

Interactive comment on “Freezing of water droplets colliding with kaolinite particles” by E. A. Svensson et al.

Anonymous Referee #2

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Overview

The primary claim of the paper is the suggestion that the relative humidity plays a role in contact nucleation. I think that all this paper can do is to *suggest* that relative humidity plays a role. The uncertainties are too big and the data are too messy to say otherwise (see below). That said, I view this paper as provocative, as in it may provoke more systematic, carefully controlled studies. (In fact, the authors themselves suggest that they are already embarking on such a course of action.) I think the paper is worthy of publication, but there are some points I want to raise.

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Freezing efficiency

The discussion of the freezing efficiency and Figure 3 need to be improved.

Why is the freezing efficiency greater than 1 for experiments performed at 242 K? (Greater than 2, in fact.) The only way I could explain this would be for droplets to freeze without having collided with kaolinite, but the authors have ruled this out as a possibility (lines 1-4 on page 2421). (Brief digression: You state that no droplets froze when droplets weren't injected into the chamber. Did you also test to see that no droplets froze when no particles were injected but when the air was humidified?) The freezing efficiency for droplets at 244 K is also greater than 1. Please explain.

I find Equation 3 to be quite confusing, so I tried some artificial data to try to make it more clear. Imagine the following experiment in which you test 4 droplets:

Froze?	1	1	0	1
Number collisions	2	1	3	2

(The one droplet which did not freeze collided with three dust particles.) Using those numbers, I get $E = \frac{\text{freezing events}}{\text{total number collisions}} = \frac{3}{8}$, but using Equation 3 I get $E = \frac{3}{5} \times \frac{3}{4} = \frac{9}{20}$. What am I missing?

Also, please take a look at the caption for Equation 3. It isn't clear to me what the notation \sum_{frozen}^2 means. Is the expression being summed, then squared? Is the 2 an index?

In line 7 on page 2423, you state that C is calculated by setting E to 1. I think this should be F .

I think it would be worthwhile to tabulate a few more of the quantities you use. For instance, a table of F at 240 would show the kind of variation you have in the experiment. Similarly, a statement of t_f for each temperature (along with a standard deviation or some other measure of the variation) would be interesting to see. (I would be par-

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ticularly interested to see if t_f is exponentially distributed.)

Relative humidity

The premise of the paper is that high relative humidity makes kaolinite a better ice nucleus in the contact mode. From Figure 3, it seems that assertion is based primarily on the data point at 263 K. The data clearly show that kaolinite becomes less effective with increasing T for the low relative humidity series. I understand that increasing relative humidity at higher temperature was a way to make the droplets evaporate more slowly, but why wasn't high relative humidity tested for the lower temperatures. The case would certainly be more convincing if E was higher for, say 250 K, for high RH than for the low RH.

The data point at 258 K (moderate RH) is not significantly different than points between 245 and 251 K. Similarly, the points between 265 and the melting point are not significantly different than 245 to 251.

These issues are why I said in the Overview that the data in the paper are *suggestive*, but do not provide conclusive evidence.

Minor points

pg. 2418, line 19: "Other influential factors are droplet volume and surface area..." For heterogeneous nucleation, droplet volume is usually considered to be irrelevant because the nucleation rate will be dependent on the surface area of the water-catalyst interface, but the rest of the volume of the droplet doesn't matter. The surface area of the heterogeneous catalyst is certainly relevant, and for contact nucleation, the surface

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area of the supercooled droplet is as well. (I suppose you could argue that, therefore, the volume is relevant because greater volume implies greater surface area.)

pg. 2422, lines 3-4: I would reverse the sense of this sentence. The probability of collision with a droplet per unit time is assumed to be proportional to the observed particle number concentration.

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