**Atmospheric
Chemistry
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Discussions**

Interactive
Comment

Interactive comment on "The two faces of cirrus clouds" *by* D. Barahona and A. Nenes

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Received and published: 4 April 2011

We thank the reviewer for the constructive and thoughtful comments.

General comments:

The author suggestion that this state of low Ni and high supersaturation (S) only occurs when temperature fluctuation is less than some threshold value (1K). Since the ice freezing is driven by vertical velocity, however, it is not clear to me from the manuscript why the low Ni can not be explained by "conventional" picture of homogeneous freezing. If the vertical velocity is sufficiently low, will you also get the observed Ni from the homogeneous nucleation?

Yes. However velocity fluctuations greater 1 cm s^{-1} would have to be neglected. Our conclusion refers to areas of the troposphere affected by temperature fluctuations

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which are commonplace. $\delta T \sim 1$ does not imply a constant low vertical velocity but rather that high u values are met less often than for higher δT. Thus our model reconciles the high velocities often measured near the tropopause with the measured cirrus ice crystal concentration.

We have expanded the introduction and conclusions sections of the manuscript to clarify the scope of the paper.

Aerosols at TTL behavior very differently for ice nucleation at low temperatures (one example, glassy aerosol). Will the glassy aerosols reproduce the observed Ni under your low temperature fluctuation framework?

Yes they will. We recognize the potential importance of heterogeneous freezing at low T and have expanded our model to account for it. A new subsection 4.1 has been added to the manuscript focusing on this point.

Specific comments:

1. Abstract: Please explain why the "dynamical equilibrium" is insensitive to IN? Please describe another regime "pulse-decay" as well.

We have expanded the assessment of IN effects in the revisited paper. The abstract has been modified accordingly also explaining the characteristics of the pulse-decay state.

2. Page 30858, Line 22. "Fridlind et al": You may not cite this paper since it is now recognized that this paper's conclusion (role of free troposphere aerosol) is based on the measured high Ni with the problem of shattering of ice crystals.

Done.

3. Page 30859. Line 29. Please explain what do you mean "specific conditions"?
Done.

4. Page 30860. Line 1. Why low Ni and high S cannot coexist? Low Ni will have slow

deposition of water vapor, thus allow high S.

The sentence has been rewritten.

5. Page 30861. Line 29. Should "heterogeneous" be "homogeneous" here?

Yes. The statement has been corrected.

6. Page 30862. Line 3. Supersaturation between 30% and 70%. Is this the in-cloud and clear-sky? If the heterogeneous IN is frozen to form ice at S=20%, further uprising of parcel will continue to increase S. why should the maximum S be below 20%?

Because supersaturation would likely be depleted by the growing ice crystals (Figure 3b). If new ice crystals remove supersaturation efficiently, both clear-sky and supersaturation would be limited by the IN freezing threshold. If very few crystals form by heterogeneous nucleation, then S can keep increasing until S_{hom} is reached where homogeneous freezing would sharply increase N_c.

We have expanded the section to make this clear.

7. Somehow the uncertainties with water vapor and ice measurements at low temperatures and how they affect your conclusions need to be discussed in the manuscript.

This is an important point. The uncertainty in RH can be typically up to 20 % (Krämer et al., 2009). This is still smaller than the difference between the homogeneous and heterogeneous freezing thresholds, i.e, between 30% and 40%. Thus, observations show that beyond experimental uncertainty RH is generally limited by some value above the heterogeneous freezing thresholds of glassy aerosol and ammonium sulfate IN and close to S_{hom}. This supports the idea that homogeneous freezing does occur at low temperatures.

The above discussion has been included in section 2.

8. The connection between section 3 and 4 is rather weak. How are the equations in section 3 used to calculate the results shown in section 4.

We have added a paragraph to section 4 explaining the calculation method.

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 30857, 2010.

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