Reply to Review 1 Part A follows the general response.

Our general response is here:

Thank you, Thank you, Thank you for taking the time to edit and review our manuscripts! We appreciate that this is a large body of work and that many of the reviewers read two manuscripts. And it has been a long process for the editor. We hope we can return the favor to each of you soon.

Below the reviewers and editor will find changes that we would like to make to each of the three parts. These changes are intended to address the issues related largely to the structure of the manuscripts and to make the overall study more rigorous.

Response to structural critiques

It is clear that a number of reviewers felt that the manuscripts should be combined in some fashion. While we can understand their perspective we also note that there is more than enough material for 3 manuscripts here. From Reviewer 3 from Part C:

"Moreover I believe that the main messages and findings of the three papers come in separate papers probably better across than in one huge one."

We would prefer that we are given the chance to improve the manuscripts such that a 3 part format works (especially considering the amount of new data, analyses, and conclusions we present across each of the three parts):

- *Publishing one paper after the next?* One possible solution would be to improve each manuscript make each one 'stand alone.' and then publish each manuscript one after the next. Such that Part B could cite Part A, etc. This could avoid the issues about simultaneous publication.

- *Combining the parts into one whole would create a large, complex, less readable paper.* If we were to combine the Parts into one whole the paper would easily have 30 figures, with 3 distinct sets of conclusions. This is the case especially because so little work has been published on debris cover from Alaska.

- *Combining individual parts will change the conclusions we have space to draw from the full body of work.* For this reason we feel that it is best that we are given the chance to make the 3 parts work together. The combination of the papers essentially diminishes, in our mind the impact of each component of the whole. Part A allows us to highlight important melt data that places Kennicott Glacier in context with other debris-covered glaciers, mostly in High Mountain Asia. Part B, introduces a novel ice cliff detection method that performs very well compared to other methods. And shows that Kennicott Glacier has a much higher density of ice cliffs than any other studied debris-covered glacier. Despite having so many ice cliffs they cannot compensate for the melt-reducing effects of debris cover. We feel that the ice cliff detection method is especially important to highlight. The proposal to have one paper would severely limit the space we have to highlight that contribution. Part C highlights new feedbacks that have never been identified before.

- *Combining papers will require that we hide some of our work in the supplemental or that we do not make that data available to other researchers.* Combining the papers requires that we 'hide' some of the work in the supplemental. For example, if we combine Parts A and B the discussion will become too complex to really put the in situ measurements in context with data from other glaciers from other regions.

- *Repetition and needing to look back at other Parts.* Some repetition is unavoidable, but some of the reviewers present a no win scenario. Where there is either too much repetition or not enough. Please see the proposed paragraphs we would add to each part as a means to clarify the structure.

- *Establishing an individual story for Part A.* We feel that building a better story for Part A would solve much of the reviewers' issues. We propose that the main conherent story be placing our mass balance data in context with data from other regions. This would be a vital contribution that places the Kennicott Glacier data in context and establishes a baseline for modelers wanting to go global with their analyses.

We find that the lack of agreement between the reviewers about how to combine the work or leave it the same is dependent on their individual background. For example:

- If the reviewer values in situ data then Part A should stand alone
- If the reviewer values assessing the in situ data while considering the melt extrapolation then Parts A and B should be combined.
- If the reviewer values new methodology then maybe Part C should be combined with Part B.
- If the reviewer values a comparison of melt and ice discharge reduction as the key then perhaps they propose to combine all 3 parts.

Because of the diversity of scholars studying debris-covered glaciers we felt that individual parts would allow different readers to engage the parts of the study that they are most drawn to. In order to make the 3 parts flow together better we propose to add these paragraphs to each manuscript:

"We present three papers which build on one another to address the control of debris on the thinning of the of Kennicott Glacier, Alaska. Each of the three parts builds upon the next. In Part A we present and analyze situ mass balance measurements focusing on the effects of debris and ice cliffs. Because scant mass balance data is available from debris-covered glaciers in Alaska we discuss these measurements in detail and place them in context with measurements from debris-covered glaciers in other regions.

In Part B, we develop a method for delineating ice cliffs and describe how we make distributed mass balance measurements across the debris-covered tongue. Because mass balance estimates, that include the effects of both debris and ice cliffs are rare even where debris-covered glaciers are more commonly studied, we discuss the importance of these estimates in the context of the thinning pattern of Kennicott Glacier.

In Part C, we introduce ice dynamical data which allows us to consider the roles of mass balance, ice dynamics, and surface processes on the thinning of Kennicott glacier. Our analysis uses the continuity equation as a guide. The intention is to treat the debris, ice cliffs, streams, ponds, and ice dynamics as components of a whole that interact to give rise to the thinning pattern of Kennicott Glacier."

The inclusion of these paragraphs will allow readers to move more fluidly between each Part.

Science critiques

For a some of the more major science critiques we address them in brief here and in more depth in the individual responses. For other scientific criticisms we refer you to our line-by-line responses to reviewers.

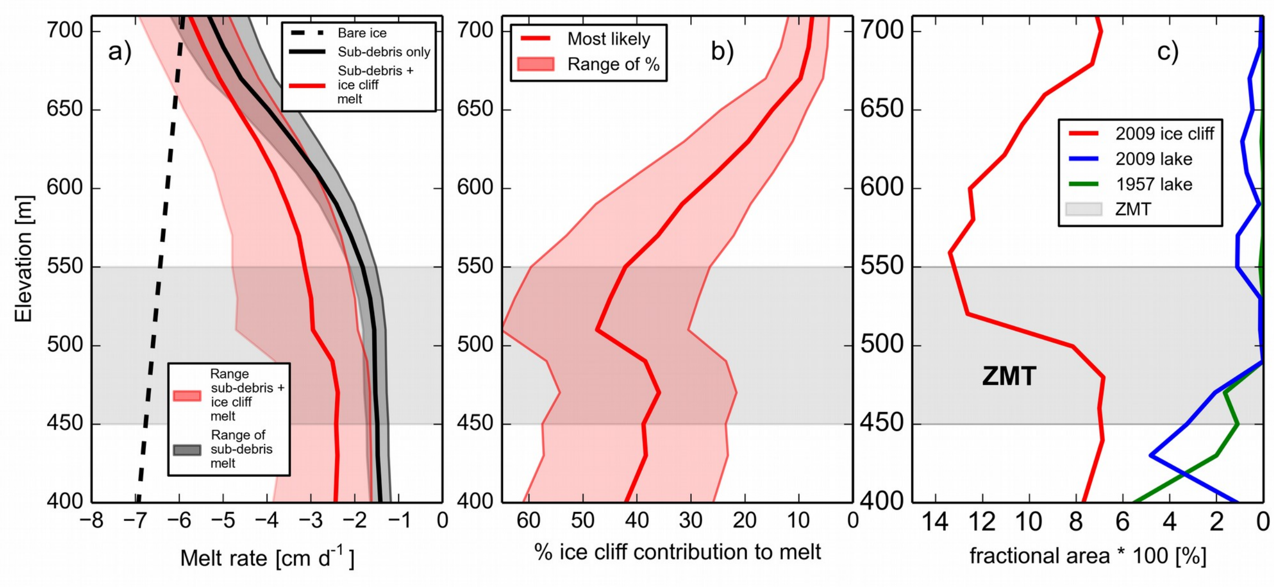
Melt factor issues related to off-glacier air temperature station (Part A)

Classical degree day factors are relative to the temperature data used to obtain the melt factors. So there is no absolutely correct meltfactor it is always relative to the temperature data. For energy balance models on-glacier temperature is required but off-glacier temperature is often more representative of the conditions of the atmosphere (they aren't so controlled by the boundary layer effects of the ice).

The melt factor correction is also very small we are simply adjusting data collected over a few weeks to a melt rate over the whole study period of a month and a half or so. If we did not include a melt factor correction our results and conclusions would be virtually the same. We will provide plots to support this in the revision stage.

Uncertainty analysis (all Parts)

A generous uncertainty estimate is already in the body of work. In Part B it must not have been clear that the red bands in Figure 10 are extreme bounds on the melt estimates. This needs to be clear. A small percentage of possible outcomes are outside this window. This plot also now includes in increased area when taking into account the slope of ice cliffs (following Evan's review).



We find that this is actually a more elegant way of representing the uncertainty that citing every value in the text with an uncertainty. We will include more uncertanties in Part A though.

Time coverage dh/dt from 1957 to 2009 (Part B)

We will present additional dh/dt data that covers the time period of in situ measurement.
Ice discharge change in time

We will incorporate additional annual surface velocities that show the change in velocity over time so we can estimate the change in ice emergence rate in time.

Including estimates of melt from ponds, streams, englacial conduits, and the sub-glacial environment (Part B).

We will include back-of-the-envelope estimates with extreme cases to explore their effect on the thinning pattern.

Part C reveals new feedbacks.

It seemed that some reviewers did not capture the new feedback we are highlighting from Kennicott Glacier. We wonder if their reviews would change if that feedback was better communicated by us?

Part A: proposed changes

We feel that there is more than enough new material here for a stand alone paper, but in order to improve the manuscript and create more of a storyline we propose that we add these additional datasets/ideas to Part A:

- Provide error bars for the data, if the plots are too messy we will but the figures with the error bars in the supplemental. Noting that these uncertainties are all less than the extreme uncertainty presented in Figure 10a of Part B.
- A detailed analysis to explain the scatter in the ice cliff backwasting rates and meltfactors.
  - Do they correlate with local debris thickness, streams, or lakes?

- Make a comparison of our in situ data with data from else where, likely showing that they are consistent
  - This is important for the important global studies that will be coming out related to debris cover.
  - We will make a broad characterization of the Kennicott Glacier in relation to other glaciers

- Global debris cover anomaly. Highlight that the debris cover anomaly is likely global. We will do this with long profiles of dh/dt from multiple glaciers in the Wrangell Mountains and their debris cover extent. One figure will be added that shows multiple thinning profiles. One table will be added that further shows this. Since the dh/dt data has already been published by Das et al., 2015 we will use this figure as motivation for the individual parts.

- We also have additional data related to the geometry of the ice cliffs that we measured. We will put these data in the supplemental of Part A.

- Add in the paragraph description that links each of the three papers and helps guide the reader through each manuscript.

Part B: proposed changes

We feel that there is more than enough new material here for a stand alone paper, but in order to improve the manuscript we propose that we add these additional datasets/ideas to Part B:

- We will add additional text supporting the usefulness of our new ice cliff detection method. In the supplemental we will include additional satellite photos showing how ice cliffs tend to be darker than the surrounding debris so this method can therefore be applied on other glaciers. We will also compare our method with other approaches from other glaciers.

- We will present new DEM differences from 2007 to 2013. These dh/dt data show that the zone of maximum thinning remains in the same spot as for the period from 1957 to 2007. We will also include additional laser altymetry data from 2007 that shows a similar thinning pattern.
  -This will address one of the main criticisms from multiple reviewers.

- We will introduce back-of-the-envelope calculations of the possible effect of englacial melt, sub-glacial melt, melt under pond surfaces, and melt by streams. This will clear up any issues related to this manuscript not being comprehensive with regards to melt hotspots.
  - We will not include stream digitizations in this manuscript because we cannot possibly digitize all streams on the glacier surface (imagery is too coarse). The streams play more into the feedbacks in Part C. We will instead make arguments about the surface area coverage of streams and their plausible effect on surface melt.

- We will use a uniform curve fit through the ice cliff backwasting data. And also explore the effect of other curve fits, producing different figure 10a and 10bs which we will put in the supplemental and discuss in the main text.

- Add in the paragraph description that links each of the three papers and helps guide the reader through each manuscript.
- Make sure it is clear how generous the uncertainty estimates already are in this paper. One of the reviewers missed these error estimates completely.
- Emphasize the increasing importance of ice cliffs under thicker and thicker debris.

Part C: proposed changes

We want to emphasize here that we do outline new feedbacks in this paper.

From Reviewer 3 from Part C:

“P 2 line 62-63: importantly in part C you not just present data on ice dynamics and supraglacial streams but crucially in part C these data and all components of the mass conservation equation (thinning, flux divergence. . .) are analysed for relation and feed-backs between them. Also say this here, as it is the backbone and most exiting part of this part C.”

On Kennicott Glacier there is a strong correspondence between ice cliffs and active ice flow. While weak relationships have been suggested here on Kennicott the correlation is more clear than anywhere else.

The highest concentration of ice cliffs occurs at the upper end of the zone of maximum thinning. The high concentration of ice cliffs also corresponds to where we expect ice emergence rates to be high. These ice emergence rates uplift the glacier surface, working to counter glacier thinning. But ice dynamics, which produce this surface uplift also seems to produce more ice cliffs (see the physical descriptions within the main article). These ice cliffs counter the effect of surface uplift, they are essentially a negative feedback on the effect of ice dynamics.

In addition to this new feedback we also present a number of new hypotheses for the interaction of surface processes with melt and ice dynamics with a new, holistic perspective.

We feel that there is more than enough new material here for a stand alone paper, but in order to improve the manuscript we propose that we add these additional datasets/ideas to Part C:

- New annual surface velocities from 2000-2010
  - These velocities allow us to calculate changes in ice emergence rate and ice flux over the in situ measurement period
  -More detailed discussion of the reduction of ice emergence rate through time.

- Delineation of drainage basins on the glacier surface (new figure) to support the stream story already within the manuscript.

- Tie in a discussion about glacier surface topography. Ice cliff maximum heights (from in situ measurements), the number of individual ice cliffs with elevation band, and calculated glacier surface relief down glacier.

- New processes drawings to show the important new observations that we are highlighting in this paper. This will greatly improve the reader’s ability to see the new process links we are describing.

- Additional photo evidence from the field outlining these new processes links. Many will go into the supplemental but they will support and clarify the process links we are highlighting.

- Description of a new ice cliff burial mechanism. Timelapse movies from the Kennicott and Ngozumpa glaciers (in the supplemental) showing a new mechanism for the burial of ice cliffs. The actual process is not yet described in detail in the text.

- A paragraph that is the same for each of the 3 parts that outlines how they build off of one another.

Reply to Reviewer 1 Part A

Review of “Debris cover and the thinning of Kennicott Glacier, Alaska, Part A: in situ mass balance measurements” by Anderson et al.

Thank you for taking the time to review our manuscripts.

This study is the first part of three publications that investigate debris cover on Kennicott Glacier in Alaska. Given the limited number of studies that measure properties and melt rates of debris-covered glaciers, these measurements and results are important for advancing our understanding of debris-covered glaciers. This is especially true when one considers the limited knowledge of debris-covered glaciers in Alaska. The measurements and results are presented well. For the most part, the study is easy to follow, well-written, and has sufficient references.

There are a few sentences/paragraphs that could be modified to improve their readability though. The only major comment is to make sure that this study is discussing results that specifically pertain to this part of the three-part study. There are also a couple places where additional detail or analysis would provide useful context to the modeling community; however, this would only require minimal additional work. Therefore, I recommend accepting this manuscript for publication subject to minor revisions. Please see my detailed comments below.

Thank you kindly. We very much appreciate your efforts, especially considering you reviewed two manuscripts.

Main Comments

The reasons for studying Kennicott Glacier largely come across as reporting results across the three papers as opposed to stating what each paper does. For example, L55-57 state that the debris is thinner than most previously studied, but there is no reference to any studies concerning debris thicknesses on Kennicott Glacier. Similarly, L58 states there are more ice cliffs than those previously studied without a reference to a study that shows this. Hence, these appear to be results (and results from other papers) that are stated in the introduction.

We did this because the papers are complementary. We feel that in the case of these three papers they come across more coherently if we include some of the justifications from the later papers. We aren’t sure this is so bad, especially if we cite those works especially since those results are well supported and reviewed simultaneously. Do these 3 papers need to be completely independent in the way this reviewer suggests? And grow from Part A to B to C? Or can we bring in justification from Parts B and C to A? As we presented here we feel that tying in the justifications from later Parts makes this work more compelling. But we can adjust this if needed.

Furthermore, the introduction states multiple times that the thinner debris increases the likelihood that melt hotspots will compensate for the insulating affects; however, thinner debris has higher melt rates, so it’s unclear why melt hotspots would be more important for debris-covered glaciers with thinner debris because there would be less contrast between the sub-debris and ice cliff melt rates. If this is a hypothesis, then please state it this way. If this is supported by a physical basis, then please explicitly state this reasoning.

It is not about the relative contribution of hotspots to sub-debris melt but rather a comparison of absolute melt rates. That is a big point here that we will emphasize better. The absolute melt rate is what matters for the debris covere anomaly.

It is the net melt (sub-debris + hotspots) compared to the bare-ice melt rates at the top of the debris cover. Or another way to put it is: where is the maximum glacier-wide melt rate? And does it correspond with the zone of maximum thinning (concept introduced later in the paper series)

Lastly, the interpretation of the transverse variations of debris thickness appear to be poorly supported by the present figures and text. L135-139 state that mean debris thicknesses increase near the glacier margins. However, site a appears to be closest to the center of the glacier, yet it has thicker debris. Similarly, site c is between sites b and d. Perhaps this is complicated by how far downglacier these sites are, but this needs to be elaborated upon. The same is true for the conclusion, where this is discussed. I would suggest removing this from the conclusion.

We see the reviewer's point. We can also slightly change the wording to highlight that the debris thicknesses are also controlled by the englacial debris concentration and the full strain history of the debris. But that there is a tendency for thickening down glacier and towards the lateral margins.

Specific Comments
Italics indicate suggested grammatical changes

L26 - use of "thick" and "thin" is a relative term. I suggest adding in parentheses what constitutes thick and thin.

We will add this distinction.

L35 – consider "and, when thick, suppresses melt rates." or "and suppresses melt rates when thick."L39 – this sentence is missing its subject, so it's an incomplete sentence. Consider using a semi-colon instead or adding the subject "Alternatively, this anomaly could be caused by...". Also, "or" and "alternatively" are repetitive.

L41 – referring to the debris-cover anomaly here almost across as a result, i.e., Kennicott Glacier experiences the debris cover anomaly. If this is already known, then the reference should be added. If this is not known, then consider changing this sentence to give a broader overview of what's being done, e.g., constrain patterns of ... to understand the role of surface melt and ice dynamics on the surface lowering of Kennicott Glacier.

We are considering adding an assessment of the debris-cover anomaly in the Wrangell Mountains as part of the results. This would add quite a bit to the study and emphasize the potential global nature of the phenomenon

L55 – it's not entirely clear why thinner debris would affect the anomalous glacier thinning explained by melt hotspots, since thinner debris will have melt rates that are closer to clean ice. Also, are there previous debris thickness measurements of Kennicott Glacier? If so, this should be cited; otherwise, the fact that Kennicott Glacier has thinner debris than those previously studied is a result.

Thank you for the comment, we need to clarify this. If rapid thinning under debris cover is primarily caused by melt (hot spots + sub-debris melt) then we are most likely to see this effect where debris is thin and sub-debris melt rates are high. The basic logic we use throughout the 3 parts is: if melt rates are the primary control on thinning then melt must also be maximized where thinning is greatest. Having thin debris already creates high melt rates, adding a high coverage of ice cliffs means that both components (hot spots and sub-debris melt) are extreme for Kennicott Glacier. We will make this clear in the updated manuscript.

We will move the results to the results section as recommended.

L60 – It remains unclear as to why thin debris increases the likelihood that melt hotspots will compensate for the insulating effects of debris.

It is very simply that thin debris reduces melt less than thick debris relative to hypothetical, local bare ice melt rates. If you have a glacier with thick debris cover melt suppression will be higher relative to hypothetical local bare-ice melt rates and will require a much higher contribution of melt from hot spots to compensate for the insulating effects of debris.

Conversely, the way the argument is stated sounds like melt hotspots cannot compensate for the insulating effects of debris on glaciers; however, because the debris on Kennicott Glacier is thinner, the sub-debris melt rates are closer to clean ice melt rates and hence the melt hotspots are less important because there's less of a difference to compensate for. The key here seems to be more on the sub-debris melt rates of thin debris than the melt hotspots. Please clarify this.

We are happy to clarify this in the text. Thin debris represents an extreme case where melt rates are already higher, adding on a high concentration of ice cliffs means that we are likely to get high melt rates in the debris-covered area.

L61 – typo "similar" should be "similar"

L72 – typo in the reported elevation range? Also, is there a reference for this data? RGI inventory perhaps?

L73 – consider "... and our study area, the debris-covered tongue of Kennicott Glacier (24.2 km 2), is only..."

L77 – be consistent with reporting elevations. Perhaps "Above 700 m a.s.l.". This should be done throughout the manuscript as well, e.g., L90, L131, L134, caption of Figure 1 "located at 1240 m a.s.l.", etc.

L77-79 – is there a reference for these observations?

We could cite LSA's dissertation here. Or move this out of the introduction following the other comments.

L86 – What do you mean by "Kennicott Glacier debris"? The debris properties? If so, state this "Because the debris properties of Kennicott Glacier have not been..."

We will clarify this.

L88 – consider "internal and surface debris temperatures, and ..."Figure 1 – delete the ")" after panel b in the caption. Change to elevations to m a.s.l. May Creek meteorological station is not shown on the map. I suggest adding this – perhaps it is covered by one of the legends.

We will fix this.

Figure 2 – caption is unclear. "Dead" ice portion has daily mean surface velocities greater than 5 cm d -1 only during sliding events? Is this meant to be less than 5 cm d -1 with the exception of sliding events? Also, what does "and the observations of Rickman and Rosenkrans, 1997" refer

to? Fix this reference.

We will clear this up. But we are following the interpretation of “dead ice” from Rickman and Rosenkrans at this point, which also match slow velocities even when sliding is at it’s maximum in the summer following Armstrong et al., 2016.

L107 – Avoid the use of unnecessary acronyms like LR for lapse rate. This only makes the manuscript less readable, especially for readers who may not be as familiar with a specific acronym.

We will fix this.

Figure 4 – The 4 panel figure is highly repetitive (e.g., shortwave radiation is shown in all 4 panels, and the MWS air temperature is shown in both panels). I would recommend using only 2 panels. Air temperature can easily show the 3 sites, and the two lapse rates can easily be shown on the same figure by using different colors or styles.

The problem is that the figures become too difficult to read following this suggestion. We are not sure that this is a big issue.

L128 – This line doesn’t make sense “at 109 locations at the same locations we also measured”. Is it means to be two sentences? Otherwise, perhaps “around the locations where we measured ...”.

We will clarify this.

Table 2 – is 0.001 cm an actual measurement? That is incredibly precise and thin for a debris thickness, which is hard to believe.

We will clarify this. You are right.

L135-139 - It would be helpful to provide context to the specific sites (panels) for each of these sentences, e.g., “debris thickness did not exceed 15 cm (Fig. 6c)”

Helpful thank you.

L144 – Given the use of MF (used by Pellicciotti et al. 2005) instead of DDF (used by Hock 2003), I would consider either changing the “MF” to “DDF” or add the example citation of Pellicciotti et al. (2005). Note that in some fields MF or DDF could refer to multiplying multiple variables. I leave it up to the authors as to whether they want to maintain this original convention or adopt newer uses of it (e.g., degree-day factors shown as f ice (Radić and Hock, 2011)).

Also very helpful. We will clarify this and add relevant citations.

L148 – Why the use of off-glacier air temperatures when you have data from on-glacier air temperatures? It would be interesting to see the off-glacier air temperatures over the same period of time – perhaps this could be added to Figure 4 as this would provide some indication of how much the debris warms the air temperature?

We use the off-glacier air stations because we do not have measurements for the full time period of the field campaign from on glacier. There is a local station in McCarthy but it is not automatic and is recorded only during work hours for the airport. For melt factors it is also common to use off glacier sites and they actually perform better than on glacier sites often times. The idea is that on glacier sites are affected by the ice surface itself but really what is controlling available energy for melt is the integrated temperature from the lower 1 km of the atmosphere.

In addition to this the meltfactor correction provides a minor correction to the melt rates. We include this to be complete and correct measurements for difference measurement intervals.

L153-157 – Given the impressive amount of data collected, it is disappointing that the authors do not provide a "best-fit" Østrem curve for comparison with other sites. While there is considerable variability in surface lowering, especially over thin debris that is dependent on local conditions as the authors state, this is clearly something that would affect all previous curves. Is there a good reason the authors did not do this? This could be a highly beneficial product for modelers. If uncertainty is the issue, the authors could easily add uncertainty bounds to the curves.

We can certainly include a curve fit. Along these lines we will also provide a 'debris-covered tongue wide estimate of melt if the area was totally debris covered.

L176-177 – What does the "mean" debris surface temperature refer to? Is this the mean temperature over the entire study period (at least one week) or was this used to estimate conductivity on a shorter time period? I assume it is the former, but it may be good to be explicit, e.g., "... we then calculate K e for each temperature profile over the entire duration of the temperature measurements.". This would avoid any misunderstandings because the effective thermal conductivity could vary over time, e.g., if there was a change in debris moisture.

Thank you for this comment. We will clarify this in the text. It is the mean temperature over the entire study period (at least one week).

Figure 9 – Why is there a point for a debris thickness of 0 with an effective thermal conductivity of 0 W C -1 m -1 ? This seems to be unphysical. I also question the "nonlinear" increase in thermal conductivity as a function of debris thickness. There appears to be a fair amount of scatter such that a linear fit might also produce a reasonable fit? Furthermore, if the (0,0) point is discarded, then the linear fit will likely cross the x-axis around 0.4 – 0.5 W C -1 W -1 , which is near the lower range of that estimated based on physical constants (L181; Nicholson and Benn, 2006). Hence, this would be more physically based. Lastly, why is thermal conductivity plotted on the x-axis? The way this is used in the statement seems to be how thermal conductivity varies due to debris thickness and not the other way around. Hence, the debris thickness is the independent variable (typically plotted on the x-axis) and the thermal conductivity is the dependent variable.

These are all good points and we will remove the zero point and reconsider the conclusions and non-linear statements, emphasizing that this is a minor change to the scientific conclusions we draw.

L181 – I question "The apparent non-linear increase". See comment above. It would be good to at least see a linear fit as well.

We will re-evaluate this and change the text as suggested.

L182 – typo, "may be due to..."

L185 – it would be valuable to make assumptions concerning the specific heat capacity and porosity such that a comparison could be shown for the differences in thermal conductivity based on the method.

This is a nice suggestion and we can add a discussion of this in a revised version of the manuscript.

L206 – type "were made..."

L205-206 – were these debris thicknesses already known from the previous debris thickness and ablation stake measurements or were these new measurements? Furthermore, how many "data points" were collected?

L214-218 - why the switch from backwasting rates to backwasting melt factors? It would be easier to read if it were consistent.

Figure 12 – caption, "based on the individual melt factor..."

L227 – shouldn't have to restate acronym, although see previous comment about removing it altogether.

L233 – "related to the large areas..."L245-248 – consider changing these sentences so that two sentences in a row don't start with "But..." as this should make it easier to read and understand.

L255 – Please state the percentage of debris thickness measurements that were derived from the top of ice cliffs to provide the reader with some sense of if this was for 50% of 100% of the measurements. "The majority (X%) of our debris thickness measurements..."

L278-279 – This sentence about Part B is confusing. What does estimate if ice cliff melt rates correspond to the location of maximum thinning under thick debris on Kennicott Glacier mean? Is "under thick debris" meant to refer to the debris-covered glacier? A specific part of the glacier? Or literally the areas where the debris is thickest? I assume this is generally referring to the debris-covered glacier, but please clarify to avoid confusion.

We will clarify these points.

L281-285 – Is (1) different than (2)? Or is the poor representation of air temperature due to using the off-glacier meteorological data, which does not account for the variations in air temperature above the debris? Also, having sentences in the middle of these various points is very hard to read. I would suggest making these three separate sentences.

We see what the reviewer means. This could be clarified with a bit more explanation.

L285 – What does this sentence of the portion of fine material have to do with ice cliffs? This seems very out of place and appears to refer to the section on thermal conductivities.

This section is actually about ice cliffs (3.4 Ice cliff backwasting). Just needs a bit more of a clear explanation. We will add this text but the point is that finer debris is better able to stay on ice cliff surfaces while more coarse debris trundles down the ice cliff. The more fine material in the debris cover the more-likely that fine material is to adhere to the ice cliff surface. We will add photos of this effect to the paper to emphasize this potentially important control on backwasting rates.

L297 – missing Oxford comma, which seems to be used throughout the rest of the manuscript

L300 – "transverse debris thickness patterns broadly correspond with surface velocities" is out of place and perhaps meant for paper B or C. This paper showed no data on surface velocities.

We can also make a more hypothetical statement here.

L302 – may want to acknowledge the limitations that were described in the discussion, i.e., that most debris thickness measurements were from on top of ice cliffs and so caution should be used when using these for tuning and validating distributed debris thickness estimates as they may underestimate the actual debris thickness.

We will consider this suggestion further.

L305 – reconsider "non-linear" relationship. See comment above. Furthermore, is the larger point that "water" or "porosity" plays an important role in heat transfer? They are certainly related to one another, but most of the discussion seemed to focus on the role of finer debris and porosity. This should be consistent in the conclusion.

We agree and will re analyze the conductivity conclusion.

L308 – there is no evidence in this paper that the ice cliffs counteract the insulating effects of thick debris. More appropriate would be to summarize how the backwasting melt rates compared to the sub-debris melt rates. If this is a conclusion from Part B, then it belongs in that paper.

This just requires a subtle change in the wording or how the sentence is read. But we will not bring in results from Parts B or C to this manuscript.

References (thanks for including these. Very kind)

Pellicciotti, F., Brock, B., Strasser, U., Burlando, P., Funk, M., and Corripio, J. (2005). An enhanced temperature-index glacier melt model including the shortwave radiation balance: development and testing for Haut Glacier d'Arolla, Switzerland, Journal of Glaciology, 51(175):573-587.

Radić, V. and Hock, R. (2011). Regionally differentiated contribution of mountain glaciers and ice caps to future sea-level rise, Nature Geoscience, 4:91-94.

In addition to the changes proposed in the text above we propose these changes:

Part A: proposed changes

We feel that there is more than enough new material here for a stand alone paper, but in order to improve the manuscript and create more of a storyline we propose that we add these additional datasets/ideas to Part A:

- Provide error bars for the data, if the plots are too messy we will but the figures with the error bars in the supplemental. Noting that these uncertainties are all less than the extreme uncertainty presented in Figure 10a of Part B.
- A detailed analysis to explain the scatter in the ice cliff backwasting rates and meltfactors.
  - Do they correlate with local debris thickness, streams, or lakes?

- Make a comparison of our in situ data with data from else where, likely showing that they are consistent

- This is important for the important global studies that will be coming out related to debris cover.
- We will make a broad characterization of the Kennicott Glacier in relation to other glaciers

- Global debris cover anomaly. Highlight that the debris cover anomaly is likely global. We will do this with long profiles of dh/dt from multiple glaciers in the Wrangell Mountains and their debris cover extent. One figure will be added that shows multiple thinning profiles. One table will be added that further shows this. Since the dh/dt data has already been published by Das et al., 2015 we will use this figure as motivation for the individual parts.

- We also have additional data related to the geometry of the ice cliffs that we measured. We will put these data in the supplemental of Part A.

- Add in the paragraph description that links each of the three papers and helps guide the reader through each manuscript.