Geosci. Model Dev. Discuss., 7, C2751–C2753, 2014
www.geosci-model-dev-discuss.net/7/C2751/2014/

Geoscientific Model Development Discussions
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Interactive comment on "*Albany/FELIX*: a parallel, scalable and robust, finite element, first-order Stokes approximation ice sheet solver built for advanced analysis" *by* I. Kalashnikova et al.

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Received and published: 22 December 2014

General comments

Modular software libraries are used to solve partial differential equations (PDEs) modeling ice sheets. The libraries are from the Trilinos project for solution of linear and nonlinear systems of equations, for discretization of PDEs with the finite element method, and for parallelization on thousands of cores. This is a good idea and extensions of the code to include inverse modeling and sensitivity estimation are possible using other parts of the libraries. The PDEs chosen here to model the ice are the Blatter-Pattyn equations. Under simplifying assumptions they can be derived from the full Stokes equations. The accuracy of the implementation is evaluated using manufactured solutions and comparisons with another code. The solution in the Greenland ice sheet is

computed in parallel in a test with a realistic geometry. The parallel scalability for the whole code is good and the convergence is as expected by theory when the mesh is refined. The paper is worth publishing if the comments below are taken into account in a revised version.

Specific comments

A major contribution in the paper is the use of software libraries to build the solver. Is it possible to estimate how much time and effort that has been saved by using these libraries? Such an estimate could encourage also similar developments for many other applications.

For prediction of ice flow, the Stokes equation has to be coupled to an equation for the motion of the surface and for long time intervals also for the bedrock. This coupling and the moving mesh or the ice surface cutting through a stationary background mesh are not discussed.

If a time dependent problem is considered, the difficulty with the nonlinear solver to find an initial guess is resolved by taking the solution from the previous time step (as remarked on p 15). Then the homotopy method may be needed only in the very first step.

A better explanation of the choice of manufactured solutions in ch 4 is needed. Are the analytical solutions typical for the ice solutions in the interior and at the boundaries? For a fair evaluation, they should have some relation to what can be expected from the Stokes equations.

On p 28, line 6, the difference between the present code and another code for the FO equations is of O(1e-10) which is remarkably small considering that at least two different finite element discretizations are used (p 25). Is there an explanation to the small difference?

The resolution in the z-direction is studied in experiments in ch 6.2. How many layers to use depends on the required accuracy. One percent relative error in Fig 14 is probably enough (considering all the modeling and data errors). Then 10 layers should suffice. A graded or a uniform mesh does not seem to matter. An explanation could be that there is a boundary layer also at the ice surface which is not resolved by the graded mesh (see e.g. Schoof, C. and Hindmarsh, R.: Thin-film flows with wall slip: an asymptotic analysis of higher order glacier flow models, Quart. J. Mech. Appl. Math., 63, 73–114, 2010). A relative accuracy less than 1e-4 can never be necessary.

Appendix A may be removed. The full Stokes equations can be found in many references.

Interactive comment on Geosci. Model Dev. Discuss., 7, 8079, 2014.