An Update on the Albany/FELIX First Order Stokes Finite Element Solver & Its Coupling to Land Ice Dycores

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This talk gives an update on the Albany/FELIX (Finite Elements for Land Ice eXperiments) dynamical core (dycore) that is currently under development at Sandia National Laboratories as a part of the PISCEES (Predicting Ice Sheet and Climate Evolution at Extreme Scales) project. The Albany/FELIX dycore is based on the "First Order" Stokes equations for ice sheet flow [1], an attractive alternative to the full Stokes model because of its reduced computational cost. The dycore is implemented within an open-source C++ Trilinos code called Albany [2] and uses various Trilinos libraries [3], which have enabled the rapid development of the code. Several methods for importing Greenland/Antarctica data (geometry, topography, surface height, basal friction, etc.) into Albany/FELIX are described, in addition to some recent work on coupling Albany/FELIX to other land ice dycores (the CISM and MPAS codes). This latter effort enables dynamic simulations of the ice sheet evolution, and facilitates the integration of the Albany/FELIX dycore into a global earth system model (ESM) to be used to support DOE climate missions by providing sea-level rise predictions. Results for some steady-state as well as dynamic Greenland and Antarctica simulations obtained on three different kinds of meshes (structured hexahedral grids, structured tetrahedral grids, true unstructured Delaunay triangle grids) are presented. Convergence of the code on a realistic Greenland geometry is demonstrated. It is shown that the Albany/FELIX code is scalable, robust and portable to new architecture machines (hybrid, multi-core, many-core, GPUs). Finally, attention is turned from forward to inverse ice sheet problems These problems are solved for the optimal Greenland/Antarctica initial state and basal sliding coefficient, and entail minimizing a merit functional involving the mismatch between measured and computed fields (e.g., surface mass balance, surface velocities), either in a deterministic or stochastic (Bayesian) setting.

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[2] M.A. Heroux et al. An overview of the Trilinos project. *ACM Trans. Math. Softw.* **31**(3) (2005).
[3] A.G. Salinger et al. Albany: A Component-Based Partial Differential Equation Code Built on Trilinos, submitted to *ACM Trans. Math. Software*.