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Geoscientific Model Development Discussions

Interactive comment on "The ICON-1.2 hydrostatic atmospheric dynamical core on triangular grids – Part 1: Formulation and performance of the baseline version" *by* H. Wan et al.

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The paper presents a global atmospheric model with relevant novel concepts and is of great interest to the scientific community. It is adequate for publication in GMD, although a few points could be better explained. The main concerns are related to its low order of accuracy (first order only). Also, it would be interesting to see more comments on the motivations of the grid and methods used, the models computational performance and its advantages/disadvantages relative to other numerical schemes and models.

1) Grid choice

- It would be interesting to see motivations regarding the choice of the triangular icosa-

hedral grid and the type of staggering.

- What are the potential advantages/disadvantages of this choice when comparing to other icosahedral models such as GME, NICAM, MPAS and OLAM?

2) Grid optimization

-The authors are using an optimized version of the icosahedral grid, using spring dynamics. This kind of optimization is sensible to the choice of some parameters and implementation. I recommend that the paper could contain more details about the grid used. For example, why was beta=0.9 used? Was it implemented with linear or non-linear spring?

-From table 1, it seems that the ratio of max/min areas is growing with resolution, indicating that, on finer grids, some loss of uniformity is happening.

-This optimization method is designed to perform well on hexagonal/pentagonal grid cells, minimizing their distortions. Are there any guarantees that it will improve quality of triangular grids as well?

-The discretization and interpolation methods used are sensitive to grid properties, this is mainly why I recommend commenting a bit more on the grid properties.

3) Vector reconstruction

- What shape parameter was used on the inverse multi-quadratic kernel?

- The RBF vector reconstruction might lead to numerical instabilities on finer grids, due to the ill conditioning of the interpolation matrix. Fortunately, the stencil used is very small and the instabilities will probably not happen on the resolutions of interest. Nevertheless, this is something to be aware of, and could be pointed out in the paper.

- Perot's reconstruction might be an interesting alternative in order to keep some mimetic properties that RBF do not.

- For some other possible alternatives I suggest the reference [1].

4) Horizontal interpolation

- What are the accuracy orders of these operators on the spherical icosahedral grid?

- Due to the non regularity of the icosahedral grid, the operator (c2e) will not be necessarily be centred. This may impact on the order of some discrete operators.

- The formula for the interpolation (e2c,aw) seems strange. If a circumcenter is near an specific edge, the weight of this edge should probably be higher than the other edges of the triangle. But using the area as shown in figure 5a, the edge weight will be the smallest. As it is, the interpolation scheme does not recover the edge value if the interpolation is to be made at the edge.

5) Discretization order

- The results shown on the truncation error analysis section are interesting, but are they extendible to the sphere?

- On the sphere, when using the icosahedral grid, the discretization of the curl (as well as the div) will be only first order accurate on some cells, which is in fact responsible for some grid imprinting (See reference [2] for more details).

- The gradient discretization will also be only first order, due to the fact that primal and dual edges do not intersect at the midpoint of both.

- Are the vector Laplacian discretizations consistent on the spherical grid used? Heikes and Randall 1995 showed that it was necessary to have a special king of grid optimization to achieve this on hexagonal icosahedral grids. I imagine that similar problems could happen on the triangular grid.

- Although many parts of the model are discretized in a second order fashion, considering a regular triangular planar grid, it seems that only first order accuracy is ensured for the icosahedral grid on the sphere. Did the authors observe any drawback regarding

this?

6) Linear system solver

- The 2D Helmholtz equations are solved with a GMRES solver. I would find interesting to see some motivation for this choice, as it can affect the performance of the model and its parallelism.

7) Computational performance

- The locality properties of the scheme allow a great deal of parallelism, essential for the model to be efficiently used in high resolution, long term climate scenarios. Was the model parallelized?

- Comparing the model with the spectral one, shown in table 2, respecting resolution and error criteria, what is the relative performance gain/loss?

References:

[1] B. Wang, G. Zhao, O.B. Fringer, Reconstruction of vector fields for semi-Lagrangian advection on unstructured, staggered grids, Ocean Modelling, Volume 40, Issue 1, 2011.

[2] P. S. Peixoto, S.R.M. Barros, Analysis of grid imprinting on geodesic spherical icosahedral grids, Journal of Computational Physics, Volume 237, 15 March 2013.

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