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Atmospheric Chemistry and Physics Discussions



# *Interactive comment on* "Supersaturation, dehydration, and denitrification in Arctic cirrus" *by* B. Kärcher

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I agree with Dr. Pfister that idealized simulations are valuable, because of their potential to study the interplay between and the relative importance of many physical cloud processes. Here follows a point-by-point reply to his constructive suggestions.

1. Describing the cloud observations

I agree that this paper should stand on its own. I will therefore provide a brief overview of the meteorological situation and the initialization of ambient profiles in Section 3.1.

2. Comparing simulation results with the lidar observations

Lin et al. (2005) provide a model-based analysis of the lidar observations detailed in Reichart et al. (2002). As I have stated on p.1841, lines 7+8, the foci of the Lin et al. study and the present work are substantially different from each other. I pointed out the good general agreement between the cloud properties presented in the discussion paper and in the Lin et al. study to avoid duplicating large parts of the latter. Rather, the discussion paper should focus on other aspects such as maintenance of supersaturation and $HNO_3$-ice interactions.

I admit that the present Section 3.2 provides too little detail about the agreement between the two model studies. I will expand this part in the revision.

3. Robustness of conclusions

I believe the conclusion of substantial supersaturation is robust. The study of Kärcher and Ström (2003) first pointed out that small-scale variability in vertical winds (hence temperature fluctuations) likely control the magnitude and variability in observed total ice crystal number concentrations in cirrus clouds. This point has been further examined by Hoyle et al. (2005) with similar and better quantified conclusions. The model studies of Haag and Kärcher (2004), Jensen and Pfister (2004), and Kärcher (2004) have shown that substantial in-cloud supersaturations exist in clouds driven by rapid temperature oscillations. In-situ measurements also demonstrate high in-cloud supersaturations (Ovarlez et al., 2003; Jensen et al., 2005a).

That being said, it is perhaps surprising that persistent in-cloud supersaturations of the order 0.2 also appear in cold cirrus forced by much slower cooling rates. I will add a figure showing the ice supersaturation relaxation times and provide a more detailed discussion.

The addition of small-scale temperature fluctuations unresolved in the present study will lead to more numerous but smaller ice crystals, as shown in the references cited above. This may reduce the potential of the cloud to transport water and nitric acid vertically due to smaller ice crystal sedimentation speeds, which will be spelled out more clearly in the revised manuscript. However, to include a realistic mesoscale forcing pattern (which is indeed obvious in the observed cloud with multiple fall streaks



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and cellular structures) requires information not available from the measurements and would deserve a study on its own.

I am currently involved in analyzing an Arctic tropopause cirrus case that was observed with a suite of in-situ instruments onboard the research aircraft Geophysica within the EU project EUPLEX. This case was affected by mesoscale orographic forcing. I look forward to study this particular point in more detail in the future with the help of measured $H_2O$ and $NO_y$ abundances, temperature, and ice crystal size distributions offered by EUPLEX, in addition to airborne lidar measurements.

4. Additional references

I will expand the discussion of $HNO_3$ uptake in the cirrus cloud as requested independently by other reviewers. I will address the studies of Jensen and Pfister (2004) and Jensen et al. (2005b) in the revised manuscript prior to Section 2.1, pointing out the similarity between the model employed there and the APSC*m*-1D.

5. Figure 6 caption

Yes, this will be corrected.

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