Atmos. Chem. Phys. Discuss., 9, S1186–S1189, 2009
www.atmos-chem-phys-discuss.net/9/S1186/2009/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Studies of heterogeneous freezing by three different desert dust samples" *by* P. J. Connolly et al.

P. J. Connolly et al.

Received and published: 31 March 2009

We would like to extend our thanks to the referee for the useful comments which we feel helped to improve the paper.

General comments

Introduction: Inserted new paragraphs discussion the results of Zimmermann, Vali and Marcolli. This line was also inserted to give reference to Bailey and Halletts work: "We also present the ice crystal habits, which were observed with the CPI during the experiments, mainly as supporting measurements, but also to look into any effects that nucleation may have on resulting ice crystal habit (Bailey and Hallett, 2002)". This does not affect the main conclusions in any case.

IASSD:

Full Screen / Esc
Printer-friendly Version
Interactive Discussion
Discussion Paper

- To highlight the differences between Marcolli et al 2008 this has been added in the section on basic assumptions and definitions: " Our assumption is slightly different to that of Marcolli et al. 2008, who attempted to define a range of nucleation rates for different areas on individual IN using the classical spherical cap model. The main difference being that, in this model, ice crystal formation occurs instantaneously at a defined temperature.";

- The IASSD is calculated each time-step, but only because of the implicit dependence on temperature. Equation 8 is consistent with the fact that the active sites are removed each time-step—the product of N_{drop}, A and $k(T)$ is the number of active sites in the whole population per temperature interval, and when these are used up, the droplet concentration decreases, so then do the number of active sites. So yes the IN properties are conserved using this approach.

- If an IN has many active sites then the product of the area and the active site density will be greater than 1. With reference to equation 9, this means that the factor on the lhs in brackets is equal to 1 and all drops freeze.

- Is the number of active sites equal to the number of ice crystals? If the number of active sites is less than 1 we can make the approximation that $1-exp(activesites)$ is equal to the number of active sites. Under that approximation equation 9 shows that the number of crystals is equal to the product of the drop number and the number of active sites.

- Our underlying assumption is not really similar to the approach of Marcolli et al. They still have nucleation rates for their singular hypothesis where as our approach assumes no time-dependence at all. It should be OK for cooling rates of 1K min^{-1}.

Comment on Freezing vs deposition nucleation: this was added in the conclusions: "In the experiments shown here all of the dust particles in the AIDA acted as CCN, leaving

ACPD

9, S1186–S1189, 2009

no interstitial dust particles that could act as deposition nuclei. In the atmosphere however, it is reasonable to assume that this would happen and significant deposition nucleation could take place before the formation of liquid drops."

Modelling: This footnote inserted to explain the reason why total water needs to be adjusted: "the cause of this is a systematic error (i.e. offset) in the instrument that measures total water. The implications for the quality of the simulation are insignificant.".

ESEM-EDX: this is an initial look at the chemical and morphological properties of the different dust and we feel it does have a place in the paper since without it the reader would have no idea of what dust we are using in the experiments. At the very least we have provided tables of the breakdown of chemicals in the dust. At a recent workshop on the Virtual Institute for Aerosol Cloud Interactions (may 2008), it was suggested that studies linking ice nucleation properties to the chemical composition of the IN was mostly what was lacking in the literature and should be an area that is concentrated on. While this study is inconclusive in this respect, I believe it is still nonetheless important to report the findings so that other researchers can compare with their results.

Specific comments

- Page 475, line 12—done.
- Page 475, line 18—yes.
- Page 479, line 11—yes. Sentence changed to: "Liquid drops formed at about $t{=}140\,\mathrm{s}$ following which some of them froze."
- Page 479, line 26—done.
- Page 479, line 28—done.
- Page 480, line 2—done.

ACPD

9, S1186–S1189, 2009

- Page 480, line 12/13—done.
- Page 480, line 18—done.
- Page 481, line 26—done
- Page 487, line 1—done.
- Page 487, lines 25-2—done.
- Figures—I think these will produce better in ACP, in my typeset version they are OK. I would like to keep all of the figures in the paper as they give the uninformed reader an appreciation of the data as a whole.

Other changes

- Page 471, line 9. Inserted a negative sign on rhs of equation for $k(T)$.
- Page 472, line 21. Inserted a negative sign on rhs of equation for $k(T)$.

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 463, 2009.