Geosci. Model Dev. Discuss., 3, C570–C572, 2010
www.geosci-model-dev-discuss.net/3/C570/2010/

Geoscientific
Model Development
Discussions

Interactive comment on "Mass-conserving tracer transport modelling on a reduced latitude-longitude grid" *by* D. Belikov et al.

Anonymous Referee #1

Received and published: 24 November 2010

The authors attack an important problem in atmospheric/oceanic composition and tracer transport that is, unfortunately, becoming ignored by the community as increasingly more complex modeling and assimilation systems are built on top of ancient methods with known problems. They combine a mix of standard tests with more realistic examples. The paper is useful and contributes to the understanding of the problems of resolution, cost and accuracy when modeling atmospheric tracer transport.

There are some minor problems and oversights that could be remedied easily with a revised manuscript, but not a re-do of the numerical simulations. Basically, the authors seemed to have missed some of the literature that is crucial to their efforts to improve the NIES high-resolution model.

Problem 1. The Prather SOM and the Lin and Rood methods have been compared

directly for the CO2 test case in a recent paper (Prather et al. 2008) that the authors missed. This addresses some of the problems here and should probably be analyzed to see if it is useful.

Problem 2. The pressure-error problem has indeed been known and is "fixed" in both Prather et al 1987 and Heimann and Keeling 1989. Cameron-Smith did a more elegant and better fix to this long-standing problem in Rotman et al 2004. For a range of GCM and analyzed wind fields this is no longer a problem.

Problem 3. The reduced latitude-longitude grid here was pioneered by Kurihara 1967 and Prather 1987, but more recent developments should be noted (even if not implemented here): the cubed sphere (Putman and Lin, 2007); the replacement of the CFL with a Lifshitz criteria (Prather et al 2008).

Problem 4. The authors talk about the much greater numerical diffusion of the van Leer method for surface CO2 (Figure 12). This does not really make sense: at 0.625 deg resolution, both the VL and Pr methods should readily preserve the emissions structures. Perhaps they had better check the code for the lower boundary-layer wind fields and advection? For example, a CTM running Pr(SOM) at 1 deg resolution (not that different from the 0.625 example here) produces highly resolved fold structures in the upper troposphere (Tang et al 2010) that do not look as washed out as Figure 12.

Problem 5. The relative timings for the different methods (Table 1) are perhaps misleading since they are not necessarily based on optimal programming. For example, the new Pr method (see appendix of Prather et al 2008, Tang et al., 2010) is optimized to run 1 deg or finer without a global CFL criterion. The authors may wish to note that the NIES-08/VL & Pr timings, especially for the 0.625 deg case, are not realistic for modern code.

Missing refs:

Heimann, M., and C. Keeling (1989), A three-dimensional model of atmospheric CO2 transport based on observed winds: 2. Model description and simulated tracer experiments, Geophys. Monogr., 55, 237–275.

Prather M.J., X. Zhu, S.E. Strahan, S.D. Steenrod, J.M. Rodriguez (2008), Quantifying errors in trace species transport modeling, Proc. Nat. Acad. Sci. 105(50): 19617-19621. Putman, W. M. and S.-J. Lin (2007) Finite-volume transport on various cubed-sphere grids. J. Comput. Phys., 227, 5578.

Rotman, D. A., et al. (2004), IMPACT, the LLNL 3-D global atmospheric chemical transport model for the combined troposphere and stratosphere: Model description and analysis of ozone and other trace gases, J. Geophys. Res., 109, D04303

Q. Tang, M.J. Prather (2010), Correlating tropospheric column ozone with tropopause folds: the Aura-OMI satellite data, Atmos. Chem. Phys., 10, 9581-9688.

Interactive comment on Geosci. Model Dev. Discuss., 3, 1737, 2010.