Comparison of Two Cloud Condensation Nuclei Counters: An Analysis of Ground-Based Measurements

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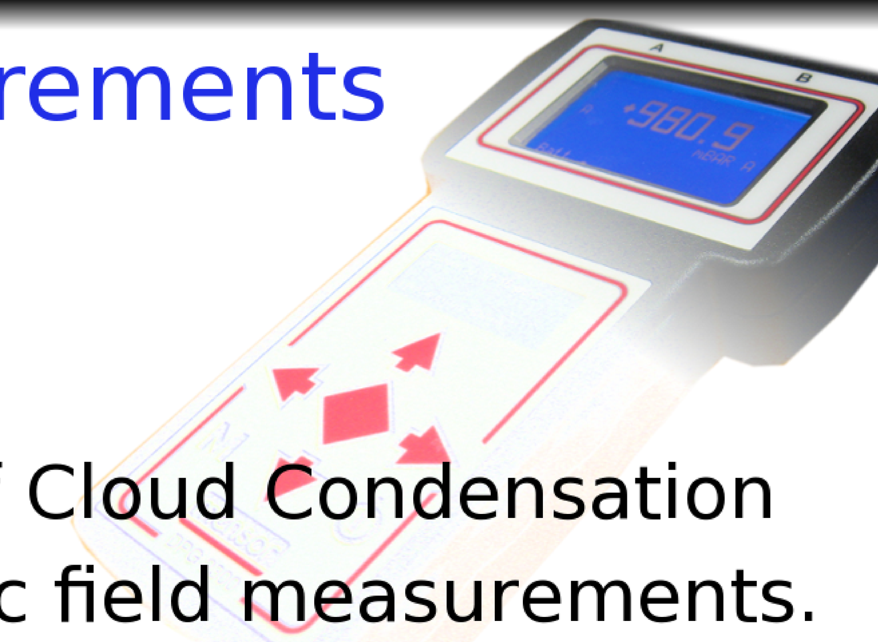
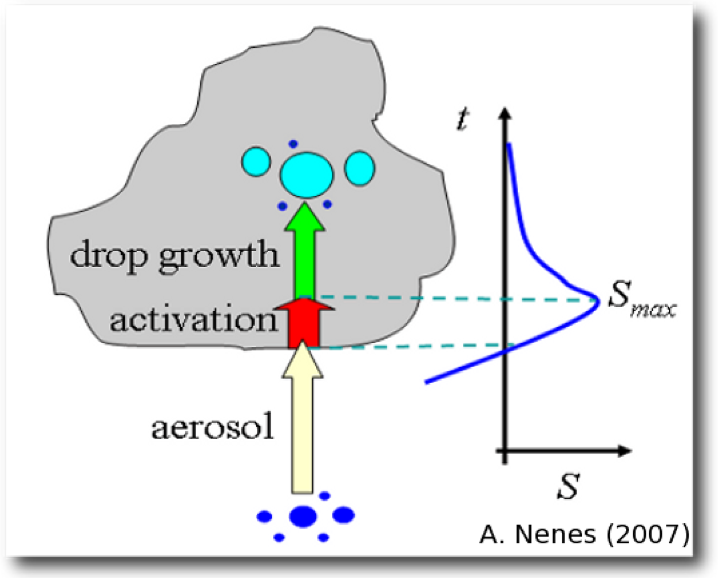


Objectives:

To test and compare Droplet Measurement Technologies (DMT) and University of Wyoming (UWyo) versions of Cloud Condensation Nuclei Counters (CCNC) for better understanding of CCN instruments, and improving the quality of atmospheric field measurements.



Aerosol: Suspended solid and/or liquid particles in gas, ranging from 1 nm to 100 µm.

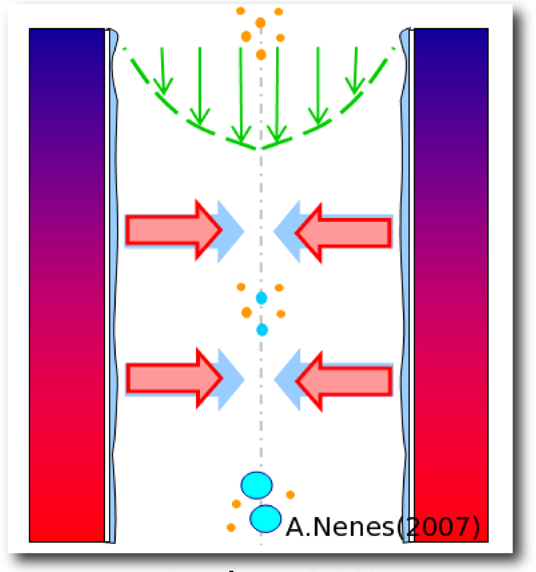
Cloud droplets form on aerosol particles.

Water droplets form at supersaturations of 2% or less (heterogeneous nucleation).

Cloud Condensation Nuclei (CCN): particles capable of forming cloud droplets under supersaturation (SS) conditions.

CCN measurements play a key role in understanding the formation of clouds and precipitation.

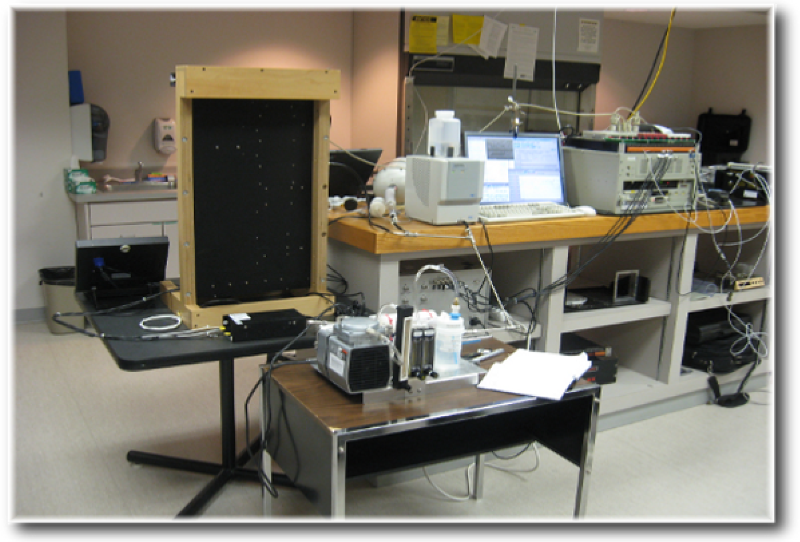
Inlet : Aerosol



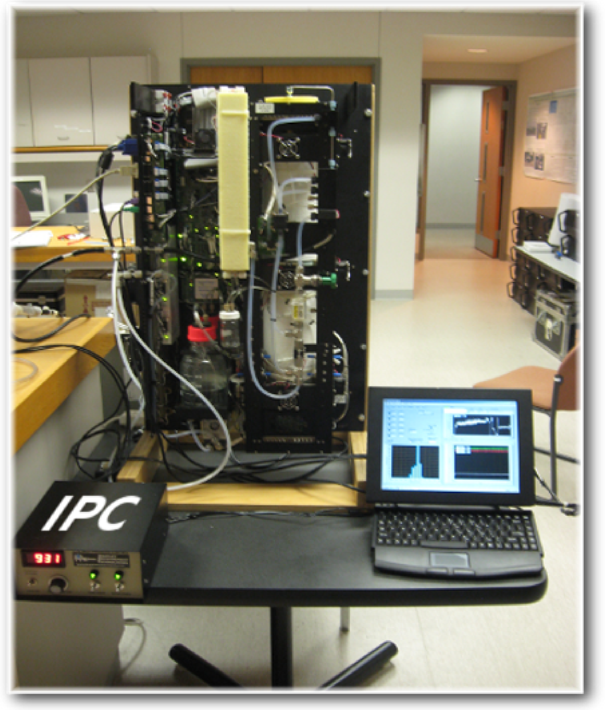
Outlet: CCN

In the DMT-CCNC, the measurements is made using a Cylindrical Continuous-Flow Streamwise Thermal Gradient Chamber.

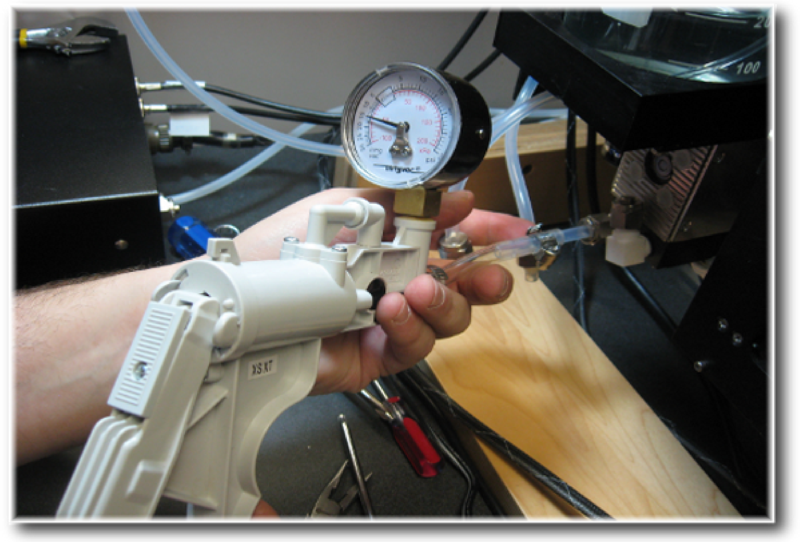
Inner walls of the cylindrical chamber are kept wet, and a temperature gradient is applied from top to bottom of the chamber to create a SS. Supersaturated aerosols grow into droplets along the centerline and are counted at end of the chamber by an optical particle counter.



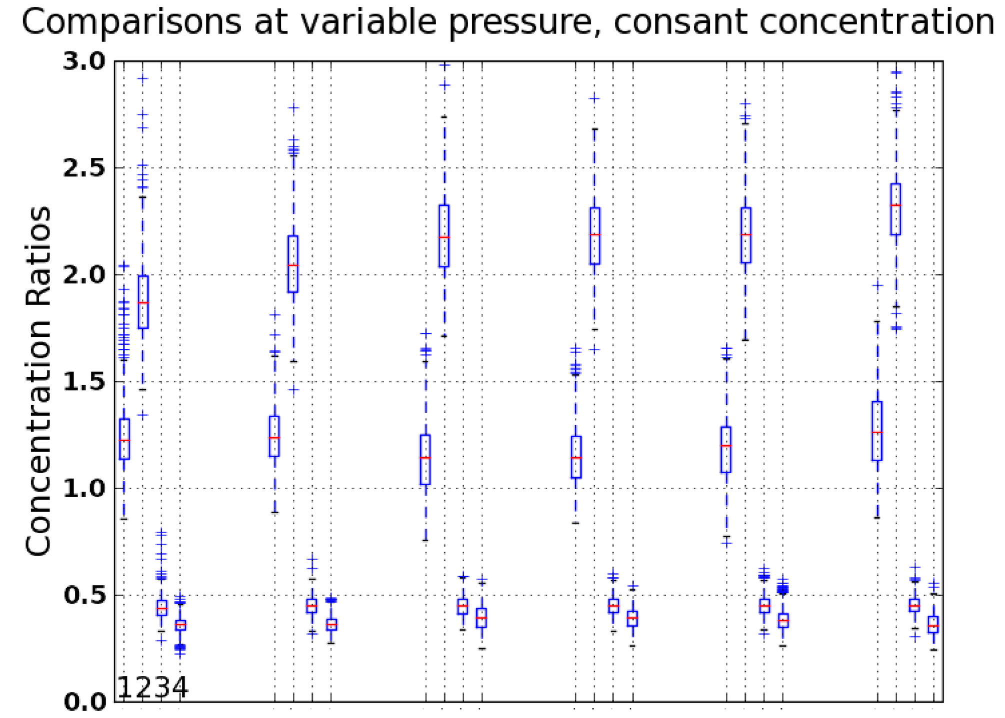
A general view from the experiment setup. Ammonium Sulfate aerosol particles were concurrently sampled by a DMT - Passive Cavity Aerosol Spectrometer Probe (PCASP), TSI - Condensation Particle Counter (CPC), DMT and UWyo CCN Counters.



A front view of the DMT-CCNC, along with an Inlet Pressure Controller (IPC) and a screen showing the system running. The counter simply measures how many cloud droplets exit its cylindrical chamber. IPC prevents the variations in supersaturation due to the changes in sample pressure, which frequently occurs in airborne experiments.

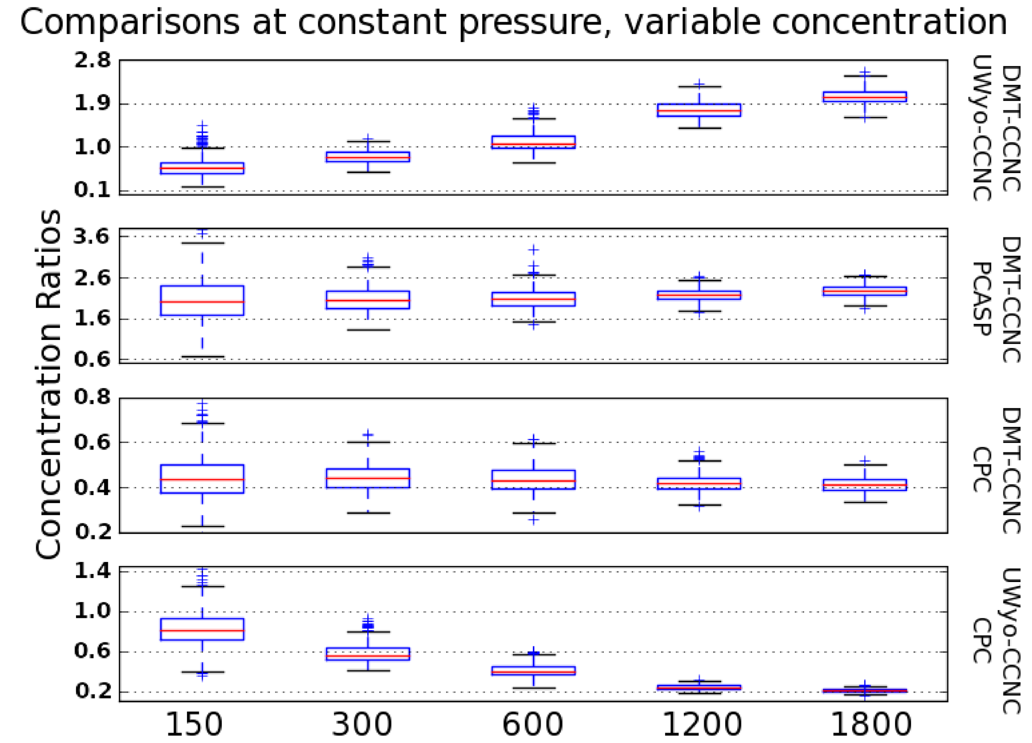


A handy leak tester is in action. Leak testing carries a great importance in order to obtain reliable measurements using a DMT-CCNC. The importance of leak testing increases furthermore especially during airborne CCN measurement field projects.

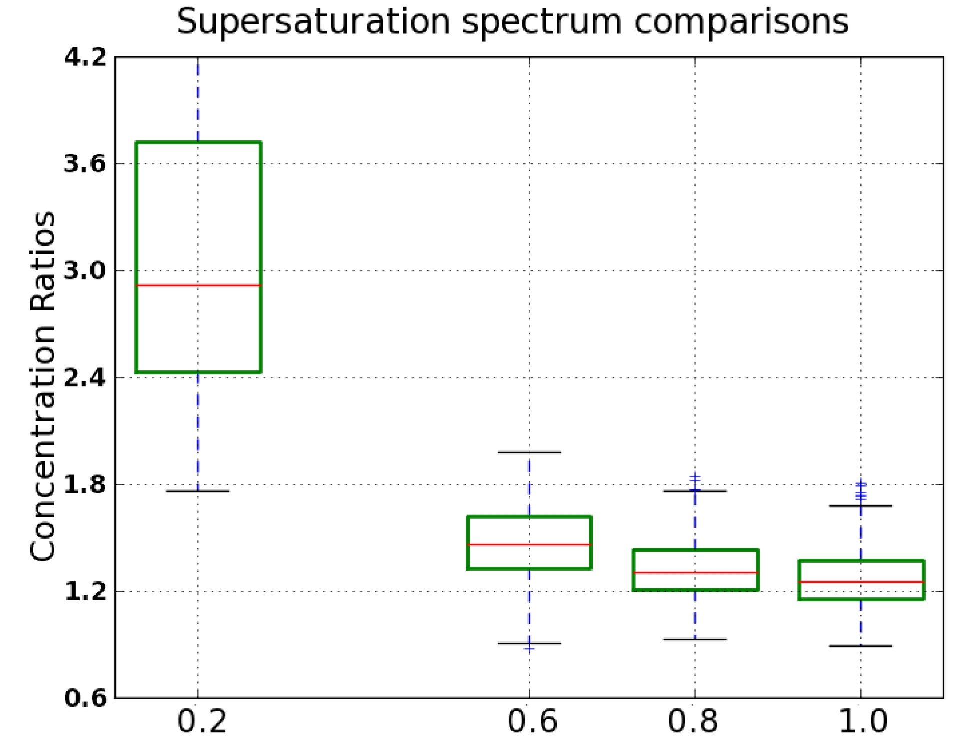


1-DMT-CCNC/UWyo-CCNC, 2-DMT-CCNC/PCASP, 3-DMT-CCNC/CPC, 4-UWyo-CCNC/CPC --rest is same with increasing pressure.

In the first leg of these experiments, the DMT-CCNC's pressure was varied from 460 to 950 mB in six steps, while sample aerosol concentration was held at 600 #/cm^3 based on the UWyo-CCNC readings. For this case and the following two cases, nine minutes measurement portions of the acquired data were analysed. The left figure shows the change of concentration ratios throughout each nine minute intervals of the four counters. Results are represented with box-and-whiskers plots.



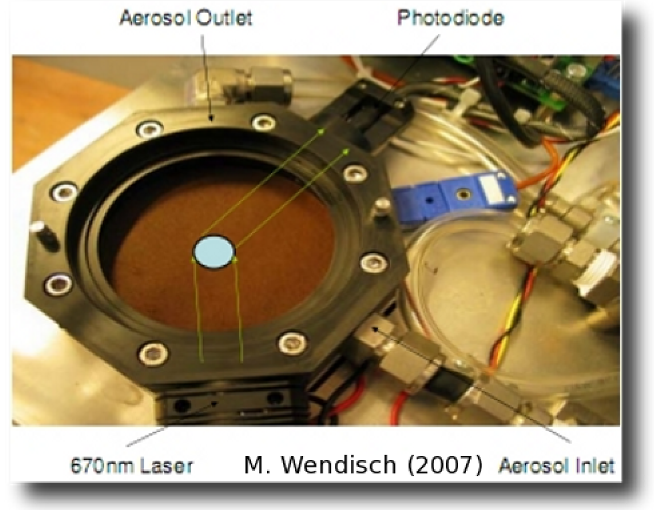
In the second test, the DMT-CCNC inlet pressure value was hold constant at 500 mB, UWyo-CCNC concentration readings changed from 150 #/cm^3 to 1800 #/cm^3 in five steps. Right ordinate labels of the subplots show which instruments used to create the ratios.



Four different supersaturation values of DMT and Uwyo CCN counters (%)

In the last experiment, both the DMT and UWyo CCNC SS were varied from %0.2, 0.6, 0.8 to %1.0, while DMT-CCNC inlet pressure was constant at 500 mB.

A front view of a UWyo CCNC



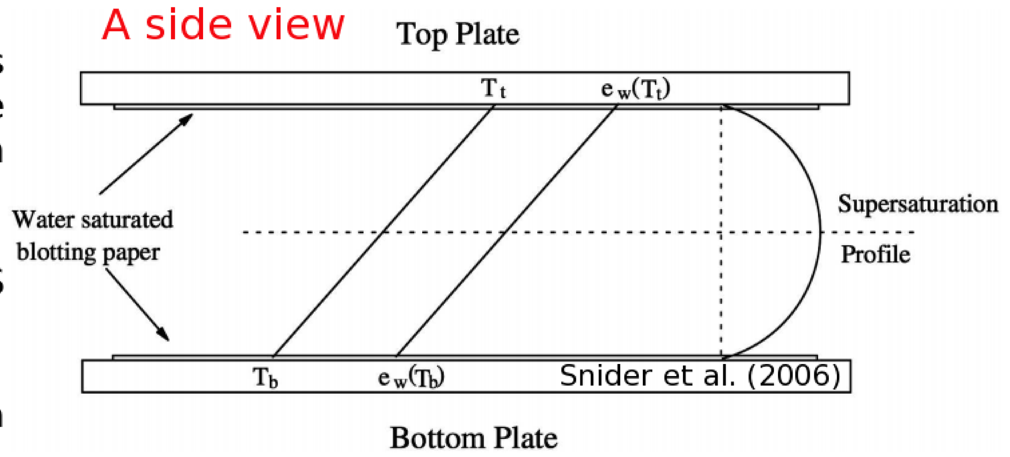
A top view of the sampling chamber in a UWyo CCNC

In the UWyo CCNC, supersaturation is created by means of temperature gradient between two plates with bottom one being colder.

SS range is ~0.2% - 2.0%, and SS values are adjusted step-by-step.

Activated particles are counted as a function of SS.

A side view



Activated droplets are counted in chamber by measuring the amount of light that is scattered from CCN particles.

Conclusions:

The ratio of the DMT to UWyo-CCNC concentration was independent of the DMT CCNC chamber pressure.

The concentration ratio of the two instruments increases with increasing sample aerosol concentrations.

The DMT-CCNC was found to count the particles 27-46% higher than the UWyo-CCNC for supersaturations in the range of 0.6 to 1.0%.

At 0.2% SS level, the DMT-CCNC measures 3.18 times more than the UWyo-CCNC in terms of average concentration comparison.

We would like to acknowledge Weather Modification, Inc. (Fargo, ND) for lending their DMT-CCNC to perform these experiments.

Future Work:

To further improve the quality of CCN measurements, a Scanning Mobility Particle Sizer (SMPS) integrated system will be used, and supersaturation calibrations performed.

Similar instrument performance tests will be repeated using a better aerosol generator and another frequently used aerosol specie: Sodium Chloride (NaCl)

Effective supersaturation calculations of both the DMT and UWyo CCN counters will be revised.

Apply adjustments to data sets which were acquired using both CCN counters.

References:

A. Nenes (2007): Constraining the Effects of Composition and Mixing State on CCN Activity. IAMA Conference, Davis, CA, December 6, 2007.

J.R. Snider, M.D. Petters, P. Wechsler and P.S.K. Liu, Supersaturation in the Wyoming CCN Instrument, Journal of Atmospheric and Oceanic Technology 23 (2006), pp. 1323–1339.