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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Limits on the ability of global Eulerian models to resolve intercontinental transport of chemical plumes" *by* Sebastian D. Eastham and Daniel J. Jacob

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This is an interesting study that I can fully recommend for publication. The paper addresses an important aspect of chemical transport modelling that probably most modelers are somewhat aware of (or maybe not), but often seem to prefer ignoring because of its inconvenience. I already liked the paper of Rastigejev et al. (2010) and this paper from the same group dwells deeper into the problems found by these authors. The paper is clear, concise and well written. I congratulate the authors for being critical about an issue that may not be very popular but is nevertheless important. The following comments may be considered by the authors when revising their paper.

Page2, lines 11-17: This text is a bit unbalanced. It is true that Lagrangian models have

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difficulties with non-linear chemistry, but that is true both in the troposphere and stratosphere, and not only in the troposphere. On the other hand, convective motions are not a problem at all (Forster et al., 2007). Convective schemes have been implemented in several Lagrangian models, so transport in the troposphere can be well represented. In fact, there are hundreds, if not thousands of papers in the literature using such models for studying long-range transport in the troposphere, even such using models without a convection scheme.

Page 6, line 3: The model uses meteorological data from an assimilation system. This can be problematic in itself for tracer advection. As shown by Stohl et al. (2004) using a trajectory model, dynamical inconsistencies due to the data assimilation lead to increased diffusivity. It would be interesting to know how important this is for the results obtained by the authors. A possibility for this would be to run GEOS-Chem on a dynamically consistent meteorological data set from a free-running simulation, not using data assimilation. Some of the diffusion the authors find may not really be due to the Eulerian advection scheme, but to the dynamically inconsistent input data used.

Page 9, lines 1-4: It is argued that plumes in the tropics are better preserved. This is true as a function of time. On the other hand, transport speeds of plumes in the tropics are typically slower and that means that, relative to distance travelled, the plumes probably diffuse at a similar rate. For intercontinental transport that probably means that plumes in the tropics are not more coherent than in the extratropics once they reach a downwind continent at a similar distance as in the extratropics. Both transport and diffusion just take a longer time.

Page 18, lines 17-18: The statement “Thus we find that increasing vertical grid resolution in the free troposphere to $\sim$100 m is an essential first step for models to resolve the intercontinental-scale transport of free tropospheric plumes.” is not really supported by the analysis. While this is a good suggestion, it is not really a finding of this study but rather an extrapolation that would need testing to be called a finding. Thus, I suggest a more careful phrasing.

Minor points, language: Page 1, line 23: “affect intercontinental scales”. This is a strange wording, as the scales are not affected but plume coherence over those scale is affected.

Page 8, line 3: “artifact information”: I would recommend removing “information” as it is not clear what the word information refers to.

Page 11, line 9: “after 9 days 1x1.25” should be “after 9 days at 1x1.25 resolution.”

Page 12, line 16: “plumes being to decay” should be “plumes begin to decay”.

References:

Forster, C., A. Stohl, and P. Seibert (2007): Parameterization of convective transport in a Lagrangian particle dispersion model and its evaluation. J. Appl. Met. Clim. 46, 403-422.

Rastigejev, Y., Park, R., Brenner, M. P. and Jacob, D. J.: Resolving intercontinental pollution plumes in global models of atmospheric transport, J. Geophys. Res., 115, D02302, 2010.

Stohl, A., O. Cooper, and P. James (2004): A cautionary note on the use of meteorological analysis data for quantifying atmospheric mixing. J. Atmos. Sci. 61, 1446-1453.

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