New development of computation and applications for ice sheet dynamics

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Abstract

Ice sheet dynamics are described by the full nonlinear Stokes equations with a strainrate-dependent viscosity coupling with thermal effect, subglacial drainage and ice stream sliding. The study of ice sheet dynamics is important because it has the potential as shown in the literature to affect the sea level rises. The computational challenges of solving this system come from the typical larger range of ice sheets, its long time period and complexities such as the nonlinear viscosity depending on the strain rate and the temperature.

In this talk, two issues about numerical methods and the applications will be presented. For the first issue, the nonlinear Stokes equations will be studied by applying finite element method, weak Galerkin method and Hybridizable Discontinuous Galerkin method, which are considered as the first step toward understanding the computational difficulties of the whole system. We implement the weak Galerkin method to nonlinear Stokes equation. We use Picard iteration to overcome the difficulty of nonlinearity and get the convergent results. We also implement the Hybridizable Discontinuous Galerkin method to solve the steady Stokes equations and assess its performance through numerical experiments.

For the second issue, this work describes the glacier iceberg calving as the terminus of a tidewater glacier, for example, Greenland's

Jakobshavn Isbræ. The streamlined diffusion stabilization method is employed for solving the nonlinear Stokes sheet model. We use an approach based on pressure and normal stress solutions to adjust the grounding line position. We show effective principal stress (EPS) contours and profiles for grounded glaciers and a notch glacier with basal crevasses open at the grounding line. Results show that the water pressure affects the notch glacier with basal crevasses open at the grounding line. The ungrounded stress profile shows a drastic variation compared with the fully grounded tidewater glacier. It should be one effect on the glacier iceberg calving. Numerical results are also presented to elucidate the impact of the slip length, notch length, grounding line, and surface slope. Finally, the streamlined diffusion stabilization effects on numerical solutions are presented.