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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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This paper examines use of spectral elements in the vertical direction for the solution of the Non-Hydrostatic Euler equations using an Implicit-Explicit (IMEX) strategy. Staggering is important to avoid stationary modes, especially in the vertical direction which is often treated implicitly (e.g. 1D IMEX with columns). This paper nicely combines these two concepts to a method referred as Staggered Nodal Finite Element Method (SNFEM). The method is explained well and validated with standard benchmarks in atmospheric modeling. Therefore, I strongly recommend this work for publication.

Here are some comments and questions

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Discussion paper

1. Page 3, Line 20: "The fact that LGL points are clustered optimally near element edges lends itself to better resolution of the ABL...", is mentioned as an advantage of SNFEM. It seems to me that is only the case if one element is used in the vertical. If two or more elements are used, there will be clustering of nodes in the middle of the domain – which results in non-optimal placement of nodes overall. Moreover, sufficiently resolving the boundary layer probably requires many near-wall elements – elongated due to the anisotropic refinement that will in-turn degrade accuracy of solution.

2. Page 31, Line 20: I would have liked to see the baroclinic or similar test case done on the sphere (curved geometry). I understand this is postponed for a future work but I am curious to see if a high-order vertical discretization would be enough to maintain hydrostatic balance on the sphere without using reference states. This was mentioned as an advantage of going high order in Page 4, Line 20.

3. Page 30, Line 15: The paper recommends use of 4^{th} order polynomials in the vertical for reasons of efficiency and stabilization of the spectral element method. I wounder if 4^{th} order polynomial , which has 2 or 3 nodes near the boundary layer, be enough to resolve the ABL (see my first point).

4. Page 20, Line 15: Are there alternatives to staggering – some kind of interpolation scheme that would be equally efficient as staggering to avoid problems with stationary modes? I ask this because once we used discontinuous Galerkin methods in one of our projects in both horiztonal/vertical directions, and I believe all thermodynamic variables were collocated.

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