

# HOW IT WORKS

The three DMT instruments included in the CAPS are the Cloud Imaging Probe (CIP), the Cloud and Aerosol Spectrometer (CAS), 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 CAS, 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. Backscatter optics also measure light in the 168° to 176° range, which allows determination of the real component of a particle's refractive index for spherical particles.

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.

# CAPS

## CLOUD, AEROSOL AND PRECIPITATION SPECTROMETER



# INCLUDED ITEMS

- » Instrument
- » Shipping case
- » Operator manual
- » One-year warranty
- » Spinning disk for CIP calibration check
- » Glass beads and dispenser for CAS 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 Cloud, Aerosol and Precipitation Spectrometer (CAPS) is a state-of-the-art cloud-particle probe. It includes three DMT instruments plus temperature and relative humidity sensors packaged into a single canister. The CAPS provides the following data:

- » Aerosol particle and cloud hydrometeor size distributions from 0.51 to 50  $\mu\text{m}$
- » Precipitation size distributions from 25  $\mu\text{m}$  to 1550  $\mu\text{m}$ , or 15-930  $\mu\text{m}$  with optional 15- $\mu\text{m}$  resolution
- » Particle images for 25  $\mu\text{m}$  to 1550  $\mu\text{m}$  particles (15-930  $\mu\text{m}$  with 15- $\mu\text{m}$  resolution)
- » Particle optical properties (refractive index)
- » Particle shape assessments (discrimination between water and ice for probes with depolarization feature)
- » Liquid water content from 0.01 to 3  $\text{g}/\text{m}^3$
- » Aircraft velocity and altitude
- » Atmospheric temperature and pressure

This instrument replaces the older PMS/PMI FSSP-100, FSSP-300, 2D-C, 2D-P and KLWC probes. It is suitable for fixed site, mobile or airborne sampling.

# FEATURES

## DEPOLARIZATION

The CAPS includes a depolarization feature that can differentiate between water and ice for particles in the 0.5 - 50  $\mu\text{m}$  range. In addition to measuring forward-scattered light, the CAPS measures the S-state and P-state polarizations with two backscatter detectors. For spherical particles, typically droplets, the polarization of the incident light will be retained and the crossed polarization in the back-scatter will not generate any signal. Depending on the asphericity of the particles, there will be increased signal in the backscatter detector with the crossed polarizer.

# APPLICATIONS

- » Cloud particle research
- » Climate studies
- » Aircraft icing
- » Storm and hurricane research
- » Weather modification
- » Contrails and contrail-induced cirrus
- » Cloud chambers
- » Agricultural and industrial spray characterization

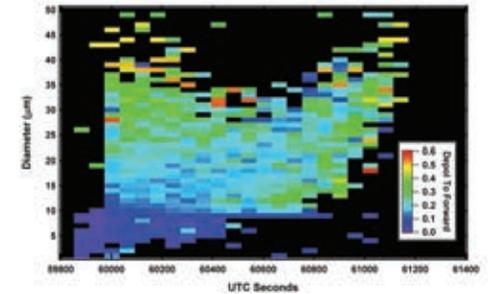
# FEATURES

## PARTICLE BY PARTICLE

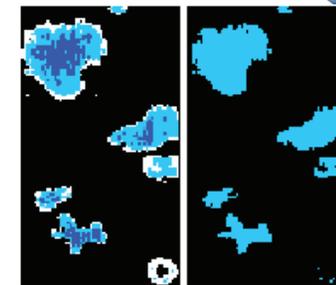
The CAPS includes particle-by-particle (PBP) data on the first 292 particles in the 0.51 to 50  $\mu\text{m}$  range. The PBP data includes measurements on forward-scattered, back-scattered, and depolarized light for each individual particles. These data are used to calculate depolarization ratios that enable particles to be classified as water or ice.

## 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).



The ratio of depolarization to forward scattering (colored squares) as a function of diameter and time. Measurements were made in the AIDA cloud chamber with the Juelich Institute's CAPS (Meyer and Kraemer, 2010).



# OPTIONAL FEATURES



The CAPS's Cloud Imaging Probe (CIP) is offered in a 15  $\mu\text{m}$  resolution as well as the standard 25  $\mu\text{m}$  resolution. In addition, it is offered with standard tips or Korolev anti-shatter tips (left). 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 CAPS instrument. For instance, the program enables the user to do the following tasks:

- » Start data recording and sampling
- » View particle image data acquired with 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 CAS
- » Monitor instrument parameters like CIP laser current and various electronics voltages
- » Play back data for post-flight viewing



Photo at left and on cover courtesy of British Antarctic Survey.

# CAPS SPECIFICATIONS

	CIP	CAS	Hotwire LWC
Technique:	Optical Array Probe with 64 elements: 62 sizing elements, end diode rejection	Forward and Back Scatter Light Sensors, dual back measurement with S and P polarization of the scattered light	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)	0.51 $\mu\text{m}$ to 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	1.1 mm x 120 $\mu\text{m}$	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	Greater than 1,000 particles/cm <sup>3</sup> after corrections for coincidence that are about 25% at 800 and 30% at 1,000 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 – 200 m/sec	10 – 200 m/sec
Number of Size Bins:	62	Selectable, 10, 20, 30, or 40	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 and latex spheres for sub-micron range	Not required
Non-absorbing Refractive Index:	N/A	1.3 – 1.7	N/A
Light Collection Angles:	N/A	4° - 12°, 168° - 176°	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:	45 lbs./20.4 kg		
Power Requirements:	28VDC: 10A for probe system, and 45A for anti-ice heaters, optional AC voltages for anti-ice heaters		

# 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 CAS and CIP is also recommended.

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*Specifications are subject to change without notice.*



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