



Data User Guide

GPM Ground Validation National Mosaic and Multi-Sensor QPE (NMQ) System IFloodS

Introduction

The GPM Ground Validation National Mosaic and Multi-Sensor QPE (NMQ) System IFloodS dataset contains quality control products, real time rain rate estimates, hourly precipitation rate estimates, and three-dimensional reflectivity products. These data products are also referred to as Multi-Radar Multi-Sensor Precipitation Reanalysis for Satellite Validation (MRMS) product and were created using the NOAA NMQ System which ingests Weather Surveillance Radar 88 Doppler (WSR-88D) radar data, Rapid Update Cycle (RUC) model analysis fields, and Hydrometeorological Automated Data Systems (HADS) gauge data. The files provided in this dataset are from the NMQ system output obtained during the GPM Iowa Flood Studies (IFloodS) field campaign that occurred throughout Iowa. These data are available in ASCII, netCDF-4, and binary formats for the dates between April 1, 2013 through June 30, 2013.

Notice:

It is requested that users refer to the National Oceanic and Atmospheric Administration's (NOAA)/National Severe Storm Sentinel's (NSSL's) National Mosaic and QPE system when using or presenting these data in any public or scientific forum including conferences, workshops, meetings, technical reports, and publications. Details of data use requirements are provided in the data use section towards the end of the user guide. This data product is also referred to as the Multi-Radar Multi-Sensor Precipitation Reanalysis for Satellite Validation (MRMS) product.

Citation

Kirstetter, Pierre-Emmanuel, Jonathan J. Gourley, Jian Zhang, and Walter Petersen. 2018. GPM Ground Validation National Mosaic and Multi-Sensor QPE (NMQ) System IFloodS [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/IFLOODS/NMQ/DATA101>

Keywords:

NASA, GHRC, GPM, IFloodS, Iowa, NMQ, MRMS, real time rain rate, hourly precipitation rate, three-dimensional reflectivity

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 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 GPM GV. More information about the GPM mission is at <https://pmm.nasa.gov/GPM/>.

The Iowa Flood Studies (IFloodS) was a ground measurement campaign that took place throughout Iowa from May 1 to June 15, 2013. The main goal of IFloodS was to evaluate how well the GPM satellite rainfall data can be used for flood forecasting. Specifically, this meant collecting detailed measurements of precipitation at the Earth's surface using ground instruments and advanced weather radars and simultaneously collecting data from satellites passing overhead. The ground instruments characterize precipitation – the size and shape of raindrops, the physics of ice and liquid particles throughout the cloud and below as it falls, temperature, air moisture, and distribution of different size droplets – to improve rainfall estimates from the satellites, and in particular the algorithms that interpret raw data for the GPM mission's Core Observatory satellite, which launched in 2014. More information about IFloodS is available at <https://pmm.nasa.gov/node/784> and <http://iowafloodcenter.org/projects/ifloods/>. The IFloodS dataset collection web page is available at <http://dx.doi.org/10.5067/GPMGV/IFLOODS/DATA101>. Additional information about the Iowa Flood Center is available at <http://iowafloodcenter.org/>.

Product Description

The National Mosaic and Multi-Sensor QPE (NMQ) System is a fully automated, multi-radar, multi-sensor system which is used to assimilate different observational networks in an effort to create high-resolution national 3D grids of radar reflectivity for numerical weather prediction model verification, data assimilation, and aviation product development, as well as for creating high-resolution national multisensor QPEs for flash flood and flood warnings and water resource management. The NMQ System is also referred to as the Multi-Radar Multi-Sensor Precipitation Reanalysis for Satellite Validation (MRMS) product and ingests data from 140 Weather Surveillance Radar 88 Doppler (WSR-88D) radars, Rapid Update Cycle (RUC) model analysis fields, and Hydrometeorological Automated Data Systems (HADS) gauge data. More information about the RUC model is available in [Benjamin et al., 2004](#).

The NMQ System product has six different outputs including rain rate estimates, hourly rain accumulation, daily rain accumulation, vertically integrated liquid content, hybrid scan reflectivity, and three-dimensional reflectivity. These products are gridded at a spatial resolution of 0.01 x 0.01 degrees over five minute intervals. More information about the NMQ System and its output products are available in [Zhang et al., 2011](#).

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Data Characteristics

The GPM Ground Validation National Mosaic and Multi-Sensor QPE (NMQ) System IFloodS dataset is also referred to as Multi-Radar Multi-Sensor Precipitation Reanalysis for Satellite Validation (MRMS) product and consists of quality controlled products, real time rain rate estimates, hourly precipitation rate estimates, and three-dimensional reflectivity products. The data files were specially made for the IFloodS campaign and are not publicly available elsewhere. These data products are considered to be Level 2 through Level 4 products based on the [NASA Data Processing Levels](#).

Table 1: Data Characteristics

Characteristic	Description
Platform	Ground stations
Instrument	WSR-88D, Canadian C-band radars, HADS gauges
Projection	n/a
Spatial Coverage	N: 55.0 , S: 20.0, E: -60.0, W: -130.0 (North America)
Spatial Resolution	0.01 x 0.01 degrees
Temporal Coverage	April 1, 2013 - June 30, 2013
Temporal Resolution	L2_Instrument_RT: associated satellite overpass <12 hours L3: hourly

	MREF3D: 5 minutes
Sampling Frequency	5 minutes
Parameter	real time rain rate estimates, hourly precipitation rate estimates, three-dimensional reflectivity product, and Quality control products
Version	1
Processing Level	Level 2-4

File Naming Convention

The GPM Ground Validation National Mosaic and Multi-Sensor QPE (NMQ) System IFloodS dataset contains seven different data products available as ASCII, netCDF-4, and binary format files. The file naming convention for these data products are shown below.

Level 2 Data files: ifloods_NMQ_<satellite>_<type>.YYYYMMDD.hhmmss.[asc.gz|nc]

Level 3 Data files: ifloods_NMQ_<type>.YYYYMMDD.hhmmss.asc

Level 4 Data files: ifloods_NMQ_MREF3D31L.YYYYMMDD.hhmmss.gz

Table 2: File naming convention variables

Variable	Description
<satellite>	The Satellite overpass name the NMQ data are associated with from: AQUA CLOUDSAT METOP-A METOP-B NOAA-15 NOAA-16 NOAA-17 NOAA-18 SUOMI-NPP TERRA
<type>	1HCF.HSR: hourly radar-gauge ratio for quantity-control purposes. It is the ratio between hourly gauge-adjusted radar and hourly radar-only products. RQI: Radar Quality Index for quality control purposes. It is the hourly averaged RQI value and ranges between 0 and 1. PRECIPRATE.HSR.GC: 5-minute / 1-km rain rates that are gauge-adjusted (using 1HCF.HSR) and filtered out when 1HCF.HSR is outside the [0.1–10] range 1HCF.HSR: pixel-by- pixel ratios between the corresponding hourly gauge-adjusted radar and the hourly radar-only products. These hourly ratios are multiplicative adjustment applied on the radar-only

	5-min product. They are provided for quality control purposes for the user. 1HGCF.HSR: hourly gauge-corrected rain rates 1HRQI:hourly radar-gauge ratio for quantity-control purposes. It is the ratio between hourly gauge-adjusted radar and hourly radar-only products.
MREF3D31L	Three-dimensional reflectivity mosaic
YYYY	Four-digit year
MM	Two-digit month
DD	Two-digit day
hh	Two-digit hour in UTC
mm	Two-digit minute in UTC
ss	Two-digit second in UTC
[asc.gz nc]	asc.gz: Gzipped ASCII file nc: netCDF-4 file format
asc	ASCII file format
gz	Gzipped binary file

Data Format and Parameters

There are seven data products within this dataset including quality control products, real time rain rate estimates, hourly precipitation rate estimates, and three-dimensional reflectivity products. These products consist of Level 2, 3, and 4 processing level products. The Level 2 products consist of Radar Quality Index ASCII files, which are hourly averaged RQI values meant for quality control purposes, hourly radar-gauge ratio ASCII files, which contain the ratio between hourly gauge-adjusted radar and hourly radar-only products meant for quantity control purposes, and a rain rate product in netCDF-4 format. Table 3 describes the variables within the Level 2 netCDF-4 rain rate product.

Level 3 products consist of Radar Quality Index (RQI) ASCII files, which are hourly averaged RQI values meant for quality control purposes, hourly radar-gauge ratio ASCII files, which contain the ratio between hourly gauge-adjusted radar values and hourly radar-only products meant for quantity control purposes, and gauge corrected/filtered hourly radar precipitation rate ASCII files, which are in mm/hr.

The Level 4 product is a three-dimensional reflectivity mosaic in binary format. These data can be read by using the [CartBinaryReader code](#). More information about these Level 4 data products is available in the [NSSL National 3-D Reflectivity Mosaic Data Specifications and Product Suite documentation](#).

Table 3: Data Fields in ifloods_NMQ_<satellite>_PRECIPRATE.HSR.GC.YYYYMMDD.hhmmss.nc

Field Name	Description	Data Type	Unit
latitude	latitude	float	degrees
longitude	longitude	float	degrees
RainRate	Rain rate product	float	mm/hr
time	time	int	Seconds since date and time given in filename

Algorithm

The derived data parameters were obtained using algorithms within the NMQ system as described in the ‘Product Description’ section above. More information about how these algorithms were developed and used to create the products are available in [Zhang et al., 2011](#).

Quality Assessment

Data from the WSR-88D radars were quality-controlled before use as inputs to the NMQ System. The quality control procedures remove non-precipitation echoes, including birds, insects, sun strobes, or residual ground clutter. More information about the quality control procedures are provided in [Zhang et al., 2011](#).

Software

The data are available in netCDF-4 and ASCII formats, so no special software is required to view the data files. [Panoply](#) can be used to easily view the netCDF-4 data files. The binary data files can be read by using the [CartBinaryReader code](#).

Known Issues or Missing Data

While these NMQ System products are improvements over other QPE products, there are still some challenges and issues. There is difficulty in removing echoes at far ranges, where small convective cells are present and have similar local structure. In order to prevent removing snow or small storms at far ranges, the small echoes are not removed from the quality-controlled radar data used as inputs to the NMQ System.

The vertical resolution of the three-dimensional radar reflectivity data is coarser at far ranges. Due to this, discontinuities may appear in the three-dimensional reflectivity mosaic fields at heights where the vertical reflectivity gradients are strong; however, gap-filling radars are integrated into the NMQ system where possible to help with the data gaps.

Four reflectivity-rain rate relationships are used in the NMQ system to derive the precipitation rate product. Due to variations of these relationships over large areas and

time scales, conditions may exceed what these four reflectivity-rain rate relationships can represent. Also, these relationships are relatively simplistic and errors caused by wind shear-induced drifting, locations of cloud-to-ground lightning, and convective precipitation have not yet been accurately accounted for.

More information about the known issues of the NMQ products is available in [Zhang et al., 2011](#).

Data Use Requirements

It is requested that users refer to the National Oceanic and Atmospheric Administration's (NOAA)/National Severe Storm Sentinel's (NSSL's) National Mosaic and QPE system when using or presenting these data in any public or scientific forum including conferences, workshops, meetings, technical reports, and publications. Details of data use requirements are provided below.

An appropriate reference to the 3-D reflectivity mosaics for publication and presentation purposes is:

Zhang, J., K. Howard, and J. J. Gourley (2005): Constructing three-dimensional multiple radar reflectivity mosaics: Examples of convective storms and stratiform rain echoes. *Journal of Atmospheric and Oceanic Technology*, 22, 30-42. doi: <https://doi.org/10.1175/JTECH-1689.1>

An appropriate reference to the 2-D products for publication and presentation purposes is:

Zhang, J., K. Howard, C. Langston, S. Vasiloff, B. Kaney, et al. (2011): National Mosaic and Multi-Sensor QPE (NMQ) System: Description, Results, and Future Plans. *American Meteorological Survey*, 92, 1321-1338. doi: <https://doi.org/10.1175/2011BAMS-D-11-00047.1>

Third-parties that wish to make use of the U.S. Government works should be aware of the provisions of 17 U.S.C. §403, in the event that the third-party claims copyright on the subsequent work. Section 403 encourages the Publisher to disclaim any copyright over U.S. Government works that are incorporated into larger works on which copyright is claimed.

Duplicating Analysis Methods in Order to Mimic the Dataset: Portions of the dataset were developed by the NOAA, U.S. Department of Commerce. For these portions, NOAA requests that users not duplicate analysis methods in order to mimic the dataset.

Excessive Revealing of Errors (related to this dataset) Without Communicating Findings to the Developers: Collaborators/Users are encouraged to communicate discovery of errors or other limitations of this dataset as means to constructively improve future Mosaic and QPE efforts.

Sharing these Data with Users Outside of the Intended Audience and Purpose: Users are requested not to share the data with other users, even within the same institute or group, without obtaining permission from the NMQ team at NSSL.

Holding the NSSL scientists liable for decisions, legal actions, or conclusions stemming from the use of the NMQ datasets: The NMQ datasets are being provided in-kind for the advance

of science and the NSSL scientists shall not be held liable for decisions made in the provision of the data. Moreover, these data are experimental and subject to revision as improvements to processing algorithms are continually being made.

References

Benjamin, Stanley G., Dezso Devenyi, Stephen S. Weygandt, Kevin J. Brundage, et al. (2004): An Hourly Assimilation - Forecast Cycle: The RUC, *Monthly Weather Review*, 132, 495-518. doi: [https://doi.org/10.1175/1520-0493\(2004\)132%3C0495:AHACTR%3E2.0.CO;2](https://doi.org/10.1175/1520-0493(2004)132%3C0495:AHACTR%3E2.0.CO;2)

Zhang, J., K. Howard, C. Langston, S. Vasiloff, B. Kaney, et al. (2011): National Mosaic and Multi-Sensor QPE (NMQ) System: Description, Results, and Future Plans. *American Meteorological Survey*, 92, 1321-1338. doi: <https://doi.org/10.1175/2011BAMS-D-11-00047.1>

Related Data

All data from other instruments collected during the IFloodS field campaign are related to this dataset. Other IFloodS campaign data can be located using the GHRC HyDRO 2.0 search tool.

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

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

Contact Information

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

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