Atmos. Chem. Phys. Discuss., 9, C8137–C8140, 2009
www.atmos-chem-phys-discuss.net/9/C8137/2009/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Numerical simulations of contrail-to-cirrus transition – Part 1: An extensive parametric study" *by* S. Unterstrasser and K. Gierens

S. Unterstrasser and K. Gierens

simon.unterstrasser@dlr.de

Received and published: 9 December 2009

Specific comments:

Abstract Part 1: This piece of information helps to estimate the potential of contrails to dehydrate the UTLS region. It shows that the dehydration potential of contrails is larger than can simply be estimated from the contrail ice masses.

Structure:

We follow the advice of the reviewer and introduce a separate section on phases of contrail evolution.

Figures 2, 4, 5, 8, 9, 10:

We understand that the graphs showing 16 curves are hard to understand and that a better illustration of the results helps the readers to faster comprehend the discussions.

We adopted your legend as given in your Fig. 1 and it is now part of our table 2.

As all figures use the same colour and linestyle coding, we think it is not a good idea to place the same legend in each plot. As each figure shows a different contrail quantity, we do not want leave out any of them.

Discussion:

We went over section 3.2 (and the rest of section 3) and added new text parts in order to faciliate the comprehension of the figures. We hope this makes the reading of the paper more enjoyable. Please note that some information relating to visibility issues is already given in the beginning of section 3.2. There τ_0 is introduced as the visibility threshold and we say that the definition of B_{OD} is such that B_{OD} should give width values as observed by the eyes of a human. Consequently, $B_{OD} = 0$ implies that the contrail is invisible.

We do not understand why to switch the right and left panels in Fig.2. This would not provide new information or make the information more easily comprehensible. Therefore we leave it as it is.

Section 4.1: This section is essential, as we give a validation of the dispersion properties of our model. This is significant as turbulent diffusion is a key process of contrail spreading and we show that our 2D-approach is justified. Compare with comments of Reviewer 3.

Section 4.3: We think that comparison with observation is essential for validation of our model.

Section 5: We reformulated the text.

Section 6: Conclusions We shortened several items.

Please avoid:

We tried to consider the reviewer's suggestions as far as we could.

Scientific comments:

POINT 1: Admittedly, contrails may form in cirrus clouds formed earlier by heterogeneous nucleation. We do not consider this possibility in our simulations because this is the first set of such simulations and we desired to have situations as simple and clear as possible. As you can see from the figures, the interpretation of the results is already quite complicated.

We can expect that there are more heterogeneous ice nuclei (IN) in regions with air traffic than in regions without air traffic. In such cases it is possible that an ice cloud forms by heterogeneous nucleation before homogeneous nucleation commences. According to Spichtinger and Gierens (2009, Part 2) there are 3 scenarios. If there are only very few IN the ice crystals do hardly consume the excess water vapour and a contrail could evolve mainly undisturbed. Homogeneous nucleation can occur in the contrail neighbourhood later if cooling goes on. In a very polluted airmass, i.e. high IN concentration, a strong cirrus may form heterogeneously which quickly reduces the relative humidity to ice saturation. In such a case a contrail may form above such a cloud where the air is still supersaturated. In a medium case, where heterogeneous nucleation is strong enough to perturb homogeneous nucleation considerably, there can exist long-lasting high ice supersaturation within the cirrus cloud which would allow a contrail to evolve. Details of these processes can only be studied by means of observations and simulations which have not yet been performed by anyone.

The situation would become still more complex. This is out of scope of this paper and will be the topic of future research.

In part 2 we consider one special aspect of such a possibility, namely that soot particles

released from the sublimating ice crystals during the vortex phase may re-nucleate. In the discussion section we quote a paper of Immler et al., 2008, which describes lidar measurements of contrails within cirrus clouds.

We agree that a comparison of contrail properties with those of surrounding cirrus clouds is necessary for a complete understanding. However as we did not make such simulations we cannot provide a thorough discussion which is also left for future work.

POINT 2:

Indeed, there is a long discussion on the influence of synoptic motions. It is important to present it since the reader should be informed on the context in which the present results should be understood; see next point.

POINT 3:

We admit that we considered in this first study on the contrail-to-cirrus transformation merely academic situations without vertical motion and without consideration of the possibility that contrails may form in areas that already contain cirrus clouds. Hence, it is clear that some aspects of our simulation results have to be considered with caution (as we already mentioned in the paper) and are not of direct relevance to GCM modelers, in particular the evolution of the optical thickness. However, there are still aspects of our simulations that are relevant, in particular: - spreading rates for different shear values - sedimentation process leads to a separation of a contrail into a core region and fallstreak - sedimentation limits the lifetime - geometric dimensions - consideration of subvisual contrail-cirrus

Furthermore our simulations, in spite of their partly academic character, represent a major step forward (in particular the use of realistic initial conditions) and are the first step towards more realistic simulations. We prefer to make one step after the other. This helps us and others to interpret the the present and future results in a correct way.

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 14901, 2009.