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Sea-level response to abrupt ocean warming of Antarctic ice shelves

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Antarctica's contribution to global sea-level rise increases steadily. A fundamental question remains whether the ice discharge will lead to marine ice sheet instability (MISI) and collapse of certain sectors of the ice sheet or whether ice loss will increase linearly with the warming trends. Therefore, we employ a newly developed ice sheet model of the Antarctic ice sheet, called f.ETISh (fast Elementary Thermomechanical Ice Sheet model) to simulate ice sheet response to abrupt perturbations in ocean and atmospheric temperature.

The f.ETISh model is a vertically integrated hybrid (SSA/SIA) ice sheet model including ice shelves. Although vertically integrated, thermomechanical coupling is ensured through a simplified representation of ice sheet thermodynamics based on an analytical solution of the vertical temperature profile, including strain heating and horizontal advection. The marine boundary is represented by a flux condition either coherent with power-law basal sliding (Pollard Deconto (2012) based on Schoof (2007)) or according to Coulomb basal friction (Tsai et al., 2015), both taking into account ice-shelf buttressing. Model initialization is based on optimization of the basal friction field. Besides the traditional MISMIP tests, new tests with respect to MISI in plan-view models have been devised.

The model is forced with stepwise ocean and atmosphere temperature perturbations. The former is based on a parametrised sub-shelf melt (limited to ice shelves), while the latter is based on present-day mass balance/surface temperature and corrected for elevation changes. Surface melting is introduced using a PDD model. Results show a general linear response in mass loss to ocean warming. Nonlinear response due to MISI occurs under specific conditions and is highly sensitive to the basal conditions near the grounding line, governed by both the initial conditions and the basal sliding/deformation model. The Coulomb friction model leads to significantly higher sensitivity compared to power-law sliding. On longer time scales, West-antarctic inter-basin connections favor nonlinear response.