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Reversibility experiments of present-day Antarctic grounding lines

Benoit Urruty[1], Emily A. Hill[2], Ronja Reese[2,3], Julius Garbe[3,4], Olivier Gagliardini[1], Gael Durand[1], Fabien Gillet-Chaulet[1], G. Hilmar Gudmundsson[2], Ricarda Winkelmann[3,4], Mondher Chekki[1], David Chandler[5], and Petra Langebroek[5]

[1]Université Grenoble Alpes, Saint martin d'Hères, France (benoit.urruty@univ-grenoble-alpes.fr)
[2]Department of Geography and Environmental Sciences, Northumbria University, Newcastle, UK
[3]Potsdam Institute for Climate Impact Research (PIK), Member of the Leibniz Association, P.O. Box 60 12 03, 14412 Potsdam, Germany
[4]Institute of Physics and Astronomy, University of Potsdam, Potsdam, Germany
[5]NORCE Norwegian Research Centre, Bjerknes Centre for Climate Research, Bergen, Norway

The stability of the grounding lines of Antarctica is a fundamental question in glaciology, because current grounding lines are in some locations at the edge of large marine basins, and have been hypothesized to potentially undergo irreversible retreat in response to climate change. This could have global consequences and raise sea levels by several metres. However, their reversibility for the current geometry has not yet been questioned, i.e. if pushed very slightly, are they able to recover their former position?

Here we approach this question using three state-of-the-art ice sheet models (Elmer\Ice, Úa and PISM) which we initialise to closely replicate the current state of Antarctic ice sheet using inverse methods or spin-up approaches and the latest observations. To assess the reversibility of the Antarctic grounding lines in their current position, we apply a small amplitude perturbation in ice shelf melt rates for 20 years, which leads to a numerically significant grounding line retreat, but does not fundamentally alter it. After reversing the forcing we examine the grounding line evolution over the following 80 to 480 years, which allows us to see the direction of the ice sheet trajectory after removing the perturbation, i.e. recovery or further retreat. However, since ice dynamics adjust over long timescales of millennia, in some cases up to 500 years are not sufficient for the grounding lines to fully recover to their initial positions. To complement these experiments and to investigate the long-term response to small perturbations, we run the lower resolved Parallel Ice Sheet Model towards equilibrium. In this case, the perturbation is the increase from 1850 to present-day climate, and the experiments indicate whether present-day climate can cause Antarctic grounding lines to retreat on the long-term.

This work is part of the TiPACCs project and complements two presentations focusing on the short-term (EGU22-7802) and long-term (EGU22-7885) reversibility experiments of present-day Antarctic grounding lines in more detail.