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Interactive Comment

Interactive comment on "A semi-Lagrangian advection scheme for radioactive tracers in a regional spectral model" *by* E.-C. Chang and K. Yoshimura

Anonymous Referee #2

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General comments

The manuscript describes the integration of a semi-Lagrangian transport scheme for mainly radioactive tracers into the National Centers for Environmental Prediction (NCEP) regional spectral model (RSM). In general, the manuscript is clearly understood with the well-chosen methodology. The semi-Lagrangian method improves the model's capability of maintaining positivity for certain tracers, which become negative due to numerical artifacts in the spectral expansion. While the paper appears to be a reasonably complete attempt and the effort is useful, the findings of the paper are not overly innovative. Semi-Lagrangian methods have been studied for a long time and their usage for tracer transport is also a well-documented idea. However, there are a few new ideas with respect to limited-area model. More detailed comments and recommendations are given below.

Specific comments

1. 1D and 2D idealized tests shown in this manuscript (Figs. 3 and 4) have been already completed satisfactorily by the previous studies (Juang 2007, 2008; Zhang and Juang 2012). Therefore, they seem to be not essential for this paper. I believe, however, that 3D idealized test is a prerequisite to real-case experiments in the presence of orography. When grid-spacing is not equal in the vertical (I guess this goes for your model), mass conservation of passive tracers should be more complicated question if dry air is not treated by SL scheme. In Fig. 7, vertical advection seems to be weakened by the SL in comparison with the ORG, which might be related to the aforementioned issue.

2. Aside from the Gibbs-related issue, I wonder how the model performance is different between the ORG and SL simulations in terms of accuracy and efficiency. In this manuscript, the analysis is overall qualitative. There are no quantitative metrics to evaluate the model performance against the observed or analyzed data in case of real-case experiment, except for mass conservation in section 3. Even though the purpose of this study is not a “beauty contest” as the author stated in the final section, it is undesirable that model performance is degraded just by applying a new advection scheme. Enhancement of physical parameterization should not be a fundamental solution to correct the error of dynamic-advection scheme. 3. There is a lack of detailed description in model and experimental design. For example, what is the perturbation method, global model program (GMP), initial and lateral boundary conditions? How did you treat negative values which are inherent in the initial fields or might be generated by physical parameterizations?

4. Newly-developed boundary treatment is not sufficiently evaluated on condition that tracers flow in and out at the boundary. Would it be difficult to include the SL simulation

with a source near the boundary?

5. P4225L8 "(1) non-iteration to find the departure and arrival points of each tracers;" In general, semi-Lagrangian approach does not require iteration for departure and arrival points but for trajectory in some cases, so this is not unique feature of the NDSL scheme.

6. P4225L13-15 "In this case, . . . to the arrival point." This is not correct: It requires solving the ODE for trajectories, which is often accomplished by a simple fixed point iteration. It could also be done by applying other ODE solvers.

7. P4225L21 ". . .the scheme is computationally efficient." Contrary to the authors' claim, the trajectory calculations are relatively cheap. Usually only two iterations suffice and communications for parallel codes are not necessary. Remapping is substantially more expensive for both serial and parallel codes. Remapping needs reconstruction, monotone and positive filters, and integration. It also needs communications across adjacent processors to maintain exact mass conservation. Therefore, it is clear that replacing a scheme with 1 trajectory + 1 remapping (two-time-level) with 2 remappings (three-time-level NDSL) is certainly less efficient. Furthermore, NDSL uses dimensional splitting and performs a series of one-dimensional remappings. To remove the bias on the order in which the remapping is done for higher dimensions, NDSL uses an average of several remappings with permutation of the order of remapping. Therefore, looking at the details of the scheme, it is inconceivable to reach the conclusion that NDSL is more computationally efficient than other schemes in the literature.

8. It seems to me that Figures 6c-6d and 7c-7d are not meaningful because there are no significant differences from Figures 6a-6b and 7a-7d.

Interactive comment on Geosci. Model Dev. Discuss., 8, 4221, 2015.