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

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Comments on "Supersaturation, dehydration, and denitrification in Arctic cirrus"

This paper presents results from a detailed, sophisticated microphysical model that can be applied to important issues in the tropopause region. The study is well motivated, with good summaries of the science questions addressable by the model. I would suggest that the author consider the following points.

(1) The author is basing his simulation, and some important conclusions (e.g., that arctic cirrus can efficiently dehydrate and denitrify the upper troposphere) on an idealized simulation (continuous upward motion from a simple profile). Nevertheless, reference

is made to an actual case from Reichardt (2002), and the initial profile comes from measurements. The details, I presume, are in another, as yet unpublished, paper of Lin et al (2005). It should not be necessary to reproduce too many details. Still, each paper should stand on its own. A paragraph describing the meteorological situation, the history of the observed air mass, how the vertical velocity is arrived at, and which of Reichardt's cases is being simulated (a, b, or c in their figure 1 –probably b) is appropriate.

(2) Though the Reichardt study is referred to as the basis for the simulation, no attempt is made to compare the results with the observations from this case (other than reference to Lin et al, 2005).

(3) An idealized study like this (with inputs based on observations) is valuable, since it allows us to understand the relative importance of the many competing physical processes going on in these clouds. The problem here is that, without sensitivity studies, we do not know how robust the conclusions are. The conclusion of substantial in-cloud supersaturation is important, for example, as is the conclusion that these clouds are efficient dehydrators and denitrifiers. The author buttresses these results by noting similarity to Lin et al's (2005) results (but does not detail the comparison). However, a number of investigators (Chris Hoyle's poster at the SPARC meeting, some of Jensen's papers) have noted the important effect of small scale temperature fluctuations on these cirrus clouds (and the mottled structure in Reichardt's figures suggests something like this). How likely is it that these conclusions will hold up under more realistic conditions? The author notes that particles take "quite a long time" to evaporate at the bottom of the cloud, and that the in cloud high relative humidities are due to "rather slow removal rates" at these cold temperatures. Faster imposed time scales will clearly have an effect (or might not). My suggestions are: (1) try including both the upward and downward part of the lifecycle of an air mass as it moves through one of these evolving cold outbreaks in the arctic upper troposphere; and (2) include more extensive discussion of how unincluded effects might affect the conclusions.

(4) References are generally quite comprehensive. However, I would recommend adding the following.

Nitrogen uptake in cirrus: Reference is made to Popp's study for the subtropics, but there are several papers on nitrate uptake in cirrus for the arctic, including, Kondo et al (GRL, 2003), Feigl et al (1999, GRL), and Meilinger et al (1999, GRL). I am not an expert on denitrification, but one of Kondo's conclusions was that there was not much uptake at temperatures above 215K. How does this relate to this model study?

Modeling: I would note that others have run models that share some of the current model's features. In particular, Jensen and Pfister (2004, JGR) and Jensen et al (2005, JGR) use a formulation that follows many individual particles. This aspect of the current model, at least, is not entirely new. It might be useful to the community to briefly point out the differences in the model formulations.

(5) The third from last sentence in the Figure 6 caption should have the words rehydration and renitrification in them, rather than dehydration and denitrification.

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