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The stability of grounding lines on retrograde slopes

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The stability of grounding lines on retrograde slopes is invested numerically. The finite-element numerical model solves the shallow-ice-stream equations in two horizontal dimensions. The prognostic and the diagnostic equations are solved in a tightly coupled manner. The implications of this fully-implicit approach for the stability of the time-stepping algorithm and robustness of the estimate of the grounding-line position with respect to mesh resolution are discussed. All nonlinearities, i.e. those due to non-linear rheology, non-linear sliding law and the unknown position of the grounding-line at any given time step, are solved using Newton's method. When solving simultaneously for these three different nonlinearities, the non-linear loop reaches the theoretical quadratic convergence rate. Using the numerical model, the possibility of stable grounding lines on retrograde slopes is investigated. Using a 2D horizontal extension of the intercomparison experiment Ex3a, several examples indicating the possibility of stable grounding lines on retrograde slopes are given. It is suggested that the well-known instability of grounding lines on such slopes in a flow-line configuration may not apply universally in the more general 2D horizontal situation.