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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Representing time-dependent freezing behaviour in immersion mode ice nucleation" *by* R. J. Herbert et al.

Anonymous Referee #2

Received and published: 14 March 2014

General comments

The article addresses the important question of bringing together ice nucleation measurements from different experimental systems and techniques. The derivation of the FROST framework is presented comprehensively and so are the physical implications. It is shown that ice nucleation by different materials exhibit different sensitivity on time. What is claimed in the abstract but not shown in detail is the applicability of FROST to represent ice nucleation in cloud resolving models. A direct comparison to the considerable number of similar approaches in the literature to fit experimental nucleation data would also be interesting. I can recommend the manuscript for publication in ACP after minor corrections, listed below.

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Specific comments

Page1401, line14: Deposition nucleation is not restricted to water sub-saturated conditions, this could be made clearer.

Page 1401, line16-21: Mixed-phase clouds always contain water droplets; this is not a sufficient argument to exclude deposition nucleation. Try to clarify and reformulate.

Page1401, line 24: Consider adding Durant and Shaw (2005) to the list of references for evaporation freezing.

Page 1402, line 7: Consider adding an example to illustrate the range of ice nucleation ability.

Page 1403, line 6: Can you add a statement for what kind of materials the stochastic nature is more important?

Page 1403, line 13: Name the properties that have been tested. Can you think of other possible, but not tested relationships?
It might be interesting to discuss the influence of particle size distribution and surface area immersed in a droplet. Can the PICOLITRE experiments on KGa-1b and feldspar or the experiments on larger K-SA particles be reconciled with the data shown in Fig. 5, 6 and 8?

Page 1404, line 5-6: Please name the materials you are referring to.

Page1407, line 7: Based on the reasons for inter-particle variability in ice nucleation

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ability given on page 1404, can you justify the assumption of a Gaussian distribution?

Page 1419, line 2-4: What is the RMSE of this fit?

Page 1421, line 17: Hoyle et al., 2011 used a fluidized bed aerosol generator with an upper size cut-off at 3μm for the ZINC experiment not 300 μm. However the ln(n_s) values in Fig. 9.a) seem to be correct.
Hoyle et al. reported additional DSC data. Consider including this measurements to your dataset to demonstrate the applicability of FROST to reconcile data from three different experiments.

Page 1423, line 11-23: It seems that more efficient IN generally exhibit a larger λ and therefore a weaker time-dependence. Can you comment on that?

Technical corrections

Page 1414, line 14: Check the numbers of equations you refer to.

Page 1419, line 21: remove "K" after $\lambda = -3.4$

Page 1419, line 22: σ,μ are inverted

Fig. 5, 6, and 8: Consider homogenizing this figures in terms of what is shown in which column.
Additionally it would be interesting to see F, n_s and J for all three datasets.

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References

Durant, A.J., and Shaw, R.A. Evaporation freezing by contact nucleation inside-out, Geophys. Res. Lett., 32, L20814, doi:10.1029/ 2005GL024175, 2005.

Hoyle, C.R., Pinti, V., Welti, A., Zobrist, B., Marcolli, C., Lou, B., Höskuldsson, A., Mattsson, H.B., Stetzer, O., Thorsteinsson, T., Larsen, G., and Peter, T.: Ice nucleation properties of volcanic ash from Eyjafjallajökull, Atmos. Chem. Phys. 11, 9911-9926, 2011.

Interactive comment on Atmos. Chem. Phys. Discuss., 14, 1399, 2014.