Geophysical Research Abstracts
Vol. 12, EGU2010-12226, 2010
EGU General Assembly 2010

Inversion for viscosity and basal drag using the full Stokes equations.

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Glaciological methods of inverting for basal drag and ice viscosity have usually been based upon approximations that suppose the ice is sliding over extremely slippery sediment. Furthermore, these methods have required the development of a separate adjoint model, either analytically, or through automatic differentiation of computer code. Assuming the geometry of the ice sheet and surface velocities are known, we show that a very simple algorithm can be used to invert for basal drag, or interior viscosity. The algorithm applies to the full Stokes system. It proceeds via a series of calculations that only use the forward solver of the Stokes equations, so there is no requirement to develop and test a separate adjoint model. The only requirement placed on the solver is that boundary conditions of Neumann (fixed stress), Dirichlet (fixed velocity) and Robin (linearly related stress and velocity) types can be implemented in the momentum equations. Test cases are presented that illuminate the performance of the method, and its sensitivity to measurement errors.