<u>Summary of Opening Fault Problem</u>

For the CIG-Short List

Jeffrey Thompson
California Institute of Technology

Model Motivation and Conceptual Summary

Seasonally, melt water lakes can form on the surface of glaciers. The lakes often rapidly drain through cracks leading directly to the bed of the glacier, and can drain to empty over the course of days or even hours. This significant input of water to the bed of the glacier results in a short-lived perturbation of the glacier's stress balance at the bed, and the resulting motion is observable in GPS stations near to the (former) lake (Das et al., 2008).

Elastic modeling of this process cannot match the GPS observations to a high degree of accuracy (e.g., Tsai and Rice; 2010, 2012), so the motivation of this project is to investigate if treating ice as a viscoelastic rather than an elastic medium results in an improvement in modeling surface GPS observations from a lake drainage event in Greenland (from Das et al., 2008). The conceptual setup for this model is shown here in figure 1. A supraglacial lake drains through a conduit to the base of the glacier, causing a fluid-filled crack to form and propagate along the interface of the glacier and the ground beneath the ice. I am trying to use PyLith to model the viscoelastic response of a modeled glacier to a crack opening at the base of the ice body that is acting under an applied pressure.

Model Setup in PyLith

In PyLith, I am only attempting to model the viscoelastic response to the fluid-filled crack at a given crack length and pressure distribution, to calculate the relative amount of viscous deformation compared to elastic deformation. I am also neglecting the vertical drainage conduit in the model.

The model setup and boundary conditions are shown schematically in figure 2. Along the set of fault nodes, I apply the predetermined fluid pressure distribution as a normal traction along a fault, as in tutorial 20 (the dyke opening) from the PyLith manual. The normal traction distribution, shown in the figure 3, has a positive traction along much of the theoretical "crack," with the pressure falling to a strongly negative value near the crack tip, and for the remainder of the unopened portion of the fault nodes. I have a longer set of fault nodes than the length of the "crack" in my diagram and example files as I wish to use the same mesh for faults of various lengths, and would prefer not having to remesh the model for different "crack" lengths unless this will really help speed up convergence.

The other boundary conditions are zero displacement conditions at the base of the elastic body and along the left and right margins of both bodies. My desire is to have these boundaries far enough from the bulk of the displacements caused by the crack such that these conditions do not influence the deformation in the region of interest.

References

Das, S., I. Joughin, M. D. Behn, I. M. Howat, M. A. King, D. Lizarralde, and M. P. Bhatia (2008), Fracture propagation to the base of the Greenland Ice Sheet during supraglacial lake drainage, Science, 320, 778–781, doi:10.1126/science.1153360.

Tsai, V. C., and J. R. Rice (2010). "A Model for Turbulent Hydraulic Fracture and Application to Crack Propagation at Glacier Beds", J. Geophys. Res., 115, F03007, doi:10.1029/2009JF001474.

Tsai, V. C., and J. R. Rice (2012). "Modeling Turbulent Hydraulic Fracture Near a Free Surface", J. Appl. Mech., 79, 031003, doi:10.1115/1.4005879

Figure 1-Conceptual Model

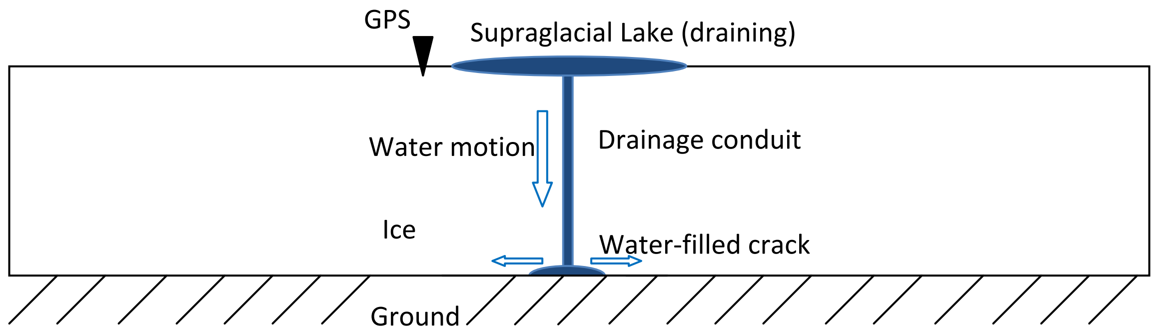

Figure 2-FEM Model Setup with Boundary Conditions

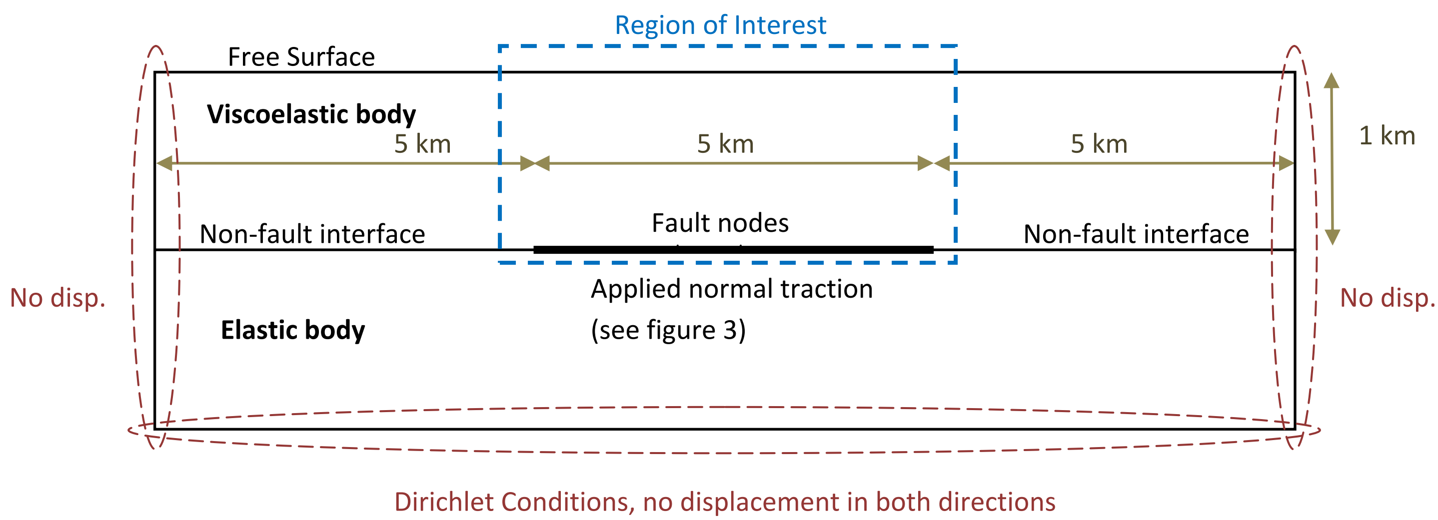

Figure 3-Example Normal Traction Boundary Condition