PROJECT SUMMARY

Overview:

Projecting the retreat rate of Thwaites Glacier, and whether it can stabilize without completely deglaciating the marine basins of West Antarctica to raise global sea level more than 3 m, are of critical importance in a warming world. The objectives of the proposed research are to learn whether basal conditions allow for rapid retreat of the Thwaites Glacier grounding line or whether retreat may slow or stop on the transverse ridge about 70 km inland, and to learn whether englacial and subglacial conditions allow for Thwaites Glacier to rapidly expand its boundaries and deglaciate adjacent marine basins. These objectives will be achieved by using dedicated ice-flow modeling to guide targeted field surveys and experiments over two seasons, to measure the most important unknown quantities and incorporate them into the models.

A suite of models, including the PSU2D higher-order model and the WAVI ice-sheet model, will be used to generate hypotheses for basal conditions that are testable through geophysical surveys, to optimize and guide those geophysical surveys, and to project future behavior of Thwaites Glacier after assimilating the resulting data. Field surveys will focus on collecting active and passive seismic observations, high-frequency and interferometric (ApRES) radar, gravity and magnetotelluric (MT) data along and adjacent to profiles selected to characterize both the most-likely site for stabilization against retreat, and a shear margin that would be important in outward migration.

Active seismic data will yield profiles of bed topography and characterization of bed properties at high spatial resolution; these data will show where the bed is soft, deformable till versus bedrock, providing and calibrating the basal flow law for the models. Passive seismic observations will identify any stick-slip behavior, testing the bed reconstructions, and also will track any crevassing and subglacial outburst flooding, providing additional insights. Radar data, including a 10 km-wide swath map along the main seismic line, will characterize the bed roughness and further test the basal flow law through its effect on englacial velocities. Radar signatures of the detailed seismic results will provide a bridge across spatial scales to results from airborne radar, allowing the knowledge acquired on the ground to be used to characterize additional regions of the ice sheet. Deeper seismic results, gravity and MT will reveal crustal temperature, constraining geothermal flux and flexural rigidity needed to model rates and wavelengths of isostatic response that may serve to help stabilize the grounding zone; insights to deeper sedimentary structures will help constrain knowledge of geologic history and sources of deforming tills.

Intellectual Merit:

Costs of sea level rise are estimated to increase super-linearly, but to be heavily discounted if rise is slow compared to typical lifetimes of infrastructure. A rapid West Antarctic collapse, with the potential to increase century-scale sea-level rise several-fold, thus would grossly dominate societal costs. Prior modeling shows that Thwaites Glacier is the most likely path for collapse, and that both stability of its modern grounding zone and rate of retreat if triggered depend in part on poorly known conditions inland. The proposed research will collect the most important data on those inland regions, improving physical understanding of this critical system. The data will be used to improve model projections of future behavior and reconstructions of past behavior, providing better understanding of many scientifically important topics and especially improving projections of sea-level rise.

Broader Impacts:

Better projections of the most important potential contributor to costs of sea-level rise will be of great societal value in decision-making about mitigation and adaptation. The proposed work will also contribute to education of students, advancement of a diverse group of junior faculty, and extension of a vigorous program of education and outreach. Development of a novel interactive educational tool, the Augmented Reality Sandbox, will advance glaciological education in museums and other venues.

International collaboration: We include a significant partnership with the Alfred Wegener Institute, who have agreed to provide a Vibroseis truck, a PistenBully tractor, and 4 personnel for the length of the project, for no cost to NSF or NERC. We include a partnership with Victoria University in NZ who will aid in field work, data analysis, and interpretation. This proposal requires fieldwork in the Antarctic.