Global Hydrology Resource Center

Data User Guide

GPM Ground Validation Micro Rain Radar (MRR) ICE POP

Introduction

The GPM Ground Validation Micro Rain Radar (MRR) 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 Measurement mission Ground Validation (GPM GV) campaign efforts to improve satellite estimates of orographic winter precipitation. This dataset consists of precipitation data collected by two MRR instruments from November 1, 2017 to March 1, 2018. These data are available in netCDF-3 and ASCII text formats.

Notice:

The MRR-2 averaged (AVE) data were processed using software designed for liquid precipitation. This lead to accuracy issues with mixed and frozen precipitation, which were corrected using a new processing algorithm later discussed in the *Algorithm* and *Quality Assessment* sections.

Citation

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Keywords:

NASA, GHRC, PMM, GPM GV, ICE-POP, MRR-2, MRR, radar, precipitation, Doppler spectra, Doppler velocity, drop size distribution, rain rate, attenuation, liquid water content

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 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.

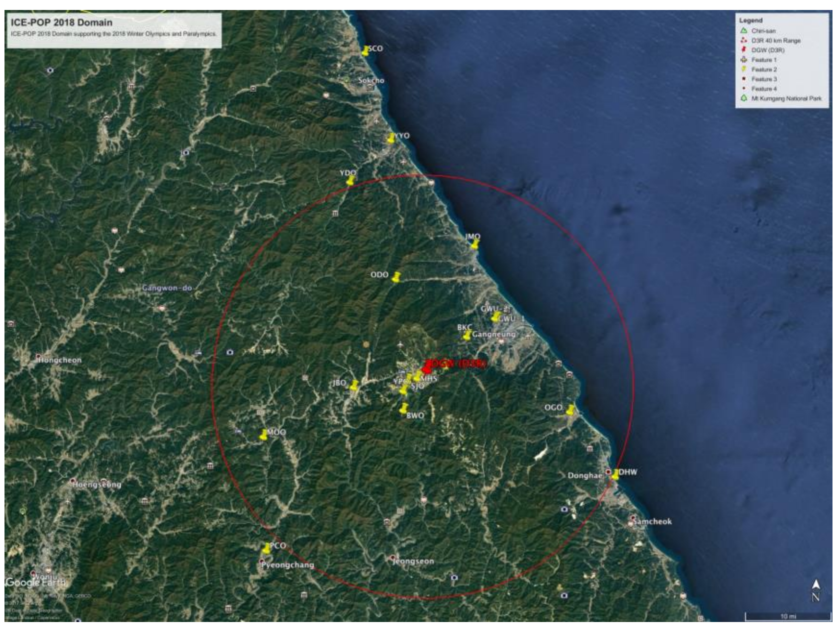

Figure 1: ICE-POP 2018 Field Campaign Domain Area (circled in red) in South Korea (Image source: GPM ICE-POP 2018 webpage)

Instrument Description

The Micro Rain Radar (MRR), specifically the MRR-2 model (Figure 2) used during ICE-POP, is a 24 GHz K-band radar profiler manufactured by Meteorologische Messtechnik GmbH (METEK). It uses the signal backscattered by precipitation particles to determine Doppler spectra and derive the drop size distribution, rain rate, radar reflectivity, and other standard measurements. The MRR-2 is a vertically pointing microwave radar that can observe precipitation particles at heights up to ~6000 meters. It has 31 range gates whose heights can be adjusted by the user from 35 m to 200 m range resolution. The MRR-2 operates in Frequency Modulated - Continuous Wave (FM-CW) mode to comply with the recommendations of radio-frequency management organizations. It is often used to observe the formation of raindrops, to monitor the melting layer, and to calibrate standard weather radars. It can perform long-term unmanned precipitation observations and its high sensitivity and temporal resolution give it the ability to detect very light precipitation that can go undetected by standard weather radars. More information about the MRR-2 can be found on the METEK MRR|MRR-2 webpage.

Figure 2: The Micro Rain Radar MRR-2
(Image source: GPM MRR webpage)

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Data Characteristics

The GPM Ground Validation Micro Rain Radar (MRR) ICE POP dataset contains Doppler spectra and the derived precipitation measurement data in ASCII and netCDF-3 format at a Level 2 processing level. More information about the NASA data processing levels is available on the EOSDIS Data Processing Levels webpage. Several MRR-2's were operating during ICE-POP, however, only two were operated by the GPM GV team, MRR03 and MRR04. MRR03 operated at the Bokwang-ri Community Center (BKC) site and MRR04 operated at the Gangneung-Wonju National University (GWU) site. Both MRR-2 instruments were operated at 200 m vertical range resolution until 11/20/2017 when they were adjusted to operate at 150 m. The characteristics of this dataset are listed in Table 1 below.

Table 1: Data Characteristics

Characteristic	Description
Platform	Ground Stations
Instrument	Micro Rain Radar (MRR-2)
Spatial Coverage	N:37.740 , S:37.675 , E:128.808, W:128.717 (South Korea)
Instrument Locations	MRR04: (Lat:37.6772 Lon: 128.719) MRR03: (Lat:37.7382 Lon:128.8058)
Spatial Resolution	150 - 200 m vertical range
Temporal Coverage	November 1, 2017 - March 1, 2018
Temporal Resolution	Daily
Sampling Frequency	Raw: 30 seconds; Averaged: 1 minute
Parameter	Precipitation
Version	1
Processing Level	2

File Naming Convention

The GPM Ground Validation Micro Rain Radar (MRR) ICE POP dataset files are named with the following convention:

Data files: icepop_mrr[03|04]_yyyymmdd.[nc|ave]

Table 2: File naming convention variables

Variable	Description
[03|04]	MRR-2 instrument number indicating instrument location: 03: BKC site 04: GWU site
yyyy	Four-digit year
mm	Two-digit month
dd	Two-digit day
.nc	netCDF-3 format
.ave	ASCII text format for averaged data

Data Format and Parameters

The GPM Ground Validation Micro Rain Radar (MRR) ICE POP dataset consists of precipitation data collected by two MRR-2 instruments, MRR03 and MRR04. METEK provides the data in four different formats, two of which are provided in this dataset: ASCII text (AVE) and netCDF-3 (NC). Details about both sets of data files are provided below.

AVE Data Files

The AVE, or averaged, data files include Doppler spectra, radar moments, and drop size distribution measurements averaged over one-minute time intervals. The MRR-2 is a profiling radar, so these data values are presented for various height levels above the radar. The data were calculated using the METEK data processing algorithm designed for liquid precipitation. Because MRR was primarily observing frozen and mixed precipitation during ICE-POP, these AVE data encounter some issues that are discussed in the *Quality Assessment* section.

Each AVE ASCII file contains data for a one-day period. These data are listed inside each ASCII file without line breaks from beginning to end. The one-minute averaged data is listed and repeated for each minute of the entire day. Each minute of data begins with a 'header' line introduced with the identifier 'MRR', indicating the beginning of the averaged data for that minute. Following 'MRR' are identifiers and their values for the measurement time, averaging time, height resolution, height of the ground level, sampling rate, version and serial numbers, the calibration constant, data quality, and data type indicator. Following this 'header' line are identifiers *H* through *W* which consist of listed values corresponding to each height level above the radar system. *H* lists the 31 range gate heights, or height levels, that increase by increments of either 150 or 200 meters distance above the radar, followed by *TF* that lists the transfer functions used at each height level. Next is the *Fnn* section which lists the spectral reflectivity at each height level for each spectral bin *nn* from 0 to 63 (i.e., the spectral reflectivity is listed for each height level for spectral bin F00 to F63). The same format follows with the *Dnn* section, listing drop sizes, and *Nnn* section, listing spectral drop densities. The *Fnn*, *Dnn*, and *Nnn* sections are followed by lists of pathway integrated attenuation (PIA), attenuated radar reflectivity (z), radar reflectivity (Z), rain rate (RR), liquid water content (LWC), and fall velocity (W) at each height level.
The order in which the data are listed for each minute is shown below, with (…) indicating a list of values for each height level. The descriptions for each identifier and variable are included in Table 3:

MRR Time UTC AVE STP ASL SMP SVS DVS DSN CC MDQ TYP AVE H… TF… F00-F63… D00-D63… N00-N63… PIA… z… Z… RR… LWC… W...

Table 3: AVE File Identifiers and Variables

Identifier	Variable	Description	Unit
MRR	-	Beginning of a dataset	-
-	Time	Measurement time in UTC (YYMMDDHHIISS) where	-

		YY = Two-digit year MM = Two-digit month DD = Two-digit day HH = Two-digit hour II = Two-digit minute SS = Two-digit second	
-	AVE	Averaging time	seconds
-	STP	Height resolution	meters
-	ASL	Height of the ground level	meters
-	SMP	Sampling rate of the radar signal in the time domain	Hz
-	SVS	Version number of the MRR service (Service version number)	-
-	DVS	Version number of the MRR firmware(Device version)	-
-	DSN	Device serial number of the MRR	-
-	CC	Calibration constant	-
-	MDQ	Micro Rain Radar Data quality: percentage of valid spectra, number of valid spectra and number of total spectra	%, #,#
-	TYP	Identifier for data type (PRO or AVE; only AVE for this dataset)	-
H	Height	Height above the radar system	meters
TF	TF	Transfer function	dBZ
Fnn	FFT spectra	FFT spectra, Fnn with nn from 0 to 63. Each line represents a profile of spectral reflectivity corresponding to the spectral bin nn	dB
Dnn	Drop sizes	Drop sizes (diameter of equivolumic sphere); Dnn with nn from min(h) to max(h)	mm
Nnn	Spectral drop densities	Spectral drop density, Nnn with min(h) to max(h)	m^{-3} mm^{-1}
PIA	PIA	Two-way path integrated attenuation by rain drops	dB
z	z	Attenuated radar reflectivity (without attenuation correction)	dBZ
Z	Z	Radar reflectivity (with attenuation correction)	dBZ
RR	RR	Rain rate	mm h^{-1}
LWC	LWC	Liquid water content	g m^{-3}
W	W	Fall velocity	m s^{-1}

NC Data Files

The NC, or netCDF-3, data files contain MRR Doppler spectra and radar moments that have been corrected by the Maahn and Kollias (2012) algorithm for mixed and frozen precipitation, discussed in the *Algorithm* section below. The NC data files do not contain drop (particle) size distribution. The data fields in the NC files are listed in Table 4 below.

Table 4: NC File Data Fields

Field Name	Description	Data Type	Unit
eta	Spectral reflectivities. If dealiasing is applied, the spectra are triplicated, thus up to three peaks can occur from -12 to +24 m/s. However, only one peak is not masked in etaMask	float	mm^6m^{-3}
eta_noDA	Spectral reflectivities NOT dealiased	float	mm^6m^{-3}
etaMask	Noise mask of eta, 0: signal, 1: noise	int	boolean
etaMask_noDA	Noise mask of eta NOT dealiased, 0: signal, 1: noise	int	boolean
etaNoiseAve	Mean noise of one Doppler Spectrum in the same units as *eta*, never dealiased	float	mm^6m^{-3}
etaNoiseStd	Standard deviation of noise of one Doppler Spectrum in the same units as *eta*, never dealiased	float	mm^6m^{-3}
height	Height above instrument	float	m
kurtosis	Kurtosis of the most significant peak	float	$m\ s^{-1}$
kurtosis_noDA	Kurtosis of the most significant peak, not dealiased	float	$m\ s^{-1}$
leftSlope	Slope at the left side of the peak	float	$dB/(m\ s^{-1})$
leftSlope_noDA	Slope at the left side of the peak, not dealiased	float	$dB/(m\ s^{-1})$
peakVelLeftBorder	Doppler velocity of the left border of the peak	float	$m\ s^{-1}$
peakVelLeftBorder_noDA	Doppler velocity of the left border of the peak, not dealiased	float	$m\ s^{-1}$
peakVelRightBorder	Doppler velocity of the right border of the peak	float	$m\ s^{-1}$
peakVelRightBorder_noDA	Doppler velocity of the right border of the peak, not dealiased	float	$m\ s^{-1}$
quality	*see the *quality* field description below	int	bin
range	Range bins	int	#
rightSlope	Slope at the right side of the peak	float	$dB/(m\ s^{-1})$
rightSlope_noDA	Slope at the right side of the peak, not dealiased	float	$dB/(m\ s^{-1})$
skewness	Skewness of the most significant peak	float	$m\ s^{-1}$
skewness_noDA	Skewness of the most significant peak, not dealiased	float	$m\ s^{-1}$

SNR	Signal-to-noise ratio of the most significant peak, never dialiased	float	dB
spectralWidth	Spectral width of the most significant peak	float	m s^{-1}
spectralWidth_noDA	Spectral width of the most significant peak, not dealiased	float	m s^{-1}
TF	Transfer Function (see METEK's documentation	float	-
time	Measurement time. Following Metek's convention, the dataset at 11:55 contains all recorded raw between 11:54:00 and 11:54:59 (if delta t = 60s)	int	seconds since 1970-01-01
velocity	Doppler velocity bins. If dealiasing is applied, the spectra are triplicated	float	m s^{-1}
velocity_noDA	Original, non-dealiased, Doppler velocity bins	float	m s^{-1}
W	Mean Doppler velocity of the most significant peak	float	m s^{-1}
W_noDA	Mean Doppler velocity of the most significant peak, not dealiased	float	m s^{-1}
Ze	Reflectivity of the most significant peak	float	dBz
Ze_noDA	Reflectivity of the most significant peak, not dealiased	float	dBz

Note: fill value of *-9999* for missing data for all variables

*The *quality* field contains flag values that indicate the condition of the data. The meaning of these values are described in the *Quality Assessment* section below.

Additional information about the GPM GV MRR ICE POP dataset is available in the MRR Data for ICE-POP documentation.

Algorithm

The data processing software provided by METEK was designed for liquid precipitation, however, Maahn and Kollias (2012) developed a new Doppler spectra processing algorithm for mixed and frozen precipitation. It improves noise removal and adds a dealiasing component to provide more effective Doppler velocity, reflectivity, and spectral width. More information about these methods are available in Maahn and Kollias (2012).

Quality Assessment

The NC data files contain a *quality* field that indicates the condition of the data. The field's flag values and their descriptions are listed below:

The *quality* Field Flag Values
A) Usually, the following errors can be ignored (no. is position of bit):

1) spectrum interpolated around 0 and 12 m/s
2)peak stretches over interpolated part
3)peak is dealiased
4)first Algorithm to determine peak failed, used backup
5)dealiasing went wrong, but is corrected

B) Reasons why a spectrum does NOT contain a peak:

8) spectrum was incompletely recorded
9) the variance test indicated no peak
10) spectrum is not processed due to according setting
11) peak removed since not wide enough
12) peak removed, because too few neighbours show signal, too

C) Things went seriously wrong; do not use data with these codes:

16) peak is at the very border to bad data
17) in this area there are still strong velocity jumps, indicates failed dealiasing
18) during dealiasing, a warning was triggered, applied to whole column

As previously mentioned, the study by Maahn and Kollias (2012) investigated the use of an improved Doppler spectra processing algorithm for mixed and frozen precipitation. The original software provided by METEK had insufficient noise removal and did not apply dealiasing (removal of velocity folding when velocities exceed the scale) to the Doppler spectra. The algorithm developed by Maahn and Kollias included improved noise removal and dealiasing as well as improved sensitivity to detect the weak echo often returned by light snowfall. They also noted the need for enhancements to the dish heating system. In their study, 4% of MRR data had to be removed using manual quality control checks due to snow accumulation on the dish.

Software

These data are available in netCDF-3 and ASCII format. No special software is required to view these data, however, Panoply can be used to easily view the netCDF-3 data files. The ASCII files can be viewed in any text file viewer such as Notepad.

Known Issues or Missing Data

As noted in the *Quality Assessment* section, the MRR AVE data were processed using software designed for liquid precipitation and therefore contain some inaccuracies for mixed and frozen precipitation. Missing data is indicated by a fill value of *-9999*.

References

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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 HyDRO2.0 search tool and entering the term 'ICE POP' in the search box. The MRR was also used in other field campaigns. These datasets can be located by searching the term 'MRR' in HyDRO2.0 and are listed below.

GPM Ground Validation Micro Rain Radar (MRR) OLYMPEX dataset (http://dx.doi.org/10.5067/GPMGV/OLYMPEX/MRR/DATA201)

GPM Ground Validation Micro Rain Radar (MRR) NASA ACHIEVE IPHEx dataset (http://dx.doi.org/10.5067/GPMGV/IPHEX/MRR/DATA201)

GPM Ground Validation Duke Micro Rain Radar (MRR) IPHEx dataset (http://dx.doi.org/10.5067/GPMGV/IPHEX/MRR/DATA202)

GPM Ground Validation NASA Micro Rain Radar (MRR) (http://dx.doi.org/10.5067/GPMGV/IPHEX/MRR/DATA203)

GPM Ground Validation Micro Rain Radar (MRR) NASA IFloodS dataset (http://dx.doi.org/10.5067/GPMGV/IFLOODS/MRR/DATA201)

GPM Ground Validation NASA Micro Rain Radar (MRR) HyMeX (http://dx.doi.org/10.5067/GPMGV/HYMEX/MRR/DATA201)

GPM Ground Validation Environment Canada (EC) Micro Rain Radar (MRR) GCPEx V2 dataset
(http://dx.doi.org/10.5067/GPMGV/GCPEX/MRR/DATA203)

GPM Ground Validation NASA Micro Rain Radar (MRR) GCPEx dataset
(http://dx.doi.org/10.5067/GPMGV/GCPEX/MRR/DATA204)

GPM Ground Validation NASA Micro Rain Radar (MRR) MC3E dataset
(http://dx.doi.org/10.5067/GPMGV/MC3E/MRR/DATA201)

GPM Ground Validation Micro Rain Radar (MRR) LPVEx dataset
(http://dx.doi.org/10.5067/GPMGV/LPVEX/MRR/DATA101)

GPM Ground Validation Advanced Microwave Radiometer Rain Identification (ADMIRARI) GCPEx dataset
(http://dx.doi.org/10.5067/GPMGV/GCPEX/ADMIRARI/DATA201)

Contact Information

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

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