

## ***Interactive comment on “Persistent Tracers of Historic Ice Flow in Glacial Stratigraphy near Kamb Ice Stream, West Antarctica” by Nicholas Holschuh et al.***

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Dear Reviewer:

Thank you for your thorough evaluation of our manuscript. Your comments on the paper's structure were appreciated and have ultimately led to a clearer narrative. Below we outline the organizational changes made in response to your review, and provide point-by-point response to your technical suggestions.

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### **1) Changes to the Introduction**

The original introduction was designed to separately emphasize the work's contributions to ice-sheet reconstruction methods as well as its contribution to the specific paleo-proxy record for the Siple Coast. We understand how that structure could seem fractured, and include material that was redundant, so we have eliminated the section headings and reorganized the introduction to provide the clearer progression you requested. Now, we introduce current paleo proxies (P1 L18 – P2 L6), indicate how englacial structures can act as paleo-flow proxies (P2 L7 – P2 L13), and finally discuss how persistent tracers could help us understand the complex Siple Coast Ice Streams (P2 L14 – P3 L8). We believe this fits your recommended structure of (1) scientific background, (2) what englacial tracers can contribute, and (3) how they will be applied to our study area.

### **2) Section 2.3 – Environmental conditions required for erosion**

We never viewed this section as a line of evidence, per se, for the formation mechanism of the unconformity. We simply thought it was necessary to address the existing literature on unconformity formation, and provide context for how surface scour may be possible over Mt. Resnik despite the high accumulation rates in West Antarctica. For a more logical structure, we have moved the original section 2.3 into the discussion section of the paper (P7 L9 – P7 L31).

### **3) Section 3 – Results**

We agree that the first paragraph of section 3 feels out of place – much of the content has been cut, and what remains has been integrated into the introduction. However, much of the discussion of unconformity geometry would lack context if it were introduced before the data. As a result, we chose to keep what could be considered an “introduction to unconformities” here, but we have renamed section 3 to “Results and Discussion”. We have also eliminated the section division between “possible mechanisms” and “favored mechanism”, and adjusted phrasing in text to eliminate any re-

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peated rejection of the disfavored mechanisms.

**Technical comments:**

*P1 L27. Ross et al., 2011 not in reference list?*

On our version, Ross et al. 2011 was included in the original reference list, P12 L17.

*P2 L9. Suggest a rewrite of "limited to reconstructions of behaviour \*outboard\* of current margins" as meaning not immediately obvious.*

Rewritten to clarify that we mean outside the ice-sheet margins (P2 L2).

*P2 L24. Stylistic point - I think "centennial timescales" is more standard than "century timescales"*

We have updated this to centennial.

*P3 L15-21. Check whether the in text referencing to Figures is correct. Text states Fig 2.B shows unconformity but caption and image itself show conformable layers. 2.A is similarly contradictory.*

This error reflected a previous version of the figure, which had since been updated to include additional panels. We have fixed these references in the current version of the manuscript.

*P6 P24. It would be clearer is the specific figure panel was referred to in text – e.g. Fig 4a, etc.*

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Fixed.

*P7 L1-7. Is Mechanism 2 mutually exclusive from the other mechanisms?*

We do not view any of the mechanisms as mutually exclusive, but rather end-member scenarios that could result in the unconformity geometry. We have changed the text to better reflect this. Mechanisms 1 and 2 allow the formation of a time-transgressive, kinked unconformity under steady-state conditions, unlike mechanism 3 which is formation by non-steady forcing. Ultimately, we find the steady-state mechanisms unsatisfactory, thus, it must form by some evolution of surface processes.

*P7 L12-14. The meaning of the sentence "This way, snow...in the radar data" is unclear. Does the blue ice area explain the unconformity? Or does the change from "quiescent" or "turbulent" snow deposition?*

In order for this time-transgressive feature to exist, the formation zone must extend from near Mt. Resnik (where the 6000 year old portion of it formed) to an area nearer to where the unconformity is observed in our data (where the 1000 year old portion formed). Thus, the observed blue ice cannot be the entire area modifying the stratigraphy. We hypothesize that surface reworking downstream of the blue ice area also disturbs the depth-conductivity profile. As the blue ice area (and its downstream expression) expand, areas formerly unaffected by the blue ice zone are now being disturbed, leading to a conductivity contrast associated with that time of transition, and an imageable unconformity. We have made subtle changes to the text on P6 L12-15 to hopefully make this clearer.

*P8 L12-13. I wouldn't say basal friction, accumulation or melt are "spatially locked" as all three are emergent and dynamic boundary conditions in ice sheet flow and, therefore, stratigraphy.*

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We did not intend to imply that any of these properties are inherently spatially locked, but that, in the event they are spatially locked, they result in a persistent tracer. We simply mean that long lived features exist that affect the ice-sheet system through each of these pathways (subglacial topography, subglacial geologic features like sedimentary basins, or even “dynamic” features like lake Vostok which perturb the surface elevation and resulting accumulation field).

*Fig 3. It would be informative to see an indication of the radar unconformity zone and modern ice flow mapped onto the current Landsat-8 identified modern day blue ice areas.*

One thing we struggled with in making the figures for this paper is providing all the relevant coincident data sets. Currently, Figure 3 does provide the unconformity zone relative to the blue ice area – the only thing missing from your request is the modern flow field. We did reconstruct this figure including the flow paths plotted in Figure 1c, but felt it was cluttered and harder to interpret. As a result, we decided that it is best to leave this figure as is, and rely on Fig 3a and Fig1c together to provide the reader with enough context to understand the system.

*Fig S1. Caption L4. “un” typo.*

Fixed

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Interactive comment on The Cryosphere Discuss., <https://doi.org/10.5194/tc-2018-58>, 2018.