



Data User Guide

GPM Ground Validation NCAR Particle Probes IPHEX

Introduction

The GPM Ground Validation NCAR Particle Probes IPHEX dataset consists of Ice Water Content (IWC), particle number concentration normalized by bin width, and total particle number concentration data that were collected from three particle probes onboard the University of North Dakota (UND) Citation II aircraft during the Global Precipitation Mission (GPM) Ground Validation Integrated Precipitation and Hydrology Experiment (IPHEX). These instruments include the PMS Two-Dimensional Cloud probe (2D-C), the SPEC Two-Dimensional Stereo probe (2D-S), and the SPEC High Volume Precipitation Spectrometer version 3 (HVPS-3). The IPHEX campaign took place in North Carolina with the goal of evaluating the accuracy of satellite precipitation measurements and using the collected data for hydrology models in the region. The campaign's intense study period occurred from May 1 through June 15, 2014. All instruments are two-dimensional optical array probes which record images of particles that travel through the sampling area. The data files are available from May 9 through June 12, 2014 in ASCII format using the NASA Ames format specification. Browse images of instrument array 5-sec measurements are available in PNG format.

Notice:

Since flights did not occur each day of the IPHEX campaign, data are only available on aircraft flight days.

Citation

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Keywords:

NASA, GHRC, GPM GV, IPHEX, North Carolina, 2D-C, PMS Two-Dimensional Cloud probe, 2D-S, SPEC Two-Dimensional Stereo probe, HVPS-3, SPEC High Volume Precipitation Spectrometer 3, particle probes, NCAR, NOAA, ice water content, IWC, particle number concentration

Campaign

The NASA Global Precipitation Measurement (GPM) mission Ground Validation (GV) campaign used a variety of methods for validation of GPM satellite constellation measurements prior to and after launch on the GPM Core Satellite, which launched on February 27, 2014. The instrument validation effort included numerous GPM-specific and joint-agency/international external field campaigns, using state of the art cloud and precipitation observational infrastructure. These field campaigns accounted for the majority of the effort and resources expended by the GPM GV mission. More information about the GPM GV mission is available at the [PMM Ground Validation webpage](#).

One of the GPM GV field campaigns was the Integrated Precipitation and Hydrology Experiment (IPHEX), which was held in North Carolina during 2014 with an intense study period from May 1 to June 15, 2014. The goals of the IPHEX field campaign were to characterize warm season orographic precipitation regimes and hydrologic processes in regions of complex terrain, to contribute to the development, evaluation, and improvement of remote sensing precipitation algorithms in support of the GPM mission, and to evaluate Quantitative Precipitation Estimation (QPE) products for hydrological forecasting and water resource applications in the Upper Tennessee, Catawba-Santee, Yadkin-Pee Dee, and Savannah river basins (IPHEX-HAP, H4SE) in conjunction with the NOAA Hydrometeorology Testbed project. More information about IPHEX is available on the [GPM IPHEX Field Campaign webpage](#), the [GHRC IPHEX Field Campaign project homepage](#), and in the [GHRC IPHEX Field Campaign micro article](#).

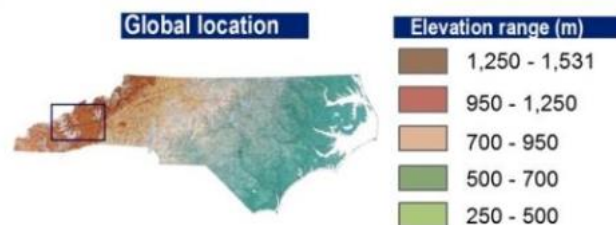


Figure 1: Region of North Carolina IPHEX campaign ground validation
(Image source: [IPHEX Science Plan](#))

Instrument Description

This National Center for Atmospheric Research (NCAR) particle probe dataset consists of data collected from three instruments onboard the University of North Dakota (UND) Cessna Citation II Aircraft (Figure 2): the PMS Two-Dimensional Cloud probe (2D-C), the SPEC Two-Dimensional Stereo probe (2D-S), and the SPEC High Volume Precipitation

Spectrometer version 3 (HVPS-3). All instruments are two-dimensional optical array probes which record images of particles that travel through the instrument sampling area. The recorded images are then analyzed to produce particle size distributions from 50 microns to 3 cm in diameter.

The 2D-C instrument is a cloud particle imaging probe that has a 32-element diode array with 30 microns per pixel. The 2D-C was oriented vertically for all flights for this dataset. More information about the 2D-C instrument is available on the [NASA Airborne Science Program 2D-C webpage](#).

The 2D-S instrument is a cloud particle imaging probe that consists of two 128-element diode arrays with 10 microns per pixel that record particles in both vertical (imaging the top view) and horizontal (imaging the side view) orientation. The vertical and horizontal orientation data are separated in this dataset. More information about the 2D-S instrument is available on the [NASA Airborne Science Program 2D-S webpage](#).

The HVPS-3 instrument is a newer version of the HVPS-2 particle probe used on previous field campaigns. The HVPS-3 probe consists of a 128-element array with 150 microns per pixel and can completely image particles up to 1.92 cm. Even larger particles can be sized in the direction of flight. The sample volume of the HVPS-3 is 400 L s^{-1} at 100 m s^{-1} . The HVPS-3 was oriented vertically for IPHEX flights between May 9 and May 29, 2014 and then rotated to a horizontal orientation for flights between June 5 and June 12, 2014. The 2D-S and the HVPS-3 make an excellent pair of probes that completely image particles from 10 microns to 1.92 cm. More information about the HVPS-3 instrument is available on the [NASA Airborne Science Program HVPS webpage](#).

The UND Cessna Citation II Research Aircraft is owned and operated by the University of North Dakota and is a twin-engine fanjet with an operating ceiling altitude of 13 km. The turbofan engines provide sufficient power to cruise at speeds of up to 175 m s^{-1} or climb at 16.8 m s^{-1} . These high performance capabilities are accompanied by relatively low fuel consumption at all altitudes, giving the UND Citation II aircraft an on-station time of three to five hours, depending on the mission type. Long wings allow it to be operated out of relatively short airstrips and to be flown at the slower speeds (72 m s^{-1}) necessary for many types of measurements. More information on the UND Cessna Citation II is available on the [UND Citation Research Aircraft webpage](#).

Exterior Instrumentation Spring 2014

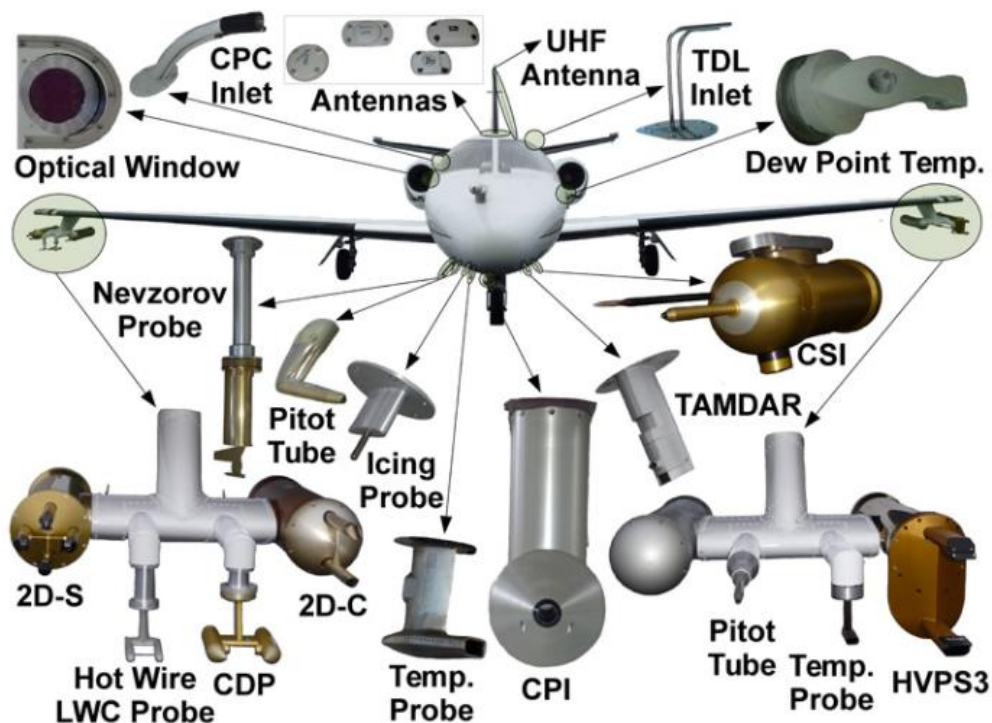


Figure 2: Positioning of the 2D-C, 2D-S, and HVPS-3 particle probes on the UND Citation aircraft during the time of IPHEX

(Image source: [UND Aerospace Citation Instrumentation webpage](#))

Investigators

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Data Characteristics

The GPM Ground Validation NCAR Particle Probes IPHEX dataset consists of Ice Water Content (IWC), particle number concentration normalized by bin width, and total particle number concentration data collected by three different two-dimensional optical array probes onboard the UND Citation II aircraft. These data files are written in ASCII format using the NASA Ames format specification, along with browse imagery stored in PNG

format. More information on the NASA Ames file format can be found in the [ASCII File Format Specification for Data Exchange documentation](#). These data are available at a Level 2 processing level. More information about the NASA data processing levels is available on the [EOSDIS Data Processing Levels webpage](#). The characteristics of this dataset are listed in Table 1 below.

Table 1: Data Characteristics

Characteristic	Description
Platform	UND Cessna Citation II Research Aircraft
Instrument	Two-dimensional cloud probe (2D-C) Two-dimensional stereo probe (2D-S) High Volume Precipitation Spectrometer version 3 (HVPS-3)
Spatial Coverage	N: 36.484, S: 30.397, E: -75.323, W: -84.934 (Southeast United States)
Spatial Resolution	2D-C: 32-element diode array, 30 microns per pixel 2D-S: Two 128-element diode arrays, 10 microns per pixel, at Vertical orientation (V) and Horizontal orientation (H) HVPS-3: 128-element diode array, 150 microns per pixel, V or H
Temporal Coverage	May 9, 2014 - June 12, 2014
Temporal Resolution	Daily (per flight which can extend past calendar day)
Sampling Frequency	1 second
Parameter	Ice water content, particle number concentration normalized by bin width, and total particle number concentration
Version	1
Processing Level	2

File Naming Convention

The GPM Ground Validation NCAR Particle Probes IPHEX dataset files are named using the following convention:

Data files:

<YYYYMMDD>_<hhmmss>.<instr>.1Hz

Browse files:

<YYYYMMDD>_<hhmmss>_<instr>.png

Table 2: File naming convention variables

Variable	Description
YYYY	Four-digit year
MM	Two-digit month
DD	Two-digit day
hh	Two-digit hour in UTC
mm	Two-digit minute in UTC
ss	Two-digit second in UTC

instr	Instrument used when taking measurements: <i>2DC, 2DS_H, 2DS_V, HVPS3, or comb.spectrum</i> for data files <i>2DC7, 2DS_H, 2DS_V, or HVPS3</i> for browse files (See the “Data Format and Parameters” section for details on each file type)
.1Hz	ASCII file using the NASA Ames format specification
.png	Portable Network Graphics (PNG) file format

Data Format and Parameters

The GPM Ground Validation NCAR Particle Probes IPHEX dataset consists of the particle number concentration normalized by the bin width in m^{-4} , the total particle number concentration above 100 microns per m^3 , and the IWC that was derived from the particle size distribution integration in g/m^3 . The total number concentration (Nt) given in the files is for particles larger than 100 microns for the 2D-C and 2D-S instruments, and larger than 1mm for the HVPS-3 instrument. The particle size distributions are given in terms of particle diameter, which is defined as the diameter of the smallest circle that can completely enclose the particle image.

The data files are written in ASCII format using the NASA Ames format specification. More information on the NASA Ames file format can be found in the [ASCII File Format Specification for Data Exchange documentation](#). Data files consist of a header followed by the platform data. The header includes investigators' information and affiliation, information about the parameters collected, and the data field titles for each column in the dataset. Bad or missing data are flagged with $9.99\text{e}+30$. Within the data portion of the ASCII file, there are 31 columns. Each column is described in Table 3 below.

Table 3: NCAR Particle Probe ASCII File Data Fields

Column #	Field Name	Description	Unit
1	Time	Time (in seconds UTC) of the start of the measurement interval	seconds
2	Nt	Total number concentration	$\#/\text{m}^3$
3	IWC	Bulk ice water content	g/m^3
4-31	Concentration	Particle number concentration normalized by bin width for each particle size bin. The bins vary by instrument with bin size details given in the header of each file.	m^{-4}

The vertical and horizontal orientation readings from the 2D-S instrument are stored in two separate files in this dataset. The HVPS-3 instrument was oriented vertically for flights between May 9 and May 29, 2014 and was then rotated to a horizontal orientation for flights between June 5 and June 12, 2014. The 2D-C instrument was oriented vertically for all flights.

For each Citation II aircraft flight, a “comb.spectrum” file is available that was created by combining a small-particle instrument measurement, such as 2DS-H or 2DS-V, for particles smaller than 1 mm in diameter with measurements from the HVPS-3 V or H for particles larger than 1 mm in diameter. The combination was created using 2DS-V when the HVPS-3 was oriented vertically, and the 2DS-H when the HVPS-3 was oriented horizontally.

Browse Imagery

The GPM Ground Validation NCAR Particle Probes IPHEX browse imagery are available as PNG files. The browse images contain 1 minute of flight time measurements in 5 second panels. Many images are not shown and one should contact the PI for more information.

Algorithm

The IWC was derived in the size distribution files for the convenience of data users, using a mass-size parameterization of $mass = 0.0061 * D^{2.05}$ from [Heymsfield et al. \(2004\)](#).

Quality Assessment

Concentrations for particles smaller than 100 microns may contain large errors due to uncertainties in the probe’s sample area; therefore, particles smaller than 100 microns are not included in measurements. Also, images that touch a side of the array are allowed. The technique described in [Field et al. \(2006\)](#) has been applied to mitigate shattering artifacts on the 2D-C and 2D-S instruments. These instruments also had modified probe tips to minimize the amount of shattering.

The IWC algorithm has been indiscriminately applied, and will not be valid in cases of rain, graupel, or ice habits that are not well represented by this mass-size parameterization.

Software

No special software is required to read the GPM GV NCAR Particle Probes IPHEX dataset files. These ASCII files can be viewed in any text editor or spreadsheet software such as Notepad++ or Microsoft Excel.

Known Issues or Missing Data

Since data files and browse files are organized by flight, both files for May 23, 2014 extend beyond midnight into May 24, 2014. Note that the date in the file does not change, so the time adjusts to show hours 24 and 25 as the data continue until 01:14 am of May 24th. The metadata for the granule file has been adjusted to show the calendar date associated with the time within the file. Use of the file contents would require special handling by the user or software. In addition, flights did not occur each day of the campaign, therefore data are only available on flight days. Bad or missing data are flagged with $9.99e+30$ within the dataset.

References

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Lawson, R. P., O'Connor, D., Zmarzly, P., Weaver, K., Baker, B., Mo, Q., & Jonsson, H. (2006). The 2D-S (Stereo) Probe: Design and Preliminary Tests of a New Airborne, High-Speed, High-Resolution Particle Imaging Probe. *Journal of Atmospheric and Oceanic Technology*, 23, 1462-1477. <https://doi.org/10.1175/JTECH1927.1>

Related Data

All data from other instruments collected during the IPHEX field campaign are related to this dataset. Other IPHEX campaign data can be located by searching the term "IPHEX" in the GHRC [HyDRO 2.0](#) search tool. Two closely related IPHEX datasets are listed below.

GPM Ground Validation UND Citation Cloud Microphysics IPHEX
(<http://dx.doi.org/10.5067/GPMGV/IPHEX/MULTIPLE/DATA201>)

GPM Ground Validation Citation Videos IPHEX
(<http://dx.doi.org/10.5067/GPMGV/IPHEX/CAMERA/DATA101>)

Other NCAR Particle Probes datasets can be located by searching the term "NCAR Particle Probes" in [HyDRO 2.0](#) and are listed below.

NCAR Particle Probes IMPACTS
(<http://dx.doi.org/10.5067/IMPACTS/PROBES/DATA101>)

GPM Ground Validation NCAR Particle Probes OLYMPEX
(<http://dx.doi.org/10.5067/GPMGV/OLYMPEX/PROBES/DATA201>)

GPM Ground Validation NCAR Cloud Microphysics Particle Probes GCPEX
(<http://dx.doi.org/10.5067/GPMGV/GCPEX/MUTIPLE/DATA201>)

GPM Ground Validation NCAR Cloud Microphysics Particle Probes MC3E

<http://dx.doi.org/10.5067/GPMGV/MC3E/MULTIPLE/DATA202>)

Contact Information

To order these data or for further information, please contact:

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