Title: DC3 PASIV Archive

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1.0 Data Set Overview:

This document describes data characteristics from National Severe Storms Laboratory (NSSL) Particle Size, Image, and Velocity (PASIV) probe observations during the Deep Convective Clouds and Chemistry (DC3) experiment in the spring of 2012. The PASIV probe is a balloon-borne microphysics probe (Waugh et al. 2015, Waugh 2016) that was used to collect in situ microphysics observations inside severe convection during the project. Two cases are archived here, 21 June 2012 and 29 May 2012.

2.0 Instrument Description:

The PASIV probe is described in detail in Waugh et al. 2015 and Waugh 2016, however a brief description is recreated here. The PASIV is a hybrid instrument system that combines a videosonde employing an HD camcorder with a Parsivel laser disdrometer (Loffler-Mang and Joss 2000) to provide redundant in situ measurements of the particle distribution. The camera optics and frame size lead to a sampling volume of 2.17 x 10^{-3} m^3 per non-overlapping frame and a pixel resolution of 0.01 mm^2. The PASIV is capable of measuring particle concentrations on various spatial scales and provides a rich data set of in situ observations in regions unreachable by conventional aircraft observations. The camera is a Panasonic model HDC-SD9P CCD high resolution camera which is capable of shooting 1920x1080 resolution at 24 frames per second.

The camera records the viewable scene on an onboard memory card as the PASVI rises through the storm, while the Parsivel instrument records binned particle data according to size and velocity onto a separate memory card. After conclusion of the flight, the instrument is recovered and the data pulled off the memory cards, archived, and processed for analysis.

Due to the limited number of Parsivel units, only the 21 June case had a Parsivel unit attached and as such is the only record with Parsivel data archived.

3.0 Data Collection and Processing:

3.1 Camera archive:

The PASIV data archived here are the raw video files as recorded from the video camera, and where available the particle table as provided by the Parsivel disdrometer. The videos begin when the camera is turned on a few minutes prior to launch, and end when the camera battery dies and the camera shuts off. This may occur during flight, or after the balloon burst when the instrument has landed on the ground. Typically it takes several hours *after* the instruments land to recover, so there can be a sizable amount of recording while the instrument is stationary after landing depending on the duration of the flight.

The files within each case are numbered in order, starting at 00000.MTS and increasing numerically throughout the duration of the flight. The camera automatically breaks the video into roughly 34 min chunks. The camera is mounted at a 90 degree angle to the horizontal to maximize the viewing space, so that the "top" of the imager is on the left of the image and the "bottom" is on the right. As the PASIV ascends, particles "fall" through the imager from left to right in the video.

In order to work with these data, the video files must be broken down into individual PNG images. Depending on the length of the flight, this can be a significant number of images (typical flights have upwards of 50-60k images). There are a variety of ways to accomplish this task, a commercially available program such as VLC being a good example. Once the images are obtained, a series of IDL and MATLAB programs manage the processing of each image, while also identifying and sizing objects, remove background clutter from the scene, and identifying the various particle objects into various hydrometeor classes. These scripts make use of several additional libraries in both environments, must be run in a specific order, and as they are research scripts were not intended to be run "stand alone". As such, it would require significant consultation with the dataset author to enable the end data user to get those scripts running on the data user's computer workstation. Given this complexity, and the various programming environments which are needed to complete the processing, the author encourages any interested users in the processing scripts themselves to contact the author for more details or copies of the required scripts. The scripts themselves contain a large number of processing steps that are beyond the scope of this document to describe. For a complete description of the details of the processing steps, the reader is referred to Waugh (2016).

The output of these various programs and scripts is an ASCII data file that contains information for each particle identified which includes size, shape, classification, geo location, and PTU data from the sonde attached to the videosonde instrument train. The in-storm videosonde sounding datasets for these cases are archived elsewhere in this EOL data catalog. This collective information can then be used for analysis as the end user sees fit.

3.2 Parsivel Archive:

The Parsivel data follows a similar procedure in that the Parsivel is turned on prior to launch of the PASIV flight. The raw data tables as recorded by the Parsivel are output every 10 seconds to the onboard SD card, and contain some particle information on the ground prior to launch. To indicate launch in the Parsivel record, the laser transmitter is blocked while the instrument is sitting on the ground. This causes the signal amplitude to fall to zero, and the immediately jump up upon launch when the laser is unblocked. This makes identification of the launch point easily identifiable in the Parsivel record.

The first step in processing the Parsivel data is to ingest the raw particle tables, and trim the record so that the first record is at launch of the PASIV instrument. The output of this step is a

ASCII data set that contains information in 10 second chunks. As with the camera data, these processing scripts were not written with the intention of being "stand alone", it is therefore suggested that any interested parties contact the dataset author for help in getting and using those scripts. More information on the processing of the Parsivel data can be found in Waugh (2016)

3.3 Radiosonde Archive:
The radiosonde data for each flight is contained in a text file of fixed width columns for each 1 second record of data transmitted from the Vaisala RS92-SGP radiosonde. This file contains all transmitted records from the radiosonde, including data collected at the ground prior to launch. To be combined with the Parsivel or camera data, the file must be trimmed to include only that data representing flight to match the other instrument records.

3.4 Training Data Archive:
The training data set which was used to train and validate the automated classification algorithm for detected particles in the video data is archived here. This file contains individual particle detections and their associated measurements, as well as the classifications applied to each object by hand.

4.0 Data Format:

There are 3 types of files potentially available for a given case, the camera data, the Parsivel data, and the radiosonde data. Additionally, the training data is comprised of objects from both cases and is presented separately.

As described earlier, the camera data is relatively straightforward as it is simply a video file that contains the recorded video of particles falling through the PASIV instrument. The filenames follow the format of XXXXX.MTS that begin at 00000 for each case and increase monotonically depending on the length of the video.

The Parsivel data, when available, is composed of comma separated ASCII records in the following format:

Parsivel run time: This is the run time in seconds, starting at 10 for the first record

Rain Intensity: This is the rain intensity as determined by the Parsivel, in mm hr^{-1}

Rain Accumulation: Rain accumulation in mm

Radar Reflectivity: Parsivel calculated radar reflectivity from the measured distribution in dBz

Sample interval: the sampling period of the Parsivel, in seconds

Signal Amplitude: the signal amplitude of the laser transmitter, unitless

Number of Particles: the total number of particles detected by the Parsivel per record

Sensor Temperature: temperature of the Parsivel board, °C

Battery Voltage: the voltage of the power supply, in volts

Time: UTC time from the Parsivel internal clock (this may differ from actual UTC depending on drift)

Date: Date from the Parsivel internal clock (this may differ from the actual date depending on drift)

Particle table: a 1024 list of the counts per size and velocity bin

For the radiosonde data, each record represents a 1 second observation as transmitted from the radiosonde. The file header contains the appropriate columns and units, but the file contains all information from the PTU sensors, the GPS output, and derived products such as winds.

The Training Data is an Excel spreadsheet containing records for individual particles identified by hand. The columns are as follows:

Image Number: the image number in the larger data set from which the particle was identified (one of the two archived cases)

Running #: A running count of the number of objects in the data set

Filename: The filename from which the particle was identified

Particle #: The object number in that image frame

Particle Type: The classification applied to the particle, determined by hand

Eccentricity: A measure of the particle's elliptical shape. 0 is non elliptical while 1 is a perfect circle.

Irregularity: A average of the amount of deviance from the fitted ellipse; a measure of the protrusions off the particle

MaxIrreg: The maximum value of irregularity of the particle

MinIrreg: The minimum value of irregularity of the particle

Radius: The particle radius in mm

Avg Brightness: The average pixel brightness value over the entire identified particle

Ellipse Area: The total area, in square pixels, covered by the fitted ellipse

# of Pixels: the number of pixels comprising the identified object

Pixel Area: the total area, in pixels, of the identified object

Graph Type: a binary value to determine the overall shape of the particle brightness histogram

Maj: the major axis of the fitted ellipse around the identified object

Min: the minor axis of the fitted ellipse around the identified object

Temperature: The environmental temperature, in C, where the object was observed

Hist_1 – Hist_10: The number of pixels in one of 10 bins spanning brightness values between 0 (black) and 1 (white)

5.0 Data Remarks:

As has been mentioned previously, extensive documentation on the PASIV instrument, the various components, and the processing steps required to work with the data can be found in Waugh (2016) and to some extent Waugh et al. (2015).Those interested in learning more about the PASIV instrument, its design, other data sets, etc., should contact the author Sean Waugh (sean.waugh@noaa.gov).

The processing of these data involves the use of several different programs, across several different platforms, and several different coding environments. Both IDL and MATLAB codes are used (requiring licenses), and several additional libraries in both environments must be installed on the data user's workstation to fully execute the processing steps. The scripts were created throughout a lengthy process of development and were done so as needed, working off previous scripts and outputs. Because of this, there is no single piece of software or script that is capable of fully processing all of the archived data. Given all of these factors, and that anyone attempting to reprocess this data would need considerable guidance from the author on how to run the various steps, it is beyond the scope of this document to fully detail that effort. Instead, those interested in learning more about the processing or those wishing to complete these steps on their own should contact the dataset author for the various processing scripts necessary and guidance about how to use them.

6.0 References:

Löffler-Mang, M., and J. Joss, 2000: An optical disdrometer for measuring size and velocity of hydrometeors. *J. Atmos. Oceanic Technol.,* **17**, 130–139.

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