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Interactive comment on "Poor performance of a common crevasse model at marine-terminating glaciers" *by* Ellyn M. Enderlin and Timothy C. Bartholomaus

Anonymous Referee #2

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In this paper the authors compile a new dataset of crevasse depths derived from lidar swaths made by IceBridge flights over 19 different glaciers in Greenland. They compare their very extensive observations with a commonly used crevasse depth model introduced by Nye and based on strain rates derived from satellite velocities. They conclude that the Nye model that has been used as a calving criterion is flawed as it appears to overestimate crevasse depths compared to observations in this study. This is a really interesting and well-written paper and I thoroughly enjoyed reading it. In many ways, the finding that the Nye model does not work very well is almost the least interesting outcome of this research, and in fact this is also one of the less novel findings, nonetheless the persistent use of the Nye model as a fracture criterion sug-

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gests that the ice modelling community has yet to absorb this message! I very much appreciated the results and discussion sections which raised many familiar points related to the difficulties in translating velocities to strain rates and stresses as well as attempting to refine the Nye Depth model. It's likely beyond the scope of this work but I look forward to future work examining the implications for a fracture mechanics approach to crevasses based on or related to the present study. The authors have done a huge amount of work and their crevasse depth dataset as well as the lidar techniques they have developed will surely be of great value for future research into the problems and processes of ice fracture on outlet glaciers. Given the hazards of measuring and observing crevasses in the field, the development of these kind of remote sensing techniques are crucial for advancing the field and many of their findings are replicating similar findings from field studies albeit on a smaller scale. Some further specific comments: 1) Perhaps the main issue with the study is the assumption that the lidar technique actually reaches the bottom of the crevasses. As extensive discussion in Colgan et al (2016) and van der Veen (1999) (a missing reference that would perhaps help to interpret their results) also showed, defining the "bottom" of a crevasse is surprisingly difficult. The authors assume a v-shape is the standard shape, but field studies indicate that the fracture often penetrates substantially further than is easy to measure with plumb lines or laser scanning techniques and the reported measured depths are usually best understood therefore as a minimum depth. A better model of crevasse shape may be an initial v-shape (partly also due to ablation processes) that narrows but extends with sides almost parallel to each other for some distance. Observations of fractures from within ice caves would also support this shape. There is no reason to believe that the lidar technique would not suffer from similar issues as manual measurements and while I think it would be unreasonable to redo all the calculations with a different profile since we don't have a clear idea what this might be, I think it would be helpful to discuss the implications if the v-shape model turns out to be an oversimplification. The authors to their credit do discuss this to some extent but their explanation on lines 110 to 124 is a little unclear and should be expanded further,

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also when considering the results. 2) Similarly the authors mention falsely identified crevassses (line 105) but it is not clear how this was done. Please expand on this and roughly how many were positive/negative. 3) In the crevasse depth comparison with modelled depths section (3.2) there are several statements that are a little confusing; on line 244, it is stated that the model failed to predict crevasses in compressional zones, but Nye's model explicitly only calculates crevasse depths where there is a positive (extensional strain) so this is not surprising – was there an extensional strain across glacier rather than down glacier in these zones that could be used? Other studies have also used the strain ellipse rather than simply the longitudinal strain rate. 4) The acceleration of an outlet glacier does not necessarily lead to enhanced longitudinal strain rates across the whole glacier, did the acceleration of Inngia Isbræ lead to a significant increase in strain rates (Line 254)?

Minor comments: Line 17: Surely this should be "are both affected by and affect" Line 60: Given that the crevasses were mostly around 6m in depth I don't think a water depth of 1 to 10 m can be described as "small" – sorry a picky point... Line 90-91: Sentences that use brackets to denote the reverse condition are really hard to read, it's better to write this as two separate sentences (alsu required by e.g. AGU style guide). Line 155: remove "a"

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