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Interactive comment

Interactive comment on "Not all feldspar is equal: a survey of ice nucleating properties across the feldspar group of minerals" *by* A. D. Harrison et al.

Anonymous Referee #2

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Harrison et al. present immersion freezing measurements of 15 different feldspar mineral samples, using a droplet freezing technique. Their intent is to explore the variability of ice nucleation properties of the feldspar mineral group, and attempt to relate this to the mineralogical properties. They also report that one of three feldspar samples tested exhibited significant and rapid loss of ice activity as the mineral sample sat in water for hours or months. As the feldspar minerals have recently been identified as the most efficient mineral ice nucleants, this topic will be interesting to this journal's readership. The paper would be a lot stronger if more details regarding the precise mineralogical properties and crystal/lattice structure of the different minerals was provided. As written there is little deeper or fundamental insight provided regarding the quite different freezing properties of the various minerals and how this relates to the actual mineral properties. The large change, or lack of change, in freezing ability with time spent in

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water is a valuable finding, though it was not clear why those 3 mineral samples were the only ones tested for the effects of time spent in water. While not a great deal of new scientific information or insights are presented here, this paper still provides some valuable new data regarding an important atmospheric ice nucleant. This manuscript should be suitable for publication in ACP, but the following issues need to be addressed first.

The information provided on the different mineralogical compositions of the feldspar minerals is good, and Figure 1 summarizes this well. I was surprised to not also see more details provided regarding the crystal lattice structure, symmetry, and space group of the different mineral phases. These properties are often referred to in the text to try to understand the observed ice nucleation properties, but without a table or figure summarizing this information it hard to understand this important aspect. Please add as much detail regarding the other known properties of these feldspar minerals in a well organized table or similar.

Introduction: It seems that the recent effort by Perlwitz et al. to incorporate better representations of the variable mineralogical composition of dust into global models should be referred to here. A major challenge regarding understanding and predicting the ice nucleation properties of atmospheric mineral particles is that we do not have a good understanding of the distribution, abundance, and transport of the different mineral types in the atmosphere.

Perlwitz, J. P.; Pérez García-Pando, C.; Miller, R. L. Predicting the mineral composition of dust aerosols – Part 1: Representing key processes. Atmos. Chem. Phys. 2015, 15, 11593–11627, doi:10.5194/acp-15-11593-2015.

On a related note, it is important to also have some discussion of the size of atmospheric feldspar mineral particles. What aerosol size mode are these typically found in? This is crucial to predict their transport, lifetime, and deposition. One of the reasons that the clay minerals have been focused on for so long is that they tend to be present in the smaller atmospheric mineral particle sizes, and thus have longer lifetimes.

Although you focus on immersion freezing here – without actually stating the heterogeneous ice nucleation mode you measure here (please clarify this so it is clear to the reader), it was odd that this paper on the depositional ice nucleation properties of Feldspar was not cited:

Yakobi-Hancock, J. D.; Ladino, L. A.; Abbatt, J. P. D. Feldspar minerals as efficient deposition ice nuclei. Atmos. Chem. Phys. 2013, 13, 11175–11185, doi:10.5194/acp-13-11175-2013.

Some discussion of the vulnerability of feldspar minerals to chemical attack by e.g. sulfuric acid should be included. This is quite important to understand the actual contribution of feldspar minerals to atmospheric ice nucleation, and also provides some insights into the nature of the ice active sites. Wex et al. (2014), already cited here, discuss some of these aspects. I believe it is well known in the mineralogy community that these feldspar minerals can be readily converted to amorphous clay structure through reaction with sulfuric acid.

Page 6: Why were those 3 mineral samples selected out of the 15 to perform the extended time in water experiments on? It would be valuable to conduct these tests on a larger number of the minerals, since the behavior seems quite variable between minerals. At the least some justification for the 3 sample chosen could be given.

Page 6, line 31: Citing 8 of the authors own publications that uses the same (and rather simple) experimental method seems like excessive and unnecessary self-citation, especially when Whale et al. (2015a) already provides a detailed discussion of the method. Please restrict these to the most necessary and relevant citations.

Page 7, line 19: More of the recently published experimental work that has explored the role of time-dependent freezing should be cited, such as:

Wright, T. P.; Petters, M. D. The role of time in heterogeneous freezing nucleation. J.

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Geophys. Res. Atmos. 2013, 118, 3731–3743, doi:10.1002/jgrd.50365.

Some discussion of the similarity of the Monte Carlo approach to estimate the uncertainty of the n_s values to other work should be presented. Is this the first time these authors have used this approach, or that anyone has used a similar approach? Wright & Petters (JGR, 2013; cited above) also used a Monte Carlo approach to analyze and interpret their droplet freezing data. Please discuss this. As it is presented it reads as if this is a completely new approach.

Page 8, line 14: "We assume that each droplet contains a representative surface area distribution." Please clarify what "representative" means. Is the goal to account for the non-uniform distribution of particle number and surface area in each droplet?

Figure 3 is hard to read at the presented size. The symbols are too small and faint.

Figure 4 is begging for some error bars or other measurement of the uncertainties, so it can be determined what degree of the observed changes in median freezing temperature are significant and above the experimental uncertainties. It seems that only the Amelia albite sample displayed any significant change.

Figure 5: Some annotations/captions added directly to the figure pointing out what data is plotted where would improve the clarity of this paper. It is difficult to have to keep going back to the figure legend to decode what each dataset is from.

Technical corrections:

Page 3, line 19: "experiments"

Page 7, line 5: Missing a space, should be "C min-1"

Page 9, line 30: "(nucleation rate) vs." Versus what?

A space in-between the number and "degreeC" is often missing, such as throughout pages 12 & 13.

Page 14, line 18: “regimen this study”. Word is missing?

Page 15, line 13: “sites”

Page 15, line 15: “that are stable”

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