PROJECT SUMMARY

Overview:

The West Antarctic Ice Sheet (WAIS) contains 2 million cubic kilometers of ice and the global scientific community considers it the most significant risk for coastal environments and cities facing future sea level rise. The risk posed by the WAIS arises from its deep, marine-based setting, with ice situated on reverse bed slopes prone to significant and prolonged retreat. Although scientists have been aware of the precarious setting of the WAIS since the early 1970s, it is only now becoming apparent that the flow of ice in several large drainage basins is undergoing dynamic change, which is consistent with, although not certain to be, the inception of a prolonged and potentially unstoppable disintegration. Understanding WAIS stability and enabling more accurate prediction of sea level rise through realistic simulation of ice flow in large-scale models are two of the fundamental global challenges facing the scientific community today. In TIME, we directly address both challenges by A) using frontier technologies to observe rapidly deforming shear margins hypothesized to exert strong control on the future evolution of Thwaites Glacier, and B) using observational record to develop parameterizations for important processes which are not yet implemented in ice sheet models used to predict WAIS contribution to sea level rise.

Intellectual Merit:

The project will test the overarching hypothesis that shear margin dynamics may exert powerful control on the future evolution of ice flow in Thwaites Drainage Basin. To test the hypothesis the team will set up an ice observatory at two sites on the eastern shear margin of Thwaites Glacier. The team argues that weak topographic control makes this shear margin susceptible to outward migration and, possibly, sudden jumps in response to the drawdown of inland ice when the grounding line of Thwaites retreats. The ice observatory is designed to produce new and comprehensive constraints on englacial properties, including ice deformation rates, ice crystal fabric, ice viscosity, ice temperature, ice water content and basal melt rates. The ice observatory will also establish basal conditions, including thickness and porosity of the till layer and the deeper marine sediments, if any. Furthermore, the team will develop new knowledge with an unparalleled emphasis on physical processes, including direct assessment of the spatial and temporal scales on which these processes operate. Seismic surveys will be carried out in 2D and 3D using wireless geophones. A network of broadband seismometers will identify icequakes produced by crevassing and basal sliding. Autonomous radar systems with phased arrays will produce sequential images of rapidly deforming internal layers in 3D while potentially also revealing the geometry of a basal water system at the bed. Datasets will be incorporated into numerical models developed on different spatial scales. One will focus specifically on shear margin dynamics, the other on how shear margin dynamics can influence ice flow in the whole drainage basin. Upon completion, the project will have confirmed whether the eastern shear margin of Thwaites Glacier can migrate rapidly, as hypothesized, and if so what the impacts will be in terms of sea level rise in this century and beyond.

Broader Impacts:

The TIME project brings together a multidisciplinary team of UK and US scientists with majority of them at early career stages. Its benefits to society include A) the full characterization the margin boundary condition, which so far has been largely ignored in numerical ice sheet models; B) new understanding of glaciological processes that may lead to collapse of the WAIS, or potentially prevent one, C) new and validated parameterization for implementation of shear margin dynamics in small- as well as large-scale ice flow models; D) an assessment of possible shear margin migration rates; and E) prediction of the future evolution of ice flow in the Thwaites drainage basin with a 3D state-of-the-art ice sheet model. This project will enhance infrastructure for research and education by creating a multidisciplinary network of scientists that will mentor three postdoctoral researchers, train four Ph.D. students while also integrating undergraduate students in the research. The education and outreach theme revolves around the central question: Is the WAIS in a state of collapse? This highly relevant question offers rich possibilities for education and outreach for the public and K-12 audiences. This proposal requires field work in the Antarctic.