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The Cryosphere Discussions

Interactive comment on "Structure and evolution of the drainage system of a Himalayan debris-covered glacier, and its relationship with patterns of mass loss" *by* Douglas I. Benn et al.

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Many thanks for these constructive comments. We have revised the paper to take account of all of the points raised. Details of the changes are as follows:

1) As you wrote 'Comparison of the drainage system structure in 2010 with evidence on Corona imagery from 1964 shows an upglacier expansion of the area occupied by closed depressions and perched lakes'(L623-625) I think analysis on the change of small basins (perched lake area) using Corona imagery (as past image) is useful to know the change of drainage system and to gain more insight of your synoptic view on the drainage system of debris-covered glaciers.

Although it would be very interesting to analyse long-term basin evolution on the glacier, this is not possible. Our methods for defining basins use contoured DEMs, which cannot be constructed for the Corona data, which consist of mono images. Text has been added in L158-60 to explain this point.

Iwata et al. (2000) have reported that high relief area expand from 1978 to 1995 at the middle ablation area of the Khumbu Glacier based on the geomorphic evidence. Although the target of Iwata's study was the Khumbu glacier (different from your target; the Ngozumpa Glacier), I think Iwata's result complement your result that lower limit of surface stream area has gone up to higher elevation recently. Therefore, Iwata et al. (2000) would be a nice reference of your manuscript.

Reference to Iwata et al. (2000) has been added (L 687)

2) In the section 4.2, 5.1 and 5.5, authors did not discuss on the start point (maximum altitude) of surface stream. The start point of surface stream strongly relates with altitude of ablation and it is significant for drainage system. I think discussion is required in the manuscript on the start point for example the difference between 1964 and 2010 (Fig. 13a and b) there is no solid evidence on the surface stream during LIA, the start point of surface stream during the LIA might (should?) be different from that of 1964. Please take into account the start point of surface stream in Fig. 13c.

The upper limit of surface streams is not determined by the ELA, but the location of topographically controlled crevasse fields. The 1964 image shows these crevasse fields in the same location. Text has been added (L 651 ff.) to explain this point.

L34-35 'since the 1970s'> Analysis period by Kääb et al., (2012) was 2003-2008.

The position of Kääb reference has been changed to remove this problem.

L357-358 (365-8)' The seasonal variations in ice velocities in the upper ablation zone are too large to be explained by changes in ice creep rates,' > Authors should write the reason

justification of this statement has been added.

L 375-385 (387) It's better to cite Fig. 13 in this section.

A reference to Fig 14 (formerly 13) has been added.

L487 'measured volume losses' is ambiguous expression. Please write specifically. If the measured volume loss is calculated from elevation change at ablation area, the value includes not only ablation but also emergence velocity.

In the paper by Thompson et al. (2016) these volume losses were calculated from elevation changes on the stagnant part of the glacier, where complications from glacier flow do not arise. Rather than clutter the text with this information, we have added the phrase 'on the stagnant part of the glacier' on line 498.

Fig 14 There is no symbols of a) and b) in the Fig. 14, although, authors used Fig. 14a, 14b in the text (L543-549)

This Figure has been redrafted.

L528 'where the overall gradient of the glacier is <3°' < reference?

Statements about the glacier gradient have been clarified (L 106), and a new Figure 3 added.

L543 'By 2010, this part of the glacier had been broken up into basins E-7, E-8 and E-9'. > In other word, you can estimate that basins E-7, E-8 and E-9 has coalesced in 1960s from the Corona image. I recommend if you can draw the basins boundary using Corona image. it would be great help to understand the geomorphic change of the Ngozumpa Glacier. (main comment 1))

This Figure has been redrafted to make the changes clearer.

L594 'On the Survey of Nepal map,' > Reference is necessary, here. I think following map is cited here. 'Nepal: Survey Department. 1997c. Namuche Bajar 1 : 50 000.

Kathmandu, Ministry of Land Reform and Management. Survey Department. (Sheet No. 2786 03.)' This map was produced based on the aerial photography taken in 1992.

Reference added.

L629 'Such a drainage system might have existed during the Little Ice Age, and persisted into the early 20th Century.' > I recommend that the supraglacial channels during the Little Ice Age is not based on Satellite imagery or other evidences. Therefore, the line of the supraglacial channels should be drawn by dotted lines.

This has been done.

Please check whole references in the text and in the reference list (not only following comment).

L39 Reynolds, 2000 > I could not find the reference in the reference list.

Reference deleted in text.

L146 Thompson et al. (2016) > I could not find the reference in the reference list.

Reference added.

L471 Horodyskuj (2015) > I could not find the reference in the reference list.

Reference added

L730 The reference has no published year.(Earth Science Reviews)

Year of publication added.

L748 In the title of Gulley et al. 2009a, 'Mechanisms of ....' has been missed.

Text corrected

L800-805 There are two Quincey et al. (2005) but I could not find Quincey et al. (2005) in the body text.

This has been reduced to one reference, with the correct year of 2007

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