A Triad for Cloud Condensation Nuclei Matter: To Measure or How to Measure

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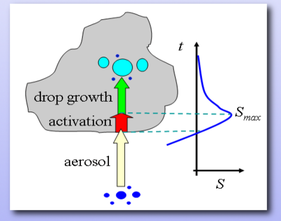
Objectives:

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



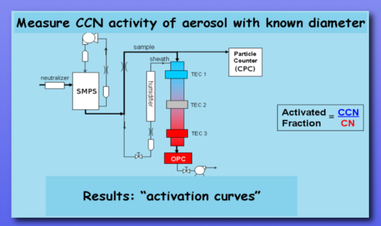
Aerosol: Suspended solid and/or liquid particles in gas, ranging from 1 nm to 100 µm.

Cloud droplets form on aerosol particles.

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

CCN: particles capable of forming cloud droplets under supersaturation conditions.

CCN concept has a key role in the formation of clouds and precipitation.



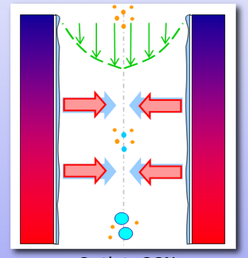
Future Work:

To further improve the quality of CCN measurements, a Scanning Mobility Particle Sizer (SMPS) integrated system -like the one seen on the above figure will be used.

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 have to be revised.

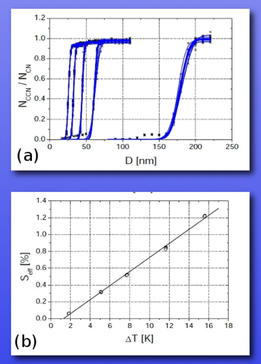
Inlet : Aerosol



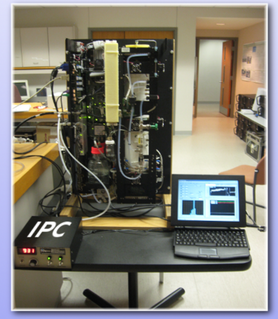
Outlet: CCN

CCN measurements in Cylindrical Continuous-Flow Streamwise Thermal Gradient Chamber:

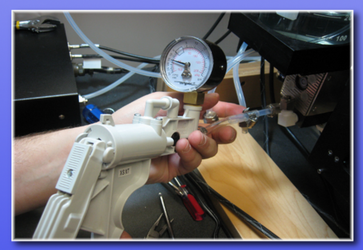
Wet conductive cylinder's walls internally. Apply a temperature gradient, and flow air. Supersaturated aerosols grow into droplets in the centerline and counted at end of the chamber by an optical particle counter.



Example calibration experiment results with ammonium sulfate aerosol. (a) CCN efficiency spectra, (b) calibration line of Seff vs. ΔT. (Mainz, 21 December 2005, Q=0.5 L/min, p=1026 hPa, T1=298.5 K) (Figures and data are from D. Rose et al.)



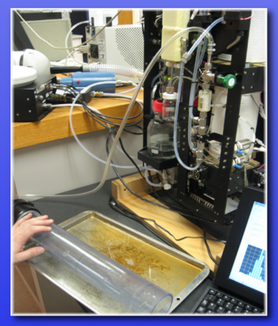
A general view from the experiment setup. Ammonium Sulfate aerosol particles were distributed into a DMT - Passive Cavity Aerosol Spectrometer Probe (PCASP), and TSI - Condensation Particle Counter (CPC) as well, to ensure the integrity of the experiments.



Sheath flow calibration was performed using a manual flow meter setup. Due to this process' being lengthy and error-prone, in the future this setup will be replaced with an automatic flow calibrator system. (Sensidyne Gilian Gilibrator II)

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 form on its cylindrical chamber. IPC prevents the variations in supersaturation due to the changes in sample pressure.

A handy leak tester is in action. Leak testing carries a great importance in order to obtain reliable measurements using a DMT-CCNC.

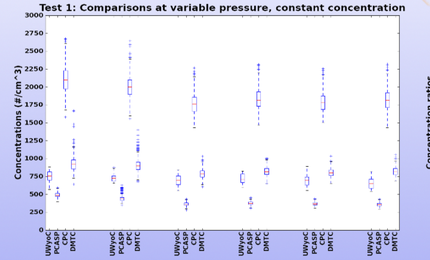


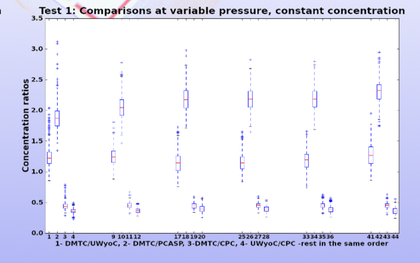
References:

D. Rose, S. S. Gunthe, E. Mikhailov, G. P. Frank, U. Dusek, M. O. Andreae, U. Pöschl. (2008): Calibration and measurement uncertainties of a continuous-flow cloud condensation nuclei counter (DMT-CCNC): CCN activation of ammonium sulfate and sodium chloride aerosol particles in theory and experiment. Atmospheric Chemistry and Physics, 8, 1153-1179

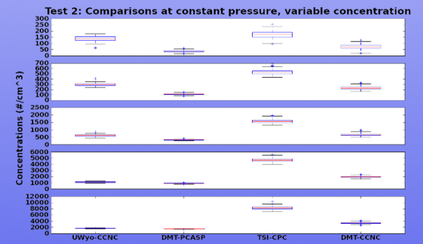
A. Nenes (2007): Constraining the Effects of Composition and Mixing State on CCN Activity. IAMA Conference, Davis, CA, December 6, 2007

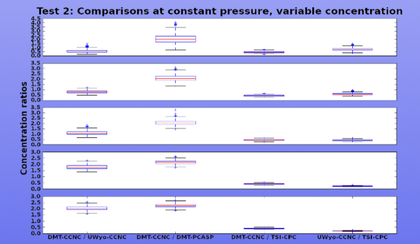
We would like to acknowledge Weather Modification, Inc. (Fargo, ND) for lending their DMT-CCNC to perform these experiments.



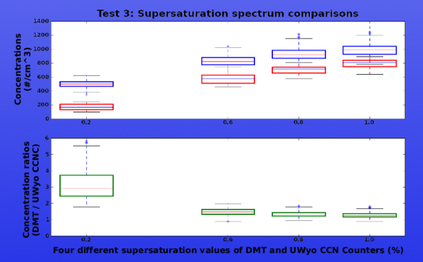


In the first leg of these experiments, while the DMT-CCNC's pressure being varied from 460 to 950 mB at six steps, aerosol concentration was adjusted to 600 #/cm^3 level based on the UWyo-CCNC readings. For this case and the following two cases, nine minutes long portion of the acquired data were analysed. The left figure shows the change of concentrations throughout each nine minutes intervals in four counters, whereas the right figure depicts the relations of the instruments with eachother.





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 at five steps. Corresponding concentration outputs of rational comparison of each instrument are given on the left, and right figures, respectively.



In the last experiment, both the DMT and UWyo CCNC measurement responses tested at 0.2, 0.6, 0.8 and 1.0 supersaturation settings, while DMT-CCNC inlet pressure was constant at 500 mB.

Conclusions:

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 concentration comparison.

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.

end of Act I - to be continued...