Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2020-339-RC1, 2020

Atmospheric Chemistry and Physics Discussions

Open Access

ACPD

Interactive comment

Interactive comment on "Application of holography and automated image processing for laboratory experiments on mass and fall speed of small cloud ice crystals" *by* Maximilian Weitzel et al.

Andrew Heymsfield (Referee)

heyms1@ucar.edu

Received and published: 7 June 2020

Review of "Application of holography and automated image processing for laboratory experiments on mass and fall speed of small cloud ice crystals", by Weitzel et al., submitted to ACP.

This is an interesting article that uses the small chamber at the University of Mainz to grow small ice crystals and then measures their sizes, masses, terminal velocity and orientation and velocity, Reynolds Number and Best Number, during fall. The properties of small ice crystals, notably mass and terminal velocity, and quite poorly known and the goal of this article is to develop a better understanding of these properties.

There are some novel methods used in this study. Most notably, the use of a holographic camera to determine their properties, and of course the Mainz tunnel. I have done work directly related to this article and have gone through the article very carefully.

There's a major difficulty that I've identified and have suggestions for how this can be amended in a future article. This has to do with the representativeness of the results for natural clouds. Here's the problem. Ice crystals are generated with a liquid nitrogen cooled rod, inserted into the chamber. The rod has a temperature (close to that of the liquid nitrogen) of below -1950C, according to the article. This homogeneously nucleated the droplets. First, the vast majority of the ice crystals take on the shape of the ice crystals that are nucleated at a temperature of -300C or below rather than the ambient temperatures of their later growth (-8 to -160C). This can readily be seen in Figures 2 and 4, and as noted on lines 237-238 "the majority of ice crystals (∼68%) showed irregular crystal growth, and aggregates. At these temperatures and for the sizes considered (equivalent diameters between 15 and 145 microns) the crystals should be dominantly planar and dendritic, not the types observed, especially aggregates, which generally form at sizes above 200 microns, suggesting very high ice concentrations. Second, the ice crystals grown are not representative of the temperatures of the temperatures used in the study, and are very unlike ice crystals that are growth in natural clouds. This was a feasibility study; perhaps in a future study ice crystals representative of the growth of natural crystals could be studied.

A related study, by Ryan et al. (1976, JAS), "The growth rates and densities of ice crystals between -3 and -210C" , covered the size range and temperatures used in the Weitzel et al study. Cloud droplet sizes in their cloud chamber were between 4 and 30 microns. Ice crystals were produced using a small pin cooled in liquid nitrogen and even with this procedure concentrations of 5-20 cm-3 were produced. Even so, the resulting ice crystal habits were entirely consistent with experiments that grew ice crystals on silk filaments, not the types that were observed in this study. Indeed, they note that "in our experiments, more complicated structures, such as polycrystalline crystals, dendrites and capped columns were never observed". They measured ice crystal masses, densities, and axial dimensions. Although they did not have the very large sample size of the crystals in this study, they do provide very useful results.

As noted above, my suggestion is that in a future study, the authors devise a method to nucleate a few crystals at a time, possibly with ice nuclei in a cage within the chamber, then open the cage and let the particle grow at their correct temperature and ice supersaturation.

I have several minor comments but wanted to get this review to ACP for discussion.

Andy Heymsfield NCAR June 3, 2020

Interactive comment on Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2020-339, 2020.