# GHRC
Global Hydrology Resource Center

## Data User Guide

# *Two-Dimensional Video Disdrometer (2DVD) IMPACTS*

## Introduction
The Two-Dimensional Video Disdrometer (2DVD) IMPACTS data were collected in support of the Investigation of Microphysics and Precipitation for Atlantic Coast-Threatening Snowstorms (IMPACTS) campaign. The IMPACTS field campaign addressed providing observations critical to understanding the mechanisms of snowband formation, organization, and evolution, examining how the microphysical characteristics and likely growth mechanisms of snow particles vary across snowbands, and improving snowfall remote sensing interpretation and modeling to significantly advance prediction capabilities. 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. Data files are available from January 15, 2020 through February 28, 2020 in ASCII format.

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## Keywords:
*NASA, GHRC, IMPACTS, 2DVD, Disdrometer, equivalent diameter, fall speed, oblateness, liquid water content, rain rate, reflectivity, rain events*

## Campaign
The Investigation of Microphysics and Precipitation for Atlantic Coast-Threatening Snowstorms (IMPACTS), funded by NASA's Earth Venture program, is the first comprehensive study of East Coast snowstorms in 30 years. IMPACTS will fly a complementary suite of remote sensing and in-situ instruments for three 6-week deployments (2020-2022) on NASA's ER-2 high-altitude aircraft and P-3 cloud-sampling

aircraft. The first deployment began on January 17, 2020 and ended on March 1, 2020. IMPACTS samples U.S. East Coast winter storms from advanced radar, LiDAR, and microwave radiometer remote sensing instruments on the ER-2 and state-of-the-art microphysics probes and dropsonde capabilities on the P-3, augmented by ground-based radar and rawinsonde data, multiple NASA and NOAA satellites (including GPM, GOES-16, and the Joint Polar Satellite System (JPSS)), and computer simulations. IMPACTS addressed three specific objectives:

(1) Provide observations critical to understanding the mechanisms of snowband formation, organization, and evolution;

(2) Examine how the microphysical characteristics and likely growth mechanisms of snow particles vary across snowbands;

(3) Improve snowfall remote sensing interpretation and modeling to significantly advance prediction capabilities.

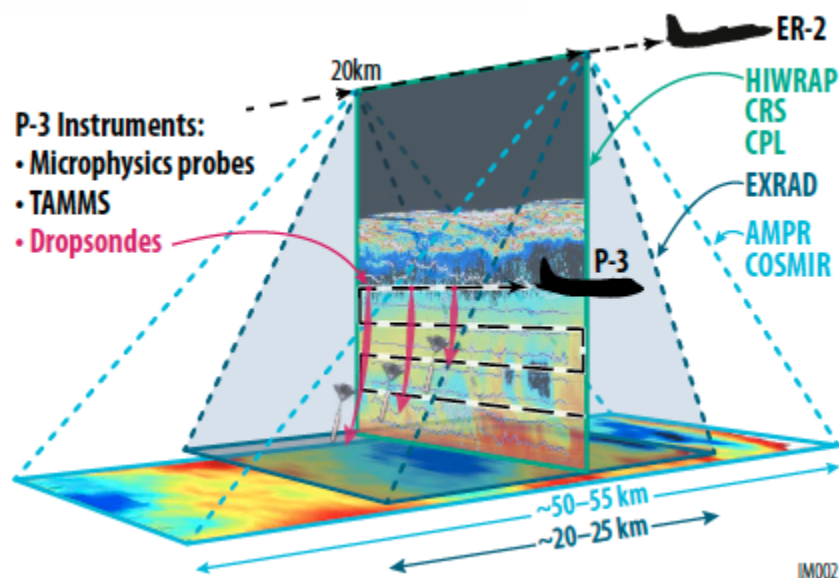More information is available from [NASA's Earth Science Project Office's IMPACTS field campaign webpage](#).



Figure 1: IMPACTS airborne instrument suite.
(Image Source: https://espo.nasa.gov/impacts)

## 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, transects the 10cmx10cm virtual measurement area and are projected onto two high speed line-scan cameras. Precipitation particles, also known as hydro meteors, 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 1 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.



Figure 2: Image of the 2DVD instrument
(Image source: GSFC)

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## Data Characteristics

The Two-Dimensional Video Disdrometer (2DVD) IMPACTS data are available in ASCII format at a L2 data processing level. More information about the NASA data processing levels are available here.

Table 1: Data Characteristics

| Characteristic | Description |
| --- | --- |
| Platform | Ground station |
| Instrument | Two-Dimensional Video Disdrometer (2DVD) |
| Spatial Coverage | N: 38.954, S: 37.919, E: -75.446, W: -75.491 (Maryland) |
| Spatial Resolution | 200 microns |
| Temporal Coverage | January 15, 2020 - February 28, 2020 |
| Temporal Resolution | File per parameter, but each file contains the whole field campaign |
| Sampling Frequency | 18 microseconds |
| Parameter | 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 |
| Version | 1 |
| Processing Level | 2 |

## File Naming Convention

The Two-Dimensional Video Disdrometer (2DVD) IMPACTS dataset consists of daily ASCII files containing data files with the file naming conventions shown below.

**Data files:** impacts_2dvd_eachdrop_sn##_[50pct|100pct].txt
impacts_2dvd_largedrop_sn##_50pct.txt
impacts_2dvd_sn##_<parameter>.txt
impacts_2dvd_diameter020.txt

Table 2: File naming convention variables

| Variable | Description |
| --- | --- |
| sn## | Site number |
| [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<br><br>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 Two-Dimensional Video Disdrometer (2DVD) IMPACTS 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 impacts_2dvd_eachdrop_sn##_100pct.txt, all drops less than 10.0 mm in diameter are included.

The impacts_2dvd_eachdrop_sn##_50pct.txt file screens the rain drops following ±50% of the terminal fall speed limit. 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. All drops less than 10.0 mm in diameter are included in this file.

The impacts_2dvd_largedrop_sn##_50pct.txt file screens the drops following ±50% terminal fall speed limit. 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. All drops greater than or equal to 5.0 mm in diameter are included in this file.

Table 4 describes the 10 columns within impacts_2dvd_eachdrop_sn##_100pct.txt, impacts_2dvd_eachdrop_sn##_50pct.txt, and impacts_2dvd_largedrop_sn##_50pct.txt files.

Table 4: Description of each column within impacts_2dvd_eachdrop_sn##_100pct.txt, impacts_2dvd_eachdrop_sn##_50pct.txt, and impacts_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 impacts_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 impacts_2dvd_diameter020.txt file.

Table 5: Description of each column within impacts_2dvd_diameter020.txt file

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

The impacts_2dvd_sn##_dropcounts.txt file uses impacts_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 impacts_2dvd_sn##_dropcounts.txt files.

Table 6: Description of each column within impacts_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 impacts_2dvd_sn##_raindsd.txt and impacts_2dvd_sn##_raindsd_ter.txt files. Both files use the impacts_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 impacts_2dvd_sn##_raindsd.txt files, the size distribution calculation is based on observed fall speed. For impacts_2dvd_sn##_raindsd_ter.txt files, the size distribution calculation is based on terminal fall speed.

Table 7: Description of each column within impacts_2dvd_sn##_raindsd.txt and impacts_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 impacts_2dvd_sn##_rainparameter.txt and impacts_2dvd_sn##_rainparameter_ter.txt files. Both files use the impacts_2dvd_eachdrop_sn##_50pct.txt files as inputs. For impacts_2dvd_sn##_rainparameter.txt files, the output is the integral rain parameters

based on measured fall velocities at 1-minute integration. For impacts_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 impacts_2dvd_sn##_rainparameter.txt and impacts_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 impacts_2dvd_sn##_raintotalhour.txt files. The impacts_2dvd_sn##_raintotalhour.txt file uses impacts_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 impacts_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<br>R = rain<br>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 rate 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 ±50% of the terminal fall speed limit. 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.

For "largedrop_sn##_50pct" data files, the drops following ±50% the 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.

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

There are no known issues in this dataset

## References

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## Related Data

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

In addition, other related data used the 2DVD instrument in previous GPM Ground Validation field campaigns:

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) 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) C3VP (http://dx.doi.org/10.5067/GPMGV/C3VP/2DVD/DATA101)

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

## Contact Information

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

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