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Atmospheric
Chemistry
and Physics
Discussions

Interactive comment on “Numerical simulations of contrail-to-cirrus transition – Part 2: Impact of initial ice crystal number, radiation, stratification, secondary nucleation and layer depth” *by* S. Unterstrasser and K. Gierens

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General comments

We now say "(not shown)" where we describe a result that we do not show in a figure.

Specific comments:

p. 14962, line 9-15

Although the uptake of water vapour is faster, the individual crystals are on average still

smaller for higher ice crystal concentration. The following qualitative example should clarify the point. Let’s say the total ice crystal number is increased by a factor of 10, then the faster uptake may cause a twice as large total ice mass. As the ice mass increase is smaller than the crystal number increase, the crystals are still smaller for higher ice crystal concentration. We present this example in the text.

p. 14965 and Figure 4

We rephrased the paragraph and now give an explicit definition of the "standard reference simulation". This should make it clearer now.

p. 14965, line 25

One might use a higher solar zenith angle for a midlatitude winter than a midlatitude summer case. However this correction would have no implication for any of the conclusion stated in this study for the following reasons: Basically the sensitivity of solar zenith angle (SZA) was implicitly studied when varying the time of day. We showed that the variation of the time of day leads to the smallest changes of the contrail evolution considering the three parameter (presence of a water cloud, season, time of day) determining the radiation scenario. In this case the SZA-variation is much larger (cos(SZA)= 0 at night, = 0.7 at day) than a potential seasonal SZA-correction. In a further sensitivity study (not discussed in the manuscript) we raised the albedo from a default value of 0.05 to 0.3. The impact is not really substantial. In both sensitivity studies (albedo-variation and SZA-variation) the shortwave radiation fluxes incidenting the contrail layer were changed. Generally, we found that a variation of parameters like surface temperature or lower-level cloudiness changing the longwave fluxes lead to stronger changes of the contrail evolution than of parameters only affecting the shortwave spectrum.

p. 14966 and Figure 3

We changed the caption of Figure 3 and added a few remarks in the according paragraph.

p. 14967, lines 13-14

Whether the optical thickness is larger or smaller than in the standard simulation depends on the actual direction of the vertical displacement. If radiation causes a downward displacement (as you may encounter with an underlying water cloud) optical depth is smaller. In cases with a contrail rise, the optical depth is larger than in the standard run. In the manuscript we added the hint that both a upward or downward displacement can occur (depending on the chosen radiation scenario) when you switch on radiation.

p. 14967, lines 17-29, p. 14968, lines 1-3

We followed the reviewer's recommendation and ran a couple of additional simulations with varied initial turbulence fields. The results are shown in a Figure attached to this reply. In Figure 1 total extinction is shown. We see that the noise is dominant over summer/winter/no-radiation differences during the first hour into the simulations. The summer cases get distinguishable from the other no-radiation case only after about 5000 s, and the winter cases even later after about 10000 s. Since this noise is inevitable (cf. discussion in part 1) it makes no sense to try to thoroughly find physical reasons for these differences between the summer/winter vs. "no-radiation" cases during the first noise-dominated period. It seems that radiation needs time of the order of 1-3 hours to produce statistically significant differences from "no-radiation" cases. From the couple of additional simulations it seems that the blue (winter) curves tend to show lower total extinction than the black (no-radiation) curves during the first two hours. It might be that there is indeed a physical mechanism that could explain this, but we could not find a convincing candidate. In order not to speculate or even to merely interpret noise we refrain from searching for an explanation.

In the light of the new results we decided to leave out the lower row of figure 4 and to delete the text explaining it.

Section 6, p. 14974

Answer to the first question: The sequence of an updraught and downdraught period was not primarily chosen to reflect a typical synoptic event. The setting was rather constructed this way in order to conveniently examine the effect of heterogeneous nucleation which could be triggered by a RH_i-increase. The advantage of the present setup is that after the downdraught we basically have the same background state as in the beginning prior to the updraught event. This allows a conclusive comparison with the default simulation with no atmospheric vertical motion and a constant background state. Answer to the second question: Yes the results would be different if you first encounter a downdraught. Yet this study is not meaningful, since the background relative humidity first decreases and then rises back to the original level. As the background RH_i is always smaller or equal the initial value, no heterogeneous nucleation could occur at all and contrail ice crystals may even sublimate.

Section 8:

We shortened several points in the conclusions.

All typographical errors have been corrected.

p. 14965, line 16: Similarly to part 1, we only mention the figure, but describe it later in detail. Unless the publisher does not allow this, we prefer to keep it as it is.

p. 14965, line 16: We modified the text and give a definition of "radiation scenario".

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 14955, 2009.

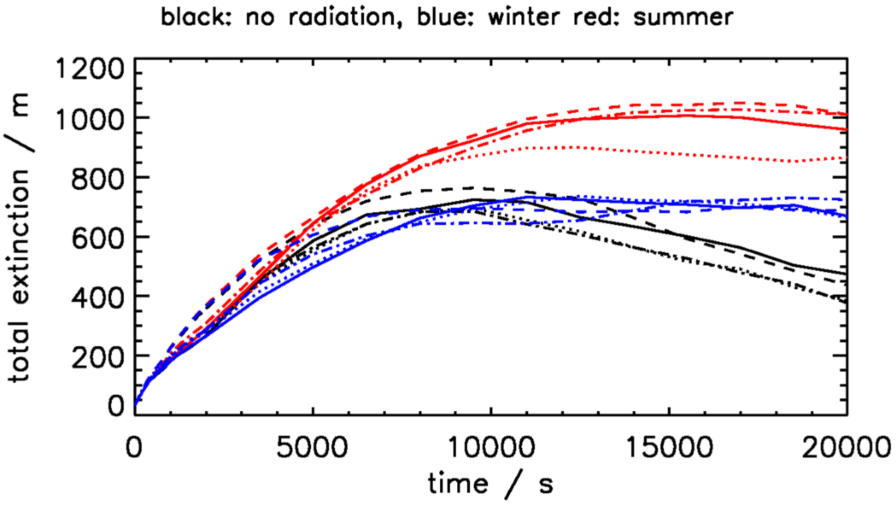

Fig. 1. Temporal evolution of total extinction. Each simulation (as dentoed by colour coding on top) was run with 4 different initial turbulence fields, denoted by the various linestyles of the curves.