Interannual to Sub-Daily Fluctuations in Thwaites Glacier Speed Associated with Calving and Ocean Forcing

Andrew O. Hoffman[1], Knut Christianson[1], Huw J. Horgan[2], Sridhar Anandakrishna[3], Kristine Larson[4], and Richard B. Alley[3]

[1]Department of Earth and Space Sciences, University of Washington. [2]Antarctic Research Centre, Victoria University of Wellington. [3]Department of Geosciences, Pennsylvania State University. [4]Department of Aerospace Engineering Sciences, University of Colorado.

Remote-sensing observations and modeling suggest that marine ice-sheet instability may already be occurring for the Thwaites Glacier Basin, West Antarctica. The pacing of this collapse and ensuing sea-level contribution in the coming decades is, however, highly uncertain due to a lack of knowledge of the glacier's behavior on timescales of a decade or less. Here we present a decade of nearly continuous GPS and seismic observations from two sites on Thwaites Glacier that document glacier speed variability on interannual to sub-daily timescales. We complement these data with observations from seasonal GPS arrays (2007-2010 austral summers) and highly-resolved (subannual) satellite-derived velocity and thinning-rate fields. Our results indicate a long-term acceleration of 10% over the 10-year record that persists more than 200 km inland from the grounding line, consistent with changes in gravitational driving stress associated with basin-wide thinning. Superimposed on this overall trend are shorter-term fluctuations in ice velocity that are likely associated with changes in oceanic forcing and ice-shelf buttressing. A transient slowdown of 1% of the glacier's speed is observed at both sites from 2013-2015 that is temporally coincident with an oceanic cooling (mCDW layer thinning) that also affected ice speed at the neighboring Pine Island Glacier. Complex shorter-term speed fluctuations at both sites are associated with calving events recorded in passive seismic data that occurred in 2012 and 2017. Discrete rifting events affect glacier speed within 30 km of the grounding line in satellite derived velocity fields, but do not appear to have a discernible influence farther inland. Taken together, our results highlight that glacier speed and ice discharge respond quickly to transient forcing (i.e., climate variability) and changes in ice-front geometry, complicating predictions of ice discharge flux on decadal timescales. To improve model projections, future observational campaigns should focus on developing and maintaining infrastructure necessary to collect time series that document glacier response on these short timescales.