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Interactive comment

Interactive comment on "Optimal numerical solvers for transient simulations of ice flow using the Ice Sheet System Model (ISSM)" *by* Feras Habbal et al.

Anonymous Referee #1

Received and published: 11 July 2016

In this work, the authors compare the performances of several different direct and iterative solvers, provided by MUMPS and PETSc libraries respectively, for solving the transient ice flow model using ISSM. Specifically, the authors target a well known transient benchmark problem (ISMIP-HOM, test F), in the case of a frozen bed or sliding bed. The flow model is constituted by the ice velocity part (Blatter-Pattyn model with constant viscosity), a part for reconstructing vertical velocities, and the mass-transport part. The authors highlight some of the solvers that perform better on different mesh resolutions, for both frozen or sliding bed.

The detailed comparison of the solvers available in ISSM is certainly useful for the several ISSM users.

However, I have a few reservations about the impact that this work can have on a broader community.

- The benchmark problem addressed in this work has several simplifications that makes it not very representative of real problems, most notably: 1. Geometry is very simple (in constrast with complex margins or bed roughness encountered in real ice sheets). 2. Viscosity is constant, making the model linear. In real problems viscosity strongly depends on velocity and temperature, which makes the problem much harder to be solved numerically. 3. A relatively high basal friction coefficient is considered, which is not representative of what can be found in ice streams and ice shelves.

- The authors consider only off-the-shelf solvers that "naturally fit the ISSM framework", whereas several efforts (not mentioned by the authors) have been done in recent years in order to build efficient solvers/preconditioners tailored on the ice sheet problems. Some of these solvers have been demonstrated on large-scale simulations of Greenland or Antarctic ice sheets. See, for example, T. Isaac et al., SIAM J. Sci. Comput., 37(6), B804–B833; Tezaur et al., Procedia Computer Science, 51:2026-2035, ICCS, 2015, S. Cornford at al. J. Comput. Phys, 232(1):529-549, 2013; plus the one by Brown et al. already cited, but not discussed, by the authors.

I recommend that the authors make it clear in the abstract that they are only considering the off-the-shelf solvers readily available in ISSM. I also recommend to consider more realistic problems and to mention relevant work in the literature.

Minor comments:

- At line 144 the authors mention that they apply single-point constraints on velocity and thickness equations. I'd like the author to expand on this, mentioning how/with what values they constrain in a single point the velocity and thickness. Typically, single-point constraining is used in presence of a singular problems (which should not happen here), and it is known to artificially modify the spectrum of the matrix, which in turn can deteriorate the convergence of iterative solvers.

- Line 150, how the vertical velocity is reconstructed? With an L2 projection?

- The time reported in the tables is solver time, or total time (including assembly, linear solvers and I/O)? The weak scaling results for the iterative solvers are not very good and it would be useful to understand what is causing this.

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