Atmos. Chem. Phys. Discuss., 10, C6108–C6111, 2010
www.atmos-chem-phys-discuss.net/10/C6108/2010/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Study of contrail microphysics in the vortex phase with a Lagrangian particle tracking model" *by* S. Unterstrasser and I. Sölch

Anonymous Referee #2

Received and published: 5 August 2010

General comments

This manuscript examines the evolution of ice crystals in a model contrail during the vortex phase by means of two-dimensional Large-Eddy Simulations. The main objective of the study is to analyze the sensitivity of ice crystal loss to the atmospheric conditions (essentially temperature and relative humidity) and to the initial number and size distributions. Two different treatments of ice microphysics are considered: a bulk microphysical scheme and a Lagrangian particle tracking approach. The manuscript is largely centered on the comparison of performances of the two models and in particular their ability to predict the ice crystal loss correctly. The main outcome of the

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

study is that the recently developed Lagrangian particle tracking method provides a better representation of sublimation which in turn allows a more accurate prediction of the fraction of surviving ice crystals. This is relevant to the initialization of the following dispersion phase where transition of contrails into cirrus clouds occurs.

I think this study is worth publication in ACP as a useful improvement of previous models developed by the authors. On the other hand, for a sound assessment of the sensitivity analysis and in view of parameterizations of the vortex phase into large-scale models (as mentioned by the authors in the Discussions), further analysis and refinement of some of the hypotheses underlying this study are still needed in my opinion. A part for the choice of using 2D dynamical models to represent inherently three-dimensional phenomena, I think the initial condition needs to be improved. It is very unlike that the spatial (and size) distribution of ice crystals at the end of the jet phase is uniform within the oval. Hence, questions may arise if the sensitivity of ice crystals loss to these initial conditions can be even higher than the sensitivity to the different microphysical models. I know it is difficult to answer unless the jet and vortex the phases are explicitly solved together, however a comment on this uncertainty should be added in the Conclusions.

Specific points

Before publication the authors should clarify some points on their modeling approach.

1) It should be made clear that the different behavior between the Eulerian (continuum) and Lagrangian approaches is due to the different representation (and transport) of the ice phase NOT to the modeled microphysical processes which are the same in the two cases (deposition/sublimation in the present set-up).

2) The reader has also the impression that the Lagrangian particle tracking is in general superior to its Eulerian counterpart. If this comes to be true for the present two-moments bulk model, it cannot be generalized (at least without a valid argument) to more sophisticated Eulerian approaches such as those based on discretization of par-

ACPD

10, C6108–C6111, 2010

Interactive Comment

ticle size distribution into bins. (Since these methods explicitly solve the tails of the size distribution it is likely that they handle sublimation much better than moments-based methods).

3) The authors correctly mention that Lagragian particle tracking methods do not suffer the large numerical dissipation of Eulerian models (unless very accurate numerical schemes are used for them, I would add). This is true for purely Lagrangian methods but in mixed Eulerian-Lagraign methods (as in the present study) caution has to be taken to generalize to situations where the particles have a feedback on the gaseous phase via exchange of mass, momentum and energy (water vapor/ice mass exchange in the present study). The reason being that the sources/sinks in the vapor mass balance (e.g. due to condensation/evaporation) are available at the particle position; at some point they have to be redistributed at each node of the grid, which necessarily introduces diffusion in the Eulerian-Lagrangian formulation. How do you cope with this phase exchange? Which kind of spatial reconstruction (linear, Gaussian, etc) do you use ? Please specify.

4) I do not understand the sensitivity analysis on Np at the end of Section 2.4 (page 14648-14649). If you are trying to demonstrate the results do not depend on the number of stochastic particles (which are artificial numerical tools) you should change either SIP or the factor 1000 in the formula Np=1000*SIP, conditioned to Np=constant in each grid. This is because Np (the number density in the grid) is a physical quantity and has to be conserved.

5) The Lagragian particle tracking method has been first used in numerical simulations of contrails by Paoli et al., J. Fluid Mech., 2004 (jet phase), please add it in the references. (Although the microphysics was much simpler than that referred to in Solch-Karcher paper, in the present set-up where deposition is the only activated microphysical process, the two formulations are equivalent.)

6) Page 14654, lines 21-29. I cannot find the figure you are referring to in this para-

ACPD
10, C6108–C6111, 2010

Interactive Comment

graph.

7) Why is the velocity field in Fig. 1 so wiggled ? Did you add noise to the initial Hallock-Burnham vortex profile ?

Minor remarks

There are some misplaced words and typos that can be easily fixed when carefully proofreading of the paper. Examples:

-) Page 14641, line 9: counterrotating

-) Page 14643, line 15: ample

-) Page 14644, line 16: analogeously

-) Page 14655, line 13: aggravate

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 14639, 2010.

ACPD

10, C6108–C6111, 2010

Interactive Comment