Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2018-601-RC2, 2019

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Tracer study to estimate the transport of cruise altitude aviation emissions in Northern Hemisphere" *by* Lakshmi Pradeepa Vennam et al.

Anonymous Referee #2

Received and published: 13 January 2019

The paper discusses the dispersion of emissions of aviation from cruise altitudes in the Northern Hemisphere atmosphere. The paper considers the emissions as given in a data set as provided by FAA and Volpe for the ACCRI project [Wilkerson et al., 2010; Brasseur et al., 2016]. The emissions are treated as passive tracers, without any removal process in the atmosphere. The emission are followed over several seasons (3 months periods), starting from zero initial concentrations. The model considers tracer transport by advection with the resolved wind field of a hemispheric global model and by diffusion from a convective mechanism. I do not know this model and information is given in this paper about this model only in terms of a few references and some resolution information.

Printer-friendly version

Discussion paper

So the paper studies how a passive tracer emitted from a more or less continuous source near the tropopause accumulates in and gets distributed over the atmosphere within 3 months periods for various seasonal meteorological conditions.

The paper studies the mass fraction of tracers in model layers and in various source and receptor domains including a surface layer (of unknown vertical thickness).

The paper aims to investigate physical processes in transporting cruise altitude emissions in the atmosphere. However, I cannot learn anything about physical processes except that they vary with season and altitude, and that convection may be important in summer. That is not new.

The paper claims to be the first in using a "tagged tracer simulation" to quantify source-receptor relationships. Tagging is needed to follow the fate of tracers in a nonlinear system [Grewe et al., 2010]. In this study, the tracer transport is linear in the concentration values. A doubling of the sources causes a doubling of the concentrations. In this case, emissions from various sources can be treated independently of each other and tagging is trivial. Similar studies of the dispersion of NOx as a passive tracer from various sources, with linear chemistry, have been presented, e.g. by Ehhalt et al. [Ehhalt et al., 1992] and Köhler et al. [Köhler et al., 1997], long ago.

So, this is an academic study. That would be acceptable if done well. However, I also have technical problems:

What is the vertical resolution. How thick is the surface layer? What are the time step sizes? Which process is simulated by asymmetric diffusion?

Page 4, line 3: why do you mention water vapor. Why not CO2?

More general, why do you talk about NOx emissions when you simulate the emissions as a passive tracer? NOx has a lifetime of typically 5 days in the free troposphere, and often much shorter near the surface. Thereafter, most NOx is converted to HNO3 and other species after a few days. CO2 would be closer to the passive tracer concept.

I am sceptical about the conservation properties of the model in this study. The paper talks about the amount of a species measured in moles. But I would expect that one should discuss a conservative concentration measure like the molar mixing ratio of the tracer (number of moles of the tracer per mole of air).

Fig. 1 presents emissions in units of moles/s. This is a species abundance source rate. In order to assess this, one needs to know the respective air volume in which the emissions occur.

When computing mean values, do the authors weigh the results with the volumes or do they add concentrations from small grid cells (near the poles and near the surface) with the same weight as sources from large grid cells (in the tropics and in the upper atmosphere)? That is not clear presently.

Fig. 3, winter, shows a maximum of mass fraction forming in the lower troposphere, i.e., in a region without sources. How can that happen? Yes it can happen temporarily when advection dominates relative to diffusion processes. When averaged over longer period, it should not happen. However that is not discussed. I have the impression that the model violates conservation laws.

The paper is good in citing many related studies. In fact, I was not aware on many of them. But it appears somewhat random in the selection of references (those of major and minor relevance for this paper). There are many other important studies which dealt with tracer or aviation emission transport in the global atmosphere earlier or more complete. Examples are as follows: Ehhalt et al. [1992]; Danilin et al. [1998] , Forster et al. [2003], Koehler et al. [1997], Brasseur et al. [1996], Brasseur et al. [1998], Gauss et al. [2006].

In summary, the paper in its present form does not satisfy the quality criteria of ACP.

I just looked at the paper Veenam et al. (JGR, 2017), cited in this paper, which just appeared. It seems that this is far more advanced. It includes the chemical processes

that are mentioned in the outlook of the ACPD paper. So, I am not convinced that the present paper is still needed.

References

Brasseur, G. P., J.-F. Müller, and C. Granier (1996), Atmospheric impact of NOx emissions by subsonic aircraft: A three-dimensional model study, J. Geophys. Res., 101, 1423-1428, doi: 10.1029/95JD02363.

Brasseur, G. P., R. A. Cox, D. Hauglustaine, I. Isaksen, J. Lelieveld, D. H. Lister, R. Sausen, U. Schumann, A. Wahner, and P. Wiesen (1998), European scientific assessment of the atmospheric effects of aircraft emissions, Atmos. Env., 32, 2329 - 2418. Brasseur, G. P., et al. (2016), Impact of aviation on climate: FAA's Aviation Climate Change Research Initiative (ACCRI) Phase II, Bull. Amer. Meteorol. Soc., 97, 561-583, doi: 10.1175/BAMS-D-13-00089.1.

Danilin, M. Y., et al. (1998), Aviation Fuel Tracer Simulation: Model Intercomparison and Implications, Geophys. Res. Lett., 25, 3947 - 3950.

Ehhalt, D. H., F. Rohrer, and A. Wahner (1992), Sources and distribution of NOx in the upper troposphere at northern mid-latitudes, J. Geophys. Res., 97, 3725 - 3738, doi: 10.1029/91JD03081.

Forster, C., A. Stohl, P. James, and V. Thouret (2003), The residence times of aircraft emissions in the stratosphere using a mean emission inventory and emissions along actual flight tracks, J. Geophys. Res., 108, 8524, doi: 10.1029/2002JD002515.

Gauss, M., I. S. A. Isaksen, D. S. Lee, and O. A. Søvde (2006), Impact of aircraft NOx emissions on the atmosphere – tradeoffs to reduce the impact, Atmos. Chem. Phys., 6, 1529–1548.

Grewe, V., T. Eleni, and P. Hoor (2010), On the attribution of contributions of atmospheric trace gases to emissions in atmospheric model applications, Geosci. Model Dev., 3, 487-499, doi: 10.5194/gmd-3-487-2010.

Koehler, I., R. Sausen, and R. Reinberger (1997), Contributions of aircraft emissions to the atmospheric NOx content, Atmos. Env., 31, 1801-1818.

Wilkerson, J. T., M. Z. Jacobson, A. Malwitz, S. Balasubramanian, R. Wayson, G. Fleming, A. D. Naiman, and S. K. Lele (2010), Analysis of emission data from global commercial aviation: 2004 and 2006, Atmos. Chem. Phys., 10, 6391-6408, doi: 10.5194/acp-10-6391-2010.

Interactive comment on Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2018-601, 2018.

Printer-friendly version

Discussion paper