DATA AND OPERATIONAL PROCESSING FOR NASA'S GPM GROUND VALIDATION PROGRAM

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Introduction

The Global Precipitation Measurement (GPM) Mission satellite and international mission led by NASA and JAXA was launched from Tanegashima, Japan on February 27, 2014. For validation support, an extensive network currently consisting of 78 dual-polarimetric weather radars in different meteorological regimes were selected by the GPM GV (ground validation) program to identify biases between ground observations and satellite retrievals, to assess the physical basis for uncertainties, and to improve both ground and space-based retrievals of precipitation.
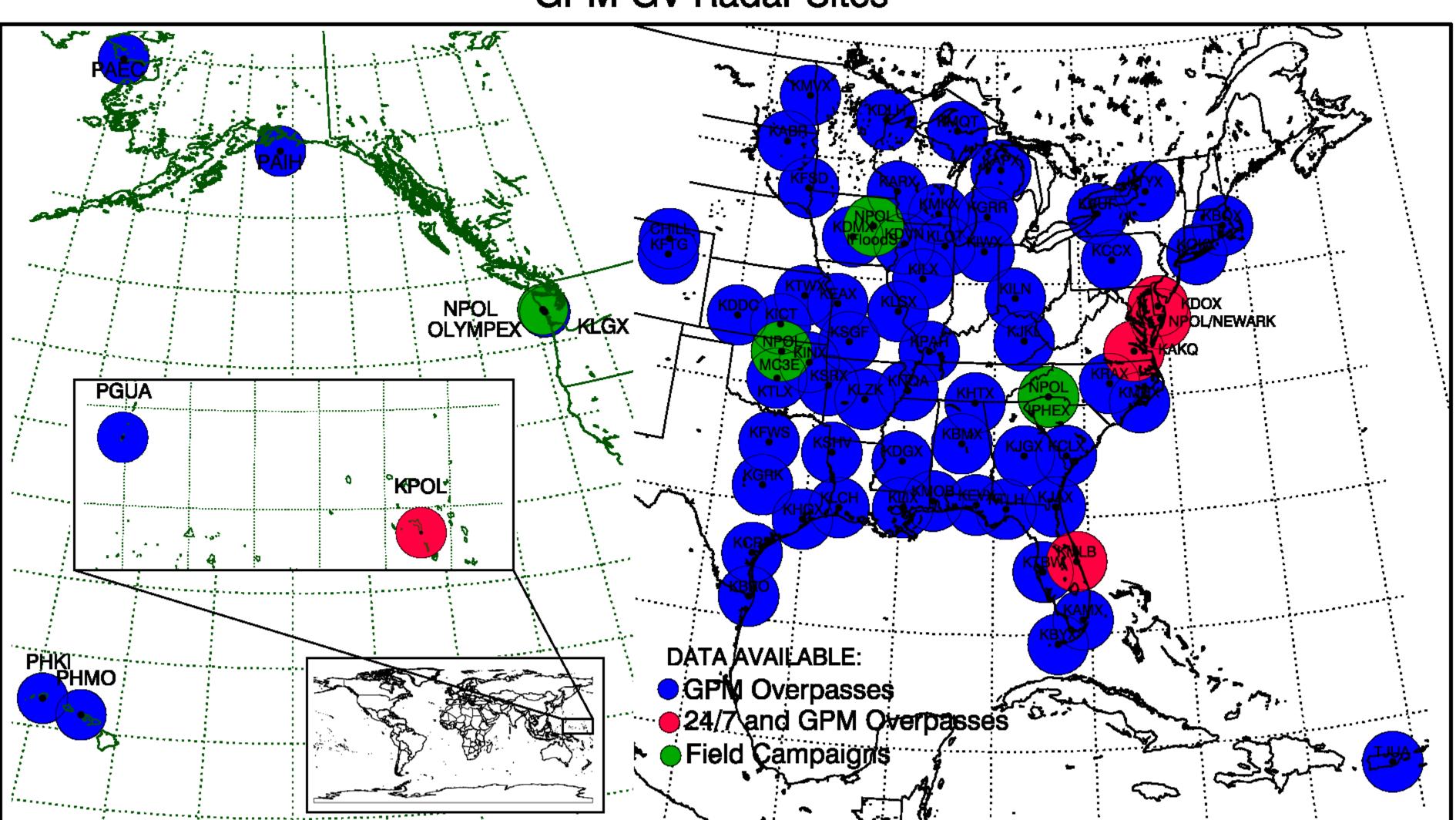
GPM-GV Radar Sites

Fig. 1. Northern hemisphere GPM-GV radar sites. A majority of the radars were selected from the eastern United States to coincide geographically with products from the NOAA/NSSL ground-based National Mosaic and Multi-Radar Multi-sensor Quantitative Precipitation Estimation (NMQ/MRMS).
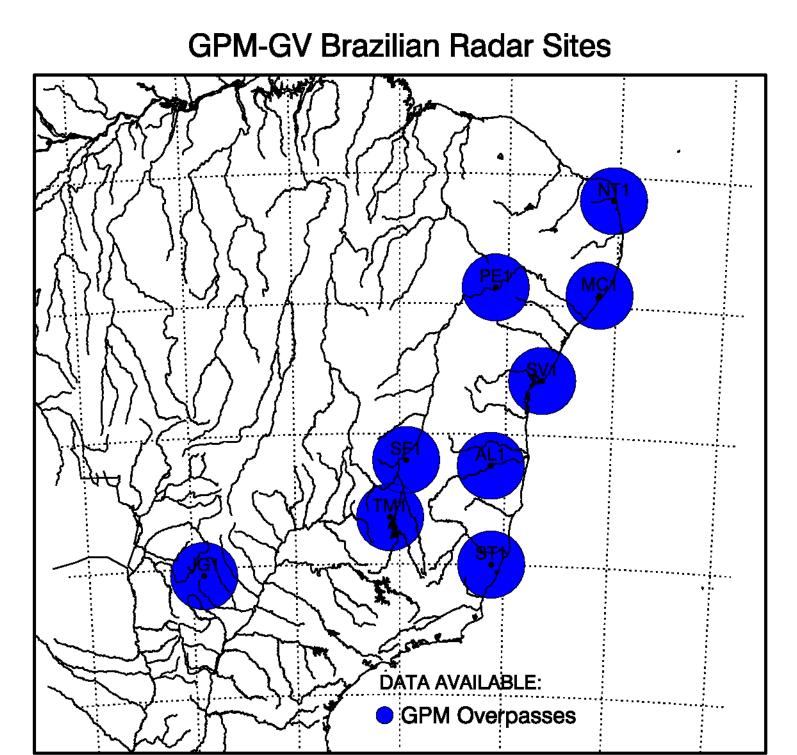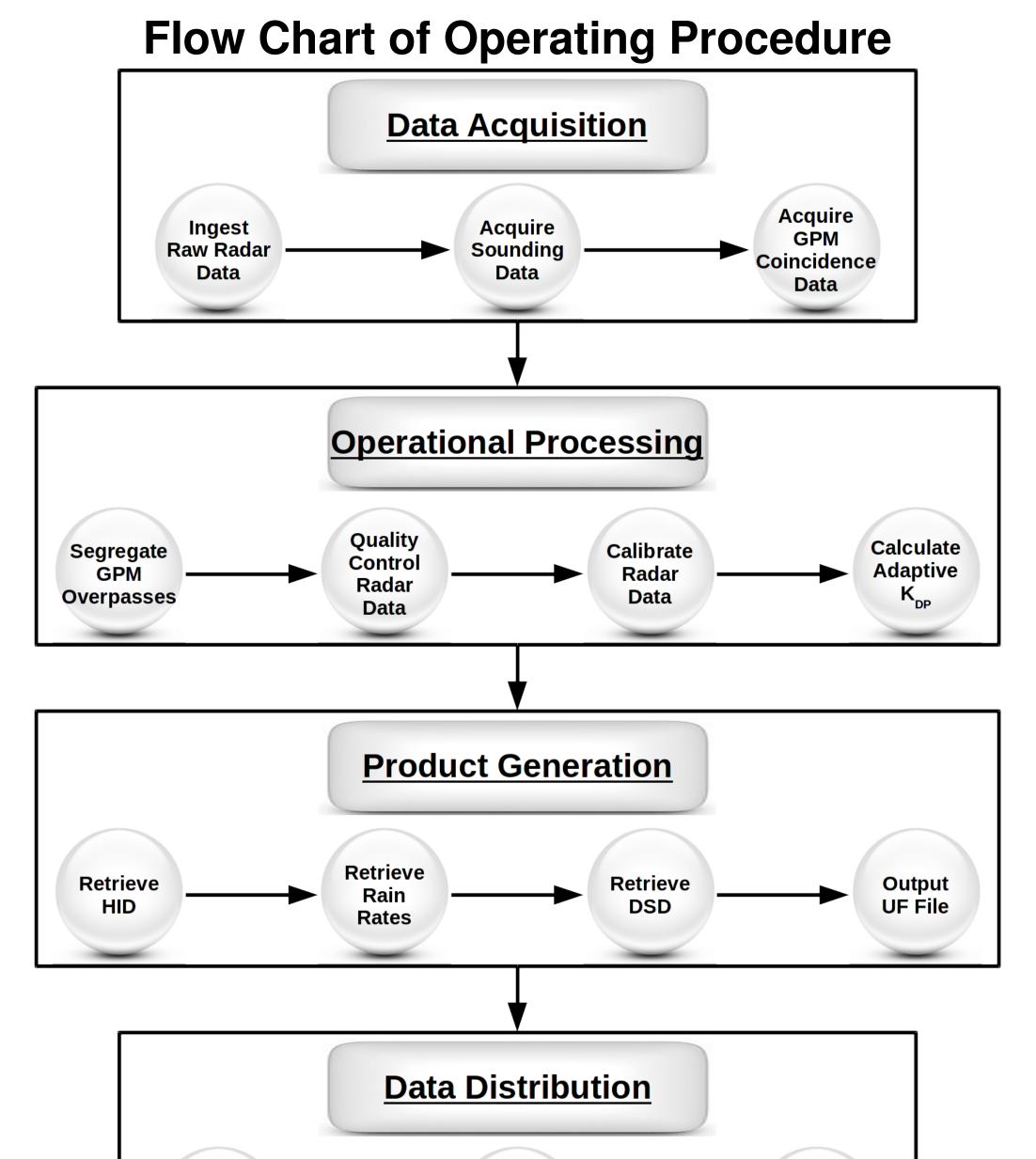
GPM-GV Brazilian Radar Sites

Fig. 2. Through an international partnership with Brazil, nine S-band radars from the Center for Monitoring and Alerts of Natural Disasters (CEMADEN) network are included in the GPM GV network.

Fig. 3. Flowchart of the GPM GV operating procedure for data acquisition, operational processing, product generation, and data distribution.

Data Acquisition

Radar Type	# of Sites	Acquisition Method
WSR-88D	66	Data are acquired in near real time via Education and Research Consortium (ERC) NEXRAD local data manger (LDM) stream.
CEMADEN	9	Data are acquired through file transfer protocol (FTP) in near real time.
KPOL	1	Provided daily via secure copy (SCP) by Atmospheric Technology Services Company (ATSC).
NPOL	1	NPOL data that correspond with a GPM overpass are obtained in near real time in full-resolution. NPOL full-resolution data sets are retrieved at the radar site on portable hard drives and transported to NASA's Wallops Flight Facility (WFF) where the data are archived.
CHILL	1	Colorado State University (CSU) provides CHILL data from GPM overpasses via FTP on a case-by-case basis.

Table 1. The majority of the radar data retrieval process has been automated through the use of programs and scripts. Radar type, number of sites, and data acquisition methods are shown.

Additional Data Retrieval

- GPM satellite coincidence files are retrieved from the NASA Precipitation Processing System (PPS) and used to identify overpass details specific to each radar.
- Hourly model soundings are obtained from NOAA and assist in identifying the melting layer and ice crystals.

Operational Processing

Quality Control

- Quality control (QC) is applied to the radar data using the NASA developed Dual Polarimetric Quality Control (DPQC) algorithm (Pippitt et. al 2013).

Calibration

- Calibration adjustments are determined via the Relative Calibration Adjustment (RCA) technique (Silberstein et al. 2008; Wolff et al. 2015), self-consistency of polarimetric variables, and vertical profile (birdbath) scans.

Specific Differential Phase

- Original specific differential phase (K_{dp}) is replaced with the calculated estimate derived from Wang and Chandrasekar (2009).

Product Generation

Rain Rate Estimates

- Method 1: a polarimetrically tuned Z-R algorithm that adjusts for drop oscillations (PolZR - Bringi et al. 2004).
- Method 2: a hydrometeor identification approach referred to as the Dual-Polarization Radar Operational Processing System (DROPS2.0 - Chen et al. 2015).

Drop Size Distribution Retrievals

- Median drop diameter (D_0), normalized intercept parameter (N_w), mass weighted mean diameter (D_m) and the associated normalized intercept parameter (N_w, but referred to in the data files as N_2) fields are retrieved using polarimetrically tuned regressions via T-matrix simulations from disdrometer data collected in a wide variety of regimes (Jensen et al. 2010).
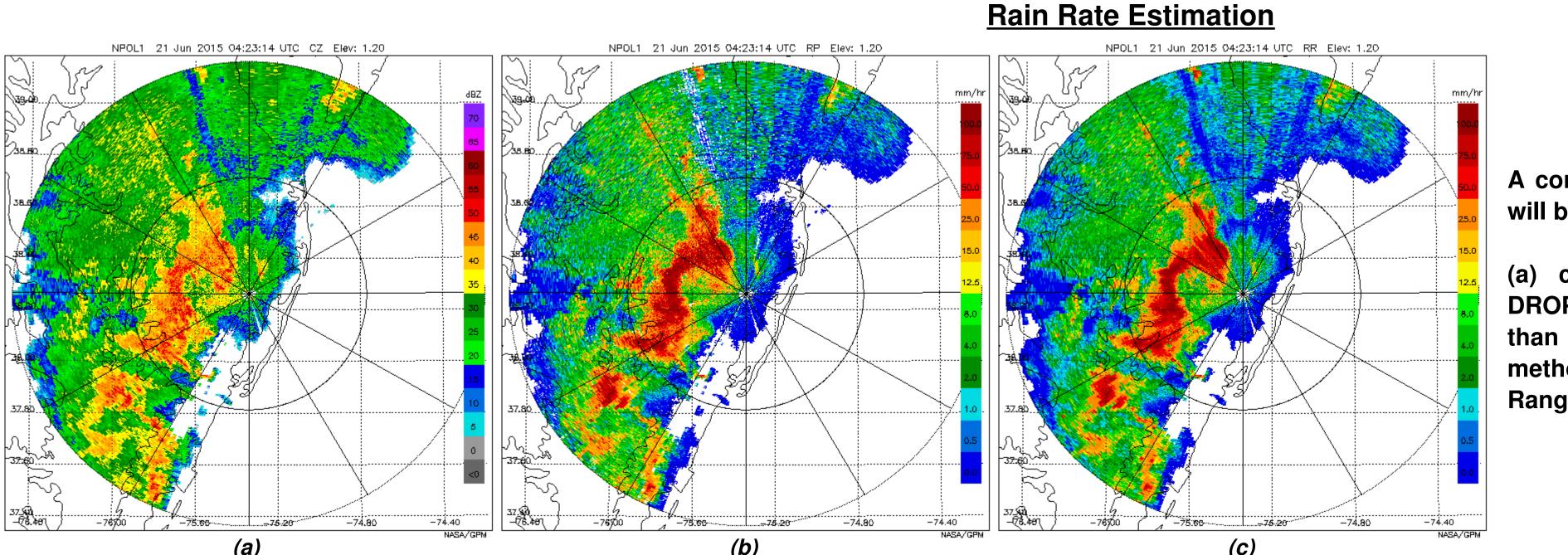
Hydrometeor Classification

- The Colorado State University (CSU) warm season Hydrometeor Identification (HID) algorithm is used to generate a detailed hydrometeor classification (Dolan et al. 2013).

HID Category	Description
UC	Unclassified
DZ	Drizzle
RN	Rain
CR	Ice Crystals
DS	Dry Snow
WS	Wet Snow
VI	Vertical Ice
LDG	Low-density Graupel
HDG	High-density Graupel
HA	Hail
BD/MH	Big Drops/Melting Hail

Table 2. HID categories.
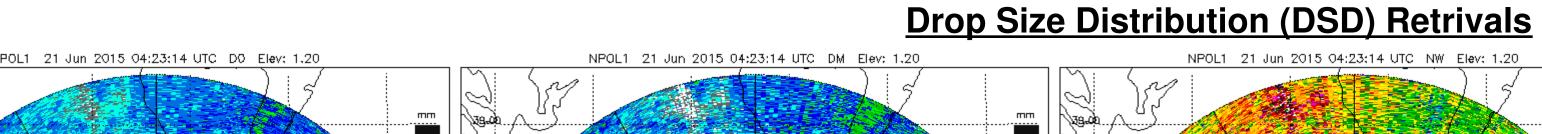
Field Name	Description	Field Name	Description
ZZ	Uncorrected Reflectivity	VR	Radial Velocity
CZ	Corrected Reflectivity	FH	Hydrometeor Identification (HID)
RH	Co-polar Cross Correlation (ρ_{hv})	D0	Median Volume Diameter
DR	Differential Reflectivity (Z_{dr})	DM	Mass Weighted Mean Diameter
PH	Differential Phase (Φ_{dp})	NW	Normalized Intercept Parameter
KD	Specific Differential Phase (K_{dp})	N2	Normalized Intercept Parameter
SW	Spectrum Width	RR	DROPS2 Rain Rate
SQ	Signal Quality Index	RP	PolZR Rain Rate
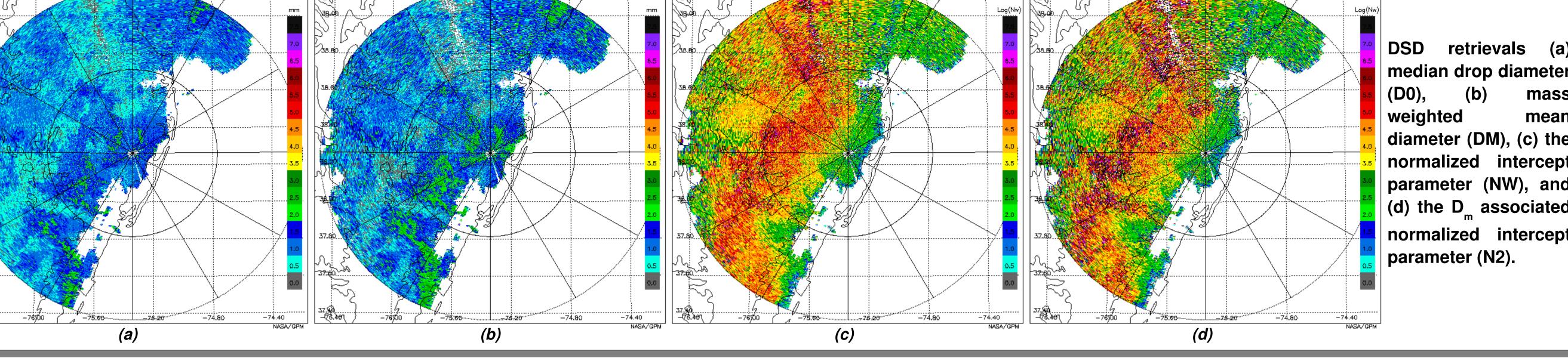
Table 3. The full complement of products generated and stored as fields in UF format radar data files.

Rain Rate Estimation

A convective event that occurred at NPOL on 21 June 2015, will be used as an example for GPM GV rainfall products.

(a) corrected reflectivity (CZ), (b) PolZR (RP), and (c) DROPS2.0 (RR). Both approaches identify rain rates greater than 75 mm hr⁻¹ within the convective cells. The DROPS2.0 method appears visually cleaner than the other method. Range rings are at 50 km intervals.

Drop Size Distribution (DSD) Retrivals

DSD retrievals (a) median drop diameter (D0), (b) mass weighted mean diameter (DM), (c) the normalized intercept parameter (NW), and (d) the D_m associated normalized intercept parameter (N2).

Hydrometeor Classification

A mixed phase case from KDOX on 15 February 2015 (a) corrected reflectivity (CZ) and (b) Hydrometeor Identification (FH). Range rings are at 50 km intervals.

A convective cell case from NPOL on 21 July 2015 (c) corrected reflectivity (CZ) and (d) Hydrometeor Identification (FH).

Data Distribution

GPM VN overpass and select full data set sites are hosted on public FTP and can be found through the following website:

http://gpm-gv.gsfc.nasa.gov/Radar/

GPM VN visualization tools that enable users to visualize the corresponding data measured by space-based Precipitation Radar (PR) and measurements collected by ground radars, can be found via:

http://opensource.gsfc.nasa.gov/projects/GPMV/index.php

Data requests and questions can be sent to: jason.l.pippitt@nasa.gov

Summary

GPM GV has established an data processing suite using a current network of 78 weather radars located in different meteorological regimes to identify errors between ground observations and GPM satellite retrievals, understand the physical basis of uncertainties, and improve both space and ground-based precipitation estimation. GPM GV has automated numerous processing procedures to streamline data flow to the community. Raw data are acquired for all sites and archived locally. Operational processing consisting of quality control, calibration, and calculation of specific differential phase is performed prior to rain rate, hydrometeor identification, and DSD retrievals. The final data are in UF format and available to the community through FTP. The resulting data is a key element in bridging the space and time gap between satellite observations and in-situ surface instrumentation such as rain gauges and disdrometers.

References

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Flow Chart of Operating Procedure

Data Acquisition
Ingest Raw Radar Data → Acquire Sounding Data → Acquire GPM Coincidence Data

Operational Processing
Segregate GPM Overpasses → Quality Control Radar Data → Calibrate Radar Data → Calculate Adaptive K_{DP}

Product Generation
Retrieve HID → Retrieve Rain Rates → Retrieve DSD → Output UF File

Data Distribution
Archive RAW & UF Files → Copy UF's To GPM VN → Post UF's To Web