A Time-Dependent Model of Pine Island Glacier Constrained by Satellite Observations

Ian Joughin and Ben Smith

Several studies have demonstrated that Pine Island Glacier should speedup as its ice shelf thins and ungrounds. Here we conduct similar experiments, but constrained by time series of velocity and recently derived grounding-line estimates. We begin by using inverse methods to infer the ice stream's basal shear stress in 1996, when a large ice plain existed just above the grounding line. Since 1996, the grounding line has retreated by more than 20 km in places, leaving behind a grounded "island" where the ice plain once existed. We force our model by reducing the bed resistance linearly with time in the region between the 1996 and 2009 grounding line positions, which produces velocity increases that agree well with the observed values. We experiment with a number of sliding parameterizations, including linear-viscous, power-law, and plastic models. The results show that for the plastic bed and some n=3 cases, thinning propagates far more rapidly inland than it does for the linear-viscous model used in earlier studies. After physically reasonable adjustment of the model parameters, we are able to reproduce the magnitude and the pattern of thinning along the entire length of the ice stream.