Overview: The fate of the West Antarctic Ice Sheet (WAIS) is one of the largest uncertainty in projections of sea-level rise. Thwaites Glacier (TG) is a primary contributor to sea-level rise and its flow is accelerating. This faster flow is a response to reduced buttressing from its thinning, floating ice shelf, and is ultimately caused by ocean-driven melting. The degree to which costly and geopolitically-challenging sea-level rise will occur therefore hangs to a large extent on ice-ocean interaction beneath Antarctic ice shelves. However, the Thwaites system is not sufficiently well understood, exposing a significant gap in our understanding of WAIS retreat, its ocean-driven forcing, and the consequences for sea level.

The chief regulators of TG's retreat are ice and ocean processes in its grounding zone, where the ice flowing from inland goes afloat. Ice and ocean processes at this precise locale are central to our understanding of marine ice-sheet instability, yet key variables have not been constrained by observation. The problem is compounded because oceanic melt occurs preferentially in the deep, narrow cavity in the grounding zone, where physical descriptions of the processes driving melt are unverified.

These gaps in knowledge are damaging because model projections of TG's future display extreme sensitivity to melting in the grounding zone and how that melting is applied. Equally-credible melt rates and grounding-zone glaciological treatments yield divergent trajectories for the future of West Antarctica, ranging from little change to large-scale ice sheet collapse with a half a meter or more of sea-level rise. The enormous uncertainty in outcome stems from the lack of observations in this critical region.

This project will observe, quantify and model the Thwaites ice-ocean system in the grounding zone, to firmly establish the physics linking ocean forcing and ice-sheet response. The time-dependent cavity will be thoroughly surveyed and instrumented with ocean monitoring devices. Melting will be observed by a network of autonomous sensors and from space over an extended period. The response of the glacier will also be observed. Our enhanced understanding of melting beneath TG's ice shelf, its grounding zone and its connection with the glacier flow will be built into state-of-the-art coupled ice sheet and ocean models. These physics-rich, high-resolution models will allow the potential sea-level contribution of TG to be bounded with unprecedented fidelity.

Intellectual Merit: Of the five themes outlined in the program solicitation, the proposed study has been designed to address two directly: **Boundary conditions** - the melt rate and geometry at the glacier-ocean boundary at the base of the ice shelf; **Processes leading to collapse** – mass loss from the glacier as a result of the retreat of the grounding line; and to enable a third: **Forecasts of future change** - this project will enable global and regional climate modellers to utilize their projections of *future* ocean conditions over the continental shelf to provide physics-based projections of TG's resulting sea-level contribution.

We propose a suite of integrated activities: (1) multi-year oceanographic time series from beneath TG's ice shelf to quantify melting processes that need inclusion in ocean models, (2) analogous measurements on the glacier to validate processes governing grounding-line retreat, (3) coupling of these in situ measurements with novel, high-resolution space-borne observations, (4) building this new understanding into state-of-the-art ocean and ice sheet models to correctly simulate the TG system, (5) coupling the models and running with realistic *present-day* ocean forcing to project the state of TG basin over the next hundred years. The international team will consist of experienced marine and glacier scientists using a range of techniques, from the well-established through to the cutting-edge. The outcome of the project will be a thorough understanding of the TG system in the critical zone extending from a few kilometers inland of the grounding line, through the grounding zone, and out under the ice shelf.

Broader Impacts: A robust assessment of the consensual view that ocean-glacier interactions at TG, particularly in the grounding zone, control ice-sheet collapse is of great societal relevance, as are quantified estimates of likely future rates of sea-level rise, and their uncertainties. The project will provide a major improvement in our understanding of near-term TG and WAIS vulnerability to ocean forcing in the grounding zone, and thus to its influence on global sea-level rise. We will fully engage graduate students and postdocs in the effort, affording them the opportunity to participate in data collection, analysis, model development, and data-model synthesis. These early career scientists will develop career-long skills in a number of cross-cutting disciplines in a cooperative international science setting. A vigorous program of media outreach and education will be pursued. We plan to actively engage the international modeling community to use our findings to produce more-realistic simulations of the ocean-glacier interactions of Thwaites, ultimately providing greater confidence in future projections.

This project requires field work in Antarctica.