TITLE: NSSL PArticle Size, Image, and Velocity (PASIV) probe data (LEE – 2022/2023)

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1. Data Set Description

This document describes data collected for the Lake Effect Electrification (LEE) experiment that took place in the winter of 2022/2023 around the Oswego, NY area using the National Severe Storms Laboratory PArticle Size, Image, and Velocity (PASIV) microphysics probe. This balloon borne instrument is specifically designed to capture high resolution images of in situ particle data in cloud through the use of a high resolution machine vision camera. The PASIV was flown for LEE on 2 occasions, with a third ground deployment also available. The PASIV was operated by NSSL, the University of Oklahoma/CIWRO, and SUNY Oswego.

The archive here contains PASIV data for two IOPs: IOP5 and IOP10, which took place on December 18th, 2022 and February 1st, 2023 respectively. The lat/lon/alt points of the data are included in the file names of the files where available. This archive is considered preliminary at this time due to more in depth processing that is required as will be expanded upon shortly.

2. Instrument Description

The PASIV is a microphysics instrument designed to collect high-resolution images of in situ precipitation particles along a balloon trajectory. This instrument has been used in a variety of field campaigns in various forms, including DC3 (Waugh et al. 2018, 2022) and BLOWN-UNDER (Kennedy et al. 2021), as well as several local deployments (Waugh et al. 2015). For more detailed information regarding the history, design considerations, construction, etc., the reader is referred to Waugh 2016 for an extensive overview of the instrument in its entirety.

At its core, the PASIV collects data by taking images of precipitation particles inside a known volume as the instrument rises through the environment. As such, the observational capacity of the instrument is determined by the resolution of the camera. For the PASIV, this is utilizing a 4k machine vision camera from XIMEA. With the current design the sampling volume is approximately 29x20X11.5 cm and the system is capable of resolving particles on the order of 100 µm at a rate of 15-20 frames per second. This allows successive non-overlapping images of particles during ascent assuming an average ascent speed of 5 m/s.

For questions, comments, concerns, or more information, contact the following individuals:
NSSL/Field Observation Facilities Support (FOFS) PASIV Lead: Sean Waugh (sean.waugh@noaa.gov)

3. Data Collection and Processing

Data collection on the PASIV is entirely on-board, meaning that the instrument must be recovered in order to retrieve the data. The files are created in real time using the proprietary XIMEA camera control system and stored as a raw binary file on the on-board SSD. This saves a significant amount of real-time processing and allows the images to be recorded directly to the SSD at a much faster rate, allowing for the necessary frame rate. Once recovered, these files must first be converted into byte data using the XIMEA image processing tool box. Once the files have been converted to byte data, a custom MATLAB script is run to convert the byte files into actual image files that can be viewed and processed. This process is done pixel by pixel for each image, and takes into account the camera settings to properly recreate the image at the correct bit depth.

The processing of the images files at this point to retrieve the particle information involves a custom script (currently written in IDL) that automatically examines each image, identifies objects, and collects information about the object such as size, shape, orientation, etc. and stores that information for each object in each image of the data set. This script is currently being rewritten to more accurately resolve particles, and this processed data will be included in an update to this archive at a later date. For now, this document describes only the creation and archive of the images themselves.

4. Data Format

The files archived here follow a general naming convection to specify the order in which the files were collected and where/when physically the files were collected. Each file has the following general structure:

Converted_YYYY-MM-DD-hh-mm-ss_lat_lon_alt_NNNNN.png

YYYY:	4 digit year corresponding to the IOP date
MM:	2 digit month corresponding to the IOP date
DD:	2 digit day of month corresponding to the IOP date
hh:	2 digit hour, in UTC

mm: 2 digit minute, in UTC
ss: 2 digit second, in UTC
lat: Latitude of the PASIV at the time of the image, using GPS
lon: Longitude of the PASIV at the time of the image, using GPS
alt: Altitude of the PASIV at the time of the image, using GPS
NNNNN: a running numeric indicator of image sequence, starting at 00000

Each file is a .png to be easily viewable on a variety of platforms and programs and to minimize compression loss. The frequency of images varies slightly throughout the flight, but is generally between 15-20 frames per second. The GPS onboard the PASIV is sampled once per second, thus files collected within a single second window will have the same location information. The GPS can take some time to lock on to a signal, and drops out during flight on occasion depending on conditions. Lat/lon/alt will be replaced by NAN in these scenarios.

Generally speaking, the camera is started on the ground and confirmation of a running program is required before launching the PASIV to avoid wasted flights containing no data. Due to this procedure, there is often data collected at the ground prior to launch. The final step before launch is activating the LED lights. Therefore the beginning of each IOP usually contains some amount of data of “blank” images after the camera has begun collecting data but before the LED’s have been turned on and flight began. These images are included in the archive for completeness.

A note about the file names. As mentioned, the GPS often takes some amount of time to register its actual time and location. The date/time information is typically the first to lock on (typically within a minute or less), followed by the position information. If the GPS does not have an accurate date/time fix, it will populate the date/time with a default value of January 1, 1970 at 00:00:00 UTC and progress from there. To avoid confusion in the file names, any instances where the date was 1970 have been reset to the actual IOP date at a fixed time of 00:00:00 UTC (to clearly mark that the time is not accurate). For example, a filename originally of:
‘Converted_1970-00-01-00-00-00_nan_nan_nan_00002.png’
would be renamed to:
‘Converted_2022-12-18-00-00-00_nan_nan_nan_00002.png’.
Note that the time reflected in these corrected files will remain at 00:00:00 until the GPS finds an actual time and then will populate with accurate values. Furthermore, the linux subsystem starts counting months at 0 rather than 1, meaning the calendar months range from 0 to 11 (Jan to Dec respectively). In all instances, these month counters have been incremented by 1 to reflect a typical 1-12 numbering system.

Each IOP should contain approximately 40,000 images, and will be available tarred together for ease of download. If there is any question or confusion regarding the file names, please contact the dataset author.

5. Data Remarks

The archive presented here is an archive of the images only. An update to this archive will be completed at a later date when the images are processed and particle counts/stats become available. As such this data set is considered preliminary.

While the PASIV is capable of resolving particles at a fairly small scale, users are cautioned against attempting to discern particles much smaller than 100 µm. While it is likely that the camera, and a human eye, can detect rather small objects on the scale of pixel or two, any automated detection algorithm will be unable to discern those objects from background noise. Furthermore, while the camera is in theory taking non-overlapping images, this is dependent on the vertical ascent speed which can vary. There may be occasions where the images are overlapping in physical space. This creates a possibility, especially for slow falling particles such as snow, for objects to be imaged more than once. It is generally assumed however that this occurs infrequently and is not a major factor in the analysis.

It should also be noted that while the PASIV was flown during IOP5, the let down reel failed to trigger during flight. Thus the PASIV spent the entire duration of the flight located roughly 3.5 m below the base of the balloon. It is likely that the balloon shadowed the instrument considerably and strongly affected the particles sampled. Data or images from IOP5 should be used with caution.

There are occasions where the camera for a number of reasons skips a file creation. This most likely is caused by a slight hang in the program running the camera acquisition or a delay in storage before the next image. The occurrences are rare and typically only last a frame or two before the program resolves. As the raw data failed to record a file, there is no associated image file and no way of recovering the data. Below is a list of files that are not in the archived data for this reason:

IOP5 – December 18th, 2022:

Converted_2022-12-18-00-00-00_nan_nan_nan_00000.png
Converted_2022-12-18-00-00-00_nan_nan_nan_00001.png
Converted_2022-12-18-00-00-00_nan_nan_nan_00007.png
Converted_2022-12-18-00-00-00_nan_nan_nan_00008.png
Converted_2022-12-18-00-00-00_nan_nan_nan_00009.png
Converted_2022-12-18-00-00-00_nan_nan_nan_00183.png
Converted_2022-12-18-00-00-00_nan_nan_nan_00184.png

Converted_2022-12-18-00-00-00_nan_nan_nan_00185.png

6. References

Kennedy, A., Scott, A., Loeb, N., Sczepanski, A., Lucke, K., Marquis, J., & Waugh, S., 2021: Bringing Microphysics to the Masses: The Blowing Snow Observations at the University of North Dakota: Education through Research (BLOWN-UNDER) Campaign, *Bulletin of the American Meteorological Society* (published online ahead of print 2021). Retrieved Sep 20, 2021, from https://journals.ametsoc.org/view/journals/bams/aop/BAMS-D-20-0199.1/BAMS-D-20-0199.1.xml

Waugh, S. M., 2016: A Balloon-borne Particle Size, Imaging, and Velocity Probe for in situ Microphysical Measurements. Ph.D. Dissertation, University of Oklahoma, 214 pp. https://shareok.org/handle/11244/45407

Waugh, S. M., Ziegler, C. L., & MacGorman, D. R., 2018: In situ micro-physical observations of the 29–30 May 2012 Kingfisher, OK, supercell with a balloon-borne video disdrometer. Journal of Geophysical Research: Atmospheres, 123. https://doi.org/10.1029/2017JD027623.

Waugh, S. M., Ziegler, C. L., & MacGorman, D. R., 2020: In situ microphysical observations of a multicell storm using a balloon-borne video disdrometer during Deep Convective Clouds and Chemistry. *Journal of Geophysical Research: Atmospheres*, **125**. https://doi.org/10.1029/2020JD032394

Waugh, Sean M., Conrad L. Ziegler, Donald R. MacGorman, Sherman E. Fredrickson, Doug W. Kennedy, and W. David Rust, 2015: A Balloonborne Particle Size, Imaging, and Velocity Probe for in Situ Microphysical Measurements. *J. Atmos. Ocean. Tech.*, **32:9**, 1562-1580.