Bed Character of Thwaites Glacier: Implications for Stability

Emily Schwans[1]; Byron R. Parizek[1,2]; Richard B. Alley[1]; David Pollard[1,3]; Mathieu Morlighem[4]; Helene Seroussi[5]; Pierre St-Laurent[6]

[1]*Department of Geosciences, and Earth and Environmental Systems Institute, Pennsylvania State University, University Park, PA, 16802*
[2]*Mathematics and Geosciences, Pennsylvania State University, DuBois, PA 15801*
[3] *Earth and Environmental Systems Institute, Pennsylvania State University, University Park, PA, 16802*
[4] *Department of Earth System Science, University of California, Irvine, Irvine, CA 92697-3100*
[5]*Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109*
[6]*Center for Coastal Physical Oceanography, Old Dominion University, Norfolk, VA 23508*

Given Thwaites Glacier's (TG's) wide, unconfined geometry, stability arises mainly from its bed and interactions of its ice tongue with pinning points, unlike other more laterally-confined ice streams that are stabilized in part by side drag. Many uncertainties exist in projecting TG's retreat from its stabilizing ridge, including future oceanic forcing, details of the bed topography, bed rheology, and more. A lack of observational data contributes to these uncertainties. This research addresses one of the main uncertainties in projections of TG, namely that of the interactions between oceanic forcing and retreat as a function of basal properties, which are characterized through existing datasets and the choice of basal sliding law.

Parizek et al. (2013) found that varying the rheology of the basal flow law within likely ranges could switch TG between stability and retreat in flowline models. Ice-flow modeling reported here extends this prior study into 2 dimensions, and expands on their results using NASA-JPL's open-source ISSM together with simulated outputs from PSU-3d (ice temperatures) and ROMS (sub-shelf melt rates). Prognostic model runs show the influence prescribed basal rheology has on TG's response to initial loss of targeted portions of its floating ice shelf and ongoing sub-shelf melt beneath intact shelf and/or regions of shelf regrowth. In response to reduced ice-shelf buttressing, a nearly viscous bed, such as might arise from Weertman-type sliding over a hard bedrock surface, localizes thinning, promotes floatation off the stabilizing ridge, and leads to GL retreat into the deep interior basins. In contrast, a nearly plastic bed, such as might arise from till deformation, rapidly spreads thinning inland and minimizes coastal thinning, such that sea-level rise from this sector is initially slightly faster, but the main instability is avoided under certain scenarios. However, if additional forcing destabilizes the grounding-line, subsequent retreat across the nearly plastic interior basins is accelerated relative to viscous beds. Results demonstrate how the timing and pattern of GL retreat on TG depend on bed character, and highlight key areas of TG's ice tongue that are critical to its stability on short timescales. Results also serve to pinpoint areas where additional data on sub-shelf melting rates and bed character are most needed from future data-collection efforts to better model the evolution of this dynamic outlet glacier, and highlight the need for the inclusion of a realistic and evolving oceanic forcing in uncoupled model simulations.