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Testing the validity of the boundary layer flux-thickness relationship at the grounding line

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The evolution of mass balance of marine ice sheets depends on changes in accumulation and fluxes at the edge of the grounded ice mass. Grounded ice sheet flow is dominated by vertical shearing while the ice shelf flow is mainly driven by longitudinal stretching and lateral shearing. Such specific mechanisms allow to simplify the Stokes equations, therefore large scale ice-sheet models commonly use the corresponding shallow ice and shallow shelf equations. However, at the transition zone, in the vicinity of the grounding line, both dynamical regimes of land-based and floating ice have to be considered for a proper modeling approach. It is now well established that migration of the grounding line is one of the weak points of ice sheet models. Recently, Schoof expressed the flux at the grounding line as a power function of the ice thickness, $q \propto h^{\sim 4.8}$, with h arising from the flotation condition. This solution has been implemented in an ice sheet model which reconstructs the large scale movement of the grounding line of the West Antarctic Ice Sheet over the past five millions years. Here, we investigate whether such an approach is pertinent to infer ice masses coastal changes in the foreseeable future. We use the full Stokes finite element model Elmer/Ice where a proper mechanical resolution of the contact problem in the ice sheet/shelf transition has been implemented. Simulations of a 2D flow line marine ice sheet resting on a downward sloping bedrock have been performed under different sea level variation scenarii and the power law that links ice thickness to ice flux at the grounding line has been calculated from the various simulations. We show that Schoof's analytical expression is well satisfied for steady state conditions, whereas during transient phases, the observed exponent is significantly lower. In the current context of rapid marginal changes, this would suggest that Schoof's approach may be limited to estimate the outflow and could lead to a misrepresentation of the coastal dynamics and unreliable estimations of the ice mass loss from the continent.