Algorithms for Processing and Correcting Cloud Microphysical Data Collected During TWP-ICE

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Introduction

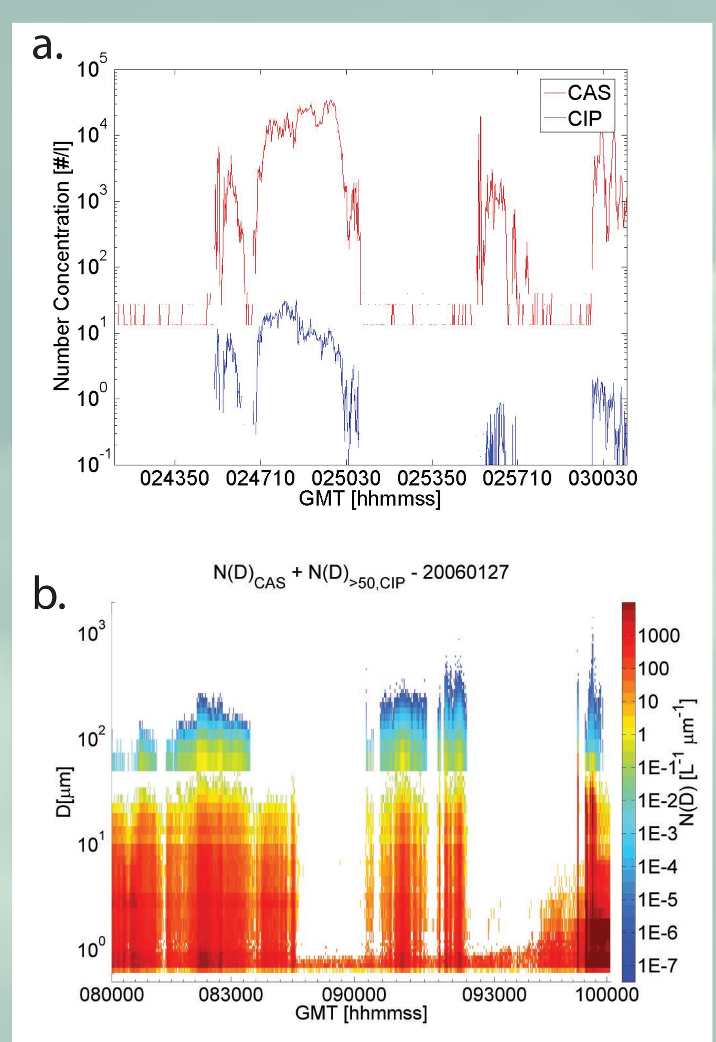
Data from in-situ microphysical probes are used by the ARM Aerial Vehicle Program (AVP) for evaluating remote sensing retrievals, for developing cloud parameterizations, and for evaluating model simulations. Programs in Matlab developed at UIUC for processing, analyzing and outputting the data into NetCDF files are presented here. An algorithm for identifying and correcting out of focus particles measured by the Cloud Imaging Probe (CIP) is highlighted.

Microphysics Overview

Algorithms available at UIUC analyze data from these probes shown in Table 1. A Matlab code (Figure 1) processes these measurements into higher level data products. Plots of various types can be generated using this code - examples are shown in Figure 2.

Probe	Type	Product	Range
CAS	Forward Scattering	Size Distributions	0.35 - 50 μm
CIP	OAP	Size Distributions	50 - 1550 μm
CDP	Forward Scattering	Size Distributions	2 - 50 μm
CPI	CCD	Size Distributions	2.3 - 2355 μm
Nevz	Hot Wire	IWC/LWC	0.005 - 3 g/m^3
CVI	Virtual Impactor	CWC	0.001 - 5 g/m^3
CIN	Nephelometer	Extinction	4 - 2500 μm

Table 1: Overview of microphysics probes carried on Proteus during TWP-ICE.



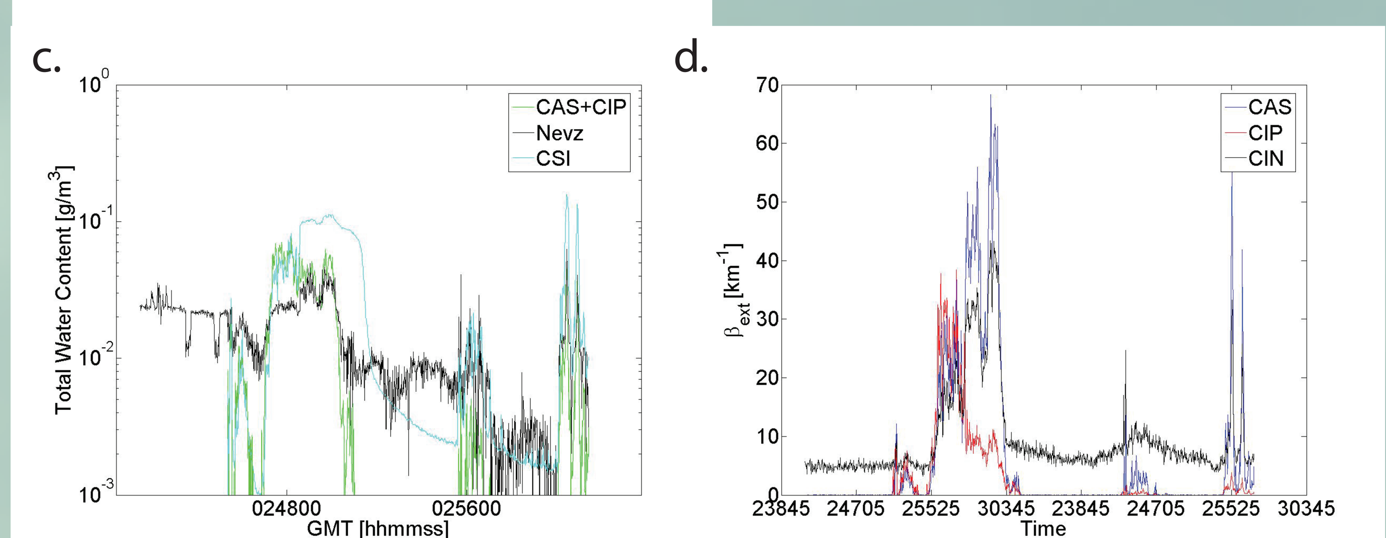


Figure 2: Examples of plots generated by the processing code. (a) CAS and CIP number concentration; (b) CAS and CIP size distribution contours; (c) CAS+CIP, Nevzorov and CVI ice water contents; (d) CAS, CIP and CIN extinction coefficient

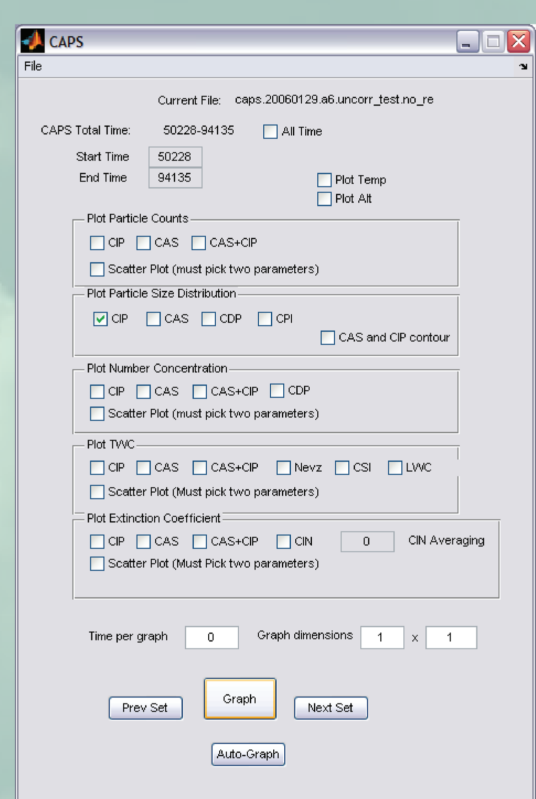


Figure 1: GUI for microphysics processing code

CIP Image Classification

The CIP records two-dimensional particle images using an array of photodiodes attached to fast response electronics. To get reliable data from the CIP, artifacts that are not representative of actual images must be removed or corrected. Examples of such artifacts are streaks, split images, hollow images and stuck bits, shown in Figure 3.

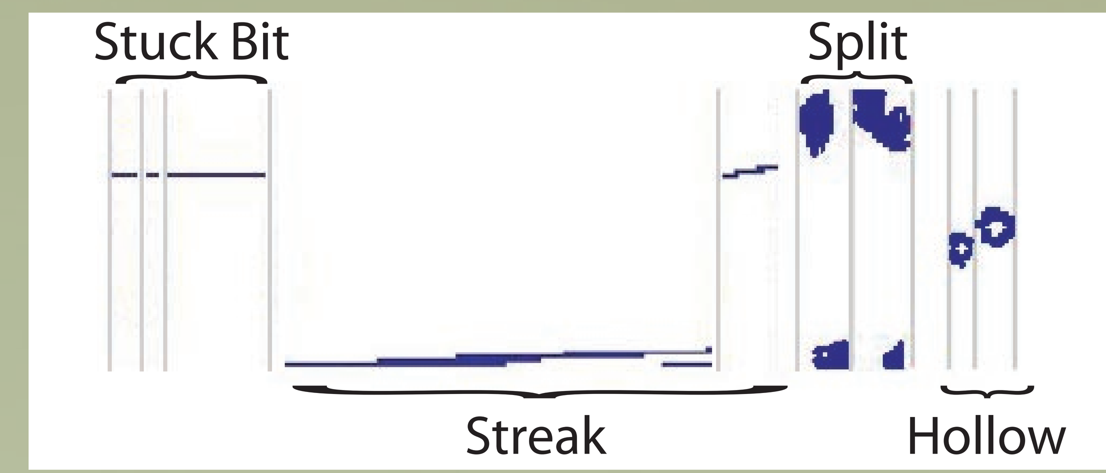


Figure 3: Examples of CIP artifacts

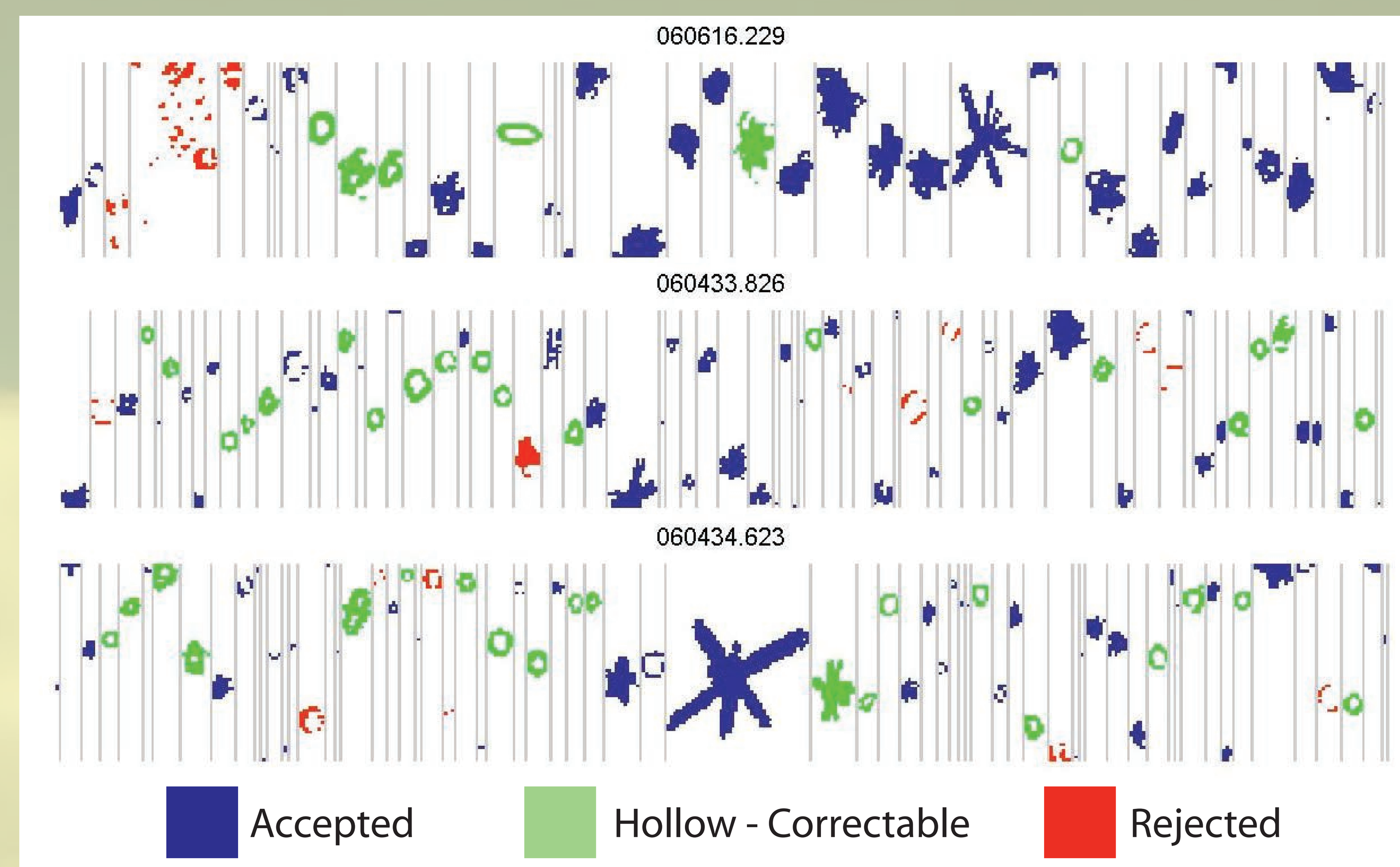


Figure 4: CIP images from Jan 29th flight showing rejection classification. In the hour of data used for the flight, 75% of particles were accepted, 17% classified as hollow - correctable and 8% were rejected.

In order to remove artifacts, information about each particle (i.e., width, length, projected area, aspect ratio, percent shadowed area (PSA), and holroyd habit) are stored. Using combinations of these parameters, particles are classified as accepted, hollow – correctable, or rejected, as shown in Figure 4. Particles are marked 'hollow -correctable' if the following criteria are met:

- unlit diodes in center third of image, with cover on 3 of the four sides
- particle classified as
  - irregular with ratio of particle area to hole diameter (A/D_h) > 20
  - hexagonal with A/D_h > 35
  - anything else with A/D_h > 40

Correcting Hollow Particles in the CIP

Correcting out of focus (hollow) particles can be done by using an algorithm developed by Korolev et al. This algorithm resizes particles using the ratio of the hollow diameter to edge diameter.

Evaluation: the algorithm was tested using a calibration dataset with particles of varying diameters on a spinning disk. The spinning disk was moved through the CIP focal plane to provide multiple simulated depths of field (Z_d). Figure 5 shows example images from the spinning disk test.

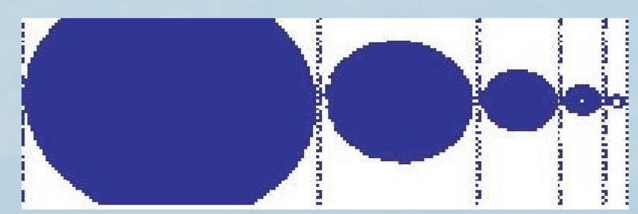


Figure 5: Example of CIP spinning disk images

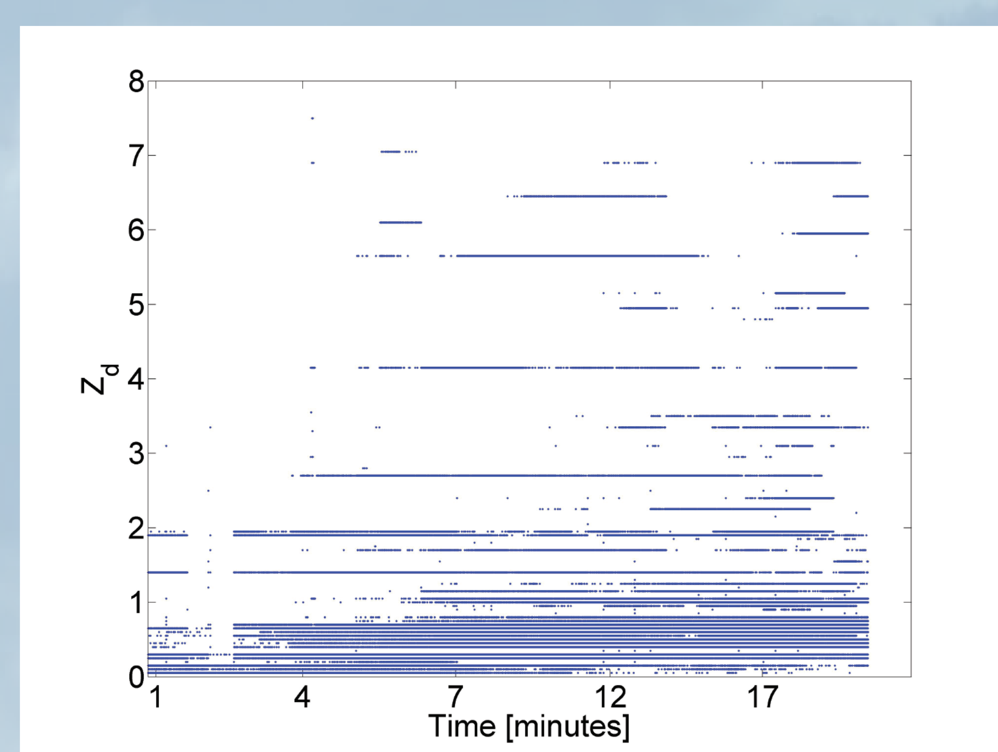


Figure 6: Depth of field (Z_d) calculated using the Korolev algorithm on CIP spinning disk test data

Results: Figure 6 shows Z_d as calculated by the Korolev algorithm. As time increases, the maximum calculated Z_d increases, reflecting the progression of the spinning disk through the focal plane. Points with Z_d < 1 are the result of the larger particles on the spinning disk not appearing sufficiently hollow.

Application: The algorithm has been applied to TWP-ICE data, to resize particles classified as 'hollow – correctable.' Figure 7 shows a comparison of CIP spectra before and after the correction and rejection of particles. Size distributions measured by the CAS, CDP and CPI for the same time period are also shown. Current work at UIUC is aimed at trying to better understand reasons for the discrepancies between these measurements.

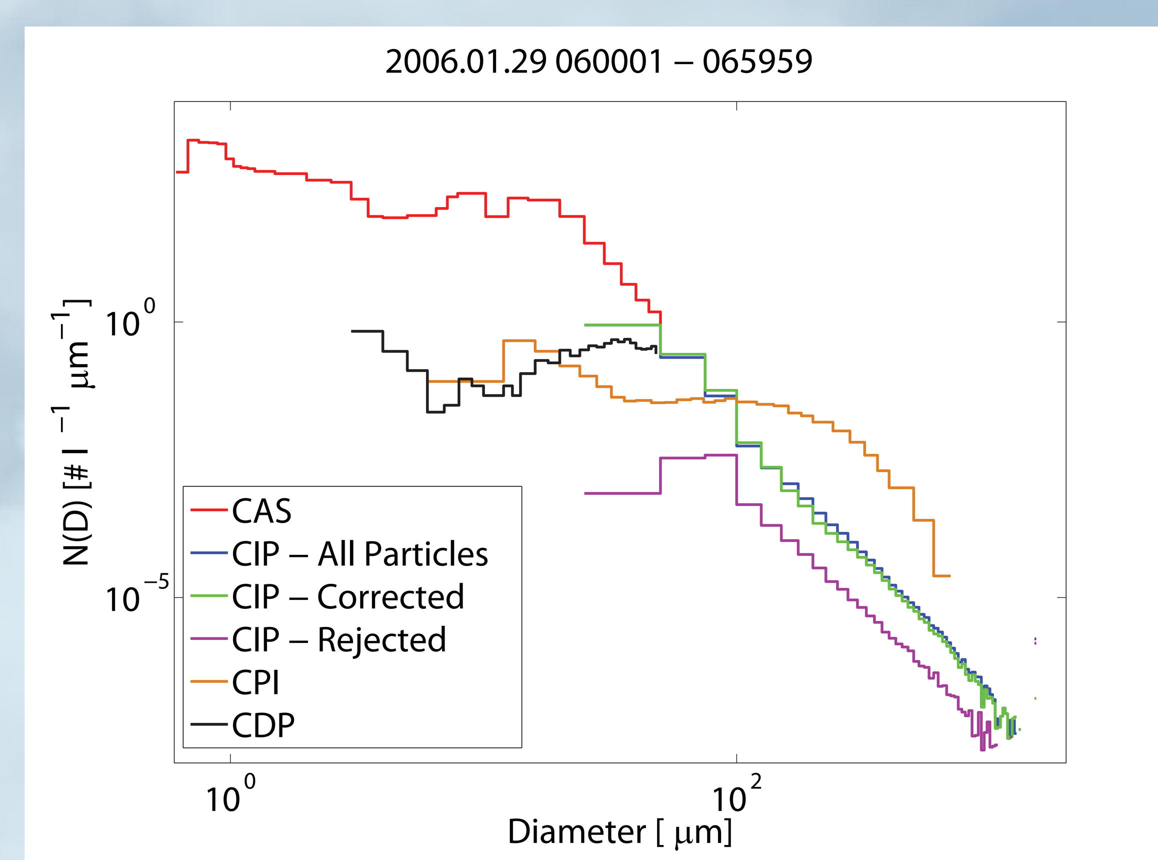


Figure 7: Size distributions from Jan 29th flight from 060001 - 065959 UTC comparing CIP SDs with CAS, CPI and CDP