Overview: Projected rates of sea level rise from the West Antarctic Ice Sheet (and Thwaites Glacier in particular) have large uncertainties due to difficulties understanding and projecting the calving and dynamic processes that control the ice sheet stability. This uncertainty is magnified by the poorly understood connection between calving processes, ice sheet stability and climate. To address these uncertainties, we propose a novel ice-dynamics model suite to explicitly resolve the processes that could cause retreat and collapse of Thwaites Glacier. This includes a discrete element model capable of simulating coupled fracture and ice-flow processes, a 3D full Stokes continuum model, and the continental scale ice-dynamics model BISICLES. Ice dynamics models will be coupled to an ocean forcing model suite including simple plume models, intermediate complexity 2-layer ocean models and fully 3D regional ocean models. This hierarchical approach will use high-fidelity process models to inform and constrain the sequence of lower-order models needed to extrapolate improved understanding to larger scales and has the potential to radically reduce uncertainty of rates of marine ice sheet collapse and associated sea level rise. The large-scale modeling approach will be tested and implemented within the open source BISICLES ice dynamics model and made publicly available to other researchers via a "calving package". Education and outreach activities involve proactive outreach to nearby community colleges and schools, with an emphasis on increasing participation from under-represented populations.

Intellectual Merits: There is growing consensus that Thwaites Glacier and its catchment is unstable and vulnerable to collapse. However, there is significant disagreement in projections of **rates** of mass loss with some studies suggesting century to millennial scale retreat of the grounding line and others forecasting more catastrophic disintegration of the ice sheet. These discrepancies are significant because rapid disintegration of Thwaites and adjacent glaciers could be felt across the larger region, potentially triggering or accelerating collapse of significant portions of the entire West Antarctic Ice Sheet with implications for global mean sea level rise (SLR) on decadal time scales. However, predicting rates of ice loss from Thwaites Glacier is currently hampered by a lack of reliable models of calving processes and the complex interactions between calving, atmospheric and oceanic forcing. Our study thus addresses a significant knowledge gap of major significance for society. The proposal brings together several novel modeling techniques pioneered by the PIs and project collaborators, including a discrete element model that represents ice as 3D arrays of particles connected by breakable elastic beams. Unlike traditional approaches, the discrete element model can exhibit brittle, elastic and viscous behavior, and can thus explicitly simulate the key processes that control ice shelf disintegration and marine ice cliff instability. By linking this model to state-of-the-art techniques for modeling the flow of damaged ice, we will develop the parameterizations urgently required to reliably simulate ice sheet instability in continental scale and regional-scale ice sheet models.

Broader Impacts: Our research is fundamentally motivated by the need to improve the SLR projections critical for policy and planning. However, there is also a gap between what scientists assert about the *usefulness* of SLR products and stakeholder's perceptions of the *usability* of that work. Our broader impacts are geared to addressing this gap, by identifying the information that is accessible and usable to a broad community of stakeholders. In addition to these stakeholder outreach efforts, we will proactively engage with under-represented communities at nearby community colleges and school districts, engaging community college students in research opportunities and providing education packages on the principles of the greenhouse effect and climate change. No fieldwork is requested as part of this proposal.