Dear Pelto Mauri, (corresponding to tcd-8-C441-2014)

We thank you for your valuable comments. Here we address how we will revise the manuscript corresponding to your specific comments. The comments are in italic font, which are followed by our replies in bold font.

The paper has several issues that should be addressed to make this a valuable contribution.
1) Better referencing of work in the region on DC impacts, the relation of DC to proglacial lakes.
We have responded in a following specific comment for 1320-13 below.

2) Explaining the impact of these being summer accumulation type glacier.
We have responded in following specific comments for 1307-8, 1316-8, and 1317-14.

3) Providing a more detailed figure looking at a specific basin from Figure 1 with the PMS slopes identified with some sort of shading.
We have responded in a following specific comment for 1312-20.

4) A better analysis of the ELA and median elevation relationship and lack of change from DC to non-DC glaciers.
We added related descriptions for 1317-21 and 1321-8. Does *the change from DC to non-DC* mean a historical change of glacial surface condition? Unfortunately we do not have any information suggesting that. Any source of previous study is welcomed.

<Specific comments>
1306-7: *PMS-can refer to potential material-supply slopes, not just potential material supply.*
PMS slope will not be described in the revised manuscript due to reviewers' recommendation. In this authors comment, it is renamed as P-M slope.

1307-8: *Should be noted that these glaciers are summer accumulation type glaciers. This is key since peak accumulation and ablation are synchronous. Pan et al (2012) have a good description of the impact of the monsoon on such glaciers. The snowline typically rises and remains high from October-December.*
We will change the sentence as "In particular, glaciers in humid monsoonal climate called as summer-accumulation type (Ageta and Higuchi, 1984), such as those in the Bhutan Himalaya, are expected to be highly sensitive to changing climate (Fujita, 2008; Fujita and Nuimura, 2011; Pan et al., 2012).". Neither general information nor evidential paper showing snowline rising from Oct. to Dec. have been found.

1307-16: *Lie et al (2003) would be a useful reference here along with Ohmura.*
Thank you. However, we will remove these sentences because we will not deal with ELA in the revised manuscript..

1307-18: *ELA's are identifiable by numerous satellite observations as well.*

As a matter of fact, snow lines, which suggest the position of ELA, are difficult to be observed and fixed due to high frequency of cloud cover in the monsoon season and occasional snowfall in the post-monsoon season.

1307-22: *"complicating" not "concerning".*
We will exchange them in the revised manuscript.

1307-29: *Should reference a couple of key studies of the debris cover on ablation in the region. Most importantly Zhang et al (2011) who noted that "Because of the inhomogeneous distribution of debris thickness, about 67% of the ablation area on Hailuogou glacier has undergone accelerated melting, whereas about 19% of the ablation area has experienced inhibited melting, and the sub-debris melt rate equals the bare-ice melt rate in only 14% of the ablation area." Bolch et al (2011) noted the fastest thinning in the area of thin debris cover just below the clean ice.*
We will add "On the other hand, other studies suggested recent faster glacier melting below thin debris-covered areas than debris-free areas (Bolch et al., 2011; Zhang et al., 2011)." at [1307-29].

1308-8: *well quantified. The influence is understood qualitatively.*
We will change "understood" to "quantified".

1312-20: *Three different ratios are used in this paragraph to quantify the PMS ratio it would be better to use just one defined ratio. This is a crucial point, that can be illustrated with a satellite image figure of adjacent PMS fed debris covered glacier and non-debris covered glacier. The figure attached is an example. The figure is a 2013 Landsat image of the headwaters of the west branch of the Pho Chu. not meant to accurately indicate the PMS slopes (P). I do have a question regarding the glacier indicated by NDC? In your Figure 1 this is identified as a debris covered glacier, I do not see the debris on this glacier in the 2013 Landsat image. Would be worth citing Osti et al (2012) who examined GLOF's in this specific area.*
We will remove the sentences related to PMS slope due to the reviewers' recommend. You can identify a debris-covered area of "NDC?" glacier by PRISM and AVNIR2 images (Fig. AC1), whereas it is unclear in the Landsat image which you showed us. We will not refer to Osti et al. (2012) to avoid misunderstanding, which contains no comparable figure to identify debris-covered area, and in which the term of "debris" is used for another meaning, outburst materials caused by GLOFs.

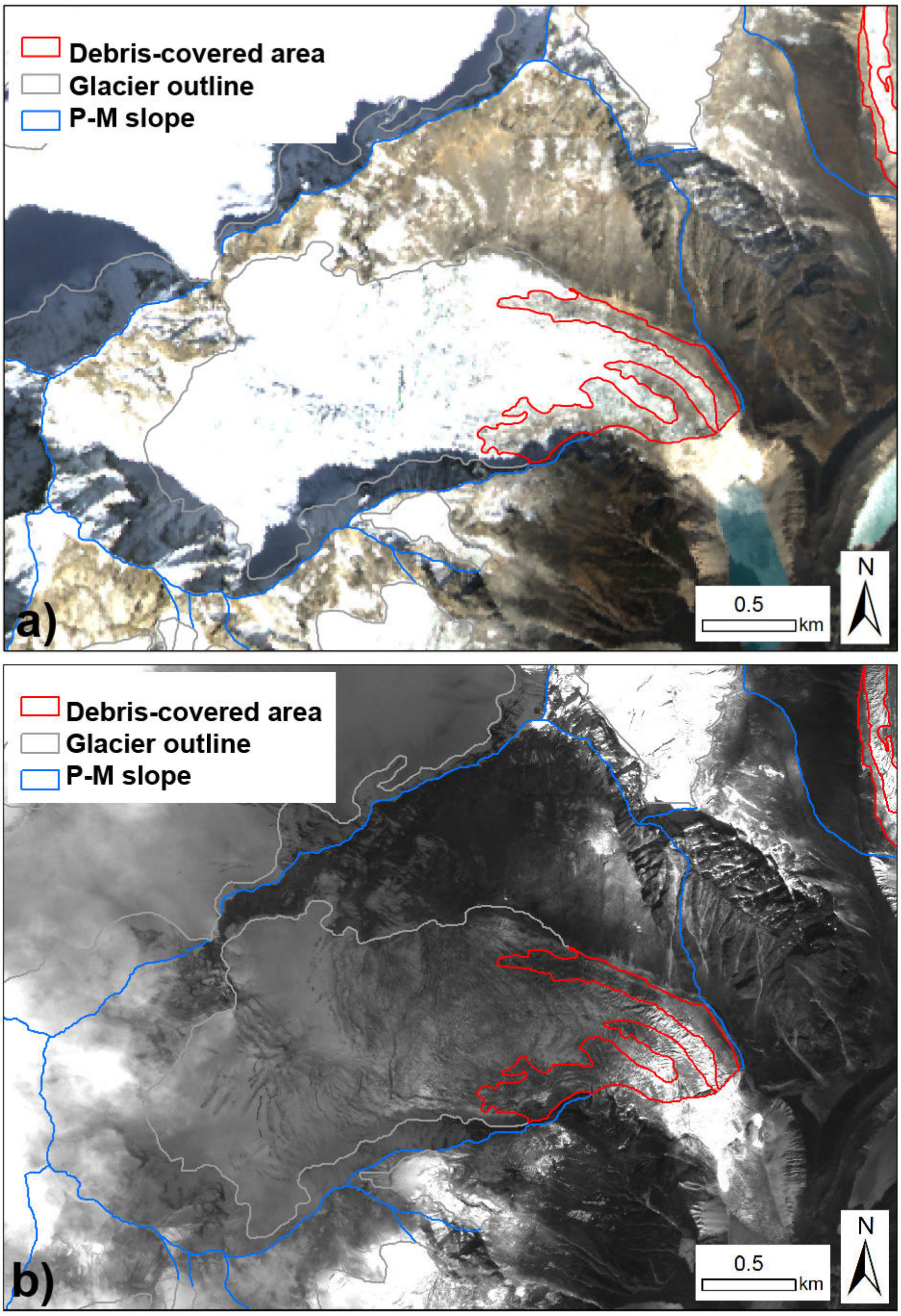

Fig. AC1. One glacier in a headwater of the west branch of the Pho Chu. Background images are (a) the AVNIR2 image and (b) the PRISM image used for the delineation of this glacier.

1314-10: *A Greenland reference for glacier size not useful since they are ice sheet fed. What about other mountain glacier areas? Pan et al (2012) and Bolch et al (2010) are important references to use here since they are both inventories of glacier regions nearby.*

We will refer to Pan et al. (2012) and Bolch et al. (2010) instead of Rastner et al. (2012) for the comparison in the revised manuscript.

1315-24: *The debris covered glaciers tend to both start higher and end lower than non-debris covered glaciers, but this is also true of larger glaciers in general in other mountain regions regardless of debris cover.*

Fig. 6 shows that numerous debris-covered glaciers share their maximum elevations with debris-free glaciers. In the Bhutan Himalaya, at least, your understanding that *the debris covered glaciers tend to*

***both start higher and end lower than non-debris covered glacier* is not supported.**

1315-13: *This implies that the terrain in the highest elevation regions is simply steeper and will always have considerable PMS slopes.*

According to our additional analysis which compares the mean slope gradient of P-M slope to the maximum elevation of each debris-covered glacier, no obvious relationship is found (r = 0.08, p > 5%) (Fig. AC2). In addition north-facing slopes would not contribute for debris supply even if they are steep and at high elevations (Nagai et al., 2013).

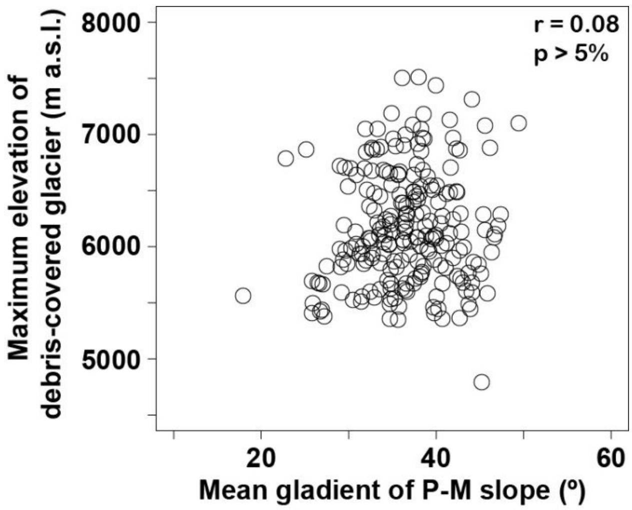

Fig. AC2. Mean gradient of PMS slope versus maximum elevation of the debris-covered glaciers.

1316-8: *Ohmura was not considering summer accumulation type glaciers.*

1317-14: *Since these glaciers have significant ablation beyond the summer period, the JJA temperature arrangement is not the best. Snowlines are typically seen to rise after the end of the summer monsoon in this region October-December, as well as prior to the beginning of the summer monsoon.*

In this analysis we did not use temperature data. Generally-used lapse rate (dT/dZ) and precipitation–air temperature gradients derived from Fig. 7 were used. However, we will not deal with ELA in the revised manuscript because of reviewers' comments suggesting shortcomings of ELA analysis in addition to your comment. On the other hand, we have no information that snowlines are typically seen to rise after the end of the summer monsoon.

1320-13: *The retreat rate of debris covered glaciers has to mention the common role of proglacial lakes. Basnett et al (2013) note that in Sikkim, "(1) the formation and expansion of supraglacial lakes on many debris-covered glaciers. We also observed that debris-covered glaciers with lakes lose a greater area than debris-covered glaciers without lakes and debris-free glaciers"*

We will here add "There is a possibility that glacial lake formation is related to the retreat (Basnett et al., 2013). Komori (2008) pointed out that glacial lakes located in the southern side of the Bhutan Himalayan mountain range are expanding later and faster than those located in the northern side. This south-to-north contrast may be related to the difference of area and shape of debris-covered areas evaluated by Nagai et al. (2013). In a future study, glacial lake inventory (Ukita et al., 2011) would be needed and should be analyzed to discuss the relationship furthermore."

1317-21: *An important point is that the annual ELA should not be impacted by debris cover, hence the ELA0 should be little changed. The median elevation of the glacier would be impacted by reduced ablation on the terminus tongue allowing further extension and greater avalanche input. The evidence that ELA is not really very sensitive to DC is Figure 2 showing non-DC glaciers have the same median elevation.*

We agree with your comment that the annual ELA should not be impacted by debris cover, because ELA described in this paper is based on climatic condition. Then we discussed median elevation as a proxy of ELA considering the influence of debris cover and avalanche accumulation (Fig. 7-9). At a primal stage (Fig. 2), glaciers under arid region and humid region are mixed. Therefore we cannot conclude that ELA is not sensitive to debris-covered glaciers from this figure.

1318-15: *This weak lowering contradicts the earlier assertion that median elevation is statistically the same.*

As mentioned above, glaciers under arid region and humid region are mixed in Fig. 2, which hampers detail discussion. A weak relationship between median elevation and surrounding slope is shown in Fig. 8a because precipitation difference is canceled by focusing of elevation deviations under same precipitation condition.

1321-8: *This conclusion of the impact of PMS on ELA is based on quite weak correlation and defies the similarity of median elevation of DC and non-DC glaciers already noted. I would suggest removing. Certainly the debris cover leads to a lower terminus elevation, but does this affect the annual ELA? If we examine the annual ELA in a given year using satellite imagery it is not likely that the PMS slopes will alter its location.*

We will remove this statement because removing of ELA is recommended at this manuscript.

Reference:

Ageta, Y. and Higuchi, K.: Estimation of mass balance components of a summer-accumulation type glacier in the Nepal Himalaya, Geogr. Ann. A, 66, 249–255, 1984.

Fujita, K.: Influence of precipitation seasonality on glacier mass balance and its sensitivity to climate change, Ann. Glaciol., 48(1), 88–92, doi:10.3189/172756408784700824, 2008.

Komori, J.: Recent expansions of glacial lakes in the Bhutan Himalayas, Quat. Int., 184, 177–186, doi:10.1016/j.quaint.2007.09.012, 2008.

Nagai, H., Fujita, K., Nuimura, T., and Sakai, A.: Southwest-facing slopes control the formation of debris-covered glaciers in the Bhutan Himalaya, The Cryosphere, 7, 1303–1314, doi:10.5194/tc-7-1303-2013, 2013.

Ukita, J., Narama, C., Tadono, T., Yamanokuchi, T., Tomiyama, N., Kawamoto, S., Abe, C., Uda, T., Yabuki, H., Fujita, K., Nishimura, K.: Glacial lake inventory of Bhutan using ALOS data: methods and preliminary results, Ann. Glaciol., 52(58), doi: 10.3189/172756411797252293, 2011.