Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2018-1036-RC1, 2018
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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Heterogeneous ice nucleation on dust particles sourced from 9 deserts worldwide – Part 2: Deposition nucleation and condensation freezing" *by* Yvonne Boose et al.

Anonymous Referee #1

Received and published: 23 November 2018

General comments:

The present manuscript is a follow up paper to "Heterogeneous ice nucleation on dust particles sourced from nine deserts worldwide – part 1: Immersion freezing" (Boose et al, 2016). In part 2 (the present paper), ice nucleation efficiency of minerals in deposition nucleation and condensation freezing modes is studied, as well as the effect of coatings (biological and volatile/semi volatile organic material). The paper is generally well written, and it complements part one nicely. However, in some way it is difficult to follow the paper as it at times rely on the reader to remember details of part 1. Gener-

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ally, the authors are asked to check that the paper is consistent with the partner paper in the use of sample names, e.g. “Tenerife” in part 1, and “Izaña” in part 2, as well as minerals (e.g. specification of Feldspar and K-Feldspar). Additionally, there is little information on why some samples are selected for further analysis and others not, e.g. XRD of one sample before and after heating, Raman mapping of two desert samples and no airborne sample, the difference in number of samples in table 2, and why is Izaña2014_2 selected and not the other Izaña samples?

In their results, the mineral fraction from feldspars and quartz correlate with the ice nucleation surface site density (ns), in both deposition and condensation mode, similar to what was found for immersion freezing in part 1. Some organic material coating the particles altered the ns, seen by comparing untreated and heated samples. In one sample, the ns is higher in the heated sample which is devoted to evaporation of volatile organic material. In this sample, also the minerology changed (gypsum to anhydrite) between the pre- and heated sample. A similar result was found in Grawe et al. (2018), but in this case it is devoted to an overestimation of ns because of large needle shaped particles that could cross the size selecting step. The authors are therefor asked to address the possibility of needle shaped particles (see more details below) and if necessary change their conclusions.

Specific comments:

Page 4 “2.1 Dust sample origins and processing”: How were the samples stored for up to 8 years. Will the storage change the samples (e.g. loss of volatile compounds, change in composition due to water uptake, changes in biological material on the surface)?

Page 10 in the subchapter 3.2 “Ice nucleation and heat labile material”: Three samples are discussed extensively from page 10 onwards, Etosha, Australia and Izaña 2014_2. It would be easier for the readers to have a summary of why these three samples are further investigated and discussed, compared to the rest.

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We learn on page 12 (line 13) that there is a change in the mineralogical composition between untreated and heated samples. Please add the XRD results of heated and unheated samples, either to the paper or in a supplement. Large uncertainty is associated with comparing particle composition and bulk chemical analysis, which the readers also are made aware of in the paper. I would like to draw the authors attention to an article where the ice nucleation efficiency of coal fly ash particles were investigated by Grawe et al. (2018). In this case, needle shaped particles could explain the higher ns of one sample where anhydrite changed to gypsum after suspension. Many of the needles were larger than 300 nm (up to $\sim$5 μm), but could - due to the fact that the dynamic shape factor of the needles differ significantly from unity - cross the size selection step in the DMA. Needles can be formed in both directions, from anhydrite to gypsum and gypsum to anhydrite. An example of the formation of anhydrite needles from gypsum is seen in Azimi and Papangelakis (2011). Can this also be the case of the one Izaña sample? The loss of the OH peak could also be explained by gypsum converting to anhydrite. If this is the case in your study then please change the conclusion. If not, then the discussion should cover why this volatile organic coating only applies to one sample. Isn't this expected from the other airborne samples too, at least the other Izaña samples?

Technical comments:

Title: Change '9' to 'nine' to be consistent with the partner paper.

'Ice nucleating particles' without hyphen, like in partner paper and in Vali et al. (2015).

Figure 1: The black color of the CALIMA2014 sample symbols covers all the other samples. Please change this to make it easier for the readers to see all results. Please remind the reader that CALIMA is the same sample location as Izaña in the figure legend.

Figure 2: Please add to the legend text explaining the astrix (as in table 2). Why is the Etosha sample not present in this figure?

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Figure 3: Please remind the reader which samples are airborne, milled and sieved in the figure legend. Why is the Atacama sample called milled and not the Australia and Morocco sample? Why does the heated sample from Morocco only have an upper limit?

Figure 5: In the text, the samples are discussed in the following order (ref. P10, L5-14) Australia, Etosha and Izaña 2014_2. The two first show no change between unheated and heated, and in the last sample a change is discussed. It would be more logical for the reader if the locations appear in the same order as the text.

Figure 6: The figure contains a lot of information, but the grey maps (1) add no important information as the images are taken at relatively low magnification so the particles can't really be seen. Also, please remove: "see text for details".

Table 2: Please define the KâĂŤfeldspar and feldspars groups in the figure legend. Please explain the readers why there are different numbers of samples.

Introduction:

Page 2, line 21: Please add a comma after the South Pole.

Page 2, line 24: The term "potassium feldspars" is used sometimes, and "K-feldspars" other times. Please be consistent.

Page 3, line 31: Please specify the minerals in the K-feldspar fraction.

Page 3, line 33: Please specify the minerals in the feldspar fraction.

Methods:

Page 4, line 23: Please add country (Crete and Peloponnese, Greece) and then use the same structure as before, e.g. "...(Crete and Peloponnese, Greece), and the 10th of May 2010 (Aburdees, Egypt)."

Page 5, line 16: "...mobility diameter between 12.2 – 615 nm..." Is the decimal place

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significant?

Page 6, line 25: Change ‘tank’ to ‘sample container’

Results and discussion:

Page 8: line 26 & 27: Please add p-value.

Page 9, line 4: Please explain why these samples are selected.

Page 10, line 6: Please remind the reader that the spectra are from bulk material. E.g. “. . .related to the dominant minerals (in bulk) in the samples”.

Page 11, line 7 & 8: “The minerals contained in the Etosha sample. . .” Please remind the reader which minerals so they don’t have to look it up in the partner paper.

P 11, line 9: Sentence too long.

Page 11, line 10: In this line you abruptly move from the discussion of minerals to organic material.

Page 11, line 33: Remove ‘the’ to During daytime,. . .

References:

Azimi, G., and Papangelakis, V. G.: Mechanism and kinetics of gypsum–anhydrite transformation in aqueous electrolyte solutions, Hydrometallurgy, 108, 122-129, 10.1016/j.hydromet.2011.03.007, 2011. Grawe, S., Augustin-Bauditz, S., Clemen, H. C., Ebert, M., Eriksen Hammer, S., Lubitz, J., Reicher, N., Rudich, Y., Schneider, J., Staacke, R., Stratmann, F., Welti, A., and Wex, H.: Coal fly ash: linking immersion freezing behavior and physicochemical particle properties, Atmos. Chem. Phys., 18, 13903-13923, 10.5194/acp-18-13903-2018, 2018. Vali, G., DeMott, P. J., Möhler, O., and Whale, T. F.: Technical Note: A proposal for ice nucleation terminology, Atmos. Chem. Phys., 15, 10263-10270, 10.5194/acp-15-10263-2015, 2015.

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