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The effect of ice rheology on contact problems

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Abrupt changes in basal conditions present a difficulty for full-Stokes isothermal ice sheet models, as the numerical solution often result in a singularity in basal stress and pressure. Although not physically likely, the singularity can in turn affect the behavior of the contact points, such as the ice-bedrock/ice-water boundary at the grounding line of marine ice sheets or in subglacial cavities. To investigate whether inclusion of temperature could help resolve and avoid the problem associated with singularities at contact points, we consider the simpler problem of an idealized ice stream across a no-slip to free-slip basal transition. Exact, analytical solution to this flow also exhibits singularities in basal shear stress and pressure, but as pointed out by Barcilon and MacAyeal (1993), non-linear ice rheology or thermodynamics could potentially alter the solution. We investigate this hypothesis numerically with a full Stokes finite element model, and present how the solutions differs from the initial solution obtained with a Newtonian rheology, when non-Newtonian rheology and thermodynamics are progressively introduced to the problem.