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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Ice nucleation properties of mineral dust particles: Determination of onset RH_i, IN active fraction, nucleation time-lag, and the effect of active sites on contact angles" *by* G. Kulkarni and S. Dobbie

Anonymous Referee #2

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Reviewer Comments for Manuscript ACP 2009-191: Ice nucleation of mineral dust particles: Determination of oncer RHi, IN active fraction, nucleation time lag and the effect of active sites on contact angles.

General Remarks: The above article presents and discusses ice nucleation behaviour of mineral dust in relation to factors such as active fraction, contact angle and time as a function of relative humidity (RH) and/or temperature (T).

The subject matter is of interest to the readers of Atmospheric Chemistry and Physics

as well as the results and conclusions reached are important. The field of ice nucleation is still young and more information is with regards to tropospheric ice cloud formation will help build our knowledge of the area.

The paper discusses contact angle determination and active site theory – while these are older approaches of assessing the efficiency of particles acting as ice nuclei (IN), they are useful as a qualitative approach toward ice nucleation efficiency studies.

I recommend the manuscript for publication after the following issues/comments have been addressed by the author(s).

Specific Remarks:

Abstract line 14: insert a comma after "...nucleability parameter" and delete the word "the" before "ice cloud modelling".

Pg. 11301 Line 20: delete "the" before "ice cloud properties..." Line 21: this would read better if written as " ..experimental study, not only do we investigate..."

Pg. 11302 Line 4: add 'heterogeneous' before ice nucleation Line 4: delete "studies of IN" Line 6: should read 'Few empirical heterogeneous ice nucleation formulations have been developed,...' Line 19: delete 'CNT' and replace with 'However, it..' Line 20: delete 'It is..' Line 21: should read '..of the aims of this study is to quantify...' Line 24: should read '....within a single...' Line 26: should start with "For the present study, a total .." Line 26: add a comma after locations and open parantheses before 'three..' Line 27: close parantheses after '..Spain' and end sentence here. Delete '..for the present study'

The authors mention in the last paragraph that using natural dust particles from the said locations will eliminate the variability from atmospheric processing. While I understand why this is important for the current mechanistic study, it should be explained further as to why using fresh or 'clean' dust particles is useful for this study, because atmospheric processing is very relevant to extrapolate ice formation onto real aerosol particles given

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that dust particles will inevitably undergo some form of chemical or physical processing in the troposphere.

At the end of the last paragraph on this page I think it should also be added that the advantage of using natural dust samples is that it eliminates the effects of cleaning/milling which is often the case with commercially available dust samples

Pg. 11303

Section 2.1: Why aren't the co-ordinates of the other cities given? Either give all or none. It would suffice to just mention the locations, I think. Line 23: delete '. . ..upper and lower. . .' Line 25: replace '. . ..in such a way. . .' with 'such'

Pg. 11304

Line 1: replace '. . .seals the..' with 'prevents' Line 3: replace the word apparatus with chamber. Line 21: should read '. . .(refer to..)' and replace over with 'onto'

Pg. 11305

Section 2.2 first paragraph: need more here about how RH was validated or add the Kulkarni 2009 reference here. Line 15: should specify that RH values are quoted for 1 particle nucleating out of an average of 10 particles, i.e. an activated fraction of 10% – since the field of view is 5 – 15 particles which has been stated.

Pg. 11306

Line 5: Should read "Figure 2 shows an example of the detailed surface features of a dust . . .' Line 10: H2O is a zero instead of the letter O

Pg. 11307

Line 5-10: Na has been mentioned in both categories – of elements that are present in greater than and less than 1%. In the tables Na is present in quantities of greater than 1%. This should be corrected.

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Pg. 11308

Line 9: ‘although’ should be changed to ‘even though’ Line 21. There should be a comma after ‘..bacteria’

Pg. 11309

Line 5: should read ‘Additional support for this..’ Line 22: has threshold RH been defined in the paper? i.e. what is the threshold RHi. Typically it is the lowest RH which is required for a given fraction to nucleate ice at a certain temperature, or the highest temperature at which ice can form at water saturation. Line 25: Why would composition influence just onset of ice formation and not activated fraction? I am not sure I understand this statement completely The onset of ice onto individual particles will give rise to a total activated fraction. I think the two quantities are not independent of one another. Perhaps there is a size dependency?

Pg. 11310

Line 1: Delete ‘types of’ Line 4: should read ‘we also observed a similar’ Line 5: ‘dust type has’ should be replaced with ‘particles have a’ Line 11: How long does a particle take to equilibrate to the surroundings? This needs to be mentioned because it may be a factor to consider when evaluating the time lag. Some of the time lag could be due to the equilibration of particles to the T and RH conditions. Line 16 ‘in a’ should be replace with ‘for’ Line 17: delete ‘of’ Line 17: The comparison to Anderson and Hallet (1976) could be more specific, i.e. putting in some numbers of time and RH to give the reader a better of idea of the time scale. Line 19-21: Why is the lower limit of the time lag longer for warmer temperatures (-30C)? Perhaps the authors can give a reason. One would expect, given faster diffusion rates, that warmer temperatures would have a smaller time lag, as in the case with the RH=116% data.

Pg. 11311

Line 5: What substance’s surface tension is being referred to? Line 19: delete ‘the’

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Line 20: should read ‘out to gain a better understanding about the type . . .’ Line 21: delete ‘the’ Line 22: delete both words ‘the’ and add an s to process.

Pg. 11312

Line 8: should read ‘it is apparent in Fig 7. that there is no systematic..’ Line 13: should read ‘One, the subtle..’ Line 20: should read ‘Shown in Table 1 are the elemental compositions of the dust particles from Dakar-1 and Nigeria. There are subtle..’

Pg. 11313.

Line 1: ‘having’ should be replaced with ‘have’ Line 8: ‘Further’ should be replaced with ‘Furthermore’ Equation 8: While K and P values have been given, they have not been defined i.e. what is their physical meaning?

Pg. 11314.

Line 8: The symbol for surface tension needs some formatting. Line 18: at the end of the sentence add the RHs that correspond to the contact angles i.e 15 to 20 degrees for RHi 110-116 respectively!

Pg. 11315

At the beginning of this page it is been implied that the fraction of surface area with active sites will be the same at different temperatures. However, wouldn’t we expect that at lower T. we’d expect more sites to be active, that otherwise may not have been considered at higher T?

Also, I understand why the probability of 0.5 is being used, because the active site could either present or absent, but perhaps it should be explained a little more i.e. as to why you choose to use a P=0.5.

Line 15: should read ‘. . .by assuming a con-’ Line 20: should read ‘. . .from the Sahara. . .’

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Pg. 11316

Line 1: Given that the onset RH for Sahara dust is 104% and for Spain dust is 106% and that your experimental uncertainty is +/-1.5%, can you really claim that the two results are significantly different. Line 6: 'results' should read 'result' Line 6: There needs to be a reference for the mentioned size limit (of 1 micron) for when an active site would occur. From my understanding of older work (P&K 1997), this limit was at 0.1 microns. i.e. particles need to be larger than 100 nm for at least one active site to occur on their surface.

Pg. 11317

Acknowledgements: replace 'thank' with 'to acknowledge' and 'by' with 'from'. In addition there should be a comma after the word 'Also'.

Please also note the Supplement to this comment.

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 11299, 2009.