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Interactive Comment

Interactive comment on "A new temperature and humidity dependent surface site density approach for deposition ice nucleation" *by* I. Steinke et al.

Anonymous Referee #2

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This study combined laboratory measurements and modeling efforts to investigate the deposition ice nucleation by Arizona Test Dust (ATD) and its time dependence. The experiments were conducted using AIDA chamber and the resulting data were analyzed using INAS approach and classical nucleation theory. A parameterization of INAS was provided for deposition ice nucleation by ATD. Further, ACPIM box model was used to evaluate time dependence of ice nucleation. Based on a case simulation, the authors conclude that the ice nucleation time dependence is not significant important for small cooling rates and at low ice-active particle fractions. The paper is well written and contains some interesting and original work. The manuscript is within the ACP scope and suitable for publication once the following comments/issues are addressed.

General comments:

1, the manuscript states that the parameterization of ns is valid between 226 and 250 K. In Figure 6, the experimental data starting at 223 K was excluded. Does that mean we need another parameterization for temperature lower than 226 K? Why the parameterization did not include the data at lower temperature? One of the purposes of parameterization is to use it in modeling studies for wider ranges of conditions, including temperature. As for the current parameterization (eqn. 16), the observed ns are within the 2 orders of magnitude. If include the data, it may go up to 3 or 4 orders of magnitude. If consider this variation/uncertainty, how would this affect on the results of the box model simulation? In other words, any sensitivity test in box model simulation to include uncertainty of the parameterization (two constants in eqn. 16)?

2, To investigate the time dependence, this study proposed another two equations (eqn. 19 and 20) for parameterization. These three (including previous one, eqn. 16) equations and three corresponding parameterizations were obtained for the same data set. When do the simulation for a reasonable range of pre-settings (temperature/RH/time), isn't it expected similar simulation results? To confirm the time dependence conclusions derived from box model simulation using ns parameterizations, one possible way is to do the same simulation using parameterizations based on classical nucleation theory (CNT).

Minor comments:

1, P18500, Eqn. 2,although used as a dimensionless parameter, is there any physical reason to directly add T and Sice as a "thermodynamic" variable? The term of Xthem shouldn't be identified as thermodynamic variable.

2,P18500, define Sice.

3, P18503-18504 and section 3.2.3, about the CNT and data analysis, what are the J values or how the J was used to derived theta? Which value of surface tension at the ice/vapor interface was used? Please provide the values of the parameters used in CNT analysis. The Delta gd in Chen et al. (2008) (Fig. 2 of the paper) was about

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2E-20 J for temperature lower than 223 K. Why the Delta gd of 4E-20 J was used here?

4, P18505, l.26, define AIDA when it was used for the first time.

5, P18508, l.11-14, does this mean that if there is sufficient water vapor and at high RH, particle with soluble materials will become aqueous droplets and could also be detected, especially at higher temperature, e.g. 250 K?

6, P18508, l.14-17, this manuscript focused on deposition ice nucleation, can you rule out the possibility of immersion freezing at high temperature, i.e., 250 K? If there is very small amount of soluble materials, once it takes up water, it will form aqueous particles then ice will nucleate through immersion freezing. It is not about the subsaturated conditions, it is about what are the soluble components and when it takes up water or deliquesces.

7, P18508, l.18-19, what is "a suitable size threshold"?

8, P18508, define SIMONE when it was first used in the text.

9, P18511, l.22, how is the RHice uncertainty calculated? What are the uncertainties of gas and wall temperatures?

10, P18516, l.3-11 and Fig. 7, at ~233 K, the RHice onsets are more than 10% lower than Kohler et al. (2010) and Welti et al. (2009), does that mean only the large particles nucleated ice in this study (polydisperse particles, see surface distribution in Fig.2)? How do these RHice onsets compare to the ice nucleation data by Knopf and Koop (2006).

11, P18516, l.15-16, "devations" should be "deviations"? This statement didn't explain the deviation. If the ATD used in these studies are from the same source, the ice nucleation efficiency (RHice thresholds) by nature should be very similar and so the INAS at the same temperature. Does the statement in l.15-16 imply that the INAS parameterization provided here is only valid or limited to AIDA experiments? Then, how this parameterization can be applied for atmospheric application? Is there any

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other possible explanation for these deviations, what is the difference in surface area compared to the cited studies?

12,P18518,l.18-19, the manuscript didn't provide sufficient proof to support this statement.

Table 1, It would be nice see the RHice threshold for each experiments.

Figure 5. please add description for the error bars showing in the figure.

Figure 6. Since the parameterization is only valid for temperature above 226 K, it is misleading showing the blue solid line for 220 K. Where is the grey dashed line in the figure?

Figure 7. Any simulation at 250 K? Do they show similar results?

Reference:

Knopf, D. A., and T. Koop (2006), Heterogeneous nucleation of ice on surrogates of mineral dust, J. Geophys. Res., 111, D12201, doi:10.1029/2005JD006894.

Interactive comment on Atmos. Chem. Phys. Discuss., 14, 18499, 2014.