Overview of GPM Products

Version 2.1

January, 2017

Japan Aerospace Exploration Agency (JAXA)

Revision history

revision	date	section	content, reason
Version 1.0	Sept. 2nd 2014	-	The first edition
Version 2.0	Mar. 1st 2016	p. 3	Update of the table of the Global Precipitation Measurement (GPM) constellation satellites.
		p. 9-12	Revision of the figure of the image scene definition of the Ku-band Precipitation Radar (KuPR) and the Ka-band Precipitation Radar (KaPR). Revision of the figure of the Outline of KuPR and KaPR Under Normal Observation.
		p. 13-14	Addition of the GPM Dual-frequency Precipitation Radar (DPR) Level 3 (L3) spectral latent heating and the GPM DPR/ GPM Microwave Imager (GMI) Combined (Comb) L3 convective stratiform heating information into the table of the scene definition for Level 3 products.
		p.15	Addition of the GPM DPR L3 spectral latent heating and the GPM DPR/GMI Comb L3 convective stratiform heating information into the table of the product level definition for GPM data processing.
		p. 17	Addition of the GPM DPR L3 spectral latent heating and the GPM DPR/GMI Comb L3 convective stratiform heating information into the figure of the GPM product processing flow.
		p. 26, 27	Addition of the GPM DPR L2/L3 spectral latent heating information into the figures of the DPR L1/L2 standard product level definition and the DPR L3 standard product level definition.
		p. 31	Addition of the GPM DPR spectral latent heating information into the tables of the description of the file naming convention of L1/L2 standard and environment auxiliary (ENV) products with orbit (scene) number, the description of the file naming convention of L3 standard products, and the description of the file naming convention of L3 latent heating products with orbit number.
		p. 32	Addition of the L2 KuPR/KaPR/DPR ENV product information.
		p. 33, 34	Addition of the L3 GPM products (GeoTIFF) without orbit number information.
		p. 55	Addition of the GPM DPR/GMI L3 convective stratiform heating information.
		p.59	Addition of the DPR/GMI L3 convective stratiform heating product information into the table of the description of the file naming convention of DPR/GMI L3 convective stratiform heating products with orbit number.

revision	date	section	content, reason
		p.62, 64, 65	Addition of information of the GeoTIFF formart of Global Satellite Mapping of Precipitation (GSMaP) products into the tables of the file naming convention of the L3 standard.
Version 2.1	Janu. 17 2017	All	Correction of the sentences.
		P. 3	Addition of the operation termination of the Defense Meteorological Satellite Program (DMSP) F19.
		P. 12	Addition of the GSMaP products (netCDF format).
		P. 26, 61	Addition of the DPR L3 products (GeoTIFF).
		P. 65	Addition of the file naming convention of GSMaP standard products (netCDF format).
		P. 66	Update of the GSMaP algorithm flow.
		P. 67	Addition of the National Oceanic and Atmospheric Administration (NOAA) snow/ice cover map (Northern Hemisphere) and NOAA snow/ice cover map (Southern Hemisphere) as the input data of the GSMaP algorithm.

Reference

(1) “GPM/DPR Level-2 Algorithm Theoretical Basis Document,” December 2010.

(2) Willam S. Olson, Hirohiko Masunaga, and GPM Combined Radar-Radiometer Algorithm Team “GPM Combined Radar-Radiometer Precipitation Algorithm Theoretical Basis Document (Version 2),” November 2011.

(3) “Global Precipitation Measurement (GPM) Science Implementation Plan,” April 2, 2013.

(4) “File Naming Convention for Precipitation Products For the Global Precipitation Measurement (GPM) Mission,” PPS_610.2_P550, V1.4.3, July 2013.

(5) Joyce Chou: “Global Precipitation Measurement (GPM) Mission Precipitation Processing System (PPS) Operational Readiness Review Level 1C(L1C) Algorithms,” Nov.13-14, 2013.

(6) “NASA Global Precipitation Measurement (GPM) Microwave Imager (GMI) Level 1B (L1B) Algorithm Theoretical Basis Document (ATBD) Version 0.2: DRAFT,” February 2014.

(7) Precipitation Processing System, Global Precipitation Measurement, File Specification for GPM Products, Version Preliminary for V04 PPS Science Algorithm Input/Output Toolkit (TKIO) 3.70.7, November 18, 2015.

Table of Contents

1. Introductory Information

1.1 Overview of GPM Products

The Global Precipitation Measurement (GPM) core satellite was jointly developed by Japan and the U.S. Two observation instruments are onboard the core satellite. One is the Dual-frequency Precipitation Radar (DPR) developed by Japan, and the other is the GPM Microwave Imager (GMI) developed by the U.S.; see Figure 1.1-1.

The GPM core satellite is able to observe not only the tropical zone, but also mid- to high-latitude areas by having an orbit inclination of 65 degrees. In addition, with its non-Sun-synchronous orbit, it can capture changes in precipitation in 1 day. Table 1.1-1 shows spacecraft orbit information.

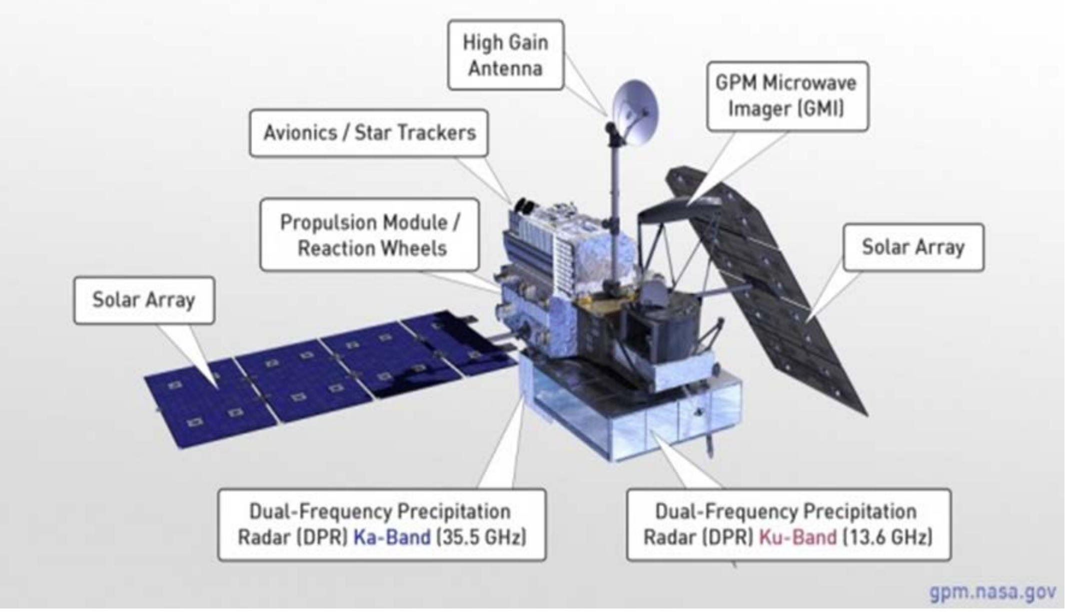


Figure 1.1-1 GPM Core satellite

Table 1.1-1 Spacecraft Orbit Information

Item	Descriptions
Inclination	65 degrees
Mean Semi-major Axis	6776.14 km
Altitude Control (A/C) Box	±1 km
Orbit Eccentricity	0.00010
Geodetic Altitude Variation Range	397 km to 419 km

The DPR is a successor of the Precipitation Radar (PR) loaded onto GPM's predecessor, the Tropical Rainfall Measuring Mission (TRMM). The 35.5 GHz (Ka-band) radar was additionally installed onto the PR at 13.6 GHz (Ku-band) for high-accuracy observation.

The GMI is also a successor of TRMM's microwave imager (TMI) with four additional high-frequency channels (on 166 GHz and 183 GHz) in addition to TMI's nine frequency bands.

The DPR's swath width is about 245 km for the 13.6 GHz radar, and about 125 km for the 35.5 GHz radar. The two radars will synchronously work when their scanning swaths are overlapped. On the other hand, GMI will perform conical scanning, and its swath width is about 900 km.

The core satellite's role is to improve its precipitation observation accuracy for microwave imagers on a constellation of satellites by simultaneously conducting observations with the radar and the microwave imager.

In addition to the DPR and GMI on the GPM core satellite, the GPM constellation satellites have the following groups of conical-scanning microwave imagers and cross-track scanning humidity sounders.

Table 1.1-2 GPM Core Satellite

Instruments	Radio Wave Frequency	Organizations
Dual-frequency Precipitation Radar (DPR)	Ku-band (13.6 GHz)	Japan Aerospace Exploration Agency (JAXA)
	Ka-band (35.5 GHz)	JAXA
GPM Microwave Imager (GMI)	10.65 GHz (V/H), 18.70 GHz (V/H), 23.80 GHz (V), 36.50 GHz (V/H), 89.00 GHz (V/H), 166.00 GHz (V/H), 183.31±3.0 GHz (V), 183.31±7.0 GHz (V)	National Aeronautics and Space Administration (NASA)

Table 1.1-3 GPM Constellation Satellites

Satellites	Instruments	Radio Wave Frequency	Organizations
Tropical Rainfall Measuring Mission (TRMM). Operation period was from 1997-2015.	TRMM Microwave Imager (TMI)	10.7 GHz (V/H), 19.4 GHz (V/H), 21.3 GHz (V), 37.0 GHz (V/H), 85.5 GHz (V/H)	NASA JAXA
Defense Meteorological Satellite Program (DMSP) F17, F18, F19[1)], F20[2)] . 1) Operations were terminated on February 11,2016. 2) To be planned in 2017.	Special Sensor Microwave Imager/Sounder (SSMIS)	19.35 GHz (V/H), 22.235 GHz (V), 37.0 GHz (V/H), 50.3 GHz (H), 52.8 GHz (H), 53.596 GHz (H), 54.4 GHz (H), 55.5 GHz (H), 57.29 GHz, 59.4 GHz , 60.793±0.358 GHz (H+V), 60.793±0.358±0.002 GHz (H+V), 60.793±0.358±0.006 GHz (H+V), 60.793±0.358±0.016 GHz (H+V), 60.793±0.358±0.050 GHz (H+V), 63.283±0.235 GHz (H+V), 91.655 GHz	United States Department of Defense (DoD)

Satellites	Instruments	Radio Wave Frequency	Organizations
		(H/V), 150.0 GHz (H), 183.31±7 GHz (H), 183.31±3 GHz (H), 183.31±1 GHz (H)	
Global Change Observation Mission - Water(GCOM-W)	Advanced Microwave Scanning Radiometer2 (AMSR2)	6.925/7.3 GHz (V/H), 10.65 GHz (V/H), 18.7 GHz (V/H), 23.8 GHz (V/H), 36.5 GHz (V/H), 89.0A GHz (V/H), 89.0 B GHz (V/H)	JAXA
Megha-Tropiques	Multi-Frequency Microwave Scanning Radiometer (MADRAS) and the multi-channel microwave humidity sounder (SAPHIR)	MADRAS: 18.7 GHz (H+V), 23.8 GHz (V), 36.5 GHz (H+V), 89 GHz (H+V), 157 GHz (H+V) SAPHIR: 183.31±0.20 GHz (H), 183.31±1.10 GHz (H), 183.31±2.80 GHz (H), 183.31±4.2 GHz (H), 183.31±6.80 GHz (H), 183.31±11.0 GHz (H)	Centre National d'Etudies Spatiales (CNES) of France and the Indian Space Research Organization (ISRO)
National Oceanic and Atmospheric Administration (NOAA)-18, 19	Advanced Microwave Sounding Unit-A (AMSU-A)	23.800 GHz (V), 31.400 GHz (V), 50.300 GHz (V), 52.800 GHz (V), 53.596±115 GHz (H), 54.400 GHz (H), 54.940 GHz (V), 55.500 GHz (H) f_0=57.290.344 GHz (H), f_0±217 GHz (H), f_0±322.2±48 GHz (H), f_0±322.2±22 GHz (H), f_0±322.2±10 GHz (H), f_0±322.2±4.5 GHz (H), 89.00 GHz (V)	National Oceanic and Atmospheric Administration (NOAA)
	Microwave Humidity Sounder (MHS)	89.0 GHz (V), 157.0GHz (V), 183.31 ± 3.0 GHz (H), 183.31 ± 1.0 GHz (H), 190.311 GHz (V)	
Meteorological Operational Polar Satellite (MetOp) A, B, C[2)] . 2)To be planned in 2018	AMSU-A, MHS	Same as above	European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT)
Suomi National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project	Advanced Technology Microwave Sounder (ATMS)	23.800 GHz (QV), 31.400 GHz (QV), 50.300 GHz (QH), 51.760 GHz (QH), 52.800 GHz (QH), 53.596 ± 0.115 GHz (QH), 54.400 GHz (QH), 54.940 GHz (QH), 55.500 GHz (QH), f_0 = 57.290344 GHz (QH), f_0 ± 0.217 GHz (QH), f_0 ± 0.3222 ± 0.048 GHz (QH), f_0 ± 0.3222 ±	NOAA NASA

Satellites	Instruments	Radio Wave Frequency	Organizations
(NPP)		0.022 GHz (QH), f_0 ± 0.3222 ± 0.010 GHz (QH), f_0 ± 0.3222 ± 0.0045 GHz (QH), 89.5 GHz (QV), 165.5 GHz (QH), 183.31 ± 7.0 GHz (QH), 183.31 ± 4.5 GHz (QH), 183.31 ± 3.0 GHz (QH), 183.31 ± 1.8 GHz (QH), 183.31 ± 1.0GHz (QH)	
Joint Polar Satellite System (JPSS)[3)]. 3) To be planned in early 2017.	ATMS	Same as above	NOAA NASA

Note: V, H are polarization.
QV, QH are quasi-polarization.

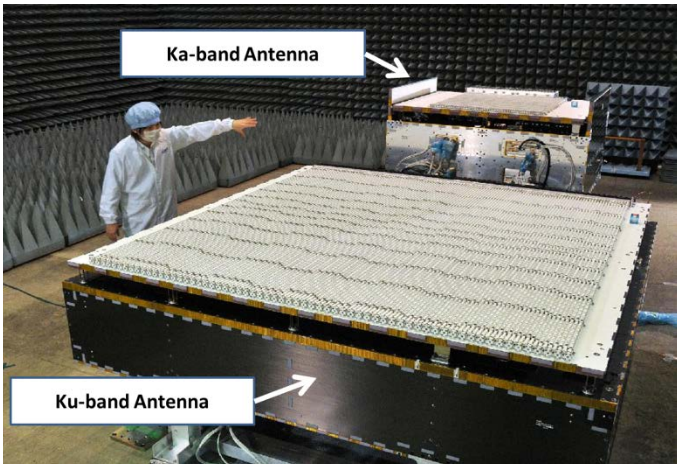
1.2 Overview of Sensors

1.2.1 Dual-frequency Precipitation Radar (DPR)

The Dual-frequency Precipitation Radar (DPR) aboard the GPM core satellite is composed of two precipitation radars (PRs), the KuPR on the Ku-band (13.6 GHz) and the KaPR on the Ka-band (35.5 GHz.). Figure 1.2-1 shows that the Ku-band of the DPR is sensitive to strong rain and that the Ka-band is sensitive to light rain and snow. Table 1.2-1 shows the DPR design specifications.

The KaPR, whose main purpose is to improve sensitivity, is useful for detecting light rain and snow that cannot be measured by the KuPR. Conducting measurements simultaneously with the KuPR, which can detect strong rain, the two radars can observe both strong rain in the tropical zone and light rain and snow in high-latitude areas. In general, strength of precipitation echoes is affected by attenuation due to precipitation on those frequencies, but the amount of attenuation depends on the frequency and the size of raindrops.

The KuPR and KaPR, therefore, match their radar beam positions and transmission pulse timings of each other to estimate the size of a raindrop (Raindrop Size Distribution, RSD) by calculating the difference in precipitation attenuations. This information cannot be acquired through only a single-frequency radar like TRMM’s PR, hence the accuracy of precipitation volume estimation is improved significantly.



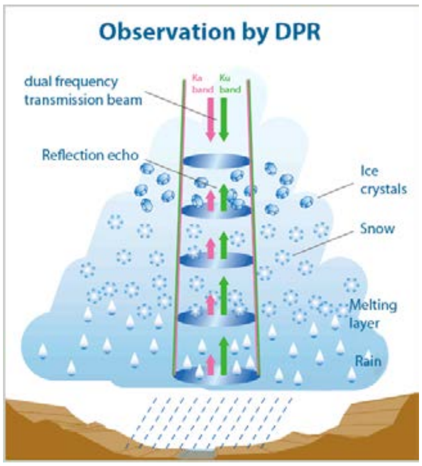


Figure 1.2-1 Dual-frequency Precipitation Radar (DPR) of Ku-band Sensitive to Strong Rain and Ka-band Sensitive to Light Rain and Snow

Table 1.2-1 DPR Design Specifications

Item	KuPR	KaPR
Swath Width	245 km	125 km
Range Resolution	250 m	250/500 m
Spatial Resolution	5.2 km (Nadir at the height of 407 km)	5.2 km (Nadir at the height of 407 km)
Beam Width	0.71 deg (Center Beam)	0.71 deg (Center Beam)
Transmitter	128 Solid-State Amplifiers	128 Solid-State Amplifiers
Peak Transmit Power	1012.0 W	146.5 W
Pulse Repetition Frequency	4000 to 4500 Hz	4000 to 4500 Hz
Pulse Width	Two 1.6 micro sec pulses	Two 1.6 micro sec. pulses in matched beams Two 3.2 micro sec. pulses in interlaced scans
Beam Number	49	49 (25 in matched beams and 24 in interlaced scans)
Minimum Measureable Rain Rate	0.5 mm/h	0.2 mm/h
Beam Matching Error	Under 1000 m	
Observable Range	19 km to surface (to –5 km near nadir)	
Dynamic Range	From -5 dB below the system noise level to +5dB above the nominal maximum surface echo level	
Receiver Power Accuracy	±1dB	
Scan Angle (in observation mode)	±17° Cross Track	±8.5° Cross Track
Frequencies	13.597 and 13.603 GHz	35.547 and 35.553 GHz
Beam Width	14 MHz	
Antenna Size	2.5 × 2.4 × 0.6 m	1.4 × 1.2 × 0.8 m
Max. Mass	472 kg	336 kg
Power (max)	446 W (orbit average)	344 W (orbit average)
Science Data Rate (max)	109 kbps	81 kbps
Housekeeping Data Rate (nominal)	1 kbps	1kbps

1.2.2 GPM Microwave Imager (GMI)

GMI is a primary microwave sensor onboard the GPM core satellite; see Figure 1.2-2 The core satellite flies in a 407 km circular orbit with a 65 degree inclination angle. The GMI has 13 channels with a frequency range from 10 to 183 GHz. Except for the heritage hot load and cold load that are commonly used for linear sensor radiometric calibrations, hot noise diodes and cold noise diodes are implemented in the GMI to determine the non-linearity and noise levels of the measurements.

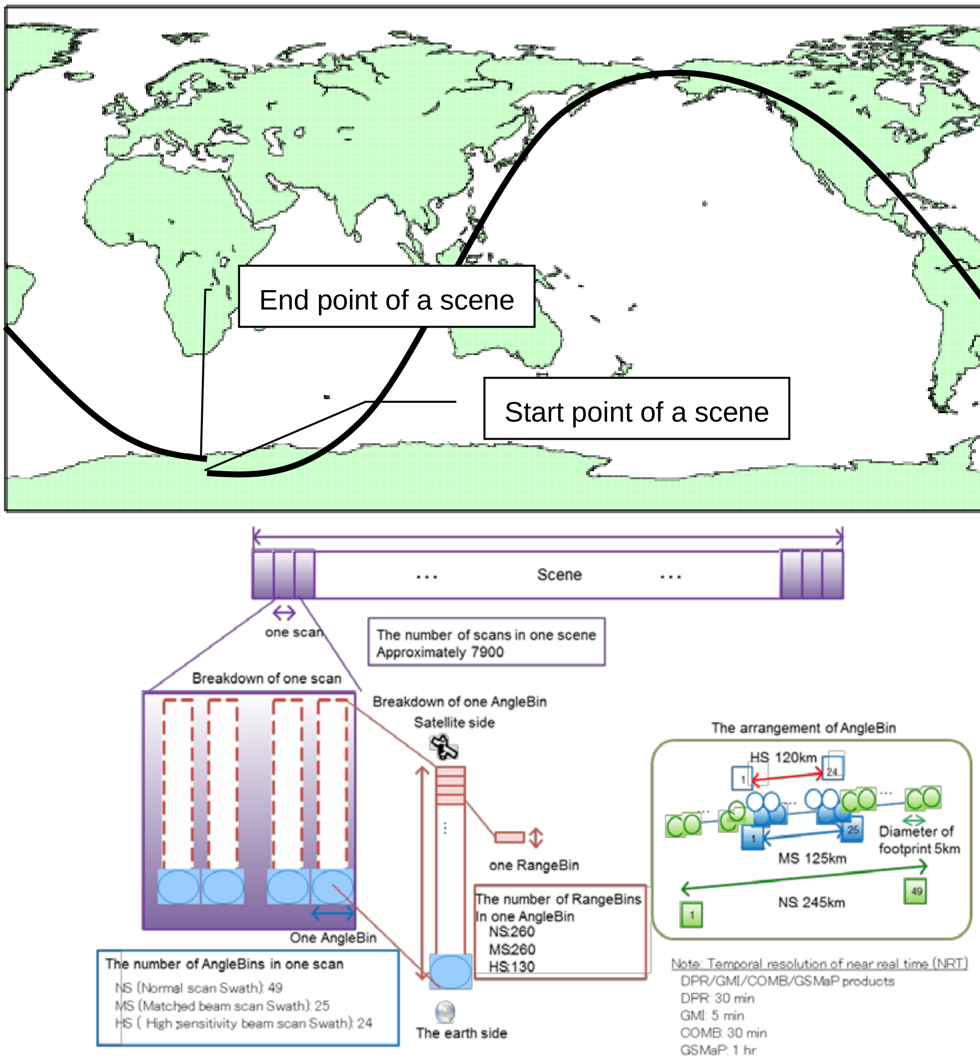
Figure 1.2-2 GPM Microwave Imager (GMI) Provided by NASA

1.3 Scene Definitions

1.3.1 Scene of Level 1 and Level 2 Products

A scene of Level 1 and Level 2 DPR products is defined as data for an orbit with the southernmost point of the Earth as the start point without overlap. A near-real-time (NRT) GMI product's file is generated by the receiving data of 5 minutes from the satellite. A near-real-time DPR and DPR/GMI COMB product's files are generated by the receiving data of 30 minutes from the satellite.

Figure 1.3-1 shows an image of the scene definition of KuPR and KaPR, except "Note: Temporal resolution of NRT. "



Note: Temporal resolution of NRT DPR/GMI/COMB/GSMaP products
DPR: 30 min
GMI: 5 min
COMB: 30 min

NS: Normal scan swath
MS: Matched beam scan swath
HS: High-sensitivity beam scan swath

Figure 1.3-1 Image of Scene Definition

The number of angle bin within one scan is 52 (0 to 51); 49 of them (1 to 49) are actually used for observation by transmitting radio wave.

Figure 1.3-2 shown below is an outline of normal observation. The swath of KaPR is about 125 km wide, and that of KuPR is about 245 km wide.

In Ku/Ka/DPR L2 products, the names of scan are used as noted below;

“NS”= Normal scan, corresponding to the blue footprint (49 angle bin) in Figure 1.3-2.

“MS”= Matched beam scan, corresponding to the yellow footprint (25 angle bin) in Figure 1.3-2.

“HS”= High sensibility beam scan, corresponding to the red footprint (24 angle bin) in Figure 1.3-2.

After product version 4, the number of instruments and the number of channels were increased. Therefore, the index definition of the DPR Level 3 product was modified. The latest index definition of the DPR Level 3 product is shown in Figure 1.3-3.

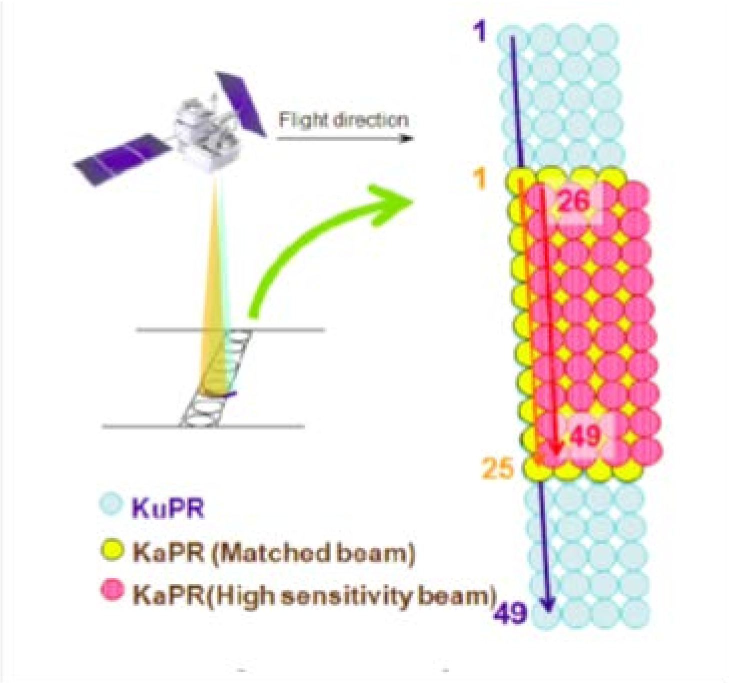
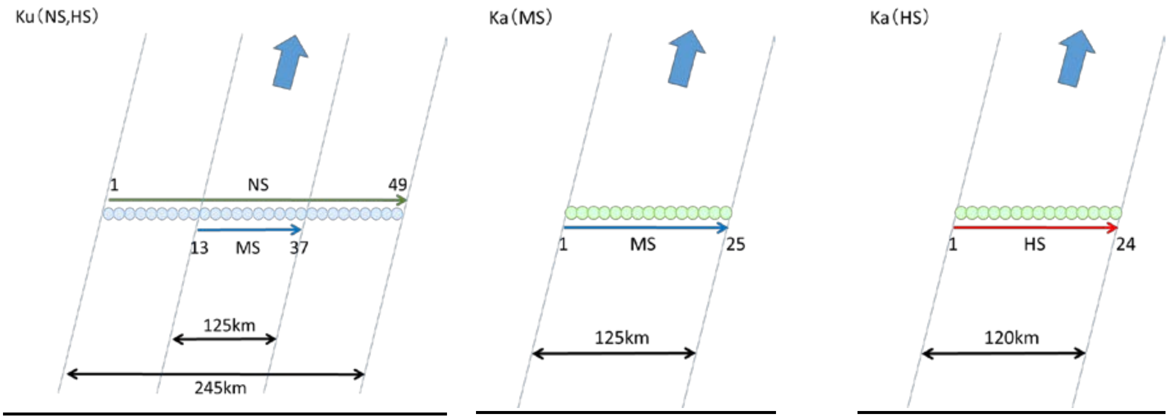
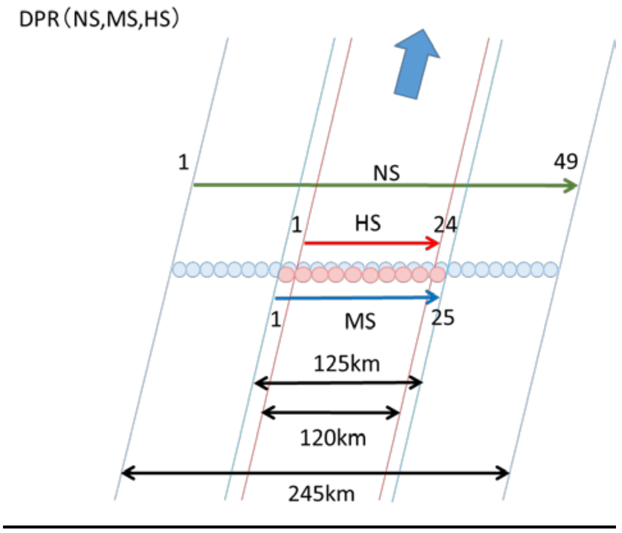


Figure 1.3-2 The Outline of KuPR and KaPR Under Normal Observation





<u>Added another index to 'instrument' and 'channel' for files in product version 4.</u>

<u>Instrument increased from 3 to 4</u>

<u>- Ku, Ka, KaH, KuMS</u>

<u>- Added index for statistics from L2Ku but only for narrow MS swath</u>

<u>Channel increased from 4 to 5</u>

<u>- Ku, Ka, KaHS, DPRMS, KuMS</u>

<u>- Recently clarified that DPRMS is data from narrow MS swath.</u>

<u>- Added index for statistics from L2Ku but only for narrow MS swath.</u>

<u>Figure 1.3-3 Modification of DPR Level 3 Dimension (Index) Definition</u>

1.3.2 Scene of Level 3 Products

The following table shows a scene definition for GPM Level 3 products. The data format of the products shown in Table 1.3-1 is gridded by using the scene coverage, respectively. However, the grid size and the scene coverage (the range of latitude) are different, respectively.

Table 1.3-1 Scene Definitions for Level 3 Products

Product	Temporal Resolution and Grid Size	Scene Coverage
GPM DPR L3 Precipitation	**Standard Product** - Daily (Text format) Resolution: 0.1° × 0.1° - Daily (HDF format) Resolution: 0.25° × 0.25° - Daily (GeoTIFF format) Resolution: 0.25° × 0.25° - Monthly (HDF format) Resolution: 0.25° × 0.25°, 5° × 5° - Monthly (GeoTIFF format) Resolution: 0.25° × 0.25°	Products covering: 67°S to 67°N, 180°W to 180°E
GPM DPR L3 Spectral Latent Heating (SLH)	**Standard Product** - Gridded Orbital Resolution: 0.5° × 0.5° - Monthly Resolution: 0.5° × 0.5°	Products covering: 67°S to 67°N, 180°W to 180°E
GPM GMI L3 Precipitation	**Standard Product** - Monthly Resolution: 0.1° × 0.1°	Products covering: 90°S to 90°N, 180°W to 180°E
GPM DPR/GMI Comb L3 Precipitation	**Standard Product** - Monthly Resolution: 0.25° × 0.25° & 0.5° × 0.5°	Products covering: 67°S to 67°N, 180°W to 180°E
GPM DPR/GMI Comb L3 Convective Stratiform Heating (CSH)	**Standard Product** - Gridded Orbital Resolution: 0.25° × 0.25° - Monthly Resolution: 0.25° × 0.25°	Products covering: 67°S to 67°N, 180°W to 180°E
GSMaP Precipitation	**Standard Product** - Hourly (Text format) Resolution: 0.1° × 0.1° - Hourly (HDF format) Resolution: 0.1° × 0.1° - Hourly (GeoTIFF format) Resolution: 0.1° × 0.1° - Monthly (HDF format)	Products covering 90°S to 90°N, 180°W to 180°E

Product	Temporal Resolution and Grid Size	Scene Coverage
	Resolution: 0.1°× 0.1° - Monthly (GeoTIFF format) Resolution: 0.1°× 0.1° - Hourly (netCDF format) Resolution: 0.1° × 0.1° - Monthly (netCDF format) Resolution: 0.1°× 0.1°	
	Near-Real-Time Product - Hourly (Text format) Resolution: 0.1° × 0.1° - Hourly (HDF format) Resolution: 0.1° × 0.1°	Products covering 90°S to 90°N, 180°W to 180°E

1.4 Product Level Definitions

Table 1.4-1 shows product level definitions for GPM data processing.

Table 1.4-1 Product Level Definitions for GPM Data Processing

Product Level	Description
Level 0	Depacketized data by Application Process Identifier (APID) as input data for Level 1 data. Level 0 data are not distributed.
Level 1A	Products of stored data of sensor output value, satellite altitude and location information, sensor condition, and conversion parameters, based on file unit (scene) defined by the certain revolution unit, using Level 0 data as input data. These data are managed as the master data in the mission operation system and are not distributed for users.
Level 1B, 1C	Products created by geometric collection and processing to derive received power or brightness temperature, etc.. using Level 1A data as input data.
Level 2	Products containing various physical quantities related to precipitation (radar cross section on Earth surface, precipitation type, bright band altitude, attenuation-compensated radar reflectivity factor and precipitation intensity, spectral latent heating etc.) calculated by Level 2 algorithms with Level 1 products as input.
Level 3	Products created by spatio-temporal statistical processing using Level 1 or Level 2 products as input data. The regional coverage of products is global: the temporal averaging period is in monthly, daily, and hourly units (global precipitation map), and gridded orbital and monthly (spectral latent heating and convective stratiform heating from combined).

1.5 Overview of Processing

Figure 1.5-1 shows the GPM product processing flow corresponding to the processing level definitions shown in Table 1.4-1. In this chart, there are standard products and near-real time products.

1.5.1 GPM Processing Flow

Standard products and near-real-time products distributed from JAXA are shown in Figure 1.5-1. The standard products are products with accuracy assurance by NASA and JAXA.

Near-real-time products are requested and produced and distributed quickly: therefore, the down-link data from a satellite are gradually processed in each time unit by GMI (5 min), DPR (30 min), and COMB (30 min). Moreover, the Japanese Meteorological Agency's (JMA's) global weather forecast (FCST) is used in processing of the physical quantity in products levels higher than Level 2. On the other hand, for the processing of standard products, JMA's Global ANALysis model data (GANAL) are used to provide atmospheric environmental conditions for the processing.

Furthermore in March 2016, GPM products were revised as version 4 and the new latent heating and convective stratiform heating products from DPR and DPR/GMI combined were released for users from JAXA and NASA. Figure 1.5-1b in addition to Figure 1.5-1a indicates the data processing flow of new latent heating products and convective stratiform heating from combined.

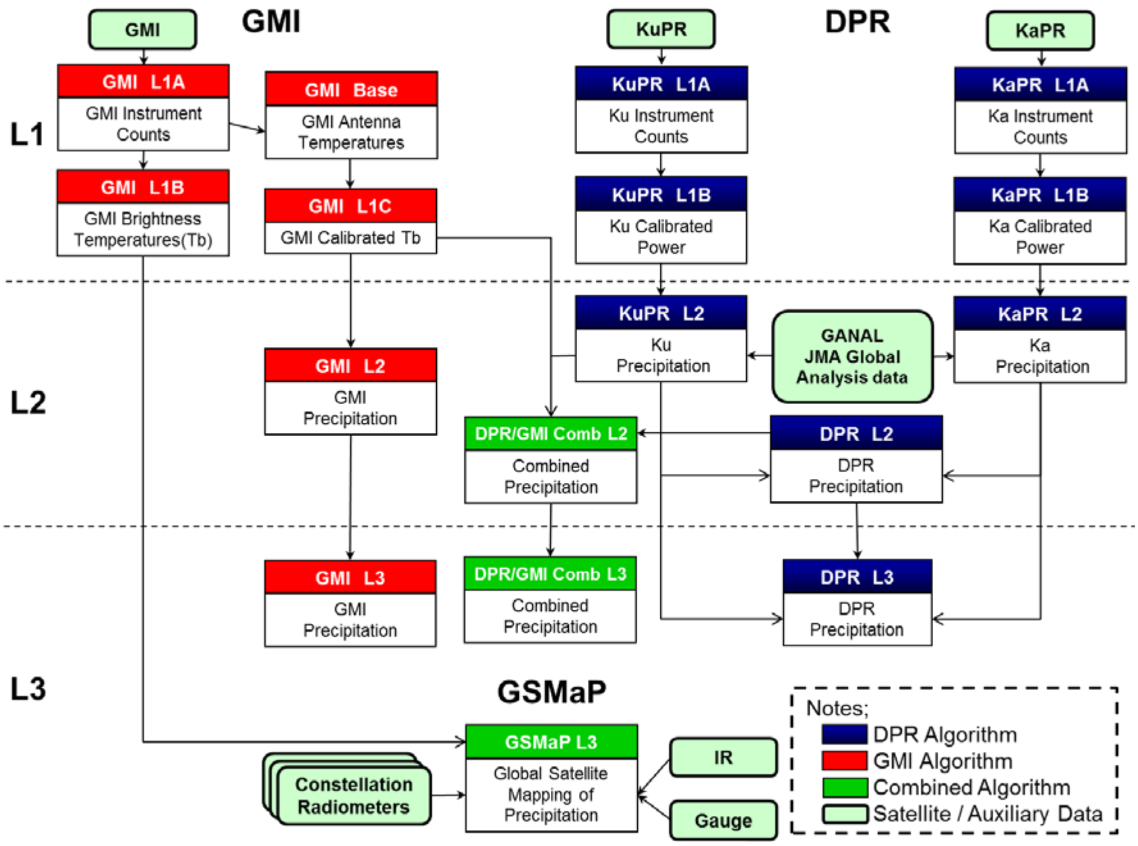


Figure 1.5-1a GPM Product Processing Flow

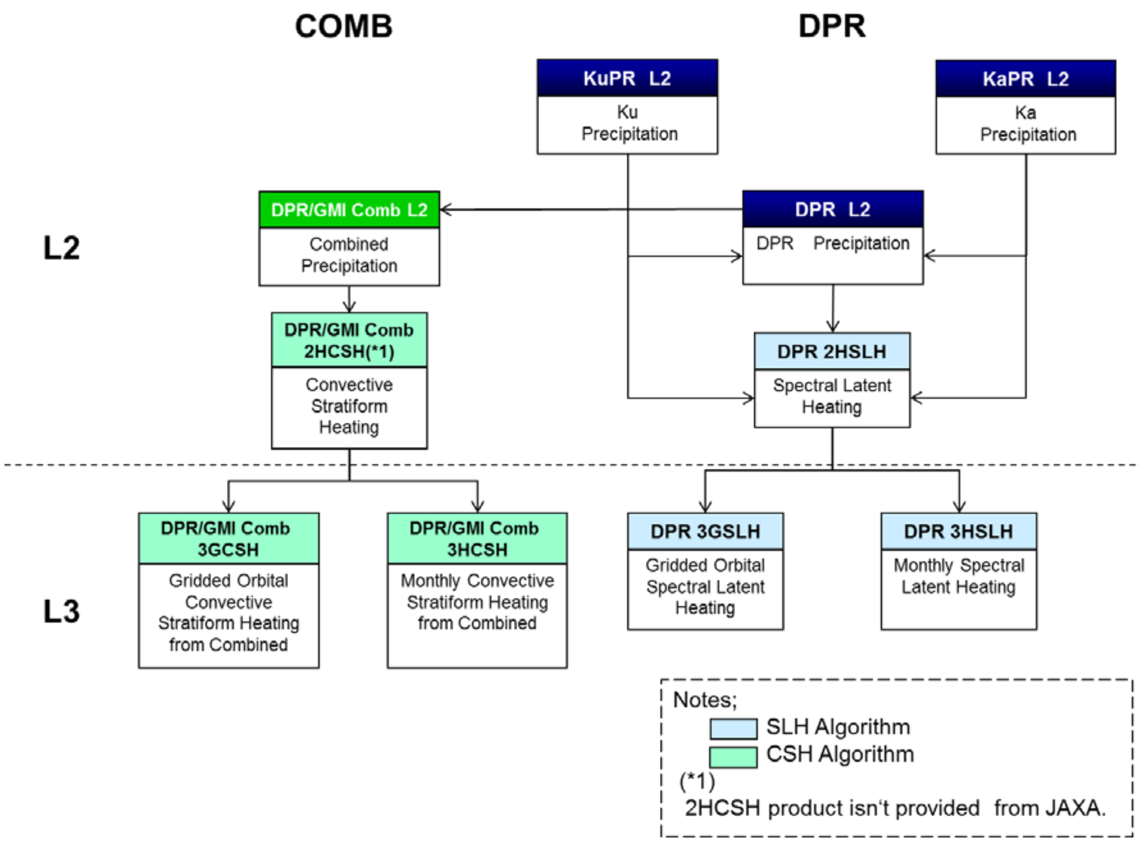


Figure 1.5-1b GPM Product Processing Flow (Downstream of Figure 1.5-1a)

1.6 GPM Products Format

1.6.1 GPM Products Format

GPM products are provided in Hierarchical Data Format (HDF). This file format is internally compressed and is useful for addressing multi-dimensional arrays. GPM products adopt HDF5 version 1.8.9. The PPS Science Algorithm Input/Output Toolkit (TKIO) can manage data in HDF5 files, specified by user programs.

1.6.2 What is HDF?

HDF is a set of file formats developed by The National Center for Supercomputing Application/University of Illinois (NCSA) and platform-independent formats. There are two types of HDF, HDF4 and HDF5. HDF5 modified the some problems of HDF4 (limitation of data size, multiple data types, and others). HDF files consist of two parts: Attribute, which contains attribute information, and dataset, which contains product data itself (see Figure 1.6-1). Attributes of GPM products contain metadata, and dataset contains product data such as observation data, latitude/longitude data, and others.

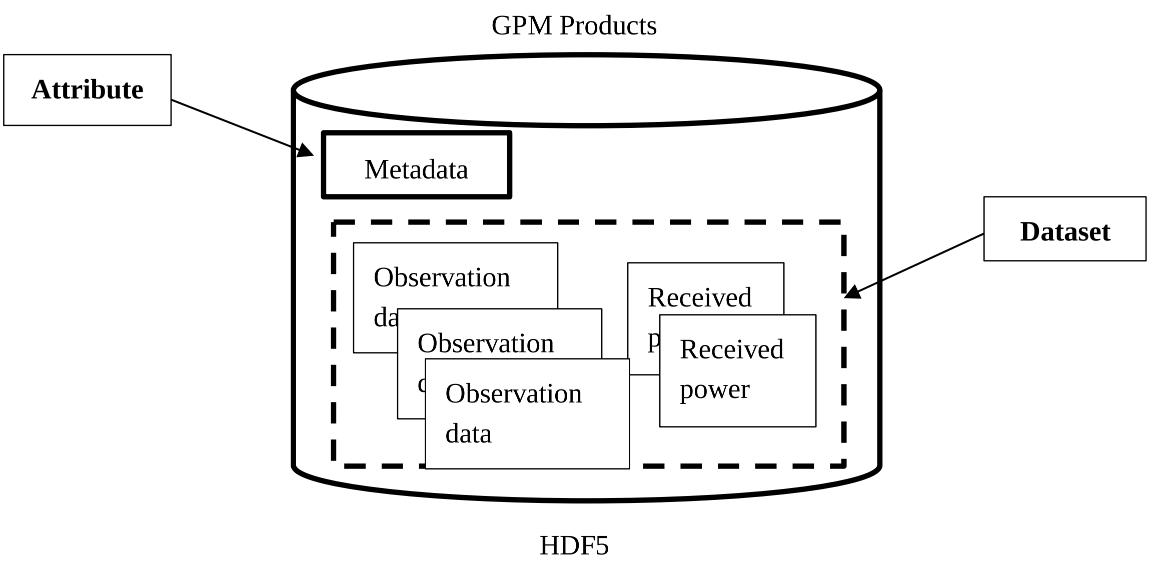


Figure 1.6-1 Structure of an HDF File

1.6.3 How To Get the HDF5 Library

HDF5 library files are available at the HDF group website. The latest version of the HDF5 library is available on the website shown below:

http://hdfgroup.org/HDF5/release/obtain5.html#obtain

Table 1.6-1 shows the library files as of June 2014. You can download the HDF5 library suitable for your platform. Although GPM products' version of HDF5 is different from the current library, the library version is compatible with GPM products.

Table 1.6-1 HDF5 Library

Platform	Filename	Notes
All Platforms	src/hdf5-1.8.13.tar.gz	Source Code
Linux 2.6 i686	hdf5-1.8.13-linux-shared.tar.gz	Binary (shared)
Linux 2.6 x86_64	hdf5-1.8.13-linux-x86_64-shared.tar.gz	Binary (shared)

The HDF library uses the sz library. You need to download the sz library if you don't have it installed (see Table 1.6-2).

Table 1.6-2 sz Library

URL	Notes
http://www.hdfgroup.org/ftp/lib-external/szip/2.1/src/szip-2.1.tar.gz	

1.6.4 Data Structure Outline of GPM Products Using HDF5

Figure 1.6-2 shows the data structure outline of a Level 1B Ku product as an example. The Level 1B Ku product consists of two components. The first component is product metadata and the second is normal scan swath (NS). Product metadata have six variables: FileHeader, InputRecord, NavigationRecord, FileInfo, JAXAInfo, and DPRKuInfo. On the other hand, NS has one metadata variable and 11 data groups. Except for Latitude, Longitude, and Swathheader data groups, data groups consist of several variables. Each variable is a specific array type and byte size.

The data structure of GPM products is described in each product’s format documentation.

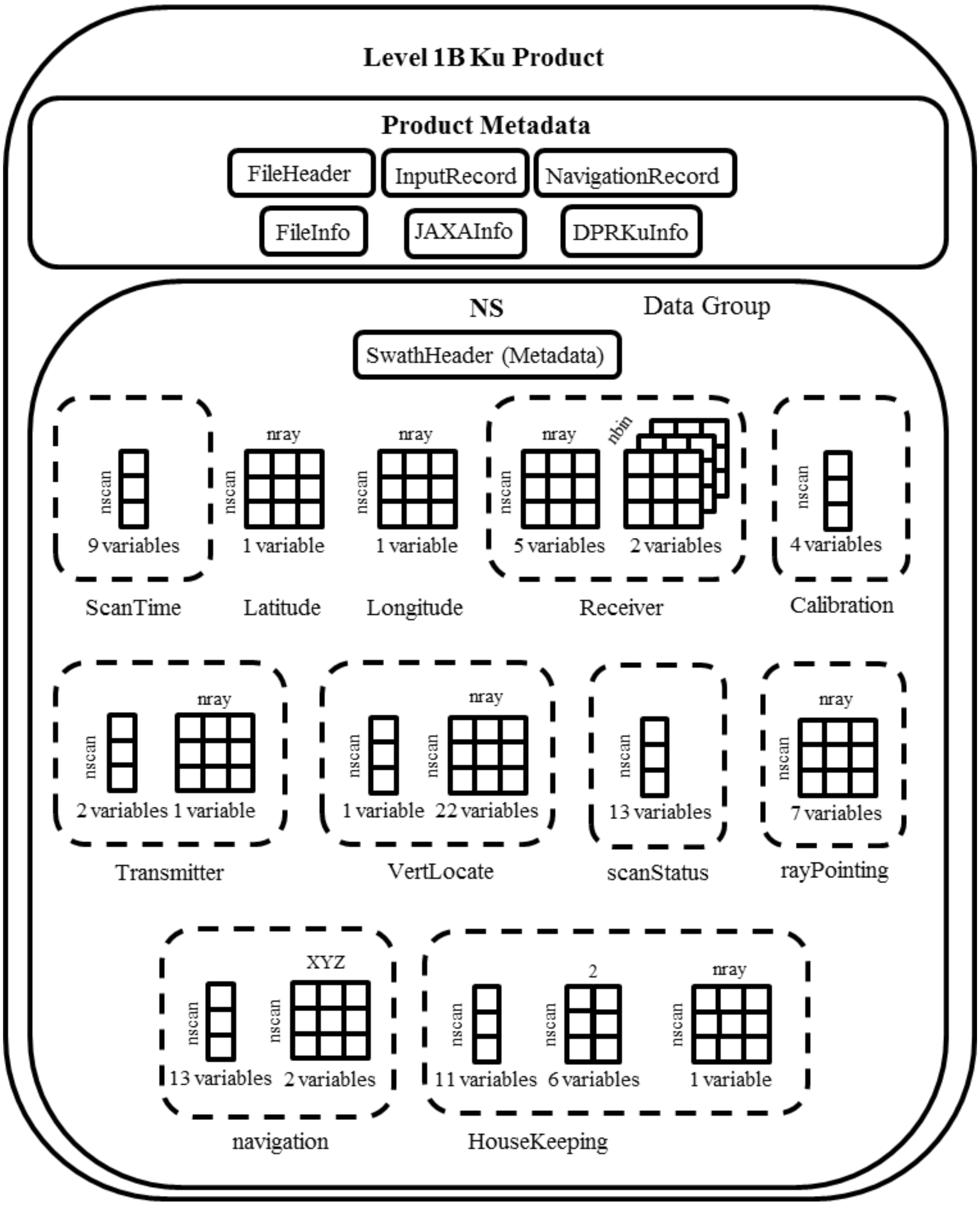


Figure 1.6-2 The Data Structure Outline of a Level 1B Ku Product

1.7 Conceptual Explanation of Product/Algorithm Versions

Product/algorithm versions are controlled by JAXA, and JAXA is responsible for data distribution, and update of the algorithms depending on the results from the calibration and validation process during the operational phase after the launch. Product versions are shown in Section 2.4, File Naming Conventions, as the products definitions include product version by three characters: Major (2 digits, such as 01, 02, 03…..) +Minor (1 letter, such as a, b, c….), where major shows increment at re-processing after the launch from 01.

2. Overview of DPR Products

2.1 DPR Sensor

The characteristics of the Dual-frequency Precipitation Radar (DPR) onboard GPM are shown in Table 2.1-1.

Table 2.1-1 Characteristics of the Dual-frequency Precipitation Radar (DPR)

Property	KuPR	KaPR
Frequency	13.597, 13.603 GHz	35.547, 35.553 GHz
Swath Width	245 km	125 km
Observation Altitude	Up to 19 km	Up to 19 km
Horizontal Resolution	5.2 km (at nadir)	5.2 km (at nadir)
Range Resolution	250 m	250 m / 500 m
Minimum Detectable Rainfall Rate	0.5 mm/h~	0.2 mm/h~

2.2 Operation Modes

Table 2.1-1 describes the operation modes of DPR.

Table 2.2-1 DPR Operation Modes

No.	Operation Mode	Descriptions	Remarks
1	Normal Operation Mode	Normal operation mode	The DPR L1 product not in normal operation mode cannot be used for the estimation of geophysical parameters such as precipitation. Therefore, users needs handling to select and use products in normal operation mode by referring “operationalMode.” Furthermore, in DPR L2 products, “missing” is stored in the data without normal operation mode.
2	External Calibration Mode	The mode to calibrate the precipitation radar by using the ground-based radar calibrator	
3	Internal Calibration Mode	The mode to calibrate the receiver-related devices by using radio frequency (RF) loop-back of FCIF	
4	SSPA Operation Analysis Mode	The mode to check that each device of SSPA amplifies signal properly	
5	LNA Operation Analysis Mode	The mode to check that each device of LNA amplifies signal properly	
6	Health Check Mode	The mode to perform health check within SCDP	
7	Standby Mode	The mode to output any of the following to science telemetry: ● Variable PRF table dump ● Phase code dump ● Memory dump	

Refer to the GPM Data Utilization Handbook for details of each operation mode.

2.3 Product Level Definitions

DPR products consist of the standard product (STD) and the near-real-time product (NRT). Table 2.3-1 shows KuPR/KaPR/DPR L1/L2 standard product level definitions. Table 2.3-2 shows KuPR/KaPR/DPR L1/L2 near-real-time product level definitions. Table 2.3-3 shows DPR L3 standard products level definitions.

Table 2.3-1 KuPR/KaPR/DPR L1/L2 Standard Product Level Definitions

GPM Standard Products					
Sensor	**Type**	**Level**	**Product Name**	**Processing Level**	**Description**
DPR	STD	L1	GPM KuPR L1B Received Power	L1B	GPM standard product Main parameters: Received power Swath width: 245 km Resolution: 5 km(horizontal), 125 m (vertical)
			GPM KaPR L1B Received Power	L1B	GPM standard product Main parameters: Received power Swath width: 125 km Resolution: 5 km(horizontal), 125/250 m (vertical)
		L2	GPM KuPR L2 Precipitation	L2	GPM standard product Main parameters: Precipitation rate, precipitation type, precipitation particle size, vertical profile of reflectivity factor, surface backscattering cross section Swath width: 245 km Resolution: 5 km(horizontal), 125 m (vertical)
			GPM KaPR L2 Precipitation	L2	GPM standard product Main parameters: Precipitation rate, precipitation type, precipitation particle size, vertical profile of reflectivity factor, surface backscattering cross section Swath width: 125 km Resolution: 5 km(horizontal), 125/250 m (vertical)
			GPM DPR L2 Precipitation	L2	GPM standard product Main parameters: Precipitation rate, precipitation type, precipitation particle size, vertical profile of reflectivity factor, surface backscattering cross section Swath width: 245 km Resolution: 5 km(horizontal), 125/250 m (vertical)

			GPM DPR L2 Latent Heating	L2	GPM standard product Main parameters: Spectral latent heating Swath width: 245 km Resolution: 5 km(horizontal), 125/250 m(vertical)

Table 2.3-2 KuPR/KaPR/DPR L1R/L2R Near-Real-Time Product Level Definitions

GPM Near-Real-Time Products					
Sensor	**Type**	**Level**	**Product Name**	**Processing Level**	**Description**
DPR	NRT	L1R	GPM KuPR L1B Received Power	L1B	GPM near-real-time product Main parameters: Received power Swath width: 245 km Resolution: 5 km (horizontal), 125m (vertical)
			GPM KaPR L1B Received Power	L1B	GPM near-real-time product Main parameters: Received power Swath width: 125 km Resolution: 5 km (horizontal), 125/250 m (vertical)
		L2R	GPM KuPR L2 Precipitation	L2	GPM near-real-time product Main parameters: Precipitation rate, precipitation type, precipitation particle size, vertical profile of reflectivity factor, surface backscattering cross section Swath width: 245 km Resolution: 5 km (horizontal), 125 m (vertical)
			GPM KaPR L2 Precipitation	L2	GPM near real-time product Main parameters: Precipitation rate, precipitation type, precipitation particle size, vertical profile of reflectivity factor, Surface backscattering cross section Swath width: 125 km Resolution: 5 km (horizontal), 125/250 m (vertical)
			GPM DPR L2 Precipitation	L2	GPM near-real-time product Main parameters: Precipitation rate, precipitation type, precipitation particle size Swath width: 125/245 km Resolution: 5 km (horizontal), 125/250 m (vertical)

Table 2.3-3 DPR L3 Standard Product Level Definition

GPM Standard Products					
Sensor	**Type**	**Level**	**Product Name**	**Processing Level**	**Description**
DPR	STD	L3	GPM DPR L3 Precipitation Daily (Text format)	L3	GPM standard product Main parameters: Precipitation rate Resolution: 0.1 degree
			GPM DPR L3 Precipitation Daily (HDF format)	L3	GPM standard product Main parameters: Precipitation rate Resolution: 0.25 degree
			GPM DPR L3 Precipitation Monthly (HDF format)	L3	GPM standard product Main parameters: Precipitation rate Resolution: 0.25 degree, 5 degree
			GPM DPR L3 Precipitation Daily, Ascending (GeoTIFF format)	L3	GPM standard product Main parameters: Precipitation rate Resolution: 0.25 degree
			GPM DPR L3 Precipitation Daily, Descending (GeoTIFF format)	L3	GPM standard product Main parameters: Precipitation rate Resolution: 0.25 degree
			GPM DPR L3 Precipitation Monthly (GeoTIFF format)	L3	GPM standard product Main parameters: Precipitation rate Resolution: 0.25 degree
			GPM DPR L3 Latent Heating (Gridded orbital)	L3	GPM standard product Main parameters: Gridded orbital spectral latent heating Resolution: 0.5 degree
			GPM DPR L3 Latent Heating (Monthly)	L3	GPM standard product Main parameters: Monthly spectral latent heating Resolution: 0.5 degree

2.4 File Naming Conventions

2.4.1 L1/L2 Standard Products With Orbit Number

KuPR/KaPR/DPR L1/L2 standard products are defined as the following type.

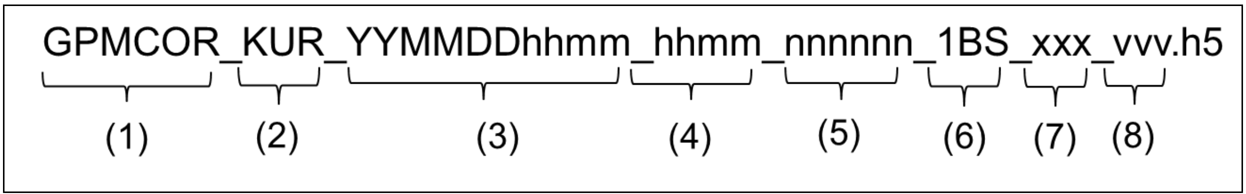


Figure 2.4-1 File Naming Convention of KuPR/KaPR/DPR L1/L2 Standard Products With Orbit Number

Table 2.4-1 Description of File Naming Convention of KuPR/KaPR/DPR L1/L2 Standard Products With Orbit Number

No.	Name	Number of Characters	Value
1	Mission ID	6	GPMCOR [fixed]
2	Sensor ID	3	KUR/KAR/DPR/
3	Scene Start, Coordinated Universal Time (UTC)	10	YYMMDDhhmm
4	Scene End (UTC)	4	hhmm
5	Orbit Number	6	nnnnnn: 000000~999999
6	Processing Level	3	Level+Type, Level:1B/L2/... , Type: S (standard)
7	Algorithm Key (Product Identifier)	3	Identify algorithm name: KuPR Level 1B: DUB KaPR Level 1B: DAB KuPR Level 2: DU2 KaPR Level 2: DA2 DPR Level 2: DD2 DPR Level 2: SLP
8	Product Version	3	Major (2 digits) + Minor (1 letter) (Major; increment at re-processing)

2.4.2 L1/L2 Near-Real-Time Products Without Orbit Number

KuPR/KaPR/DPR L1/L2 near-real-time products are defined as the following type.

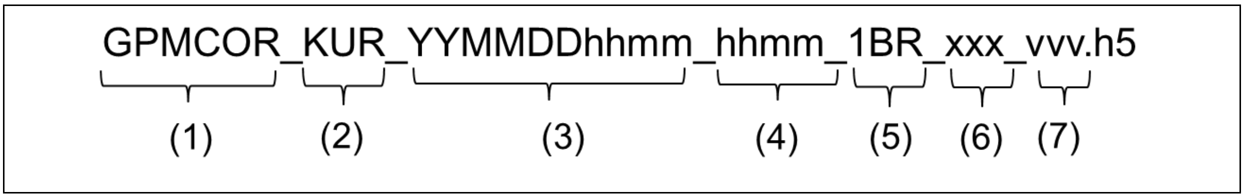


Figure 2.4-2 File Naming Convention of KuPR/KaPR/DPR L1/L2 Near-Real-Time Products Without Orbit Number

Table 2.4-2 Description of File Naming Convention of KuPR/KaPR/DPR L1/L2 Near-Real-Time Products Without Orbit Number

No.	Name	Number of Characters	Value
1	Mission ID	6	GPMCOR [fixed]
2	Sensor ID	3	KUR/KAR/DPR/
3	Scene Start (UTC)	10	YYMMDDhhmm
4	Scene End (UTC)	4	hhmm
5	Processing Level	3	Level+Type, Level:1B/L2/... , Type: R (NearRealTime)
6	Algorithm Key (Product Identifier)	3	Identify algorithm name: KuPR Level 1B: DUB KaPR Level 1B: DAB KuPR Level 2: DU2 KaPR Level 2: DA2 DPR Level 2: DD2
7	Product Version	3	Major (2 digits) + Minor (1 letter) (Major; increment at re-processing)

2.4.3 L3 Standard Products

DPR L3 standard products are defined as the following type.

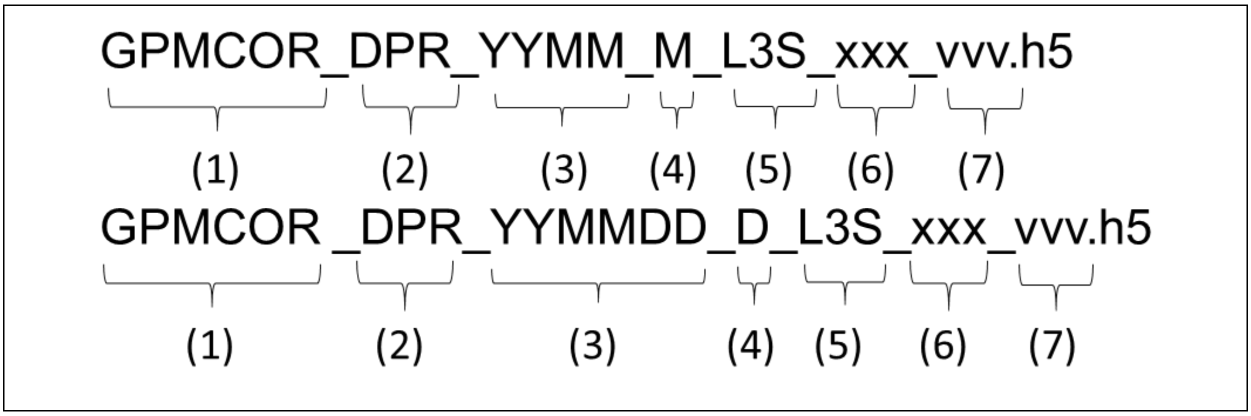


Figure 2.4-3 File Naming Convention of DPR L3 Standard Products

Table 2.4-3 Description of File Naming Convention of DPR L3 Standard Products

No.	Name	Number of Characters	Value
1	Mission ID	6	GPMCOR [fixed]
2	Sensor ID	3	DPR [fixed]
3	Scene Start (UTC)	4, 6	YYMM: Monthly YYMMDD: Daily
4	Process Unit	1	M: Monthly, D: Daily
5	Process Level	3	Level+Type, Level: L3, Type: S (standard)
6	Algorithm Key (Product Identifier)	3	Identify algorithm name: DPR Level 3（Daily, HDF format）: D3Q DPR Level 3（Daily, Text format）: D3D DPR Level 3(Monthly, HDF format): D3M DPR Level 3(Monthly, HDF format): SLM
7	Product Version	3	Major (2 digits) + Minor (1 letter) (Major; increment at re-processing)

2.4.4 L3 Standard Latent Heating Products With Orbit Number

GPM DPR L3 standard latent heating (orbital) products are defined as the following type.

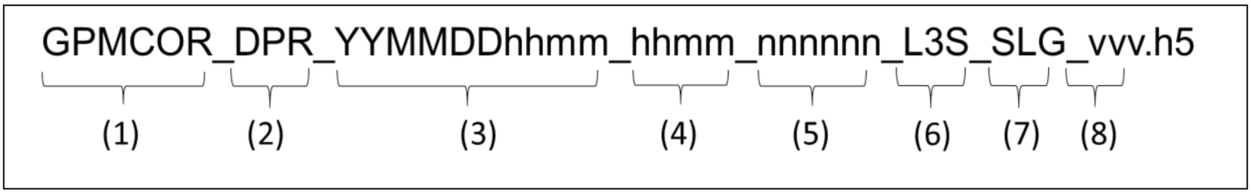


Figure 2.4-4 File Naming Convention of DPR L3 Standard Latent Heating Products With Orbit Number

Table 2.4-4 Description of File Naming Convention of DPR L3 Standard Latent Heating Products With Orbit Number

No.	Name	Number of Characters	Value
1	Mission ID	6	GPMCOR [fixed]
2	Sensor ID	3	DPR
3	Scene Start (UTC)	10	YYMMDDhhmm
4	Scene End (UTC)	4	hhmm
5	Orbit Number	6	nnnnnn: 000000~999999
6	Process Level	3	Level+Type, Level: L3, Type: S (standard)
7	Algorithm Key	3	Identify algorithm name: DPR Level 3: SLG
8	(Product Identifier)	3	Major (2 digits) + Minor (1 letter) (Major; increment at re-processing)

2.4.5 KuPR/KaPR/DPR Environment Auxiliary (ENV) Product

Level 2 KuPR/KaPR/DPR environment auxiliary (ENV) standard products are defined as the following type.

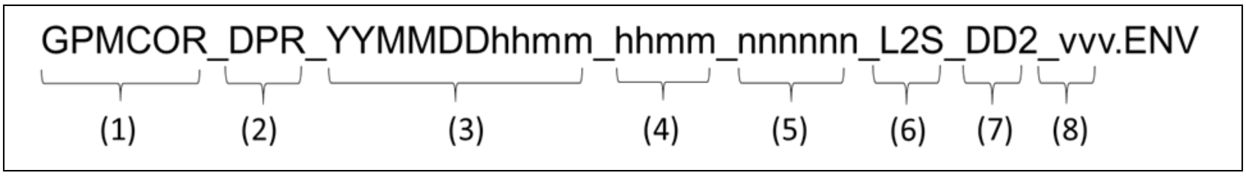


Figure 2.4-5 File Naming Convention of L2 KuPR/KaPR/DPR ENV Standard Products With Orbit Number

Table 2.4-5 Description of File Naming Convention of L2 KuPR/KaPR/DPR ENV Standard Products With Orbit Number

No.	Name	Number of Characters	Value
1	Mission ID	6	GPMCOR [fixed]
2	Sensor ID	3	KUR: KuPR KAR: KaPR DPR: DPR
3	Scene Start (UTC)	10	YYMMDDhhmm
4	Scene End (UTC)	4	hhmm
5	Process Level	6	nnnnnn (000001～999999)
6	Process Level	3	Level+Type, Level: L2, Type: S (standard)
7	Algorithm Key (Product Identifier)	3	Identify algorithm name: KuPR L2 :DU2 KaPR L2 :DA2 DPR L2 :DD2
8	Product Version	3	Major (2 digits) + Minor (1 letter) (Major; increment at re-processing)

2.4.6 L3 GPM Products (GeoTIFF)

DPR L3 standard products (GeoTIFF format) are defined as the following type.

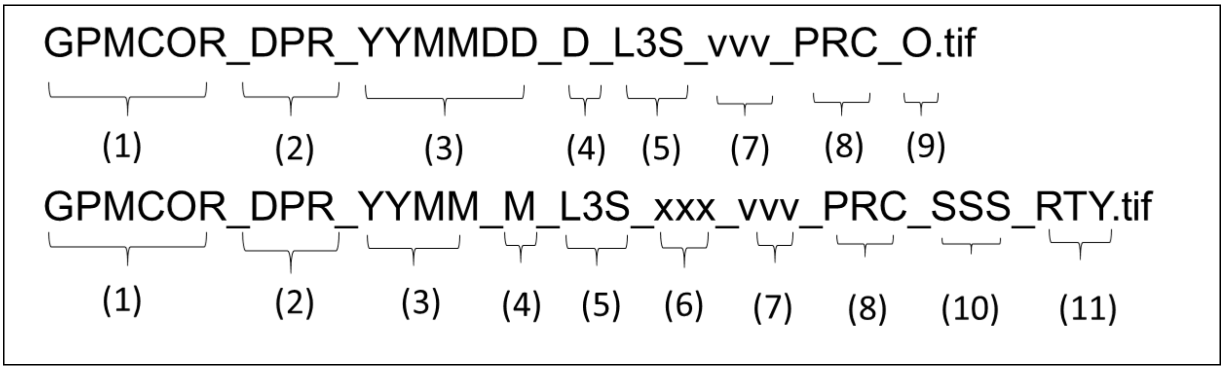


Figure 2.4-6 File Naming Convention of DPR L3 Standard Products (GeoTIFF)

Table 2.4-6 **Description of File Naming Convention of DPR L3 Standard Products (GeoTIFF)**

No.	Name	Number of Characters	Value
1	Mission ID	6	GPMCOR [fixed])
2	Sensor ID	3	DPR [fixed]
3	Scene Start (UTC)	4~10	YYMMDDhhmm YYMMDD YYMM
4	Process Unit	1	Daily: D [fixed] Monthly: M [fixed]
5	Process Level	3	Level+Type, Level: L3 [fixed], Type: S (standard) [fixed]
6	Algorithm Key (Product Identifier)	3	Identify algorithm name: DPR L3 Daily: D3Q [fixed] DPR L3 Monthly: D3M [fixed]
7	Product Version	3	Major (2 digits) + Minor (1 letter) (Major; increment at re-processing)
8	Variable Name	3	Average precipitation (1hour, 1 day or 1 month): PRC [fixed]
9	Orbital Type	1	A (Ascending) or D (Descending)
10	Sensor Type	3	KuNS: KUN KaMS: KAM KaHS: KAH DPRMS: DPM KuMS: KUM
11	Rainfall Type	3	Stratiform: STR Convective: CON All: ALL

2.5 Overview of DPR Data Processing

2.5.1 Level1 Processing

This section provides an overview of Level 1B processing.

(1) Standard Processing

In DPR Level 1B standard processing, a Level 1A product is read as input data and a product containing a received power profile and geometric information, such as observation positions, is outputted. During the course of processing, radiometric correction is carried out, missing data are processed based on missing data information, scan time is corrected, and geometric calculation of the time, latitude, longitude, and height of each piece of scan data in each range bin is performed.

The processing described above is carried out for KuPR and KaPR radar input values. Figure 2.5-1 shows the processing flow.

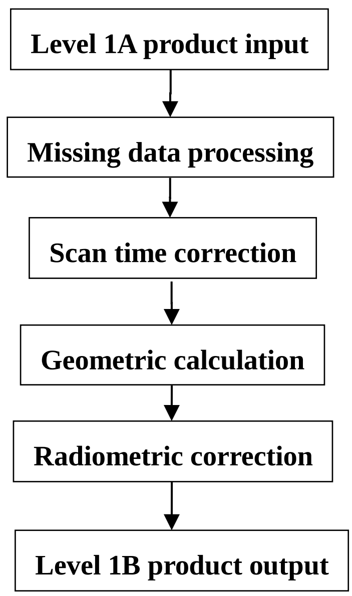


Figure 2.5-1 DPR Level 1B Standard Processing Flow

(2) Near-Real-Time Processing

Refer to Section 1.5.1, GPM Processing Flow, for an overview of near-real-time processing.

2.5.2 Level 2 Processing

Level 2 processing can be standard processing or near-real-time processing. This section provides an overview of each type of processing.

(1) Standard Processing

The Level 2 processing algorithm of the DPR additionally uses received power value profiles observed by KuPR and KaPR to estimate a precipitation intensity profile. It also estimates precipitation type, precipitation top height, and bright band height.

Figure 2.5-2, Flow of the Level 2 Processing Algorithm shows the flow of the algorithm.

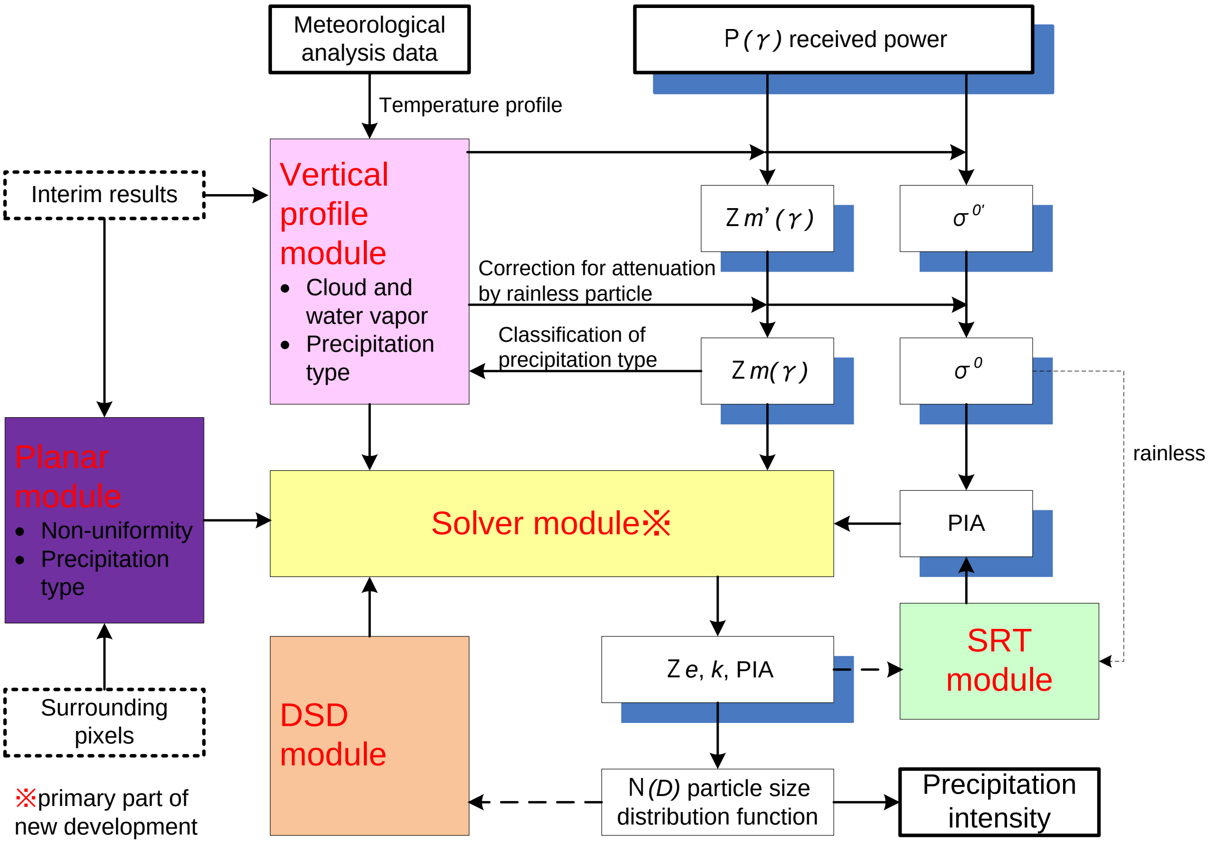


Figure 2.5-2 Flow of the Level 2 Processing Algorithm

DSD: Drop Size Distribution, SRT: Surface Reference Technique, PIA: Path Integrated Attenuation

Level 2 algorithm input data are a Level 1 DPR product ($P(\gamma)$ calibrated radar echo power value profile), and Level 2 algorithm output data are a Level 2 product (precipitation intensity profile).

KuPR, KaPR, and DPR products are created by the standard algorithm. For a KuPR product, the Level 2 algorithm processes a wide swath (approximately 245 km wide) based only on the observation data obtained by KuPR. For a KaPR product, the Level 2 algorithm processes a narrow swath (approximately

125km wide) based only on the observation data obtained by KaPR. For a dual-frequency precipitation product, the algorithm uses KuPR's and KaPR's observation data to process a narrow swath, while it expands information obtained from KuPR's observation and also information obtained from narrow swath observation by KuPR and KaPR to processes a wide swath, which does not include the narrow swath.

(2) Near-Real-Time Processing

The Level 2 near-real-time algorithm creates KuPR Level 2R, KaPR Level 2R, and DPR Level 2R products. Refer to Section 2.5.1(1), Standard Processing, for the processing algorithm.

2.5.3 Level 3 Processing

This section provides an overview of Level 3 processing.

(1) Standard Processing

Level 3 standard processing algorithm flow is shown in Figure 2.5-3. Monthly products are created by 28~30 daily products on a data stack. HDF products, daily/monthly, are processed by the algorithm developed by NASA, and text products, daily, are processed by the algorithm developed by JAXA.

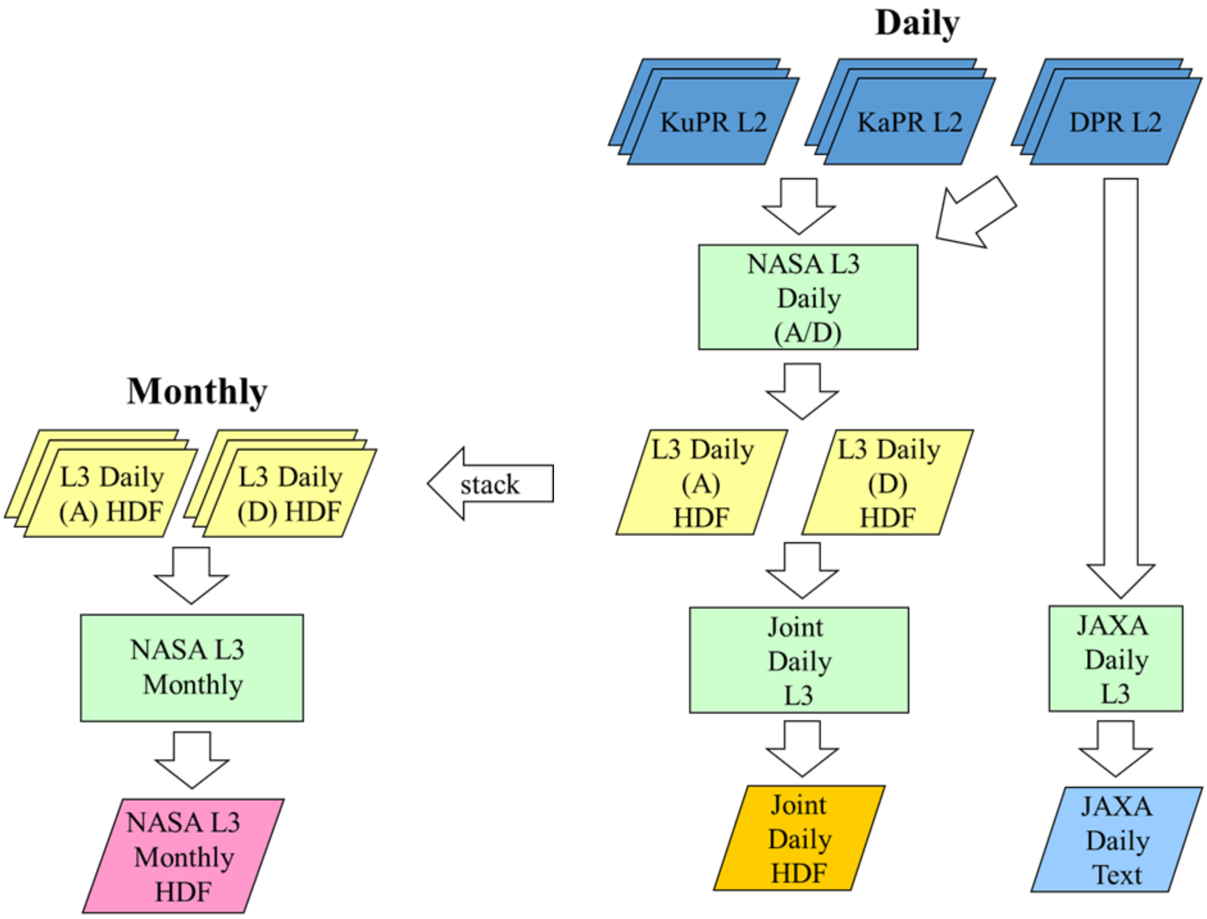


Figure 2.5-3 Flow of the L3 Standard Processing Algorithm

Note: A/D means ascending/descending.

2.6 Environment Auxiliary (ENV)

Environment auxiliary (ENV) is meteorological analysis data used as input data to the Level 2 processing shown in Table 2.6-1. They are the Japanese Global Analysis model data (GANAL) used to provide atmospheric environmental conditions.

In the current algorithm formulation, only the analysis data must be integrated from an external source during combined algorithm processing.

Analysis data are required to produce initial estimations of environmental parameters such as total precipitable water, TPW_{anal}, cloud liquid water path, $CLWP_{anal}$, surface skin temperature, $Tsfc_{anal}$, and 10m altitude wind speed, $U10m_{anal}$. The current algorithm design requires space-time interpolation of these data from the Japanese Meteorological Agency's (JMA's) global analysis during standard algorithm processing. The data are interpolated to the DPR footprint/range bin locations and overpass times in the Vertical Profile Submodule (VER) of the Level 2 radar algorithm and then output. For-near-realtime processing, the JMA forecast fields are used, but if these fields are not received in time for any reason, the climate value data are substituted for the JMA analysis/forecast data in the VER processing.

Table 2.6-1 Environment Auxiliary (ENV)

Auxiliary	Description
GPM KuPR Environment Auxiliary (ENV)	Main parameters: Air temperature, air pressure, water vapor, cloud liquid water Swath width: 245 km Resolution: 5 km (horizontal), 125 m (vertical)
GPM KaPR Environment Auxiliary	Main parameters: Air temperature, air pressure, water vapor, Cloud liquid water Swath width: 125 km Resolution: 5 km (horizontal), 125/250 m (vertical)
GPM DPR Environment Auxiliary	Main parameters: Air temperature, air pressure, water vapor, cloud liquid water Swath width: 245 km Resolution: 5 km (horizontal), 125/250 m (vertical)

3. Overview of GMI Products

3.1 GMI Sensor

GMI is a primary microwave sensor onboard the GPM core satellite. The core satellite flies in a 407-km circular orbit with a 65^{o} inclination angle. The GMI has 13 channels with a frequency range from 10 to 183 GHz. Except the heritage hot load and cold load that are commonly used for linear sensor radiometric calibrations, hot noise diodes and cold noise diodes are implemented in the GMI to determine the non-linearity and noise levels of the measurements. Table 3.1-1 shows reference for important instrument and orbital parameters.

Table 3.1-1 Reference for Important Instrument and Orbital Parameters

channel #	center frequency (GHz)	pol	nadir angle (degree)	nominal Earth incidence angle (degree)	beam width (degreee)	footprint (km x km)	cold samples per scan	hot samples per scan	Earth samples per scan	band width (MHz)
1,2	10.65	v/h	48.5	52.821	1.72	32.1 x 19.4	19/25	13/19	211/221	100
3,4	18.7	v/h	48.5	52.821	0.98	18.1 x 10.9	31/37	13/19	211/221	200
5	23.8	v	48.5	52.821	0.85	16.0 x 9.7	31/37	13/19	211/221	400
6,7	36.64	v/h	48.5	52.821	0.81	15.6 x 9.4	45/51	19/25	211/221	1000
8,9	89	v/h	48.5	52.821	0.38	7.2 x 4.4	45/51	25/31	211/221	6000
10,11	166	v/h	45.36	49.195	0.37	6.3 x 4.1	45/51	27/33	211/221	3400
12	183.31±3	v	45.36	49.195	0.37	5.8 x 3.8	45/51	27/33	211/221	2000
13	183.31±7	V	45.36	49.195	0.37	5.8 x3.8	45/51	27/33	211/221	2000

Key GMI sensor data include:

Nominal altitude: 407 km

Orbital inclination: 65 deg

Spin rate: 32 rpm

Scan time: 1.875 sec

Earth swath width: 885 km

Earth viewing sector: 140 deg

Earth samples: 221

Integration time: 2.2-9.7 ms

3.2 Observation

The conical scan geometry of GMI is shown in Figure 3.2-1. The off-nadir-angle defining the cone swept out by the GMI is set at 48.5º, which represents an Earth incidence angle of 52.8º (identical to that of TMI on TRMM). The offset parabolic reflector rotates about the vertical axis of the instrument at a rate of 32 rpm; during each revolution, the Earth-viewing scan sector is about 140º centered along the spacecraft velocity vector. Figure 3.2-1 shows a schematic view of the observation geometries with the GPM core instruments. The remaining 260º of each scan (revolution) is used for instrument calibration and housekeeping functions. The (140º) GMI swath represents an arc of 885 km on Earth's surface. The GMI instrument calibration by observation of deep space was performed once in the early phase, but no calibration was planned for the operational phase.

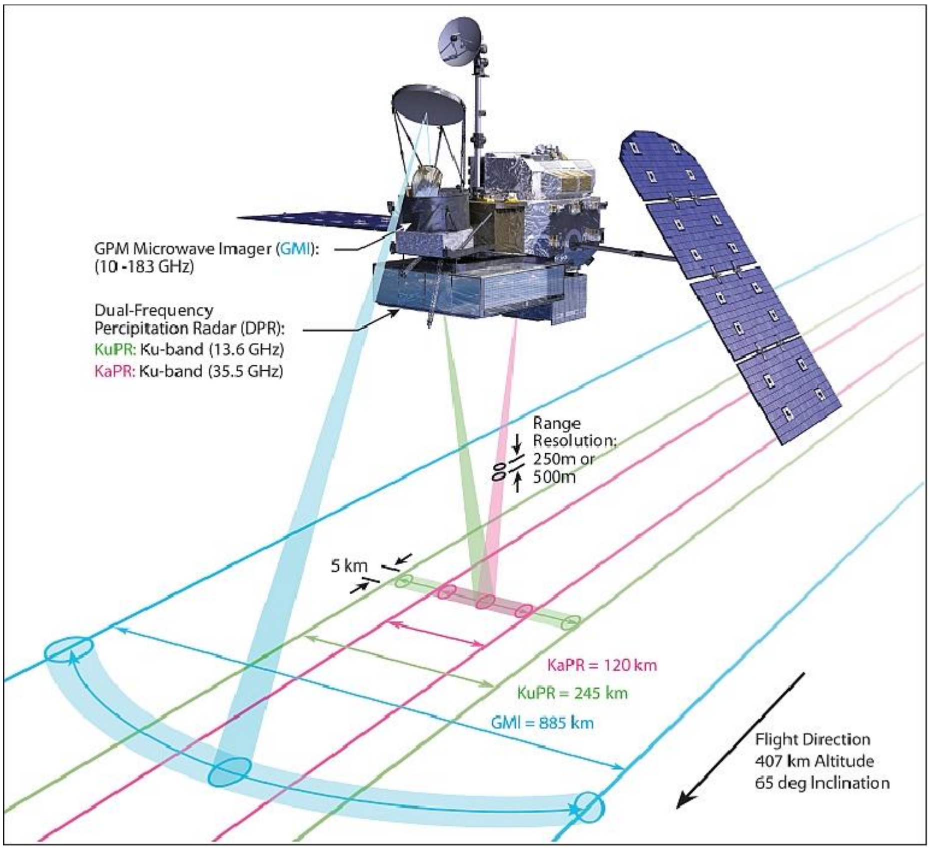


Figure 3.2-1 Schematic View of the Observation Geometries With the GPM Core Instruments (Image Credit: NASA)

The footprint sizes vary with the frequency of the individual channels (see Table 3.1-1). Figure 3.2-2 shows the channel footprint scheme of GMI in successive along-scans. The lower frequencies have large footprints that have sufficient overlap in the along-scan direction to achieve a continuous and complete coverage. Channels 8 through 13 no longer have overlap from one scan to the next causing gaps in coverage: however, the minimum coverage requirement is maintained with the instrument fields of view (IFOVs) of these channels. To satisfy the Nyquist criterion, all channels are being sampled at a minimum of two times as the GMI scans a single IFOV. To guarantee satisfactory co-registration, the sample times for each channel were set as integral multiples of each other.

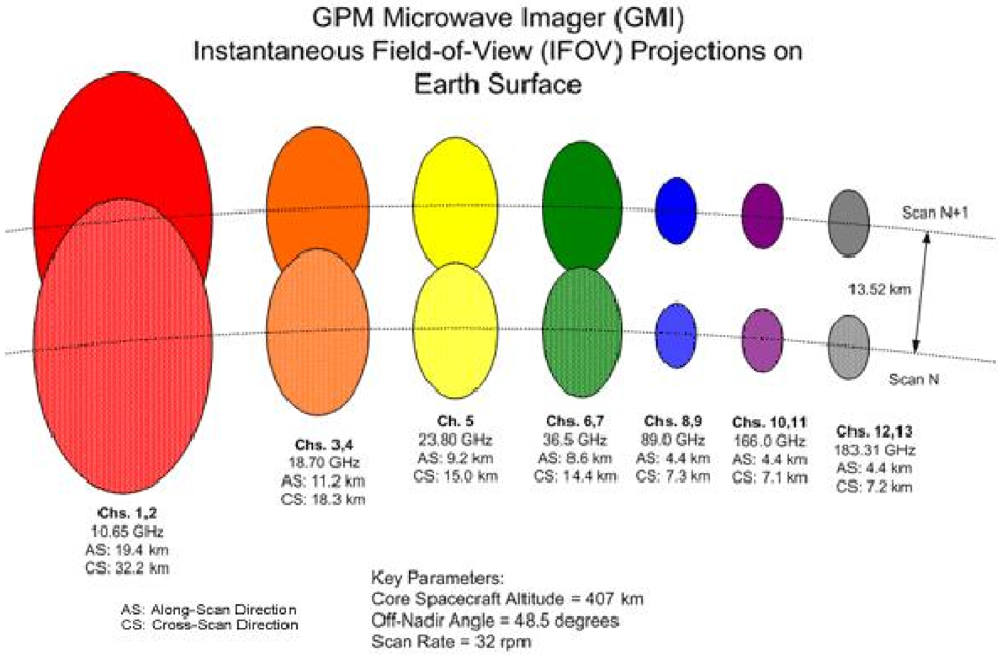


Figure 3.2-2 Channel FootprintScheme of GMI in Successive Along-Scans (Image Credit: NASA)

3.3 Product Levels Definitions

Tables 3.3-1 to 3.3-3 show GMI products level definitions. GMI products consist of the standard product (STD) and the near-real-time product (NRT).

Table 3.3-1 GMI L1/L2/L1C Standard Product Level Definitions

GPM Standard Products					
Sensor	**Type**	**Level**	**Product Name**	**Processing Level**	**Description**
GMI	STD	L1	GPM GMI L1B Brightness Temperature	L1B	GPM standard product Main parameters: Brightness temperature Swath width: 800 km
			GPM GMI L1C Intercalibrated Brightness Temperature	L1C	GPM standard product Main parameters: Brightness temperature Swath width: 800 km
		L2	GPM GMI L2 Precipitation	L2	GPM standard product Main parameters: Precipitation rate, total cloud liquid/ice water, cloud mask classification, total water vapor column, sea surface temperature Swath width: 800 km

Table 3.3-2 GMI L1R/L2R/L1C Near-Real-Time Product Level Definitions

GPM Near-Real-Time Products					
Sensor	**Type**	**Level**	**Product Name**	**Processing Level**	**Description**
GMI	NRT	L1R	GPM GMI L1B Brightness Temperature	L1B	GPM near-real-time product Main parameters: Brightness temperature Swath width: 800 km
			GPM GMI L1C Intercalibrated Brightness Temperature	L1C	GPM near-real-time product Main parameters: Brightness temperature Swath width: 800 km
		L2R	GPM GMI L2 Precipitation	L2	GPM near-real-time product Main parameters: Precipitation rate, total cloud liquid/ice water, cloud mask classification, total water vapor column, sea surface temperature Swath width: 800 km

Table 3.3-3 GMI L3 Standard Product Level Definition

GPM Standard Product					
Sensor	**Type**	**Level**	**Product Name**	**Processing Level**	**Description**
GMI	STD	L3	GPM GMI L3 Precipitation	L3	GPM standard product Main parameters: Precipitation Resolution: 0.1 degree

3.4 File Naming Conventions

3.4.1 L1/L2 Standard Products With Orbit (Scene) Number

GMI L1/L2 standard products and partner L1C products are defined as the following type.

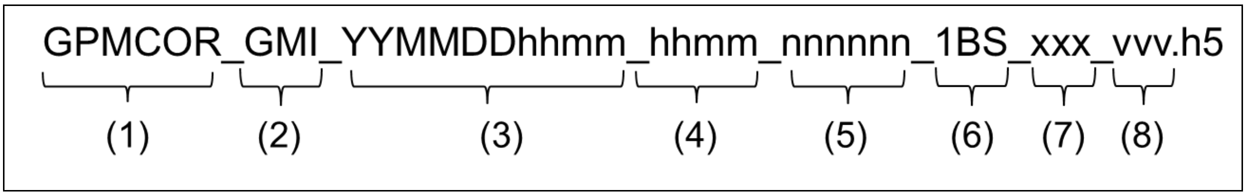


Figure 3.4-1 File Naming Convention of GMI L1/L2/L1C Standard Products With Orbit (Scene) Number

Table 3.4-1 Description of File Naming Convention of GMI L1/L2/L1C Standard Products With Orbit (Scene) Number

No.	Name	Number of Characters	Value
1	Mission ID	6	GPMCOR [fixed]
2	Sensor ID	3	GMI [fixed]
3	Scene Start (UTC)	10	YYMMDDhhmm
4	Scene End (UTC)	4	hhmm
5	Orbit Number	6	nnnnnn: 000000~999999
6	Processing Level	3	Level+Type, Level: 1B/L2/... , Type: S (standard)
7	Algorithm Key (Product Identifier)	3	Identify algorithm name: GMI Level 1B: G1B GMI Level 1C: G1C GMI Level 2: GL2
8	Product Version	3	Major (2 digits) + Minor (1 letter) (Major; increment at re-processing)

3.4.2 L1/L2 Near-Real-Time Products Without Orbit Number

GMI L1/L2/L1C near-real-time products are defined as the following type.

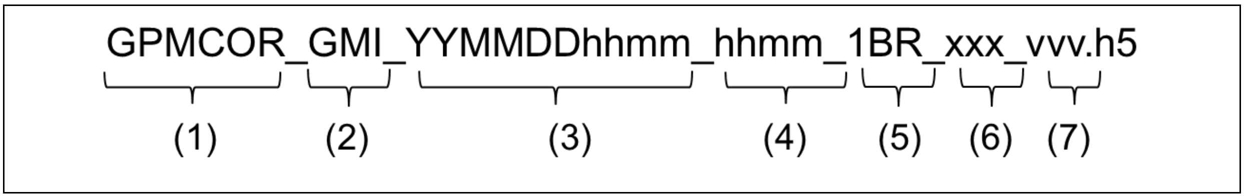


Figure 3.4-2 File Naming Convention of GMI L1/L2/L1C Near-Real-Time Products Without Orbit Number

Table 3.4-2 Description of File Naming Convention of GMI L1/L2/L1C Near-Real-Time Products Without Orbit Number

No.	Name	Number of Characters	Value
1	Mission ID	6	GPMCOR [fixed]
2	Sensor ID	3	GMI [fixed]
3	Scene Start (UTC)	10	YYMMDDhhmm
4	Scene End (UTC)	4	hhmm
5	Processing Level	3	Level+Type, Level:1B/L1C/L2/... , Type: R (nearRealtime)
6	Algorithm Key (Product Identifier)	3	Identify algorithm name: GMI Level 1B: G1B GMI Level 1C: G1C GMI Level 2: GL2
7	Product Version	3	Major (2 digits) + Minor (1 letter) (Major; increment at re-processing)

3.4.3 L3 Standard Products

GMI L3 standard products are defined as the following type.

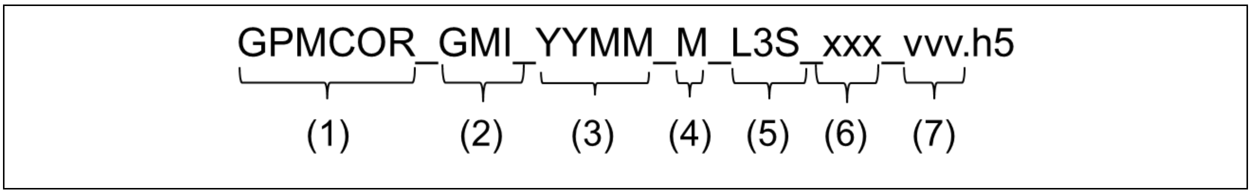


Figure 3.4-3 File Naming Convention of GMI L3 Standard Products

Table 3.4-3 Description of File Naming Convention of GMI L3 Standard Products

No.	Name	Number of Characters	Value
1	Mission ID	6	GPMCOR [fixed]
2	Sensor ID	3	GMI [fixed]
3	Scene Start (UTC)	4	YYMM: Monthly
4	Process Unit	1	M [fixed]
5	Process Level	3	Level+Type, Level: L3, Type: S (standard)
6	Algorithm Key (Product Identifier)	3	Identify algorithm name: GMI Level 3: GL3 [fixed]
7	Product Version	3	Major (2 digits) + Minor (1 letter) (Major; increment at re-processing)

3.5 Overview of GMI Processing

3.5.1 L1B Algorithm Overview

The Level 1B algorithm and software transform Level 0 counts into geolocated and calibrated antenna temperature (Ta) and brightness temperature (Tb). Ta is obtained by utilizing the sensor radiometric calibration. Tb is derived from Ta after antenna pattern correction (APC) and vicarious calibrations. Figure 3.5-1 describes the relationship between algorithm components and products (or output).

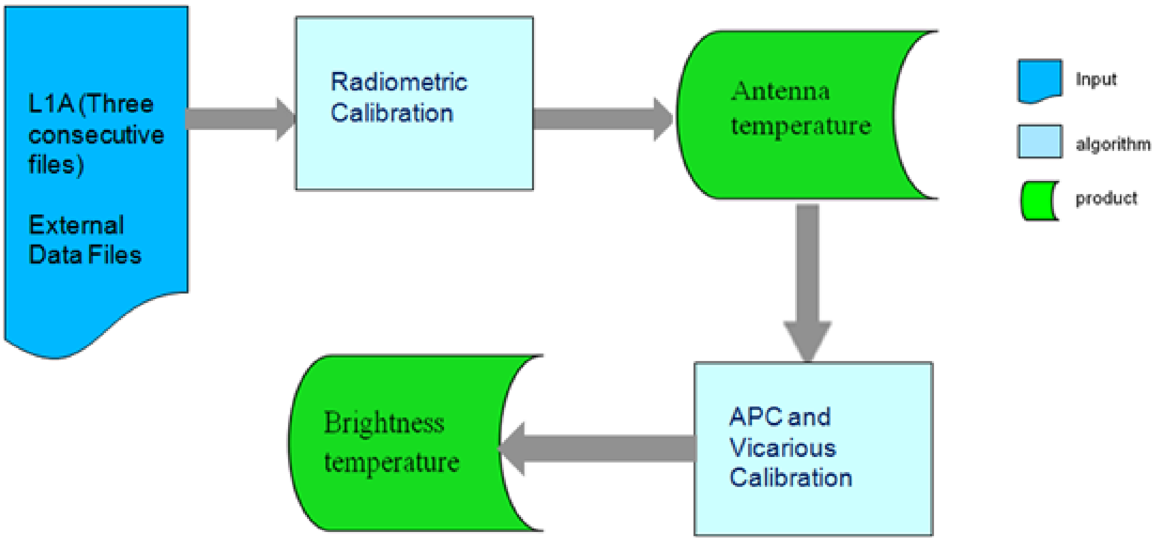


Figure 3.5-1 The Top-level Flow Chart of the GMI L1B Algorithm

3.5.2 L1C Algorithm Overview

The L1C processing flow of standard production of the L1C orbital product (Figure 3.5-2) and the L1C near-real-time product (Figure 3.5-3) by the NASA Precipitation Processing System (PPS) was introduced for Operational Readiness Review. The purpose of the L1C algorithm is to produce intercalibrated brightness temperature (Tc) products for GPM core and constellation satellites, and to provide uniform and consistent datasets for precipitation retrieval.

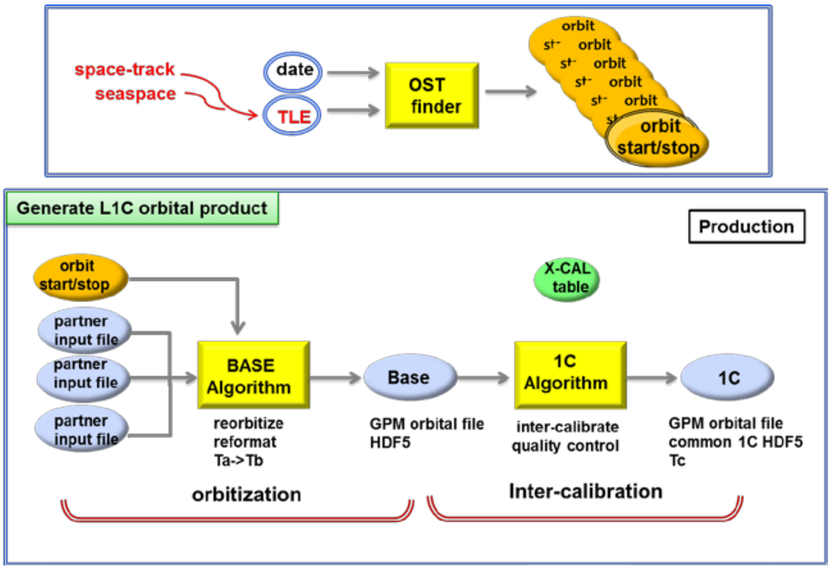


Figure 3.5-2 L1C Processing Flow Standard Production

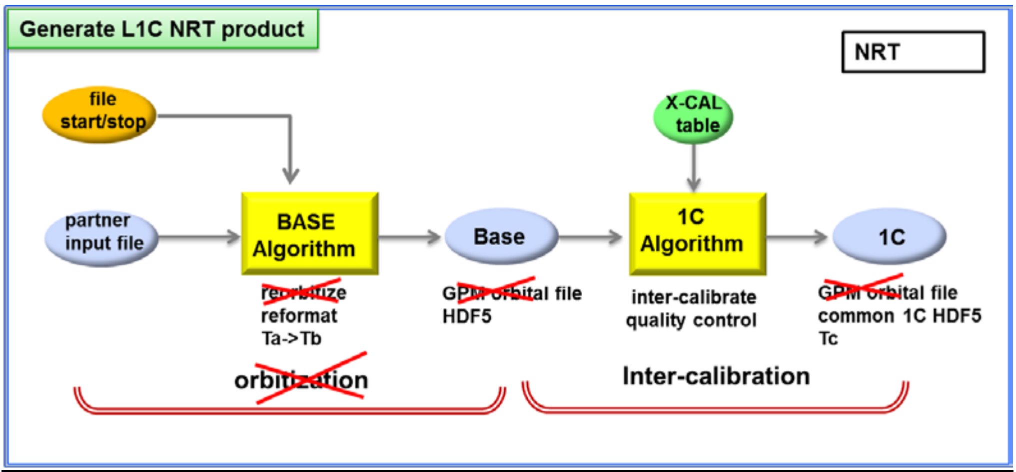


Figure 3.5-3 L1C Processing Flow Near-Real-Time

Note: In the figures above, TLE stands for two-line element, OST stands for orbit start/stop times, and x-cal stands for intercalibration.

3.5.3 L2 Processing

The Global Precipitation Measurement Mission Algorithm Theoretical Basis Document (ATBD) describes the GPM passive microwave rainfall algorithm, which is a parametric algorithm used to serve GPM's radiometers. The output parameters of the algorithm are enumerated in Table 3.5-1.

Table 3.5-1 Key Output Parameters From the Level 2 Rainfall Product

Pixel Information		
Parameter	**Units**	**Comments**
Latitude, Longitude	Deg.	Pixel Earth coordinate position
Surface Type	None	Land surface emissivity, class/ocean/coast/sea ice
Retrieval Type	None	Identifies if pixel retrieved with S0, S1, or S2
Pixel Status	None	Identifies pixel eliminated by quality control (QC) procedures
Quality Flag	None	Pixels without good Tb matches in database
Skin Temperature, Total Column Water Vapor, 2 Meter Temperature	K, mm, K	Pass-through variables from model
Suface Precipitation	mm/hr	Total precipitation
Liquid Precip Fraction (pf) Convective Precip Fraction	0-1.0 0-1.0	Portion pf surface precip. in liquid state Portion pf surface precip. that is convective
Precipitation Structure	None	Index for self-similar hydrometeor profiles; 28 layers, separated by hydrometeor species
Precipitation Diagnostics	None	Precip. retrieval diagnostics and uncertainties
Cloud Water Path, Rain Water Path, Mixed Phase Path, Ice Water Path	kg/m^2	Integrated from retrieved profile

Five processes—model preparation, GPM preprocessors, GPM precipitation algorithm – GPROF2014, GPM merge, and GPM post-processor (Figure 3.5-4 in the purple boxes) —are to be run by PPS to complete the radiometer precipitation algorithm (PA).The model preparation process ingests both the GANAL and European Centre for Medium-Range Weather Forecasts (ECMWF) gridded binary (GRIB) formatted files. For example, GANAL TCWV from a profile of relative humidity are computed.

For real-time and near-real-time GPROF2014, the JMA GANAL global model fields are used. These can be retrieved from the JMA to JAXA to the PPS data flow very shortly after the analysis time. Parameters retrieved are at the surface: surface pressure, MSL pressure, U and V component winds at 10 meters, 2 meter temperature, 2 meter relative humidity, and skin temperature. The vertical profiles on constant pressure surfaces are: temperature, vertical velocity, U and V component winds, relative humidity, and geopotential height (actural altitude from the pressure surfaces). Model data are assimilated every 6 hours for both profile and surface. The spatial resolution of the GANAL global grids is 0.5×0.5 degrees. See Figure 3.5-4 for an overview of the processing steps for the GPM precipitation algorithm.

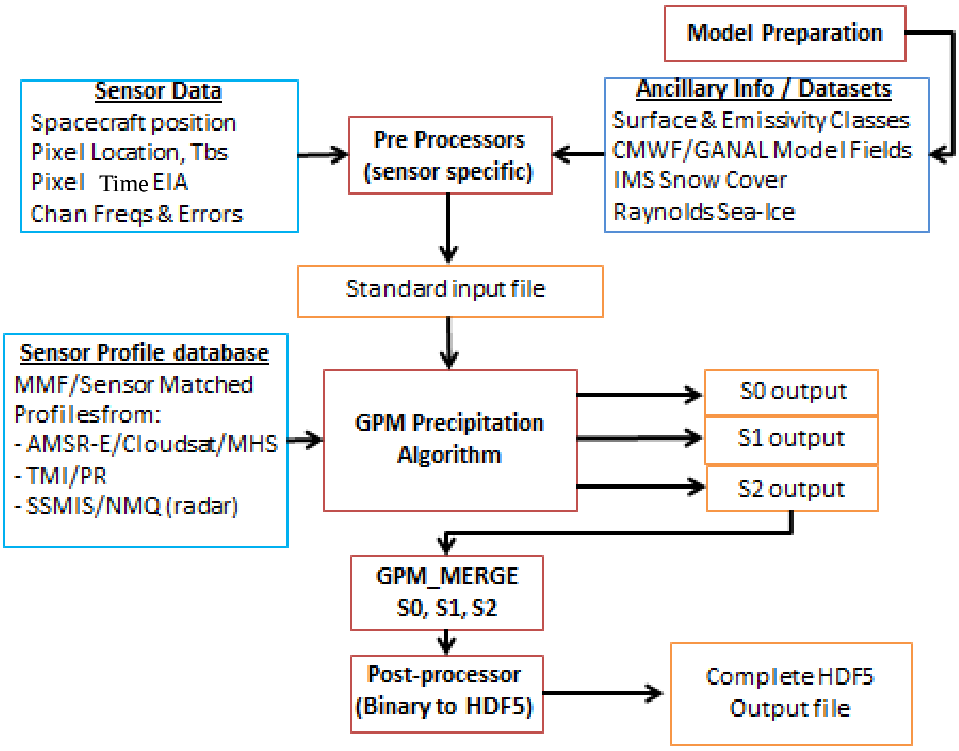


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Figure 3.5-4 Overview of the Processing Steps for the GPM Precipitation Algorithm

4. Overview of DPR/GMI Combined Products

4.1 Product Levels Definitions

Tables 4.1-1 to 4.1-3 show DPR/GMI combined product level definitions. DPR/GMI combined products consist of the standard product (STD) and the near-real-time product (NRT). The product is called as DPR/GMI Comb, DPR/GMI, COMB (Combined), and/or CMB.

Table 4.1-1 DPR/GMI COMB L2 Standard Product Level Definition

GPM Standard Product					
Sensor	**Type**	**Level**	**Product Name**	**Processing Level**	**Description**
DPR/ GMI (COMB)	STD	L2	GPM DPR/GMI COMB L2 Precipitation	L2	GPM standard product Main parameters: Precipitation rate Swath width: 125/245 km Resolution: 5 km (horizontal), 250 m (vertical)

Table 4.1-2 DPR/GMI COMB L2 Near-Real-Time Product Level Definition

GPM Near-Real-Time Product					
Sensor	**Type**	**Level**	**Product Name**	**Processing Level**	**Description**
DPR/ GMI (COMB)	NRT	L2R	GPM DPR/GMI COMB L2 Precipitation	L2	GPM near-real-time product Main parameters: Precipitation rate Swath width: 125/245 km Resolution: 5 km (horizontal), 125/250 m (vertical)

Table 4.1-3 DPR/GMI L3 Standard Product Level Definitions

GPM Standard Products					
Sensor	**Type**	**Level**	**Product Name**	**Processing Level**	**Description**
DPR/GMI (COMB)	STD	L3	GPM DPR/GMI L3 Precipitation	L3	GPM standard product Main parameters: Precipitation Resolution: 0.25, 0.5 degree
			GPM DPR/GMI L3 Convective Stratiform Heating (Gridded Orbital)	L3	GPM standard product Main parameter: Gridded orbital convective stratiform heating Resolution: 0.25 degree
			GPM DPR/GMI L3 Convective Stratiform Heating (Monthly)	L3	GPM standard product Main parameter: Monthly convective stratiform heating Resolution: 0.25 degree

4.2 File Naming Conventions

4.2.1 L2 Standard Products With Orbit (Scene) Number

DPR/GMI L2 standard products are defined as the following type.

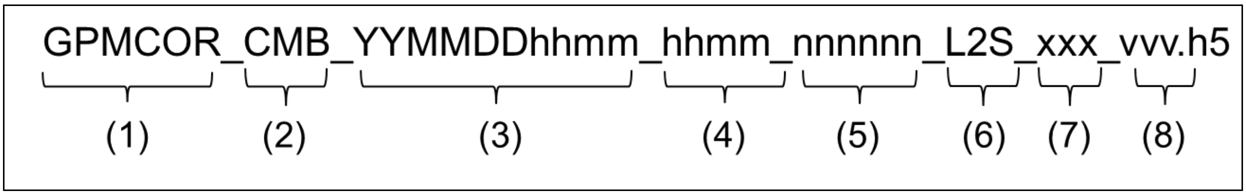

Figure 4.2-1 File Naming Convention of DPR/GMI L2 Standard Products With Orbit (Scene) Number

Table 4.2-1 Description of File Naming Convention of DPR/GMI L2 Standard Products With Orbit (Scene) Number

No.	Name	Number of Characters	Value
1	Mission ID	6	GPMCOR [fixed]
2	Sensor ID	3	CMB [fixed]
3	Scene Start (UTC)	10	YYMMDDhhmm
4	Scene End (UTC)	4	hhmm
5	Orbit Number	6	nnnnnn: 000000~999999
6	Processing Level	3	Level+Type, Level: L2, Type: S (standard)
7	Algorithm Key (Product Identifier)	3	Identify algorithm name: DPR/GMI Combined Level 2: CL2 [fixed]
8	Product Version	3	Major (2 digits) + Minor (1 letter) (Major; increment at re-processing)

4.2.2 L2 Near-Real-Time Products Without Orbit Number

DPR/GMI L2 near-real-time products are defined as the following type.

Figure 4.2-2 File Naming Convention of DPR/GMI L2 Near-Real-Time Products Without Orbit Number

Table 4.2-2 Description of File Naming Convention of DPR/GMI L2 Near-Real-Time Products Without Orbit Number

No.	Name	Number of Characters	Value
1	Mission ID	6	GPMCOR [fixed]
2	Sensor ID	3	CMB [fixed]
3	Scene Start (UTC)	10	YYMMDDhhmm
4	Scene End (UTC)	4	hhmm
5	Processing level	3	Level+Type, Level: L2, Type: R (NearRealTime)
6	Algorithm Key (Product Identifier)	3	Identify algorithm name: DPR/GMI Combined Level 2: CL2 [fixed]
7	Product version	3	Major (2 digits) + Minor (1 letter) (Major ; increment at re-processing)

4.2.3 L3 Standard Products

DPR/GMI L3 standard products are defined as the following type.

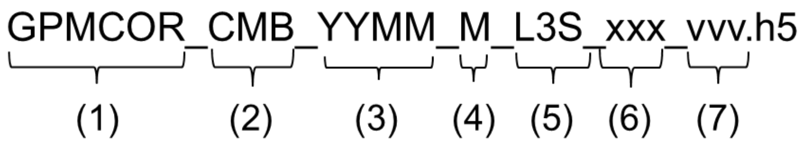

Figure 4.2-3 File Naming Convention of L3 Standard Products

Table 4.2-3 Description of File Naming Convention of L3 Standard Products

No.	Name	Number of Characters	Value
1	Mission ID	6	GPMCOR [fixed]
2	Sensor ID	3	CMB [fixed]
3	Scene Start (UTC)	4	YYMM
4	Process Unit	1	M [fixed]
5	Process Level	3	Level+Type, Level: L3, Type: S (standard)
6	Algorithm Key (Product Identifier)	3	Identify algorithm name: DPR/GMI Combined Level 3 precipitation: CL3 DPR/GMI Combined Level 3 LH (Monthly): CSM
7	Product Version	3	Major (2 digits) + Minor (1 letter) (Major; increment at re-processing)

4.2.4 DPR/GMI L3 Convective Stratiform Heating Products

DPR/GMI L3 convective stratiform heating products are defined as the following type.

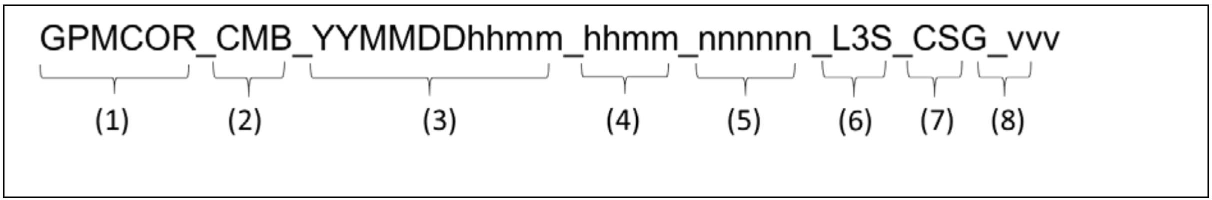

Figure 4.2-4 File Naming Convention of DPR/GMI L3 Convective Stratiform Heating Products With Orbit Number

Table 4.2-4 Description of File Naming Convention of DPR/GMI L3 Convective Stratiform Heating Products With Orbit Number

No.	Name	Number of Characters	Value
1	Mission ID	6	GPMCOR [fixed]
2	Sensor ID	3	CMB
3	Scene Start (UTC)	10	YYMMDDhhmm
4	Scene End (UTC)	4	hhmm
5	Orbit Number	6	nnnnnn: 000000~999999
6	Processing Level	3	Level+Type, Level: L3, Type: S (standard)
7	Algorithm Key (Product Identifier)	3	Identify algorithm name: DPR/GMI Combined Level 3 LH (Gridded orbital): CSG
8	Product Version	3	Major (2 digits) + Minor (1 letter) (Major; increment at re-processing)

4.3 Overview of GMI/DPR Processing

The current algorithm design is based upon an Ensemble Kalman Filtering (EnKF) approach for inverting the DPR reflectivities and GMI brightness temperature to estimate precipitation profiles. The general architecture of the GPM combined algorithm is illustrated in Figure 4.3-1. In case of near-real-time processing, estimate environmental parameters in no-rain regions of the environment module should be simplified by using forecast data (FCST) instead of global analysis data (GANAL) shown in the boxes of environmental parameter analysis.

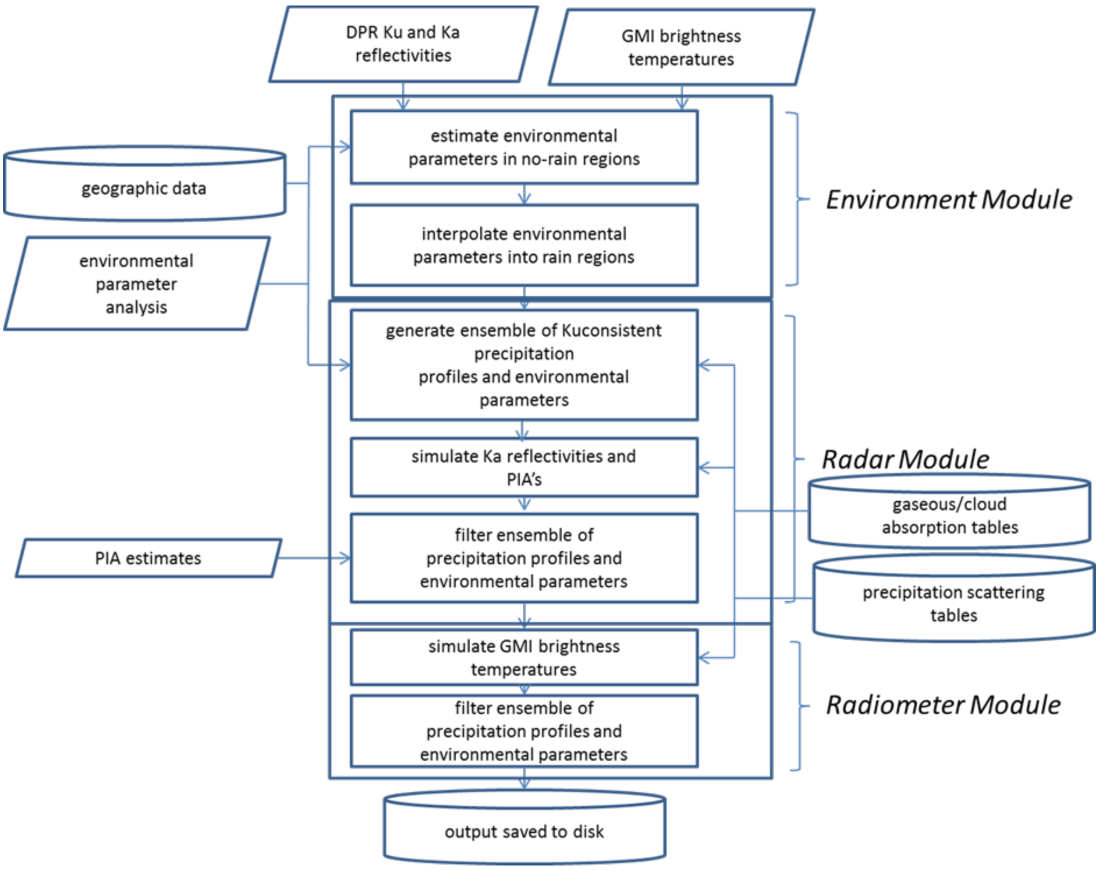

Figure 4.3-1 Basic Architecture of the GPM Combined Radar-Radiometer Algorithm

There are three primary modules in the combined algorithm: an environment module, which establishes the environmental background of the precipitation distributions to be estimated, a radar module, which produces ensembles of radar-consistent precipitation profile solutions at each DPR footprint location; and a radiometer module, that modifies the radar-derived precipitation ensembles to be more consistent with the GMI observations.

The outputs of the algorithm are the mean (best estimate) and standard deviation (uncertainty of estimate) of the DPR/GMI filtered ensemble of estimated precipitation profiles at each DPR footprint location. Post-launch validation of GPM combined algorithm products is in two parts: well-calibrated polarimetric radars, operating in conjunction with vertical radar profilers and collocated disdrometers during GPM field campaigns, will provide comparative data for detailed microphysical validation of GPM

DPR+GMI vertical profiles.

5. Overview of Global Satellite Mapping of Precipitation (GSMaP) Products

5.1 Product Level Definitions

Tables 5.1-1 to 5.1-2 show GSMaP product level definitions. GSMaP products consist of the standard product (STD) and the near-real-time product (NRT).

Table 5.1-1 GSMaP L3 Standard Product Level Definitions

GPM Standard Products					
Sensor	**Type**	**Level**	**Product Name**	**Processing Level**	**Description**
GSMaP	STD	L3	GSMaP Precipitation Hourly (HDF format))	L3	GPM standard product Main parameters: Precipitation rate Resolution: 0.1 degree
			GSMaP Precipitation Hourly (Text format)	L3	GPM standard product Main parameters: Precipitation rate Resolution: 0.1 degree
			GSMaP Precipitation Hourly (GeoTIFF format)	L3	GPM standard product Main parameters: Precipitation rate Resolution: 0.1 degree
			GSMaP Precipitation Monthly (HDF format)	L3	GPM standard product Main parameters: Precipitation rate Resolution: 0.1 degree
			GSMaP Precipitation Monthly (GeoTFF format)	L3	GPM standard product Main parameters: Precipitation rate Resolution: 0.1 degree
			GSMaP Precipitation Hourly (netCDF format)	L3	GPM standard product Main parameters: Precipitation rate Resolution: 0.1 degree
			GSMaP Precipitation Monthly (netCDF format)	L3	GPM standard product Main parameters: Precipitation rate Resolution: 0.1 degree

Table 5.1-2 GSMap Near-Real-Time Product Level Definitions

GPM Near-Real-Time Products					
Sensor	**Type**	**Level**	**Product Name**	**Processing Level**	**Description**
GSMaP	NRT	L3	GSMaP Precipitation Hourly (HDF format)	L3	GPM near-real-time product Main parameters: Precipitation rate Resolution: 0.1 degree
			GSMaP Precipitation Hourly (Text format)	L3	GPM near-real-time product Main parameters: Precipitation rate Resolution: 0.1 degree

5.2 File Naming Conventions

5.2.1 GSMaP Standard/Near-Real-Time Products

GSMaP standard products (HDF and text format) and near-real-time products are defined as the following type.

Figure 5.2-1 File Naming Convention of GSMaP Standard and Near-Real-Time Products

Table 5.2-1 Description of File Naming Convention of GSMaP Standard and Near-Real-Time Products

No.	Name	Number of Characters	Value
1	Mission ID	6	GPMMRG [fixed]
2	Sensor ID	3	MAP [fixed]
3	Scene Start (UTC)	4,10	YYMM YYMMDDhhmm: Hourly (mm=00. [fixed])
4	Process Unit	1	M:Monthly, H: Hourly
5	Process Level	3	Level+Type, Level: L3 Type: S (standard)/R (NRT)
6	Algorithm Key (Product Identifier)	3	Identify algorithm name: GSMaP(Hourly, Standard, HDF): MCH GSMaP(Hourly, Standard, Text): MCT GSMaP(Hourly, Near-Real-Time, HDF): MFW GSMaP(Hourly, Near-Real-Time, Text): MFT GSMaP(Monthly): MCM
7	Product Version	3	Major (2 digits) + Minor (1 letter) (Major ; increment at re-processing)

GSMaP L3 standard products (GeoTIFF format) are defined as the following type.

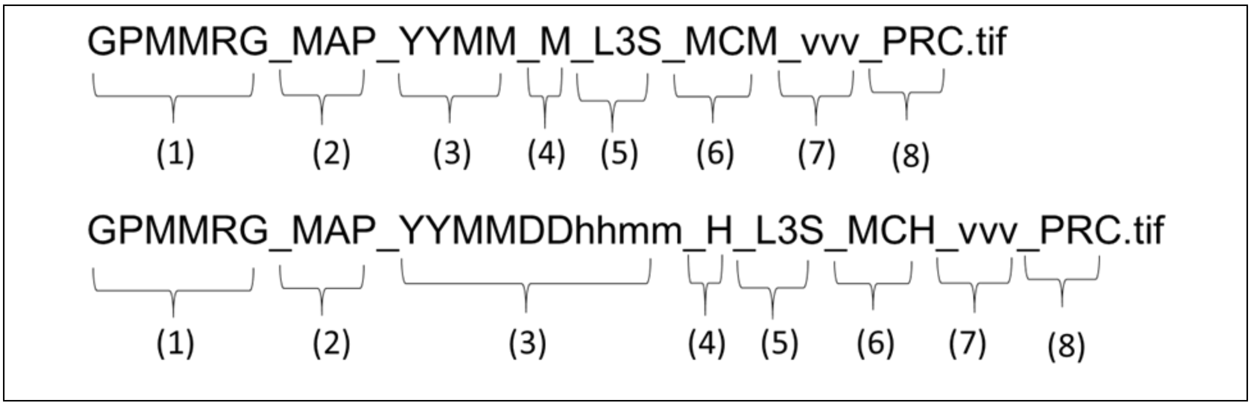

Figure 5.2-2 File Naming Convention of GSMaP Standard Products (GeoTIFF Format)

Table 5.2-2 Description of File Naming Convention of GSMaP Standard Products (GeoTIFF Format)

No.	Name	Number of Characters	Value
1	Mission ID	6	GPMMRG [fixed]
2	Sensor ID	3	MAP [fixed]
3	Scene Start (UTC)	4,10	YYMM YYMMDDhhmm: Hourly (mm=00. [fixed])
4	Process Unit	1	M: Monthly, H: Hourly
5	Process Level	3	Level+Type, Level:L3 Type: S (standard)
6	Algorithm Key (Product Identifier)	3	Identify algorithm name: GSMaP (Hourly, Standard): MCH GSMaP (Monthly): MCM
7	Product Version	3	Major (2 digits) + Minor (1 letter) (Major; increment at re-processing)
8	Variable Name	3	Average precipitation (1 hour or 1 month): PRC [fixed]

GSMaP L3 standard products (netCDF format) are defined as the following type.

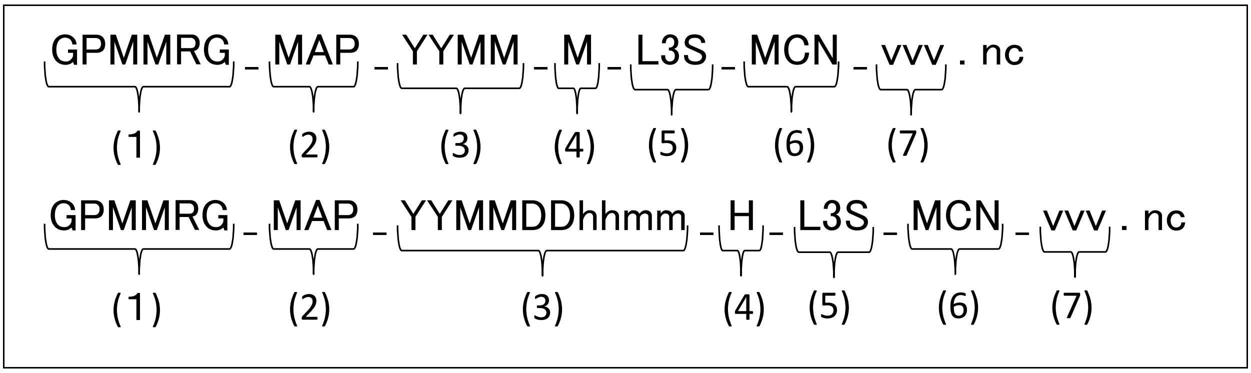

Figure 5.2-3 File Naming Convention of GSMaP Standard Products (netCDF Format)

Table 5.2-3 Description of File Naming Convention of GSMaP Standard Products (netCDF Format)

No.	Name	Number of Characters	Value
1	Mission ID	6	GPMMRG [fixed]
2	Sensor ID	3	MAP [fixed]
3	Scene Start (UTC)	4,10	YYMM YYMMDDhhmm: Hourly (mm=00. [fixed])
4	Process Unit	1	M: Monthly, H: Hourly
5	Process Level	3	Level+Type, Level: L3 Type: S (standard)
6	Algorithm Key (Product Identifier)	3	Identify algorithm name: GSMaP (Hourly, Standard, netCDF): MCN GSMaP (Monthly, netCDF): MCN
7	Product Version	3	Major (2 digits) + Minor (1 letter) (Major; increment at re-processing)

5.3 Overview of GSMaP Products Processing

The global satellite mapping of precipitation (GSMaP) algorithm is a map creation algorithm whose accuracy has been improved by DPR data and information. It generates a map of global satellite mapping of precipitation, which is a spatio-temporally averaged Level 3 product, by combining: estimated precipitation based on readings of multiple microwave radiometers (imager/sounder) including the GPM microwave radiometer (GMI) and cloud travel information obtained from geostationary infrared (IR) data. Figure 5.3-1, Flow of the Global Satellite Mapping of Precipitation Algorithm, gives an overview of the processing flow.

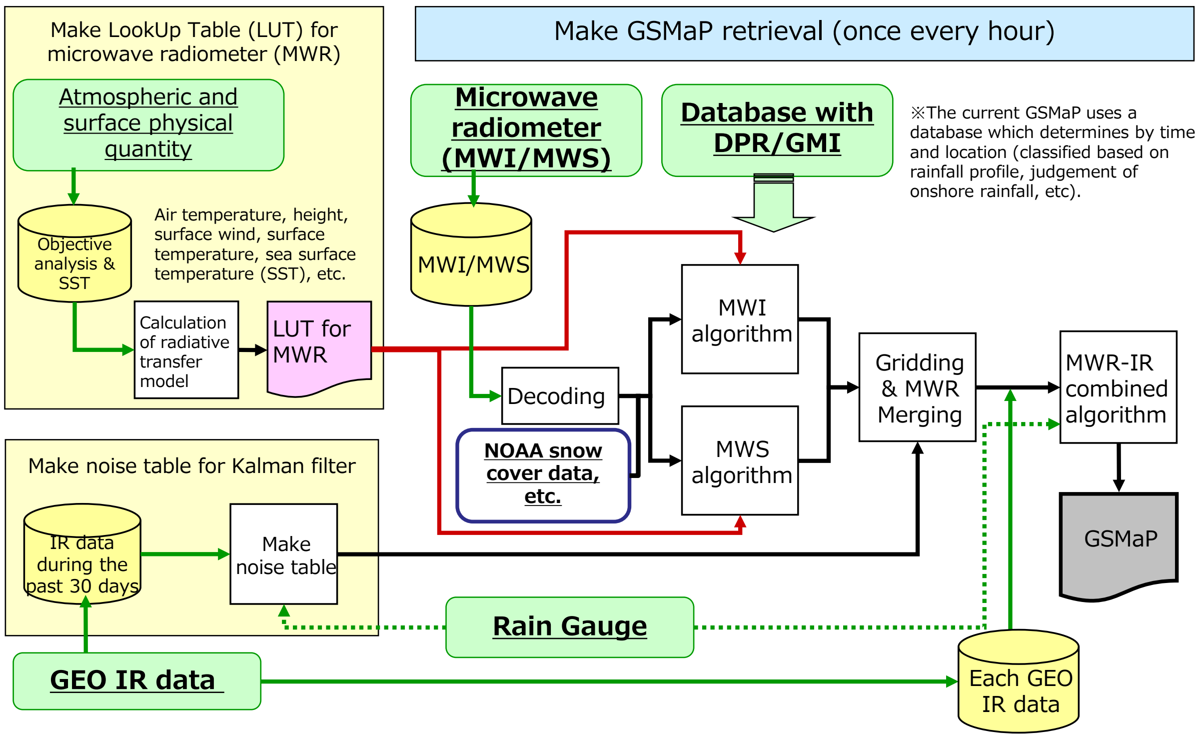

Figure 5.3-1 Flow of the Global Satellite Mapping of Precipitation Algorithm

The GSMaP algorithm can be roughly divided into the following three algorithms: microwave imager (MWI) algorithm, microwave sounder (MWS) algorithm, and microwave-Infrared (IR) combined (MVK) algorithm.

Global satellite mapping of precipitation can be subject to standard processing or near-real-time processing. In standard processing, hourly observation data are processed and data are averaged monthly. Near-real-time processing provides a higher data frequency than standard processing (every hour).

5.4 File Input/Output

Table 5.4-1 shows input data and output products used in GSMaP.

Table 5.4-1 Input Data and Output Products Used in GSMaP

(I:Input/O:Output)

No.	Standard Processing	Near-Real-Time Processing	I/O
1	MicroWave radiometer Imager (MWI) data (TRMM/TMI, DMSP-F16-19/SSMIS, GCOM-W/AMSR2, etc.)	MicroWave radiometer Imager (MWI) data (TRMM/TMI, DMSP-F16-19/SSMIS, GCOM-W/AMSR2, etc.)	I
2	MicroWave radiometer Sounder (MWS) data (NOAA 18-19/AMSU-A,B, NPP/ATMS, MetOp-A,B,C/MHS, etc.)	MicroWave radiometer Sounder (MWS) data (NOAA 18-19/AMSU-A,B, NPP/ATMS, MetOp-A,B,C/MHS, etc.)	I
3	JMA's Global ANALysis data (GANAL)	JMA's global ForeCaST data (FCST)	I
4	Merged satellite and in situ data Global Daily Sea Surface Temperature (MGDSST)	Merged satellite and in situ data Global Daily Sea Surface Temperature (MGDSST)	I
5	Daily totalizing rain-gauge data	Daily totalizing rain-gauge data	I
6	Composite IR data of NOAA/CPC (GOES-12, GOES-11, METEOSAT, and MTSAT)	IR data of satellites (GOES-12, GOES-11, METEOSAT, and MTSAT)	I
7	NOAA snow/ice cover map (Northern Hemisphere) NOAA snow/ice cover map (Southern Hemisphere)	NOAA snow/ice cover map (Northern Hemisphere) NOAA snow/ice cover map (Southern Hemisphere)	I
8	GSMaP Level 3 (hourly average)	GSMaP Level 3R (1 hour)	O
9	GSMaP Level 3 (monthly average)	None	O

6. Overview of Constellation Satellite Products

6.1 Constellation Satellite Products

In addition to the DPR and GMI onboard the GPM core satellite, the GPM constellation satellites have the following groups of conical-scanning microwave imagers and cross-track scanning humidity sounders. Figure 6.1-1 shows GPM constellation status as of January 13, 2014. Table 6.1-1 lists the GPM constellation satellites.

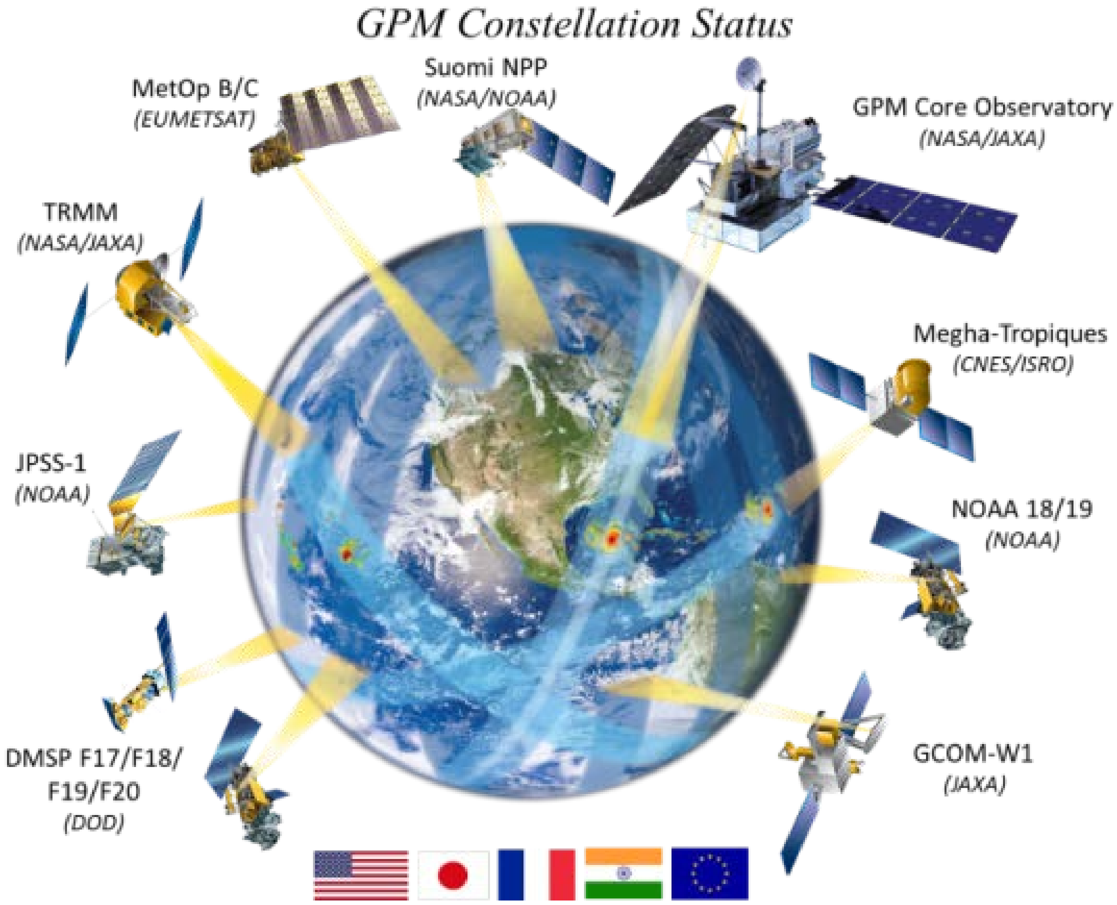

Figure 6.1-1 GPM Constellation Status as of January 13, 2014

Table 6.1-1 GPM Constellation Satellites

Instruments	Satellites	Organizations
TRMM Microwave Imager (TMI) (operation period was from 1997-2015)	Tropical Rainfall Measuring Mission (TRMM)	Japan Aerospace Exploration Agency (JAXA), National Aeronautics and Space Administration (NASA)
Special Sensor Microwave Imager/Sounder (SSMIS)	Defense Meteorological Satellite Program (DMSP)	United States Department of Defense (DoD)
Advanced Microwave Scanning Radiometer-2 (AMSR2)	Global Change Observation Mission - Water (GCOM-W)	JAXA
Multi-Frequency Microwave Scanning Radiometer (MADRAS) and the multi-channel microwave humidity sounder (SAPHIR)	Megha-Tropiques	Centre National D'Etudies Spatiales (CNES) of France and the Indian Space Research Organisation (ISRO)
Advanced Microwave Sounding Unit-A(AMSU-A)	National Oceanic and Atmospheric Administration (NOAA)-18,19	National Oceanic and Atmospheric Administration (NOAA)
Microwave Humidity Sounder (MHS)		
AMSU-A	Meteorological Operational Polar Satellite (MetOp) series	European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT)
MHS		
Advanced Technology Microwave Sounder (ATMS)	Suomi National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP)	NOAA NASA
ATMS	Joint Polar Satellite System (JPSS)	NOAA NASA
Microwave Imager	Defense Weather Satellite System (DWSS)	DoD

Refer to Table 1.1-3.

6.2 GMI and the Constellation Satellites

The GPM Microwave Imager (GMI) developed by NASA is a companion instrument to the DPR aboard the GPM core satellite. This conical-scanning microwave imager with multiple frequencies and polarized waves is a successor of the microwave imager on the TRMM (TMI).

The major role of the GMI is to improve the accuracy of precipitation prediction by simultaneously performing observations with the DPR. It also bridges between the high-accuracy observations by the GPM core satellite and high-frequency observations by microwave imagers aboard the constellation satellites. Furthermore, the GMI is expected to diminish disparity in precipitation strength prediction due to biases between sensors through calibration of brightness temperature of the microwave imagers on the constellation satellites.

The major features of the GMI as compared to the TMI are that the GMI is equipped with four more channels on the 166 GHz channel of a milli-wave zone (“window” channel) and the 183.31 GHz (water vapor absorption line) band in addition to the TMI’s nine channels on the 10.65 to 89 GHz bands. With those high-frequency bands, the GMI is expected to contribute to the improvement of the estimation accuracy of light rain and snow, which frequently occur mainly on land and sea in high-latitude areas. Additionally, the antenna diameter of the GMI is 1.2 meters, which is twice that of the TMI; thus its spatial resolution is significantly increased.

6.3 Product Levels Definitions

Tables 6.3-1 and 6.3-2 show MWI/MWS products level definitions. MWI/MWS products consist of the standard product (STD) and the near-real-time product (NRT).

Table 6.3-1 MWI/MWS L1C Standard Product Level Definition

GPM Standard Product					
Sensor	**Type**	**Level**	**Product Name**	**Processing Level**	**Description**
MWI/MWS	STD	L1	XXX L1C Intercalibrated Tb[1)]	L1C	GPM standard product. Main parameters: Brightness temperature
			1): XXX is a specific product name based on the sensor.		

Table 6.3-2 MWI/MWS L1C Near-Real-Time Product Level Definition

GPM Near-Real-time Product					
Sensor	**Type**	**Level**	**Product Name**	**Processing Level**	**Description**
MWI/MWS	NRT	L1	XXX L1C Intercalibrated Tb [2)]	L1C	GPM near-real-time product Main parameters: Brightness temperature
			2): XXX is a specific product name based on the sensor.		

6.4 File Naming Convention

6.4.1 MWI/MWS L1C Standard Products

MWI/MWS L1C standard products are defined as the following type.

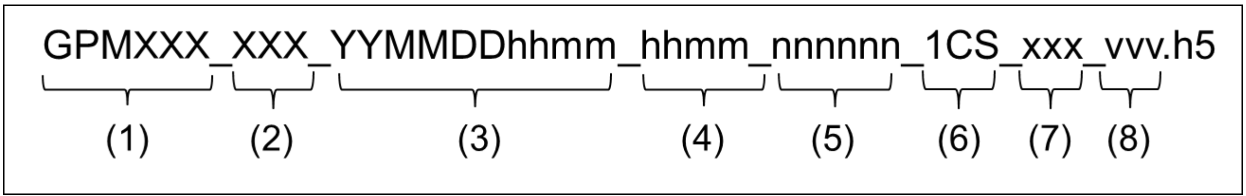

Figure 6.4-1 File Naming Convention of MWI/MWS L1C Standard Products With Orbit (Scene) Number

Table 6.4-1 Description of File Naming Convention of MWI/MWS L1C Standard Products With Orbit (Scene) Number

No.	Name	Number of Characters	Value
1	Mission ID	6	GPM+xxx, xxx:Satellite identifier e.g. GW1/TRM/...; see Table 6.4-2
2	Sensor ID	3	e.g. AM2/TMI/... See Table 6.4-2
3	Scene Start (UTC)	10	YYMMDDhhmm
4	Scene End (UTC)	4	hhmm
5	Orbit Number	6	nnnnnn: 000000~999999
6	Processing Level	3	Level+Type, Level:L1C/... , Type: S (standard)
7	Algorithm Key (Product Identifier)	3	Identify algorithm name See Table 6.4-3
8	Product Version	3	Major (2 digits) + Minor (1 letter) (Major; increment at re-processing)

Table 6.4-2 Description of Satellite Identifier and Sensor ID of MWI/MWS L1C Products

Satellite	Operating Organization	Sensor	Satellite Identifier	Sensor ID
Megha Tropiques	CNES, ISRO	SAPHIR	MGT	SPH
GCOM-W	JAXA	AMSR2	GW1	AM2
DMSP F16	NOAA, DOD	SSMIS	F16	MIS
DMSP F17	NOAA, DOD	SSMIS	F17	MIS
DMSP F18	NOAA, DOD	SSMIS	F18	MIS
DMSP F19	NOAA, DOD	SSMIS	F19	MIS
NOAA-18	NOAA	MHS	N18	MHS
NOAA-19	NOAA	MHS	N19	MHS
NPP	NOAA, NASA	ATMS	NPP	ATS
MetOp-A	EUMESAT	MHS	MTA	MHS
MetOp-B	EUMESAT	MHS	MTB	MHS
MetOp-C	EUMESAT	MHS	MTC	MHS
TRMM	JAXA, NASA	TMI	TRM	TMI

Table 6.4-3 Description of Algorithm Key of MWI/MWS L1C Products

Algorithm	Algorithm Key
MWI/MWS Level 1C	Sensor ID See Table 6.4-2

6.4.2 MWI/MWS L1C Near-Real-Time Products

MWI/MWS L1C near-real-time products are defined as the following type.

Figure 6.4-2 File Naming Convention of MWI/MWS L1C Near-Real-Time Products Without Orbit Number

Table 6.4-4 Description of File Naming Convention of MWI/MWS L1C Near-Real-Time Products Without Orbit Number

No.	Name	Number of Characters	Value
1	Mission ID	6	GPM+xxx, xxx:Satellite identifier e.g. GW1/TRM/...; see Table 6.4-2
2	Sensor ID	3	e.g. AM2/TMI/... ; See Table 6.4-2
3	Scene Start (UTC)	10	YYMMDDhhmm
4	Scene End (UTC)	4	hhmm
5	Processing Level	3	Level+Type, Level: L1C/..., Type: R (NearRealTime)
6	Algorithm Key (Product Identifier)	3	Identify algorithm name See Table 6.4-3
7	Product Version	3	Major (2 digits) + Minor (1 letter) (Major; increment at re-processing)