Atmos. Chem. Phys. Discuss., 15, C9969–C9972, 2015
www.atmos-chem-phys-discuss.net/15/C9969/2015/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Cloud chamber experiments on the origin of ice crystal complexity in cirrus clouds" *by* M. Schnaiter et al.

Anonymous Referee #3

Received and published: 1 December 2015

Review of "Cloud chamber experiments on the origin of ice crystal complexity in cirrus clouds" by Schnaiter et al.

Recommendation: Accept after minor revision

This paper reports on the origin of ice crystal complexity and its influence on the angular light scattering properties of cirrus clouds based on cloud simulation experiments in the AIDA cloud chamber. Ice particles were grown by both homogeneous and heterogeneous nucleation, and subsequently grown and sublimation at super and sub-saturated conditions. Ice crystal complexity was subsequently deduced from light scattering patterns measured by the SID-3. The principle finding was that ice crystal complexity is dependent on the available water vapor, and that this complexity dominates the microphysics. As with observations from natural clouds, the measured scat-

tering phase functions were featureless resulting in low asymmetry factors that differ from those of several idealized crystals that are used to make up common scattering libraries. I think the paper is appropriate for publication in ACP because it is the first effort that shows ice crystal complexity is correlated to the available water vapor, and shows that some of the featureless phase functions observed in nature can be replicated in a laboratory environment. Nevertheless, I think there are some aspects of the presentation that could be improved before the paper is accepted for publication. Many of these aspects have already been identified by the other reviewers of the paper, so I will restrict my comments to a few other aspects of the presentation and emphasize a couple of the points previously made.

The major comment I would make is that crystal complexity needs to be better defined or better described. There are many aspects of ice crystals that affect their complexity and how they affect radiation from their three-dimensional shapes and their complexity, to the small-scale surface roughness to variations in aspect ratios. I think crystal complexity goes much beyond surface roughness as is described in the introduction. I don't think this paper ever formally describes what exactly is meant by crystal complexity or gives any perspective about the importance of complexity in affecting radiative properties compared to other microphysical properties (e.g., aspect ratio, size, shape, etc.). I would recommend that such material be added to the introduction.

Related to the above point, details about the modeling work and the parameter ke are currently found in Appendix B. As this paper is about crystal complexity and ke is found to be the most robust feature parameter to characterize crystal complexity with the SID-3, I think this modeling work should not be relegated to an Appendix but rather should appear in the main body of the paper.

In terms of experimental procedure, the authors claim that a sublimation period was applied in order to remove the ice particle surface characteristics from the initial growth. How confident are they that they are removing all of these surface characteristics? It would seem that apart from a derived measurement of the scattering function, it would

be very difficult to know how these surface characteristics are changing. In addition to the effects investigated by the authors, would any small scale imperfections in the ice nuclei have impacted the surface roughness, complexity, and scattering patterns as well?

Page 30513, line 16. Although the net radiative effect of a single cirrus cloud can be altered by this much, the global effect as a whole is much less. I think this point should be made more clear so as to avoid over stating the impact of complexity.

I would recommend that a photo of the experimental setup be added to the manuscript. That gives more of a visual description of how the experiment was setup. Alternatively, a schematic of the experimental setup would suffice.

Page 30520, line 19: Is there any bias to the sample by restricting to images with a narrow mean brightness range between 10 and 25? Were any sensitivity tests done to determine the effect of broadening?

Page 30522, line 21: The speed of 10 m/s is substantially smaller than that which would be used in an aircraft flight campaign where many prior scattering phase functions were measured. Is there any impact of the flow velocity on your results?

Page 30523, last 2 paragraphs: Were any other cloud probes also used to make measurements during the cloud expansion runs? This might provide an interesting data set for comparison against the scattering functions.

Page 30524, line 5: Can you quote the uncertainty on water vapor measurements here since this is a critical parameter for interpreting the results?

Page 30524, line 19: how much uncertainty was there in the saturation with respect to ice, and how repeatable were the measurements?

Page 30527, line 2: Define all acronyms.

Apart from these minor points, I think this paper is acceptable for publication in ACP.

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 30511, 2015.