Review of "Local stress models do not predict observed crevasse patterns at Greenland's marine terminating glaciers"
by Enderlin and Bartholomaus, for *The Cryosphere Discussions*

Summary of manuscript

This manuscript describes a new, large dataset of lidar-derived estimates of crevasse depths on Greenland outlet glaciers and compares these depths to calculations by two simple, physically based models for crevasse depths. As in its earlier draft, the manuscript reports that the data-derived and model-based depths are "unrelated" and thus crevasse depth models have questionable utility. Compared to the earlier draft, this version briefly acknowledges the shortcomings in the central dataset, and adds comparison with a second crevasse depth model.

Concerns about validation

New datasets, particularly ones as large in scope as the one presented here, are typically validated before they are used. Unfortunately, no validation was done for this dataset. Therefore, it is hard to have confidence in the authors' conclusions that local stress models are inaccurate. This is my first major criticism with the work presented.

The authors' justification of their V-shape model (lines 131–138) remains problematic. They advocate that a crevasse initially forms as a V, and later processes, like serac toppling, cause deviations from a V. This manuscript assumes "negligible fracture extent beyond the bottom of the V", but as I pointed out in my previous review, crevasses in lower surface stress regimes are more irregular than a V and tend to quickly go off-nadir with depth. For example, Figure 1a in Smith et al. (2015) is a field photo that shows a near-surface cross section of a Greenland crevasse in a lower-stress setting. The surface expression (a V, rough depth estimate 3 meters based on the scale of the person in the background) gives way to a curved, inclined fracture of at least the same depth beneath the tip of that V. For the outlet glacier crevasses the authors here are studying, the deviatoric stresses are higher and the V shape extends much deeper, but below the tip of the V, where the stresses decay, this field photo should be representative. Clearly, beneath the tip of the V lies a narrow, fractured plane that is not measureable by a lidar with a 1 meter footprint.

The authors attempt to quantify the ability of the lidar to locate the "true crevasse bottom" by comparing up-glacier to down-glacier swaths (lines 155–158). Unfortunately, this does not actually evaluate the accuracy of the lidar, merely its repeatability. The 1 meter footprint of the lidar is too large to measure sub-centimeter fractures, and this will be the case regardless of the direction of flight or the time of day.

The revision contains a few added sentences (lines 85-89) that address (but does not put to rest) the above concern.

> "While the full crevasse depth is unmeasurable from glacier surfaces, we assume here that the depth of the visible, near-surface void space is positively correlated with the full depth of the crevasse, which likely extends beyond the depth of the void space. We

refer to the maximum, visibly open depth below the surface as the observed crevasse depth."

First, "observed crevasse depth" is misleading, since full crevasse depth is not actually being observed. I suggest "observable depth" or "observed minimum depth", which I perceive as more accurate.

More importantly, this assumption needs to be tested (the dataset validated). It may well be the case that the depth of the V is correlated to the full depth of the crevasse. However, it may not. It is unreasonable to discredit long-standing theories with an unvalidated dataset that the authors "assume" is correlated with truth.

Concerns about correlation analysis

The authors have reframed some of their discussion to emphasize the lack of correlation between "observed" crevasse depth and modeled or expected crevasse depth. However, a lack of correlation should be the expected result, due to the two significant limitations inherent to the dataset: (1) scan angle limitations described in my first review, and (2) the false approximation of a V-shape described above. For both these reasons, and as now mentioned in the manuscript (lines 131–138), the crevasse depth "observations" are minima.

An attempt to compare truncated depth "observations" with model-based predictions that span a full range of depths will clearly return no correlation. This is indeed what the authors find, yet they attribute this to deficiencies in the models.

The above forms my second major concern with the analysis: the known bias in the dataset renders it (as currently presented) unable to test the accuracy of any models. One idea the authors might pursue to address limitation (1) above is selecting only crevasses whose sensed depth-to-width ratios are within the range of the lidar.

Review conclusions

Overall, the dataset requires validation, and the manuscript needs to more responsibly represent the limitations of the "observed depth" dataset throughout the manuscript. It is evident that a lot of work went into producing this dataset. Therefore, I hope that the authors can think deeper into the limitations of the data, then validate the dataset so that it may be used for analysis.

References

Smith, L. C. et al. (2015), Efficient meltwater drainage through supraglacial streams and rivers on the southwest Greenland ice sheet, Proceedings of the National Academy of Sciences, 112(4), 1001–1006, doi:10.1073/pnas.1413024112.