



Data User Guide

GPM Ground Validation Multi-Radar/Multi-Sensor (MRMS) Precipitation Reanalysis for Satellite Validation Product

Introduction

The GPM Ground Validation Multi-Radar/Multi-Sensor (MRMS) Precipitation Reanalysis for Satellite Validation Product dataset contains precipitation rate and type estimates, quality control products, and precipitation corrective factors products. These data products were created using the NOAA MRMS System which ingests Weather Surveillance Radar 88 Doppler (WSR-88D) radar data, Rapid Update Cycle (RAP) model analysis fields, and gauge data. It should be noted that these data products are not standard MRMS. Significant post-processing is applied to MRMS to generate products specifically adapted to satellite purposes and needs over North America. These data are available from March 2, 2014 through October 30, 2018 in ASCII format.

Citation

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Keywords:

NASA, GHRC, WFF, MRMS, NMQ, RAP, HADS, Ground Validation, precipitation rate, rainfall, precipitation rate estimates, precipitation type, radar quality index

Campaign

The Global Precipitation Measurement (GPM) mission Ground Validation (GV) campaign used a variety of methods for validating GPM satellite constellation measurements prior to and after launch of the GPM Core Satellite, which occurred on February 27, 2014. The GPM

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). Surface rainfall was measured by very dense rain gauge and disdrometer networks at various field campaign sites. These field campaigns accounted for the majority of the effort and resources expended by GPM GV. This dataset results from a continuous effort as part of the GPM GV program. More information about the GPM mission is available at <https://pmm.nasa.gov/GPM/>.

Product Description

The Multi-Radar/Multi-Sensor (MRMS) system was created at the NOAA National Severe Storms Laboratory (NSSL) to produce severe weather and precipitation products for decision-making capabilities to improve severe weather forecasts and warnings, hydrology, aviation, and numerical weather prediction. MRMS currently integrates about 180 operational radars and creates a seamless 3D radar mosaic across the conterminous United States (CONUS) and southern Canada at very high spatial (1 km) and temporal (2 min) resolution. The radar base data are integrated with atmospheric environmental data, satellite data, and lightning and rain gauge observations to generate a suite of severe weather and quantitative precipitation estimation (QPE) products.

It should be noted that products in this dataset are not standard MRMS and are his data product is continuously produced. They are derived from MRMS after several quality controls, adjustments, and quantity controls are applied to the MRMS precipitation products to further refine the surface reference dataset towards specific satellite purposes and needs. This conservative post-processing is designed to maximize accuracy, minimize uncertainties and standardize the precipitation reference products across the CONUS. It covers dates from March 2, 2014 through October 30, 2018 over North America. Thanks to their higher resolution than any satellite precipitation product, these data are designed to be pixel matched in both time and space, and to build statistics for comparing reference precipitation intensities to satellite-based estimates.

More information about the MRMS system can be found at [NSSL's MRMS webpage](#), the [MRMS Fact Sheet](#), and [Kirstetter et al., 2012](#).

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Data Characteristics

The GPM Ground Validation Multi-Radar/Multi-Sensor (MRMS) Precipitation Reanalysis for Satellite Validation Product data files are available in ASCII format. They are available for comparison with Level 2 and Level 3 satellite-retrieved precipitation products. These data consist of real time precipitation rate and types estimates (2-min and 30-min temporal resolution for Level 2 and Level 3 satellite comparison, respectively), hourly radar-gauge precipitation rate corrective factors, and quality control products. More information about the NASA data processing levels are available on the [EOSDIS Data Processing Levels](#) webpage.

Table 1: Data Characteristics

Characteristic	Description
Platform	Ground stations
Instrument	WSR-88D, Canadian C-band radars, gauges
Spatial Coverage	N: 55.0, S: 20.0, E: -60.0, W: -130.0 (North America)
Spatial Resolution	0.01 degrees (interpolated)
Temporal Coverage	March 2, 2014 - October 30, 2018
Temporal Resolution	Hourly-<Daily
Sampling Frequency	Level 2: 2 minutes Level 3: 30 minutes
Parameter	precipitation rate estimates, precipitation type estimates, quality control and quantity control products
Version	1
Processing Level	Level 2 and Level 3

File Naming Convention

The GPM Ground Validation Multi-Radar/Multi-Sensor (MRMS) Precipitation Reanalysis for Satellite Validation Product dataset has the file naming convention shown below. These data are available at Level 2 and Level 3 processing levels in ASCII format.

Data files:

mrms_<type>_YYYYMMDD_[hhmmss|hhmmss_xxxxx].asc.gz

Table 2: File naming convention variables

Variable	Description
<type>	<p>1HCF: : hourly / 1-km pixel-by-pixel ratios between the corresponding hourly gauge-adjusted radar and the hourly radar-only products. These ratios are multiplicative adjustments applied on the radar-only 2-min and 30-min rain product. They are provided for quantity control purposes for the user for Level 2 and Level 3 satellite comparison.</p> <p>MASK: 2-minute / 1-km precipitation type product for comparison with Level 2 satellite.</p> <p>PRECIPRATE_GC: 2-minute / 1-km precipitation rates. In rain they are gauge-adjusted (using 1HCF) and filtered out when 1HCF.HSR is outside the [0.1–10] range. In snow they are radar-only. This product is for comparison with Level 2 satellite.</p> <p>RQI: 2-minute / 1-km Radar Quality Index for quality control purposes. It ranges between 0 and 1 (best value). This product is for comparison with Level 2 satellite.</p> <p>30MGCP: 2-minutes / 1-km gauge corrected precipitation rate product accumulated over 30-min. This product is for comparison with Level 3 satellite.</p> <p>30MRQI: 30-min accumulated radar quality index. It is the averaged RQI values with ranges between 0 and 100 (best). This product is for comparison with Level 3 satellite.</p> <p>30MTYPE##: 30-min precipitation type proportion in occurrence in percent. ## represents type codes. Please refer to table 4 for type code descriptions. This product is for comparison with Level 3 satellite.</p>
YYYY	Four-digit year
MM	Two-digit month
DD	Two-digit day
[hhmmss hhmmss_XXXXX]	<p>hh: two-digit hour in UTC mm: two-digit minute in UTC ss: two-digit second in UTC XXXXX: five-digit satellite orbit number</p>
asc.gz	Gzipped ASCII file

Data Format and Parameters

There are seven data products within this dataset including quality control products (2-min and 30-min), precipitation rate estimates (2-min and 30-min), precipitation corrective factors (hourly), and precipitation type estimates (2-min and 30-min). These products are designed for comparison with satellite Level 2 and Level 3 precipitation. These products consist of Radar Quality Index (RQI) files, which are meant for quality control purposes, hourly radar-gauge ratio files, which contain the ratio between hourly gauge-adjusted radar and hourly radar-only products meant for quantity control purposes, and precipitation type files, where a description of each variable in this file can be found in table 3 for the Level 2 product and table 4 for the Level 3 product.

Table 3: Description of values in MASK data files

Variable	Description
-1	Missing data
0	No precipitation
1.0	Warm stratiform rain
2.0	Warm stratiform rain at ground, but radar data is in or above the melting layer
3.0	Snow
4.0	Snow at ground, but radar data is 1.5 km or higher above the ground
6.0	Convective
7.0	Hail
91.0	Tropical/stratiform rain mix
96.0	Tropical/convective rain mix
10.0	Cool stratiform rain

Table 4: Description of type codes in 30MTYPE## data files

Variable	Description
00	No precipitation
01	Warm stratiform rain
02	Warm stratiform rain at ground, but radar data is in or above the melting layer
03	Snow
04	Snow at ground, but radar data is 1.5 km or higher above the ground
06	Convective
07	Hail
91	Tropical/stratiform rain mix
96	Tropical/convective rain mix
10	Cool stratiform rain
M	Missing data

Algorithm

The MRMS severe weather algorithms are derived using components from the Warning Decision Support System–Integrated Information (WDSS-II), and MRMS QPE algorithms are largely based on components from the National Mosaic and Multi-Sensor QPE (NMQ) systems ([Zhang et al., 2016](#)).

MRMS ingests 3D volume scan data from about 146 S-band dual-polarization Weather Surveillance Radar-1988 Doppler (WSR-88D) radars and about 30 C-band single-polarization weather radars operated by Environment Canada. The volume scan duration from these networks ranges from 3 to 10 min. A dual-polarization radar quality control (dpQC) is applied to WSR-88D data to remove non-hydrometeor echoes.

MRMS ingests approximately 7,000 hourly rain gauges from various networks such as the Hydrometeorological Automated Data System ([HADS](#)). Hourly analyses (i.e., freezing-level height, temperature, wind, and relative humidity) from the Rapid Refresh ([RAP](#)) model have been used extensively in MRMS. MRMS generates a set of experimental radar products including high-resolution (0.01, 2-min) instantaneous precipitation rates and types mosaics available over the CONUS. Hourly radar estimates are adjusted with rain gauge networks. A radar quality index (RQI) is associated with the radar quantitative precipitation estimates (QPE). Radar QPE is potentially subject to numerous sources of error (e.g. non-weather echoes, vertical profile of reflectivity variability, conversion of radar reflectivity to rain rate, calibration of the radar signal).

While several procedures are already in place within the MRMS system to correct for these errors, postprocessing is used to further refine the reference dataset by adjusting and quality-controlling instantaneous radar-only products using the RQI and collocated rain gauge observations:

- Precipitation rates are gauge-based bias adjusted and a basic filtering is applied
- The bias adjustment is a multiplicative adjustment using hourly ratios 1HCF.HSR down to 2-min (30-min) on the radar-only 2-min (30-min) QPE for liquid rain rates only; no correction is applied for snow rates (snow precipitation rates are radar only)
- The basic filtering is applied where there is too much quantitative disagreement between radar and gauges at the hourly time step (i.e. 1HCF.HSR is outside the [0.1–10] range); snow rates are filtered out when the radar beam is too high (>2.5km AGL) because the ice aloft might not have direct relationship with surface level falling snow
- Precipitation phase identification uses RAP surface temperature (< 2C) and wet bulb temperature (< 0C) for snow, and a fixed Z-S relationship $Z = 75 S^2$ is applied

For Level 2 users are free to apply more conservative filtering using RQI and 1HCF.HSR by (i) discarding precipitation values where 1HCF.HSR is outside e.g. the range [0.5–2] and (ii) by quality filtering with RQI.

For Level 3 users are free to apply more conservative filtering using 30MRQI and 1HCF.HSR by (i) discarding precipitation values where 1HCF.HSR is outside e.g. the range [0.5–2] and (ii) by quality filtering with 30MRQI.

Quality Assessment

Basic filtering was applied to all of the Level 2 and Level 3 files where there is too much quantitative disagreement between radar and gauges at the hourly time step (i.e., 1HCF data files outside the [0.1-10] range). Snow rates are filtered out when the radar beam is too high (>2.5 km above ground level) because the ice aloft might not have direct relationship with surface level falling snow. More information about the quality control steps of these data products can be found in [Kirstetter et al., 2012](#), Kirstetter et al., 2014, and [MRMS Product Description document](#).

Software

These data are in ASCII format; therefore, no software are required to view these data.

Known Issues or Missing Data

Even following a rigorous post-processing procedure on MRMS precipitation products, some residual errors may still exist in the ground-based estimates of precipitation, such as issues with the input radar-based data: non-uniform beam-filling because of VPR effects, inaccurate conversion from reflectivity to rain intensity, and calibration errors. More information about possible issues with this data product can be found in [Kirstetter et al., 2012](#).

Snow rates are radar-only and not gauge-adjusted. They are subject to uncertainties in the radar reflectivity to snow rate relation.

In the precipitation type data files (MASK and 30MTYPE## files), missing data will show as 'M' or '-1' as described in tables 3 and 4. Other files show missing data as '-9999'.

References

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Related Data

All data from other instruments collected during the GPM Ground Validation project are related to this dataset. Other GPM Ground Validation data can be located using the [GHRC HyDRO 2.0 search tool](#).

The MRMS data product can also be found in the IPHEX and IFloodS field campaigns in support of the GPM Ground Validation project and are also available at the GHRC:

GPM Ground Validation National Mosaic and Multi-Sensor QPE (NMQ) System IFloodS (<http://dx.doi.org/10.5067/GPMGV/IFLOODS/NMQ/DATA101>)

GPM Ground Validation Hydro-Estimator IPHEX (<http://dx.doi.org/10.5067/GPMGV/IPHEX/MULTIPLE/DATA401>)

GPM Ground Validation Hydro-Estimator IFloodS (<http://dx.doi.org/10.5067/GPMGV/IFLOODS/MULTIPLE/DATA101>)

Contact Information

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

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