

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.

In this paper, authors have developed a comprehensive view on the drainage system of debris-covered glaciers in the Himalayas. Since almost part of drainage system are invisible by satellite images, they have linked various phenomena using geomorphic evidence (Google Earth, satellite images), and seasonal changes of surface velocity and speleological exploration. Although some parts of those links includes speculations, they attained a reasoned interpretation of view on the drainage system of debris-covered glaciers. I have never been to the Ngozumpa Glacier, but, the image was very understandable for me without difficulty. Therefore, I think the images of drainage system of debris-covered glaciers can be applied to other glaciers (as authors wrote). I believe this paper will have great contribution to understand the drainage system of the debris-covered glacier (not only present but also transition process).

<Major comment>

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.

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.

[http://iahs.info/uploads/dms/iahs\\_264\\_0003.pdf](http://iahs.info/uploads/dms/iahs_264_0003.pdf)

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).

Although 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.

<Specific comment>

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

L357-358 '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

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

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.

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)

L528 'where the overall gradient of the glacier is  $<3^\circ$  < reference?

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))

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.

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.

<Reference>

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.

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

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

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

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

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