

Interactive comment on “Supersaturation, dehydration, and denitrification in Arctic cirrus” by B. Kärcher

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I agree that the discussion paper provides not enough information on which observations the model case study is based and how the model has been initialized. I will take care of these points in the revised manuscript.

As mentioned in the discussion paper, I am referring to the measurements taken with the GKSS Raman lidar near Kiruna, Sweden, published by Reichhardt et al. (2002), in particular their Figure 1b. As the observation is described there, and no further in situ information (e.g., from aircraft measurements) is available, I find it not necessary to repeat the lidar image in the discussion paper, but will describe the lidar backscatter image and the meteorological situation in more detail in the revised manuscript.

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The initial vertical profiles of Θ , T , and S_i have been taken from the model study of Lin et al. (2005), who analyzed this cloud with a focus on homogeneous and heterogeneous ice nucleation. The profiles have been taken from a nearby radiosonde, roughly 250 km downwind of Kiruna and 2 hours after cloud started to form. The ice saturation profile has been used as a first guess by Lin et al. (2005); together with the imposed vertical ascent, $S_i(z)$ has been tuned such that the general cloud development could be reproduced.

The lidar measurements clearly show that while the cloud drifted across the measurement site, its top was lifted from 8.5 km to more than 10 km within 7 hours with an almost constant rate. Some variation is present in the top heights, likely caused by turbulence or mesoscale variability in the wind fields. For instance, the cloud top seems to stagnate or slightly sink after 6 hours. Regardless, values 4–6 cm/s can be estimated from the observed cloud top heights.

As requested by another reviewer, I will add some more details on the relaxation times of supersaturation and compare these results to those recently presented by Jensen et al. (2005). The findings that high ice supersaturations are only found in homogeneous freezing regions or when ice particles sediment into supersaturated air are generally consistent with Jensen et al. (2005). Supersaturation relaxation times between 4–150 min predicted by the model are long enough to render quite persistent in-cloud supersaturations of 0.2 or so (as shown in Figure 3) plausible.

The addition of small-scale temperature fluctuations unresolved in the present study will lead to more numerous but smaller ice crystals. It may in large parts be responsible for the multiple fall streaks and cellular structures visible in the observed particle backscatter, but missing in the idealized simulation. The fluctuations may reduce the potential of the cloud to transport H_2O and HNO_3 vertically due to smaller ice crystal sedimentation speeds. However, to include a realistic mesoscale forcing pattern requires information not available from the measurements and would deserve a study on its own.

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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 with the help of measured H₂O and NO_y abundances, temperature, and ice crystal size distributions, in addition to lidar measurements.

In sum, the simulation is idealized, but it is partly based on information from atmospheric soundings and its salient geometrical characteristics are roughly consistent with lidar measurements. I do not make an attempt to model the small-scale cloud structure explicitly as it cannot be constrained by the available data, rather I place emphasis on the dehydration and denitrification potential of this cloud type and discuss sensitivities. Open questions concerning small-scale cloud structure and denitrification raised in this study will be examined in future work based on in situ measurements of H₂O, NO_y, aerosols, and ice particles.

Reference

Jensen, E., et al., Formation of a tropopause cirrus layer observed over Florida during CRYSTAL-FACE. *J. Geophys. Res.* 110, D03208, doi:10.1029/2004JD004671, 2005.

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