

## ***Interactive comment on “Ice nucleation by surrogates for atmospheric mineral dust and mineral dust/sulfate particles at cirrus temperatures” by C. M. Archuleta et al.***

**Anonymous Referee #2**

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Archuleta et al. present an elaborated laboratory investigation of heterogeneous ice nucleation using aluminum oxide, alumina silicate, and iron oxide powder particles as surrogates for mineral dust. The results for the surrogate particles were, for particles of 200 nm in diameter, compared to a sample of Asian dust aerosol particles. The relative humidities with respect to ice, RH<sub>i</sub>, at which 1 % of the size-selected particles were active ice nuclei, have been measured at cirrus temperatures between −45 and −60 °C for unprocessed particles and particles coated with several monolayers of sulphuric acid. The freezing data for the sulphuric acid coated particles was compared to literature data which show the effect of dust inclusion on freezing of ammonium sulphate

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particles. The authors showed that modified homogeneous freezing parameterisations apply to the immersion freezing mode of mineral dust-like particles with sulphuric acid coatings. Strictly speaking, this conclusion is only valid for monodisperse surrogate particles of mobility diameters 100 and 200 nm with almost uniform particle surface. The effect of particle size is carefully discussed by the authors (may also be mentioned in the abstract).

As a general point I would recommend to more clearly state that, for atmospheric mineral particles with irregular surface and inhomogeneous mineral composition, the heterogeneous freezing parameters may significantly differ from the parameters for the surrogate particles summarized in Table 6, at least one may expect some scatter. The assumption of uniform surface area and distribution of ice active sites is even more important for the calculation of surface nucleation rates (according to equation 4). Of course it is very difficult to assess freezing nucleation rates even for almost uniform systems like supercooled water droplets. Therefore I would read the nucleation rates discussed in the present manuscript rather like an estimate than a recommendation for use in numerical models. Although the present work by Archuleta et al. provides valuable contributions and significant progress to heterogeneous freezing parameterizations, further work is needed to approve the concepts of modified homogeneous freezing nucleation rates for use in atmospheric models.

In general, I enjoyed reading this interesting, clearly written, and well structured manuscript and recommend publication in ACP. A few more minor comments and questions are addressed below.

### **Comments and questions:**

(1) Mobility size selection with the DMA: There seem to be a strong size dependence of ice nucleation efficiency. Can the authors give an estimate of the number fraction of multiply charged larger particles contributing to the selected mobility size classes?

(2) Ice crystal growth time and IN sensitive volume fraction of the CFDC: Do all ice

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crystals grow to  $d > 2\mu m$ , independent of their location to nucleate in the CFDC? Or do the authors expect all (or most) IN to activate in the upper section of the CFDC with enough time to grow to  $d > 2\mu m$ , even at the lowest T? Otherwise the IN efficiency may be underestimated. This could also affect the nucleation rate calculations.

(3) Summary of ice nucleation results: Comparison to Heymsfield and Milosevich (1995) is somewhat speculative here because the CFDC results are limited to particles less than  $2\mu m$  in diameter whereas the HM95 study tells, as far as I know, nothing about the aerosol properties. This may be mentioned here.

(4) The authors may add the line for homogeneous freezing to Figure 7.

#### **Minor typographic comments:**

p.3428, caption Fig. 1: ... which evaporate and condense on ...

p.3406, l. 5: DeMott, 2000 is missing in the reference list.

p.3432, caption figure 6: Arrows represent the melting point ... I guess you refer to the vertical arrows here, with the upper arrow indicating the melting point depression of the sulphuric acid solution and not for pure water.

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Interactive comment on Atmos. Chem. Phys. Discuss., 5, 3391, 2005.

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