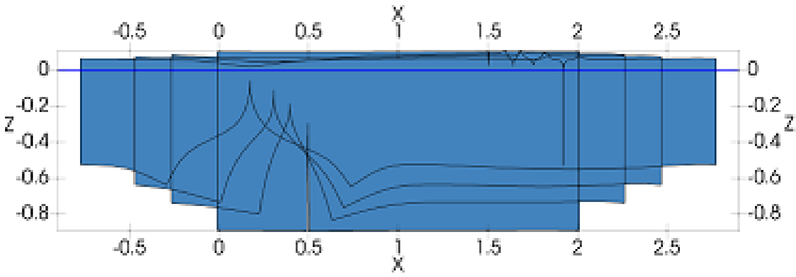
EGU23-1190, updated on 24 Apr 2024
https://doi.org/10.5194/egusphere-egu23-1190
EGU General Assembly 2023

A periodic visco-elastic model for crevasses propagation in marine ice shelves

Maryam Zarrinderakht[1], Thomas Zwinger[2], and Christian Schoof[1]
[1]University of British Columbia, Earth, Ocean and atmospheric science, Vancouver, Canada
[2]CSC-IT Center for Science, Espoo, Finland

Calving is a key mechanism that controls the length of floating ice shelves, and therefore their buttressing effect on grounded ice. A fully process-based model for calving is currently still not available in a form suitable for large-scale ice sheet models. Here we build on prior work that treats crevasse growth in the run-up to calving as an example of linear elastic fracture growth. Purely elastic behaviour is confined to short time intervals, much less than a single Maxwell time (the ratio of viscosity to Young's modulus) in duration: this is typically hours to a few days for cold polar ice shelves, depending on temperature and state of stress. We explicitly recognize that the elastic stresses occurring during fracture propagation act on an ice-mass subject to a pre-stress created by long-term viscous deformation. By coupling a boundary element solver for instantaneous elastic stress increments and the resulting fracture propagation with the Elmer/Ice Stokes flow solver that computes the pre-stress and is able to model the long-term evolution of the domain, we are able to show how viscous deformation end elastic fracture mechanics interact. We show that viscous deformation is in general an essential part of calving, and as a result, viscous deformation ultimately sets the time scale for calving. The geometric changes resulting from that deformation are necessary to cause continued growth to calving of fractures that initially propagate only part-way through the domain. We identify two distinct modes of fracture propagation: either fractures propagate episodically, the crack lengthening in each instance by a finite difference over short (elastic) time scales. Alternatively, fractures grow gradually in such a way as to keep the viscous pre-stress near the crack tip from becoming tensile, with elasticity playing a secondary role. Our results point to the purely instantaneous stress-based calving laws that have become popular in large-scale ice sheet mechanics being too simplistic.



- Figure1: ice shelf geometry evolution and crevasse propagation