Access review to "Size-Resolved Atmospheric Ice Nucleating Particles during East Asian Dust Events" by Chen et al.

Chen et al. present a laboratory investigation of the immersion freezing ice nucleation ability of filter-collected ambient Asian dust particles collected in Beijing.
Overall, I find that the topic of the manuscript fits well within the scope of ACP. This study extends previous studies on the immersion freezing ice nucleation ability of mineral dust particles to size-resolved measurements, and the experimental procedures and analysis are straight forward and sound. Based on the presented measurements a set of new parametrizations are developed that can predict the ice nucleation active surface site density of differently sized mineral dust particles at mixed-phase cloud conditions. While the results are mostly well presented and clear, the discussion of the parametrizations and comparison to previous parametrizations remains partly speculative. Therefore, I suggest the authors to address the below comments fore this manuscript is published in ACP

General comments:

- The discussion in Sect. 3.5 (in particular L321-335) to me reads somewhat confusing and in parts remains speculative. The present study does not present analysis of the mineralogical composition of the samples investigated. This makes it hard to follow the argumentation why the newly presented parametrizations should or should not follow previous parametrizations of desert dust samples that are based on samples of different but distinct mineralogical composition, but mostly on polydisperse aerosol particles (see Fig. 7b). Overall, it remains unclear whether the authors attribute the ice nucleation activity observed in the present study to particle composition or to particle size, when comparing to previous parametrizations. This section needs to be revised and more clearly structured upon revision.
- The authors suggest that the results help to understand the effect of chemical aging (e.g. L66, L73). However, specific aging mechanisms and or effects on the ice nucleation activity of the collected dust particles are not presented. I therefore suggest to remove the discussion of aging from the manuscript, unless a more comprehensive discussion of this topic is provided.

Specific comments:

- L17: Replace "warm" by "high"
- L24: Why is the upper limit -6 °C and not -5 °C, i.e. the upper limit of the presented immersion freezing experiments?
- L35: Delete "in-situ"
- L38: Change to: "... affects ice particle formation"
- L38-40: "simplified parametrizations" and "to accurately predict" seems contradictory; I suggest rephrasing this statement.
- L41: I suggest replacing "efficiency" by "ability", as the former implies some sort of time-dependence.
- L43: Add space before parenthesis here and on L44
- L46: Replace "and so on" by "such as"
- L47: "High content" and "increasing ratio" of what? Please specify.
- L49: Add Kumar et al. (2019)
- L53 : Add Kumar et al. (2019a), Zolles et al. (2015)
- L55 : Larger particles often… add Welti et al. (2009)
- L61: Do you mean "enhance the ice nucleation ability *to* higher temperatures"?
- L64-67: How does gravitational settling affect the dust transport and/or ice nucleation activity? Rephrase this statement.
- L69: Change to: "…in differently sized particles…"
- L71: Change to: "…activity of different…"
- L75: Change to: "…efficiency of Asian dust and its sensitivity to particle size, airborne…"
- L77: Change to: "…INP number concentration…"
- L78: Change "warm" to "high"
- L81: Climate models? Please specify.
- L86: Please specify the time resolution.
- L89: "A 8-stage…"

- L90: Change to: “We used stages 1 to 8 of the…at a flow rate of 30 L/min in this study.” Move reference of Marple et al. (1991) to L89.
- L93: Delete “text”
- L104: Delete: “operated after careful temperature calibration”
- L108: How did the authors ensure that everything was washed of the filters? Was there any evidence from more sticky aerosol components, such as secondary organic material associated with the mineral dust particles?
- L120: Change to: “…concentration of ice active sites above…”
- L123: Change to: “is calculated as: …”
- L125: Change to: “…activity of samples with different aerosol particle size…”
- L127: Change to: “…(Vali et al. 2015) is calculated from the INP concentration as:…”
- L128: “and per droplet”?
- L128: Delete “based on the particulate matter information”
- L130: I do not follow this statement, please expand.
- L131: Delete “population”
- L133: Rephrase to. “Following the method of O’Sullivan et al. (2018)…”
- L137: Add “each particle size class”
- L143: Change to: “ultrafine condensation... »
- L184 : Change to : «…indicating different ice nucleating…”
- L193 vs. L195: Please write out “2” as “two” for consistency
- L227: Change “efficiency” to “ability”
- L230: “The higher…” Do the authors have any particle data to support this claim? Are there other studies that suggest the northwest pathway to be associated with a higher feldspar content?
- L233: Change to “Figures 4 (a) and (b) compare…”
- L236: Add a sentence a long the lines: “The ns values of this study are compared to literature values.”
- L237: Change to “…desert in Africa”
- L243: Change to: “The difference in the temperature range between this study (…) add R19 (…) is due to the droplet volume…”
- L246: Change to: “…demonstrate that despite different origins of the dust samples investigated here and in R19, as well as the varying atmospheric transport...”
- L248: Delete “great” (it seems also a bit contradictory with the statement on L250).
- L253-255: Is this known? This statement should be supported by appropriate refernces
- L258: “The near-surface…” This is unclear, here you compare ns, which is normalized to particle size/surface area, or am I misunderstanding you here?
- L260: “…to be more active INPs” compared to dust?
- L262: Delete “green”
- L264-265: Can be reduced to 2-3 main references, as you detail these studies in Sect. 3.4.
- L270: Replace “population” by “number concentration”
- L272: Add: “…ice nucleation”
- L274: Delete space in front of D50
- L275: “and” should not be italicized
- L277: Replace “warm” by “high”
- L280: Do the indicated uncertainties correspond to standard deviations for the 12 samples? Please specify here and in the caption of Fig. 5.
- L290-293: This contradicts your hypothesis presented in Sect. 3.3. that different feldspar content contributes to different freezing abilities.” There is not sufficient evidence provided to claim/suggest a difference in mineralogical composition between the two transport pathways. I suggest to completely leave this out and focus on the aspect of the biological fraction, where direct measurements and support is provided by your data. Please see my main comment above.
- L296: Change “can’t” to “cannot”
- L304: Replace “Where” by “Here”
- L313: Replace “the first two lines” by “…between the lines of D50 = 5.6 µm and the ns curve for submicron particles.”
- L317: “1.0 ~ 3.2 µm” I assume this line corresponds to the average of the D50 = 3.2, 1.8 and 1.0 µm lines which overlap in Fig. 7a, right? This should be specified in the text. I also suggest to replace “~” by “-“ and chose a color that is distinctively different to any color used for the individual lines to avoid confusion.
- L319: “was less than 1 to 5 µm”: Do you mean “below 5 µm”?

- L322: contain more highly ice active minerals”
- L323: Delete “exactly”
- L324: “-25 °C”. From the figure it appears to be more likely “-29 °C”.
- L324-325: “This phenomenon can…” If this was the case, why does your submicron parametrization deviate strongly from the quartz parametrization of Harrison et al. (2019) at higher temperatures? Is this because feldspar ice nucleation activity dominates at higher temperatures? This should be specified.
- L333: Replace “components” by “factors”
- L334-335: “…are mire active…” Compared to what? The Atkinson et al. (2013) K-feldspar line ?
- L335 : « Overall… » This statement seems misplaced and should be moved to Sect. 4
- L342-343: Please see my comment above. Your data suggest that the difference is mainly driven by a difference in the biological material present on the dust particles from the two transport pathways.
- L354: Replace “warm” by “high”
- L355: Are you trying to say that Asian dust has a higher abundance of biological material compared to desert dust?
- L362: “…emphasizing the importance…” I suggest to tune this down a little bit: “…potentially suggesting the importance of larger particles for cloud formation.”
- L363: “as particle size reflects … » This statement should be support by references.
- L364-365: “Due to the single requirement…” Unclear what you mean, please rephrase.
- Fig. 3: Why are there two blue lines coming from the northwest pathway, i.e. lie on top of the red trajectories?
- Fig. 5: Include space between value and unit, i.e. “10 °C”

Kumar, A., Marcolli, C. and Peter, T.: Ice nucleation activity of silicates and aluminosilicates in pure water and aqueous solutions – Part 2: Quartz and amorphous silica, Atmospheric Chem. Phys., 19(9), 6035–6058, doi:https://doi.org/10.5194/acp-19-6035-2019, 2019a.

Kumar, A., Marcolli, C. and Peter, T.: Ice nucleation activity of silicates and aluminosilicates in pure water and aqueous solutions – Part 3: Aluminosilicates, Atmospheric Chem. Phys., 19(9), 6059–6084, doi:https://doi.org/10.5194/acp-19-6059-2019, 2019b.

Welti, A., Lueoend, F., Stetzer, O. and Lohmann, U.: Influence of particle size on the ice nucleating ability of mineral dusts, Atmospheric Chem. Phys., 9(18), 6705–6715, 2009.

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