Modeling the Elastic Transmission of Tidal Stresses to Great Distances Inland in Channelized Ice Streams

Jeffrey Thompson, Mark Simons and Victor Tsai

California Institute of Technology

Geodetic surveys suggest that ocean tides can modulate the motion of Antarctic ice streams, even at stations many tens of kilometers inland from the grounding line. These surveys suggest that ocean tidal stresses can perturb ice stream motion at distances about an order of magnitude farther inland than tidal flexure of the ice stream alone. Recent models exploring the role of tidal perturbations in basal shear stress are primarily one- or two-dimensional, with the impact of the ice stream margins either ignored or parameterized. Here, we use two- and three-dimensional finite element modeling to investigate transmission of tidal stresses in ice streams and the impact of considering more realistic, three-dimensional ice stream geometries. Using Rutford Ice Stream as a real-world comparison, we demonstrate that the assumption that elastic tidal stresses in ice streams propagate large distances inland fails for channelized glaciers due to an intrinsic, exponential decay in the stress caused by resistance at the ice stream margins. This behavior is independent of basal conditions beneath the ice stream and cannot be fit to observations using either elastic or nonlinear viscoelastic rheologies without nearly complete decoupling of the ice stream from its lateral margins. Our results suggest that a mechanism external to the ice stream is necessary to explain the tidal modulation of stresses far upstream of the grounding line for narrow ice streams. We propose a hydrologic model based on time-dependent variability in till strength to explain transmission of tidal stresses inland of the grounding line. This conceptual model reproduces observations from Rutford Ice Stream.

Submitting to: Ice-ocean interaction *(Surfin' USA)* / everywhere else (*Promised Land)*