

# HOW IT WORKS

The three DMT instruments included in the CCP are the Cloud Imaging Probe (CIP), the Cloud Droplet Probe (CDP), and the Hotwire Liquid Water Content Sensor (Hotwire LWC).

The CIP, which measures larger particles, operates as follows. Shadow images of particles passing through a collimated laser beam are projected onto a linear array of 64 photodetectors. The presence of a particle is registered by a change in the light level on each diode. The registered changes in the photodetectors are stored at a rate consistent with probe velocity and the instrument's size resolution. Particle images are reconstructed from individual "slices," where a slice is the state of the 64-element linear array at a given moment in time. A slice must be stored each time interval that the particle advances through the beam a distance equal to the resolution of the probe. Optional grayscale imaging gives three levels of shadow recording on each photodetector, allowing more detailed information on the

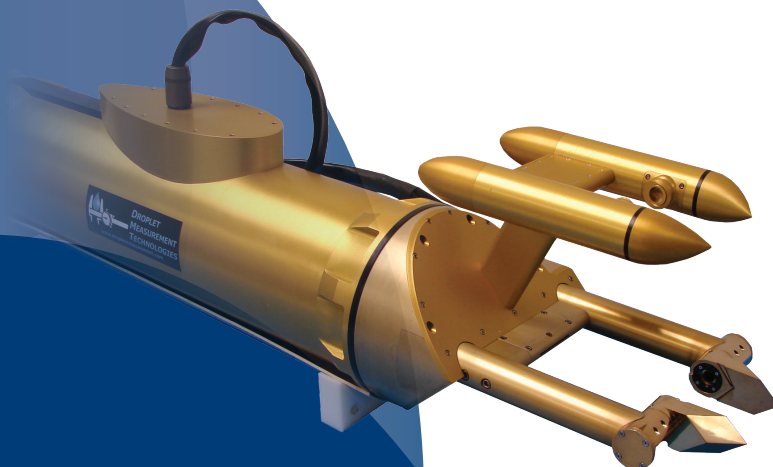
particles.

The CDP, which measures smaller particles, relies on light-scattering rather than imaging techniques. Particles scatter light from an incident laser, and collecting optics guide the light scattered in the 4° to 12° range into a forward-sizing photodetector. This light is measured and used to infer particle size.

The Hotwire LWC instrument estimates liquid water content using a heated sensing coil. The system maintains the coil at a constant temperature, usually 125 °C, and measures the power necessary to maintain this temperature. More power is needed to maintain the temperature as droplets evaporate on the coil surface and cool the surface and surrounding air. Hence, this power reading can be used to estimate LWC. Both the LWC design and the optional PADS software contain features to ensure the LWC reading is not affected by conductive heat loss.

# CCP

## CLOUD COMBINATION PROBE



## INCLUDED ITEMS

- » Instrument
- » Shipping case
- » Operator manual
- » One-year warranty
- » Spinning disk for CIP calibration check
- » Glass beads and dispenser for CDP calibration check
- » One day of training at DMT's facility
- » Email and telephone technical support

## ACCESSORIES

## HOW TO ORDER

- » Particle Analysis and Display System (PADS) software
- » Data Acquisition System

Contact DMT for pricing or more information:  
+1.303.440.5576,  
[customer-contact@dropletmeasurement.com](mailto:customer-contact@dropletmeasurement.com).



# OVERVIEW

The CCP is an ideal choice for those who want an all-purpose, simple-to-use cloud probe. Five instruments are packaged into a single canister and integrated measurement system. The CCP provides the following data:

- » Aerosol particle and cloud hydrometeor size distributions from 2 to 50  $\mu\text{m}$
- » Precipitation size distributions from 25  $\mu\text{m}$  to 1550  $\mu\text{m}$
- » Liquid water content from 0.05 to 3  $\text{g}/\text{m}^3$
- » Aircraft velocity
- » Atmospheric temperature and pressure

This instrument replaces PMS Inc.'s FSSP-100, FSSP-300, 2D-C, 2D-P and KLWC.

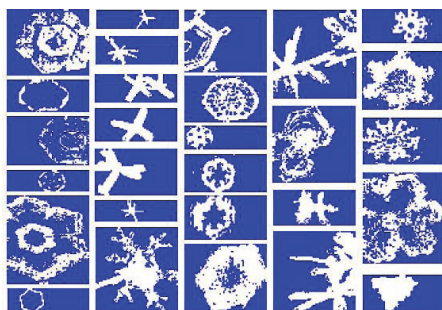
# APPLICATIONS

- » Cloud particle research
- » Climate studies
- » Aircraft icing
- » Hurricane and storm research
- » Weather modification
- » Agricultural and industrial spray characterization



# ADVANTAGES

- » Covers a sizing range from 2 to 1550  $\mu\text{m}$  (or 2  $\mu\text{m}$  to 930  $\mu\text{m}$  for a 15- $\mu\text{m}$  resolution CIP), plus Liquid Water Content, Temperature and RH sensing
- » Generates 2-dimensional images of particles from 25 - 1550  $\mu\text{m}$  (see figure below)
- » Provides airspeed and altitude measurements from the heated Pitot tube
- » Offers easily interpreted data



CIP images courtesy of Forschungszentrum Jülich

# OPTIONS

## PARTICLE BY PARTICLE (PBP)

The PBP feature provides precise information on particle scattering intensity and inter-arrival times for particles in the 2 to 50  $\mu\text{m}$  range. The standard CCP lists times for these particles with one-second resolution. PBP provides times that are accurate to within a microsecond—an improvement by a factor of a million. These data are useful when investigating smallscale cloud structure to identify mixing and entrainment, drop breakup and coalescence, and micro-scale turbulence.

## GRAYSCALE IMAGING

Grayscale imaging provides detail about particle composition that is missed with monoscale imaging. In particular, grayscale imaging gives three levels of shadow recording on each photodetector as opposed to one. The pictures at left show the same particles recorded with grayscale imaging (near right) and monoscale imaging (far right).

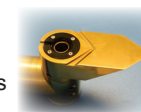


## CIP OPTICAL AND ELECTRICAL OPTIONS

The CCP's Cloud Imaging Probe (CIP) is offered in a 15  $\mu\text{m}$  or 25  $\mu\text{m}$  resolution. In addition, the CIP is available with 28 VDC or 115 VAC anti-ice heaters.

## KOROLEV TIPS

The CCP's CIP is offered with standard tips or Korolev anti-shatter tips (right). Korolev tips significantly reduce the incidence of particle artifacts in the sample area.



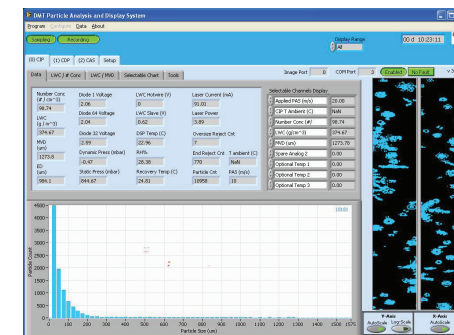
# SOFTWARE

The Particle Analysis and Display System (PADS) is optional software that displays a user-friendly virtual instrument panel. PADS allows for the control, data display, logging, and playback of the CCP instrument. For instance, the program enables the user to do the following tasks:

- » Start data recording and sampling
- » View particle image data from the CIP
- » View particle volume and number concentrations, as well as Median Volume Diameter (MVD) and Effective Diameter (ED)
- » View LWC as measured or calculated by the

hotwire sensor, CIP, and CDP

- » Monitor instrument parameters like CIP laser current and various electronics voltages
- » Play back data for post-flight viewing



# CCP SPECIFICATIONS

	CIP	CDP	Hotwire LWC
Technique:	Optical Array Probe with 64 elements: 62 sizing elements, end diode rejection	Light-scattering probe with 10, 20, 30, or 40 size bins (user programmable)	Temperature-Controlled Hotwire Sensor
Measured Particle Size Range:	12.5 $\mu\text{m}$ – 1.55 mm (for 25- $\mu\text{m}$ resolution CIP) 7.5 – 930 $\mu\text{m}$ (for 15- $\mu\text{m}$ resolution CIP)	2 $\mu\text{m}$ – 50 $\mu\text{m}$	N/A; measured LWC range is 0 - 3 g/m <sup>3</sup>
Sample Area:	Variable; depends on tip configuration and particle size	0.24 mm <sup>2</sup>	N/A
Upper Concentration Range:	Depends on particle size, but up to 500 particles/ cm <sup>3</sup> for a CIP with standard tips and arm width	0 - 2,000 particles/cm <sup>3</sup>	3 g/m <sup>3</sup>
Air Speed Range:	10 – 300 m/sec (for 25- $\mu\text{m}$ resolution CIP) 10 - 180 m/sec (for 15- $\mu\text{m}$ resolution CIP)	10 – 250 m/sec	10 – 200 m/sec
Number of Size Bins:	62	30	N/A
Sampling Frequency:	1D histogram data: 0.05 to 25 Hz; 2D image data: variable interval, when buffer fills	Selectable, 0.05 to 25 Hz	
Laser:	658 nm, 30 mW	658 nm, ~50 mW	
Calibration Verification:	Spinning glass disk with opaque dots of known size	Precision glass beads	Not required
Non-absorbing Refractive Index:	N/A	Non-absorbing, 1.33 (the industry standard for water)	N/A
Light Collection Angles:	N/A	4° - 12°	N/A
Auxiliary Parameters:	Ambient Temperature, Relative Humidity, Static Pressure, Dynamic Pressure (CIP)		
Data System Interface:	2D CIP data: RS-422, High Speed, 4 Mb/sec Baud Rate System data: RS-232 or RS-422, 56.6 kb/sec Baud Rate		
Software:	Particle Analysis and Display System (PADS) (Optional)		
Weight:	29 lbs./13.2kg for probe and canister		
Power Requirements:	System Power bus: Auxiliary bus (formerly "LWC bus"): CIP Anti-Ice bus: CDP Anti-Ice bus:	28 VDC, 3A 28 VDC, up to 8A (depends on LWC content) 28 VDC, 13A 28 VDC, 7A	

# SPECIFICATIONS, CONT.

Environmental Operating Conditions	Temperature: -40 °C to +40°C (-40 °F to +104 °F) RH: 0 – 100%, non-condensing Altitude: 0 - 50,000 ft
Routine Maintenance:	DMT recommends conducting basic instrument performance checks and inspecting the CIP optical windows before a flight. A weekly calibration check of the CDP and CIP is also recommended.

# SELECTED BIBLIOGRAPHY

Schuyler, H., M. Asselin, and D. Baumgardner. "Observations of ice ridge formation on the SJ30-2 leading edge slat in freezing drizzle conditions." SAE Technical Paper 2007-01-3365, 2007, doi:10.4271/2007-01-3365.



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Specifications are subject to change without notice. The CCP is a Class IIIb laser product.

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