Global Hydrology Resource Center

Data User Guide

GPM Ground Validation NCAR Particle Probes OLYMPEX

Introduction

The GPM Ground Validation NCAR Particle Probes OLYMPEX dataset consists of ice water content, particle concentration normalized by bin width, and total particle concentration collected from three instruments flown on the University of North Dakota (UND) Citation aircraft during selected dates in November and December 2015. The PMS Two-Dimensional Cloud probe (2D-C), the SPEC Two-dimensional Stereo probe (2D-S), and two SPEC High Volume Precipitation Spectrometer 3 (HVPS-3) instruments were used in the Global Precipitation Mission (GPM) Olympic Mountains Experiment (OLYMPEX) campaign. All instruments are two-dimensional optical array probes which record images of particles that travel through the sampling area. Data files are available in ASCII format, and browse images are available in PNG format.

Notice: Bad or missing data are flagged with 9.99e+30 within the dataset.

Citation

Heymsfield, Andrew, Aaron Bansemer, and Michael Poellot. 2017. GPM Ground Validation NCAR Particle Probes OLYMPEX [indicate subset used]. Dataset available online from the NASA EOSDIS Global Hydrology Resource Center Distributed Active Archive Center, Huntsville, Alabama, U.S.A. doi: http://dx.doi.org/10.5067/GPMGV/OLYMPEX/PROBES/DATA201

Keywords:

NASA, GHRC, OLYMPEX, Washington, NCAR, Particle probes, 2DS, 2DC, Cloud probe, HVPS, UND Citation II, cloud liquid water, ice water content, cloud droplet concentration, cloud droplet size, particle size distribution

Campaign

The Global Precipitation Measurement (GPM) mission Ground Validation campaign used a variety of methods for validation of GPM satellite constellation measurements prior to and

after launch of 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 (polarimetric radars, profilers, rain gauges, and disdrometers). Surface rainfall was measured by very dense rain gauge and disdrometer networks at various field campaign sites. These field campaigns accounted for the majority of the effort and resources expended by GPM GV. More information about the GPM mission is available at https://pmm.nasa.gov/GPM/.

One of the GPM Ground Validation field campaigns was the Olympic Mountains Experiment (OLYMPEX) which was held in the Pacific Northwest. The goal of OLYMPEX was to validate rain and snow measurements in midlatitude frontal systems as they move from ocean to coast to mountains and to determine how remotely sensed measurements of precipitation by GPM can be applied to a range of hydrologic, weather forecasting, and climate data. The campaign consisted of a wide variety of ground instrumentation, several radars, and airborne instrumentation monitoring oceanic storm systems as they approached and traversed the Peninsula and the Olympic Mountains. The OLYMPEX campaign was part of the development, evaluation, and improvement of GPM remote sensing precipitation algorithms. More information is available from the NASA GPM Ground Validation web site https://pmm.nasa.gov/olympex and the University of Washington OLYMPEX web site http://olympex.atmos.washington.edu/.

Figure 1: OLYMPEX Domain
(Image Source: https://pmm.nasa.gov/OLYMPEX)

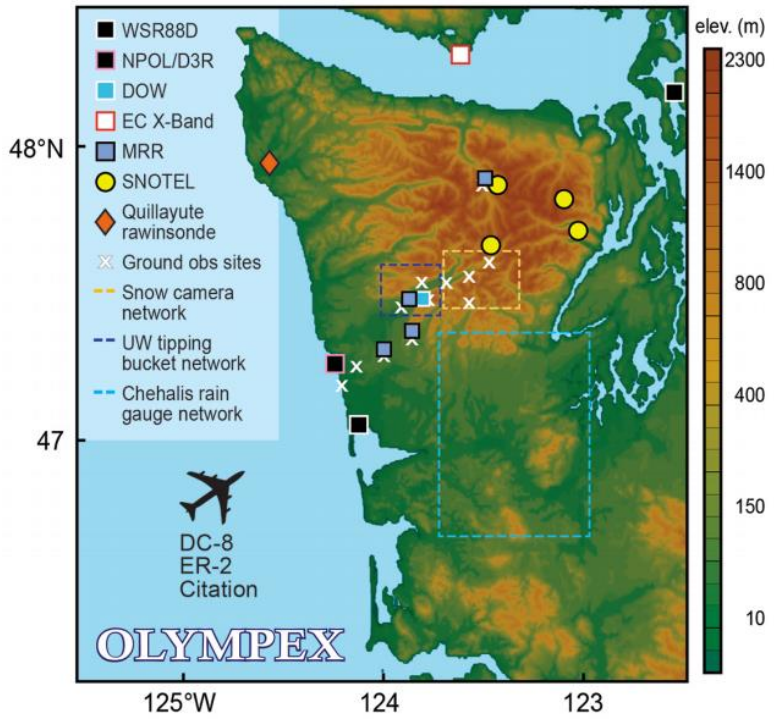

Figure 2: OLYMPEX Field Locations
(Image Source: https://pmm.nasa.gov/OLYMPEX)

Instrument Description

This NCAR particle probe dataset consists of data collected from three instruments onboard the UND Cessna Citation II Aircraft: the 2D-C, the 2D-S, and two 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 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 13km. 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 Cessna Citation II Research Aircraft an on-station time of 3 to 5 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 at http://cumulus.atmos.und.edu/.

The 2D-S instrument on the UND Cessna Citation II Research Aircraft 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 considered as two separate instruments in this dataset.

The 2D-C 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.

The HPVS-3 instrument is a newer version of the HPVS-2 particle probe used on previous field campaigns. The HPVS-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. Sample volume of the HVPS-3 is 400 L s-1 at 100 m s-1. There were two HPVS-3 instruments placed on the Citation for OLYMPEX, one in the horizontal orientation (HVPS3A) and one in the vertical orientation (HVPS3B). The HVPS3A probe was rotated to the vertical position on the two flights on December 18, 2015 for comparison with the HVPS3B probe.

The 2D-S and the two HVPS-3 make an excellent pair of probes that completely image particles from 10 microns to 1.92 cm.

Previous positioning of the 2D-S, 2D-C, and HVPS-3 particle probes on the Citation aircraft is shown at http://airborneresearch.atmos.und.edu/Instrumentation/external14F.aspx. Some of the positioning has been changed for OLYMPEX. For instance, there are two HVPS-3 instruments.

Investigators

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Data Characteristics

The GPM Ground Validation NCAR Particle Probes OLYMPEX data are available in ASCII (NASA Ames format specification) files for the data processing level 2. The browse images are tarred files which contain PNG format files of particle probe plots over a one minute flight time. More information about the NASA data processing levels are available here.

Table 1: Data Characteristics

Characteristic	Description
Platform	UND Cessna Citation II Research Aircraft
Instruments	2D Cloud Probe (2D-C) 2D Stereo Particle Probe (2D-S) High Volume Particle Sampler (HVPS-3)
Projection	n/a
Spatial Coverage	N: 48.354 , S: 46.221, E: -97.181, W: -126.129 (Washington)
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, two on aircraft, one with vertical (A) and one with horizontal (B) orientation
Temporal Coverage	November 12, 2015 - December 20, 2015
Temporal Resolution	Daily (per flight which can extend past calendar day)
Sampling Frequency	1 second
Parameter	Ice water content, particle 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 OLYMPEX dataset has the naming conventions shown below. The data files are available in NASA Ames specification ASCII file format, and the browse images are available in PNG format.

Data files: YYYYMMDD_hhmmss.inst.1HZ
Tarred Browse files: YYYYMMDD_hhmmss.inst.images.tar
Untarred Browse files: MMDDYYYY_hhmmss_inst.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
inst	Instrument used when taking measurements: 2DC (2DC7 in browse files), 2DS_H, 2DS_V, HVPS3A, HVPS3B, or comb.spectrum (described below)

.1HZ	ASCII files containing data at 1 second intervals
.tar	Tarred files
.png	Portable Network Graphics (PNG) format

Data Format and Parameters

The vertical and horizontal orientation readings from the 2D-S instrument are considered as two separate instruments in this dataset. The vertical and horizontal HVPS data are actually from two instruments, one positioned for vertical measurement, the other positioned for horizontal measurement. The GPM Ground Validation Particle Probes OLYMPEX data files are in ASCII format using the NASA Ames specification, while the browse images in PNG format contain 1 minute of flight time measurements displayed in 5-second panels.

Data files consist of 37 header lines followed by the aircraft data. The first three header lines consist of investigator information and affiliation. Header lines 4 through 36 consist of information about the parameters collected. The last header line consists of titles for each column in the dataset. Data measurements follow the header. The data columns are described in Table 3. Bad or missing data are flagged with 9.99e+30.

A combined spectrum contains data from both the 2D-S for small particles (<1mm in diameter), and the HVPS-3 instruments for larger particles (>1mm in diameter). Both vertically oriented data were used (2D-Sv and HVPS3B). There is one combined spectrum file for each flight.

The total number concentration (Nt) given in the files is for particles larger than 100 microns for the 2D-C and 2D-S, and larger than 1mm for the HVPS-3.

Table 3: Data Fields

Column Number	Description	Unit
1	Elapsed UTC seconds from 0 hours on day given in DATE	seconds
2	Total concentration above 100 microns	$\#/m^3$
3	Condensed water content from particle size distribution integration	g/m^3
4	Particle number concentration by 50.0 microns	m^{-4}
5	Particle number concentration by 70.0 microns	m^{-4}
6	Particle number concentration by 90.0 microns	m^{-4}
7	Particle number concentration by 112.5 microns	m^{-4}
8	Particle number concentration by 137.5 microns	m^{-4}
9	Particle number concentration by 175.0 microns	m^{-4}
10	Particle number concentration by 225.0 microns	m^{-4}
11	Particle number concentration by 275.0 microns	m^{-4}
12	Particle number concentration by 325.0 microns	m^{-4}
13	Particle number concentration by 437.5 microns	m^{-4}

14	Particle number concentration by 512.5 microns	m^{-4}
15	Particle number concentration by 587.5 microns	m^{-4}
16	Particle number concentration by 662.5 microns	m^{-4}
17	Particle number concentration by 750.0 microns	m^{-4}
18	Particle number concentration by 850.0 microns	m^{-4}
19	Particle number concentration by 950.0 microns	m^{-4}
20	Particle number concentration by 1,100.0 microns	m^{-4}
21	Particle number concentration by 1,300.0 microns	m^{-4}
22	Particle number concentration by 1,500.0 microns	m^{-4}
23	Particle number concentration by 1,700.0 microns	m^{-4}
24	Particle number concentration by 1,900.0 microns	m^{-4}

Algorithm

Condensed water content measurements were computed using mass = 0.0061 * (D^2.05) from Heymsfield et al., 2004.

Quality Assessment

Concentrations from 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 condensed water content 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

Software is not required to read these data since they are in ASCII format.

Known Issues or Missing Data

Bad or missing data are flagged with 9.99e+30.

References

Field, P. R., A. J. Heymsfield, and A. Bansemer (2006): Shattering and Particle Interarrival Times Measured by Optical Array Probes in Ice Clouds. *J. Atmos. Oceanic Technol.*, 23, 1357-1371. doi: https://doi.org/10.1175/JTECH1922.1

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Related Data

All data from other instruments collected during the OLYMPEX field campaign are related to this dataset. Other OLYMPEX campaign data can be located using the GHRC HyDRO 2.0 search tool.

In addition, other data related to NCAR Particle Probes are in previous GPM Ground Validation campaigns. The following datasets are NCAR Particle Probes data from other field campaigns:

GPM Ground Validation NCAR Particle Probes **IPHEx**
(http://doi.org/10.5067/GPMGV/IPHEX/MUTIPLE/DATA201)

Contact Information

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

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