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Resolution-dependent performance of grounding line motion in a shallow model compared to a full-Stokes model according to the MISMIP3d intercomparison

Johannes Feldmann (1,2), Torsten Albrecht (1,2), Constantine Khroulev (3), Frank Pattyn (4), Anders Levermann (1,2)

(1) Potsdam Institute for Climate Impact Research (PIK), Potsdam, Germany, (2) Institute of Physics, University of Potsdam, Potsdam, Germany, (3) Geophysical Institute, University of Alaska Fairbanks, Fairbanks, AK, USA, (4) Laboratoire de Glaciologie, Université Libre de Bruxelles, Brussels, Belgium

Making confident statements about the evolution of an ice sheet-shelf-system with a numerical model requires its capability of reproducing the migration of the grounding line. While full-Stokes models on high resolutions may be most accurate in doing so, their simulations are usually of high computational cost. In contrast simplified models provide a less time consuming alternative, but are often argued as not being able to resolve crucial aspects of ice sheet dynamics. Here we show that the SIA/SSA hybrid-type Parallel Ice Sheet Model (PISM), with its recent improvements, is capable of modeling the grounding line motion in a perturbed ice sheet-shelf-system. The model is set up according to the three-dimensional Marine Ice Sheet Intercomparison Project (MISMIP3d) and simulations are carried out across a broad range of spatial resolutions. Using 1) a linear interpolation of the grounding line with locally interpolated basal friction and 2) an improved driving stress computation across the grounding line, the reversibility of the grounding line (i.e. its retreat after an advance forced by a local perturbation of basal resistance) is captured by the model even on medium and low resolutions ($\Delta x > 10$ km). As far as we know, it is the first time that a shallow model captures grounding line reversibility at low resolutions without applying a flux correction at the grounding line. The transient model response is qualitatively similar to that of higher-order models but reveals a higher initial sensitivity to perturbation on very short time scales. Our findings support the application of PISM to the Antarctic Ice Sheet from a regional up to the continental scale also on relatively low spatial resolutions.