



Data User Guide

GPM Ground Validation Two-Dimensional Video Disdrometer (2DVD) WFF V2

Introduction

The GPM Ground Validation Two-Dimensional Video Disdrometer (2DVD) WFF data were collected during the Global Precipitation Mission (GPM) Ground Validation (GV) campaign at the NASA Wallops Flight Facility (WFF) in Wallops Island, Virginia. These data consist of the size, equivalent diameter, fall speed, oblateness, cross-sectional area of raindrops, particle concentration, total number of drops, total drop concentration, liquid water content, rain rate, reflectivity, and rain event characteristics. The data are in ASCII format and available from July 24, 2013 through October 5, 2015.

Notice:

This is Version 2, replacing the previous 2DVD WFF dataset published by GHRC in 2016 (DOI for previous version: <http://dx.doi.org/10.5067/GPMGV/WFF/2DVD/DATA201>).

Overall data dates range from July 24, 2013 through October 5, 2015; exact dates may vary per site.

The 2DVDs except SN70 were deployed to the Integrated Precipitation Hydrology Experiment (IPHEX) from April to June 2014 which are therefore not included in this dataset.

If there is no data on a given day, then the instrument was not functioning or rain was not recorded that day.

Citation

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<http://dx.doi.org/10.5067/GPMGV/WFF/2DVD/DATA301>

Keywords:

NASA, GHRC, GPM, Ground Validation, 2DVD, WFF, disdrometer, equivalent diameter, fall speed, oblateness, liquid water content, rain rate, reflectivity, rain events

Campaign

The Global Precipitation Measurement (GPM) mission Ground Validation (GV) campaign used a variety of methods for validating GPM satellite constellation measurements prior to and after launch of the GPM Core Satellite, which occurred on February 27, 2014. The GPM 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/>.

Instrument Description

The 2DVD instrument 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 approximately 10x10cm 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 6mm 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 et al., 2001](#).

These data were collected by six 2DVDs at the NASA Wallops Flight Facility (WFF) in Wallops Island, Virginia (Table 1). Overall data dates range from July 24, 2013 through October 5, 2015; exact dates may vary per site. The 2DVDs except SN70 were deployed to the Integrated Precipitation Hydrology Experiment (IPHEX) from April to June 2014 which are therefore not included in this dataset.



Figure 1: Two-Dimensional Video Disdrometer (2DVD)
(Image Source: <https://wallops-prf.gsfc.nasa.gov/Disdrometer/index.html>)

Table 1: WFF 2DVD sites and location information.

Site	Latitude (°)	Longitude (°)
SN25	37.937N	75.466W
SN35	37.944N	75.481W
SN36	37.944N	75.463W
SN37	37.937N	75.456W
SN38	37.929N	75.473W
SN70	37.934N	75.471W

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Data Characteristics

The GPM GV 2DVD WFF V2 dataset were collected at the NASA Wallops Flight Facility (WFF) in Wallops Island, Virginia in support of the GPM GV campaign. Data files are in

ASCII format and at a Level 2 processing level. More information about the NASA data processing levels are available on the [EOSDIS Data Processing Levels](#) webpage. Table 2 shows the characteristics of this dataset.

Table 2: Data Characteristics

Characteristic	Description
Platform	Ground stations
Instrument	Two-Dimensional Video Disdrometer (2DVD)
Projection	N/A
Spatial Coverage	N: 37.944, S: 37.929, E: -75.457, W: -75.478 (Virginia)
Spatial Resolution	Point
Temporal Coverage	July 24, 2013 - October 5, 2015
Temporal Resolution	File per parameter, but each file contains the whole campaign of data
Sampling Frequency	18 microseconds
Parameter	Drop count, drop size, drop concentration, drop fall velocity, terminal fall velocity, drop oblateness, sampling cross section, liquid water content, rain rate, reflectivity in Rayleigh regime
Version	2
Processing Level	2

File Naming Convention

The GPM GV 2DVD WFF V2 dataset consists of ASCII format data files with the following file naming convention.

Data files: wff_2dvd_eachdrop_sn###_[50pct|100pct].txt
wff_2dvd_largedrop_sn##_50pct.txt
wff_2dvd_sn##_<parameter>.txt
wff_2dvd_diameter020.txt

Table 3: File naming convention variables

Variable	Description
sn##	Site number (25, 35, 36, 37, 38, or 70)
[50pct 100pct]	50pct: If the drop fall is outside the $\pm 50\%$ 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
<parameter>	dropcounts, raindsd, raindsd_ter, rainparameter, rainparameter_ter, raintotalhour
.txt	ASCII format

Data Format and Parameters

The GPM GV 2DVD WFF V2 data consists of the size, equivalent diameter, fall speed, oblateness, cross-sectional area of raindrops, particle concentration, total number of drops, total drop concentration, liquid water content, rain rate, reflectivity, and rain event characteristics.

For wff_2dvd_eachdrop_sn###_100pct.txt, all drops less than 10.0 mm in diameter are included.

The wff_2dvd_eachdrop_sn###_50pct.txt file screens the rain drops following $\pm 50\%$ of the terminal fall speed limit. If the drop fall is outside the $\pm 50\%$ of its terminal fall speed, it is considered as a secondary drop and eliminated from the processing. All drops less than 10.0 mm in diameter are included in this file.

The wff_2dvd_largedrop_sn###_50pct.txt file screens the drops following $\pm 50\%$ terminal fall speed limit. If the drop fall is outside the $\pm 50\%$ of its terminal fall speed, it is regarded as a secondary drop and eliminated from the processing. All drops greater than or equal to 5.0 mm in diameter are included in this file.

Table 4 describes the 10 columns within wff_2dvd_eachdrop_sn###_100pct.txt, wff_2dvd_eachdrop_sn###_50pct.txt, and wff_2dvd_largedrop_sn###_50pct.txt files.

Table 4: Description of each column within wff_2dvd_eachdrop_sn###_100pct.txt, wff_2dvd_eachdrop_sn###_50pct.txt, and wff_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

The wff_2dvd_diameter020.txt file presents the midsize diameter in mm, size bin width (0.2 mm), and terminal fall velocity in m/sec for 50 size bins from 0 to 10.0 mm. Please note 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 diameter, and assumed constant for the drops larger than 8.0 mm in diameter. Table 5 describes the 3 columns within the wff_2dvd_diameter020.txt file.

Table 5: Description of each column within wff_2dvd_diameter020.txt file

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

The wff_2dvd_sn###_dropcounts.txt file uses wff_2dvd_eachdrop_sn###_50pct.txt file as input, and outputs 50 size bin drop counts 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 are considered an event. Table 6 describes the 54 columns within wff_2dvd_sn###_dropcounts.txt files.

Table 6: Description of each column within wff_2dvd_sn###_dropcounts.txt files

Column	Description	Unit
1	Year	-
2	Day of the year	-
3	Hour	hour
4	Minute	minute
5-54	number of drops 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 hydrometeors were detected	-

Table 7 describes the 54 columns within wff_2dvd_sn###_raindsd.txt and wff_2dvd_sn###_raindsd_ter.txt files. Both files use the wff_2dvd_eachdrop_sn###_50pct.txt files as inputs, and output 50 size bin raindrop size distribution. The output files are generated for each minute where at least 10 drops were observed and a minimum rain rate of 0.01 mm/hr are considered an event. For wff_2dvd_sn###_raindsd.txt files, the size distribution calculation is based on observed fall speed. For wff_2dvd_sn###_raindsd_ter.txt files, the size distribution calculation is based on terminal fall speed.

Table 7: Description of each column within wff_2dvd_sn###_raindsd.txt and wff_2dvd_sn###_raindsd_ter.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

Table 8 describes the 13 columns within wff_2dvd_sn##_rainparameter.txt and wff_2dvd_sn##_rainparameter_ter.txt files. Both files use the wff_2dvd_eachdrop_sn##_50pct.txt files as inputs. For wff_2dvd_sn##_rainparameter.txt files, the output is the integral rain parameters based on measured fall velocities at 1-minute integration. For wff_2dvd_sn##_rainparameter_ter.txt files, the output is the integral rain parameters based on terminal fall velocities at 1-minute integrations. There are 13 columns within these files. It should be noted that four of these rain parameters, 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 8: Description of each column within wff_2dvd_sn##_rainparameter.txt and wff_2dvd_sn##_rainparameter_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 Ulbrich and Atlas, 1998	-

Table 9 describes the 10 columns within wff_2dvd_sn##_raintotalhour.txt files. The wff_2dvd_sn##_raintotalhour.txt file uses wff_2dvd_sn##_rainparameter.txt file as inputs, and provides 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.

Table 9: Description of each column within wff_2dvd_sn##_raintotalhour.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	minute
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

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 rates less than 0.01 mm/hr are removed to eliminate noise.

The precise measurement of oblateness and fall speed was not achieved due to severe wind conditions and the change of instrument calibration during the campaign, as compared with the 80 m fall experiment described in [Thurai et al., 2007](#).

In “raintotalhour” data files, the rain 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.

For “eachdrop_sn##_50pct” data files, the file screens the rain drops following $\pm 50\%$ of the terminal fall speed limit. If the drop fall is outside the $\pm 50\%$ of its terminal fall speed, it is considered as a secondary drop and eliminated from the processing.

For “largedrop_sn##_50pct” data files, the drops following $\pm 50\%$ the terminal fall speed limit are screened. If the drop fall is outside the $\pm 50\%$ of its terminal fall speed, it is regarded as a secondary drop and eliminated from the processing.

In “rainparameter” data files, total concentration, liquid water content, reflectivity in Rayleigh regime, and mass-weighted drop diameter requires fall speed information in their formulations.

Software

No software is required to read these ASCII data files.

Known Issues or Missing Data

Overall data dates range from July 24, 2013 through October 5, 2015; exact dates may vary per site. The 2DVDs except SN70 were deployed to the Integrated Precipitation Hydrology Experiment (IPHEX) from April to June 2014 which is therefore not included in this dataset.

If there is no data on a given day, then the instrument was not functioning or rain was not recorded that day.

References

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[https://doi.org/10.1175/1520-0450\(1998\)037%3C0912:RMARPA%3E2.0.CO;2](https://doi.org/10.1175/1520-0450(1998)037%3C0912:RMARPA%3E2.0.CO;2)

Related Data

All data from other instruments collected at the Wallops Flight Facility (WFF) in support of the Global Precipitation Mission (GPM) are considered related datasets. These data can be located by searching 'WFF' in [HyDRO 2.0](#).

In addition, the 2DVD instrument was used in other GPM Ground Validation field campaigns. These other 2DVD datasets are listed below as these other datasets may be of interest.

GPM Ground Validation Two-Dimensional Video Disdrometer (2DVD) OLYMPEX
(<http://dx.doi.org/10.5067/GPMGV/OLYMPEX/2DVD/DATA/301>)

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) GCPEX
(<http://dx.doi.org/10.5067/GPMGV/GCPEX/2DVD/DATA101>)

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) MC3E
(<http://dx.doi.org/10.5067/GPMGV/MC3E/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) NSSTC
(<http://dx.doi.org/10.5067/GPMGV/NSSTC/2DVD/DATA201>)

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

Contact Information

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

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