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# Global Precipitation Measurement (GPM)

# Science Data Management Plan


Goddard Space Flight Center
Greenbelt, Maryland

National Aeronautics and
Space Administration

## CM FOREWORD

This document is a Global Precipitation Measurement (GPM) Project Configuration Management (CM)-controlled document. Changes to this document require prior approval of the applicable Configuration Control Board (CCB) Chairperson or designee. Proposed changes shall be submitted to the GPM CM Office (CMO), along with supportive material justifying the proposed change. Changes to this document will be made by complete revision.

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# 1.0 INTRODUCTION

## 1.1 IDENTIFICATION OF THE DOCUMENT

This document is the Science Data Management Plan for the Global Precipitation Measurement (GPM) Mission.

## 1.2 SCOPE OF THE DOCUMENT

This document describes the flows of GPM data from data ingest through data product generation, data distribution, and archival of science data products.

## 1.3 PURPOSE OF THE DOCUMENT

The purpose of this document is to describe all aspects of data product generation and data management by the PPS for the GPM mission.

## 1.4 DOCUMENT STATUS AND SCHEDULE

This document identifies the data flows for GPM. Revisions will be made to this document as additional details for the GPM Mission become available.

## 1.5 DOCUMENT ORGANIZATION

The introduction and related documentation comprise the first two sections of this document. A brief overview of the PPS facility and the GPM Mission are provided in Section 3. Section 4 describes the external interfaces with the PPS. This is followed by a discussion of PPS standards and policies in Section 5. Section 6 describes the types of data products handled by the data system, including both products that are ingested and those that are created by the PPS. Section 7 contains configuration management information. This is followed by a discussion of data access and services in Section 8. Data archival is discussed in Section 9. Abbreviations and acronyms are listed in Section 10.

# 2.0 RELATED DOCUMENTATION

## 2.1 PARENT DOCUMENTS

1. GPM Level-2 Requirements Document, GPM 422-01-01-200, Draft, September 2008
2. PPS Requirements Document, Preliminary Draft, October 2008

## 2.2 APPLICABLE DOCUMENTS

1. GPM MOC-GPM PPS Interface Control Document, Draft, May 17, 2009
2. GPM Science Implementation Plan, October 2008
3. JAXA-NASA GPM Mission Operational Interface Specification
4. PPS File Naming Convention for Precipitation Products for the Global Precipitation Measurement (GPM) Mission, PPS_610.2_P550, V1.2, August 24, 2011

## 2.3 INFORMATION DOCUMENTS

1. EOS Data Products Handbook, Volume 2, October 2000

# 3.0 DATA SYSTEM OVERVIEW

## 3.1 DESCRIPTION OF THE PPS FACILITY

The Precipitation Processing System (PPS) is a measurement-based system capable of supporting NASA's precipitation missions. The PPS provides the science data processing facility and science information system for precipitation missions within NASA. In support of GPM, the PPS has the responsibility for receiving satellite data streams provided by NASA and other partner satellite sites and generating the global precipitation data products as determined by the Precipitation Measurement Missions (PMM) Science Team.

The PPS ingests Level-0 and Level-1 instrument data from ground systems that support automated protocols. The data are calibrated and processed into higher-level products using science algorithms developed by the PPS and the PMM Science Team. Finally, the PPS generates spatially gridded science products using software developed by the PPS and/or the Science Team by agreement between the GPM Project Scientist and the PPS Project Manager.

The PPS resides at the Goddard Space Flight Center (GSFC), where it operates 24/7. However, it is staffed by the PPS Operations Team only 8/5. The PPS is not staffed otherwise, except in response to spacecraft or ground system anomalies and emergencies. The PPS core system is based on the concept of automated data processing, data management, and error reporting. The ingest module of the PPS provides automated ingest software with the built-in capability for incorporation of custom modules to interface with a variety of external systems.

Once data have been ingested, they are maneuvered through the system as needed by automated data handling and archive functions. The heart of the PPS is its automated scheduler backed up by a production database, which executes the functions described above, in addition to managing processing schedules and product delivery to external sites. In the event of problems, the PPS provides a comprehensive error system that will automatically notify the appropriate operations and support staff of the problem regardless of on-site/off-site presence, as appropriate. The PPS also provides an external interface for PMM Science Team members and general users to access various system services, such as data ordering and instrument planning aids and reports from the GPM Mission Operations Center (MOC). In addition, the PPS provides the PMM Science Team with a test bed for evaluating new science algorithms.

The PPS has a generic framework that is easily adaptable to any precipitation mission, allowing modification to processing streams and equipment, as each mission requires.

## 3.2 GPM MISSION DESCRIPTION

GPM is a multi-satellite-based data collection research mission jointly developed under partnership by NASA and the Japan Aerospace Exploration Agency (JAXA). GPM is an

international program that will measure precipitation on a global basis with sufficient quality, Earth coverage, and sampling to improve prediction of the Earth's climate, weather, and specific components of the global water cycle. Such measurements are essential for the improvement of knowledge of the overall Earth system. Evaporation and subsequent condensation to produce precipitation constitute a primary driving force of atmospheric circulation and are critical to the Earth's habitability for humans and other species.

The GPM Mission will obtain a minimum of 3 years (with a target of 5 years) of observations of global precipitation to produce a data set of 30-day average precipitation resolved into a world-wide grid with element areas of 0.25 deg. by 0.25 deg. or higher and a half-hour global data set with a resolution of 0.25 deg. by 0.25 deg. or higher, and to estimate the vertical distribution of latent heat release. GPM will also provide near-real-time products and outreach products for public access.

The current plans for the GPM include a multi-satellite data collection constellation using various types of microwave radiometers and precipitation radars contributed by the GPM partners. A NASA-provided "core" spacecraft will carry at least two instruments. The first instrument is a Dual-Frequency Precipitation Radar (DPR) system provided by JAXA. DPR consists of two radars, Ku-band (KuPR) radar and Ka-band (KaPR) radar. The DPR will provide good measurements of rain rates over both land and ocean. The radar will be instrumental in obtaining drop size distribution (DSD) information as well as the height profile of the precipitation content, from which the profile of latent heat release can be estimated. The second instrument is the GPM Microwave Imager (GMI), a conically-scanning multi-channel passive microwave radiometer. The GMI will give reliable measurements of precipitation rates over the oceans, and through the use of radar data together with land emissivity, it will provide rain-rate estimates over land, where the surface non-homogeneous emissivity makes interpretation of radiometric information more difficult. GPM will also produce a combined radar/radiometer product, initially over the Ku radar swath but ultimately over the GMI swath. This combined product will be the key GMI swath product.

The GPM core satellite orbit is presently planned to be at an altitude of 407 km and at an inclination of 65°. Many of the satellites in the constellation are currently planned for Sun-synchronous orbit with slight variations in altitude. These orbits will give near-global coverage and will permit extraction of the climatological diurnal cycle for precipitation. The relatively low altitude also allows for much smaller instrument footprints than those of many previous microwave space sensors, leading to substantially better resolution retrieval capabilities of the precipitation variations, which normally occur over rather small spatial scales.

NASA-provided instruments on-board GPM satellites will generate Earth observation science data, instrument engineering data, and housekeeping information. This information will be recorded on the platform and stored in 5-minute science data files, one per instrument. For the GMI instrument, data will be transmitted primarily in real-time over a Tracking and Data Relay Satellite System Multiple Access (TDRSS-MA)

link. Any data that are not transmitted on the MA link and any necessary re-transmissions of data will occur once per orbit on a TDRSS Single Access (TDRSS-SA) link. For the DPR instrument, the data will be transmitted over a TDRSS-SA link. The science data files will be relayed through the TDRSS to the White Sands Ground Terminal (WSGT), New Mexico. These data will then be passed via the NASA Integrated Services Network (NISN) to the GPM Mission Operations Center. The MOC will deliver the files to the PPS for processing. The files transferred to PPS will contain all information necessary to process the science data contained within each file.

The GPM MOC will receive telemetry data via the NISN from the WSGT. The on-board GPS data will be analyzed to determine the orbital state of the platform. Platform ancillary data will be used to verify the platform attitude.

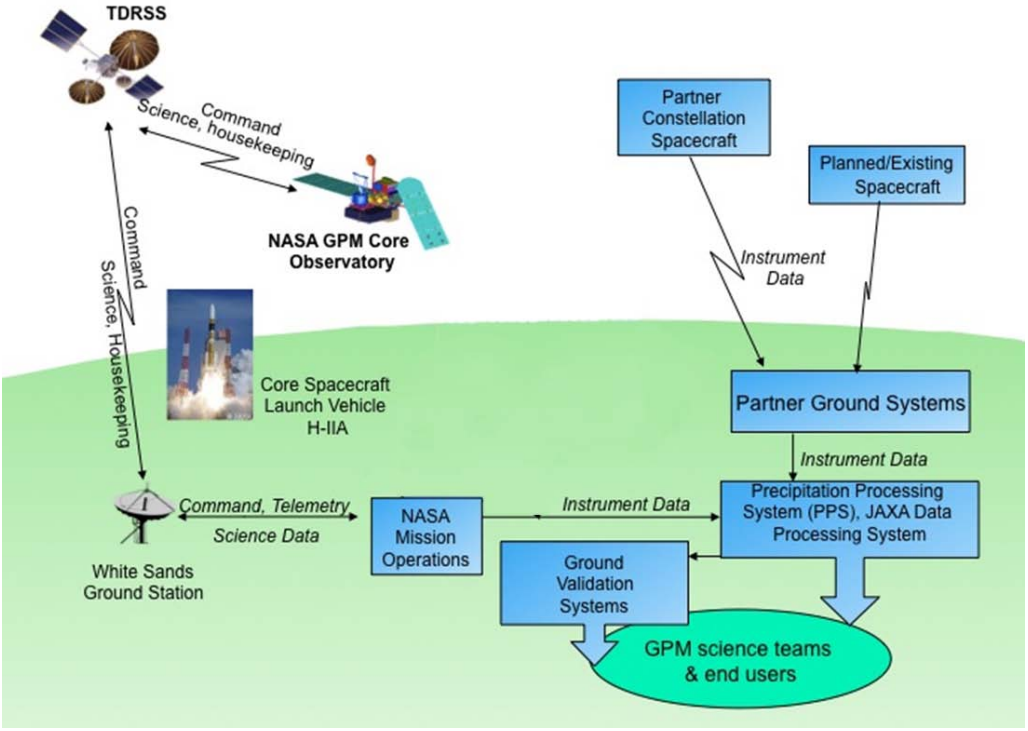


**Figure 3.2.1.** GPM Program Architecture Overview

# 4.0 EXTERNAL INTERFACES WITH THE PPS

## 4.1 GPM MOC

The GPM Mission Operations Center is responsible for issuing commands to the NASA GPM satellites for the purpose of acquiring mission data and for maintaining the health and safety of the satellites and their scientific instruments. The MOC will distribute mission data and reports to the PPS and it will ingest operations requests from the Instrument Scientists through the PPS interface.

The MOC will acquire raw telemetry data from the NASA GPM satellites and will re-acquire data, as needed. The MOC will create data sets packaged as 5-minute segmented instrument science data files, 5-minute instrument housekeeping data files, 5-minute spacecraft housekeeping data files, and 5-minute ephemeris and attitude ancillary data files. These files will be transferred (via SFTP push) to the PPS. The PPS will send an XML-formatted data receipt notice to the MOC corresponding to each file received. The data receipt notice will indicate the result of the PPS ingest check, and will indicate if a file must be retransmitted.

The PPS will serve as the communication interface between the Instrument Scientists and the MOC. The PPS will accept instrument operations requests from the GPM Instrument Scientists (including JAXA), and it will forward them to the MOC. These requests can include command loads, special calibrations, and special engineering tests. The PPS will also provide technical advice from the Instrument Scientists to the MOC as soon as possible in emergency situations.

The MOC will provide instrument operations and planning products to the PPS. These products will include, at a minimum, information relating to solar beta angle, spacecraft ground track, command planning and execution, and a predictive 30-day ephemeris product. These products will be made available to the GPM Instrument Scientists by the PPS. The complete list of products will be identified in the interface control document (ICD) between the GPM MOC and the PPS.

The PPS will also serve as the interface between the U.S. GPM Project Scientist and the MOC for the purpose of coordinating instrument operations planning and scheduling, as needed. The instrument operations status report will be provided by the PPS to the Project Scientist upon request.

The PPS will request a re-transmittal of any data or report files that fail ingest checks. All definitive operational reports ingested from the MOC will be stored for the life of the GPM Mission and then transferred to the permanent archive.

The exchange of data and products between the MOC and the PPS will occur using secure protocols.

## 4.2 MISSION PARTNERS

The PPS will interact with designated mission partners (Memorandum of Understanding [MOU] formal and informal) to obtain or provide data and/or products for processing with GPM algorithms. Depending upon the agreement reached with each partner, data will be either pushed to or pulled by the PPS. The data types to be supplied by mission partners may include raw instrument data, instrument and spacecraft housekeeping data, and geolocated brightness temperatures. When data files fail ingest checks, the PPS will re-attempt to retrieve those files via pull before requesting a re-staging of the data. As needed, successfully ingested data will be subsetted or concatenated into granules of one orbit's duration.

JAXA will receive 5-minute DPR science, ancillary, and housekeeping granules from the PPS. JAXA will pull these files from a PPS server. The files will be made available to JAXA as soon as possible after the data are received from the MOC. JAXA will deliver Level-1A, Level-1B, and Level-1C DPR products formatted as one-orbit granules to the PPS. PPS will pull the data products from a dedicated JAXA server.

GPM data and data products will be accessible to mission partners via FTP link to the PPS. Mission partners will be identified by NASA Headquarters. It is expected that there will be both domestic and international partners. Anticipated partners are JAXA, the U.S. Department of Defense (DoD), the National Oceanic and Atmospheric Administration (NOAA), and the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT). The PPS will be able, though not limited, to ingest scientific data and data products from up to seven partner spacecraft.

## 4.3 GVS SITES

The PPS will be able to ingest ancillary data and data products from up to two NASA Ground Validation System (GVS) sites and up to two partner GVS sites. Transfers will be made using a secure transfer method to a designated ingest location at the PPS, via a data notice protocol. The PPS will send to an originating GVS site a list of data/products that fail ingest checks and must be re-transmitted. The PPS will provide two products of interest to the GVS sites. The first product is overpass predictions. These are predictions of the times when instruments on the GPM satellites pass over a GVS site, such that the swath covers 100% of the GVS site. The duration of an overpass prediction is 168 hours (7 days), commencing with the time of completion of the file. One prediction file will be generated every day for each GVS site. The files will be written in American Standard Code for Information Interchange (ASCII) format and will contain the name of the satellite, the name of the instrument whose swath passes over the GVS site, and the anticipated time of overpass. GVS sites will have the option of pulling the overpass prediction files from a PPS server or having the PPS push the files to them. File transfer will use a secure method that will be identified in the PPS-to-GVS ICD. The second product is a coincidence file, which contains subsets of satellite swath data products during an overpass. Coincidence products will contain Level-1 and Level-2 product subsets for each GPM instrument. Coincidence files will be generated every day for each GVS site.

# 5.0 PPS STANDARDS AND POLICIES

## 5.1 DATA ACCESS POLICY

Users will access PPS data through the Science Team On-line Resource Module (STORM) interface. Both guests and registered science users (SUs) will have full on-line access to the mission research data products. All users will additionally have access to special data products, such as orbit start times and coincidence products, and to reports provided by the GPM MOC. Access to near-real-time data products will be restricted to those users who register to receive them.

Access to GPM Core Observatory data and products will be restricted to the NASA and JAXA PMM Science Teams and other approved users for no longer than 6 months after launch. During this time, the instruments will be undergoing their initial calibration/validation and the science algorithm developers will be evaluating the results of their algorithms and making necessary changes, if any, to assure the quality of the data products. When a data release recommendation is received from the U.S.-Japan Joint PMM Science Team, the mission data and products will become available to all users. Outreach products will not be subject to release restrictions.

## 5.2 PPS INTERNAL STANDARDS AND POLICIES

### 5.2.1 PPS Data Formats

The data formats that are likely to be used for the PPS are shown below.

**Table 5.2.1.** Data Types and Formats

| Data Type | Formats |
|---|---|
| Level-0 | Binary |
| Level-1 and Higher | HDF5 v1.8<br>NetCDF v4 |
| MOC Reports, Data Notices, Etc. | XML or ASCII |
| Images and Graphics | PNG |

### 5.2.2 Time and Geometry Standards

The representation of time for GPM data will follow the standard for Tropical Rainfall Measuring Mission (TRMM) data, which has the form of YYYY-MM-DDTHH:mm:ss:ssss, where YYYY is year, MM is month, DD is day of month, T is a delimiter, HH is hours, mm is minutes, ss is seconds, and ssss is milliseconds.

Positions on the Earth are represented by a coordinate system defined by latitude, longitude (0-360 degrees), and altitude (m). The vertical axis is defined as positive upward from the surface of the Earth.

### 5.2.3 Orbit Definition Standard

Satellite data for GPM will be partitioned into orbits that begin with the southernmost point on the ascending node. The orbits will be constructed from the 5-minute scan files for each instrument.

Scientific instrument data supplied by mission partners will be reconfigured by the PPS to have the same orbit structure as the GPM Mission data. Data and data products will be concatenated or subsetted, as necessary, to create the desired orbit structure and length.

### 5.2.4 Geolocation

The PPS will write algorithms to geolocate GPM data. DPR data will be geolocated to within 2.5 km knowledge accuracy. GMI data will be geolocated to within 3.7 km cross-scan and 2.2 km along-scan accuracies. Validation of geolocation accuracies will be achieved through spot checks of images, consistency checks on attitude and orbit data, and independent roll computation using DPR data. Whenever geolocation accuracies are substantially lower than acceptable limits, the PPS will notify the Science Team.

### 5.2.5 Science Algorithm Coding Guidelines

The algorithm coding guidelines will be provided to the PMM algorithm developers. Scientific algorithms that will be run in the PPS can be written in F90, F95, C, and C++. To facilitate integration of the algorithms into the processing system, all input/output (I/O) in the algorithms must utilize an algorithm toolkit, which the PPS will supply to the algorithm developers and to any other user desiring it.

### 5.2.6 Data Security

The PPS will have in place measures to assure that GPM data and data products are protected from corruption, loss, and malicious tampering.

Data archival will use measures (e.g., checksums) to assure that the stored data and products are free from corruption. Data backups and offsite archival will be provided to guard against data loss. A plan will be produced to recover mission data and products in the event of a catastrophic loss of equipment in the PPS facility. The PPS will also provide adequate hardware (e.g., firewalls) and software (e.g., anti-virus, anti-malware) protections to guard against external tampering of GPM data products.

### 5.2.7 Product File Naming

Science data products generated by the PPS will be named according to the PPS file naming convention. This convention is found in the document: PPS File Naming Convention for Precipitation Products for the Global Precipitation Measurement (GPM) Mission, PPS_610.2_P550, V1.2.

## 5.3 PPS EXTERNAL STANDARDS

### 5.3.1 Mission Partner Data and Product Formats

Mission partners will identify the data or products that they will provide to the PPS. They will also provide information regarding the formats used for their data/products. Any special characteristics of the data products will be identified.

### 5.3.2 Distribution Formats

GPM data products will be produced in HDF5 v1.8 and NetCDF v4 formats. The PPS may distribute products in other formats. Both full and subsetted data products will be available in HDF5 v1.8 and NetCDF v4. Graphical images, such as browse images, will be available in portable network graphics (PNG) format. Reports provided by the MOC will be available in XML or ASCII format.

### 5.3.3 Data Availability

All mission data products will be maintained in an on-line local archive. All users will obtain their data from this archive. There will be no capability at the PPS for data delivery by non-electronic means.

#### 5.3.3.1 Products Created by the PPS

Level-0 data from NASA-provided radiometers will be available immediately following successful ingest from the GPM MOC. Level-1 and Level-2 near-real-time products will be made available immediately upon their completion. Near-real-time science products will be retained for retrieval from a PPS server (via pull) for 3 days, after which time the products will be deleted.

For standard and intermediate research science products, Level-1 products will be available to users within 30 minutes of receipt of all required input data. Level-2 products will be available within 3 hours of receipt of all required input data. Level-3 products will be available within 5 hours of receipt of all required input data. Browse products will be available within 3 hours of completion with all necessary input products.

Research science products will be available from the PPS on-line archive for the life of the GPM Mission plus 6 months. Only the latest two versions of the data products will be retained.

The rain map and rain map animation outreach products will be available to the general public immediately upon their completion. Rain map products will be retained for 24 hours following the time of completion.

Overpass prediction files will be created each day. These files will be available via push or pull between the GVS sites and a PPS server. Other users will have access to these files via the STORM interface.

Coincidence swath products will be available to all of the GVS sites within 1 hour of product completion. Only GVS sites will receive these products. These products will not be archived.

#### 5.3.3.2 Products Ingested From Partner Sites by the PPS

Level-1 data products ingested from partner sites will be accessible (as approved by the partner) from a PPS server (via pull) once the products become available. These products will be available for the life of the GPM Mission plus 6 months. It is anticipated that only the latest version of the data products will be retained.

# 6.0 DATA PRODUCTS

## 6.1 DATA LEVELS

Data levels are assigned according to the content of the files. The data levels are adopted from the Earth Observing System (EOS) Handbook. Table 6.1 describes the data levels to be used for GPM.

**Table 6.1.** Data Levels and Descriptions

| Data Level | Description |
|---|---|
| Raw Data | Unprocessed telemetry from the spacecraft and instruments. |
| Level-0 | Reconstructed unprocessed instrument data at full resolution that have been separated by instrument. The data are time-ordered with duplicates removed. |
| Level-1 | Instrument data at full resolution, time-referenced and annotated with ancillary information including geometric parameters. The data have been processed to radiometric or other scientific units. |
| Level-2 | Derived scientific parameters at the retrieval resolution. |
| Level-3 | Geophysical parameters mapped to a uniform, Earth-referenced space-time grid. |
| Level-4 | Model output. |

## 6.2 DATA TYPES

The PPS will process the raw DPR and GMI science data into 5-minute scan files. It will process ancillary data files into ephemeris and attitude files sized for the near-realtime segment and for PPS production. The PPS will also generate orbit granules for the GMI.

Three types of scientific data products will be generated for GPM: near-real-time science products, research science products, and outreach data products. The near-real-time and outreach products will be created within short time spans to meet the particular needs of their end users. The research science products are full data products of research quality. Two additional data types that are needed for the GPM Mission are ancillary data products, which are used to produce the scientific data products, and browse products. Each data type is described in more detail below.

### 6.2.1 Near-Real-Time (Immediate) Science Products

GPM near-real-time science products are quick versions of research science products, which are created as soon after collection as possible. With the exception of the merged near-real-time science products, these products are generated with little delay. Table 6.2.1 lists the near-real-time science products anticipated for GPM.

**Table 6.2.1.** Near-Real-Time Science Products for GPM

| Instrument(s) | Level | Product Description |
|---|---|---|
| GMI | 1 | Calibrated Brightness Temperature |
| | 2 | Surface Rain Product |
| DPR | 2 | KuPR Surface Rain Product |
| | 2 | KaPR Surface Rain Product |
| | 2 | KuPR-KaPR Multi-Level Rain Product |
| Partner Radiometers | 1C | Cross-Calibrated Brightness Temperature Products |
| | 2 | Surface Rain Products |
| Merged | 1C | All Radiometers |
| | 3 | Low Latency (<5 hours) Precipitation Products |
| | 3 | High Latency (<8 hours) Precipitation Products |
| Combined | 2 | DPR & GMI, within 3 hours of collection |

Two types of near-real-time products will be produced for the GMI instrument. A Level-1 calibrated brightness temperature product will be created at the instrument field of view. A Level-2 surface rain product will also be created at the instrument field of view.

For the DPR, products will be created for each instrument individually, and for a combined instrument approach. A Level-2 surface rain product will be created for both the KaPR and KuPR instruments, in each case at the instrument field of view. A third Level-2 product will be created using both the KaPR data and the KuPR data to produce a multi-level rain product, also at the instrument field of view.

Near-real-time products for the partner radiometers will be cross-calibrated brightness temperatures and a surface rain product for each radiometer. These products will be created at the instrument field of view for each radiometer.

There will be two merged near-real-time science products of half-hour duration. One will be a low-latency precipitation product, which utilizes DPR, radiometer, and infrared (IR) data that are no older than 5 hours. The other will be a high-latency product, which also collects DPR, radiometer, and IR data. It will be produced only a few times each day so as to be more inclusive of input data. A third merged product will be created using Level-1C products from all of the radiometers (GMI and partners).

A combined instruments product will utilize data from the DPR and the GMI instrument. The product will be generated at the Ku-radar swath width. This product will be created within 3 hours of collection of the input data.

### 6.2.2 Research Science Products

Table 6.2.2 lists the GPM research data products that are envisioned for the mission. A brief description is given for each algorithm.

**Table 6.2.2.** GPM Data Product Descriptions

| Instrument | Level | Product Description |
|---|---|---|
| Radiometer | 1B | GMI Brightness Temperature |
| | 1C | Cross-Calibrated Partner Brightness Temperature |
| | 2 | GMI and Partner Surface Rain Product |
| | 3 | 0.25 deg. x 0.25 deg. Individual Radiometer Products |
| | 3 | 0.25 deg. x 0.25 deg. Gridded Combined Radiometer Products |
| DPR | 1B | KaPR Radar Power |
| | 1B | KuPR Radar Power |
| | 1C | KaPR Radar Reflectivity |
| | 1C | KuPR Radar Reflectivity |
| | 2 | KaPR Rain Products |
| | 2 | KuPR Rain Products |
| | 2 | KaPR-KuPR Combined Rain Products |
| | 3 | 0.25 deg. x 0.25 deg. Gridded Monthly Rain Products |
| Merged | 1C | All Radiometers |
| | 3 | 0.5-Hour 0.1 deg. x 0.1 deg. Products (Radar, Radiometer, IR) |
| | 3 | Monthly 0.1 deg. x 0.1 deg. Products (Radar, Radiometer, IR) |
| Combined | 2 | DPR & GMI, at IFOV |
| ECMWF | 4 | Global Precipitation Forecast Product |
| GMAO | 4 | Global Precipitation Analysis Product |

The granule size for Level-1 and Level-2 GPM research science products will be one orbit. Orbits for partner data will be reconstructed, as needed, to have the same orbit definition as data from the GPM core spacecraft.

The Level-1 product for the radiometers will be brightness temperature. Data from the GPM constellation radiometers (both NASA-provided and partner instruments) will be cross-calibrated to Level-1C. These radiometer products are radar-enhanced through the use of an a priori database that is built from the combined products. Level-2 surface rain products will be created for each radiometer, using the calibrated brightness temperatures together with a common cloud database for retrieving precipitation information from the passive microwave data. Two types of Level-3 radiometer products will be produced. Both are monthly gridded products with a latitude/longitude resolution of 0.25 deg. x 0.25 deg. One product type will represent data from individual radiometers, and the other will be a combined radiometer product.

The DPR consists of two instruments: the shorter wavelength Ka radar and the longer wavelength Ku radar. Level-1B (radar power) and Level-1C (radar reflectivity) products will be created for both the Ka and Ku radars, at the instrument field of view. These Level-1 DPR products will be ingested from JAXA. Higher level DPR products will be created by the PPS. Level-2 rain products will be created for the Ka and Ku radars individually. Additionally, a Level-2 “combined radars” rain product will be created. Level-3 gridded monthly rain products at a latitude/longitude resolution of 0.25 deg. x 0.25 deg. or higher will also be produced for the DPR.

Two Level-3 merged precipitation products will be produced for GPM. Each will be a gridded product with a latitude/longitude resolution of 0.1 deg. x 0.1 deg. Both products will be created using inputs from radar, radiometer, and IR data sources. The products differ in the time period covered by the input data. One product will be created for 0.5-hour intervals, whereas the other will be a monthly product. A third merged product will be created from the Level-1C products for all of the NASA and partner radiometers.

A combined instruments product will be created, which will utilize data from the DPR and GMI instruments. The product will be generated at the instrument field of view using the Ku-radar swath width.

There will be two Level-4 products for GPM. The first product is a global precipitation forecast product, which is created by the European Centre for Medium-Range Weather Forecasts (ECMWF). The principal role of the PPS is to provide portal access to this product for GPM users. The PPS will copy the product locally to assist some users in accessing the product since the original server location is in Europe. The second product is a global precipitation analysis product created by the Goddard Modeling and Assimilation Office (GMAO). The resolution of the product is currently TBD. The PPS will serve as a portal to this product, which will reside on a GMAO server.

### 6.2.3 Outreach Data Products

The PPS will create outreach rain map products. These products are global rain map images and selected regional rain map images. Outreach products will be produced using all Level-2 near-real-time precipitation products that are available at the time of processing. The products will be generated using the most recent 3 hours of data.

A 24-hour rain map animation outreach product will also be created, consisting of a color rain map such that the latest data will be distinguishable from the older data by using a fade-to-black color shading, where the latest data will be the brightest in the image. The 24-hour rain map outreach product will be re-created every 3 hours.

### 6.2.4 Ancillary Data Products

Ancillary data products are those that will be used for the generation of the mission scientific data products. No decisions have been made yet on which specific data sets or sources will be used for GPM.

### 6.2.5 Browse Products

Browse products are images that will be created for each research data product. They are used by customers as an aid in selecting specific orbits/days/months of data to download from the PPS servers.

Each Level-1 and Level-2 browse image will display product data for one granule. Each image will display a single parameter for a particular data product, complete with a color-

coded legend for the range of values for that parameter. The parameters may include brightness temperature, radar power, radar reflectivity, or rain. Each image will include continent outlines, latitude/longitude grid lines, and the name of the granule.

Level-3 browse products will display one parameter for a particular data product in a gridded latitude/longitude format. These products will cover a monthly or half-hourly time period. Each month will begin at 0000 UTC on the first day of the month, whereas the first half-hourly time interval of each day will begin at 0000 UTC on that day. A color-coded legend will be supplied as part of each image, as with Level-1 and Level-2 browse products.

## 6.3 RE-PROCESSING

At the outset of the GPM Mission, the PPS will generate data products using an "at-launch" set of science algorithms, which will be labeled Version 1. Over the course of the mission, GPM Algorithm Scientists will improve/modify their scientific algorithms, which will necessitate re-processing events that will be applied to all of the mission science data. The timing of re-processing events will be determined by a Joint Science Team consisting of the U.S. GPM Project Scientist, the Japanese GPM Project Scientist, and other scientists who are invited to participate in this team's efforts.

A new version of the GPM science algorithms will be implemented in the PPS concurrently for re-processing data from the mission onset to the implementation date and for forward processing with current data. Beginning with the second re-processing event, the oldest version of the data products will be deleted from the local on-line archive prior to the start of re-processing. The newest version of the data products will replace the deleted version of the data products, such that only the two newest versions of the data products will be accessible in the PPS on-line archive. Note that forward processing will be applied only to the most current version of the data products.

Mission partners will decide when/if their data products will be re-processed. They will be responsible for re-processing their data and delivering the new products to the PPS. Should partner data be reprocessed, then as with PPS-created data products, the oldest copy (in this case the current copy) of the data products for a mission partner will first be deleted from the archive. Those products will then be replaced by the newly re-processed data products. It is anticipated that only the single most current version will be saved for mission partner data products.

# 7.0 CONFIGURATION MANAGEMENT

Details of the configuration management process will be contained in the PPS Configuration Management Plan. Configuration management for the PPS will use the Git version control software.

## 7.1 SYSTEM SOFTWARE

System software refers to software needed to run the PPS, in particular the different components that make up the PPS architecture. System software includes custom-built software written by PPS staff and commercial off-the-shelf (COTS) software. Configuration items for custom software include the component source code, the name of the software developer, and build instructions.

## 7.2 SCIENCE ALGORITHMS

Most of the science algorithm software for GPM will be written by members of the PMM Science Team. The exceptions will be the Level-1 algorithms for the GMI, which will be written by the PPS, and the Level-1C algorithm for cross-calibrating the partner radiometer data products, which will be written by the PPS using instrument calibration algorithms provided by the PMM Science Team. Also, the Level-3 radiometer algorithm will be coded by PPS personnel. All of these algorithms will be configuration controlled at the PPS. In addition to the algorithm source code, configuration items will include benchmark test procedures, test data, and results; date and time of installation in the operational system; the identification (ID) and version of the compiler; and algorithm documentation.

## 7.3 ICDs AND OTHER PPS DOCUMENTS

Copies of PPS documents, including ICDs with external organizations, will be maintained in the PPS library. Electronic copies will be available on-line and they will be maintained consistent with the requirements of the International Organization for Standardization (ISO) 9001 standard. The PPS will configuration control the PPS-specific documents and those ICDs that it is responsible for creating. Other ICDs with the PPS will be controlled by the organizations that are responsible for writing them.

# 8.0 DATA ACCESS AND SERVICES

## 8.1 USER SUPPORT

Support for the GPM science user community will include access to data products, instrument support, and evaluation and testing of mission science algorithms.

The principal means to access mission research data products will be through the STORM interface. Both full data products and user-specified subsetted data products will be made available to all users. It is possible that direct access via FTP may be possible for select data/data products, especially for mission partners and GVS sites. Access to GPM near-real-time products will be provided to forecast centers via direct network connection.

Instrument support to GPM Instrument Scientists (including JAXA) will include access to reports provided by the GPM MOC, orbit start/stop time (OST) files, coincidence tables (CT), and quick-look data products or other specially requested data/data products.

The PPS will provide an Integration and Testing Environment (ITE), which will serve as a test bed for evaluating GPM science algorithms. PPS Scientists will receive new science algorithms from the algorithm developers and run them through operational benchmark tests in the ITE.

Support for guest users (e.g., public users) will include data product access through the Guest page of the STORM interface. Guest users will be able to browse and download data products from the on-line archive.

GPM near-real-time products will be provided to any users that request access.

The PPS will provide access to outreach products via an Internet link.

## 8.2 VISUALIZATION TOOLS AND APPLICATIONS

Numerous visualization tools and applications that were created for TRMM will be adapted for use in GPM. They will be available to all users of GPM data products. A brief description of these products follows.

A Data Viewer will provide users with the capability to view the contents of science data files. The Data Viewer will be able to display images of standard products at their full resolution, with the option of zooming in on a single pixel or set of pixels in the image. Data will be displayed in the vertical or the horizontal, and the display will be regional or global. The data and their attributes can also be displayed in text form. The data viewer will be able to run on Linux, Windows, and Mac OS X operating systems.

A Mission Index will provide a quick way to search the mission data for precipitation events. It will use a low-resolution version of the mission data set to create a

precipitation time series for a user-selected region. Selecting a precipitation peak will display a low-resolution image of the region. This image will identify the orbit number for the overpass, which will be helpful with data ordering using the STORM interface and with higher resolution viewing with the Data Viewer. The Mission Index will be used for data acquired by the GPM core platform only.

An Overflight Finder will provide the ability to identify satellite overpass information for a specified location on the ground, by inputting the latitude and longitude of the site and a date/time range to be scanned.

A data trending function will also be available for the data products created by the PPS. Both time series plots and histograms will be updated daily with the latest data. The displayed data will cover the entire duration of the mission following initial instrument activation and checkout.

Subsetting on-the-fly will be available when using the STORM interface. Both geographic subsetting and parameter subsetting will be supported.

OPeNDAP services will be provided to allow users to order data stored in archived products. This service will enable users to extract those parts of data products that they need, without the overhead (and data volume) of the full data products.

## 8.3 HELP DESK SUPPORT

The principal function of the PPS Help Desk will be to provide support to registered science users (SUs) of the PPS. These users will mostly be members of the PMM Science Team. Other SUs will include GPM Instrument Scientists and any other personnel approved by the U.S. GPM Project Scientist or the PPS Project Manager.

The Help Desk will provide user accounts to science users for access to the PPS products. Access to privileged information will be assigned based on need. Science users will be able to use the Science Team login feature of STORM. Guest users will use the Guest login feature of STORM.

Inquiries from all users will be handled by the Help Desk. The Help Desk will seek the assistance of other PPS personnel in responding to requests and inquiries, as needed.

The Help Desk will also inform the PPS user community of any special maintenance, data corruption/loss, or emergency issues that will affect access to the PPS or its products/services.

# 9.0 DATA ARCHIVAL

## 9.1 ON-SITE ARCHIVE

The PPS will maintain a local on-site archive of all of the GPM data and products that it ingests or creates. This will include all data provided by GPM partners and all ancillary data that will be used to create GPM products. This archive will be accessible on-line by all PPS users, whether they are registered users or guests. Users will be able to search the archive from the STORM interface by date, data product, or instrument (or other identifier). As data are re-processed over the course of the mission, only the two most current versions of the GPM data products will be kept in the archive. For GPM partner data products, it is anticipated that only the most current version will be maintained in the on-site archive.

## 9.2 OFF-SITE ARCHIVE

Some mission data will be stored in an off-site archive to ensure the survival of the data should a catastrophic event affect the PPS facility. The PPS will store raw science data, ephemeris and attitude ancillary data, and housekeeping data for the DPR and the GMI instruments (i.e., on the core and constellation platforms), Level-1A data partitioned into orbits for the GMI instrument, Level-1B data for the partner radiometers, Level-1C radiometer data, Level-1B and Level-1C DPR data, and any ancillary data that are required to produce GPM data products. All other data products will be re-created from these data, as needed. An off-site archive will be located in Building 28 at the Goddard Space Flight Center.

## 9.3 PERMANENT ARCHIVE

A final re-processing of the entire mission data set will be performed within the 6 months following the conclusion of the mission. These data products will be stored in a permanent archive at the Goddard Earth Sciences Data and Information Services Center (GES-DISC) at the Goddard Space Flight Center.

## 10.0 ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| ASCII | American Standard Code for Information Interchange |
| CCB | Configuration Control Board |
| CM | Configuration Management |
| CMD | Command |
| CMO | Configuration Management Office |
| COTS | Commercial Off-the-Shelf |
| CT | Coincidence Tables |
| DoD | Department of Defense |
| DPR | Dual-Frequency Precipitation Radar |
| DSD | Drop Size Distribution |
| ECMWF | European Centre for Medium-Range Weather Forecasts |
| EOS | Earth Observing System |
| EUMETSAT | European Organisation for the Exploitation of Meteorological Satellites |
| F90 | FORTRAN 90 |
| F95 | FORTRAN 95 |
| FTP | File Transfer Protocol |
| GES-DISC | Goddard Earth Sciences Data and Information Services Center |
| GMAO | Goddard Modeling and Assimilation Office |
| GMI | GPM Microwave Imager |
| GPM | Global Precipitation Measurement |
| GPS | Global Positioning System |
| GSFC | Goddard Space Flight Center |
| GVS | Ground Validation System |
| HDF | Hierarchical Data Format |
| HSK | Housekeeping Data |
| I/O | Input/Output |
| ICD | Interface Control Document |
| ID | Identification |
| IFOV | Instrument Field of View |
| IR | Infrared |
| ISO | International Organization for Standardization |
| ITE | Integration and Testing Environment |
| JAXA | Japan Aerospace Exploration Agency |
| KaPR | Ka-Band Precipitation Radar |
| Kbps | Kilo-Bits per Second |
| KuPR | Ku-Band Precipitation Radar |
| Mbps | Mega-Bits per Second |
| MOC | Mission Operations Center |
| MOU | Memorandum of Understanding |
| NASA | National Aeronautics and Space Administration |
| NetCDF | Network Common Data Format |
| NISN | NASA Integrated Services Network |
| NOAA | National Oceanic and Atmospheric Administration |
| OPeNDAP | Open-Source Project for a Network Data Access Protocol |

| | |
|---|---|
| OST | Orbit Start/Stop Times |
| PMM | Precipitation Measurement Missions |
| PNG | Portable Network Graphics |
| PPS | Precipitation Processing System |
| SFTP | Secure File Transfer Protocol |
| STORM | Science Team On-Line Resource Module |
| SU | Science User |
| TBD/TBR | To Be Determined/To Be Resolved |
| TDRSS | Tracking and Data Relay Satellite System |
| TDRSS-MA | TDRSS Multiple Access |
| TDRSS-SA | TDRSS Single Access |
| TLM | Telemetry |
| TRMM | Tropical Rainfall Measuring Mission |
| UTC | Universal Time Coordinated |
| WSGT | White Sands Ground Terminal |
| XML | Extensible Markup Language |