Reply to Editor (Tobias Bolch)

Thank you for informative comments. I wrote my reply in blue Arial font in this reply letter. And revised part in the text are also written in blue. Please note that the last revision in the text were remained in red.

The reviewer raised specifically two issues: The better description between rock glaciers and debris-covered glaciers. This is a valid point I am aware that this is quite difficult but I agree that some more details are needed. You may here also refer to Moelg et al. (2018).

> I have added some description on rock glaciers citing Bodin et al. 2010 (which was written in Moelg et al. 2018) at Page 4 line31-P5 line5.

The second issue is the uncertainty. I also believe that 15% is quite high. I agree to be conservative, but I cannot follow how you come up with the 15% and 30%. I am also missing results of the delineation tests in the main manuscript.

> I have tried to revise the latter part of the section 3.3 (Page 5 Line 18-).

 'The proportion of debris-covered glaciers in each area class in the Eastern Himalayas (85.0°–92.0°E, 27.5°–29.0°N) (Ojha et al., 2017) (Fig. S6) was applied for all study area (HMA), then, they are used to calculate the number-weighted average NSD of glacier area for each glacier area class, including both debris and debris-free glaciers (Fig. S6). Here, the NSDs of the glacier area were assumed to be 15% for smaller (< 0.25 km^2) debris-free glaciers and 30% for smaller (< 2 km^2) debris-covered glaciers based on Fig. S5. NSD for all glaciers in Fig. S6 was assumed to be the uncertainty in glacier area for all types of glacier (including debris-covered and debris-free). Finally, the maximum NSD 19% was found for glaciers with 1-2 km^2 in area (Fig. S6).'

I also want to mention that I do not agree with all of the reviewers comments (e.g. fully remove section 3.1 or L. 21-29 on page 4) and you also do not need to agree with all comments by the reviewer, but in case not please provide a good reason.

 > I hope I could give good reasons.

Please find my comments below:
P2L9: I think you can leave "millions" (see reviewers comments) as the glaciers are important but not really for all billion people living downstream.

P2L13: Considering the uncertainty it is not clear whether Karakoram glaciers are really gaining mass. I suggest to adjust to: "…are in balance or show a slight mass gain" or similar.

> I have revised as your suggestion.

L18: Update the Huss 2012 citation with the recent paper by Farinotti et al. 2019

> corrected

L22: Thanks for citing my work here. However, I did not consider the area uncertainty properly in my 2011 paper. Maybe you can refer to the 2017, TC paper or others which take the area uncertainty explicitly into account.

>Thank you for your comment. I have revised.

P3L2f: I do not understand what you mean. Can you please be more precise or add a figure in the supplement?

>I have added '(Fig. S1a)' at the end of the sentence.

P5L22ff (Results section): I like the structure better how it has been before. The second sentence now is already a comparison to GGI15 and needs to be presented there.

> I have changed the statement of the order as follows, 'The GGI15 reported a total glacier area of 91,263 ± 13,689 km^2 (Nuimura et al., 2015), which included the combined area of holes in glacier polygons. Excluding polygon holes, I recalculated the total glacier area in GGI15 as 87,583 ± 3137 km^2 (Table 1).While, the GGI18 comprises 134,770 glaciers with a total area of 100,693 ± 11,790 km^2 (Table 1).'

P7L7ff.: I do not fully agree with this statement. First of all Moelg et al. used also high resolution images in addition to the coherence images (see Fig. 3) and whether or whether the movement of rock glaciers are detected depends on their activity/flow velocity and the time difference between the SAR image acquisition.

> I see. I removed the statement.

L10f: What does complicated mean? Did Moelg et al. 2018 used similar images than you? If not then they must have had the similar problem.

>I revised to 'delineation of debris-covered glacier termini in the Karakoram and Pamir was

hampered by seasonal snow cover in the high-resolution Google Earth imagery.'

P7L25: What does clearer mean? More suitable images with better snow and cloud conditions?
> Yes, I have revised to 'cloud-free and least seasonal snow satellite imagery…'

One comment regarding the correct writing of "Nyen Chen Tanglha". You find also "Nyenchen Tanglha" or "Nyainqentanglha", You may write the alternative transcription in brackets the first time used.
> I have revised all "Nyen Chen Tanglha" to "Nyainqentanglha".

The layout of the supplement needs to be improved. Try to avoid figures without captions on one page and have consistent space between the figures and the captions.
E.g. Fig S1: There is a lot of uncaused space, maybe one example can be omitted and the caption shortened when a legend is included (e.g. for "with glacier outlines for the GGI15 and GGI18 inventories indicated by red and yellow lines, respectively"
>I removed two images. And deleted 'with glacier outlines for the GGI15 and GGI18 inventories indicated by red and yellow lines, respectively' in the caption.

Fig. S3: The single figures can be smaller so that 2 figures can be shown beside each other.
> corrected

Fig. S5: It is a bit large and should be cantered
> corrected

Reply to 2nd review by Dr. Guo

Thank you for careful check. I wrote my reply in blue Arial font in this reply letter. And revised part in the text are also written in blue. Revised part in the last time were remained in red in the text.

One suggestion on future works

I am truly suspecting that the author's research group has overestimated the overall area uncertainty (15%) in both versions merely by comparisons between different delineation tests, which is much larger than the generally achievable areal accuracy (3‐5%) by Landsat series suggested by many authors. I suggest Dr. Sakai or other interested researchers to do further works on precisely evalutating the areal uncertainties of both versions of GGI. It can be done by comparing the glacier outlines with those delineated from free high resolution images from Google Earth or BING map, etc. The direct comparisons suggested in Paul et al. (2013)@Annals of Glaciology or the definitive method used by us (in Guo et al., 2015@Journal of Glaciology) are suggested, but also can be done by some other solutions. The comparisons should consider different circumstances, i.e. on typical debris‐covered glaciers, and glaciers influenced by long lasting snow/cloud covers and also heavy cast shadow, as well as clean‐ice glaciers with fine image quality, to provide an overview of the precise areal uncertainties achieved by GGI dataset.

Thank you for your suggestion for my future work.
I will keep in mind to evaluate the uncertainties of those inventories.
As for the last comment about the error under different circumstances in GGI18, I have already evaluated the uncertainty. Please read section 4.3. You wrote that the detail of this section is not necessary in the below comments. But, I will not delete because the detail is the reply to your above comment.

Some specific comments:

Page 2:

Line 8: "millions of" should better to be "billions of" here considering the much large area of the HMA region in this manuscript.

> Here, "millions of" is underestimated expression, but "billions of" is overestimated, then, I only deleted "millions of" here.

Line 15: Suggest to delete "overall" after "less sensitive".

> deleted "overall"

Line 17 - 22: This sentence seems too long and should better to be more summarized.

> I think this sentence is important to insist usefulness of glacier inventory. I have cited only on or two example. So, I did not remove.

Line 26: Actually the CGI2 was compiled firstly by automatic glacier delineation, then by intensive and multi - round of manual corrections, although the manual works have completely changed the appearances of the glacier outlines.

> Thank you for the details on CGI2. I have revised to 'produced by automatic delineation with manual correction. '

Line 32: It's better to add "in" or "of" before "longitude" and "latitude".

> added "in"s.

Page 3:

Line 6: "final" may means that you will never change it in the future, but in Section 4.3 you mentioned this version may need further revison. Is it the right word?

> corrected 'updated version'.

Actually, this is final version as the GAMDAM glacier inventory. But, the title of this paper is 'updated…'. For the consistency, I have revised 'updated version…' at line6 Page 3 and also line 30 in page 7.

Line 14 - 15: You may not having clearly defined glacier outlines when selecting the Landsat images.

> I totally agree with you. I could not find clearly defined glacier outlines for all glaciers in HMA. Then, I include glacier outlines based on images with seasonal snow, shadow to evaluate uncertainty (see 3.3). Further, I wrote section 4.3 'Glacier outlines requiring further revision', which include seasonal snow cover.

Line 16: The citations to figures all through the manuscript are inconsistent (many Fig. and also many Figure).

> 'Figure' is used when it is at the head of the sentence. In other case (in the middle or at the end of the sentences), we use 'Fig.'. Please check other papers.

Section 3.1: Since you have remove the section of Quality of Landsat images in previous version, it's not necessary to explain the selection of the imageries in such detail. Although the selection of Landsat image is really a hard work for you considering the vast spatial coverage of GGI dataset, it's a common challenge faced by all researchers want to accurately delineate glacier outlines using remote sensing methods, and all of them may use identical method you mentioned here. Therefore, I suggest to completely remove this section and related supplementary figure.

> Selection of Landsat image might be common challenge. But, if this section have to be removed, this paper is not valuable to publish, because change of source images is the main reason of the difference between GGI15 and GGI18. I have also discussed about the image selection at section 4.1 (Fig. S9).

Page 4:

Line 12: "for which ……" seems not a common expression. Suggest to revise.

> I think this word is not abnormal.

Line 16‐19: "Furthermore, …… measuring area.", this part is not necessary and suggested to be deleted.

> For line 16-17 Including small glaciers in GGI18 is main difference from GGI15. Then, I did not decide to remove sentences. And if I delete Line 18-19, there is no description that the revision is conducted by one (single) person. Then, I have not deleted the sentence.

Line 21‐29: I suppose that the author didn't use any criterion on the slope range when delineating glacier areas on steep back‐wall, so just describe here on how to distinguish hanging ice/glacier from seasonal snow in prevous para is good enough (I think it should be done by visual check from multiple Landsat images). Therefore, this part is also not necessary and should better to be completely deleted.

> Including steep head wall covered with ice in GGI18 is important difference. Further, there is no clear criterion on the slope range, then I have to describe the detail, here.

Line 32‐33: Not a question, but honestly to say, I cannot see the reasonability to exclude the lowest part as rock glacier in Figure S3c&d.

> The screen shot images of Google Earth might not show the detail, But, we can find winkles geometry in the excluded area.

Page 5:

Section 3.3: This section can also be much shortened, by simply tell the method you used to evaluate the area uncertainty (multiple delineation test on different images, and expressed in NSD value, maybe in several sentences).

> Thank you for your suggestion. But, if I remove the detail, readers will misunderstand the uncertainty. For example, only 'different images' indicates no information about the situation of images (e.g. with shadow or with seasonal snow…). And NSD have to be explained the calculation method. Then, I did not delete.

Line 31: It's better to add a blank space between "RGI" and "6.0". Same in other places.

> Added a space for all 'RGI 6.0'.

Line 34: Should "RGI16" here be "RGI 6.0"?

> corrected to "RGI 6.0"

Page 6:

Line 32: Should "Figs. 11b, c and 12b, c" be "Figure S11b, c and S12b, c"?

> corrected

And "greater" maybe ambugious here, suggest to use "more" or other word instead.

> Here, the sentence express 'greater <u>number</u>' specifically. I think 'more smaller glaciers…' is more ambugious.

Page 7:

Line 19 - 22: "For instance, ⋯⋯ (Fig. S13c)", this part is also in too much detail, and suggested to be removed.

> removed and added only one sentence.

Line 25: Suggest to revise the last part of this sentence as "and shorter acquisition interval ($\leq$5 days)".

>I have added some words as your suggestion.

Line 30: See comment on Line 6 in Page 3. Maybe "latest version" or "new version" is better.

>For consistency, I have revised to updated version' as I wrote above reply.