Geosci. Model Dev. Discuss.,
doi:10.5194/gmd-2016-265-RC1, 2016

Geoscientific Model Development Discussions

Interactive comment on "Vorticity-Divergence semi-Lagrangian Global Atmospheric Model SL-AV20: Dynamical Core" *by* Mikhail Tolstykh et al.

Anonymous Referee #1

Received and published: 23 December 2016

General Comments:

This manuscript deals with the development of a hydrostatic global atmospheric dynamical core based on the semi-Lagrangian (SL) method with a vorticity-divergence formulation. This model combines several nice features such as the reduced latitude-longitude grid system, variable resolution option, semi-implicit time stepping and the use of conservative SL approach based on an efficient algorithm. The research involved is interesting and worth publishing in GMD. The technical aspect of the model is well described in the manuscript. However, the numerical experiment section requires improvements, and this may be addressed by performing more challenging tests for validation.

Major Comments:

(1) Sections 2, 5: The reduced latitude-longitude grid system can alleviate some major issues with the "pole problems." However, it is not clear whether your reduced grid system includes the singular pole points in the computations. The spherical operators in Eqn.2-5, involves terms with the cosine of the latitude in the denominator, which may lead to instability at the vicinity of the poles when using FD discretization. How do you address this issue? Please provide some description on this in the revised manuscript.

(2) Section 3.2: The SL computational efficiency is obtained with the dimension-splitting conservative cascade scheme (CCS). This scheme uses an efficient sequence of 1D operations for multi-dimensional problems. Authors should briefly outline the CCS for the sake of clarity, which would help the readers. Moreover, the basic paper on CCS algorithm (Nair et al. (2002), MWR, vol.130, pp 2059-2073) should be cited in the revision.

(3) Section 9: The performance of the model is validated with a couple of experiments. The J-W baroclinic instability test is a relatively simple test for SL models, both reduced and full grid models produce very similar results. The Held-Suarez test shows the time-space averaged results over 1000 days, it is not a challenging test for comparing the numerical schemes or grid systems. What it shows is the model's overall ability to maintain an equilibrium for long-term integrations.

Authors should consider performing a short-term integration experiment, based on flow over an isolated mountain, similar to the SW test-case 5 proposed by Williamson et al. (1992). The mountains/topography pose problems particularly for the SL models, and such a test would be far more interesting. See the "mountain-induced Rossby wave test" in Simmaro et al. (2013), Tellus A 2013, 65, 20270, http://dx.doi.org/10.3402/tellusa.v65i0.20270).

Also the reference: Jablonowski, C., Lauritzen, P. H., Taylor, M. A. and Nair, R. D. 2008. Idealized test cases for the dynamical cores of atmospheric general circulation models:

a proposal for the NCAR ASP 2008 summer colloquium. http://esse.engin.umich.edu/admg/publications.php

Minor Comments:

(1) In the Abstract please indicate that your model is hydrostatic, these days dynamical cores mostly imply non-hydrostatic model development. (2) Reference: On Page 26, lines 25-28: The two references for baroclinic instability tests by Jablonowski, C. and Williamson, D... refer to same test, keep any one of them. (3) It would be nice to include your future extensions plans (if any) with this hydrostatic dynamical core, in the Conclusions.

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