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Numerical modelling of grounding line dynamics and migration with a full Stokes ice-sheet model

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Prediction of grounding line migration and the effect of changes in the grounding line are still unsolved problems. Since the EISMINT experiments on grounding line treatment (Huybrechts et al., 1998), only a few model studies have tried to deal with the numerical inconsistencies at the grounding line that most finite difference models suffer from (e.g. Hindmarsh & Le Meur, 2001; Vieli & Payne, in press). These models, however, focus on the dynamical problem, i.e. by solving the ice-sheet equation across the grounding line and testing whether perturbations are reversible in terms of grounding line migration. Less attention is paid to the mechanical coupling between the ice sheet and the ice shelf. In most cases an ice sheet frozen to the bedrock is considered, solved with the shallow-ice approximation, where the ice shelf - if needed - is taken as a boundary condition. Here, we present experiments with a time-dependent higher-order ice-sheet model (Pattyn, 2002) as well as a full-Stokes model, where the mechanical coupling between sheet and shelf flow is taken into account properly. The position of the grounding line is determined with sub-grid accuracy and defined in terms of basal friction, which becomes zero when the ice starts to float. Using such a model setup, mass balance and sea level perturbations are reversible, even on a finite difference grid. A sensitivity analysis is presented on the influence of the width of the transition zone, and hence the nature of ice streams. A comparison with a shallow-ice model demonstrates that neglecting the transition zone, and hence longitudinal coupling across the grounding line, makes a significant difference.