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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

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Introduction:

We included more references in section 1.1 and the new section 1.3.

p. 14904, line 8-9:

We rephrased our sentence such that our statement cannot be misinterpreted as a definition of the end of the jet phase.

p. 14905, line 7:

We removed the word CC-tool

Sect 2.1, paragraph 1: The subgrid model used a TKE-closure approach. As stated in sect 4.1, for the grid sizes used in our simulations the most efficient turbulent eddies are explicitly resolved. Switching to an alternative subgrid model (Smagorinsky) led to negligible differences in the plume dispersion properties and spatial contrail dimensions. Our simulations in this paper start at 120s plume age while the vortex breakup in UGS08 happened at 135s. Thus our initial conditions contain slightly too many ice crystals, i.e. those that would sublimate between 120 and 135s. To compensate for this we have introduced these vortices simply as a numerical trick with a low amount of kinetic energy (their energy was reduced to 20% of its original value at 120 s). Over a course of six hours the contrail spreading is a much more important process than the decaying vortex dynamics in the first few minutes. We rephrased sentences in sect 2.1 and sect 4.1.

p.14906, line 19-26:

Yes, the grid resolution has been set to balance computational cost against grid resolution. We reformulated one sentence in the "model setup"-section. Grid sensitivity is mentioned in the extended section 4.1.

p. 14906, line 19-26:

We added "as follows", to make clear that the modification is described next.

p. 14914, line 17-18:

We agree that our model shows smaller vertical expansion than the 3D model of Dürbeck and Gerz (Sect. 4.1). As the figure shows, our model underestimates the vertical expansion by about 10% (take the square root of the values on the y-axis). We reformulated the text accordingly.

p. 14914, line 25-26:

ACPD

9, C8145–C8149, 2009

We have reformulated the text and avoid to talk about dehydration at this point.

p. 14917, line 14-18:

In our model background relative humidity is constant. If we assume that the available supersaturation is consumed quickly by the growing ice crystals, the ice mass I of the contrail per meter of flight path is proportional to the cross-sectional area A of the contrail. Thus the ice water content is constant ($IWC = I/A$) without sedimentation.

Section 3.3.4, paragraph 1:

The IWC-field contains strong local maxima in some simulations which are apparent as peaks in the IWC_{pre}-curves (brown and blue dotted curves) in Figure 6 (right).

p.14920, line 16-17:

No. The vertical profiles are shown in the right column of Figure 7.

p.14920, line 23-24:

We removed this sentence from the text.

p.14924, line 4:

With "quasi-constant" we mean that the rms-values decays slowly. This is now explicitly stated in the text. No further external forcing is used to drive this (low-level) turbulence. We supplement this reply with a figure showing the temporal evolution of rms of u (dotted), w (dashed) and total velocity (solid line). We might call the rms-value "quasi-constant" after $t = 2000s$. In this case we would use the velocity fields at $t = 2000s$ for initializing the actual simulation.

Figure 11:

This is for technical reasons. When you evaluate the skewed and the horizontal variance, resp., you have to evaluate the term $x - x_c$ which is the horizontal distance from a specific point x and the centre of the plume at x_c. We used periodic boundary con-

ACPD

9, C8145–C8149, 2009

ditions in the horizontal direction in the passive tracer tests. Thus the evaluation of the horizontal distance is not straightforward since you have to take into account that parts of the plume cross the lateral boundary at some point of time. With some simple tricks it was possible to correctly determine $(x - x_c)^2$ and the horizontal variance. Unfortunately, you do not always get the correct sign of $x - x_c$ with the simple trick which yields erroneous values for the skewed variance after $t = 3000$, as there $(x - x_c)$ enters linearly. Nevertheless, we think that the figures are convincing.

Technical corrections:

All typos have been corrected.

Now we consequently use RH_i^* and T_{CA} to refer to a specific simulation setup. Furthermore we now mention that relative humidity is always with respect to ice.

We want to thank the reviewer for his/her thorough review and helpful recommendations.

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

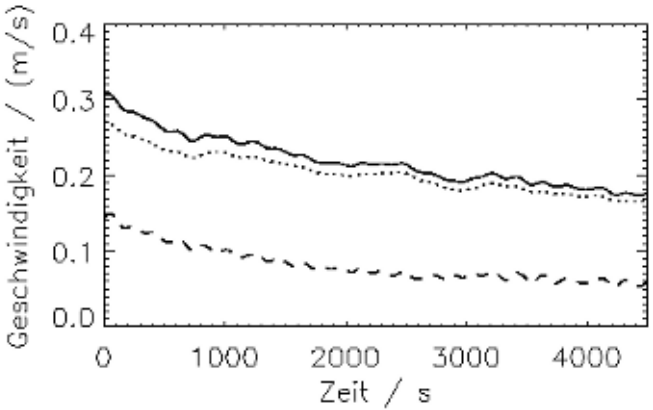

Fig. 1. y-axis: rms of turbulent velocity fluctuation, x-axis: time; rms of u (dotted), w (dashed) and total velocity (solid line)

ACPD
9, C8145–C8149, 2009