

Interactive comment on “Estimating lateral moraine sediment supply to a debris-covered glacier in the Himalaya” by Teun van Woerkom et al.

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This paper shows a very unique data set with several repeat DEMs that were acquired over highly erodible lateral moraines. These data allow a quantification of the debris flux from such moraines to the glacier surface, where they influence the thickness of the supraglacial debris layer and thus the glacier's mass balance. The paper is highly relevant and I recommend publication. There are several opportunities to make it clearer, however, and I recommend a number of revisions.

Overall, there are two issues that should be addressed clearer in the paper:

C1

1) In the paper erosion from several sources (headwall, lateral, basal) is treated similarly and independently. But this is not really the case. All sediment in lateral moraine has originated from headwall erosion, transported by the glacier and is now remobilized. It's not primary erosion. So it doesn't really make sense to compare rates, these are two different things. It would improve the paper greatly if this distinction was clearly made in the Introduction as well as the Discussion. This would also outline some of the issues that need to be addressed in coupled debris/ice flow models, namely sediment deposition and re-activation.

2) The derived rates are based on the assumption that none of the elevation changes on the moraine are due to melting ice. This seems like a big assumption and it is only mentioned in one sentence and no potential errors due to this assumption are discussed.

Detailed comments:

p.1, l.5: I don't know if this is standard terminology, but I find the use of 'headwall' confusing, especially in the abstract, which should be readable without looking at figures. From what I can tell, 'headwall erosion' is basically all primary erosion that is not subglacial. In particular it includes erosion from valley sides, if it does not originate from moraines. To me, headwalls are the mountain sides at cirques at the very top of an accumulation area.

p.1, l.14/15: rewrite sentence or split into two

p.2, l.1: I'm not a fan of the proliferation of acronyms. You only use debris-covered glaciers two or three times, just write it out.

p.2, l.1: The numbers are not clear: Is 11% the area that is debris covered, or are 11% of the glaciers debris-covered glaciers? Also, you must mean 'ice area' not 'ice mass'

p.2, l.15-: See my overall comment 1.

p.2, l.26: are -> is; vary -> varies

C2

p.3, l.4/5: Why are you mentioning this here? What is the relevance of englacial vs supraglacial transport?

p.3, l.8: larger -> longer

p.3, l.1-16: see my comment 1.

p.4, l.15/16: It is not clear to me what you're doing here. Is it legitimate to remove outliers, because they might represent 'extreme events'? A large event should not be ignored if it is not just a data artifact? I suppose you have a way of checking this; the imagery should show large events.

sec. 3.3: When using correlation techniques on debris cover it seems you have to be careful with processes that can generate apparent motion, such as back-wasting of cliffs? The flow field in Fig. 6 looks very odd with vectors pointing across the glacier.

p.4, l.23/24: Can you be more specific how you capture large events that happen 'within a few minutes' and how this information is used?

sec 3.6: Isn't debris that falls onto the glacier in the accumulation area and then transported englacially protected from rounding and will thus preserve its angularity?

p.6, l.20: You say most change occurs on the loose part (0.35 m/yr), but this is almost the same rate as the average (0.31 m/yr) mentioned two lines earlier.

p.6, l.21/22: Again, these rates are not comparable. One is a long term denudation rate, lateral moraine erosion cannot proceed at such high values for centuries; the sediment will be exhausted relatively quickly.

sec. 4.3: I suggest rewriting the first few sentences, because the same things are presented twice, first as averages and then as ranges. This is confusing.

p.8, l.20: What is 'advection of a prominent zone'?

p.8, l.24/25: I don't understand this sentence

C3

p.8, l.27: '... of this process.' What process? The whole paragraph should be edited for clarity.

p.8, l.30: Is it legitimate to assume something to be small, just because it's infrequent? For example, individual large landslides might only occur on decadal timescales or longer, but can dominate the sediment budget of a glacier.

p.9, sec. 4.5: Significant figures! Don't state numbers to sub-meter, which is meaningless in this context.

p.9, l.6: what is the 'observed runout length'? Is that extracted from imagery?

p.9, l.26: check sentence for missing word

p.9, l.29: why 'through the ice'? Isn't it just being dragged along the sides?

p.10, l.7: delete 'being'

p.11, l.1: I would hope that observations are plausible! The question is whether the interpretation of the observations are plausible.

p.11, l.1: an -> a

Figure 1: It took a bit of reading and re-reading to understand the difference between process b and c2; this comes back to the issue of what a headwall is

Figure 2 would be nice if it could be made bigger

Figure 6: give a scale for the velocity arrows.

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C4