Data User Guide

GPM Ground Validation Two-Dimensional Video Disdrometer (2DVD) OLYMPEX

Introduction

The GPM Ground Validation Two-Dimensional Video Disdrometer (2DVD) OLYMPEX dataset contains information on individual hydrometeors including their size distribution, terminal fall speed, and total concentration collected during the Global Precipitation Measurement mission (GPM) Ground Validation (GV) Olympic Mountains Experiment (OLYMPEX). The OLYMPEX field campaign took place between November 2015 and January 2016, with additional ground sampling continuing through February 2016, on the Olympic Peninsula in the Pacific Northwest of the United States. The purpose of the campaign was to provide ground-validation data for the measurements taken by instrumentation aboard the GPM Core Observatory satellite. The Two-Dimensional Video Disdrometer (2DVD) data were collected from four sites during the campaign. The dataset files are available from October 31, 2015 through January 17, 2016 (though the exact dates may vary per site) in ASCII-tsv format.

Notice:
The collection of the GPM Ground Validation Two-Dimensional Video Disdrometer (2DVD) OLYMPEX dataset included mixed and frozen precipitation. It should also be noted that the SN37 2DVD site stopped operating on December 24, 2015, and had interruptions in the data collection due to power failure and other technical issues, so this site was not ideal and users should be cautious in using SN37 data.

Citation

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http://dx.doi.org/10.5067/GPMGV/OLYMPEX/2DVD/DATA/301

Keywords:
NASA, GHRC, GPM GV, OLYMPEX, Washington, Olympic Peninsula, 2DVD, disdrometer, hydrometeors, raindrop size distribution, equivalent diameter, terminal fall speed, oblateness, liquid water content, precipitation amount, precipitation rate, reflectivity

Campaign
The 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 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 on the NASA PMM GPM webpage.

One of the GPM GV field campaigns was the Olympic Mountains Experiment (OLYMPEX) which was held in the Pacific Northwest (Figure 1). The goal of OLYMPEX was to validate rain and snow measurements in mid-latitude 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 (Figure 2). The OLYMPEX campaign was part of the development, evaluation, and improvement of GPM remote sensing precipitation algorithms. More information about OLYMPEX is available from the NASA GPM OLYMPEX Field Campaign webpage, the University of Washington OLYMPEX website, the GHRC OLYMPEX Field Campaign homepage, and the GHRC OLYMPEX Field Campaign Micro Article.

Figure 1: OLYMPEX Domain
(Image Source: GPM OLYMPEX webpage)

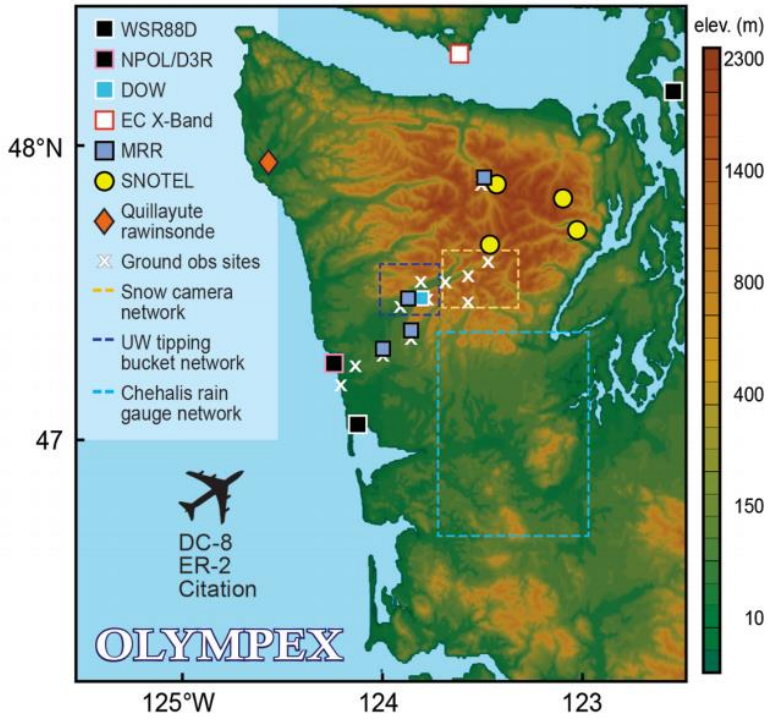

Figure 2: OLYMPEX Field Locations
(Image Source: GPM OLYMPEX webpage)

Instrument Description

The Two-Dimensional Video Disdrometer (2DVD) instrument (Figure 3) uses two high speed line scan cameras to provide continuous measurements of size distribution, shape, and fall velocities of all precipitation particles and types. Two orthogonal light planes, provided by two internal lamps, transect the approximate 10 x 10 cm virtual measurement area and are projected onto two high speed line-scan cameras. Precipitation particles, also known as hydrometeors, that fall through the light planes cast a shadow that is recorded by the two cameras nested within the instrument. Detailed shape and size information for each individual hydrometeor is available through the two "side image shadows" that are recorded by the two cameras. The light planes are separated by a calibrated distance of 6 mm from which the vertical fall velocity can be measured. The line scan cameras sample each plane every 18 microseconds at a horizontal resolution of 200 microns. Therefore, as a raindrop falls through the measurement area, several line scans of each image are recorded from two sides and two different heights. This allows for precise measurements to be made. More information about the 2DVD instrument can be found in Kruger and Krajewski (2002) and in the GHRC 2DVD Instrument Micro Article. During OLYMPEX, there were four 2DVD collection sites. Information about each site is listed in Table 1.

Figure 3: Two-Dimensional Video Disdrometer (2DVD)
(Image Source: GSFC GPM GV webpage)

Table 1: OLYMPEX 2DVD sites and location information

Site	Latitude (°)	Longitude (°)	Range (km) from NPOL	Azimuth (°) from NPOL
SN35 (Fishery)	47.360	-123.993	18.85	060.6
SN36 (Amanda Park)	47.460	-123.890	31.60	049.8
SN37 (Neilton Point)	47.389	-123.867	28.76	064.2
SN38 (Bishop CRN)	47.514	-123.812	39.96	048.6

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Data Characteristics

The GPM Ground Validation Two-Dimensional Video Disdrometer (2DVD) OLYMPEX data consists of information on individual hydrometeors including their size distribution, terminal fall speed, and total concentration in ASCII-tsv format. The files are separated by site, precipitation parameter, and terminal fall speed. The 2DVD ASCII-tsv files are available at a Level 3 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 2 below.

Table 2: Data Characteristics

Characteristic	Description
Platform	Ground-Based, In-Situ
Instrument	Two-Dimensional Video Disdrometer (2DVD)
Spatial Coverage	N: 47.514, S:47.360, E: -123.812, W: -123.993 (Olympic Mountains, Washington)
Spatial Resolution	Point
Temporal Coverage	October 31, 2015 - January 17, 2016
Temporal Resolution	File per parameter, but each file contains the whole campaign of data
Sampling Frequency	18 microseconds
Parameter	Size, equivalent diameter, fall speed, oblateness, cross sectional area, total number of drops, total concentration, liquid water content, rain rate, reflectivity, and rain event characteristics
Version	1
Processing Level	3

File Naming Convention

The GPM Ground Validation Two-Dimensional Video Disdrometer (2DVD) OLYMPEX dataset files are named using the following convention:

Data files:
olympex_2dvd_diameter020.txt
olympex_2dvd_eachdrop_sn##_[50|100]pct.txt
olympex_2dvd_largedrop_sn##_50pct.txt
olympex_2dvd_sn##_[raindsd|rainparameter|raintotalhour]_[50pct|100pct].txt
olympex_2dvd_sn##_[raindsd|rainparameter]_[50pct|100pct]_ter.txt

Table 3: File naming convention variables

Variable	Description
sn##	Site number (35, 36, 37, or 38)
[50pct|100pct]	50pct: If the drop fall is outside the ±50% of its terminal fall speed, it is considered as a secondary drop and eliminated from the processing 100pct: all drops less than 10.0 mm in diameter are included in this file
.txt	ASCII-tsv text file

Data Format and Parameters

The GPM Ground Validation Two-Dimensional Video Disdrometer (2DVD) OLYMPEX data files are separated by site, precipitation parameter, and terminal fall speed. Each file type is described in detail below:

olympex_2dvd_eachdrop_sn##_100pct.txt
For *olympex_2dvd_eachdrop_sn##_100pct.txt files*, all drops less than 10.0 mm in diameter are included. There are 10 columns within these files and each column is described in Table 4.

olympex_2dvd_eachdrop_sn##_50pct.txt
For *olympex_2dvd_eachdrop_sn##_50pct.txt* files, the rain drops following ±50% of the terminal fall speed limit are screened. If the drop fall is outside the ±50% of its terminal fall speed, it is considered as a secondary drop and eliminated from the processing. There are 10 columns within these files and each column is described in Table 4.

olympex_2dvd_largedrop_sn##_50pct.txt
For *olympex_2dvd_largedrop_sn##_50pct.txt* files, drops following ±50% terminal fall speed limit are screened. If the drop fall is outside the ±50% of its terminal fall speed, it is regarded as a secondary drop and eliminated from the processing. Drops greater or equal to 5.0 mm in diameter are included in these files. There are 10 columns within these files and each column is described in Table 4.

Table 4: Description of each column within *olympex_2dvd_eachdrop_sn##_100pct.txt*, *olympex_2dvd_eachdrop_sn##_50pct.txt*, and *olympex_2dvd_largedrop_sn##_50pct.txt* files

Column	Description	Unit
1	Year	-
2	Day of the year	-
3	Hour	hour
4	Minute	minute
5	Second	second
6	Drop equivalent diameter	mm
7	Measured drop fall velocity	m/s
8	Terminal fall speed	m/s
9	Measured drop oblateness	-
10	Sampling cross section	mm^2

olympex_2dvd_diameter020.txt

The *olympex_2dvd_diameter020.txt* file presents the midsize diameter, bin width size (0.2 mm), and terminal fall speed velocity measurements following Beard et al. (1976) for 50 size bins from 0 to 10.0 mm. It should be noted that the terminal fall speeds are interpolated for the drops between 6.0 and 8.0 mm in diameter using measured fall speed increments just under 6.0 mm in diameter and assumed constant for the drops larger than 8.0 mm in diameter. The three columns within this file are described in Table 5.

Table 5: Description of each column within *olympex_2dvd_diameter020.txt* file

Column	Description	Unit
1	Midsize diameter	mm
2	Size bin width	mm
3	Terminal fall velocity	m/s

olympex_2dvd_sn##_raindsd_100pct.txt

The *olympex_2dvd_sn##_raindsd_100pct.txt* files use the *olympex_2dvd_eachdrop_sn##_100pct.txt* files as input and then output a 50 size bin raindrop size distribution in number of drops per cubic meter of air per mm for 0.2 mm size width from 0 to 10.0 mm in diameter. The output file is generated for each minute where at least 10 drops were observed and a minimum rain rate of 0.01 mm/hr is considered as an event. The size distribution calculation is based on observed fall speed. Table 6 describes each of the 54 columns contained within each file.

olympex_2dvd_sn##_raindsd_100pct_ter.txt

The *olympex_2dvd_sn##_raindsd_100pct_ter.txt* files use *olympex_2dvd_eachdrop_sn##_100pct.txt* files as input and then output a 50 size bin raindrop size distribution in number of drops per cubic meter of air per mm for 0.2 mm size width from 0 to 10.0 mm in diameter. The output file is generated for each minute where at least 10 drops were observed and a minimum rain rate of 0.01 mm/hr is

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olympex_2dvd_sn##_raindsd_50pct_ter.txt
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Table 6: Description of each column within *olympex_2dvd_sn##_raindsd_50pct_ter.txt*, *olympex_2dvd_sn##_raindsd_100pct_ter.txt*, *olympex_2dvd_sn##_raindsd_50pct.txt*, and *olympex_2dvd_sn##_raindsd_100pct.txt* files

Column	Description	Unit
1	Year	-
2	Day of the year	-
3	Hour	hour
4	Minute	minute
5-54	Raindrop concentration in each of the 50 diameter bins (0-10.0 mm spaced every 0.2 mm: 0.2, 0.4, 0.6, …, 10.0); each minute rain was detected	Number of drops/m^3/mm

olympex_2dvd_sn##_rainparameter_100pct.txt
The *olympex_2dvd_sn##_rainparameter_100pct.txt* files use the *olympex_2dvd_eachdrop_sn##_100pct.txt* files as input, and the output is the integral rain parameters based on measured fall velocities at 1-minute integration. The files consist of 13 columns, and it should be noted that total concentration, liquid water content, reflectivity in Rayleigh regime, and mass-weighted drop diameter require fall speed information in their formulations. More information on the disdrometer-based calculation of integral rain parameters can be found in Tokay et al. (2001). Table 7 describes each column within these files.

olympex_2dvd_sn##_rainparameter_100pct_ter.txt

The *olympex_2dvd_sn##_rainparameter_100pct_ter.txt* files use *olympex_2dvd_eachdrop_sn##_100pct.txt* files as input, and the output is the integral rain parameters based on terminal fall velocities at 1-minute integration. Table 7 describes each column within these files.

olympex_2dvd_sn##_rainparameter_50pct.txt
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Table 7: Description of each column within *olympex_2dvd_sn##_rainparameter_100pct.txt*, *olympex_2dvd_sn##_rainparameter_100pct_ter.txt*, *olympex_2dvd_sn##_rainparameter_50pct.txt*, and *olympex_2dvd_sn##_rainparameter_50pct_ter.txt* files

Column	Description	Unit
1	Year	-
2	Day of the year	-
3	Hour	hour
4	Minute	minute
5	Total number of drops	-
6	Total concentration	drops m^{-3} of air
7	Liquid water content	g/m^3
8	Rain rate	mm/h
9	Reflectivity in Rayleigh regime	dBZ
10	Mass-weighted drop diameter	mm
11	Maximum drop diameter	mm
12	Minimum drop diameter	mm
13	Standard deviation of the mass-weighted drop diameter following Ubrich and Atlas (1998)	-

olympex_2dvd_sn##_raintotalhour_100pct.txt
The *olympex_2dvd_sn##_raintotalhour_100pct.txt* files use *olympex_2dvd_sn##_rainparameter_100pct.txt* files as input and provide the rain event summaries. The events are separated by 1-hour-or-more rain-free periods in rain rate time

series. Events that are less than 3 minutes in duration or with rain totals less than 0.1 mm are not included. The files consist of 10 columns, which are described in Table 8.

olympex_2dvd_sn##_raintotalhour_50pct.txt
The *olympex_2dvd_sn##_raintotalhour_50pct.txt* files use *olympex_2dvd_sn##_rainparameter_50pct.txt* files as input and provide the rain event summaries. The events are separated by 1-hour-or-more rain-free periods in rain rate time series. Events that are less than 3 minutes in duration or with rain totals less than 0.1 mm are not included. The files consist of 10 columns, which are described in Table 8.

Table 8: Description of each column within *olympex_2dvd_sn##_raintotalhour_100pct.txt* and *olympex_2dvd_sn##_raintotalhour_50pct.txt* files

Column	Description	Unit
1	Year	-
2	Event start day of the year	-
3	Event start hour and minute in *HH:MM* where HH=hour and MM=minute	hour and minute
4	Event end day of the year	-
5	Event end hour and minute in *HH:MM* where HH=hour and MM=minute	hour and minute
6	Event rainy minutes	minutes
7	Event maximum rain rate	mm/h
8	Event rain total	mm
9	Event maximum drop diameter	mm
10	Precipitation type: R = rain S = snow	-

Algorithm
The fall velocity for each drop was calculated by using the time it takes for the drop to enter into the measurement plane of Camera A, the time proceeding from the upper Camera A to the lower Camera B, and the time the drop enters into the measurement plane of Camera B of the instrument, as well as the distance between the two cameras. More information about these calculations is available in Schönhuber et al. (2008).

Quality Assessment
The 2DVD instrument is calibrated by measuring spheres with known diameter provided by the manufacturer. Software was provided to ensure proper alignment for the 2DVD apparatus. The manufacturer also has software available that uses an algorithm to correct measurements for horizontal movement of the precipitation particles. In this dataset, raindrops exceeding 50% of their terminal fall speed are removed to eliminate spurious measurements, such as insects or splash drops. Also, minutes during a rain event with

fewer than 10 drops and a rainfall rate less than 0.01 mm hr^{-1} are removed to eliminate noise.

Within the *olympex_2dvd_eachdrop_sn##_100pct.txt* and *olympex_2dvd_eachdrop_sn##_50pct.txt* files, note that the precise measurement of oblateness and fall speed was not achieved due to severe wind conditions and the change of instrument calibration during the field campaign, as compared with the 80 m fall experiment described in Thurai et al. (2007).

Software

No special software is required to read the 2DVD OLYMPEX data files. These ASCII-tsv files can be viewed in any text editor or spreadsheet software such as Notepad++ or Microsoft Excel.

Known Issues or Missing Data

The collection of the GPM Ground Validation Two-Dimensional Video Disdrometer (2DVD) OLYMPEX dataset includes mixed and frozen precipitation. SN35 had no snow days. SN36 had some mixed precipitation between December 23-27, 2015, while SN38 had mixed precipitation between December 23-28, 2015. SN37 was located at a relatively higher elevation and had snow measurements on November 15-16, November 19, November 24, November 30, December 12, December 17, and December 19-23 of 2015. The SN37 site stopped operating on December 24, 2015, and had interruptions in the data collection due to power failure and other technical issues.

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Related Data

All data collected during the OLYMPEX field campaign should be considered related datasets. These data can be located using HyDRO 2.0 with the search term 'OLYMPEX'. In addition, the 2DVD instrument was used in other field campaigns. These data can be located by searching '2DVD' in HyDRO 2.0 and are listed below:

Two-Dimensional Video Disdrometer (2DVD) IMPACTS (http://dx.doi.org/10.5067/IMPACTS/2DVD/DATA101)

GPM Ground Validation Two-Dimensional Video Disdrometer (2DVD) IPHEx (http://dx.doi.org/10.5067/IPHEX/2DVD/DATA301)

GPM Ground Validation Two-Dimensional Video Disdrometer (2DVD) IFloodS (http://dx.doi.org/10.5067/GPMGV/IFLOODS/2DVD/DATA301)

GPM Ground Validation Two-Dimensional Video Disdrometer (2DVD) HyMeX (http://dx.doi.org/10.5067/GPMGV/HYMEX/2DVD/DATA301)

GPM Ground Validation Two-Dimensional Video Disdrometer (2DVD) GCPEx (http://dx.doi.org/10.5067/GPMGV/GCPEX/2DVD/DATA101)

GPM Ground Validation Two-Dimensional Video Disdrometer (2DVD) MC3E (http://dx.doi.org/10.5067/GPMGV/MC3E/2DVD/DATA301)

GPM Ground Validation Two-Dimensional Video Disdrometer (2DVD) LPVEx (http://dx.doi.org/10.5067/GPMGV/LPVEX/2DVD/DATA301)

GPM Ground Validation Two-Dimensional Video Disdrometer (2DVD) NSSTC
(http://dx.doi.org/10.5067/GPMGV/NSSTC/2DVD/DATA201)

GPM Ground Validation Two-Dimensional Video Disdrometer (2DVD) WFF V2
(http://dx.doi.org/10.5067/GPMGV/WFF/2DVD/DATA301)

Contact Information

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

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