1. Overview

We propose to conduct coupled ice-ocean numerical simulations of Thwaites Glacier (TG) to predict its future contribution to global sea level change, and to provide both statistical and structural error estimates using three state-of-the-art ice flow numerical ice-flow models (ISSM, Úa and STREAMICE) coupled with the ocean model MITgcm. We will implement and improve the representation of several key physical processes (calving, ice damage, mechanical basal conditions) that have either not been included, or poorly represented in previous ice-flow modelling work.

We will quantify the relative role of different proposed external drivers of change (e.g., ocean-induced ice-shelf thinning, loss of ice-shelf pinning points), and explore systematically the stability regime of TG with the aim of identifying internal thresholds separating stable and unstable grounding line retreats.

Using inverse methodology, we will produce new physically consistent high-resolution (300 m) data sets on ice-thicknesses from available radar measurements. Furthermore, we will generate several new remote sensing data sets on ice velocities and rates of elevation change. These will be used to constrain and validate our numerical models, and will also be highly valuable as stand-alone data sets.

2. Intellectual Merit

The proposal will lead to a greatly improved representation of several key processes known to have decisive effects on the transient evolution and the stability of large ice masses such as the West Antarctic Ice Sheet (e.g. calving, ice damage, mechanical basal conditions). For the first time, three modeling groups will here join forces, exchange ideas and interact frequently, and work as one team towards improving their respective numerical models. Pushing forward the frontiers of ice-sheet modeling in this manner will leave a lasting legacy on which the modeling community will be able to continue to benefit and build on for years to come. We will take full benefit of the impending avalanche of new remote-sensing data sets (e.g. ice surface velocities, rates of elevation change) to both initialize and validate our numerical ice and ocean models. This will allow the numerical models to be constrained much more tightly by data than has previously been possible, ultimately resulting in more robust and trustworthy model predictions of the near-future impact of TG on global sea levels that can form the basis for policy relevant decisions.

All the datasets generated through this project (bed topography, basal reflectivity, weekly velocity maps and ice front positions) will be publicly released, and the implementation of new physical processes (damage and calving) will be available to the community as all three models are open source.

3. Broader impacts

The stability of TG and its future impacts on global sea levels is a scientific question of worldwide societal significance. The proposal will address this question directly by conducting the first large-scale coupled ice-ocean runs of TG. This will be of interest to the general public as well as policy makers. By including and improving the representation of important physical processes directly within our large-scale ice-flow models we will push forward the boundaries of ice-ocean modeling, and this will impact the broader climate change community. Undergraduate and graduate students will be exposed to this work through seminar and classes at UC Irvine and University of Edinburgh, as well as through the yearly ISSM and Úa workshops. Our Public engagement efforts will include a YouTube channel where we will, through a series of professionally made videos, both explain our key results and "demystify" numerical modeling of glacier flow to the public.