



photo Debrisieux

Cloud Particle Imaging Probes

Sondes à Image pour la mesure des Particules Nuageuses

R. Dupuy, C. Gourbeyre, C. Duroure, G. Mioche, A. Schwarzenboeck and J.-F. Gayet

Laboratoire de Météorologie Physique, Centre National de la Recherche Scientifique / Université Blaise Pascal, Aubière, France

Cloud Particle Imager

The Cloud Particle Imager (CPI) produces high resolution images of particles that are detected within the depth-of view of the imaging optics by particle detection lasers. The accuracy of its images and the quasi continuous levels of grey make the CPI best suited for crystal shape recognition and accurate retrieval of corresponding dimensions.

Specifications

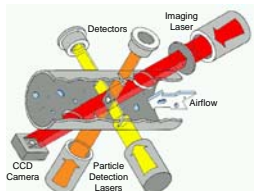
- Imaging :
- 1 000 000 pixel digital CCD camera
 - 2.3 μm pixel size
 - 8 bit grey scale (256 levels)
 - 40 frames per second maximum rate
 - Many particles per frame can be collected
 - 25 ns laser flash freezes motion of particle
 - Data system only saves image area with particles



The Cloud Particle Imager (CPI) on the Do 228 (AWI) during the ASTAR experiment (Spitzberg, 2007).

Sampling :

- Dual beam Particle Detection System (PDS) triggers the imaging laser
- Maximum sample volume of 1 L.s⁻¹ at 200 m.s⁻¹

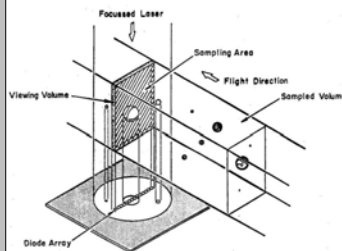


Schematics of PDS system and imaging laser of CPI



The Cloud Particle Imager (CPI) probe without canister.

2D Imaging Probes



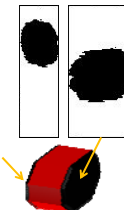
Two Dimensional Particle Imaging Probes are optical instruments that record cloud particle images in order to retrieve particle shape, size and concentration.

Principle

In general, 2D Imaging Probe uses a collimated laser beam to illuminate a linear array of photodiodes. As a particle passes through this beam, a shadow image is cast on the diodes. This image is captured by recording the intensity levels of light during the crossing of the particle. Thus, the total number of occulted diodes represents the particle size.

The 2D-S is the first probe to offer a stereoscopic view of hydrometeors. Simultaneous operation of two perpendicular laser beams enable 3D images of hydrometeors to be recorded on corresponding arrays of photodiodes (128) at a 10 μm resolution.

The Precipitation Imaging Probe (PIP) uses a wide sampling area with a 100 μm resolution on a 64 photodiodes array for measuring the largest cloud particles.



Ice crystal shape number frequency distribution with temperature in an Arctic Stratocumulus sampled

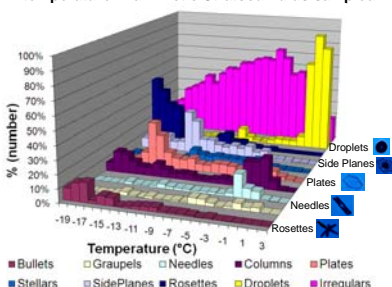
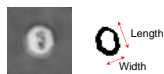


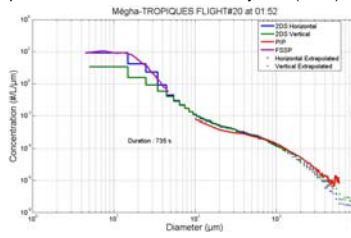
Image Analysis Steps

- Background subtraction
- Filtering and thresholding (black and white image)
- Loose pixels removal
- Contour definition
- Habit extraction and retrieval of particle dimensions
- Calculation of microphysical and radiative parameters for a fixed time step



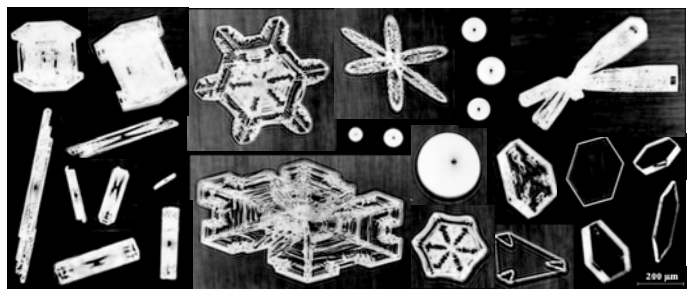
Instrument Synopsis

Cloud particle size spectrum composed of FSSP, 2D-S and PIP during the Mégha-Tropiques project (Niger, 2010) in the liquid part of a Mesoscale Convective System (MCS).

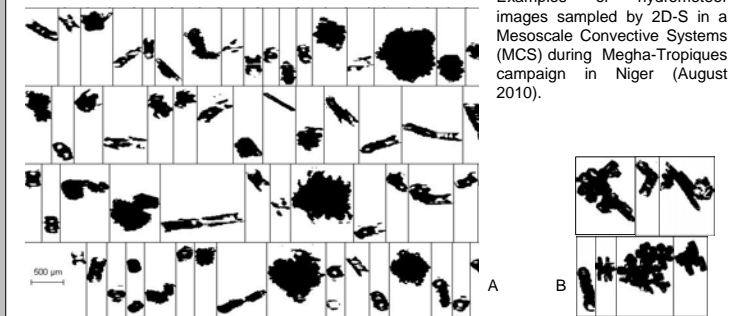


Artifacts removal and image corrections

- 1) Spurious Events: Shattering or splashes on the mirrors
- 2) Out of focus images and size corrections
- 3) Changes in true air speed and corrections for elongated and compressed particles



Examples of particle images taken by the Cloud Particle Imager (CPI) during the ASTAR experiments (Spitzberg, 2004 and 2007).



Acknowledgements : The Cloud Imaging Probes (CIP, 2D-S and PIP) of the LAMP/OPGC airborne measurement platform have been mainly funded by CNES, INSU and the Region Auvergne.