

Interactive comment on “Review article: The hydrology of debris-covered glaciers – state of the science and future research directions” by Katie E. Miles et al.

Anonymous Referee #2

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This paper provides a summary of the current state of knowledge about the hydrological systems of debris covered glaciers. The paper is well written and researched, and I found it quite interesting to read. However, I am not convinced of its merits as a review paper in The Cryosphere. The paper is more of a literature review, such as might be found in a thesis or a grant proposal (as such, it is good), rather than a ‘review article’ in which I would expect to see more synthesis based on the literature (rather than a summary of what is in the literature).

A second issue is that I am not convinced the field of debris-covered-glacier hydrology is sufficiently well developed (as distinct from glacier hydrology more generally)

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to warrant a review paper. This manuscript makes frequent comment about how little is known, especially the sections on englacial and subglacial hydrology, and that leads to considerable speculation. If so little is known, why a review paper? In places the review focusses more broadly on debris-covered glaciers, and at times more on 'Himalyan glacier hydrology' (eg, the introduction is mostly taken up with disucssion of Asian water security and how debris-covered glaciers are expected to evolve with climate change).

I can understand that the authors want to demonstrate a need for more work to study such glaciers, but I think there needs to be a clear dicussion of why the hydrology (in particular) of these glaciers is important. In particular, why and in what way, are the en- and sub-glacial systems of a debris-covered glacier thought to be different from other glaciers. It seems clear that the supra-glacial hydrological system is quite different, but a lot of the disucssion of this is tied up with the surface energy and mass balance - and would seem to fit better within a review of the mass balance of debris-covered glaciers rather than the hydrology per se.

I would suggest that the paper might be better framed with a focus just on supraglacial and near-surface hydrology of debris-covered glaciers. This would allow for an expanded and in-depth discussion of this area, on which there has been more work and for which it is clear that the debris cover is important. This could include the effects of the debris cover on the proglacial discharge hydrograph, but I think this needs to have greater emphasis on what is different from other glaciers and why a different treatment is needed.

Specific comments

Section 2, paragraph beginning on l129 - some of the differences from clean-ice glaciers are discussed here, but apart from the supraglacial and near-surface englacial drainage this seems largely speculative or is not specific to the debris-cover (possible presence of cold ice, low hydraulic potential gradients, presence of proglacial lake,

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monsoon-dominated climate).

Section 3.2 - much of the discussion here is presented rather speculatively - 'a similar situation may hold...', 'these situations could be plausible within the debris layer...', 'meltwater could augment the melt of glacier ice...'. These seem quite obvious comparisons to permafrost and proglacial environments with underlain ice, but could it be made more definite what the similarities and/or differences might be for supraglacial debris. Eg. what is the permeability of the debris layer, does the continual release of debris melting out of the ice make a difference?

Section 3.4 - it would be helpful to have more detailed comparison with clean-ice glaciers here. How much less common are supraglacial streams on debris covered ice than clean ice? In what way are they different? (the discussion the final paragraph seems inconclusive as both more and less crevassing are implied on different regions of the glacier).

Section 4 - the statement on I436 is debatable. The thermal structure may certainly influence the formation of an englacial hydrological system, but it is not clear that it 'determines the water content', which suggests a direct relationship. Water is commonly transferred englacially through cold ice in Greenland and Arctic glaciers. It is therefore not clear why knowing the thermal structure of debris-covered glaciers is so important here. It would again help to explain why the thermal structure of these glaciers is expected to be different from other glaciers (does the presence of debris on the surface have a greater effect than other factors such as altitude, accumulation rate, etc?).

Section 5 - It would help to be explicit about why the subglacial drainage systems of debris-covered glaciers are different to other glaciers, or at least to discuss based on some physical arguments why they might be different. Most of the studies quoted don't sound dissimilar from what might be found studying non debris-covered glaciers.

I581 - why does a proglacial lake increase the likelihood of some form of subglacial drainage?

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Section 6, l660 - is this section suggesting that debris-covered glaciers necessarily go through a cyclic behaviour involving growth and recession, purely through their internal dynamics, or is it referring particularly to glaciers that are retreating for climatic reasons? In regime two, 'surface lowering has begun', suggesting the glacier is not in balance, but it's not clear if this is thought to be *due* to the formation of the proglacial lake, or due to other external factors.

l747 - should this say 'variations in discharge' are muted? I couldn't see why discharge itself should be muted (other than due to differences in surface mass balance). The figure looks like it has a variance larger than the 1% quoted in the text - is this correct? Is it clear that the differences between these glaciers are due to the debris cover and not due to other factors (differences in catchment areas and travel times etc)?

Section 7 - the first paragraph here would have been good in the introduction.

l900 - this seems to be divorced from the earlier discussion and references. From what was described earlier it seems clear that there *is* some englacial and subglacial drainage?

For points 4,5 and 6, it would be helpful to hypothesise how these are likely to be different from other glaciers, on which more work has been carried out.

Figures - most of the figures are field photos. I think it would help to replace some of these with more schematics that demonstrate the *processes* discussed (more specific details than in figure 10).

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