

# **'Holocene thinning and grounding-line retreat of Darwin and Hatherton Glaciers, Antarctica' by Hillebrand et al. to *The Cryosphere***

Reviewed submitted 18 January 2021 by Dr. Lauren Simkins (University of Virginia)

## **Review summary**

This study integrates cosmogenic exposure ages and numerical modeling to investigate the history of Darwin and Hatherton glaciers. The major conclusion is that the two glaciers are in-sync and experienced 500 m of thinning between 9,000 and 3,000 year before present. While the geochronology is convincing enough to support the major conclusion, the addition of some of the model brings novel insight to SMB and ice flux that sheds light on the geochronology. However, the flowline modeling work beyond experiment 1 is not supported by the geochronology (which is the backbone of this study) and, in my mind, unnecessary.

Very little motivation and broader significance is presented, leaving the reader either not convinced of the importance of the study or having to do extra work to make those leaps on their own. In both the abstract and introduction, the problem, questions, and broader significance are completely lacking. I urge the authors to explicitly address "why is this study needed/timely/significant?" and "what can we learn from small catchments of the TAM during/since the LGM?" The text is dominated by results, some of which seem unnecessary to present which end up shrouding the important results/interpretations. Careful consideration is needed regarding what results and methodological details to divulge and to what degree they are integral to the story. The text would benefit greatly from revision of the introduction, results, and conclusion.

In summary, the study has significance for understanding the history of Darwin and Hatherton glaciers. I, however, think the impact of this work is underdeveloped as it is currently written. Explicit hypotheses or questions would go a long way in boosting the importance of the study to better understand (a)synchronicity of neighboring glacial systems and relatively small glacial systems of the TAM and EAIS in general.

## **Line comments**

### *Abstract*

16: explicitly state what is the Ross Sea Ice Sheet

20: as an example of removing unnecessary words, the phrase "of Darwin and Hatherton **g**laciers" is not needed, rather implied

21-22: remove "Our modeling shows that" and start with "The constraints"

23: replace semicolon with period and capitalize "rapid"

29: change to "...convergent ice flow from..."

Throughout text when using a series of proper nouns with a shared word, like in reference to more than one drift deposit, valley, or glacier, the correct grammar is to not capitalize the shared word; therefore, you should write e.g., "Darwin and Hatherton glaciers".

### *Introduction*

Prior to section 1.1, *what* was done is mentioned but not *why* the work was done; therefore, the text in its current state will likely not engage a broader audience who works outside of the Ross Sea/Transantarctic Mountain region. Some of the text from sections 1.2 and 1.3 - sections that would benefit from being more concise - could be reworked and moved up to set the stage for this work. Otherwise, as written, there is a considerable amount of text to read before any motivation/significance for the study can be gleaned.

35: remove "In this paper," and capitalize "we"

36: first use of "D" in main text; therefore, rephrase to 1.5-dimensional (D)

41: an updated chronology for the offshore record in the context of terrestrial chronology is provided in [Prothro et al. \(2020\) in QSR](#) that would be interesting to consider in this study, which suggest major reorganization of the EAIS grounded in the Ross Sea during the Holocene.

110: replace last glaciation with "LGM"

111: modify to read "...thickening grounded ice..."

146: exhumation by what process?

150: specify by what magnitude of time is considered "prolonged" - hundreds to thousands of years?

157-160: as an example of making the text more concise throughout the manuscript, here is the original text:

[King et al. \(2020\)](#) were able to date the advance and retreat of Hatherton Glacier in the Lake Wellman valley using radiocarbon dating of freeze-dried algae. They showed that the glacier advanced to the Britannia-I limit at 9.5 kyr BP, and argued that both the majority of their own exposure ages and those of 160 Storey et al. (2010) were overestimates due to prior exposure of the samples.

And here is what I would suggest:

[Based on radiocarbon dating of algae in Lake Wellman, Hatherton Glacier advanced to the Britannia-I limit at 9.5 kyr BP suggesting exposure ages in the region were overestimates due inheritance from prior exposures \(King et al., 2020\).](#)

169: Still by this point in the text, motivation, significance, questions, and/or hypotheses are not *explicitly* addressed. Also it would be useful at some point to address how the study is organized: first present the chronology/thickness changes and interpretations and then modeling to help explain the geological observations.

### *Records of glacier fluctuations*

I suggest having one subsection for Dubris, Bidra, and Magnis valleys and Lake Wellman and another for Brown Hills, Diamond Glacier, and Diamond Hill, followed by the summary section

203: Goehring et al. (2019a) I presume

203-208: why mention the failed preparation technique in detail rather than simply referring to the Nichols and Goehring (2019) manuscript? That is six lines of text that could be half a line to one line of text.

221-222: move up to preceding paragraph

247: remove "if the ages at the...of prior exposure,"

253: remove "Based on...along Hatherton Glacier". Modeling results have not been presented yet, and I presume you went into the model with the indication that you could use the chronology from the sites together representing a single system.

276: remove "()"

305-307: Considering modern ice-flow velocities that suggest flow solely due to internal deformation, paleo-evidence of warm-based ice indicates a major change in ice-bed coupling and the potential for major changes in magnitudes of ice flow velocity. I think this is an interesting point that is not taken any further, but could be followed up on in either/both the modeling or/and discussion section.

403-409: suggest removing all text starting with "we prefer..." to the end of the paragraph

### *Numerical modelling of glacier fluctuations*

Both "modelling" and "modeling" used in the text .

Combine sections 3.1-3.3 and make more concise, particularly information in section 3.2 should be in section 3.1 to explain constraints on variables.

432: remove first sentence

443: rephrase to "...grid point (c.fl., Golledge et al., 2014)."

444: curious what range of basal sliding is used here that is considered plausible

447-450: rephrase to "While we have limited information available to constrain the values of the sliding and deformation, inferred patterns of these parameters generate a surface elevation and velocity profiles that match modern values within their uncertainties."

450-451: this sort of statement would be best at the beginning of section 3.1 to explain why the modeling work was conducted.

461: I would argue that you are not investigating the role of catchment geometry, rather catchment flow change which could result from a number of glaciological changes.

Section 3.3 can be much shorter and, like mentioned above, integrated into a combined section with 3.1 and 3.2

473: are you estimating 2-sigma uncertainty? Or calculating it? Not clear what is being done to geologically constrain centerline positions for the model...

480: "Figures 10-12."

481-486: seems out of place

For the transient experiments, I would argue that experiments 2 and 3 are distracting and not useful in the scheme of the work presented here. It is interesting to note in the discussion that these small glacial systems show no geological evidence for rapid thinning. Experiment 3 could be retained if authors feel that can be justified given lack of constraints and seemingly arbitrarily chosen LGM ice thickness. I am, however, a proponent of the presentation of negative results, but feel like these extra steps in the modeling are not supported or justified by the geological observations and thus do the study a disservice by distracting readers with unnecessary negative findings that do the opposite of what the modeling work is supposed to do - which I interpret as aiming to help explain the geological observations.

### *Ice sheet model ensemble*

I am largely on board with this work, but think the text could be much more concise (apologies for repeating that point).

*Discussion* is fine; however, broader significance for other small glacial systems in the TAM and beyond could be integrated here.

*Conclusion* would benefit greatly from not being written as a list. I suggest that authors have a go at linking the findings and major outcomes between the geochronology and the modeling work. As currently written, the reader has to do a lot of work to piece the listed bits together and come away from this text with take-aways that will invoke further thought, questions, and applications.

### *Figures*

The figures look really nice.

Figure 1: the bathymetry colormap you have used is not categorized, like the legend suggests. Include Bidra Valley

Suggest combining figures 2 and 3, figures 4 and 5, and figures 6 and 7.

Make sure consistent reference to figure panels, e.g. figure 3 caption that uses "(a)" and "panel c"

*References* were not checked.

### *Supplementary documents*

Units for ages in the data table are needed.