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New FOSLS Formulation of Nonlinear Stokes Flow for Glaciers

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This talk describes two First-order System Least-squares (FOSLS) formulations of the nonlinear Stokes flow used to model glaciers and ice sheets. The first is a Stress formulation and the second a Stress-Vorticity formulation. Both use fluidity, which is the reciprocal of viscosity and avoid the difficulties of infinite viscosity. Coercivity and continuity in appropriate Sobolev norms will be discussed. A Nested Iteration (NI), Newton-FOSLS-AMG approach is employed, in which the majority of the work is done on coarse grids.

In current ice sheet codes, viscosity is modeled using a formula known as Glen's law. It becomes infinite as the gradient of velocity approaches zero, which can happen near the bed and along the top surface, where ice is carried along undeformed. In current ice sheet codes, this is mitigated by a small modification to Glen's law that bounds the maximum value of viscosity. The fluidity formulation presented here avoids this difficulty and requires no modification to Glens law.

Numerical tests are presented that demonstrate the efficacy of the NI-Newton-FOSLS-AMG approach on model problems from the ISMIP-HOM problem set.