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

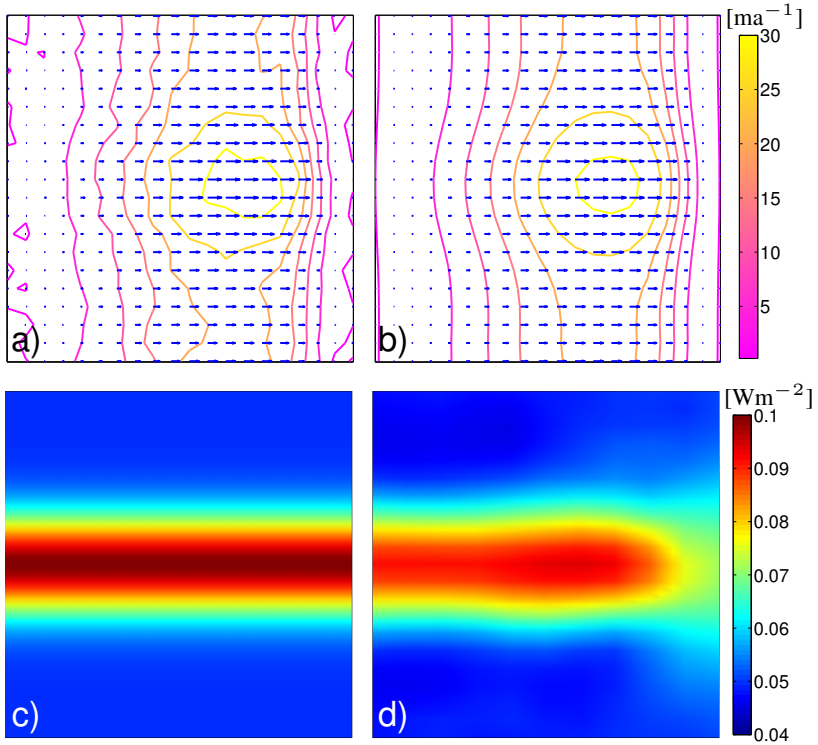
Goal

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%



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.

Impact

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

H. Zhu, N. Petra, G. Stadler, T. Isaac, T. J. R. Hughes and **O. Ghattas.** Inversion of geothermal heat flux in a thermomechanically coupled nonlinear Stokes ice sheet model. *The Cryosphere*, 10, 1477-1494, (2016).