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Inferring the subsurface flow of Antarctic ice from satellite observations and other challenges for ice sheet prediction

Nowadays there are a large number of satellite and airborne observations of the large ice sheet that covers Antarctica. These include maps of the surface elevation, ice thickness, surface velocity, the rate of snow accumulation, and the rate of change of surface elevation. Uncertainty in the possible rate of future sea level rise motivates using all of these observations and models of ice-sheet flow to project how the ice sheet will behave in future, but this is still a challenge. To make useful predictions, especially in the presence of potential dynamic instabilities, models will need accurate initial conditions, including parameters that control the ice flow velocity throughout the ice thickness. The ice sheet can be several kilometres thick, but most of the observations identify quantities at the upper surface of the ice sheet, not within its bulk. There is thus a question of how the subsurface flow can be inferred from surface observations. The key parameters that must be identified are the viscosity in the interior of the ice and the basal drag coefficient that relates the speed of sliding at the base of the ice sheet to the basal shear stress. Neither is characterised well by field or laboratory studies, but for incompressible flow governed by the Stokes equations they can be investigated by inverse methods analogous to those used in electric impedance tomography (which is governed by the Laplace equation). Similar methods can also be applied to recently developed 'hybrid' approximations to Stokes flow that are designed to model shallow ice sheets, fast-sliding ice streams, and floating ice shelves more efficiently. This talk will give a summary of progress towards model based projections of the size and shape of the Antarctic ice sheet that make use of the available satellite data. Some of the outstanding problems that will need to be tackled to improve the accuracy of these projections will also be discussed.