Comments to "A leading-order viscoelastic model for crevasse propagation and calving in ice shelves" by Zarrinderakht et al.

1 General comments

In this paper, the authors coupled a boundary element method with the viscous ice-flow model, in order to combine the cracks propagation process with the viscous ice-flow model. The authors improved previous elastic models by using the real geometry at the time of crack propagation in their calculation. This work is potentially valuable to the cryosphere community, where the fracture and calving models are poorly developed.

However, I find the manuscript is hard to follow. This is partly because it's heavily citing other papers, some hasn't been published (Zarrinderakht et al., submitted), and some are not well known in glaciology. Furthermore, some of the key reference, which is used to describe the numerical solution, is wrongly cited. I hope the authors could improve the writing by being accurate, and bearing in mind that fracture mechanics is not widely implemented in ice-flow models, and some concepts are not well known (not as good as Stokes equations, for example). For example, when introducing equations, not only cite the original publication but also put the essential equations in the paper; also describe the physical meaning of the variables and equations in more details. I suggest a major revision to this manuscript. I hope the authors can put some effort in the writting style. There are some specific examples in the following comments.

Abstract: The authors mention they solved the fracture mechanics problem on the actual domain geometry. I think here actual domain geometry here doesn't mean real glacier/ice shelf, but solve the cracks boundary. This is slightly misleading. Nevertheless, can we use observational datasets to validate the model?

The key novelty of this work is the implementation of the boundary element method. A general description of boundary element method and why it's a good solution for the crack propagation problem (advantage) should be necessary?

2 Specific comments

L31: Unit of extensional stress is missing

L110-L114: Give the physical description of equations (5a).

Equation (7), extra comma

Citation of Figure 1 is missing. It should be somewhere in section 2.1. Furthermore, the first figure citation in the main text is Figure 5a, which is also unusual.

Equation (10), consider indicating h_w and s in Figure 1 sketch.

L156: a d→and

L192: where... the sentence is not finished (?)

L194: $t_i \rightarrow t_c$

L205: $\partial\Omega_b^+$ should be $\partial\Omega_s^-$?

Equation (21): delete the negative sign before 0.

Line 237: Again, try to cite figures in order, e.g. Figure 2a?

L250: The authors are using stress and displacement matching method to estimate the static stress intensity factor. The stress matching method requires high degree of mesh resolution to obtain accurate value. Did the authors implement convergence studies on this problem? What would be the relative efficiency compare to the J integral approach?

L261: "We assume that such short cracks are readily available as material flaws in the ice shelf...". Does this sentence indicate cracks can potentially develop everywhere (with tensile effective pre-stress) with the rate defined by equation (24), although only at the predefined locations in this study?

L299: "sea spring" scheme is not a well known scheme in glaciology (at lease to me). Furthermore, the citation Durand et al., 2009 does not has section 3.4 and is not about handling the normal stress condition. Therefore, this part and the rest of that paragraph is quite unreadable to me.

section 2.5: How sensitive is the model to temporal ($\delta t/10$) and spatial mesh resolution?

L335: Describe the physical meaning of Rxx and $\tilde{R}xx$ rather than cite the variable from other references.

L363-: Again, these variables (same with κ mentioned a few times) are cited from other papers (especially unpublished) without explanation. Very hard (if possible) for the readers.

L386: correct the unit of temperature

L406: Are d_b^{tot} and d_t^{tot} crack lengths at the bottom and top, correspondingly?

L416: variables are repetitive

L417: $h_b, h_t \rightarrow H_b, H_t$?

Figure 2: no units for t?

L436: 'can begin', delete 'can'

L447-L451: Figure 2b1 and Figure 2b2 should be Figure 4b1 and Figure 4b2

L461: involve-¿ involving

Figure 4: are there some plotting issues such that the axes are smaller than the domain?

Figure 7: same problem as Figure 4, the axis is offset, and there are two blue lines in the panels.

section 3.3: Could you present a figure with the mesh on top, so we can see the finite element mesh in the calculation domain as well as the boundary element?

L478-479: What are the different element sizes tested here? I think a proper mesh convergence study should be conducted and presented.

Section 3.4: In L346 and L362, $\tau*$ and $\eta*$ are described as 'a constant', while these are actually the two essential forcing parameters tested in section 3.4. For these important parameters, the physical meaning should be clear, and the chosen of the ranges should be justified.