

Interactive comment on “A High-order Staggered Finite-Element Vertical Discretization for Non-Hydrostatic Atmospheric Models” by J. E. Guerra and P. A. Ullrich

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Thank you for your thorough review of our work. I'd like to respond here to your general comments. The specific comments you gave and technical corrections will all be addressed upon revision of the paper.

About your general comments:

1) Tempest is intended and built to be a general framework for atmospheric simulation. This includes all relevant scales in both spherical and Cartesian domains with and without topography. We will include this context more explicitly into the language. Clarifying this point will help illuminate our use of the equations in arbitrary coordinates

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as it benefits the implementation.

2) We clearly see this as an oversight and will make sure to incorporate a better literature review of mixed finite elements.

3) I will take the recommendation of using the bubble test at 300s to perform spatial convergence and temporal convergence tests. This is certainly an important piece of information that is needed to evaluate the quality of our method. We expect from experience with our simulations that these tests will be unremarkable and show self convergence near the theoretical rates.

4) The results we report in the validation section were done on 10+ to 100+ cores using a distributed node cluster available at UC Davis. However, this is a shared resource and node allocation is only partially under our control. So, it is quite difficult to have run-to-run consistency in the hardware we are allocated. That is the reason we used a small local machine to do a small time performance study. Another reason is that Tempest is not yet optimized for performance i.e. no preconditioner for the linear solver, and other code improvements currently underway to improve parallelization.

5) We will consider including mass and energy conservation results. We fully expect that mass conservation is achieved in our tests. Energy conservation requires an analysis of the interpolation/differentiation operators for staggered column configurations that have revealed some requirements in the implementation. Also, our explicit dissipation strategy is still subject to heuristic tuning of diffusion coefficients (mainly in the horizontal hyperdiffusion, but also for the vertical velocity dependent diffusion) so we expect that mild energy loss is present. Our goal is, of course, to find configurations that are stable with minimal diffusion.

6) We will include our previous study and description of the method. However, that work differs in the equation system used. The difference is in the use of covariant velocity components as prognostics. This has some important implications in the construction of the various operators and we have found the current system to be better suited to

the discretization.

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