Now revised as “…long-term glaciological mass-balance measurements.”

- P3, L27 Correct “Over the past 50 years” and give a specific time period.
Reply: We have referred the literature and give a specific time period from 1959-2008.

- P3, L31-37 I suggest that related literatures should be cited here.
Reply: Now cited related literatures as follows:

References:

Li, Z., Li, H., and Chen, Y.: Mechanisms and simulation of accelerated shrinkage of continental glaciers: a case study of Urumqi Glacier No. 1 in Eastern Tianshan, central Asia. J. Earth Sci., 22, 423–430. http://dx.doi.org/10.1007/s12583-011-0194-5, 2011.

Liu, C., and Han, T.: Relation between recent glacier variations and climate in the Tien Shan mountains, Central Asia. Ann. Glaciol. 16, 11–16, 1992.

Han, T., Ding, Y., Ye, B., Liu, S., and Jiao, K.: Mass-balance characteristics of Urumqi Glacier No. 1, Tien Shan. China. Ann. Glaciol. 43, 323–328, 2006.

Huintjes, E., Li, H., Sauter, T., Li, Z., and Schneider, C.: Degree-Day Modelling of the Surface Mass Balance of Urumqi Glacier No. 1, Tian Shan, China. The Cryosphere Discussions, 4, 207–232, 2010.

- P4, L4-7 This paragraph would be better in section 3.3 as it already mentions methodology
Reply: Now removed this paragraph and changed section 3.3 accordingly.

3 Data and methodology
- P4, L25: Replace “Fig” by “Figs”
Reply: Replaced.

- P4, L26: Everywhere else in the manuscript, please replace “GPS” by “GNSS”
Reply: Replaced.

- P5, L1: Add “…in the range of…”
Reply: Done.

- P6, L9: It seems the authors mixed the triangle (â˝U¸s) and capital Greek letter delta (Δ), and whole manuscript: please replace “â˝U ¸s” by “Δ”.
Reply: Replaced accordingly.

- P6, L26: Please rephrase "volume changes are considerable" to be more precise.
Reply: Now revised as "volume changes significantly different from zero"

- P6, L36: Figs
Reply: Done.

- P7, L7: Add "…the glacier and evenly distributed…"
Reply: I think here is L12, now added.
- P7, L18: I know what you meaning of "the specific mass balance is calculated from the product of the level change between readings and the ice density" as I have calculated glaciological surface mass balance, but it is not easy to understand for wide readers. Please rewrite the sentence to be clearer.
Reply: Subsection 3.3.1 is about glaciological measurements, so we have removed the sentence into subsection 3.3.1, and then the sentence was revised as:
Glaciological mass balance includes point and glacier-wide mass balances. The rate of mass gain and loss per unit time is accumulation rate $\dot{c}$ and ablation rate $\dot{a}$, respectively, $\dot{c}$ minus $\dot{a}$ equals mass-balance rate $\dot{b}$. Integrating $\dot{b}$ over the time span from t_0 to t_1 gives point mass balance Δb

- P7, L29: Which energy-balance model? Please give a brief introduction and refer corresponding literatures.
Reply: We revised the sentence as "together with simulated values obtained using a simple energy-balance model (the energy divide into shortwave radiation and temperature dependent energy budget) in areas with no measurements (Oerlemans, 2010; WGMS, 2017)"

In the revised manuscript we refer corresponding literature as follows:
Reference:
Oerlemans., J.: The Microclimate of Valley Glaciers, Igitur, Utrecht Publishing and Archiving Services, Universiteitsbibliotheek Utrecht, Utrecht, 2010.

- P8, L3: Correct "Figs"
Reply: Corrected.

4 Uncertainty assessments
- P8, L19: Add "windless weather conditions"
Reply: Added.

- P8, L31: Can you give absolute values of the proportions of the two artefacts over the entire glacier and then quantify the errors related to unscanned areas.
Reply: Good comments! We had delineated unscanned regions and the corresponding proportions of the two artefacts over the glacier surface were in the range of 3.1-4.6%. The

lack of dense measured 3-D coordinates of the two artefacts limits us to assess terrain-induced errors quantitatively. The artefacts were not taken into account in calculating the mass balance in order to be precise, but the errors related to unscanned areas should be very small because the proportions of the two artefacts were minor. This did not influence a direct comparison between glaciological and geodetic mass balances.

Now the paragraph was revised as:

For precision, the artefacts were not taken into account in calculating the mass balance, but the errors related to unscanned areas should be very small because the relative proportions of the artefacts over the entire glacier surface were minor (3.1% for summer 2015, 3.2% for 2015-16, 3.6% for summer 2016, and 4.6% for 2016-17, Fig. 5).

- P9, L13: The given errors can be listed with 2 decimal places to reflect appropriate level of certainty.
Reply: Agree! Now mass balance and uncertainty values with 2 positions after decimal were written.

- P9, L35: You should write clearly here that the value you cited indicates point mass balance.
Reply: Now revised as "…found an uncertainty of ±0.2 m w.e. a^{-1} for point mass balance. Beedle et al. (2014) suggested an error of point mass balance to be about ±0.1 m w.e. a^{-1} for accumulation-area measurements."

- P10, L4: What the meaning of sampling sites? Please rephrase to be more specific
Reply: Here sampling sites mean ablation stakes and snow pits (if firn exists). Now the sentence was revised as "…the number of ablation stakes and snow pits (if firn exists)…"

- P10, L4: You mean something was given in Table 4? Add some sentences to be clear.
Reply: Now revised as "Resulting values of σ_{glac} are listed in Table 4."

5 Results
- P10, L23: Replace "clear" by "clearer"
Reply: Done.

- P10, L29: Correct "Figs"
Reply: Done.

- P10, L29-30: I know debris cover on a glacier may alleviate ablation when the debris thickness exceeds a certainty value. But your argument explaining the phenomena is quite speculative. Please support your opinion by some semi-quantitative or quantitative data.

Reply: Thanks for the constructive comments. We agree that debris cover on a glacier may alleviate ablation when the debris thickness exceeds a certainty value. Actually, the relative proportion of debris-covered area is very small from our field observation and does not influence the calculation of glaciological mass balance. Therefore, we have not measured surface ablation of debris-cover area and can only give some qualitative explanation.

- P10, L33: Use "with" instead of "by"
Reply: Done.

- P10, L33: Please correct "Figs"
Reply: Corrected.

- P11, L2: Again: please correct "Figs"
Reply: Corrected.

- P11, L7: Rephrase "…all of the four investigated periods"
Reply: Done.

- P11, L9: It makes no sense that the value is rounded to three decimal places, please change everywhere else in the manuscript.
Reply: We have changed accordingly.

- P11, L11: Add "compared to the corresponding values of EB" after "…more negative"
Reply: Now added as suggested.

- P11, L16: Fig. 5 instead of Fig 7?
Reply: Yes! We have changed accordingly.

- P11, L17: Replace "sites" with "ablation stakes"
Reply: Done.

6 Discussion
- P12, L30: Add "of each scan positions"
Reply: Done.

- P12, L30: Fig. 4 instead of Fig. 3?
Reply: Yes! We have changed accordingly.

- P12, L32: Replace "are" with "is"
Reply: Replaced

- P13, L9: I know the number and location of ablation stakes vary from year to year as stakes melt out and sink. Please give a specific period for the average value.
Reply: Now the sentence was revised as "the average density is about 28 stakes km^{-2} from 2015 to 2017".

- P13, L11: Delete “in”

Reply: Done.

- P13, L13; How did you decide the annual discharge? I guess you use the mean value here, can you calculate the internal and basal ablation using the measured data of each year?

Reply: Here Q_{m} is mean annual discharge of glacier melting, which was determined by using the cumulative measured surface ablation over the two years. Now we checked the measured glacier surface ablation and estimated the value of Q_{m} to be about 1.4×10^{9}. And then internal ablation was recalculated.

Now the paragraph was revised as:

Thus the TLS device yields accurate geodetic results and the quality of the glaciological mass balances is also very good. Nonetheless, the glaciological method cannot measure internal and basal mass balances, but these processes are implicitly captured by the repeated geodetic surveys. We need to provide a rough estimate of internal and basal mass balances of UG1 to detect their contributions to the differences between glaciological and geodetic mass balances. UG1 is a cold glacier, and its internal ablation (B_{pe}) is weak (Huang, 1999; Albrecht et al., 2000), mainly because of the released potential energy of descending water:

$$B_{\mathrm{pe}} = \frac{Q_{\mathrm{m}}\,\mathrm{g}}{L_{\mathrm{f}}\bar{s}\rho_{\mathrm{water}}} \cdot \frac{\bar{h}_{\mathrm{ELA}} - h_{\mathrm{term}}}{2}, \tag{11}$$

where Q_{m} denotes annual discharge of flowing water, g is the gravitational acceleration, L_{f} is the latent heat of fusion, $\bar{h}_{\mathrm{ELA}}$ and h_{term} are average equilibrium-line altitude (ELA) (4152 m) and the altitude of the glacier terminus (3775 m), respectively, $\bar{s}$ is the average glacier area between 2015 and 2017. The cumulative measured glacier surface ablation over the two years was used to determine annual discharge and the value of Q_{m} was estimated to be about 1.4×10^{9}. A calculation of B_{pe} = -0.005 m w.e. a^{-1} is made.

Basal ablation from geothermal heating (B_{gt}) was evaluated using

$$B_{\mathrm{gt}} = \frac{qt}{L_{\mathrm{f}}\rho_{\mathrm{water}}}, \tag{12}$$

where q = 0.059 W m^{-2} is the geothermal heat flux (Huang, 1999), t is the mass-balance period; here we primarily consider annual scale and basal ablation was estimated to be about 0.005 m w.e. a^{-1}. The calculated internal and basal ablation totaled -0.01 m w.e. a^{-1}.

We assessed internal accumulation dominated by refreezing percolating water in the cold interior of the glacier as well as the freezing of water in cold snow and firn following Zemp et al. (2010), who assumed that internal accumulation was 4% of the winter mass balance, and the resulting value was about 0.01 m w.e. a^{-1} in this study. Finally the total value of internal and basal mass balances was closed to zero, which is far less than the difference (ΔB)

between the two methods. This suggests that the contribution of annual internal and basal processes is negligible and does not affect the differences between the two methods.

- P13, L32: I would delete the first sentence in this paragraph as it had appeared in the introduction.
Reply: Done.

- P14, L7-9: Can you quantify the influences of unscanned areas?
Reply: Thanks for the good comments; we have explained there-in-before. The errors related to unscanned areas should be very small because the relative proportions of the artefacts over the entire glacier surface were minor (3.1% for summer 2015, 3.2% for 2015-16, 3.6% for summer 2016, and 4.6% for 2016-17).

- P14, L10: Rephrase "a discrepancy in mass balance elevation distributions of WB was observed at…"
Reply: Done.

- P14, L11: Replace "takes" with "take"
Reply: Done.

- P14, L33: The discussion about the potential of the long-range TLS to measure glacier mass balance is very weak and not really satisfying, but I believe that there is more to say. e.g. Comparison with other technologies, such as unmanned aerial systems, terrestrial photogrammetry, and then you can discuss the advantages/disadvantages of each technology. We see some data voids; can you say something about future application of such TLS to monitor glacier evolution. I am firmly sure that artefacts will also exist for other glaciological applications. The data voids can be avoided when combining with other approaches? Density conversion is still a challenge at annual and seasonal scales, which assuredly influences the wide application. What do you advise as reduction of the density conversion? I don't really think the majority of glaciers can be measured using the TLS as some of them lie at remote locations. I would rather suggest you to select some representative glaciers (evenly distributed at different mountains, different types and areas, etc.) with easily accessible locations for the geodetic mass balance monitoring. Can you discuss something about application of TLS to monitor the representative glaciers; it would be very interesting and relevant to know additional information of those glaciers for future studies. Can you give more information about TLS-derived geodetic results to validate the distributed glacier mass-balance models; I think it is very important for future glaciological studies since its high spatiotemporal resolution and the shortage of in situ measurements.
Reply: Thanks for the constructive comments; we have added new information to discuss the potential of the long-range TLS. Please see subsection 6.4 in the revised manuscript.

This study presents the application of multi-temporal Riegl VZ®-6000 TLS point clouds in mass balance monitoring of UG1. The long-range TLS can provide high-temporal-spatial-resolution and -accuracy DEMs to allow more detailed insight into glacier evolution (e.g. Gabbud et al., 2015; Fischer et al., 2016). To take advantage of this and provide more-precise glacier surface elevation changes, it is worth remembering that fixed scan positions are highly important between consecutive scans when using our approach. We should also note that not all glaciers in China are as easily accessible as UG1. For many large glaciers, it is not always easy to fix scan positions using reinforced concrete with a standard GNSS-leveling point, but we can mark stable bedrock outcrop as a scan site. Another advantage of this type of TLS is the long scanning range, and such an instrument could allow most of the glacier surface to be scanned from one or several scan positions, especially for remote and inaccessible glacier areas (e.g. crevasses, steep ice, debris cover, etc.). Therefore the instrument provides a quantitative evolution in spatial coverage compared to glaciological in situ measurements, which can be seen as a beneficial complement to glaciological mass balance, particularly for calibrating inaccessible areas. TLS surveys can provide updated glacier boundary and surface DEMs, and the location of stakes may also be identified based on high-quality point clouds; all of these parameters are favorable for glaciological mass-balance calculations. A combination of glaciological and TLS observations may yield optimum results. Besides, TLS-derived geodetic results can validate the distributed glacier mass-balance models as the TLS can provide high spatial and temporal resolution measurements, especially in the strong ablation season, the instrument can be used to investigate daily or sub-daily ablation, which can completely meet the requirements of time resolution for glacier mass-balance models.

One drawback of the TLS surveys is the presence of data voids (unscanned areas), even for very small glaciers (e.g. Fischer et al., 2016). This is due to limited scanning angle and complex glacial terrain. An emerging low-cost Unmanned Aerial Vehicles (UAV) has the potential to avoid data voids in glaciological monitoring since the good surveying angle of UAV. Immerzeel et al. (2014) showed that UAV combined with a Structure from Motion (SFM) workflow provide a powerful tool for monitoring mass balance and surface velocity of a Himalayan glacier with high spatial accuracy. From our field experiment at UG1, rarefied air and frequent blustery wind around glaciers usually induce the power of UAV were nondurable, and rock outcrops results in difficult operations of such instrument. Hence we mainly consider using UAV to survey unscanned area, integrating of UAV- and TLS-acquired data can provide the whole glacier surface terrain of interest. Other technology such as terrestrial photogrammetry also has the ability to estimate mass balance, and the quality of photogrammetric estimation is similar to the quality of TLS (e.g. Piermattei et al., 2015; Fugazza et al., 2018). However, the reliable of UAV and terrestrial photogrammetry in glacial environments is more dependent on the natural features (i.e. characteristic image objects) of the surveyed surfaces compared with TLS. The cost of TLS is higher than UAV and groundbased photogrammetric surveys.

Now the TLS has been successfully applied to monitor mass balance of UG1. From our experience, the monitoring tool is potentially applicable to other glaciers provided that these glaciers have small to medium size and relative steep terrain. High Mountain Asia (HMA) contains the largest number of glaciers outsides the polar regions (Pfeffer et al., 2014). China is the main region of HMA, most glaciers (~83% of the total number) in western China have an area smaller than1 km^2 and only ~3% with an area lager than 5 km^2, and the mean glacier surface slope of GIC-2 is 19.9° according to the second Chinese glacier inventory (CGI-2) (Guo et al., 2015), which is very close to corresponding value of UG1 (23.4°) (Fig. 10a). Therefore, the majority of glaciers can be measured using the TLS. Furthermore, if we assume that glaciers with an area of ≤ 1.555 km^2 (area of UG1) and a surface slope greater than 23.4° have a good visibility to be monitored using the TLS, the number of theoretical appropriate glaciers is ~58.5% of the total and these glaciers are evenly distributed at different mountains. Note that it is not always easy for us to monitor all of the appropriate glaciers as some of them locate in remote areas (i.e. far away from road). We can select some benchmark glaciers with easily accessible locations for future application of TLS measurements, such as Kanas Glacier, Muztaw Glacier, Qingbingtan Glacier No.72, Haxilegen Glacier No. 51, Yushugou Glacier, Laohugou Glacier No.12, Qiyi Glacier, Xiao Dongkemadi Glacier, Parlung No.94 Glacier and Baishui Glacier No.1, etc. All of these selected glaciers have a relatively high ratio of visibility (most part of the benchmark glaciers surface can be scanned from several possible scan positions) according to our filed observations. What's more, these glaciers possess different areas (small, medium and large size), different types (clod and temperatures) and evenly locate at different regions of western China. Measuring mass balance of different sized, typed, and located glaciers is relevant for us to understand them to past, present, and future climate changes. So the TLS system has huge application potential for glacier mass-balance monitoring in China.

Nevertheless, TLS measurements and point cloud data post-processing are challenges for a broader application. One disadvantage of the TLS is that it requires specific knowledge, skills and experience for its use and data processing. Other limitations of this TLS are related to suitable scan positions for obtaining good visual angles of the glacier surface and stable scan positions for multi-temporal registration of repeated scans for change detection. In addition, the uncertainties of density conversion still remain at seasonal and annul scales as in situ measured densities of all benchmark sites are difficult to obtain (very sparse glaciers in China have such detailed observations as UG1). The day when relatively smaller amount of snow on the accumulation area and the absence of snow on the ablation area (i.e. snow line is clearly distinguished) should be chosen to perform TLS measurements. We may use a built-in camera of the TLS to create high resolution panorama images of a glacier (RIEGL Laser Measurement Systems, 2014a), then firn/snow and bare ice areas (i.e. snow line) can be determined (e.g. Barandun et al., 2018). We can use the area-weighting method to estimate a density due to the lack of in situ measured densities makes volume-weighting approach difficult to extensively use. For longer time intervals (≥ 5 years), a density assumption based on physical models is also important since most glaciers in northwest China are cold and multi-thermal.

References:

Immerzeel, W. W., Kraaijenbrink, P. D. A., Shea, J. M., Shrestha, A. B., Pellicciotti, F., Bierkens, M. F. P., and de Jong, S. M.: High-resolution monitoring of Himalayan glacier dynamics using unmanned aerial vehicles, Remote Sens. Environ., 150, 93-103, https://doi.org/10.1016/j.rse.2014.04.025, 2014.

Fugazza, D., Scaioni, M., Corti, M., D'Agata, C., Azzoni, R. S., Cernuschi, M., Smiraglia, C., and Diolaiuti, G. A.: Combination of UAV and terrestrial photogrammetry to assess rapid glacier evolution and map glacier hazards, Nat. Hazards Earth Syst. Sci., 18, 1055-1071, https://doi.org/10.5194/nhess-18-1055-2018, 2018.

Pfeffer, W. T., Arendt, A. A., Bliss, A., Bolch, T., Cogley, J. G., Gardner, A. S., Hagen, J. O., Hock, R., Kaser, G., Kienholz, C., Miles, E. S., Moholdt, G., Mölg, N., Paul, F., Radic, V., Rastner, ´ P., Raup, B. H., Rich, J., Sharp, M. J., and the Randolph Consortium: The Randolph Glacier Inventory: a globally complete inventory of glaciers, J. Glaciol., 60, 537–552, 2014.

- P15, L9: I think microwave remote sensing is not an effective technology as the limited time and space resolution.

Reply: We have deleted corresponding sentences.

7 Conclusions

Cloud need to be a bit change after taking account the comments mentioned above.

Reply: Now revised and adapted accordingly.

8 Figures and tables

- Figure 2: In the caption, please add some scientific content to illustrate the figure.

Reply: Now added as suggested.

- Figure 3: Please improve the figure to obtain clear content.

Rely: Now improved accordingly.

- Figure 4: Please again improve the figure to obtain clear content.

Rely: Now improved accordingly.

- Figure 5: Please again improve the figure to obtain clear content.
Rely: Now improved accordingly.

- Figure 6: Please again improve the figure to obtain clear content.
Rely: Now improved accordingly.

- Table 3: Please hold two decimal places.
Rely: Now values with 2 positions after decimal were written.

- Table 4: Please again hold two decimal places.
Rely: Now values with 2 positions after decimal were written.

9 References
Please check the reference, both in the text and at the end, to meet the requirements of the journal. e.g.: - P1, L29: Correct "Liu and Liu, 2016" - P2, L2: Correct "Xie and Liu, 1991" - P18, L19: Lichti et al., 2005 in references not in text -P19, L12: Rolstad after RIEGL - etc.
Rely: Thanks for the warm prompt. We have checked and standardized all the references to meet the requirements of the journal, both in the text and at the end. "Liu and Liu, 2016", "Xie and Liu, 1991" were corrected. "Lichti et al., 2005" was added in text. Rolstad was moved after RIEGL

With best regards, Chunhai Xu et al.