Global Hydrology Resource Center

Data User Guide

GPM Ground Validation Dual-frequency Dual-polarized Doppler Radar (D3R) ICE POP

Introduction

The GPM Ground Validation Dual-frequency Dual-polarized Doppler Radar (D3R) ICE POP dataset includes reflectivity, differential reflectivity, copolar correlation coefficient, differential propagation phase, radial velocity, and spectrum width data collected by the Dual-frequency Dual-polarized Doppler Radar (D3R) 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. The D3R was developed by a government-industry-academic consortium with funding from NASA's GPM Project. It operates at the ku (13.91 GHz ± 25 MHz) and ka (35.56 GHz ± 25 MHz) frequencies covering a fixed range from 450 m to 39.75 km. The D3R dataset files are available from November 1, 2017 through March 17, 2018 in netCDF-4 format.

Notice:
There are several dates during ICE-POP when D3R data are not available due to maintenance or clear weather. These dates are listed in the *Known Issues or Missing Data* section.

Citation

Chandrasekar, Chandra V. 2019. GPM Ground Validation Dual-frequency Dual-polarized Doppler Radar (D3R) ICE POP [indicate subset used]. Dataset available online from the NASA Global Hydrology Resource Center DAAC, Huntsville, Alabama, U.S.A. doi: http://dx.doi.org/10.5067/GPMGV/ICEPOP/D3R/DATA101

Keywords:
NASA, GHRC, PMM, GPM GV, ICE-POP, South Korea, precipitation, D3R, dual-polarized radar, Doppler radar, reflectivity, differential reflectivity, copolar correlation coefficient, differential propagation phase, radial velocity, spectrum width

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.

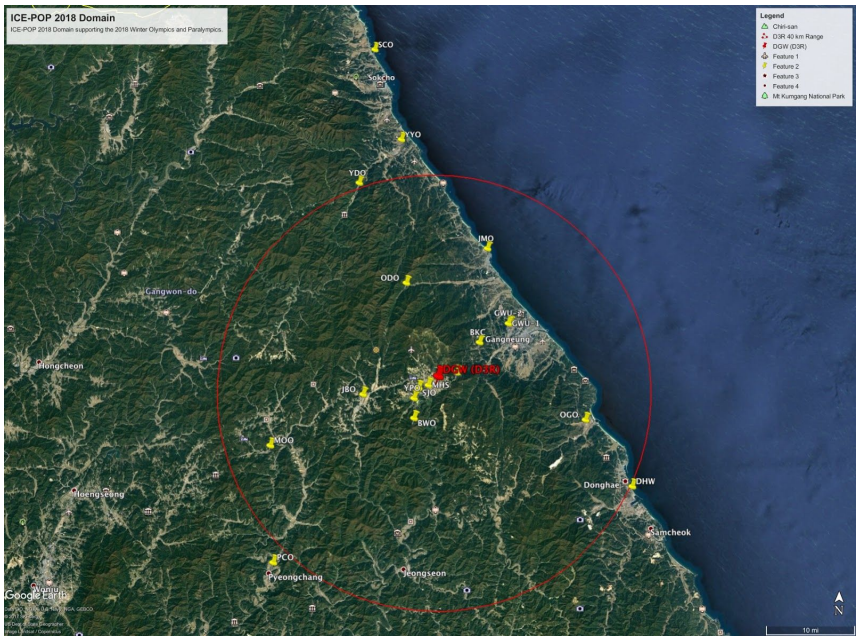

Figure 1: ICE-POP Field Campaign Domain Area (circled in red) on the east coast of South Korea
(Image source: GPM ICE-POP 2018 webpage)

Instrument Description

The Dual-frequency Dual-polarized Doppler Radar (D3R) (Figure 2), developed with funding from NASA's GPM Project, is a polarimetric, scanning Doppler weather radar system that provides estimations of hydrometeor classification and drop size distribution retrievals. The “dual-polarized” description means that D3R can transmit radar pulses at two orientations: horizontal (H) and vertical (V). This gives it the ability to discern target size and shape. The “Doppler” description means that D3R can produce velocity data from the return signal. The first generation D3R design is comprised of two separate co-aligned single-frequency antenna units mounted on a common pedestal with a dual-frequency dual-polarized solid- state transmitter. The D3R operates at the ku (13.91 GHz ± 25 MHz) and ka (35.56 GHz ± 25 MHz) frequencies covering a fixed range from 450 m to 39.75 km. These frequencies were selected for close compatibility with the GPM Dual-frequency Precipitation Radar (DPR) instrument onboard the GPM Core Observatory satellite. During ICE-POP, the D3R instrument was located at latitude 37.6774° N and longitude 128.719° E. More detailed information about the D3R instrument can be found in this D3R information document and the GPM requirements for mobile Ka-/Ku-band radar are available here.

Figure 2: The D3R on its trailer
(Image source: PMM D3R webpage)

Investigators

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Data Characteristics

The GPM Ground Validation Dual-frequency Dual-polarized Doppler Radar (D3R) ICE POP dataset files contain reflectivity, differential reflectivity, copolar correlation coefficient, differential propagation phase, radial (Doppler) velocity, and spectrum width data in netCDF-4 format at a Level 1B processing level. More information about the NASA data processing levels is available on the EOSDIS Data Processing Levels webpage. There is 1 radar scan per file. The characteristics of this dataset are listed in Table 1 below.

Table 1: Data Characteristics

Characteristic	Description
Platform	Ground Station
Instrument	Dual-frequency Dual-polarized Doppler Radar (D3R)
Instrument location	Lat: 37.6774 Lon: 128.719
Spatial Coverage	N: 38.037, S: 37.318 , E: 129.078 , W: 128.360 (South Korea)
Spatial Resolution	450 m - 39.75 km range
Temporal Coverage	November 1, 2017 - March 17, 2018
Temporal Resolution	1 scan per file; Each scan takes < 2 minutes to complete
Sampling Frequency	1 second
Parameter	Reflectivity, differential reflectivity, copolar correlation coefficient, differential propagation phase, radial velocity, spectrum width
Version	1
Processing Level	1B

File Naming Convention

The GPM Ground Validation Dual-frequency Dual-polarized Doppler Radar (D3R) ICE POP dataset files are in netCDF-4 format and are named using the following convention:

Data files: icepop_d3r_[ka|ku]_YYYYMMDD_hhmmss_<scan>.nc

Table 2: File naming convention variables

Variable	Description
[ka|ku]	Frequencies: ku (13.91 GHz ± 25 MHz) or ka (35.56 GHz ± 25 MHz)
YYYY	Four-digit year
MM	Two-digit month
DD	Two-digit day
hh	Two-digit hour
mm	Two-digit minute
ss	Two-digit second
scan	Scan number (01, 02, 03, 04, etc.)
.nc	netCDF-4 file format

Data Format and Parameters

The GPM Ground Validation Dual-frequency Dual-polarized Doppler Radar (D3R) ICE POP dataset consists of netCDF-4 data files with each individual file consisting of 1 radar scan. There are a total of 266 range gates in each ray (each range gate is 150 m) and the D3R uses two frequency diverse pulses: a "short" and "medium" pulse. The short pulse is used for the first 27 range gates (up to 3.3 km) while the medium pulse is used for the remaining data. These pulses are denoted by the text "Short" and "Medium" in data variable names. The pulse orientation is indicated by an "H" for horizontal and "V" for vertical. More information is available in the D3R ICE POP PI documentation. Table 3 below lists the data fields within each netCDF-4 file.

The *RawPower_** variables are the received power without any noise subtraction or manipulation . The *SignalPower_** variables are the power used to estimate reflectivity (without compensation for range or the radar constant).

Table 3: Data Fields

Field Name	Data Type	Unit
Azimuth	double	degrees
Azimuth_Ray_End	double	degrees
Azimuth_Ray_Start	double	degrees
ClutterPowerH	float	dBu
ClutterPowerV	float	dBu
CopolarCorrelation	float	-

DifferentialPhase	float	degrees
DifferentialReflectivity	float	dB
Elevation	double	degrees
Elevation_Ray_End	double	degrees
Elevation_Ray_Start	double	degrees
GateWidth	int	mm
GcfState	int	-
MaskSecondTrip	float	-
NoiseSourcePowerH_Short	double	dBu
NoiseSourcePowerV_Short	double	dBu
NormalizedCoherentPower	float	-
PolarizationMode	int	-
PRTMode	int	-
RawPower_H	float	dBu
RawPower_HV	float	dBu
RawPower_V	float	dBu
Reflectivity	float	dBZ
ReflectivityHV	float	dBZ
ReflectivityV	float	dBZ
Signal+Clutter_toNoise_H	float	dB
SignalPower_H	float	dBu
SignalPower_HV	float	dBu
SignalPower_V	float	dBu
SpectralWidth	float	m/s
StartGate	int	-
StartGate_Medium	int	-
StartGate_Short	int	-
StartRange	double	mm
Time	int	seconds
TxFrequency_Medium	double	Hz
TxFrequency_Short	double	Hz
TxLength_Medium	double	seconds
TxLength_Short	double	seconds
TxPowerH_Medium	double	dBm
TxPowerH_Short	double	dBm
TxPowerV_Medium	double	dBm
TxPowerV_Short	double	dBm
Velocity	float	m/s

The “PolarizationMode”, “PRTMode”, and “GcfState” variables give the flag values for the radar polarization, pulse repetition time (PRT), and ground clutter filter (Gcf). Tables 4 - 6 below describe each field’s flag values.

Table 4: “PolarizationMode” states

Flag Value	Description
0	Passive (no transmitter fired)
1	H Only
2	V Only
3	Alternate
4	Simultaneous
99	Error

Table 5: “PRTMode” states

Flag Value	Description
0	Uniform PRT
1	Staggered ⅔ PRT

Table 6: “GcfState” states

Flag Value	Description
0	Off - No ground clutter filter used
1	On - GMAPTD ground clutter filtering enabled

Note: The ground clutter filter was not applied for this dataset

Algorithm

One of the purposes of D3R in the GPM GV program was to provide validation for spaceborne radar precipitation measurements. Due to hardware limitations on space-based platforms, spaceborne radars have to operate at higher transmission frequencies. Therefore, the ka- and ku-band frequencies used by D3R provide valuable validation measurements for satellite retrieval algorithms. The use of these high frequencies requires additional modifications to standard retrieval methods. For example, D3R provides ground-based statistics for raindrip size distribution (DSD) to help improve satellite DSD retrievals. However, the DSD retrieval algorithms using differential phase shift had to be adjusted for D3R because the instrument’s ka- and ku- bands observe different precipitation signatures and are more affected by attenuation than the more common S- and C- band radars. More information about these algorithm adjustments can be found in Chandrasekar et al. (2010).

Quality Assessment

The GPM GV radars routinely undergo various calibration procedures to maintain system accuracy and performance including receiver and sphere calibration. More information on these calibration procedures can be found in Chandrasekar et al. (2015). For the D3R data, differential reflectivity bias and initial differential phase shift offset have been corrected and the corrected values can be found under the global attribute “Modified” in the netCDF-4 data files. The ground clutter filter was not enabled for this dataset and therefore

ground clutter will be present in the results. This information can be found in the D3R ICE POP PI documentation.

Software

No software is required to view these data; however, Panoply can be used to easily open and examine the data files.

Known Issues or Missing Data

As noted in the D3R ICE POP PI documentation, there are several dates during ICE-POP when D3R data are not available due to maintenance or clear weather. Below are the dates during the campaign (*MM/DD/YYYY*) in which D3R was down for maintenance:

01/19/2018 to 02/02/2018
02/16/2018 to 02/17/2018

Below are the dates during the campaign *(MM/DD/YYYY*) in which D3R was not scanning due to clear weather:

11/05/2017
11/18/2017
11/26/2017
12/11/2017
12/16/2017
12/26/2017
12/31/2017
01/01/2018
01/06/2018
01/13/2018
03/03/2018
03/14/2018

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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 HyDRO2.0.

In addition, the D3R was used in other GPM GV field campaigns. These other D3R datasets are listed below and may be of interest.

GPM Ground Validation Dual-frequency Dual-polarized Doppler Radar (D3R) OLYMPEX (http://dx.doi.org/10.5067/GPMGV/OLYMPEX/D3R/DATA101)

GPM Ground Validation Dual-frequency Dual-polarized Doppler Radar (D3R) IPHEx (http://dx.doi.org/10.5067/GPMGV/IPHEX/D3R/DATA101)

GPM Ground Validation Dual-frequency Dual-polarized Doppler Radar (D3R) IFloodS (http://dx.doi.org/10.5067/GPMGV/IFLOODS/D3R/DATA101)

GPM Ground Validation Dual-frequency Dual-polarized Doppler Radar (D3R) GCPEx (http://dx.doi.org/10.5067/GPMGV/GCPEX/D3R/DATA101)

Contact Information

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

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