The comments from the reviewers are in black font and our responses are in blue font.

As the other reviewer mentions, I think the authors should be clear on the uncertainties within their estimates of the advection and production timescales, and how does this propogate through to δ. What is the maximum and minimum value that δ can take given these uncertainties on the stress threshold, glacier length etc.? Where might this assumption not be valid?

This is a great point. We have added text in the revision to provide clarity about this point. δ depends on both the advective timescale (which itself depends on the characteristic length scale and velocity scale of the glacier) and the fracture timescale (which is set by the damage model; in the case of the Pralong and Funk model, this depends on the stress scale, the damage rate factor B, and the damage exponent r). It does not depend on the stress threshold, which only sets the spatial locations for which fractures will begin to accumulate. The fracture timescale parameters we use are taken from experimental results and thus are calibrated for ice.

The range of values that δ may be in ice are shown in the shaded regions of Figure 2 (which is now redone to show results for 1000 year simulations, rather than 1 year simulations, based on a suggestion by the other reviewer). As is pointed out in this review, this depends on things like the glacier length scale, which can vary between glaciers. We intended this to be a broad range that could encompass many different ice sheet glacier configurations, though we have set up this theory so that the advective and fracture timescales can be individually calculated for any simulation a modeler wishes to run to determine whether their setup allows for the diagnostic damage model. This assumption would not be valid, for instance, for representing rapid fracture processes on a short timescale (e.g. rifting and calving events), as demonstrated by the δ parameter space.

The supplement is significant, and I think it would be helpful to move some of it into the main text. In particular, I think Fig S2 and the accompanying text would be helpful to further show that this diagnostic model is still valid in less idealised configurations.

We agree with this point. We have moved the comparison between the transient and diagnostic models in a 2D (less idealized) configuration into the main text, in a new section 2.5: Reconciling the Diagnostic Damage Model with Other Damage Models in 2D. This section presents comparisons between the diagnostic damage model and two other commonly-used damage models: Pralong and Funk 2005 model and Sun et al. 2017 model (see Figure 1 of this response). We show that, with consistent model setups, the diagnostic damage model replicates both of these model results very well and produces very similar ice mass loss estimates.

The rest of the supplement is primarily extra parameter sensitivity studies (e.g. other melt scenarios, mesh sizes and timesteps, $D_{\max}$ values, choice of pressure calculation) and other experiments for comparison to the MISMIP+ experiments (Ice 1ra, a simulation out to 500 years rather than 100 years) and therefore, we believe, aren't needed in the main text for the ultimate takeaways of the paper.

Line 324: Am I correct in thinking that limiting the value of Dmax effectively limits the maximum softening caused by damage? Such that Dmax = 0.5 gives a max softening of 8 etc.? If so this may be helpful to explain in the text.

Yes this is correct and is now formally stated.

Fig 5: The label for (b) (i) ?Damage field after 100 years? is directly over a subplot for t=0 years: this label should be changed for part (b) of the figure.

Changed to "Damage fields".

Supplement Line 119: WhenIf

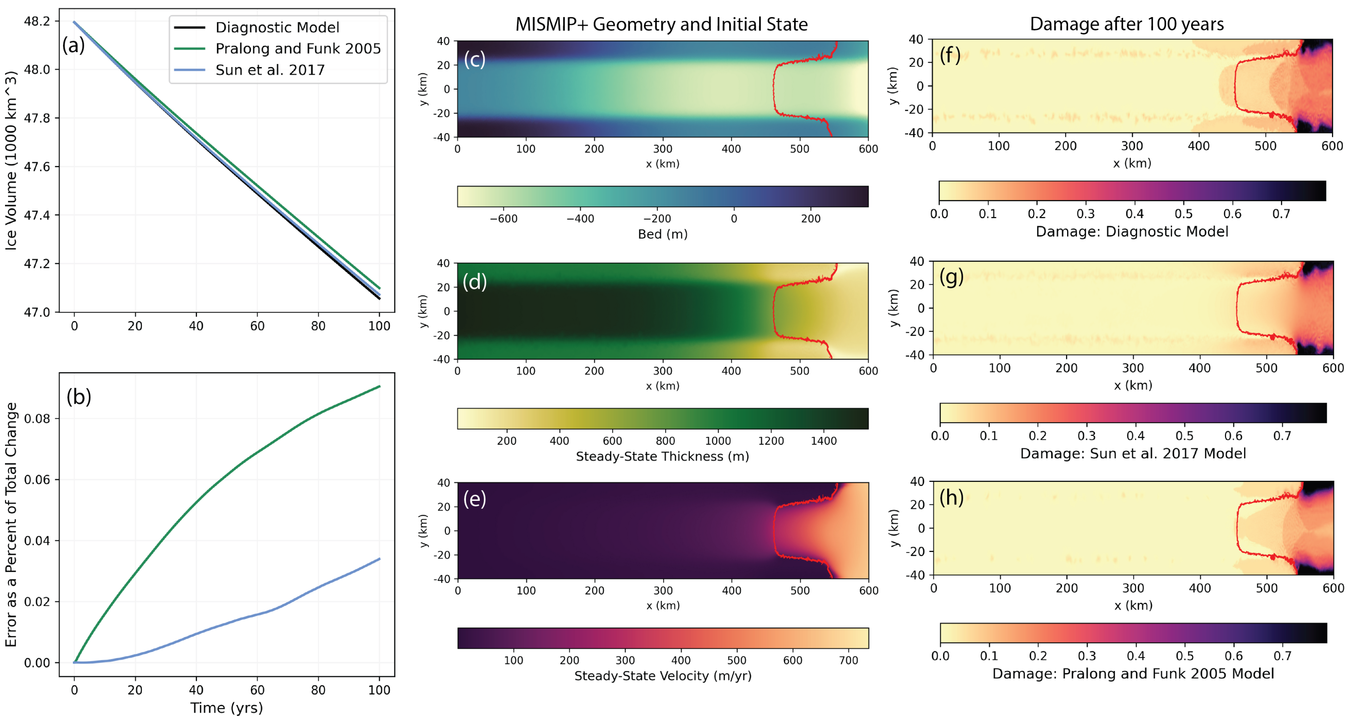

Figure 1: **Comparison between 2D transient and diagnostic damage models:** We set up a 2D model geometry as prescribed by the MISMIP+ configuration [1] and run this from a steady state (c-e) without climate forcing with couplings to three different damage models: the model of [2], the model of [3], and the diagnostic damage model proposed in this study. We will refer to the models of [2] and [3] as "full" models. We show mass loss as estimated from each of these three models (a) and the errors between the full models and the diagnostic damage model (b). The error is reported as the mass loss from the full model coupling minus the mass loss from the diagnostic damage model coupling, scaled by the total mass loss from the full model coupling. We show the final damage fields after 100 years for each of the three model couplings (f-h). The red line denotes the grounding line position.

Fixed.

References

[1] Xylar S. Asay-Davis, Stephen L. Cornford, Gal Durand, Benjamin K. Galton-Fenzi, Rupert M. Gladstone, G. Hilmar Gudmundsson, Tore Hattermann, David M. Holland, Denise Holland, Paul R. Holland, Daniel F. Martin, Pierre Mathiot, Frank Pattyn, and Hlne Seroussi. Experimental design for three interrelated marine ice sheet and ocean model intercomparison projects: MISMIP v. 3 (MISMIP +), ISOMIP v. 2 (ISOMIP +) and MISOMIP v. 1 (MISOMIP1). *Geoscientific Model Development*, 9(7):2471–2497, July 2016.

[2] A. Pralong and M. Funk. Dynamic damage model of crevasse opening and application to glacier calving. *Journal of Geophysical Research*, 110(B1):B01309, 2005.

[3] Sainan Sun, Stephen L. Cornford, John C. Moore, Rupert Gladstone, and Liyun Zhao. Ice shelf fracture parameterization in an ice sheet model. *The Cryosphere*, 11(6):2543–2554, November 2017.