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A PRIMAL-DUAL FORMULATION FOR NUMERICAL SIMULATIONS OF MARINE ICE SHEETS WITH VARIOUS FRICTION LAWS

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Marine ice sheets are ice masses with grounded and floating areas which are separated by the grounding line (GL). Understanding the evolution of this GL over time is complex because it results from a balance between the effects of gravity, viscosity, and friction with the bedrock over the grounded part. By relying on perturbation methods, it is possible to derive from the governing equations an analytical formula for the so-called flux condition, which corresponds to the advective flux at the GL in an equilibrium configuration. Based on already existing expressions of this flux condition for Weertman and Coulomb friction laws, we have recently derived an expression of this flux condition for a more general class of friction laws [1].

These analytical studies can be compared with numerical results, but this requires a general code capable of handling a large variety of friction laws. To that end, we have developed a primal-dual finite-element discretization of the ice-flow equations, thus allowing the treatment of the grounded and floating parts in a unified way. This strategy allows to stabilize instabilities associated with the grounding-line migration for pressure-dependent friction laws, and to benefit from mathematical developments and numerical methods already obtained in contact mechanics [2].

In this presentation, we describe this primal-dual formulation and its numerical implementation. We compare the numerical results that can be obtained for the Weertman and the Budd friction laws with the associated flux conditions. We will also study the convergence of the method, and how the friction law itself can impact its efficiency. Finally, we present some directions for future work relative to the use of CPU-GPU architectures to accelerate the numerical simulations [3].

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