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Interactive comment on "Ice shelf rift propagation: stability, three dimensional effects, and the role of marginal weakening" *by* Bradley Paul Lipovsky

Anonymous Referee #2

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The paper "Ice shelf rift propagation: stability, three dimensional effects, and the role of marginal weakening" by Bradley Paul Lipovsky presents a study on the stability of central or marginal rifts for different boundary conditions. The stress intensity factors are computed with the displacement field from a three-dimensional finite element model assuming linear elasticity. These factors are then used as a criterion if the rift is stable (critical stress intensity factor is larger than the computed stress intensity factor) or not. Marginal weakening by free slip or water pressure destabilizes rifts that originate in the margins and central rifts are always found to be stable.

General comments: - What is the value the author uses for the critical stress intensity factor Kc? In the text, there is no explicit value given.

- Could the author please include the text of both appendices in the main text? The

points that are discussed there are critical for the comprehension of the paper. There is no reference to the Appendix and it is not directly clear, for instance, why the author uses the displacement in one direction only dependent on one critical stress factor of a certain loading mode (displacement direction method). The author can also shortly discuss that this method/approximation has first-order accuracy.

- At the moment it is also not clear which equations the author uses for the numerical finite element and which only for the analytical solution. For instance, Eqs. (1)-(3) are only used for the analytical solution. Is this right? For the numerical solution, the displacement field can be derived with three-dimensional elasticity and the different boundary conditions and then in a post-processing step the stress intensity factors are computed out of the displacement field. Then the author should mention this procedure in the text that it is directly clear for the reader. Maybe it is then also better to solve Eqs. (6)-(8) for the stress intensity factors: KII(z)=. . ..

- Does the author also consider rifts that are not filled by water? The water cannot percolate in all rifts occurring in an ice shelf, for example, if the rift is too far away from the ice front also dry (not filled by ocean or melt water) rifts can exist. How is the stability of dry rifts? Maybe the author can also add a short comment on these studies in the text.

- Figure 3: the arrows for mode II should also be plotted at the rift edges as the author did it for mode I and mode III.

- What is the minimum element size along the rift? Did the author a mesh convergence study to also verify that the results are not mesh dependent (a crucial check if one would consider stress intensity factors at the crack tip).

Specific comments and questions: - Eq. 6-8: I do not have access to the Tada et al. 2000 paper, but are the factors in these equations right? I found in Gupta et al. 2017 ("Accuracy and Robustness of Stress Intensity Factor Extraction Methods for the Generalized/eXtended Finite Element Method") sqrt(r/(2*pi)) and mu/(4-4*nu). Could the author please check the equations.

- Equations: Why do the author sometimes use an equality sign and sometimes the sign for identical statements with three strokes above the other (see Eqs. (2) and (3))? For example, Eq. (1) and Eq. (4) are both statements how the stress component or the stress tensor for the boundary condition is computed.

l.58: the traction boundary condition should be zero (stress-free boundary due to zero pressure) at the top of the ice shelf. The author only gets non-zero values as the simplified assumptions of Weertman and Reeh are used. Here, a comment that these results are not necessary for the finite element formulation could be helpful for the understanding of this paper.

l.93 and Fig. 2: The geometry of the rift in the figure looks like a rhomb, but in the text the rift is described with a uniformly 10 m width and only near the rift tip it is tapered. Could the author update the figure that it fits to the description of the rift? The author already states in the caption that the width and shape are exaggerated but if the author could also include the width of only 10 m in the figures, it will be clearer that LEFM could be applied where an infinitesimal small crack tip is absolutely necessary.

l. 98: Is the perturbation stress tensor the deviatoric stress tensor? Can the author also include the word deviatoric to make it directly clear for everyone and maybe add at the end of the sentence “times identity tensor”? Eq. (4): Why is the pressure boundary condition only applied for the deviatoric stress tensor and not as common to the total (Cauchy) stress tensor?

Figure 3: Could the author please add a legend to the plots A, B, D, E? Could the author please also use capital letters for the reference to the figures, see for instance l.154,155.

Why does the author choose slightly different density values of 0.9 (l.55) and 0.89 (l.263)?

l. 265: What are the boundary conditions for the case studied in Fig. 3? At each boundary water pressure? Why are all computed values of this geometrical factor negative in Table A1 (2D and 3D)? Is this due to the boundary conditions acting in an embayment? Does this statement mean that a rift longer than 217m will never be stable in a free-floating ice shelf?

Fig. 1: The author should add in the caption of this fuigure that the boundary conditions on the side of the ice shelf are too far away to have an influence on the rift. If this is not the case, then the bending moment of the water pressure at the side counteract the closure of the rift top by the opening of the rift.

Fig. 4: Why are the orange and blue curves for alpha»0.5 not reaching or converging to the red curve? The boundary conditions of free slip or water pressure are in this case far away from the rift and therefore the difference of all three cases should be minimal.

Fig. 6B: Shows the red curve in this figure not an unstable rift if alpha is in between 0.1 and 0.3? For the stress intensity factor of the shearing mode (Mode-II) it is sufficient for rift propagation that the magnitude is greater than 1 (cf. l. 228).

Technical corrections: title, l. 97, ...: standardize the spelling of three-dimensional (cf. l.3) with hyphen l.2: sea-level rise Fig. 2: Adjust the case sensitivity after a semicolon for “Entirely” and “half” l.128: delete that mue is the elastic shear modulus and nu is the elastic Poisson ratio as both of them are already introduced in l. 103 l.131: dependence instead of dependence l.169: either “approach to approximate” or “approach approximating” l.172: add a s to results: “the final results of Eqs. (11)- (13) are compared” Equations: They should be referred to by the abbreviation "Eqs." and the respective numbers in parentheses, see l. 172, l. 261, l.309

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