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Atmospheric Chemistry and Physics
Discussions

Interactive comment on "A new multi-component heterogeneous ice nucleation model and its application to Snomax bacterial particles and a Snomax-illte mineral particle mixture" *by* Hassan Beydoun et al.

Anonymous Referee #2

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This is an interesting paper where the authors apply a previously developed model to multiple component ice nucleating systems. They study ice nucleation by snowmax (which has multiple types of sites) and a mixture of snowmax plus nx illite. They conclude that when mixed with illite the snowmax behaves much like pure snowax, which is important because this was not necessarily known (I mention this again below and I think the motivation for this study needs to be made clearer). The manuscript is reasonably well written, but I think the authors should try to be more concise wherever possible. In particular, use of scientific notation would make the manuscript far eas-

ier to follow and must be corrected. In addition, I would like to see some discussion over the advantages/disadvantages of this method over singular descriptions. I support publication in ACP once the following specific points have been addressed.

P2., lines 18. How does 'analysis of ice crystal/precipitation sample residues' show that 'droplet freezing can occur at temperatures higher than -12 °C'?

P2, ln 20-25. 'higher than -12 °C. This is a temperature range no investigated mineral samples of atmospherically relevant particle sizes (or other atmospherically relevant non-biological particles) can induce freezing in'. This is incorrect, there is a finite possibility of nucleation at these warmer temperatures. If the authors are referring to a situation in a cloud, are they sure about this? Very rare ice nucleation events seem to lead to secondary ice production, so is conceivable that mineral dust could account for a lot of very warm freezing.

P3. In the main para in which the study is justified, some of the concepts introduced by O'Sullivan et al. [2016] should be mentioned. One reason why it is important to study dust-bio INPs is that it is not obvious that the proteins responsible for ice nucleation should retain their ice nucleating ability when adsorbed onto other materials. There is a literature on the subject of binding of proteins to clay surfaces and examples of where the function of the protein is impaired when adsorbed.

Intro. Some discussion of competing models would be useful. For example, how does this approach contrast with that of Knopf and Alpert [2013]. This is a very different approach, what are the strengths and weaknesses? For example, it could be argued that these multiple component models are not based on a physical model since the distribution of sites is empirically fitted to data.

Also, what advantage does this approach have over the commonly applied ice active site density?

Fig 1. The label (4) is missing from the images of droplets.

P6. Top paragraph. The multiple component stochastic model described in Herbert et al. [2014] and Broadley et al. [2012] should be mentioned here.

P7 What are 'nucleation critical temperatures'?

Throughout: The term 'ice nuclei' is used. I urge the authors to use the terminally set out in the Vali ACP 2015 definitions paper. 'Ice nuclei' is used in the context of classical theory in reference to the cluster of water molecules, not the particle on which the cluster is stabilised.

P11. Ln 15. Homogeneous nucleation can occur at a much higher T than -38 C. It is not that helpful to consider homogeneous nucleation occurring with a 'limit'.

P12, ln 14-16. Use scientific notation. In fact, use it throughout.

Fig 2. If this data were plotted as nm (i.e. sites per unit mass) would the different curves fall on top of one another? How does this data compare with literature data for snowmax? Also, does nm capture enough detail to reproduce these fraction frozen curves, or is nm flawed?

P23. Ln 13-15. Why is this an atmospherically relevant system?

P26. In the discussion of weather the snowmax-illite system is a 'close proxy to real atmospheric bio-dust mixtures', O'Sullivan et al. [2016] should be discussed. They argue that in soil particles will adsorb ice nucleating macromolecules. Soil borne fungus can shed its ice nucleating proteins into water and these proteins apparently bind to clay particles. This represents a distinct scenario of bio-dust mixtures compared to mixing snowmax with illte.

References.

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