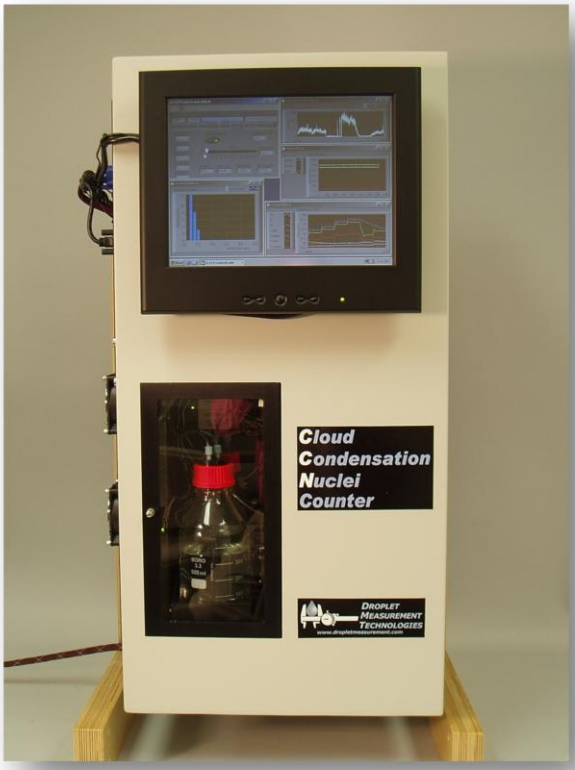
Cloud Condensation Nuclei (CCN) Counter

With Single (CCN-100) or Dual (CCN-200) Growth Columns



Clouds are a key factor in moderating climate change. Cloud condensation nuclei (CCN) are those aerosol particles that can form into cloud droplets, and an understanding of CCN concentrations in space and time is necessary if models are to accurately predict the magnitude of global climate change. The DMT CCN counter measures the concentration of these particles and can be operated on the ground or on aircraft. The DMT CCN counter is being used in laboratories to measure how different materials form cloud droplets, in urban environments to study how pollution affects cloud and precipitation formation, and in weather modification studies to determine when and where to seed clouds. This popular instrument comes equipped with single (CCN-100) or dual (CCN-200) columns for extended versatility.

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Advantages

- Measures the spectrum of cloud condensation nuclei (CCN) concentration as a function of supersaturation ***continuously*** using uninterrupted flow and a multichannel, optical particle counter that measures the size of the activated droplets
- Features supersaturation as low as 0.07% up to 2%
- Offers complete automation of up to 250 programmable and scanned supersaturation settings
- Minimizes size and buoyancy effects with cylindrical geometry
- Features onboard computer for control and data logging
- Provides fast response and continuous flow, which allows airborne as well as ground-based applications

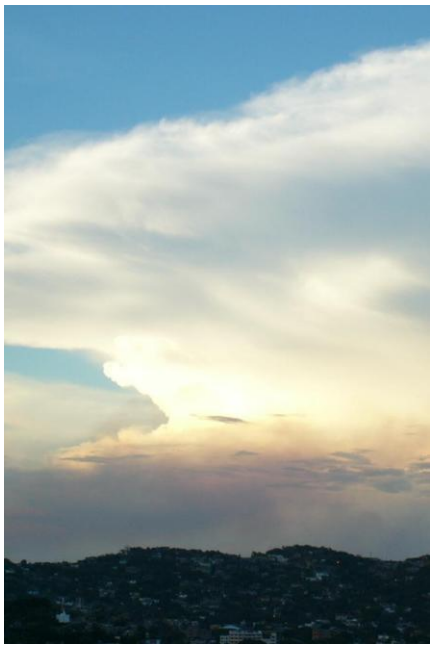

Photo: Clouds near Salina Cruz, Mexico. Photo by Darrel Baumgardner.

Applications

- Atmospheric research
- Climate change studies
- Pollution research
- Weather modification

Photo at left: The CCN (inset) at a research station in Barrow, Alaska (main photo). Photos by Robert Albee, NOAA Earth System Research Laboratory.

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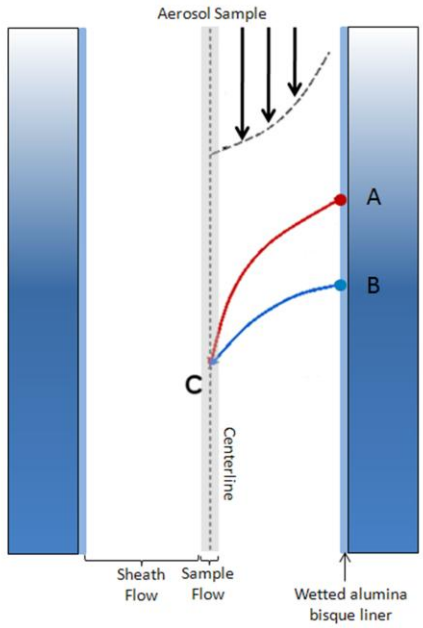
Principle of Operation



The CCN Counter is a continuous-flow thermal-gradient diffusion chamber for measuring aerosols that can act as cloud condensation nuclei. The CNN-100 draws an aerosol sample into 50-cm tall column, while the CNN-200 features two identical such columns. Inside the column(s), a thermodynamically unstable, supersaturated water vapor condition is created by taking advantage of the difference in diffusion rates between water vapor and heat. Water vapor diffuses from the warm, wet column walls toward the centerline at a faster rate than the heat. The wall temperature along the column gradually increases to create a well-controlled and quasi-uniform centerline supersaturation. Through software controls, the user can modify the temperature gradient and flow rate to change supersaturations and obtain the CCN spectra.

In the figure above, we show point C along the centerline where the diffusing heat originated higher on the column (red-line, point A) than the diffusing mass (blue line, point B). Assuming the water vapor is saturated at the column wall at all points and the temperature is greater at point B than at point A, the water vapor partial pressure is also greater at point B than at point A. The actual partial pressure of water vapor at point C is equal to the partial pressure of water vapor at point B. The temperature at point C is lower than at point B, however, which means that there is more water vapor (corresponding to the saturation vapor pressure at point B) than thermodynamically allowed.

Seeking equilibrium, the supersaturated water vapor condenses on the cloud condensation nuclei in the sample air to form droplets, just as cloud drops form in the atmosphere. An Optical Particle Counter (OPC) using side-scattering technology counts and sizes the activated droplets.

Calibration

DMT recommends periodically calibrating the CCN Counter supersaturation rate, flow sensors, pressure transducers, and the optical particle counter. The user can calibrate the supersaturation rate themselves by comparing the instrument's output to that of reference instruments Differential Mobility Analyzer (DMA) and a CN Counter. Annual cleaning and calibration is also available from DMT.

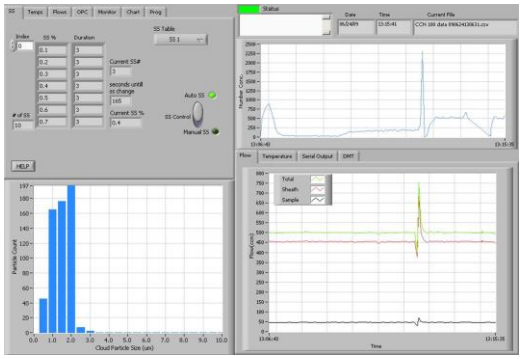
	Frequency	Equipment
Supersaturation rate	Annually	DMA and CN Counter
Flow sensors	Monthly	Flow meter, soap bubble unit/automated system
OPC	Annually	DMT aerosol generator, 2.0 µm polystyrene latex (PSL) particles

Once the calibration analysis is complete, the user can easily adjust the instrument by entering new values into the CCN Counter software.

Software

The CCN Counter comes with a software program that provides a user-friendly virtual instrument panel for the control, data display, and data logging of the CCN instrument. The program enables the user to do the following tasks:

- Collect data
- Change supersaturation settings
- Adjust temperature and air flow settings
- Manipulate instrument pumps (e.g., turn air pumps on high to prevent condensation)
- Quickly detect any operational problems
- Update instrument calibration parameters
- Adjust the instrument to prepare it for shipping or re-humidify it after shipping



CCN Software

Information gathered during sampling sessions is written to output files that can be viewed in real-time and played back later for detailed analysis.

The software also regulates the instrument to prevent hardware damage due to factors such as excessive temperature, leaks, and laser problems.

In addition to the standard software, the CCN Counter interfaces with DMT's Particle Analysis and Display System (PADS). PADS allows the user to analyze data collected from the CCN Counter and other DMT instruments simultaneously, but does not allow control of the CCN Counter.

Cloud Condensation Nuclei Counter Specifications

Technique	Activation of CCN particles at constant supersaturation maintained in a 50-cm-high column with continuously wetted walls and a longitudinal thermal gradient; sizing of the activated droplets using an optical particle counter
Aerosol Medium	Air, 5 - 40 °C (41 - 104°F)
Number Concentration Range	Depends on supersaturation: • 6,000 particles/sec at supersaturations below 0.2% • 20,000 particles/sec at supersaturations above 0.3%
Measured Particle Size Range (from OPC, after supersaturation)	0.75 – 10 µm
Number of Particle Size Bins	20
Sampling Frequency	1 Hz / 1 Second

Supersaturation Range	0.07 – 2.0%
Time Required for Supersaturation Change	~30 seconds for 0.2% change
Maximum number of automatically scanned supersaturation settings	250
Optical Particle Counter Laser	660 nm, 35 mW
Flow Range	• Total flow: 200 – 1000 volume cc/min (factory calibrated at 500 Vccm) • Sample flow: 20 – 100 Vccm • Sheath flow: 180 – 900 Vccm
Flow Control	• Total flow is adjustable from within CCN Counter software • Sample/Sheath flow ratio is adjustable using manual metering valve
Pump	Solenoid pumps for water; diaphragm pump for air
Routine Maintenance	*Every Four Days/Before Every Flight* • Empty and refill water bottles • Check OPC water trap and bottom of case for water leakage *Monthly:* • Check air inlet filters • Check flow calibration • Check desiccant tube *Every Three Months:* • Replace airflow filter
Recommended Service	Annual cleaning and calibration at DMT service facility
Front Panel Display	Computer monitor, water supply bottle
Side Panel Connections	• System power switch • LED for overall system power • Watchdog light • Air vents • Inlet and exhaust valves • +28 VDC pin connector • Ethernet connection • USB connection • Mouse and keyboard connections • Touchscreen connection • Video connection • Serial data port • LED power connection
Computer System	On-board Intel® Celeron® 1 GHz processor 512 MB RAM 80 GB hard drive for data storage User interface via standard keyboard and monitor (included)
Software	• CCN Counter Software, Playback Software • Optional Particle Analysis and Display System (PADS) (to record data in an aircraft system—not required for instrument operation)
Data System Interface	RS-232, 9.6 Kb/sec Baud Rate (single CCN Counter) or 57.6

	Kb/sec (Dual CCN Counter)
Data System Features	• Onboard computer for control and data logging • Touch screen control and display • Serial data output for external computer
Calibration	Comparison of CCN Counter output to reference instruments (Differential Mobility Analyzer (DMA) and a CN Counter)
Features for Easy Aircraft Mounting	• Rack-mount compatible • Center of gravity located 15.5" from bottom of back base plate • Instrument plumbing system sealed for operation on pressurized aircraft
Power Requirements	28 VDC
Current	*CNN-100:* 15 A at startup, nominal 7 A during normal operation *CCN-200:* 25 A at startup, nominal 20 A during normal operation
Shipping Container	Durable Atlas Case Corporation ATA Transit Case that conforms to the Air Transport Association's Specification 300 Category 1 standards
Size (same for CCN-100 and CCN-200)	*For lab use (with frame):* • 35.0" H x 19.3" W x 15.6" D / • 88.9 cm H x 48.9 cm W x 39.7 cm D *For aircraft use (without frame):* • 32.0"H x 15.25" W x 10.6" D / • 81.3 cm H x 38.7 cm W x 27 cm D
Weight	*CCN-100:* • For lab use (with frame): 35.2 kg / 77.5 lb • For aircraft use (without frame): 29.0 kg / 64.0 lb *CCN-200:* • For lab use (with frame): 50 kg / 110 lb • For aircraft use (without frame): 43.8 kg / 96.5 lb
Environmental Operating Conditions: Temp RH	 5 – 40°C (41 – 104 °F) 0 – 100% RH non-condensing

Specifications are subject to change without notice. The CCN Counter is a Class 1 Laser Product.

Accessories (Purchased Separately)

- Kits for consumable and spare parts
- Airborne CCN Counter inlet assembly kit:
  - CCN Counter rail mount
  - CCN Counter aircraft inlet
  - Constant pressure inlet
- PADS Particle Analysis and Display System (optional software to record data in an aircraft system—not required for instrument operation)

How to Order

For more information or to obtain a sales quote, contact DMT at 303.440.5576 or customer-contact@dropletmeasurement.com. Please specify dual or single growth columns when ordering.

Acknowledgments

The Cloud Condensation Nuclei (CCN) Counter is based on the design of Dr. Greg Roberts of Scripps Institute of Oceanography and Dr. Athanasios Nenes of the Georgia Institute of Technology. The patent for their design is licensed exclusively to DMT, patent number 10/528,348.

Selected Bibliography

The following papers provide a representative sample of research conducted with the DMT CCN Counter. For a comprehensive bibliography of CCN-related publications, see http://www.dropletmeasurement.com/user-community/academic-papers/ccn.html.

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