Global Hydrology Resource Center

Data User Guide

GPM Ground Validation Precipitation Imaging Package (PIP) ICE POP

Introduction

The GPM Ground Validation Precipitation Imaging Package (PIP) ICE POP dataset includes precipitation measurements and video images collected by the Precipitation Imaging Package (PIP) during the International Collaborative Experiments for Pyeongchang 2018 Olympic and Paralympic Winter Games (ICE-POP) field campaign in South Korea. The two major objectives of ICE-POP were to study severe winter weather events in regions of complex terrain and improve the short-term forecasting of such events. These data contributed to the Global Precipitation Measurement mission Ground Validation (GPM GV) campaign efforts to improve satellite estimates of orographic winter precipitation. Data values obtained using PIP measurements include particle size distributions, fall velocity distributions, precipitation density estimates, and precipitation rates. The dataset files are available from June 18, 2017 through December 30, 2018 as generic data files (.dat) in ASCII-CSV format with browse imagery and video available in PNG and AVI format.

Notice:
This dataset includes additional data collected before and after the main ICE-POP field campaign study period.

Citation

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Keywords:

NASA, GHRC, PMM, GPM GV, ICE-POP, South Korea, PIP, precipitation, hydrometeors, DSD, equivalent density, fall velocity

Campaign

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

The International Collaborative Experiments for Pyeongchang 2018 Olympic and Paralympic Winter Games (ICE-POP) field campaign took place during the 2018 Pyeongchang Winter Olympic and Paralympic Games in South Korea (Figure 1). This field campaign was a collaboration between various international organizations to study and improve the understanding of severe winter weather events, specifically in regions of complex terrain. Researchers sought to improve short-term predictions of orographic winter precipitation and test model based predictions by studying various aspects of winter weather including snowfall physics, winds, visibility, and cloud structure. The Winter Games, with their need for short-term forecasting of rapidly developing winter weather in a mountainous location, provided the perfect test environment for this study. Data was also collected to validate and improve satellite estimates of orographic winter precipitation in support of the GPM GV campaign. More information about the ICE-POP field campaign can be found on the PMM ICE-POP webpage.

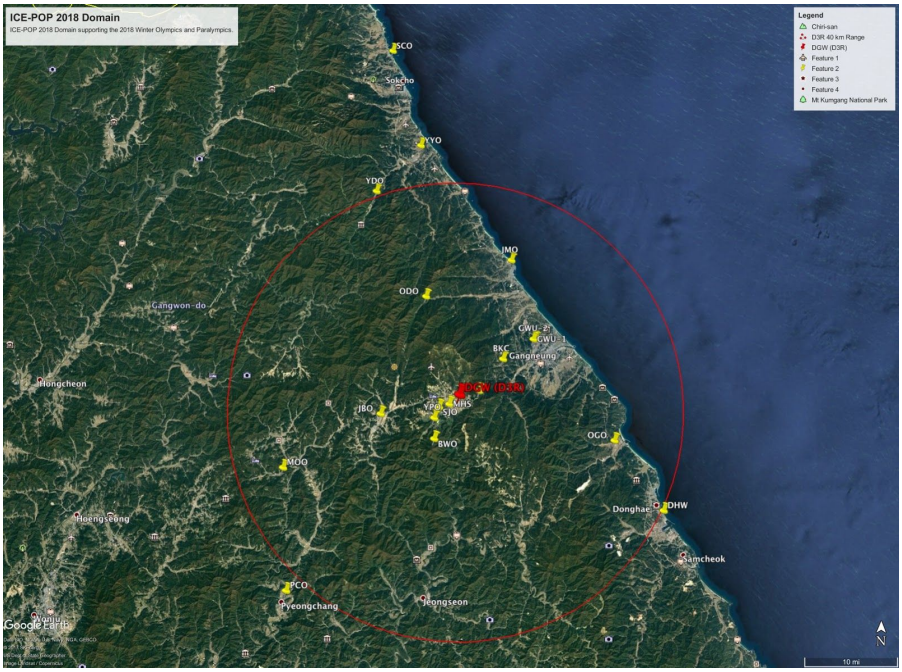

Figure 1: ICE-POP Field Campaign Domain Area (circled in red) on the east coast of South Korea (Image source: GPM ICE-POP 2018 webpage)

Instrument Description

The Precipitation Imaging Package (PIP) is a high-speed camera system that records video of falling precipitation, including rain and snow (Figure 2). There were two PIP instruments used during the ICE-POP field campaign (Instr. 002 and 003). The package includes a high-speed video camera, a halogen lamp, and the computer processing system. The camera and the lamp are positioned directly across from each other. The high-speed camera records grayscale images of precipitation particles at 380 frames per second as they fall over a 640 x 240 pixel window. These video images allow PIP to provide information such as drop size distribution (DSD) and fall velocity. PIP uses this information to extract characteristics about the falling precipitation. For example, PIP can differentiate rain and snow using the fall speed of the hydrometeors. After collecting these precipitation images, PIP's software system creates figures, tables, and movies from the data. More information about PIP can be found on the GSFC WFF PIP webpage and in the PIP User Manual.

Figure 2: The PIP halogen lamp (left) and high-speed video camera (right) (Image source: GSFC WFF PIP webpage)

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Data Characteristics

The GPM Ground Validation Precipitation Imaging Package (PIP) ICE POP dataset consists of precipitation data in generic data files that behave as ASCII-CSV files, along with browse imagery in PNG image format and AVI video format. 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	Ground Stations
Instrument	Precipitation Imaging Package (PIP)
Spatial Coverage	N: 37.738 ,S: 37.665, E: 128.806, W: 128.700 (South Korea) (PIP 002) Lat: 37.738 Lon: 128.806 (PIP 003) Lat: 37.665 Lon: 128.700
Spatial Resolution	640 x 240 pixel window (64 x 48 mm)
Temporal Coverage	June 18, 2017 - December 30, 2018
Temporal Resolution	Daily files (*Daily_dat.zip): ~ 1 day Video data files (*_q.dat): 1 minute -< 1 hour YTD files (*YTD_dat.zip): 1 month -< 1 year
Sampling Frequency	PIP high-speed video camera: 380 frames per second (The timestamps within the data files vary)
Parameter	Precipitation particles
Version	1
Processing Level	2

File Naming Convention

The GPM Ground Validation Precipitation Imaging Package (PIP) ICE POP dataset consists of generic data files (*.dat) that function as tab-delimited ASCII-CSV files, stored both in compressed ZIP archive files and individually. The ZIP files include daily files (*Daily_dat.zip) and year-to-date (YTD) files (*YTD_dat.zip). There are also video data files (*_q.dat) included in this dataset along with zipped browse images and video files in PNG and AVI format. There is a seperate browse plot summary image (*summaryplt.png) that is not contained within the zipped browse image files. Each dataset file is named using the following convention:

Zipped Data files:
icepop_pip_[002|003]_YYYYMMDD_Daily_dat.zip
icepop_pip_[002|003]_YYYY_YTD_dat.zip

Unzipped Data files (for Daily):

icepop_pip_[002|003]_YYYYMMDD_01_<file type>.dat

Unzipped Data files (for YTD):
icepop_pip_[002|003]_YYYY_[KO1|KO2|DCN]_<file type>.dat

Video Data files
icepop_pip_[002|003]_YYYYMMDDhhmm_q.dat

Zipped Browse files:
icepop_pip_[002|003]_YYYYMMDD_Daily_png.zip
icepop_pip_[002|003]_YYYYMM_YTD_Precip.zip
icepop_pip_[002|003]_YYYYMM_YTD_PSDVel.zip
icepop_pip_[002|003]_YYYYMMDDhhmm_LAR_AVI.zip

Unzipped Browse Image files (for Daily):
icepop_pip_[002|003]_YYYYMMDD_01_<file type>.png

Unzipped Browse Image files (for YTD):
icepop_pip_[002|003]_YYYYMMDD_<file type>.png

Unzipped Browse Video files:
icepop_pip_[002|003]_YYYYMMDDhhmm_<file type>.avi

Browse Plot Summary Image files:
icepop_pip_[002|003]_YYYYMMDD_summaryplt.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
[002|003]	Instrument number
[KO1|KO2|DCN]	Station ID: KO1, KO2, or DCN
<file type>	File type (see Table 3)
AVI	Audio Video Interleave
LAR	Largest AVI from each 10 minute interval
VVR	Fall velocity data
.zip	ZIP archive file
.dat	Generic text-based data file
.png	Portable Network Graphic (PNG) image file
.avi	Audio Video Interleave (AVI) video file

Table 3: Data and Browse File Types

Zipped file	File Type	Data description
Daily data	*dsd	Drop size distribution
	*P_Minute	Precipitation rate
	*rho_Plots_D_minute	Density
	*vvd_A	Fall velocity distribution (average)
	*vvd_N	Fall velocity distribution (particle count)
	*vvd_S	Fall velocity distribution (standard deviation)
YTD data	*eDen_Minute	Equivalent density
	*FallV_A_Minute	Fall velocity (average)
	*FallV_N_Minute	Fall velocity (particle count)
	*P_Day	Precipitation totals
	*P_Minute	Precipitation rate
	*PSD_Minute	Particle size distribution
	*R_Day	Rain totals
	*R_Minute	Rain rate
Browse imagery	*summaryplt	4 plot summary image
	*dsd_minute	Drop size distribution plot
	*P_Minute	Precipitation rate plot
	*rho_minute	Equivalent density plot
	*VVR_Plots_D_minute	Fall velocity plot
	*4eDen_Final	4 plot summary image (includes density plot)
	*Summary4_DSD_VEL	4 plot summary image (includes additional fall speed plots)
Browse Video	*LAR	AVI falling particle video

Note: *_*Minute* means "by minute" and *_*Day* means "by day"

Data Format and Parameters

The GPM Ground Validation Precipitation Imaging Package (PIP) ICE POP dataset consists of text-based generic data files (*.dat) that function as tab-delimited ASCII-CSV files. Each data file begins with a header in its top left corner, indicating the instrument name, station ID, and other general information. The data files contain fields for each diameter bin (a range of particle diameters into which particles of that size are grouped) at each time stamp. There are 131 diameter bins in the data files, each 0.2 mm in size, that list the data for particle diameters ranging from 0.1 to 26 mm. The column headers for the "bin" fields include the bin width, the lower boundary of the bin and the center diameter of the bin. The bin fields that are listed vary based on the type of data file.

An example is shown below in Figure 3 of an "equivalent density" file (*eDen_Minute.dat) viewed in Microsoft Excel. The "NaN" values are empty placeholder fields included for formatting purposes. The cells outlined in green are the timestamp fields. The cells outlined in blue are the "bin" fields indicating the diameter bin of each column. The cells outlined in

orange are the actual data values that are referenced in the filename; “equivalent density” in the case of the example below. These values are listed for each diameter bin at each timestamp. The example in Figure 3 only shows a file for “equivalent density”. Other file types in the dataset follow this same format while others follow a more standard format with column headers from left to right followed by data fields listed underneath. The browse files for this dataset include plot images and video files. Each file type is described in more detail below, grouped into sections for the daily, year-to-date (YTD), video data, and browse files. Tables 4 - 18 list the fields included in each file type.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	PIP_Rev												
2	1701												
3	Instr_Num												
4	PIP												
5	Station												
6	KO1												
7	eDen(g/m	bins(mm)											
8	NaN	NaN	NaN	NaN	NaN	NaN	NaN	Bin_edge	0	0.2	0.4	0.6	0.8
9	NaN	NaN	NaN	NaN	NaN	NaN	NaN	dBin	0.2	0.2	0.2	0.2	0.2
10	yr	DOY	month	day	hr	minute	NaN	Bin_cen	0.1	0.3	0.5	0.7	0.9
11	2017	286	10	13	2	30	NaN	NaN	0	0	0	0	0
12	2017	286	10	13	3	28	NaN	NaN	0	0	0	0	0
13	2017	286	10	13	3	31	NaN	NaN	0	0	0	0	0
14	2017	286	10	13	4	25	NaN	NaN	0	0	0	0	0
15	2017	286	10	13	4	59	NaN	NaN	0	0	0	0	0
16	2017	286	10	13	5	42	NaN	NaN	0	0	0	0	0
17	2017	286	10	13	6	49	NaN	NaN	0	0	0	0	0
18	2017	286	10	13	7	55	NaN	NaN	0	0	0	0	0
19	2017	286	10	13	8	34	NaN	NaN	0	0	0	0	0
20	2017	286	10	13	8	35	NaN	NaN	0	0	0	0	0
21	2017	286	10	13	8	36	NaN	NaN	0	0	0	0	0
22	2017	286	10	13	8	55	NaN	NaN	0	0	0	0	0
23	2017	286	10	13	9	10	NaN	NaN	0	0	0	0	0
24	2017	286	10	13	9	24	NaN	NaN	0	0	0	0	0
25	2017	286	10	13	9	47	NaN	NaN	0	0	0	0	0

Figure 3: The “*eDen_Minute.dat” file format

Daily Files

These files include DSD, precipitation rate, density, and fall velocity data. Each file begins with a header that lists the date, station ID, and other general information. The fields for each file type are listed in Tables 4 - 9. For files of Figure 3’s format, the data field description corresponding to the cells outlined in orange above is listed in the first row of the table.

DSD

Table 4: Data Fields for **dsd.dat* files

Field Name	Description	Unit
-	DSD	m^{-3} mm^{-1}
DSD_avg	Average DSD	m^{-3} mm^{-1}

Bin_edge	Edge of the diameter bin; the smallest diameter (lower-boundary) that is categorized into the bin	mm
dBin	Size of the diameter bin	mm
Bin_cen	Bin center	mm
day_time	The percentage of the day that has passed at that time e.g. hour 17 minute 56 = 0.747 (74.7% of the day has passed)	-
hr_d	Hour (UTC)	-
min_d	Minute	-
Num_d	Number of drops/particles	-

Precipitation rate

Table 5: Data Fields for **P_Minute.dat* files

Field Name	Description	Unit
yr	Year	-
DOY	Day of the year	-
hr	Hour (UTC)	-
minute	Minute	-
R_mmhr	Rainfall rate	mm/h
nR_mmhr	Frozen precipitation rate	mm/h
eDensity	Equivalent Density	g/ml

Density

Table 6: Data Fields for **rho_Plots_D_minute.dat* files

Field Name	Description	Unit
-	Density	g/ml
rho_avg	Average density	g/ml
Bin_edge	Edge of the diameter bin; the smallest diameter that is categorized into the bin	mm
dBin	Size of the diameter bin	mm
Bin_cen	Bin center	mm
day_time	The percentage of the day that has passed at that time e.g. hour 17 minute 56 = 0.747 (74.7% of the day has passed)	-
hr_d	Hour (UTC)	-
min_d	Minute	-

Fall velocity distribution (average)

Table 7: Data Fields for **vvd_A.dat* files

Field Name	Description	Unit
-	Fall velocity	m/s
Vel_avg	Average fall velocity	m/s

Bin_edge	Edge of the diameter bin; the smallest diameter that is categorized into the bin	mm
dBin	Size of the diameter bin	mm
Bin_cen	Bin center	mm
day_time	The percentage of the day that has passed at that time e.g. hour 17 minute 56 = 0.747 (74.7% of the day has passed)	-
hr_d	Hour (UTC)	-
min_d	Minute	-

Fall velocity distribution (particle count)

Table 8: Data Fields for **vvd_N.dat* files

Field Name	Description	Unit
-	Velocity count (the number of particles used to determine the average fall velocity in **vvd_A.dat* files)	-
Vel_cnt	Velocity count; Total the number of particles in the bin (for each timestamp of the day) used to determine the average fall speed/velocity	-
Bin_edge	Edge of the diameter bin; the smallest diameter that is categorized into the bin	mm
dBin	Size of the diameter bin	mm
Bin_cen	Bin center	mm
day_time	The percentage of the day that has passed at that time e.g. hour 17 minute 56 = 0.747 (74.7% of the day has passed)	-
hr_d	Hour of the day (UTC)	-
min_d	Minute of the hour	-

Fall velocity distribution (standard deviation)

Table 9: Data Fields for **vvd_S.dat* files

Field Name	Description	Unit
-	Standard deviation of the average velocity	-
Std_avg	Average velocity	m/s
Bin_edge	Edge of the diameter bin; the smallest diameter that is categorized into the bin	mm
dBin	Size of the diameter bin	mm
Bin_cen	Bin center	mm
day_time	The percentage of the day that has passed at that time e.g. hour 17 minute 56 = 0.747 (74.7% of the day has passed)	-
hr_d	Hour of the day (UTC)	-
min_d	Minute of the hour	-

YTD Files

These files include precipitation rate, equivalent density, and fall velocity data for the majority of the campaign observation period. The fields for each file type are listed in Tables 10 - 17. As noted, for files of Figure 3's format, the data field description corresponding to the cells outlined in orange is listed in the first row of the table.

Equivalent Density

Table 10: Data Fields for **eDen_Minute.dat* files

Field Name	Description	Unit
eDen(g/ml)	Equivalent density	g/ml
Bin_edge	Edge of the diameter bin; the smallest diameter that is categorized into the bin	mm
dBin	Size of the diameter bin	mm
Bin_cen	Bin center	mm
yr	Year	-
DOY	Day of the year	-
month	Month	-
day	Day	-
hr	Hour (UTC)	-
minute	Minute	-

Fall velocity

Table 11: Data Fields for **FallV_A_Minute.dat* files

Field Name	Description	Unit
vel(m/s)	Precipitation fall speed	m/s
Bin_edge	Edge of the diameter bin; the smallest diameter that is categorized into the bin	mm
dBin	Size of the diameter bin	mm
Bin_cen	Bin center	mm
yr	Year	-
DOY	Day of the year	-
month	Month	-
day	Day	-
hr	Hour (UTC)	-
minute	Minute	-

Fall velocity (particle count)

Table 12: Data Fields for **FallV_N_Minute.dat* files

Field Name	Description	Unit
-	Velocity count (the number of particles used to determine the average fall velocity in **FallV_A_Minute.dat* files)	-
Bin_edge	Edge of the diameter bin; the smallest diameter that is categorized into the bin	mm

dBin	Size of the diameter bin	mm
Bin_cen	Bin center	mm
yr	Year	-
DOY	Day of the year	-
month	Month	-
day	Day	-
hr	Hour (UTC)	-
minute	Minute	-

Precipitation totals

Table 13: Data Fields for **P_Day.dat* files

Field Name	Description	Unit
yr	Year	-
DOY	Day of the year	-
month	Month	-
day	Day	-
hr	Hour (UTC)	-
minute	Minute	-
R(mm)	Rainfall total	mm
nR(mm)	Not-rain total	mm
Den(g/ml)	Density	g/ml

Precipitation rate

Table 14: Data Fields for **P_Minute.dat* files

Field Name	Description	Unit
yr	Year	-
DOY	Day of the year	-
month	Month	-
day	Day	-
hr	Hour (UTC)	-
minute	Minute	-
R(mm/hr)	Rainfall rate	mm/h
nR(mm/hr)	Not-rain rate	mm/h
Den(g/ml)	Density	g/ml

PSD

Table 15: Data Fields for **PSD_Minute.dat* files

Field Name	Description	Unit
val(mm/m3)	Particle size distribution	mm/m^3
Bin_edge	Edge of the diameter bin; the smallest diameter that is categorized into the bin	mm
dBin	Size of the diameter bin	mm
Bin_cen	Bin center	mm

yr	Year	-
DOY	Day of the year	-
month	Month	-
day	Day	-
hr	Hour (UTC)	-
minute	Minute	-
Total_cnt	Total count	-

Rain totals

Table 16: Data Fields for **R_Day.dat* files

Field Name	Description	Unit
yr	Year	-
DOY	Day of the year	-
month	Month	-
day	Day	-
hr	Hour (UTC)	-
minute	Minute	-
R(mm)	Rainfall total	mm
nR(mm)	Not-rain total	mm
Den(g/ml)	Density	g/ml

Rain rate

Table 17: Data Fields for **R_Minute.dat* files

Field Name	Description	Unit
yr	Year	-
DOY	Day of the year	-
month	Month	-
day	Day	-
hr	Hour (UTC)	-
minute	Minute	-
R(mm/hr)	Rainfall rate	mm/h
nR(mm/hr)	Not-rain rate	mm/h
Den(g/ml)	Density	g/ml

Video Data Files

The original PIP video camera images were captured at 380 frames per second, stored into PIV compressed video files, and then converted into AVI video files for easier viewing. These video data files (*_q.dat) contain the PIV and AVI video image (i.e. frame) numbers. The header indicates the instrument, station, date, and hour of the data. The data fields include the minute (*Min*), second (*Sec*), PIV frame (*piv_frame*), and AVI frame (*avi_frame*). The piv_frame and avi_frame fields lists the frame numbers for each timestamp. The AVI video data only include the first 2000 frames containing precipitation particles for each minute of PIV video data. The data fields for these files are listed in Table 18 below.

Table 18: Data files for **_q.dat* files

Field Name	Description	Unit
Min	Minute	-
Sec	Second	-
piv_frame	PIV video frame numbers	-
avi_frame	AVI video frame numbers	-

Browse Imagery

The browse imagery include plots of particle size distributions, fall velocity distributions, density estimates, and rain and not-rain rates. There is also grayscale video of falling precipitation particles. There are zipped *Daily* files (*_Daily_png.zip) containing 4 individual plot images, summary files (*_summaryplt.png) containing all 4 of those plots grouped into one image, zipped *YTD* files containing 4-plot summary images of precipitation data (*_Precip.zip), and zipped *YTD* files containing 4-plot summary images of velocity data (*_PSDVel.zip). The data within each plot is charted over a 24-hour period. The AVI video files are zipped and contain browse video of falling precipitation particles. Each video file contains the largest AVI from each 10-minute interval of the PIV video.

Algorithm

The PIP software creates various figures, plots, and video products from the raw video files of falling precipitation. The precipitation particles are grouped into size bins based on their diameter. There are 131 diameter bins ranging from 0.1 to 26 mm that are used to create the particle size distributions for each minute. PIP uses the particle diameter and fall speed to determine the characteristics of the precipitation. For example, PIP can distinguish between rain and snow using the precipitation particle's fall speed. More information about the PIP data processing software is available in the PIP User Manual.

Quality Assessment

Each PIP instrument is calibrated at the NASA GSFC Wallops Flight Facility (WFF). For calibration, the high speed camera it pointed at a meter stick located in the camera's focal plane at about 133 cm away while the lens is adjusted so that the horizontal length of the image is approximately 6.4 cm. A string is used to complete an initial alignment of the halogen lamp and high-speed camera followed by a more in-depth alignment process. More information about the PIP instrument's calibration procedures is available in the PIP User Manual.

Software

No special software is required to view these data files. The *.dat* ASCII-CSV files are viewable in a standard text editor or spreadsheet software such as Notepad++ or Microsoft Excel. The PNG and AVI browse files can be viewed in most image and video software.

Known Issues or Missing Data

The number and types of files contained in each zipped folder are not always the same. Also, data were not collected during times when no precipitation occurred. Both PIP instruments' data are not included for all time periods. Bad values are indicated by "-99".

References

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Related Data

All data from other instruments collected during the ICE POP field campaign are considered related datasets. These data can be located by searching 'ICEPOP' in GHRC's HyDRO2.0 search tool.

Contact Information

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

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