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Atmospheric Measurement Techniques Discussions

Interactive comment on "A new thermal gradient ice nucleation diffusion chamber instrument: design, development and first results using Saharan mineral dust" *by* G. Kulkarni et al.

G. Kulkarni et al.

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First of all, we thank anonymous referee 1 for the comments and suggestions. We have revised the manuscript accordingly in response to his or her comments.

Specific Comments:

We have added the Bundke et al. 2008 to our reference list.

We agree with the referee that once dust gets transported in the atmosphere, depend-

ing upon its surface elemental chemical composition, it gets coated with the various chemical species [Stith et al. 2009; Levin et al. 2005]. Our experiments have focused to study ground collected dust particles and not the airborne. Here we are performing process level studies to understand the basic ice nucleation properties on the natural mineral dust particles which are not subjected to atmospheric processing. In the revised manuscript we have removed the particular ambiguous statement.

Yes we agree with the referee that present experimental set up do not have the capability to sample aerosols directly from the air. We have added this comment into the paper. However, we like to point out that with few modifications, the TGDC experimental set up can be run into continuous flow mode and can directly sample aerosols from the air. The diametrically opposite peripheral ports of the bottom plate can be used as input and output of the aerosol flow stream. Yet we have not tested this capability, but plan to perform continuous flow experiments in the future. Thus the experimental set up can be run in both static and continuous aerosol flow mode.

The particles are deposited on the substrate by the method of dry deposition. We do not use any wet atomization process. Initially the particles are deposited on the substrate and using clean compressed air the particles are uniformly distributed across the substrate. We have added this comment in the revised manuscript.

It is true that airborne found dust particles are about the 1 micron in size. As mentioned above we are performing process level studies to understand more about ice nucleation properties such as what is the role of mineral surface or active sites, memory effects, surface elemental composition on the ice nucleation. Use of larger size particles (with median diameter of 10 - 15 micron) helps us to perform these process level studies. The aim of the present paper is to validate the instrument concept and demonstrate its capability to detect the ice nucleation events. The

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experimental results, its implications and parameterizations work we are publishing in our second paper. These details are described in the revised manuscript.

The theoretical limit of resolution of the optical system is 1.1 micron. Although this high resolution is achievable, but the experimental limitations to collect and deposit the dry particles on the substrate did not allowed us to experiment with these small particles.

We calibrated the temperature of Teflon substrate by observing the phase change of the ammonium sulfate (AS) particles deposited over the substrate. We set the chamber conditions in such way that combination of top and bottom plate temperatures produces the DRH temperature and RHw at desired height between the plates inside the chamber. To make it more clear we elaborate this procedure here by using an example. The top and bottom plate temperatures are established in such way that their average temperature is -22.0 deg C (observed at the mid plane) and produces 83 %RHw , which is DRH of the AS at -22.0 deg C temperature. Initially the AS particles are deposited on the substrate, which is positioned at bottom plate temperature where sub-DRH conditions exists. Slowly the substrate is raised inside the chamber, this exposes the particles to higher temperature and RHw, but below DRH. We found that once substrate reaches near the DRH point, which is in this case is a mid point between two ice layers, phase change is observed. In general by knowing the height of the substrate from bottom ice layer, we calculated the temperature where the phase change observed. Please note that temperature varies linearly from bottom to top ice layer, therefore knowing the substrate height from the bottom ice layer one can calculate the corresponding temperature where phase change is observed. Equations (2) and (3) described in the paper are used to calculate the desired temperatures. We have added these extra details into the revised manuscript.

The temperature calibration using melting point of ice is performed in addition to DRH

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calibration procedure. The experimental procedure is similar to as observing DRH at eutectic point of AS described in Section 4.1. Instead here we make use of the ice crystals deposited on the substrate raised inside the chamber. At the start of the experiment the temperatures of both the plates are -10 deg C and both are warmed at the rate of 0.25 deg C/min to reach above 0 deg C. When substrate temperature reaches near to 0 deg C the ice is observed to start melting. The uncertainty in the temperature measurement is described in the paper. We have added these extra details into the revised manuscript.

The onset experiments are performed by raising the substrate inside the chamber by a distance of 1 mm at each time. At this height there is only one value of temperature and supersaturation. If the nucleation is not observed then we raise the substrate by another 1 mm inside the chamber. Similarly we keep raising the substrate by 1 mm each time until we observe the nucleation. But we can raise the substrate to maximum of 6mm height from the bottom ice layer, because here we observe the maximum supersaturation. Thus at each height, where the particles are exposed, we have only one value of each temperature and supersaturation given by the Eqn. (2) - (5). Therefore we obtained the onset values as a function of only these thermodynamic conditions, and these conditions are plotted in the Fig. 7 (square boxes).

Minor comments:

The short form DRH is written where it is first observed.

Temperature value in Fig. 6 is mentioned.

Bundke, U., Nillius, B., Jaenicke, R., Wetter, T., Klein, H. and Bingemer, H.: The fast

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Interactive Comment

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Levin, Z., Teller, A., Ganor, E., and Yin, Y.: On the interactions of mineral dust, sea-salt particles, and clouds: A measurement and modeling study from the mediterranean Israeli Dust Experiment campaign, Journal of Geophysical Research, 110, D20202, doi:10.1029/2005JD005810, 2005

Stith, J. L., et al.: An overview of aircraft observations from the Pacific Dust Experiment campaign, J. Geophys.Res., 114, D05207, doi:10.1029/2008JD010924, 2009

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