Review of "Ice nucleation efficiency of natural dust samples in the immersion mode" by Kaufmann et al.

In this study, Kaufmann et al. use a DSC method to examine the nucleating behavior of a wide range of both natural dusts and reference minerals. It is found that the variability in freezing behavior for natural dusts is relatively small. The consequences of this finding is that for model studies, it may be sufficient to represent natural dusts with a single paramaterisation, at least in the temperature ranges examined during this study. The difference in variability in the freezing behavior between natural dust samples and reference materials, which was found to be greater in the case of the latter, is also a key finding, is sure to be of interest to researchers in this area.

My main comments/questions on the paper surround the experimental procedure, and how the data is interpreted. Following clarification of these points, I would recommend the paper for publication in ACP.

Comments and Suggestions:

- It is not immediately obvious why the data from DSC measurements cannot be normalized to nucleation rates or ice active site densities. I can envisage some difficulties in doing this, but a statement on why nucleation rates or ice active site densities are not calculated would be of value to the reader.
- At this point in time, there are two other pertinent papers which are in peer review in ACPD (Harrison et al., 2016; Peckhaus et al., 2016), which are not considered here, but I would highlight that they are very relevant. For the final ACP version of this paper, if these related papers are accepted prior to this one, I would certainly include discussion of them.
- Throughout the paper, IN is used, instead of INPs. I would consider changing this as per (Vali et al., 2015)
- P1L18: for clarity, I would add point out that the 2 um figure given here is from the number distribution.
- P3L7-8 an L18-19: The references here don't all match with the statements made on how organic matter can influence ice nucleating activity, in particular, Baker 2005 and to a lesser extent maybe Hallar 2011; neither of these studies examined ice nucleation as far as I'm aware. Also, there are multiple more pertinent references here e.g. (Augustin-Bauditz et al., 2016; O'Sullivan et al., 2014; Tobo et al., 2014)
- P3L20: "important" is a very qualitative word- I suggest changing to something more concise.
- P4 experimental setup: Very high concentrations of dusts are used during some experiments, up to 50% (!). The authors refer to these as suspensions (by 50 wt %, I envisage this is more of a slurry than a "suspension"), but no indication is given on their stability. Emersic et al. (2015) suggest that aggregation, and surface area occlusion in droplets of 1 wt% is an issue for droplet freezing experiments- could this be an issue

for these experiments at much higher concentrations? A discussion on these points is warranted, perhaps in the experimental section.

- P5L 8-17 and Appendix A2: I have missed it elsewhere, but it would be useful to know here how many separate emulsions were examined in the determination of the droplet size distributions, and the total number of droplets examined. Also, this info should be added to the caption of figure 5.
- P5L20: were these wet or dry sieved?
- P6, section 3: If I understand correctly here, the authors are using size distributions measured by SMPS/APS, but are then using this information to estimate the number of particles in suspension droplets. The particle size distributions will be different in the suspension than from the aerosol phase due to aggregation. Will this not lead to significant errors in the calculation of the number of dust particles per droplet, and hence f_{act}?
- P19 L14-30: The authors attempt to explain the freezing behaviors of dusts which did not entirely fit with their hypothesis that mineralogical composition is the dominant factor accounting for this. Again, it would seem to me that recent papers in open discussion (Harrison et al., 2016; Peckhaus et al., 2016) are particularly pertinent to the discussion here.
- P19L16-18. Do the authors have data to substantiate that in solution, the milled reference samples do not aggregate also?
- P19L29-30: Perhaps the amount of organic matter could be expected to be small, but the OM content of the dusts was not investigated here. Even trace amounts of organic matter could affect the nucleating abilities of the dusts. Either the authors should further add to arguments that the amounts of OM are too small to affect the freezing behavior, or drop this last sentence.
- P20L12: This relates to my first comment above again: it would be useful to state why the thermogram data cannot be transformed into a parameterization which could be implemented in models.

References:

Augustin-Bauditz, S., Wex, H., Denjean, C., Hartmann, S., Schneider, J., Schmidt, S., Ebert, M. and Stratmann, F.: Laboratory-generated mixtures of mineral dust particles with biological substances: characterization of the particle mixing state and immersion freezing behavior, Atmos. Chem. Phys., 16(9), 5531–5543, doi:10.5194/acp-16-5531-2016, 2016.

Emersic, C., Connolly, P. J., Boult, S., Campana, M. and Li, Z.: Investigating the discrepancy between wet-suspension-and dry-dispersion-derived ice nucleation efficiency of mineral particles, Atmos. Chem. Phys., 15(19), 11311–11326, doi:10.5194/acp-15-11311-2015, 2015.

Harrison, A. D., Whale, T. F., Carpenter, M. A. ., Holden, M. A., Neve, L., O'Sullivan, D., Vergara Temprado, J. and Murray, B. J.: Not all feldspar is equal: a survey of ice nucleating properties across the feldspar group of minerals, Atmos. Chem. Phys. Discuss., (February), 1–26, doi:10.5194/acp-2016-136, 2016.

O'Sullivan, D., Murray, B. J., Malkin, T. L., Whale, T. F., Umo, N. S., Atkinson, J. D., Price, H. C., Baustian, K. J., Browse, J. and Webb, M. E.: Ice nucleation by fertile soil dusts: relative importance of mineral and biogenic components, Atmos. Chem. Phys., 14(4), 1853–1867, doi:10.5194/acp-14-1853-2014, 2014.

Peckhaus, A., Kiselev, A., Hiron, T., Ebert, M. and Leisner, T.: A comparative study of K-rich and Na/Ca-rich feldspar ice nucleating particles in a nanoliter droplet freezing assay, Atmos. Chem. Phys. Discuss., 0, 1–43, doi:10.5194/acp-2016-72, 2016.

Tobo, Y., Demott, P. J., Hill, T. C. J., Prenni, A. J., Swoboda-Colberg, N. G., Franc, G. D. and Kreidenweis, S. M.: Organic matter matters for ice nuclei of agricultural soil origin, Atmos. Chem. Phys., 14(16), 8521–8531, doi:10.5194/acp-14-8521-2014, 2014.

Vali, G., DeMott, P. J., M??hler, O. and Whale, T. F.: Technical Note: A proposal for ice nucleation terminology, Atmos. Chem. Phys., 15(18), 10263–10270, doi:10.5194/acp-15-10263-2015, 2015.