Global Hydrology Resource Center

Data User Guide

GPM Ground Validation Autonomous Parsivel Unit (APU) ICE POP

Introduction

The GPM Ground Validation Autonomous Parsivel Unit (APU) ICE POP dataset was collected 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 Global Precipitation Measurements mission Ground Validation (GPM GV) campaign efforts to improve satellite estimates of orographic winter precipitation. This dataset consists of precipitation data including precipitation amount, precipitation rate, reflectivity in Rayleigh regime, liquid water content, drop diameter, and drop concentration. Data are available in ASCII format from October 31, 2015 through July 1, 2018. It should be noted that this dataset extends prior to the field campaign.

Citation

Petersen, Walter and Ali Tokay. 2019. GPM Ground Validation Autonomous Parsivel Unit (APU) ICE POP [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/ICEPOP/APU/DATA101

Keywords:

NASA, GHRC, ICE POP, South Korea, APU, precipitation, precipitation rate, precipitation amount, droplet size, hydrometeors, liquid precipitation, drizzle, rain, liquid water equivalent, snow water equivalent, solid precipitation

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. 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 were 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](#).

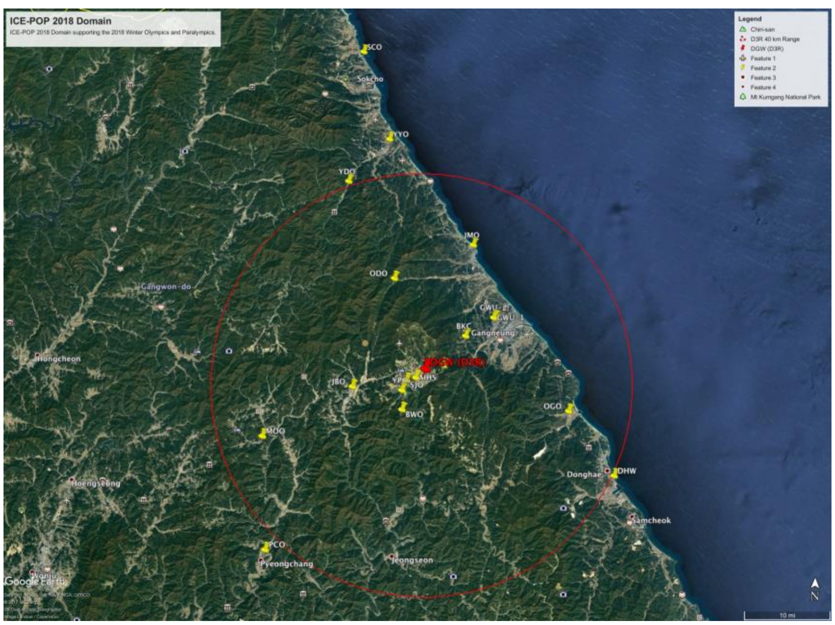

Figure 1: ICE-POP 2018 Field Campaign Domain Area (circled in red) in South Korea (Image source: GPM ICE-POP 2018 webpage)

Instrument Description

The Autonomous Parsivel Unit (APU) is an optical laser-based disdrometer that uses single-particle extinction to measure particle size and fall velocity. The APU used for the

GPM GV campaign consists of the Parsivel² and supporting hardware to allow for automatic data reporting.

The Parsivel² disdrometer produced by OTT Hydromet is a modern, laser-based optical system for measuring all types of precipitation. The transmitter unit of the sensor generates a flat, horizontal strip or sheet of light, in which the receiver converts into an electrical signal. When no particles pass through the horizontal beam, the maximum voltage is detected at the receiver. The signal changes whenever a hydrometeor falls through the sheet of light anywhere within the measurement area. The blocked portion of the laser signal results in reduced voltage output. The degree of dimming is a measure of the size of the hydrometeor and, together with the duration of the blockage, the fall velocity can be derived. The Parsivel² can also classify precipitation particles into 32 separate size classes and 32 velocity classes. Further information on the Parsivel² can be found at OTT Parsivel² Fact Sheet and Tokay et al., 2014.

This dataset consists of precipitation data collected from six APUs positioned at 19 different sites in support of the ICE POP field campaign. Table 1 lists the locations of these APU sites.

Table 1: ICE POP APU sites

Site ID	Latitude (°)	Longitude (°)
apu09	37.771	128.867
apu13	37.738	128.806
apu14|mhs	37.665	128.700
cpo	37.687	128.759
bwo	37.611	128.672
dgw	37.677	128.719
dhw	37.507	129.124
dro	37.610	128.773
jmo	37.898	128.821
jpo	37.648	128.565
moo	37.562	128.378
odo	37.767	128.612
ogo	37.614	128.029

pco	37.378	128.395
scw	38.251	128.565
sjo	37.660	128.680
ydo	38.007	128.541
ypo	37.643	128.680
yyo	38.087	128.630

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Data Characteristics

The GPM Ground Validation APU ICE POP dataset consists of precipitation data including precipitation amount, precipitation rate, reflectivity in Rayleigh regime, liquid water content, drop diameter, and drop concentration. Data files are in ASCII format at a Level 3 processing level. More information about the NASA data processing levels is available on the EOSDIS Data PRocessing Levels webpage.

Table 2: Data Characteristics

Characteristic	Description
Platform	Ground stations
Instrument	Autonomous Parsivel Unit (APU)
Spatial Coverage	N: 38.251, S: 37.378, E: 129.124, W: 128.378 (South Korea)*
Spatial Resolution	point
Temporal Coverage	October 31, 2015 - July 1, 2018
Temporal Resolution	One file per site, each site had various operation periods
Sampling Frequency	10 seconds integrated to 1 minute
Parameter	Precipitation amount, precipitation rate, reflectivity in Rayleigh regime, liquid water content, drop diameter, and drop concentration
Version	1
Processing Level	3

*Individual site locations are listed in Table 1.

File Naming Convention

The GPM Ground Validation APU ICE POP dataset files are in ASCII format and have the following naming convention:

Data files: icepop_<inst>_<parameter>.txt
icepop_<inst>_<parameter>_<site>.txt

Table 3: File naming convention variables

Variable	Description
<inst>	Instrument name: apu09, apu13, apu14, par1, par2, parsivel
<parameter>	data, dropcounts_min, flakecounts_min, phase, precipphase, raindsd_min, raindsd_min_ter, rainevent, rainparameter_min, rainparameter_min_ter, snowdsd_min, snowevent, snowparameter_min, diameter, matrix*
<site>	Site name
.txt	ASCII text format

*More information about each parameter can be found in the *Data Format and Parameters* section below.

Data Format and Parameters

The GPM Ground Validation APU ICE POP dataset consists of precipitation, precipitation amount, precipitation rate, reflectivity in Rayleigh regime, liquid water content, drop diameter, and drop concentration measurements. There are 14 files per parsivel site. Tables 4-9 describe how these measurements are organized in each file, as well as their units.

icepop_parsivel_diameter.txt files:

These files have four columns showed in Table 4. It should be noted that terminal fall velocities for drops above 6.0 mm in diameter (bins 22-32) are subject to error since Beard, 1976 do not extend to drops larger than 6.0 mm. A linear interpretation has been performed for the drops larger than 6.0 mm in diameter.

Table 4: Data fields in icepop_parsivel_diameter.txt files

Column	Description	Unit
1	Drop shape corrected mid-bin size diameters	mm
2	Corresponding bin width	mm
3	Corresponding terminal fall speed following Beard, 1976	m/s
4	Corrected mid-bin fall velocities	m/s

icepop_parsivel_matrix.txt files:

These files are a 32 x 32 matrix that corresponds to the drop size and fall velocities of the manufacturer output. These files screen the drops following ±50% of its terminal fall speed. If the drop fall is outside the ±50% of its terminal fall speed, it is regarded as secondary drop and eliminated from the processing. The matrix consists of “1” for accepted and “0” for rejected drops. This matrix is used for rain only. A fall velocity based threshold matrix is used for snow.

As part of the data processing, the 10-second observations are integrated into 1-minute; however, the timestamp of the 10-second observations has been documented in a file to distinguish the non-rainy periods from non-data collection periods. It should be noted that the thresholds of 10 drops and 0.01 mm/h have been applied to 1-minute observations to eliminate noise from rainy minutes.

icepop_<inst>_data.txt files:
These data files provide the existing database. They consist of 5 to 10 columns: year, day of the year, hour, minute, and seconds (6 columns maximum from 0 to 50). The files at one-minute resolution do not contain a 'seconds' column.

icepop_<inst>_dropcounts_min.txt files:
These files provide the total number of drops at each bin size at 1-minute integration. The files consist of 36 columns: year, day of the year, hour, minute, and 32 size bin drop counts.

icepop_<inst>_flakecounts_min.txt files:
These files provide the total number of flakes at each bin size at 1-minute integration. The files consist of 36 columns: year, day of the year, hour, minute, and 32 size bin flake counts. This product differs from *icepop_<inst>_dropcounts_min.txt* files as it uses the snow algorithm described in the *Algorithm* section below.

icepop_<inst>_rainparameter_min.txt files:
These files are designed to present the integral rain parameters based on *measured* fall velocities at 1-minute integration. The files consist of 11 columns described in Table 5. 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 5: Data fields in icepop_<inst>_rainparameter_min.txt files

Column	Description	Unit
1	Year	-
2	Day of the year	-
3	Hour	UTC
4	Minute	UTC
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

icepop_<inst>_rainparameter_min_ter.txt files:
These files provide the integral rain parameters based on *terminal* fall velocities at 1-minute integrations. The files consist of 11 columns described in Table 6.

Table 6: Data fields in icepop_<inst>_rainparameter_min_ter.txt files

Column	Description	Unit
1	Year	-
2	Day of the year	-
3	Hour	UTC
4	Minute	UTC
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

icepop_<inst>_snowparameter_min.txt files:
These files are designed to present the integral snow parameters based on *measured* fall velocities at 1-minute integration. The files consist of 10 columns described in Table 7. This product differs from *icepop_<inst>_rainparameter_min.txt* as it uses the snow algorithm described in the *Algorithm* section below.

Table 7: Data fields in icepop_<inst>_snowparameter_min.txt files

Column	Description	Unit
1	Year	-
2	Day of the year	-
3	Hour	UTC
4	Minute	UTC
5	Internal temperature	Degrees C
6	Total number of drops	-
7	Total concentration	drops/m^3 of air
8	Snow rate	mm/h
9	Mass-weighted flake diameter	mm
10	Maximum flake diameter	mm

icepop_<inst>_raindsd_min.txt files:
These files provide the raindrop size distribution based on *measured* fall velocities at 1-minute integrations. The files consist of 36 columns: year, day of the year, hour, minute, and 32 bin raindrop size distribution in drops/m^3mm^1.

icepop_<inst>_raindsd_min_ter.txt files:

These files provide raindrop size distribution based on *terminal* fall velocities at 1-minute integration. The files consist of 36 columns: year, day of the year, hour, minute, and 32 bin raindrop size distribution in drops/m^3mm^1.

icepop_<inst>_snowdsd_min.txt
These files provide the snowdrop size distribution based on *measured* fall velocities at 1-minute integrations. The file consists of 35 columns: year, day of the year, hour, minute, and 32 bin snow size distribution in drops/m^3mm^1. This product differs from *icepop_<inst>_raindsd_min.txt* as it uses the snow algorithm described in the *Algorithm* section below.

icepop_<inst>_phase.txt files:
These files provide the phase of precipitation. The APU instrument is a present weather sensor and outputs the phase as two different synoptic codes, and it classifies the phase as drizzle, rain, snow, snow grains, freezing rain, hail, as well as for drizzle and rain, and drizzle, rain, and snow. The codes are also different for light, moderate, and heavy precipitation based on the APU's calculated rain rate. The phase is stored for 10-second output and printed out for a 1-minute interval if precipitation is detected. The columns are year, day of the year, hour, minute, and 12 columns of synoptic code. The first two of the 12 columns represent the phase at the top of the minute for two synoptic codes. The following two columns represent the phase at 10-seconds of the minute and so on. For the one-minute data, there are two columns of phase information.

icepop_<inst>_rainevent.txt:
These files provide the rain event summaries. The events are separated by 1 hour or more rain-free periods in rain rate time series. The events that are less than 3 minutes or the rain total is less than 0.1 mm are not included. The files have 9 columns described in Table 8.

Table 8: Data fields in icepop_<inst>_rainevent.txt files

Column	Description	Unit
1	Year	-
2	Event start day of the year	-
3	Event start hour and minute	UTC
4	Event end day of the year	-
5	Event end hour and minute	UTC
6	Event rain minutes	-
7	Event maximum rain rate	mm/h
8	Event rain total	mm
9	Event maximum drop diameter	mm

icepop_<inst>_snowevent.txt:
These files provide the snow event summaries. The events are separated by 1 hour or more snow-free periods in snow rate time series. The events that are less than 3 minutes or the snow total is less than 0.1 mm are not included. The files have 9 columns as described in

Table 9. This file differs from *icepop_<inst>_rainevent.txt* as it uses the snow algorithm described in the *Algorithm* section below.

Table 9: Data fields in icepop_<inst>_snowevent.txt files

Column	Description	Unit
1	Year	-
2	Event start day of the year	-
3	Event start hour and minute	UTC
4	Event end day of the year	-
5	Event end hour and minute	UTC
6	Event snowy minutes	-
7	Event maximum snow rate	mm/h
8	Event snow total	mm
9	Event maximum flake diameter	mm

Algorithm

There are two sets of data processing: rain and snow. All APU observations were processed for using a rain algorithm that uses the *icepop_<inst>_matrix.txt* file for accepting or rejecting particles. APU observations from December 2017 through April 9, 2018 were processed using the snow algorithm that accepts particles having fall velocities less than 4 m/h.

Quality Assessment

All APU observations were processed for using a rain algorithm that uses the *icepop_<inst>_matrix.txt* file for accepting or rejecting particles. For apu14, the observations from November 2017 were also included.

The *icepop_parsivel_matrix.txt* files screen the drops following ±50% of its terminal fall speed. If the drop fall is outside the ±50% of its terminal fall speed, it is regarded as secondary drop and eliminated from the processing. The matrix consists of "1" for accepted and "0" for rejected drops. As part of the data processing, the 10-second observations are integrated into 1-minute; however, the timestamp of the 10-second observations has been documented in a file to distinguish the non-rainy periods from non-data collection periods. It should be noted that the thresholds of 10 drops and 0.01 mm/h have been applied to 1-minute observations to eliminate noise from rainy minutes.

For *icepop_<inst>_diameter.txt* files, it should be noted that terminal fall velocities for drops above 6.0 mm in diameter (bin 22 through bin 32) are subject to the error since Beard, 1976 do not extend for the drops larger than 6.0 mm. A linear interpretation has been performed for the drops larger than 6.0 mm in diameter.

Software

These data files are available as ASCII text files, so no software is required to view these data.

Known Issues or Missing Data

There are no known issues or missing data with this dataset.

References

Beard, K. V. (1976). Terminal Velocity and Shape of Cloud and Precipitation Drops Aloft, *Journal of the Atmospheric Sciences*, 33, 851-864. doi: https://doi.org/10.1175/1520-0469(1976)033<0851:TVASOC>2.0.CO;2

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Related Data

All other datasets collected during the ICE POP field campaign are considered related datasets. They can be located using the GHRC HyDRO 2.0 search tool and entering the term 'ICE POP' in the search box. The APU was also used in other field campaigns as listed below:

GPM Ground Validation Autonomous Parsivel Unit (APU) LPVEx (http://dx.doi.org/10.5067/GPMGV/LPVEX/APU/DATA301)

GPM Ground Validation Autonomous Parsivel Unit (APU) GCPEx (http://dx.doi.org/10.5067/GPMGV/GCPEX/APU/DATA301)

GPM Ground Validation Autonomous Parsivel Unit (APU) MC3E (http://dx.doi.org/10.5067/GPMGV/MC3E/APU/DATA301)

GPM Ground Validation Autonomous Parsivel Unit (APU) OLYMPEX (http://dx.doi.org/10.5067/GPMGV/OLYMPEX/APU/DATA301)

GPM Ground Validation Autonomous Parsivel Unit (APU) HyMeX (http://dx.doi.org/10.5067/GPMGV/HYMEX/APU/DATA301)

GPM Ground Validation Autonomous Parsivel Unit (APU) Wallops Flight Facility (WFF)
(http://dx.doi.org/10.5067/GPMGV/WFF/APU/DATA101)

GPM Ground Validation Autonomous Parsivel Unit (APU) IFloodS
(http://dx.doi.org/10.5067/GPMGV/IFLOODS/APU/DATA301)

GPM Ground Validation Autonomous Parsivel Unit (APU) IPHEx
(http://dx.doi.org/10.5067/GPMGV/IPHEX/APU/DATA301)

GPM Ground Validation Autonomous Parsivel Unit (APU) NSSTC
(http://dx.doi.org/10.5067/GPMGV/NSSTC/APU/DATA201)

Contact Information

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

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