Geoscientific Model Development Discussions

Geosci. Model Dev. Discuss., author comment AC2
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Reply on RC2

Ludovic Räss et al.

Author comment on "Assessing the robustness and scalability of the accelerated pseudo-transient method" by Ludovic Räss et al., Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2021-411-AC2, 2022

Dear reviewer,

We thank you for the suggestions made to our initial mansucript draft and addressed your major and minor comments. Please find hereafter the answers to your comments and suggestions.

Thank you for your insights

Ludovic Räss on behalf of the authors

Detailled replies:

Title: "towards exascale computing" is not necessary. Remove.

We removed it.

Major Comments:
1. In the introduction, the authors contrast the pseudo-transient methods with Krylov iteration methods, such as conjugate gradient or GMRES methods. A benefit of pseudo-transient is that they are local and do not require global reductions unlike standard Krylov methods. First, there has been work on communication avoiding Krylov methods that reduces/avoids many of these global comms. See, for example, the widely cited Ph.D. thesis:
Hoemmen, Mark. Communication-avoiding Krylov subspace methods. University of California, Berkeley, 2010, or the more recent work the reduces the number global reductions for Gram-Schmidt and GMRES:
Åwirydowicz, Katarzyna, et al. "Low synchronization Gram–Schmidt and generalized minimal residual algorithms." Numerical Linear Algebra with Applications 28.2 (2021): e2343.

Thank you providing these references. We added one paragraph to the introduction including and discussing them.

In addition, preconditioning and "intelligent" guesses for the initial Krylov vector

can vastly reduce the number of iterations required, thus making Krylov methods more competitive. A computational comparison and discussion of the proposed method with Krylov would be a welcome addition to the paper.

A comparison between advanced communication-hiding Krylov solvers and the accelerated PT method would certainly be valuable. However, this initiative represents a project on its own and goes beyond the scope of this study. This will be addressed in a subsequent study.

2. In Section 2, the authors assume the the computational domain is a cube with the same number of cells in each dimension. In geoscientific models, such as the atmosphere and the ocean, there is are order of magnitude differences in scales between the horizontal and vertical, and hence large differences in the grid spacing. The PT methods requires choosing an optimal Reynolds number, which depends on the length scale. How would the authors adapt the PT method to handle these scale differences--they claim "the solution strategy is not restricted to cubic meshes with similar resolution..."

Good point. We added one more figure (Fig. 14) reporting the normalised iteration count for various numerical resolutions varying the aspect ratio from 1 to 8 using the visco-elastic Stokes flow in 2D. We show that the convergence is not hindered by larger aspect ratio while keeping the cell aspect ratio constant.

3. The English is sub-standard and needs to be improved. See the minor comments.

We worked on it.

Minor Comments/questions:
1. Line 31: "see a regain in active development..." is awkward. Replace with "are in active development". Citations to back this assertion would be nice.

We removed "active" but did not further change the sentence as the suggested changes do no longer convey our message, namely, "there is a regain in development" is not similar to "there is an active development".

2. Line 121: The notation [0;L] is not standard. [0,L] is standard.

We've changed it.

3. Equation (1): Odd notation for the divergence operator on the right hand side. This is the continuity equation assuming constant density.

Thank you for the comment. Note, however, that we never refer throughout the manuscript about Equation (1) standing for diffusion of mass (for which case some minor inconsistencies with respect to density may rise). Within this study we use the diffusion equation as inspired by, e.g., heat diffusion. The here diffusion (and not continuity) equation has the rho parameter as a factor of proportionality written down as such for internal consistency with the following steps.

4. Equation (2): Why is "i" used instead of "k" ?

K is for summation, i is per dimension. We added some clarification to the text.

5. Line 138: Replace "to assemble" with "assembling"

We fixed it.

6. Line 146: Replace Eq. (15) with Eq. (3).

We fixed it.

7. Line 149: Replace the comma after tau with a semicolon.

We fixed it.

8. Line 174: Remove "the" before "Eq. (7)".

We fixed it.

9. Equation 7: This is the equation for Cattaneo diffusion. See, for example, "Methods of Theoretical Physics" by Morse and Feschbach. It is also called the Telegrapher's Equation in .

Thank you for the comment. We did not modify the text since the suggested naming may not be that standard.

10. Line 181: What happens to C if the grid spacing is different in different dimensions? See major comment 2.

One could expect some loss of accuracy in the FD scheme.

11. Line 335: Replace "it's" with "its".

We fixed it.