

## ***Interactive comment on “The spectral element method on variable resolution grids: evaluating grid sensitivity and resolution-aware numerical viscosity” by O. Guba et al.***

### **Anonymous Referee #1**

Received and published: 22 July 2014

This is a high quality paper that thoroughly evaluates the performance of the CAM spectral element model with dissipation of grid scale variance using hyperviscosity. Tensor-based hyperviscosity is shown to perform very well when using a non-uniform resolution grid. The error in low resolution regions is shown to be unaffected by noise that can result from grid refinement. This is important for climate applications. Two grid generation methods are evaluated. A new open-source, SQuadGen, is shown to produce low-valence node, high grid-quality, variable resolution grids that are well suited for this application.

I have a few specific comments regarding the content of the paper:

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- **p:4086 In:2** Can you give a brief derivation of how  $\nu\Delta^2 = (\nabla \cdot \tau\nabla)\Delta$ ?
- **Eq. (2) & (3)** It is unclear to me how these equations are formed from equation (1). It would have been very useful to have defined what  $q$  is at least. Ideally some brief details about how these equations are derived would be useful.
- **Section 5.3** You discuss how grid refinement gives the expected 4<sup>th</sup>-order convergence rate. I can not find anywhere where you describe what your time step is in each of the simulations used to assess the convergence rate. Your time-discretisation is 2<sup>nd</sup>-order accurate. If the time step is reduced at the same rate as the grid size, and the errors arising from the time-discretisation are of similar magnitude to the spatial-discretisation errors, then I would expect the error to show 2<sup>nd</sup>-order convergence as the time-discretisation errors will become dominant. I assume you either use a very small time step such that the spatial discretisation errors dominate or you decrease your time step at a much higher rate than you decrease your grid spacing. Could you add details about what you do? Indeed, throughout the entire paper I can see no reference as to what the time step is in any of the simulations. This would be useful information.

And minor comments:

- **Eq. (1)** The subscript  $t$  in this equation is described after equation (3). It should be described after equation (1) is defined. It would also be useful to mention that  $Q$  is a model variable.
- **p:4086 In:5** 'the equations' - should this be equation (1)?
- **p:4095 In:14** Missing a word in this sentence at \*\*\* - less noise \*\*\* the refined
- **p:4096 In:5** The sentence does not make sense - probably do not need the from in 'solution from computed'

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- **p:4097 In:6** Change 'that' to 'than'

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Interactive comment on Geosci. Model Dev. Discuss., 7, 4081, 2014.

**GMDD**

7, C1219–C1221, 2014

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