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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Dust ice nuclei effects on cirrus clouds" *by* M. Kuebbeler et al.

M. Kuebbeler et al.

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We thank the referee for his/her valuable comments and suggestions. The responses to your comments are below each comment.

Review of "Dust ice nuclei effects on cirrus clouds" by Kuebbler et al. This manuscript describes a new ice nucleation scheme in the ECHAM General Circulation Model. It describes the scheme and presents results and comparisons to observations. The manuscript is generally well written and contains original material suitable or publication in ACP. I have a few concerns that probably warrant significant revisions. The scheme in ECHAM is probably not described sufficiently. It is not possible for the reader to understand exactly how the scheme functions in the model. Thus it needs a bit more explanation of the scheme application, as I note below. The box model also needs some further description, perhaps a paragragh detailing how it works. I would

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also suggest that perhaps it would be better to describe the scheme first, then show the box model results. With these changes, the manuscript will be suitable for publication in ACP.

Detailed comments: Page 9752, Line 26: Are the effects of preexisting ice and homogeneous nucleation on dust separable? What is RF of each one?

- Yes, they are. We will add these numbers to Table 3.

Page 9755, Line 15: Perhaps the scheme should be described before the box model results presented.

- Actually the scheme is discussed before the box model results are presented.

Also, I am not clear how the preexisting ice is handled: does the scheme condense mass on preexisting ice, or just remove some mass from the Sice calculation? Some more detail is needed here so that the reader can understand the scheme.

- Yes, the scheme condenses mass on pre-existing ice and removes that from Sice. We added that.

I assume all supersaturation is then removed in the timestep if there are activated nuclei present? Again, more detail is required

- No, not all supersaturation is removed. Only as much supersaturation is removed as can be turned into depositional growth in one time step. The new aspect of this paper is the introduction of the aerosol-induced ice formation (Kärcher et al., 2006). The saturation adjustment for cirrus clouds was already removed in a previous version of ECHAM (Lohmann and Kärcher, 2002). A model validation of the cirrus scheme and how it represents ice supersaturated regions can be found in Lohmann et al. (2008). We added that.

Page 9759, Line 11: Please describe the box model in a bit more detail or provide a reference: does it allow for settling as a column? Are there feedbacks between latent

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heating, temperature and updrafts?

- No, the box model does not allow for settling in a column. It only includes nucleation and depositional growth. The increase in temperature due to latent heating is taken into account, but not the change in updraft velocity, which is prescribed as 20 cm/s in the box model simulations. We added that.

Page 9761, Line 10: How is the down draught calculated? Is it just sedimentation?

- No, the exact formula is given in Kärcher et al., 2006, equation 13. The fictitious down draught describes the water vapor uptake of preexisting ice crystals.

Page 9765, Line 2: Extend–>extent

- Corrected.

Page 9765, Line 2: A few more sentences on the depositional growth would be helpful. In particular: what sizes are assumed for the growth of each nucleation mode, or how are they calculated and combined?

- The box model calculates the sizes for each nucleation mode and returns them to ECHAM. In ECHAM the depositional growth is calculated for each mode separately and then the ice water content is summed up over the modes (see section 2.2)

Page 9773, Line 1: Supersaturation should be plural: supersaturations are.

- Corrected.

Page 9773, Line 7: simulations match (plural)

- Corrected.

Page 9775, Line 10: Are the LW and SW offsetting contributions in the same regions?

- Liu et al. (2012) only present zonal means. These plots show that the LW and SW changes occur in the tropics (10S-10N) and in midlatitudes of both hemispheres. They are offsetting in the same regions; we added that.

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Page 9776, Line 13: What are the vertical updraughts driving the scheme in the model? Are they low or high?

- The vertical velocities in cirrus regions from ECHAM were compared in Kärcher and Ström (2003). The pdf of ECHAM vertical velocities matches the observed data from the INCA campaign very well with an average of 31 cm/s as compared to 26 cm/s. We added that.

Page 9777, Line 29: Why the big oscillations with different temps that occur in all runs?

- The oscillations, which are also visible in the observations, have to do with sorting the data in 1K bins. In the model these cold temperatures do not occur so frequently. Considering that a model level in the UT is up to 2km thick, the temperature resolution is very coarse. Had we used coarser bins, the oscillations would have decreased. An indication for the low frequency of simulated cirrus at the coldest temperatures is the large difference between the average and median values here.

Page 9778, Line 19: But do you have the high frequency gravity waves described by Spichtinger and Kramer? What are the vertical velocities in echam? Please restate.

- No, we don't have high-frequency gravity waves. We have a superposition of the large-scale velocity with either turbulent fluctuations parameterized based on the turbulent kinetic energy or gravity waves as stated in lines 7-10 on page 9755. We added the equations for this.

Page 9779, Line 20: Actually: there are significant differences at low temperatures: the data show only supersaturated conditions, while the model does not get high frequency of high supersaturations? Why? Is this the vertical velocity? Now might this be related to ICNC biases in the model ?

- The model gets the high supersaturations in simulation COMP. You are right that they are missing in HOM because there homogeneous nucleation depletes Sice too efficiently.

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Page 9782, Line 10: Results may point? I think you can say they point to the same confusion: "may" is not needed.

- Corrected.

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 9751, 2013.