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Interactive comment on "Debris cover and the thinning of Kennicott Glacier, Alaska, Part C: feedbacks between melt, ice dynamics, and surface processes" *by* Leif S. Anderson et al.

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This interesting and topical paper synthesizes a range of glaciological data to improve understanding of the process feedbacks between glacier flow, melt distribution under debris cover, and thinning, at a large compound Alaskan glacier. The ambition of the paper is welcome: there is an increasing output of papers dealing with one or two aspects of debris-covered glacier (DCG) monitoring and evolution, many based on state-of-the-art data gathering, but few attempts have hitherto been made to understand interactions at appropriate timescales, and to come up with integrative explanatory models. The paper bases its approach on mass continuity and the debris-thickness/melt

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relationship (the Ostrem Curve).

My general comment is that this is a rigorous and well-argued study which shows some interesting results, different from other papers I am familiar with. The core finding is that the interaction of ice flow, debris emergence, melt and thinning have produced a subtle "bulge" several kilometres above the terminus, marking the transition from active ice flow and debris emergence upstream to relatively stagnant, heavily debris-covered ice downstream. My surprise is that the active/stagnant transition is manifest as a convexity in the long profile, rather than a concavity as described in DCGs elsewhere. While Figs 2 and 5 are vertically exaggerated to show this subtle topographic evolution (as they must be), it is convincingly demonstrated. The transition corresponds to the kink in the downward limb of the Ostrem Curve at which the rate of sub-debris melting becomes less sensitive to debris thickness.

The paper raises some interesting questions, but also contains some inferences of cause-effect which are less well substantiated than others. There is perhaps a tendency in places to make easy inferences of causation based on only the available data, when other variables have not been considered. (This is not to denigrate the high-quality datasets presented). As such, I don't think it provides definitive answers to the problem of quantifying the feedbacks in these complex systems, but it does point to a way forwards.

Another issue (also in no way a criticism here) is that the literature presents the "debris-covered glacier" as if it is a single class of glacier: this is not the case. DCGs take many forms and origins, and are unlikely to have a single unifying model of behaviour and evolution. This study of Kennicott Glacier is of a very large compound valley glacier terminating in a proglacial lake, whose debris cover is fed by coalescing medial moraines. We might not expect models from this glacier to apply easily to (for example) smaller moraine-dammed DCGs whose flow is obstructed towards the terminus, or single-basin glaciers with transverse foliation. Perhaps some acknowledgement of this diversity would be appropriate.

It isn't clear from this paper (Part C of three) what the ice thickness distribution is, but this information would be useful. This is because, while velocity evolution is a key variable, the causes of velocity change and its distribution on the long profile are not covered, yet this information is essential for understanding the dynamic evolution of the glacier. I would like to see some consideration of the effects of both thinning rates and surface gradient changes on the driving stresses, to explore why the observed pattern of stagnation has developed: it implies a collapse in the driving stress from the terminus upstream, which in turn must be some combination of reduced ice thickness and slope. It is noteworthy (though largely unrecognised generally) that very thick, very gentle glaciers such as DCG tongues are sensitive to small changes in slope, at least as much as in thickness. So there is scope for a fuller explanation than is given in the manuscript.

I have some minor line-by-line comments to improve the presentation, and to correct minor editorial mistakes (attached).

Please also note the supplement to this comment:
https://www.the-cryosphere-discuss.net/tc-2019-178/tc-2019-178-RC4-supplement.pdf

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