Development of a New Parameterization for the Effect of Nitric Acid Coating on the Ice Nucleation Efficiency of Mineral Dust Particles

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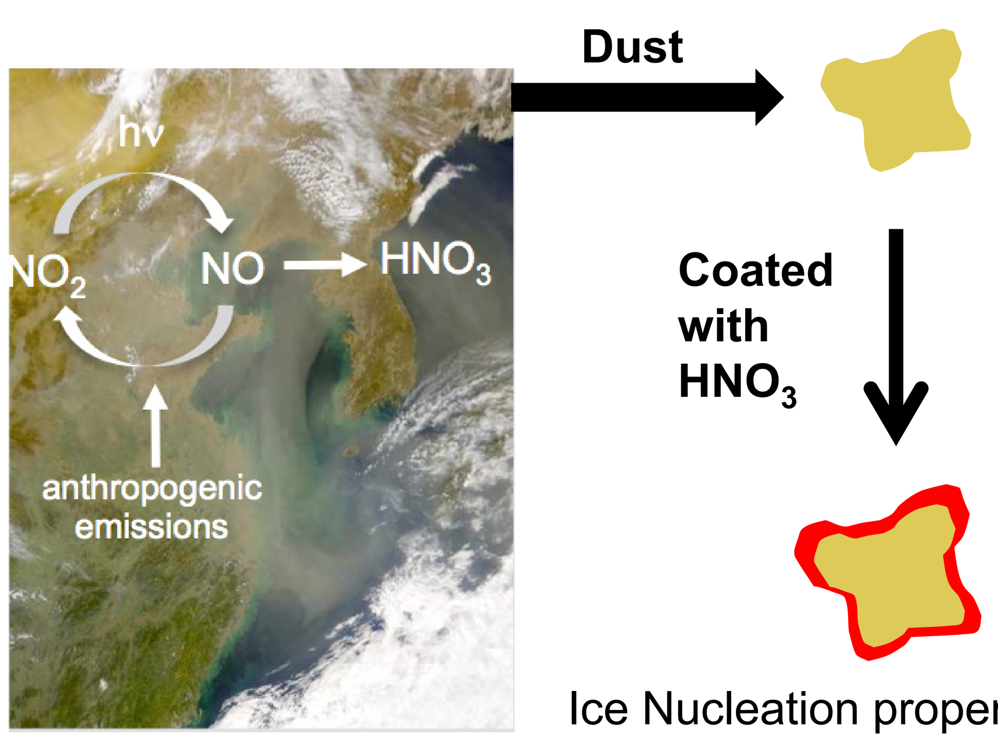
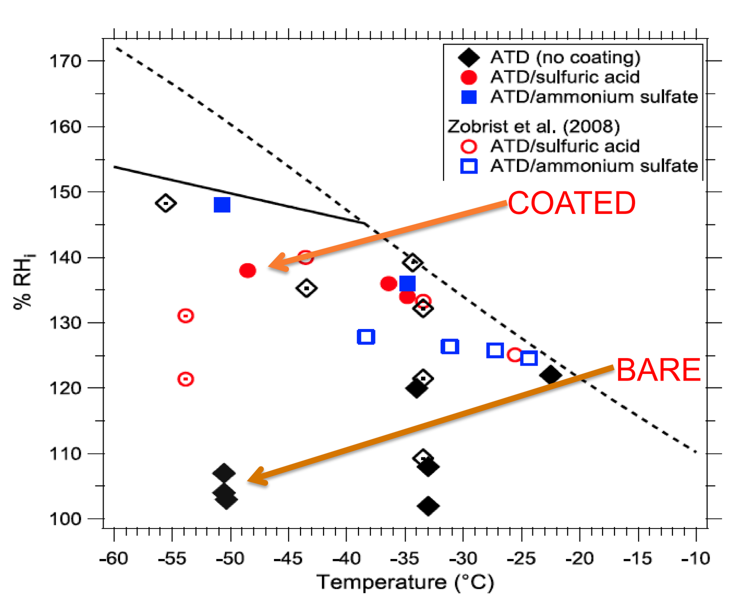
INTRODUCTION



Ice Nucleation properties of nitric acid coated dust particles are currently not treated in a cloud model.

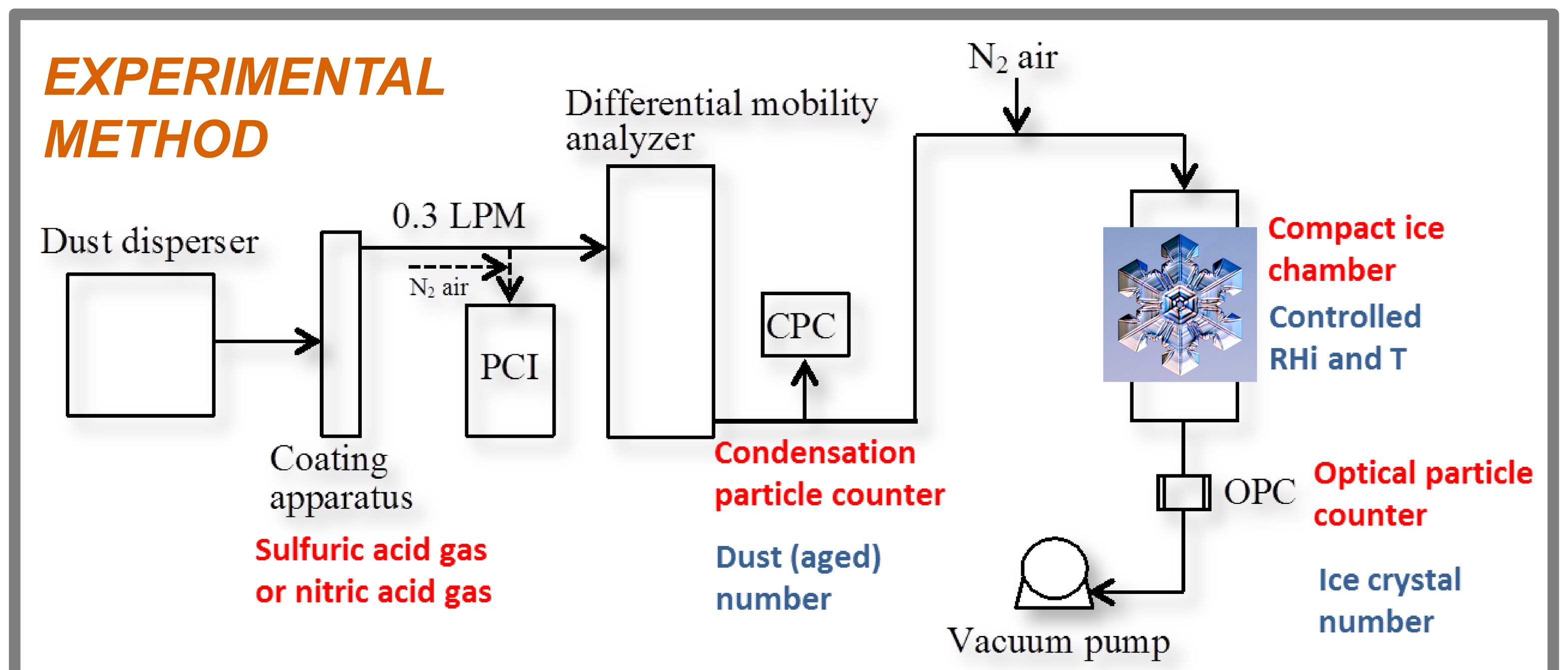
BACKGROUND



Sensitivity of coating towards ice nucleation of dust particles (Cziczo et al., 2009).

Previously, researchers have shown that the ice-nucleating ability of bare mineral dust particles could deteriorate if the dust particles are coated with soluble materials such as sulfuric acid. These studies (e.g., Cziczo et al., 2009; Sullivan et al., 2010; Tobo et al., 2012) indicated that the coated chemical species can block ice-active sites and, therefore, can inhibit the dust particles to act as IN by increasing the onset of saturation conditions and/or lowering the freezing temperature required for ice nucleation.

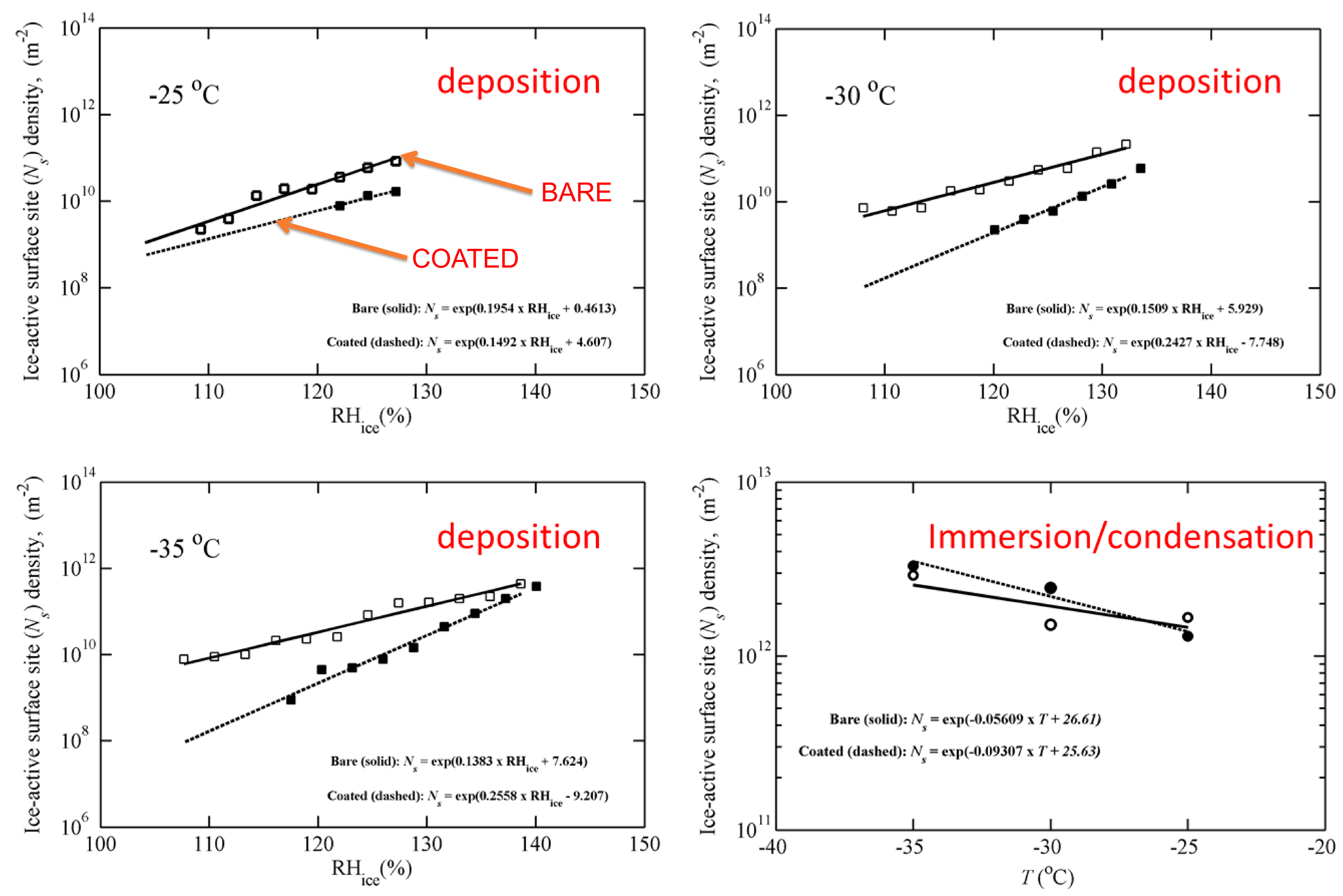
EXPERIMENTAL METHOD



Schematic of the experimental setup.

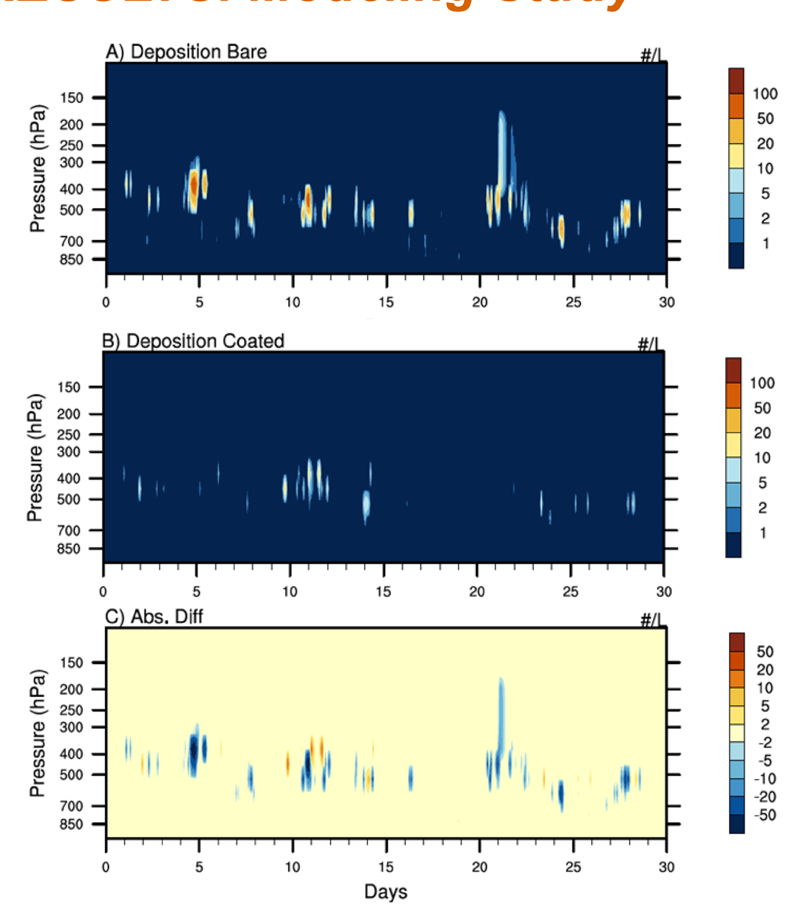
Various dust particles were dry generated in a dust disperser and passed through a coating apparatus that had a heated reservoir of nitric acid. Particles of mobility diameter 200 nm were transported to the condensation particle counter (CPC), PIXE cascade impactor (PCI) and compact ice chamber (CIC). CIC was connected to the optical particle counter (OPC) and further to the vacuum pump. Fraction of dust particles that nucleated ice were calculated using CPC and OPC measurements.

RESULTS: Lab Study



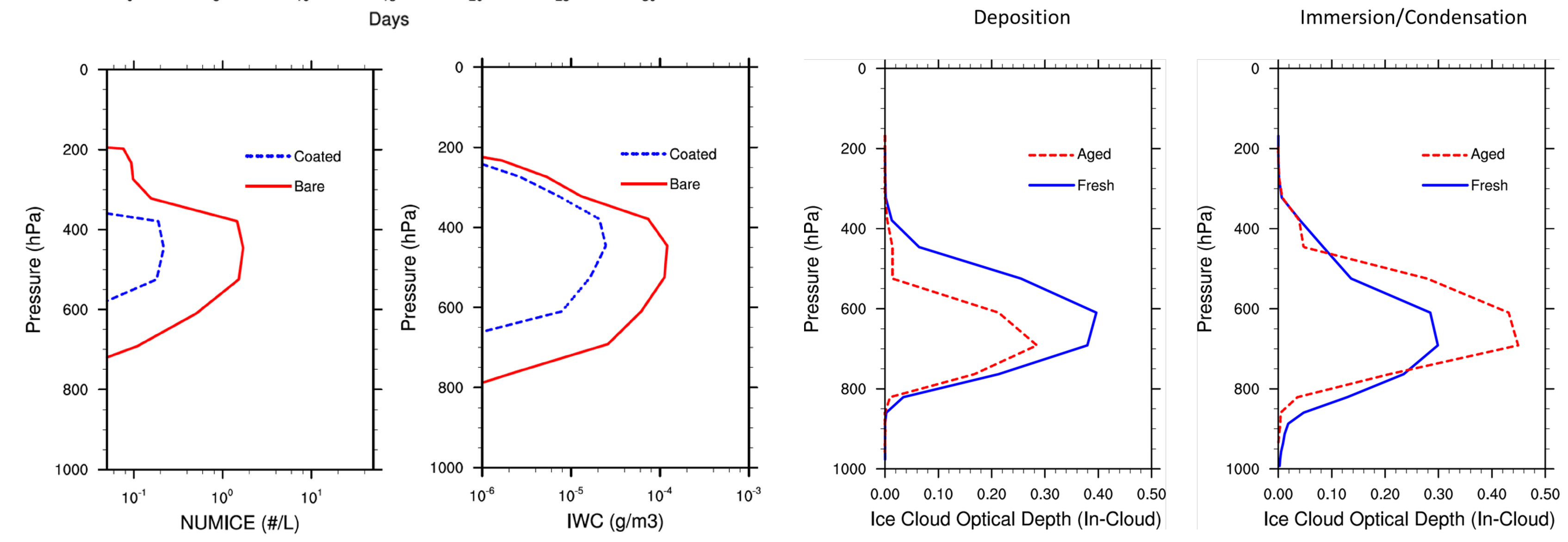
Ice-active surface site (N_s) densities for illite particles. Different panels represent N_s densities in deposition and condensation/immersion freezing modes. Fit lines show the parameterizations of N_s for bare and coated particles.

RESULTS: Modeling Study



CAM Simulated time evolution of ice crystal number concentration (color scaled; L^{-1}) over the ARM-SGP site in April 2010 using SPARTICUS case.

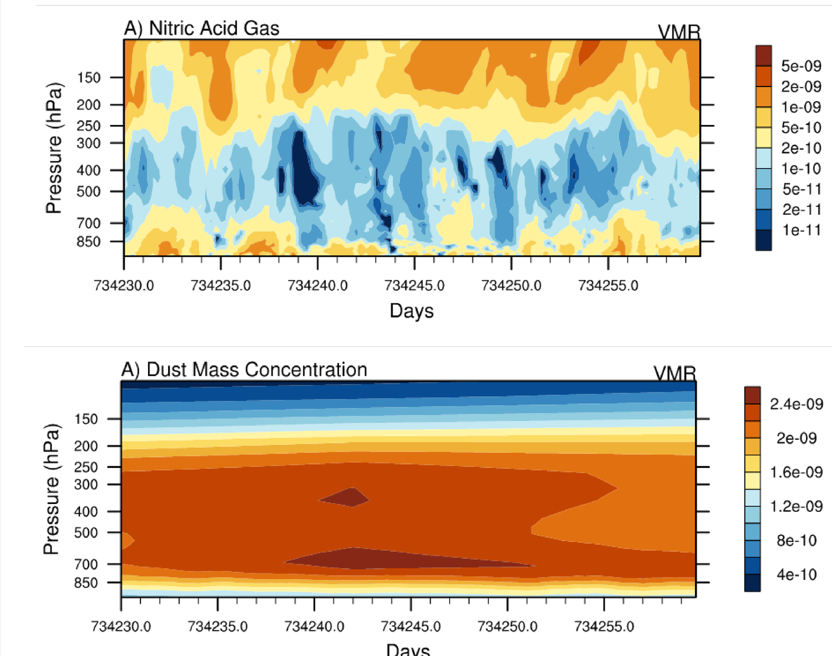
Ice nucleation parameterizations derived from laboratory measurements were implemented into model. Our model consider complex ice microphysical processes as well as temporal evolution of mass and number densities of four hydrometeor classes (i.e., cloud droplets, ice crystals, raindrops and snow). Top panel shows the result of a simulation with bare particles and middle panel shows that of the aged particles. Bottom panel shows the absolute difference between these two simulations.



Simulated monthly mean vertical profile of (A) ice crystal number concentration (L^{-1}) and (B) ice water content (gm^{-3}) over the ARM-SGP site in April 2010.

In deposition mode, higher IN concentration leads to increase in the ice cloud optical depth and enhanced precipitation. In immersion/freezing condensation mode, the effect was not significant.

FUTURE WORK



3-D chemical transport model, MOZART, simulations showing hourly and monthly mean fields of nitric acid and dust concentrations, respectively.

- MOZART simulations to determine coated dust fractions
- Implementation of dust coating and aged fraction calculation in SCAM5
- More realistic model simulations using
  - HNO_3 and dust from WRF-CHEM
  - Online-calculated aged fraction of dust particles
  - Switch on other ice nucleation modes in SCAM5 simulations, including homogeneous ice nucleation, contact nucleation, and detrained ice crystals from convective clouds
  - Compare with SPARTICUS measurements
- Long-term plans
  - Modify MAM7 and CESM chemistry package; Couple MAM7 with the new ice nucleation parameterization
  - Perform global CAM5 simulations and look at global impact

SUMMARY

- **Laboratory experiments on various nitric acid coated dust species were performed to derive ice nucleation parameterization.**
- **Simulations from single column model of CAM5 shows that coated dust influences cloud properties in deposition mode.**
- **WRF-CHEM model simulations are underway to estimate coated dust fractions. In future we plan to use these results in GCM.**

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