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Simulating the evolution of Thwaites Glacier with a coupled ice-ocean model

Helene Seroussi (1), Yoshihiro Nakayama (1), Dimitris Menemenlis (1), Eric Larour (1), Mathieu Morlighem (2), Eric Rignot (2,1), and Ala Khazendar (1)

(1) Jet Propulsion Laboratory, United States (helene.seroussi@jpl.nasa.gov), (2) University of California Irvine, Irvine, United States

Ice shelves and floating glacier termini play an important role in the stability of ice sheets and interact strongly with the ocean. They account for much of the buttressing against the flow of inland glaciers that drain the Antarctic ice sheet. Changes in their geometry due to ice-front retreat, thinning or even collapse profoundly affect the flow of their tributary glaciers, which in turn affects the volume of grounded ice carried by these tributary glaciers into the ocean, and the extent of resulting sea level rise. Recent simulations of glaciers in Antarctica show that the largest climatic impact on ice dynamics is the rate of ice shelf melting, which rapidly affects glaciers' speed over several hundreds of kilometers upstream of the grounding line. However, accurate knowledge of these melting rates, as well as their spatial and temporal evolution remain largely unknown. Coupled ice-ocean models are the best available approach to address this question.

In this study, we focus on Thwaites glacier in the Amundsen Sea sector, a glacier that has been accelerating, widening and experiencing a complex grounding line retreat pattern over the past three decades. We simulate the coupled ice-ocean system using a new two-way coupled system between the Massachusetts Institute of Technology general circulation model (MITgcm) and the Ice Sheet System Model (ISSM). We investigate the feedbacks between changes in the ice and ocean, and the dynamic response of the glacier to changes in the ocean circulation. Our results reproduce the grounding line retreat and ice flow acceleration observed over the last couple decades, and show the rapid adjustment of ocean-induced melting rates to the evolution of the sub-ice shelf cavity, demonstrating the importance of simulating the coupled ice-ocean system to produce accurate melting rates under the ice shelf and at the grounding line. The simulations suggest that Thwaites Glacier is likely to undergo substantial changes in the coming decades.

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