85

Experimental Investigation of CCN and IN Abilities of Various Aerosol Types in the MRI Cloud Simulation Chamber

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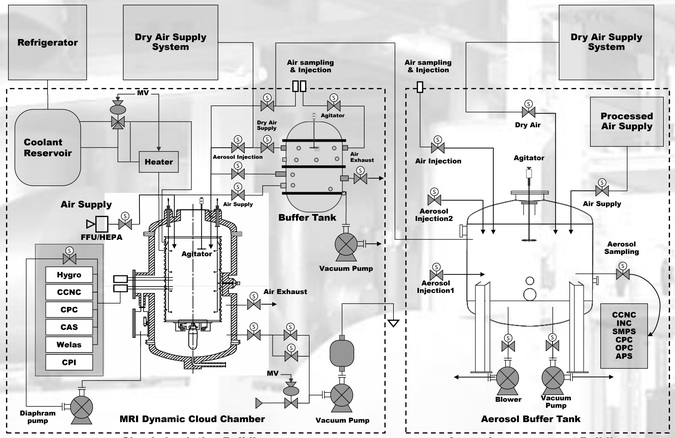
Introduction

A cloud simulation chamber facility run by the Meteorological Research Institute (MRI) has been used to investigate the details of the fundamental processes of cloud formation. An accurate and quantitative description of the relation between physicochemical and biological properties of aerosol particles and their activity and potential role in cloud formation is a crucial subject for improvement of numerical cloud simulation and weather/climate prediction models.

In addition to the well-known aerosol types such as ammonium sulfate, dust and soot, we are currently capable of handling variety of specific aerosol particles and certified reference materials including the biological aerosols, the artificial ice nuclei (AgI), etc. The study herein focuses on the chamber experiments in progress and shows results from the experiments of various types of specific aerosol particles.

MRI Cloud Simulation Chamber



MRI Chamber Facility System Diagram

Preconditioning Method

Evacuation
Aerosol free ~30hPa
Dry-air Purged
Aerosol free ~900hPa
Particle injection with P control
Setting Particle conc. 1,000hPa
Humid air supply
Tdew set
Tair control
Fixed Conc. 1,000hPa
P/T/Td djust
Ex. Set Init. P= 1,000hPa T= 5℃ Td= -10℃
→ ***Ascent*** *(Expansion) 3, 5, 10m/s . . .*

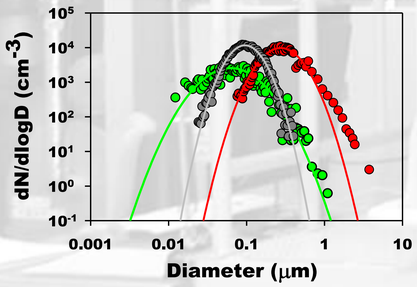
Operational Ranges
Wall Temp. 30 ～ −100degC
Pressure 1000 ～ 30hPa
Ascent Rate 0 ～ 30m/s
Air Temp. homogeneity ±0.3degC or less

Experimental procedure is loaded into auto-controlled data acquisition system as form of a detailed, step-by-step list.

Both temperature and pressure are automatically controlled to simulate an adiabatic expansion under a wide range of atmospheric conditions.

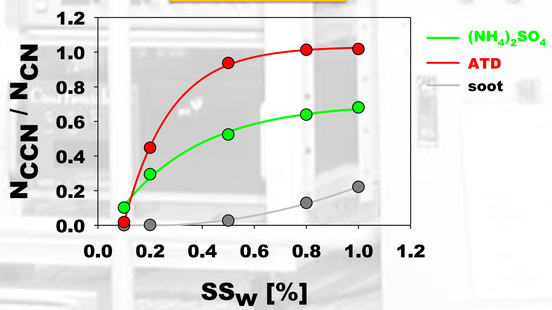
Aerosol Characterization Measurements

SMPS/CAS/OPC/APS



Aerosol size distributions

DMT-CCNC



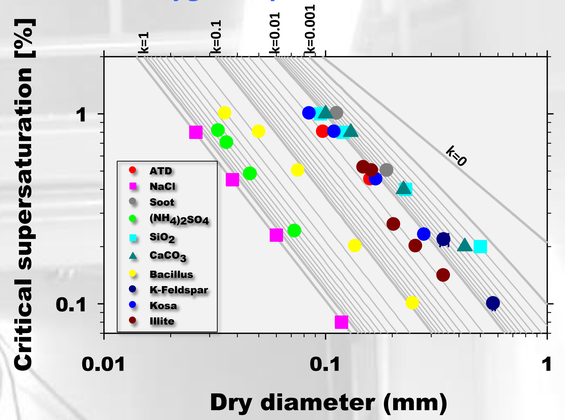
CCN activity spectra (0.07-1.0% SSw)

Experiment

List of the different types of test particles

type	particle	supplier	generator
Dust	ATD	Powder Technology Inc.	RBG-1000
	NX Illite	Arginotec	RBG-1000
	K-feldspar	University of Leeds	RBG-1000
	Kosa (CJ-1)	NIES	RBG-1000
Soot	Soot (Spark discharge)	PALAS	DNP-2000
Ammonium sulfate	$(NH_4)_2SO_4$	Kanto Chemical Co., Inc.	Model3079
Bio	Snomax	York snow Inc.	Model3079
	Bacillus	Kanazawa Univ.	Model3079
	Pollen	Kanazawa Univ.	Model3079
Artificial	AgI	--------	Smoke generator
	SiO_2	Ako Kasei Co., Ltd	Vibration
	$CaCO_3$	Ako Kasei Co., Ltd	Vibration

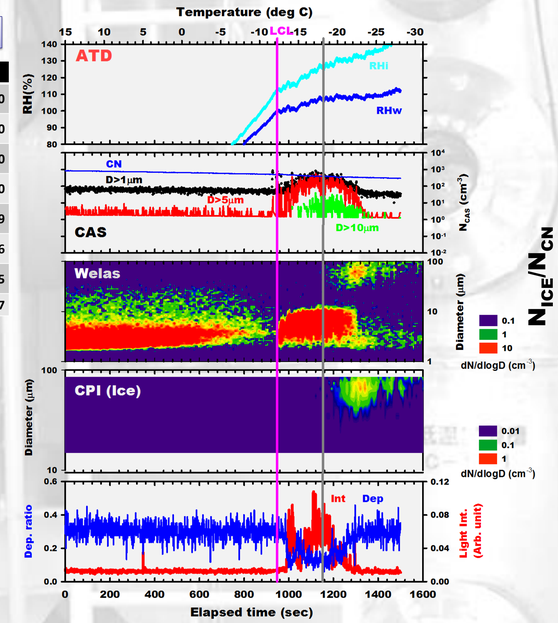
Hygroscopic measurements



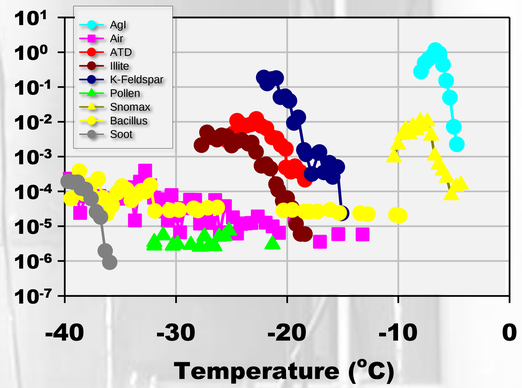
An example of the experiments of ice formation in the chamber

Setup parameters

Sample Aerosol	ATD
Initial Particle Number Concentration (cm-3)	1,000
Programmed Initial Pressure (hPa)	1000.0
Programmed Initial Temperture (℃)	15.0
Programmed Adiabatic Ascent Rate (m/s)	3.0
Actual Initial Pressure (hPa)	999.9
Actual Initial Air Temperture (℃)	14.6
Initial Dewpoint Temperature (℃)	-7.5
Temperture at LCL (℃)	-12.7



Activated fraction of various aerosol particles as ice nuclei



Summary

Performance tests demonstrate the chamber's usefulness as a facility to investigate cloud droplet and ice crystal formation processes through the activation of various types of aerosol particles. For instance, during expansion at an evacuation rate (3m/s), super-micron size particles (cloud droplets) rapidly appeared at water saturation. In mixed-phase conditions above -20degC, ATD was activated as IN. Ice nucleation continued to occur down to below -30degC and produced relatively high activated fraction of ice crystals (more than 10^{-2}). ATD could serve as both CCN and IN.

From comparisons with various types of aerosol particles tested,

CCN ability: Hygroscopicity parameter (kappa) → NaCl > $(NH_4)^2SO_4$ > Bio (bacillus) > Dust > SiO_2 ～ $CaCO_3$ ～ Soot

IN ability: Onset temperature of freezing → AgI ～ Snomax > bacillus > Dust ～ Pollen > Soot?

IN ability: Activated Fraction → AgI > K-Feldspar > ATD ～ Snomax > Illite > bacillus ～ Soot > Pollen

were indicated so far.

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