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

Anonymous Referee #2

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Review on paper: "Vorticity-Divergence semi-Lagrangian Global Atmospheric Model SL-AV20:Dynamical Core"

January 9, 2017

1 Overview

This paper describes the new version of the hydrostatic SL-AV20 hydrostatic dynamical core used by the Russian Hydrometeorological Centre for global weather forecasting. It is based on a vorticity-divergence formulation and semi-Lagrangian semi-implicit timestepping using a reduced lat/lon unstaggered grid to reduce computational cost. The model formulation and the numerical discretizations are described in the paper and the reduced grid version of the model is compared against a standard (unreduced) lat/lon grid version on two well known test cases for dynamical cores.

SL-AV20 dynamical core has noticeable differences from other hydrostatic semi-implicit, semi-Lagrangian dynamical cores both in the formulation and the implementation. Some of these aspects are novel and therefore I would be happy to recommend publication of this paper in GMD, however, it requires some revision as outlined in my comments in the following sections.

2 Major comments

Section 2 describes the governing equations. The paper relies to some degree on reader's familiarity with the particular approach followed in SL-AV. For this reason this section needs few modifications to improve its clarity. In particular:

1. Eq (1). It is mentioned that it is derived by applying $k \cdot \nabla\times$ to the momentum equations. I think that it would be better to start from (and explicitly write) the original form of momentum equations that give Eq (1). This must be Eq (3). In this case lines 5-10 need some re-arrangement so that description evolves from the simpler to the more complex form. It is not very clear where the coefficient $B(\eta)p_s/(A(\eta)p_0 + B(\eta)p_s)$ comes from and would be helpful to guide the reader on this. I wonder if the Rochas, 1990 reference is available through a web-link? If that is so please provide it.
2. Please add some information on how you derived Eq (6). I assume that this equation is the analogue of Eq (15) of McDonald and Haugen 1993 if you consider T_v?
3. Continuity equation (8). Please explain how is this derived from original Eq (2) of McDonald and Haugen 1993 or any other form you may have considered.

In the topics of implementation and numerical experiments I have the following questions/comments:

1. Please comment somewhere in the paper on the efficiency/scalability of their proposed approach compared with other similar hydrostatic spectral semi-Lagrangian approaches on reduced Gaussian grids where transpositions are also necessary for the Fourier/Legendre transforms.
2. For the experiments in section 9, the timestep used is 1200s reduced by a resolution depending factor c as the resolution increases. What is the maximum CFL

in these experiments? Given that SISL timestepping is used the model should be able to run stably at max CFL larger than 1 (e.g. 5) without loss of accuracy.

3. Is there a standard verification comparison (e.g. 500hPa geopotential height RMSE / Anomaly Correlation Coefficient) between fixed and reduced SL-AV20 model on real forecast cases available? If such comparison exists I would recommend to include it to strengthen the validation part of the paper.

3 Minor comments

I think that the fact that this is a hydrostatic dynamical core should appear very early in the text and in the abstract.

1. Line 8: "test cases"
2. page 2, lines 4-5. I think that for "computational efficiency" we want to achieve a solution at a given accuracy at the shortest possible time for a given number of processors.
3. page 2, line 8: perhaps "few kilometers" is meant instead of "first kilometers"?
4. page 2, line 16: "cost" instead of "pattern"?
5. page 21, line 9: "deterministic"