

Response to comment by C. Plate (original comments in gray box)

We thank C. Plate for her useful comments and suggestions which have helped us to improve the paper.

The present paper provides an extensive comparison of the crack depths of measured bottom and surface crevasses and modelled crevasse depth using linear elastic fracture mechanics. The authors name several approaches for the evaluation of the depth of closely and wider spaced crevasses. The choice to take a model for wider spaced crevasses is motivated by radar.

General remarks:

The authors conclude from several GPR data series that the width of the basal crevasses is several hundreds of meters (p. 2041) with a height of 100-200m. The LEFM approach following Rist et al. (2002) applied in section two implies the presence of a sharp (Griffith) crack, where the crack width is much smaller than the crack depth/the length of the flaw. On p. 2047 the authors also mention this requirement, yet not further respect it in the analysis. An aspect ratio of crack width/crack depth larger than 0.1 should not be considered as sharp and therefore the method of Rist et al. (2002) should not be applied in this situation.

The crevasses we investigated have been modified for up to 100 years (19km at 190m/a) since their formation nearer the grounding line so the current aspect ratio is not indicative of the conditions at formation. Following other authors we assume that the crevasses formed almost instantaneously closer to the grounding line where appropriate conditions for the application of LEFM principles existed, and they have been widening through creep and melt ever since.

On p. 2046 the authors argue that ice can be treated as brittle linear elastic solid in the context of fracture mechanics. This tacitly assumes elastic material parameters, the Young's modulus and the Poisson's ratio, even though they are not explicitly incorporated in the calculation of the stress intensity factors for stress boundary value problems as present in this paper. The assumption at hand of a lithostatic stress state in the ice (p. 2047) is only valid for incompressible materials (Poisson's ratio = 0.5). Literature of Greve and Blatter (2009) or Schulson and Duval (2009) show that ice on the short time scale should be treated as compressible solid with Poisson's ratios ranging from 0.2 to 0.4. Compressible material behaviour demands for a more complex evaluation of the normal horizontal stresses acting to close the crevasses. Fracture mechanical analyses treating ice as compressible solid can be found in Rist et al. (1999) and Hulbe et al. (2010).

Yes, there is probably always an even better, more exact approach. But LEFM modelling has been used many times before in this context and our comparison to an established approach will be of interest to others, especially as there is some consistency. We do not claim that this approach is perfect, but merely test it as the most widely recognised model for crevasse propagation in ice.

Minor remark:

with regard to reproducibility of the modelling part of this paper it will be helpful to display (as an equation or a graph) the depth dependent horizontal stress function that leads to the evaluated stress intensity factors in Fig. 6.

The horizontal stress is, as stated, a balance of longitudinal stress, overburden pressure or lithostatic stress, and water pressure. All boundary conditions are given or referenced and we do not think a further figure or equation would enhance the paper.

Thanks.