We thank the reviewer for their comments that will help improve the quality of the manuscript. The reviewer's comments are highlighted in blue with our response and how corresponding changes to the manuscript below in black.

Major comment 1: numerical experiments

The model capabilities are demonstrated with two closely related sets of experiments: they differ in that experiment 1 (unpinned) has no pinning point and experiment 2 (pinned) has two. Here, a pinning point is a local rise in the bedrock where the glacier front will tend to less motion. These are idealized experiments, and well chosen to demonstrate the ultimate capabilities of the model. However, the results are not sufficient to demonstrate convergence with mesh spacing, and clearly show that the results do *not* converge with decreasing time step in either the pinned or unpinned case. The authors do note the lack of convergence in the unpinned case where it is most obvious.

Looking at table 1 (a summary of all experiments), we see that as the time step decreases (2d->1d->1/2d-1/4d) the retreat rate in the pinned case (BTW the column labels are incorrect in table 1) follows the sequence 2.51,3.31,2.99,3.67. This is not convergent: the difference between successive elements is not decreasing. This might improve with yet smaller time steps. In the unpinned case (which is at least as likely in real glaciers as the pinned case) the sequence is clearly diverging. As it stands the method cannot be used with any confidence.

As for space convergence: pick four resolutions following a geometric sequence for each case (e.g 80,40,20,10 m). Then correct (or not correct) behaviors will be evident. It does look from the figures presented as though the unpinned case will not be convergent but the pinned case might be.

Many authors would hide these flaws (or not check at all) and I don't think they are fatal for the paper, but further experiments could show why they occur. The text hints (and I think is probably correct) that the crevasse depth law is the cause rather than the remeshing procedure per se. But this can be tested: carry out simulations with a simple calving rate.

Firstly, to clarify the argument we put forward in the paper, when we discuss 'convergence' we are specifically talking about the predicted changes in terminus position that stem from the calving law. This is not the same as numerical convergence. In the manuscript, we made a conscious effort to discuss and demonstrate the utility of the crevasse depth (CD) law as it represents one of the leading options for a universal calving law. The effects of a position based calving law are rarely discussed in the literature and unlike rate-based laws cannot be related to the numerical convergence of the velocity solution. As the reviewer notes, this distinction between the effects of the calving law and potential numerical convergence issues was not clear in the manuscript.

The crevasse depth calving law predicts the location of attractor points within the advance and retreat system of the glacier. Therefore, when a glacier is in transient state (i.e., the case with no pinning points) the rate of change can be altered by unphysical parameters such as timestep. However, when a clear attractor is present the terminus centres around this point. When altering the unphysical parameters, we described this as converging.

Following the reviewer's comments, we have clarified the distinction between the effects of the calving law and the novel algorithm for implementing any law. An additional set of experiments was run using a rate based calving law of the form:

$$C = \boldsymbol{u}_s - R,$$

where C is the calving rate, $\mathbf{u_s}$ is the surface velocity vector at the terminus and R is the prescribed scalar retreat distance normal to the terminus. Additionally, experiments have been conducted using this rate-based law with an R value of 1500m/yr. These experiments clearly show that there is limited discrepancy introduced through the remeshing methods (Fig. 1 and Table 1). The algorithm thus exhibits numerical convergence, but solutions based on the CD law can exhibit parameter-related variance in some circumstances. We have taken care to make this distinction clear in the revised text. The results of the additional experiments using the rate based law will be provided in the supplement of the revised manuscript.

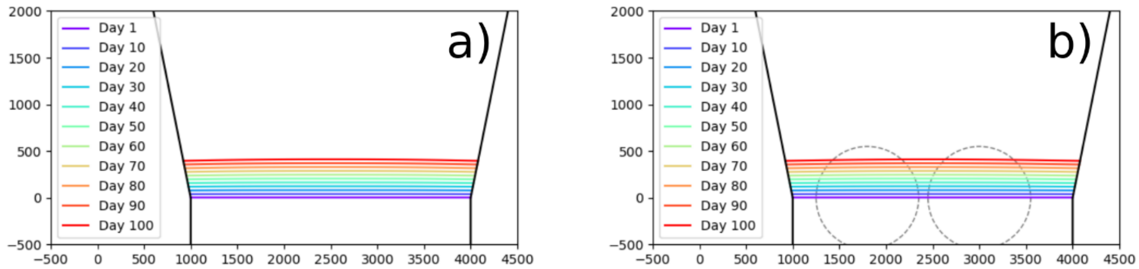

Figure 1. Terminus positions through time using a rate-based calving law where the retreat has been specified as 1.5km/yr on a) the domain with no pinning points and b) with pinning points. The outline of the pinning points is shown by the dashed circles.

Table 1. Summary of the mean retreat rates for 100d experiments testing the non-physical parameters using a rate based calving law. The table produced for the redrafted manuscript will include all the relevant variables tested on the crevasse depth calving law

		Mean retreat rate (m/d)	
Non-physical parameter	Experiment	No pinning points	Pinning points
Control		4.07	4.06
Timestep	0.25d	4.06	4.06
	0.33d	4.06	4.06
	0.5d	4.07	4.06
	2d	4.07	4.06

Major comments 2: presentation

I found the paper quite disorganized, at multiple levels. In my opinion it requires a wholesale rewrite.

We have reorganised the paper as requested by the reviewer.

Many parts of the text are difficult to understand, they are usually descriptions of some model behaviors or feature without examples of quantification, so as a reviewer I am not able to say whether they are likely to be correct or not. This is particularly acute in section 4.4, where numerous algorithmic details are mentioned but it is not clear how they are implemented – following this paper to implement the ideas in (say) ISSM would be impossible.

The reviewer notes an issue we have struggled with when choosing the best way to present the paper. We felt the best compromise was to provide the full algorithm details as a supplement (all 53 pages) which is available outlining everything needed to implement the method within another model. This supplement is too long and method heavy to be of interest to the vast majority of the community and so most of this material has been omitted from the main text. We felt it was more important to show an analysis of the CD law, because this is the only calving law previously used in detailed 3D modelling studies but limited sensitivity testing had been performed. As the reviewers note there may be some confusion created by reference to details only outlined in the supplement and we have tightened up the main text accordingly.

Figure 3 is overall a very useful figure, providing a set of diagrams that explain the whole procedure well. It does have a minor flaw: there are no scales and figures are presented at different scales. I can make out what is going on in each case, but published figures should be made with more care. The color scale legend labels in panels a and h are too small.

The figure has been adjusted to include scales for each panel and the colour legends have been made larger.