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## ***Interactive comment on “Southwest-facing slopes control the formation of debris-covered glaciers in the Bhutan Himalaya” by H. Nagai et al.***

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Reviewer Recommendation & Comments for Manuscript tc-2013-43 Reviewer: Dan Shugar

Paper No.: tc-2013-43 Author(s): Nagai, Fujita, Nuimura, and Sakai Title: Southwest-facing slopes control the formulation of debris-covered glaciers in the Bhutan Himalaya

General Comments The paper by Nagai et al. provides a description of the source slopes of debris-covered glaciers in the Bhutan Himalaya. It is a well-designed study, elegantly executed and worthy of publication in The Cryosphere after fairly minor edits. Debris-covered glaciers have received increasing attention in recent years, and the contribution by Nagai et al. represents a hitherto understudied aspect – that of the

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slopes contributing the debris.

I identify some issues, mostly minor, that I feel should be addressed prior to publication. Generally speaking, the manuscript is well-written although there are some confusing passages that should be clarified, and some comparisons to other mountain ranges (e.g. Akaishi Range, Japan) that seem out of place. Two factors that I would have thought would play a big role in debris production – geological setting and post-Little Ice Age glacier thinning (by debuttressing on north vs south slopes) are not discussed at all, and should at least be mentioned. Last, it is not clear how the authors know which are the potential debris supply (PDS) slopes in the first place. Below I give my specific editorial comments, and point out some inconsistencies.

Specific Comments P1675 L4 – See also Shugar et al. (2012, JGR doi:10.1029/2011jf002011). P1675 L6 – It is unclear why ponds should be considered rugged topography. P1675 L16 – The paragraph describing implications for glacier lake outburst floods, while important, is perhaps a little long. Since glacier lakes are not the focus of the paper, and indeed hardly appear in it at all except for here, I suggest shortening this paragraph. P1677 L25 – It is unclear what is meant by “. . .delineation error was modified.” Please clarify. Further, it is unclear why the authors overlaid the 2.5-m PRISM- and 10-m AVNIR-derived glacier outlines onto Google Earth imagery. Is the Google Earth data higher resolution? P1678 L1 – I don’t understand what “topographic contour lines” used to delineate glacier outlines are. Do the authors mean they looked at the inflection point in the lateral slopes? P1679 L14 – As above, what role does Google Earth play in the analysis? P1679 L19 – The description of the potential Debris-supply slopes is somewhat confusing. A figure might help to clarify. P1679 L25 – Why were the lateral and terminal moraines included? P1680 L21 – It is surprising that the melting point was exceeded at elevations of up to 7500 m asl in winter! Wow. P1681 L8 – I found it very interesting that north-flowing glaciers had smaller debris-covered areas than south-flowing glaciers. P1682 L17 – I like the idea of the geometric shape index. It is similar to what we did in Shugar and Clague (2011), where we calculated a

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dimensionless spreading index as the quotient of the landslide deposit's maximum and initial widths. P1683 L14 - I don't understand how the authors know which particular slope(s) failed in any particular case. For example, in Figure 6, which slope failed (or both?), to provide all the debris on the south-facing glacier? Part of the headwall is also north-facing. This is an important point that is not discussed in the manuscript. P1683 L 22 – Some large leaps of faith are required for this last sentence. P1685 L11 – As described above in the general comments, I think the authors need to discuss other possible mechanisms for debris transfer from the slopes to the glaciers. The two most obvious are geological setting (both lithology and tectonic setting) and magnitude of post-LIA glacier thinning and debuitressing. P1686 L20 – Another relevant study is by Shugar et al. (2012, JGR). P1687 L6 – I suggest the authors cite any number of Ken Hewitt's papers in which he describes avalanche-fed glaciers in the Karakoram. P1701 Fig 4 – In the figure,  $r$  values are given (e.g.  $r=0.81$ ) but in the caption,  $R^2$  values are given (e.g.  $R^2=0.80$ ). Are these typos or intentionally different? P1702 Fig 5 – I'm not sure this figure is necessary.

Technical Corrections P1676 L15 – The sentence beginning “In this study...” should begin a new paragraph. P1684 L17 – Do the authors mean decimetres rather than deca-centimetres? P1686 L17 – The sentence beginning “In the course of our research...” should begin a new paragraph. P1694 L14 – GJ Young's last name is misplaced. Instead of after GJ, it is before the word 'Edited', on L13.

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