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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Laboratory measurements and model sensitivity studies of dust deposition ice nucleation" *by* G. Kulkarni et al.

Anonymous Referee #1

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This manuscript describes an experimental and modeling study of ice nucleation initiated by mineral dust surrogates Arizona test dust and Kaolinite dust particles. The ice activated fraction was determined applying a continuous flow diffusion chamber approach for particles 100 to 500 nm in diameter and temperatures from -25 to -35 C. The data were analyzed using classical nucleation theory following two approaches: onset single angle and probability density function (PDF). Experimentally derived parameters are applied to a cloud resolving model. These simulations show that cloud properties (i.e. ice number concentration, ice water content, and cloud initiation times) are sensitive to onset single contact angles and PDF distribution parameters. Experimentally derived onset single contact angle are in agreement with previous literature but derived

PDF parameters are not.

This study fits nicely in the scope of Atmos. Chem. Phys. Although ice nucleation from Arizona Test Dust and Kaolinite are well studied systems the systematic investigation of size dependency for various temperatures, application of two different analytical approaches, and implementation of experimental results into cloud resolved models make this manuscript a worthwhile addition to the recent literature. This manuscript is recommended for publication after the authors have addressed the comments given below.

General comments:

The paper is concerned with deposition ice nucleation. How do you know that the particles triggered deposition ice nucleation. Can this be validated? I assume for lower temperatures this might be correct but at -25 C maybe not.

Instead of "deposition freezing" maybe use "deposition ice nucleation" since no liquid water is present in this nucleation process.

This manuscript could benefit from additional analysis of the experimental data with respect to classical nucleation theory as given in more detail below. This is something the authors might consider.

Specific comments:

p. 2490, l. 16: What is the number density of water molecules at the ice nucleus/water interface you applied?

p. 2492, l. 17: Is it justified to use the integrated number of dust particles. This would indicate that dust size dependence is neglected. However, the ice nucleation experiments indicate differences in activated fraction with different sizes, in particular at higher RH. I assume you are using the fitted dust size distribution in your model (Fig. 3)? What ice nucleation activity do you assign to particles larger 0.5 micrometer? Please elaborate here.

p. 2493, l. 1: Please give a reference why you can assume that deposition ice nucleation occurs at T < -22C?

p. 2493, l. 2: Figs 4 and 5: Why is an active fraction of 1 not reached?

p. 2493, l. 20: Tables 1 and 3 do not show any uncertainties. For this reason one cannot be convinced or it cannot be stated that there is no significant difference of the data.

p. 2494, l. 12: The sentence beginning “It might be that the. . .” reads awkward and should be reworded. Looking at previous literature which could be cited here, one can see that the onset for mineral dust does not change significantly with temperature within the deposition ice nucleation regime.

p. 2494, l. 16: This discussion is based on classical nucleation theory and should be made clear. For example “According to classical nucleation theory larger size particles should nucleate at . . .” (reference). As a matter of fact, I believe, the authors have all the parameters to calculate expected change in RH onset when changing the particle size. Assuming a similar Jhet (you obtained similar contact angles) you can change S_v,l in Eq. 3 when employing a different particle size to reproduce Jhet (or contact angles). This would be a valuable addition when doing this for all your data. It will give you an idea if classical nucleation theory can capture the observations.

Section 3.2:

This paragraph may need further explanation (text or equations):

a) Why does the onset approach result in Nice=N0 but only in the regime of water saturation. The experiments indicate that the onset occurs in subsaturated conditions?

b) The PDF approach yields Nice<N0 at water saturation. However, it also yields ice particles at lower RH compared to the onset approach. Shouldn’t the total (accumulated) number of ice crystals derived from the PDf approach be compared to initial number N0?

c) For what reason is the water saturation regime at all discussed?

d) Figure 6, 100nm, upper panel: Why does the onset approach produces 10-3 L-1 at 140% RHice?

p. 2496, l. 25: Maybe state the ice nucleation mechanisms which are not included.

p. 2497, l. 12: “The particles . . .” please reword. The particles do not nucleate; they might induce ice nucleation, etc.

p. 2497, l. 16: What changes in cloud radiative forcing are expected? Please elaborate and give references.

p. 2497, l. 25: “In the last case . . .” please reword. The particles do not nucleate; they might induce ice nucleation, etc.

p. 2498, l. 25: What do you mean with “errors in the IN measurements”? How do you want to minimize potential error sources.

Technical corrections:

p. 2485, l. 22: Change “comes” to “come”.

p. 2486, l. 29: Omit “the” in front of “climate”.

p. 2487, l. 1: Omit “the” in front of “CNT”.

p.2489, l. 14: Insert “the” before”DMA”.

p. 2489, l. 25: I assume “with” should be “the”.

p. 2490, l. 13: Change “further” to “lastly”.

p. 2491, l. 12: Change table sequence: table 3 should be table 2 and vice versa.

p. 2491, l. 15: Insert “off” after “read”.

p. 2493, l. 20: Please check table numbers.

Tables: include uncertainty as mentioned above.

Table 3: There is a “0” missing for experimental temperatures.

Figures:

Fig. 1: Omit “and” before “size”.

Fig. 2: Reword: “Active fraction of ATD particles, 400 nm in diameter, is given as a function of RHice.

Fig. 8: A title for the color bar is missing.

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 2483, 2012.