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FELIX: advances in modeling forward and inverse ice-sheet problems

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Several models of different complexity and accuracy have been proposed for describing ice-sheet dynamics. We introduce a parallel, finite element framework for implementing these models, which range from the "shallow ice approximation" up through nonlinear Stokes flow. These models make up the land ice dynamical core of FELIX, which is being developed under the Community Ice Sheet Model. We present results from large-scale simulations of the Greenland ice-sheet, compare models of differing complexity and accuracy, and explore different solution methods for the resulting linear and nonlinear systems. We also address the problem of finding an optimal initial state for Greenland ice-sheet via estimating the spatially varying linear-friction coefficient at the ice-bedrock interface. The problem, which consists of minimizing the mismatch between a specified and computed surface mass balance and/or the mismatch between observed and modeled surface velocities, is solved as an optimal control problem constrained by the governing model equations.