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Geoscientific Model Development Discussions

Interactive comment on "P-CSI v1.0, an accelerated barotropic solver for the high-resolution ocean model component in the Community Earth System Model v2.0" *by* Xiaomeng Huang et al.

Anonymous Referee #2

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1 General comments

This paper presents a new solver and preconditioner for the barotropic mode of the POP ocean model, focusing on parallel performance. The new CSI solver is slower than the previous CG solver in serial, but it removes a parallel reduce operation which makes it significantly faster at high number of processes. The new EVP preconditioner reduces the number of iterations required by the solver, thus reducing both computation and communication time. The authors demonstrate that the new P-CSI solver significantly improves the efficiency of the POP model in massively parallel runs.

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Discussion paper

The paper extends an earlier proceedings paper (Hu et al. 2015) by presenting: a more detailed description of the barotropic solver used in POP, analysis of the eigenvalues and condition number of the associated linear operator, analysis of the convergence rates of different solvers, and new estimates of the computational complexity of the solvers. It is however debatable whether the additional material merits another publication as most of the material originates from Hu et al. (2015). In addition the analysis of the condition numbers could be improved.

2 Specific comments

Section 4.1 Spectrum and condition number

As we are dealing with a 2D shallow water solver, this analysis would be clearer if it incorporated the non-dimensional barotropic CFL number. It would be useful to know what the CFL number of the 2D mode is in typical CESM runs, and use that as a basis for the analysis and idealized experiments.

Noting that $CFL = c\Delta t/\Delta x$, with $c = \sqrt{gH}$ being the speed of the gravity waves, ϕ in eq. (14) (and consequently the condition number) can be expressed as a function of CFL. Specifically $\phi = 1/(CFL_x CFL_y)$ and (using $\lambda_{min}, \lambda_{max}$ from line 273) the condition number is approximately $\kappa \approx 4CFL^2 + 1$ for large time steps and aspect ratio=1, which shows the dependency clearly.

Similarly in Figs 5, 6 and 7 it would be useful to use the CFL number instead of the time step or 2D velocity. The value of the time step alone, for example, is not informative as it depends on how the idealized run was set up.

Section 3.2 A block EVP preconditioner

In the last paragraph the authors mention that the drawback of the EVP preconditioner is that it cannot be used to solve large problems due to propagation of errors. Does this imply that EVP cannot be used at low processor counts? If so have the authors experimented with or documented the failure of EVP? Is it possible to derive a threshold problem size under which the EVP preconditioner is reliable?

Section 4.3 Computational complexity

These estimates of computational complexity are similar to those presented in Hu et al. (2015). Some of them are different however (e.g. eqns. 26, 27, 28) especially in terms of the computation time T_c. Why the difference?

line 400: Fig. 8 shows that the P-CSI solver converges slower compared to PCG. Why is it so? The analysis in Section 4.2 concluded that the convergence rate should be similar.

line 415: It is not clear how the grid is divided in blocks. It might be worth explaining this is Section 2.1.

3 Technical corrections

line 109: ρ_0 is the constant reference density, not the actual water density

line 122: Meaning of the last sentence is unclear, please elaborate/reformulate.

line 170: typo: scalar

line 285: Here the authors assume that the time step satisfies the CFL condition, i.e. CFL<=1, where the velocity v is chosen rather arbitrarily. It would be better to use CFL numbers typical to CESM applications.

fig 7: what is the grid aspect ratio used in this test?

line 335: T_c is not defined in this paper

line 513: typo: scalar

figs. 16 and 17: these figures are not mentioned in the manuscript

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