Inversion of geothermal flux in a thermo-mechanically coupled Stokes ice sheet model

Goal
Development of methods for the inversion of the geothermal flux at the base of ice sheets from surface velocity observations. Geothermal flux is a source of uncertainty for ice sheet internal temperatures and thus ice rheology.

Approach
Inverse problem constrained by the thermo-mechanically coupled, nonlinear Stokes ice sheet model equations

- derivatives computed through adjoints
- scalable Newton inversion algorithm
- inexactness in gradient computation due to operator staggering is studied
- findings: inversion of heat flux features of size >20x ice thickness can be reconstructed from data containing errors of 1%

Impact
Systematic methods to invert for geothermal flux could improve model-based predictions of ice sheet mass loss and sea-level rise

Example of reconstructed heat flux in 3D model problem. Shown are (a) synthetic velocity observations, (b) modeled surface velocity for the reconstructed heat flux, (c) the “true” (synthetic) heat flux, and (d) its reconstruction found by solving the inverse problem.