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Interactive comment on "Climatic and topographic influences on glacier distribution in the Bhutan Himalaya" *by* H. Nagai et al.

M. Pelto

mauri.pelto@nichols.edu

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Nagai et al (2014) provide a detailed topographic inventory of of Bhutan glaciers, with a particular emphasis on debris cover (DC). The most noteworthy part of the analysis is the quantification of the relationship of potential material supply slopes to the development of DC glaciers. This is a valuable aim, and this is an excellent early examination of the concept. 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. 2) Explaining the impact of these being summer accumulation type glacier. 3) Providing a more detailed figure looking at a specific basin from Figure 1 with the PMS slopes identified with some sort of shading. 4) A better analysis of the ELA and median elevation relationship and lack of change from DC to

non-DC glaciers.

Specific Comments:

1306-7: PMS-can refer to potential material-supply slopes, not just potential material-supply.

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.

1307-16: Lie et al (2003) would be a useful reference here along with Ohmura.

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

1307-22: "complicating" not "concerning".

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.

1308-8: well quantified. The influence is understood qualitatively.

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.

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.

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.

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

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.

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"

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.

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

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.

Basnett, S., Kulkarni, A. V., and Bolch, T.: The influence of debris cover and glacial lakes on the recession of glaciers in Sikkim Himalaya, India, J. Glaciol., 59, 1035–1046, doi:10.3189/2013JoG12J184, 2013.

Bolch, T., Yao, T., Kang, S., Buchroithner, M. F., Scherer, D., Maussion, F., Huintjes, E., and Schneider, C.: A glacier inventory for the western Nyainqentanglha Range and the Nam Co Basin, Tibet, and glacier changes 1976–2009, The Cryosphere, 4, 419-433, doi:10.5194/tc-4-419-2010, 2010.

Bolch, T., Pieczonka, T., and Benn, D. I.: Multi-decadal mass loss of glaciers in the Everest area (Nepal Himalaya) derived from stereo imagery, The Cryosphere, 5, 349-358, doi:10.5194/tc-5-349-2011, 2011.

Lie, O., Dahl, S.O., Nesje, A. A theoretical approach to glacier equilibrium-line altitudes using meteorological data and glacier mass-balance records from southern Norway. The Holocene 13 (3), 365–372, 2003.

Osti R, Egashira S, Adikari Y. Prediction and assessment of multiple glacial lake outburst floods scenario in Pho Chu River basin, Bhutan. Hydrol Process. http://dx.doi.org/10.1002/hyp.8342, 2012.

Pan, B. T., Zhang, G. L., Wang, J., Cao, B., Geng, H. P., Wang, J., Zhang, C., and Ji, Y. P.: Glacier changes from 1966–2009 in the Gongga Mountains, on the south-eastern margin of the Qinghai-Tibetan Plateau and their climatic forcing, The Cryosphere, 6, 1087-1101, doi:10.5194/tc-6-1087-2012, 2012.

Zhang, Y., Fujita, K., Liu, S., Liu., Q., and Nuimura, T.,: Distribution of debris thickness and its effect on ice melt at Hailuogou glacier, southeastern Tibetan Plateau, using in situ surveys and ASTER imagery. J. Glaciol., 57, 1147-1157, 2011.

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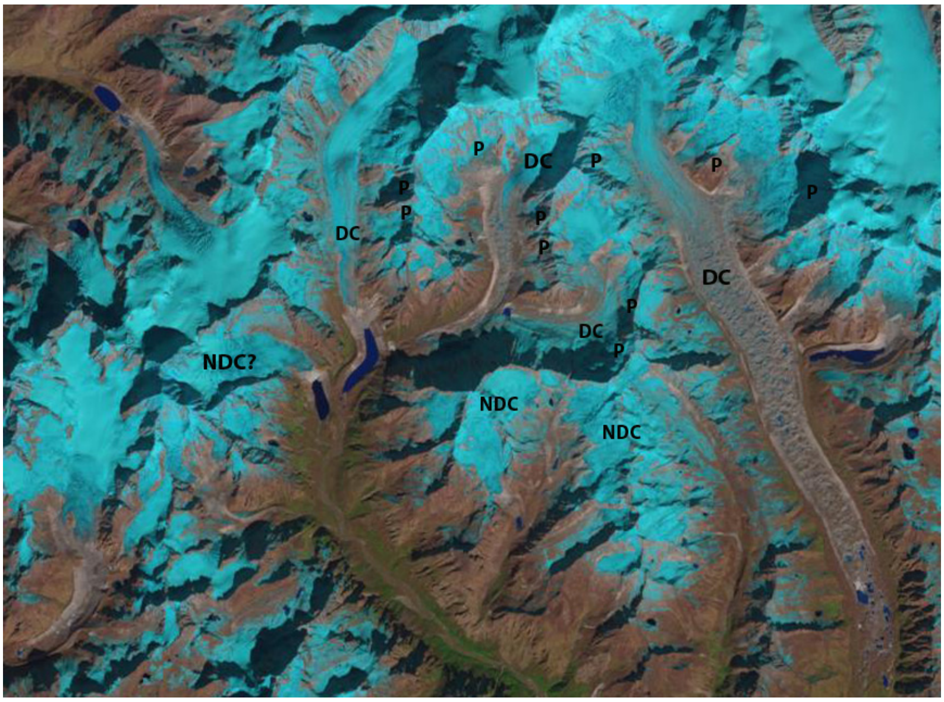

Fig. 1. November 2013 Landsat 8 image. Headwaters west branch Pho Chu. A suggested template for a detailed complimentary figure to Figure 1 that better illustrates PMS slopes.