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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Freezing thresholds and cirrus cloud formation mechanisms inferred from in situ measurements of relative humidity" *by* W. Haag et al.

W. Haag et al.

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We thank the reviewer for his encouraging comments. Below, we list the suggested modifications of the manuscript, based on the reviewer's general and specific comments. With the revision of our work, we try to fully answer all of the questions raised and hope that the paper becomes acceptable for ACP.

General comments

The reviewer feels that the paper places too much emphasis on the qualitative statistics and presents too little analysis on the underlying physics.

We improve the paper and shorten the lengthy subsections on how the distributions generally come about from a statistical point of view. This aspect of the work will be

presented in a separate publication. Importantly, we will prove our hypothesis given on p.3282 by presenting detailed numerical simulations of the distributions of RHI (analogous to the experimental data currently shown in Figs.4 and 6).

The results of these simulations will provide more discussion of physics, as requested by the reviewer. We do keep the focus on relative humidity because this quantity can directly be related to freezing processes and mechanisms.

We will include references to possible CN known to cause heterogeneous freezing and highlight the core findings more clearly in the abstract and in the introduction.

Specific comments

1. Our new simulations will inlcude the effects of sedimentation, albeit in a parameterized manner (first order loss of ice mass and crystal concentrations out of the computational domain determined by the particle fall speed).

We note here, that RHI cut-offs are not changed by sedimenting ice crystals, but the slope of the RHI distributions may well be affected. The physics noted by the reviewer (Clausius-Clapeyron, sedimentation) is considered in the revised manuscript and will be discussed.

2. The RHI data alone do not give us hints about what differences in CN could have caused the deduced difference in freezing thresholds, except that our Fig.5 suggests that these must be tied to differences in the chemical or morphological properties of the freezing aerosol. But we add some educated guesses of what the particles have been composed of during the INCA campaigns.

The microphysical model to be employed is able to confirm the hypothesis of how the difference in RHI cut-offs between Punta and Prestwick come about. As far as sufficient concentrations of potential IN are concerned, they were indeed abundant during the observations. (Refer to: (1) Minikin, A., Petzold, A., Ström, J., Krejci, R., Seifert,

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M., van Velthoven, P., Schlager, H., and Schumann, U.: Aircraft observations of the upper tropospheric fine particle aerosol in the northern and southern hemispheres at midlatitudes, *Geophys. Res. Lett., 30*, 1503, doi:10.1029/2002GL016458, 2003 and (ii) Kärcher, B., and Lohmann, U.: A parameterization of cirrus cloud formation: Heterogeneous freezing, *J. Geophys. Res., 108*, 4402, doi:10.1029/2002JD003220, 2003 (see paragraph [9]).)

3. The presentation of GCM results is an update on results obtained in a previous publication, including a new advection scheme. We'd like to keep that rather short section for future reference.

According to the agreement at 200 hPa, please note that the meterorological conditions during MOZAIC and those extracted from the GCM are likely to be different. A close comparison would require much more computational effort.

In any case, we only expected a qualitative agreement (see p.3285 and p.3286, l.27–29 and 1–5). The big step forward is, as will be stressed in the revised paper, that GCMs are now capable of calculating ice supersaturation, with a distribution that looks reasonable (showing the quasi-exponential fall-off and the cut-off).

The model shows RHI values up to 170%, but this is already explained in some detail in the text (p.3286, l.5–23). That discussion also makes clear that cut-off values deduced from such type of simulations are only approximate.

Technical corrections

Those will all be taken into account.

Interactive comment on Atmos. Chem. Phys. Discuss., 3, 3267, 2003.