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The Cryosphere Discussions

Interactive comment on "Longest time series of glacier mass changes in the Himalaya based on stereo imagery" *by* T. Bolch et al.

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Bolch et al. (2010) provide an important assessment of volume change of glacier in the Mount Everest region, Nepal using multiple remote sensing imagery sources. The important result is the extension of the previous understanding of the distribution of glacier thinning on Khumbu Glacier to other glaciers in the area. That debris cover plays a key role and the greatest thinning is some distance above the terminus as a result. To gain full value from this valuable data the authors must expand their discussion and visual presentation on debris cover as this variable is key. They must reconcile the brief mention of nearly stable terminus position with previous work by Bajrachaya and Mool (2009).

2594-20: This study focuses primarily on the ablation zone, a reference would be valu-

able supporting the idea most of the volume change should be occurring in this region of the glacier and your limited accumulation zone data supports this.

2593-22: Can a typical AAR be given for the Khumbu or Imja Glacier at least. Given the high avalanche accumulation and debris cover one would expect a different equilibrium AAR than typical for alpine glaciers.

2595-24: What is the percent increase in the debris covered area? Use Nakawo (1999) here, or at 2599-24, to elaborate on the change in debris covered area.

2593-25: The brief comment on the almost stable terminus position does not agree with the work of Bajrachaya and Mool (2009) who in examining most of the same glacier noted a 1976-2000 retreat rate of -10 to -59 m/a (Table 1). Further in Table 1 they provide 2000-2007 terminus retreat rates and the elevation range for these glaciers.

2600-4: Given the importance of debris cover it is imperative that the reader be given a measure of how this changes spatially and temporally. This should be done visually with a satellite image of the lower Khumbu and or Imja Glacier. A profile of the increase in thickness or percentage coverage of the debris cover on Khumbu Glacier should be provided. Additionally it was noted that the debris cover had expanded, was this largely at the upper elevation of the debris covered region? Nakawo (1999) explored this. Since debris cover is the key variable cited for the change in thinning, it needs greater attention.

Kadota and others (2000) should be cited as it supports the findings here. They surveyed the Khumbu glacier in 1995 and compared the results with those of the 1978 survey. They found that the surface of the glacier lowered about 12-15 meters over most of the length but by only 6-8 meters near the terminus.

Takeuchi and others (2000) should be utilized more extensively as they noted that for Khumbu Glacier debris cover less than 5 cm increases ablation, debris greater than 5 cm in thickness reduces ablation. On Khumbu Glacier their ablation measurements indicate that ablation is reduced 40% from that of clean ice when the debris cover is 10 cm thick. Thicker debris cover reduced ablation even more, but only slightly. At what elevation is the ice no longer clean? At what elevation is the thickness more than 5 cm? How does this fit with the thinning?

Expand on your point of support with Naito et al. (2000, as this enhances the value of the paper. They developed a model coupling mass balance and flow dynamics of debris covered glaciers and applied it to the Khumbu Glacier. The model predicts formation and enlargement of a depression in the lower ablation area about 5 km upstream of the terminus.

2601-1-12: Move this section earlier to the other portion on Khumbu Glacier.

2601-20: I would suggest this is an appropriate to reiterate that the greatest thinning is in the areas of thinner debris cover. Further an important conclusion from this, is that the greatest thinning is not associated with an area of a glacier where black carbon would play a significant role. Ramanthan and Cunningham (2008) and others have noted the potential role of black carbon in volume losses. With respect to the heavily debris covered monsoon dominated glaciers of Nepal, evidence of thinning distribution does not support this. Given that debris cover areas would not be sensitive to black carbon deposition, nor the accumulation zone where the summer monsoon is also the main accumulation season, this is not a surprise.

References:

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