Earth Observation Research Center (EORC), Japan Aerospace Exploration Agency (JAXA)

updated 25 July 2017
10 October 2008

Global Rainfall Map in Near Real Time (GSMaP_NRT) and Gauge-calibrated Rainfall Product (GSMaP_Gauge) Data Format Description

This document describes data format and information of Global Rainfall Map in Near Real Time (hereafter refers as GSMaP_NRT) distributed from JAXA Global Rainfall Watch, and Gauge-calibrated Rainfall Product (GSMaP_Gauge), which was developed based on activities of the GSMaP (Global Satellite Mapping of Precipitation) project. The GSMaP project is based on the heritage of the study "Production of a high-precision, high-resolution global precipitation map using satellite data," sponsored by Core Research for Evolutional Science and Technology (CREST) of the Japan Science and Technology Agency (JST) during 2002-2007. Since 2007, GSMaP project activities are promoted by the JAXA Precipitation Measuring Mission (PMM) Science Team.

1. Product Overview

Table 1 Summary of GSMaP_NRT Products

No	Parameter [unit]	Data format	Coverage	Grid size	Horizontal resolution	Temporal resolution	FTP directory
1	Hourly Rain Rate [mm/h]	4-byte float plain binary, little-endian	Global (60°N-60°S)	3600 x 1200	0.1 degree grid box	Hourly	Latest 24-hr: /realtime_ver/**VV**/latest/ Archive: /realtime_ver/**VV**/archive/**YYYY**/**MM**/**DD**/
2	Satellite Information Flag	4-byte singed integer plain binary, little-endian					/realtime_ver/**VV**/sateinfo/**YYYY**/**MM**/**DD**/
3	Observation Time Flag	4-byte float plain binary, little-endian					/realtime_ver/**VV**/timeinfo/**YYYY**/**MM**/**DD**/
4	Reliability Flag	1-byte integer plain binary					/realtime_ver/**VV**/reliability/**YYYY**/**MM**/**DD**/
5	Hourly Gauge-calibrated Rain Rate [mm/h]	4-byte float plain binary, little-endian					/realtime_ver/**VV**/gauge_hr/**YYYY**/**MM**/**DD**/
6	Hourly Rain Rate in text format (old) [mm/h]	ASCII, CSV format	Global but divided to 54 areas	200 rows x 400 lines			/realtime_ver/**VV**/txt/**AAABBBB**/**YYYY**/**MM**/**DD**/
7	Hourly Rain Rate & Gauge-calibrated Rain Rate in text format (new) [mm/h]	ASCII, CSV format	Divided to 15 areas	--			/realtime_ver/**VV**/txt/**XX_ZZZZZZ**/**YYYY**/**MM**/**DD**/
8	Daily Rainfall in 0.25-deg [mm/h]	4-byte float plain binary, little-endian	Global (60°N-60°S)	1440 x 480	0.25 degree grid box	Daily (averaged from 00Z to 23Z of the specified day)	/realtime_ver/**VV**/daily/00Z-23Z/**YYYYMM**/
9						Daily (averaged from 12Z of previous day	/realtime_ver/**VV**/daily/p12Z-11Z/**YYYYMM**/

						to 11Z of the specified day)	
10	Gauge-calibrated Rainfall in 0.25-deg [mm/h]	4-byte float plain binary, little-endian	Global (60°N-60°S)	1440 x 480	0.25 degree grid box	Daily (averaged from 00Z to 23Z of the specified day)	/realtime_ver/**VV**/gauge_dy/00Z-23Z/**YYYYMM**/
11						Daily (averaged from 12Z of previous day to 11Z of the specified day)	/realtime_ver/**VV**/gauge_dy/p12Z-11Z/**YYYYMM**/
12	Daily Rainfall in 0.1-deg [mm/h]			3600 x 1200	0.1 degree grid box	Daily (same as **7**)	/realtime_ver/**VV**/daily0.1/00Z-23Z/**YYYYMM**/
13						Daily (same as **8**)	/realtime_ver/**VV**/daily0.1/p12Z-11Z/**YYYYMM**/
14	Gauge-calibrated Rainfall in 0.1-deg [mm/h]					Daily (same as **9**)	/realtime_ver/**VV**/gauge_dy0.1/00Z-23Z/**YYYYMM**/
15						Daily (same as **10**)	/realtime_ver/**VV**/gauge_dy0.1/p12Z-11Z/**YYYYMM**/

Note: **YYYY**: 4-digit year, **MM**: 2-digit month, **DD**: 2-digit day, **AAA**: latitude of the corner of left-top position (2-degit latitude + S or N), **BBBB**: longitude of the corner of left-top position (3-degit longitude + E or W), **XX_ZZZZZZ**: area name (9-digit), and **VV**: 2-digit Algorithm version.

2. Hourly Rainfall and Flag Files in Binary (products (1)-(3))

2.1. Basic Information

Temporal resolution:	1 hour (hourly data)
Grid resolution:	0.1 degrees latitude/longitude grid (10km at the equator). Latitude and longitude of the first grid [1, 1] is [59.95°N, 0.05°E].
Domain:	Global (60°N-60°S)
Data latency:	4 hours after observation
Data archived period:	File will be removed when reanalysis data (GSMaP_MVK) is uploaded (about 3days).

2.2. FTP Directory Information

Hourly Rain Rate data;

Latest 24 hour data:	/realtime_ver/**VV**/latest/
Archive:	/realtime_ver/**VV**/archive/**YYYY**/**MM**/**DD**/
Satellite Information Flag;	/realtime_ver/**VV**/sateinfo/**YYYY**/**MM**/**DD**/
Observation Time Flag;	/realtime_ver/**VV**/timeinfo/**YYYY**/**MM**/**DD**/
Reliability Flag;	/realtime_ver/**VV**/reliability/**YYYY**/**MM**/**DD**/

where;

YYYY: 4-digit year;
MM: 2-digit month;
DD: 2-digit day; and
VV: 2-digit Algorithm version.

2.3. File Naming Rules

Data and flag files are named according to the following rules;

Hourly Rain Rate data:	gsmap_nrt.**YYYYMMDD**.**HHNN**.dat
Satellite Information Flag:	gsmap_nrt.**YYYYMMDD**.**HHNN**.sateinfo.dat
Observation Time Flag:	gsmap_nrt.**YYYYMMDD**.**HHNN**.timeinfo.dat
Reliability Flag:	gsmap_nrt.**YYYYMMDD**.**HHNN**.reliability.dat

where;

YYYY: 4-digit year;
MM: 2-digit month;
DD: 2-digit day;
HH: 2-digit hour; and
NN: 2-digit minute (currently fixed as 00).

2.4. Data Format

Data format was slightly changed since 10 Oct. 2008 due to algorithm version up. Satellite Information Flag and Observation Time Flag are newly added after 10 Oct. 2008. History of version up is described in GSMaP_NRT_HISTORY.txt file in ftp server.

All binary files are produced in little-endian byte order platform, and archived with compressed using “gzip”. Grid of those files consists of 3600 rows x 1200 lines, which are longitude-latitude elements corresponding to

a 0.1 x 0.1 degree grid that covers the global region from 60°N to 60°S. The center longitude and latitude of the first pixel [1, 1] (left top corner) are [0.05°E, 59.95°N] (Figure 1).

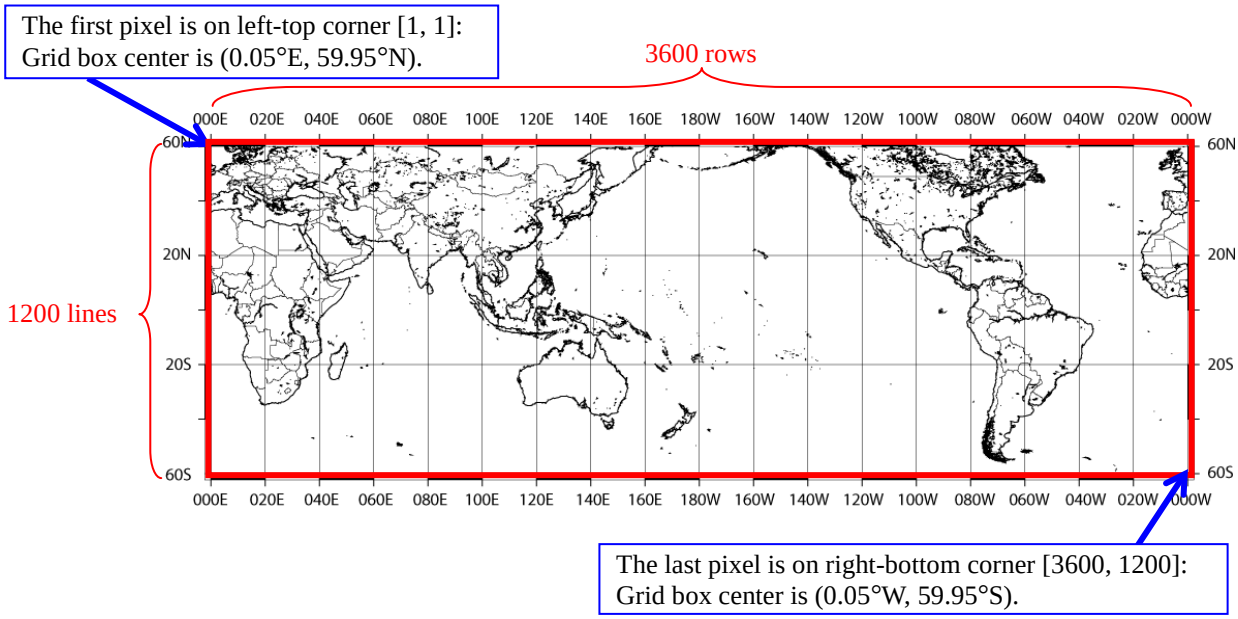

Figure 1 Data Coverage Map (Rain and Flag data)

2.5. Stored Values of Hourly Rain Rate

"Hourly Rain Rate" data are stored in 4-byte float plain binary format. Unit is [mm/hr]. Negative value denotes missing in observation data or no retrieval was done in microwave retrieval algorithm. Detailed description for missing data is shown in Table 2.

Table 2 Stored Values of Hourly Rain Rate

Value	Description
(positive)	Hourly rain rate [mm/hr].
−4	Missing due to sea ice in microwave retrieval algorithm.
-8	Missing due to low temperature in microwave retrieval algorithm.
−99	Missing due to no observation by IR and/or microwave.

Please note that specification of missing value has changed since 10 October 2008. Products prior to 10 October 2008, no missing value is defined (all set to zero).

2.6. Stored Values of Satellite Information Flag

2.6.1. Version 6

"Satellite Information Flag" data are stored in 4-byte integer plain binary format. Satellite and sensor name are assigned to each bit, and the flag indicates all satellite/sensor which are used in estimation of rainfall at each pixel during one-hour time period. If the flag shows 0, there is no satellite observation by both microwave and geo-stationary IR. If flag shows negative value, there is NO microwave radiometer observation. Following meanings are assigned to each bit in 32-bit integer (Table 3-A).

Table 3-A Stored Values of Satellite Information Flag (old)

Pixel Value		Description	
Value	**Bit**	**Sensor Category**	**Satellite/Sensor**
1	0	Microwave imager and/or sounder aboard low orbital satellite	TRMM/TMI
2	1		Aqua/AMSR-E
4	2		DMSP-F13/SSM/I
8	3		DMSP-F14/SSM/I
16	4		DMSP-F15/SSM/I
32	5		DMSP-F16/SSMIS
64	6		DMSP-F17/SSMIS
128	7		NOAA-19/AMSU-A/MHS
256	8		MetOp-A/AMSU-A/MHS
512	9		DMSP-F18/SSMIS
1024	10		GCOM-W/AMSR2
2048	11		GPM-Core/GMI
4096	12		NOAA-18/AMSU-A/MHS
8192	13		MetOp-B/AMSU-A/MHS
16384	14		DMSP-F19/SSMIS
32768	15		not used
65536	16	Infrared Imager aboard Geo-stationary meteorological satellite (before 22Z 28 Mar. 2012)	GOES-EAST
131072	17		GOES-WEST
262144	18		INDEX
524288	19		METEOSAT
1048576	20		MTSAT
2097152−536870912	21−29		not used
1073741824	30	Infrared Imager aboard Geo-stationary meteorological satellite (since 23Z 28 Mar. 2012)	
−(negative)	31	No microwave radiometer observation	

2.6.2. Version 7

"Satellite Information Flag" data are stored in 4-byte integer plain binary format. Satellite and sensor name are assigned to each bit, and the flag indicates all satellite/sensor which are used in estimation of rainfall at each pixel during one-hour time period. If the flag shows 0, there is no satellite observation by both microwave and geo-stationary IR. Following meanings are assigned to each bit in 32-bit integer (Table 3-A).

Table 3-B Stored Values of Satellite Information Flag (new)

Pixel Value		Description	
Value	**Bit**	**Sensor Category**	**Satellite/Sensor**
1	0	Infrared Imager aboard Geo-stationary meteorological satellite	NOAA/CPC Globally Merged IR data
2	1	Microwave imager and/or sounder aboard low orbital satellite	TRMM/TMI
4	2		GPM-Core/GMI
8	3		Megha-Tropiques/MADRAS
16	4		Megha-Tropiques/SAPHIR
32	5		ADEOS-II/AMSR
64	6		Aqua/AMSR-E
128	7		GCOM-W1/AMSR2
256	8		GCOM-W2/AMSR2 f/o (TBD)
512	9		GCOM-W3/AMSR2 f/o (TBD)
1024	10		DMSP-F11/SSM/I
2048	11		DMSP-F13/SSM/I
4096	12		DMSP-F14/SSM/I
8192	13		DMSP-F15/SSM/I
16384	14		DMSP-F16/SSM/I
32768	15		DMSP-F17/SSM/I
65536	16		DMSP-F18/SSM/I
131072	17		DMSP-F19/SSM/I
262144	18		DMSP-F20/SSM/I
524288	19		NOAA-15/AMSU-A/B
1048576	20		NOAA-16/AMSU-A/B
2097152	21		NOAA-17/AMSU-A/B
4194304	22		NOAA-18/AMSU-A/B
8388608	23		NOAA-19/AMSU-A/B
16777216	24		NPP/ATMS
33554432	25		JPSS-1/ATMS
67108864	26		MetOp-A/AMSU-A/MHS
134217728	27		MetOp-B/AMSU-A/MHS
268435456	28		MetOp-C/AMSU-A/MHS
	29−31		Spare

2.7. Stored Values of Observation Time Flag

"Observation Time Information Flag" are in 4-byte float plain binary format. The Flag indicates relative time of latest microwave radiometer observation at each pixel, and 0 means start time of the file (**HH** in file name). Values are stored as indicated in Table 4.

Table 4 Stored Values of Observation Time Flag

Value	Description
$0 \leq X < 1$	If value is positive, microwave radiometer observation is available at the pixel during current one-hour period. X ($0 \leq X < 1$) indicates relative observation time of latest microwave radiometer, and is stored as differences from the start time of the file. For example, if UTC of the file (**HH**) = "01" and X = 0.2, observation time of the pixel will be 01:12 UTC.
$X \leq 0$	If value is negative, NO microwave radiometer observation is available at the pixel during time period of the file. X ($X \leq 0$) indicates relative observation time of latest microwave radiometer, and stored as differences from the start time of the file. For example, if UTC of the file (**HH**) = "01" and X = −2.5, latest observation time of microwave radiometer at the pixel will be 22:30 UTC of previous day.
X = −999	No microwave observation (Missing)

2.8. Stored Values of Reliability Flag

2.8.1. Version 6

"Reliability Flag" are in 1-byte integer plain binary format. The Flag indicates a reliability of the precipitation at each pixel in consideration of sensor and algorithm characteristics. Values range from 1 to 10 and these are stored as described in Table 5-A. Basically, 10 is the best and the 1 is the worst, and, higher values demonstrate higher reliability. Especially, please be careful to use the GSMaP data when the reliability flag is lower than 4.

Table 5-A Stored Values of Reliability Flag

Value	Description			
	Microwave radiometer observation		NO microwave radiometer observation	
	Over Land / Coast	Over Ocean	Over Land / Coast	Over Ocean
10		● not sounder		
9	●	● sounder		
8				● ~1 hour after obs.
7			● ~1 hour after obs.	
6				● 1~2 hour after obs.
5			● 1~2 hour after obs.	
4	● temperature < 2 deg C		● temperature < 2 deg C	● 2~3 hour after obs.
3			● 2~3 hour after obs.	
2			● 1~2 hour after obs. in lower temperature region	● 3~4 hour after obs.
1		● Freezing Level<500m	● 3~ hour after obs. or 2~ hour after obs. in lower temperature region	● 4~ hour after obs. or 0~ hour after obs. in lower freezing level region

2.8.2. Version 7

"Reliability Flag" are in 1-byte integer plain binary format. The Flag indicates a reliability of the precipitation at each pixel in consideration of sensor and algorithm characteristics. Values range from 1 to 10 and these are stored as described in Table 5-B. Basically, 10 is the best and the 1 is the worst, and, higher values demonstrate higher reliability. Especially, please be careful to use the GSMaP data when the reliability flag is lower than 4.

Table 5-B Stored Values of Reliability Flag

Value	Description			
	Microwave radiometer observation		NO microwave radiometer observation	
	Over Land / Coast	Over Ocean	Over Land / Coast	Over Ocean
10		● not sounder		
9	●	● sounder		
8				● ~1 hour after obs.
7			● ~1 hour after obs.	
6				● 1~2 hour after obs.
5			● 1~2 hour after obs.	
4	● temperature <2 deg C	● Freezing Level<500m	● temperature <2 deg C	● 2~3 hour after obs.
3			● 2~3 hour after obs.	
2			● ~1 hour after obs. in lower temperature region	● 3~4 hour after obs. or ~1 hour after obs. in lower freezing level region
1			● 3~ hour after obs. or 1~ hour after obs. in lower temperature region	● 4~ hour after obs. or 1~ hour after obs. in lower freezing level region

2.9. GrADS Control File

Sample control files of the Grid Analysis and Display System (GrADS) for each product are also available from ftp server.

Hourly Rain Rate data:	/realtime_ver/**VV**/archive/GSMaP_NRT.hourly.rain.ctl
Satellite Information Flag:	/realtime_ver/**VV**/sateinfo/GSMaP_NRT.hourly.sat.ctl
Observation Time Flag:	/realtime_ver/**VV**/timeinfo/GSMaP_NRT.hourly.time.ctl
Reliability Flag:	/realtime_ver/**VV**/timeinfo/GSMaP_NRT.hourly.reliability.ctl

where;

VV: 2-digit Algorithm version.

About usage of GrADS tool, please see GrADS home page (http://grads.iges.org/grads/head.html).

2.10. File Size

Approximately 800 Kbyte (with gzip), and 17 Mbyte (uncompress) for each file.

3. Hourly Gauge-calibrated Rain Rate (GSMaP_Gauge) in Binary (product (4))

3.1. Basic Information

Temporal resolution:	1 hour (hourly data) averaged from 00-minute to 59-minute of the specified hour.
Grid resolution:	0.1 degrees latitude/longitude grid (10km at the equator).
	Latitude and longitude of the first grid [1, 1] is [59.95°N, 0.05°E].
Domain:	Global (60°N-60°S).

3.2. FTP Directory Information

Hourly Gauge-calibrated Rain Rate data: /realtime_ver/**VV**/gauge_hr/**YYYY**/**MM**/**DD**/

where;

YYYY: 4-digit year;
MM: 2-digit month;
DD: 2-digit day; and
VV: 2-digit Algorithm version.

3.3. File Naming Rules

Data and flag files are named according to the following rules;

Hourly Gauge-calibrated Rain Rate data: gsmap_gauge.**YYYYMMDD**.**HHNN**.dat

where;

YYYY:	4-digit year;
MM:	2-digit month;
DD:	2-digit day;
HH:	2-digit hour; and
NN:	2-digit minute (currently fixed as 00).

3.4. Data Format

Same as Hourly Rain Rate Data (product (1)). See Section 2.4.

3.5. Stored Value of Hourly Gauge-calibrated Rain Rate

Same as Hourly Rain Rate Data (product (1)). See Section 2.5.

3.6. File Size

Same as Hourly Rain Rate Data (product (1)). See Section 2.6.

4. Hourly rainfall in text format (old) (product (5))

4.1. Basic Information

Temporal resolution:	1 hour (hourly data)
Grid resolution:	0.1 degrees latitude/longitude grid (10km at the equator).
Domain:	Global (60°N-60°S), but data are divided into 54 subset area files (area of 40 degree for latitude, 20 degree for longitude).
Data latency:	4 hours after observation
Data archived period:	Stored only one week on the ftp server.

4.2. FTP Directory Information

Data files are archived at following directory; /realtime_ver/**VV**/txt/**AAABBBB**/**YYYY**/**MM**/**DD**/

where;

YYYY: 4-digit year;
MM: 2-digit month;
DD: 2-digit day;
AAA: The corner of left-top position is appeared with Latitude (2-degit latitude + S or N);
BBBB: The corner of left-top position is appeared with Longitude (3-degit longitude + E or W); and
VV: 2-digit Algorithm version.

4.3. File Naming Rules

Data files are named according to following rules; gsmap_nrt.**YYYYMMDD**.**HHNN**.**AAABBBB**.csv

where;

YYYY: 4-digit year;
MM: 2-digit month;
DD: 2-digit day;
HH: 2-digit hour;
NN: 2-digit minute (currently fixed as 00);
AAA: The corner of left-top position is appeared with Latitude (2-degit latitude + S or N); and
BBBB: The corner of left-top position is appeared with Longitude (3-degit longitude + E or W).

4.4. Data Format

Text files are stored in CSV format. Unit is [mm/hr]. Negative value denotes missing in observation data or no retrieval same as binary format data (see Table 2).

Each file is one of global coverage fractionated 54 areas and consists of 200 rows x 400 lines which is longitude-latitude elements corresponding to a 0.1 x 0.1 degree grid that covers each fractionated area. The number of effective digits is zero pint two digits. This file is available to open using Microsoft Excel directory. Figure 2 is example of data coverage for the case of **AAABBBB** = 60N140E.

List of area code **AAABBBB** and its corresponding latitude and longitude of left-top and right-bottom pixels are stored in following file; /realtime_ver/**VV**/txt/area_list.pdf.

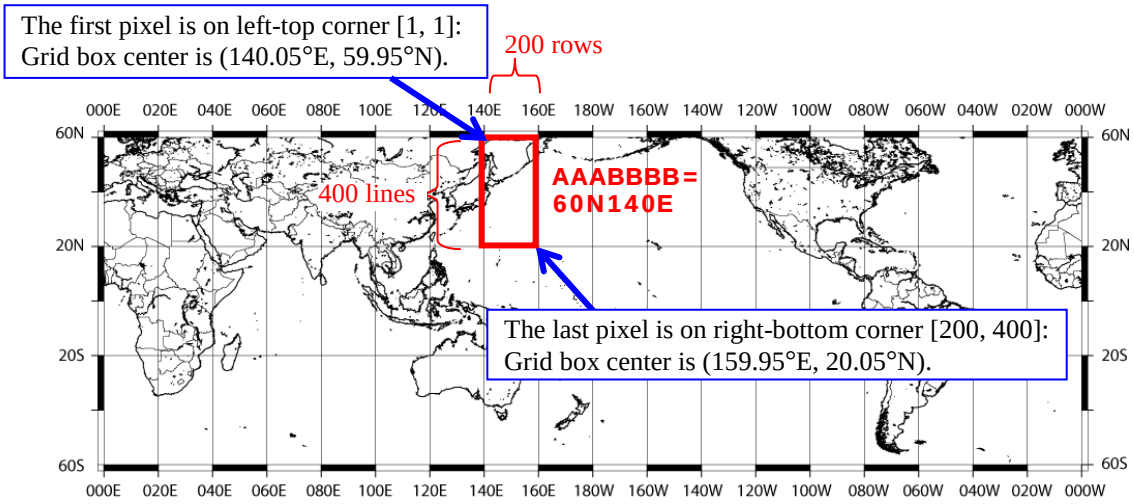

Figure 2 Example of Data Coverage (Text file)

4.5. File Size

Approximately 5 Kbyte (with gzip), and 560 Kbyte (uncompress) for each file.

4. Hourly Rain Rate & Gauge-calibrated Rain Rate (GSMaP_Gauge) in text format (new) (product (6))

4.1. Basic Information

Temporal resolution:	1 hour (hourly data)
Grid resolution:	0.1 degrees latitude/longitude grid (10km at the equator).
Domain:	15 areas (see 4.4)
Data latency:	4 hours after observation
Data archive period:	File will be removed when reanalysis data (GSMaP_MVK) is uploaded (about 3days).

4.2. FTP Directory Information

Data files are archived at following directories;

Hourly Data; /realtime_ver/**VV**/txt/**XX_ZZZZZZ**/**YYYY**/**MM**/**DD**/

where;

YYYY: 4-digit year;
MM: 2-digit month;
DD: 2-digit hour;

XX_ZZZZZZ: 9-digit area name; and
VV: 2-digit Algorithm version.

4.3. File Naming Rules

Data files are named according to following rules;

Hourly Data;

gsmap_nrt.**YYYYMMDD_HH**00_**XX_ZZZZZZ**.csv

where;

YYYY: 4-digit year;
MM: 2-digit month;
DD: 2-digit day;
HH: 2-digit hour; and
XX_ZZZZZZ: 9-digit area name.

4.4. Area definition in text format

15 areas are defined for Text format as in Figure 3.

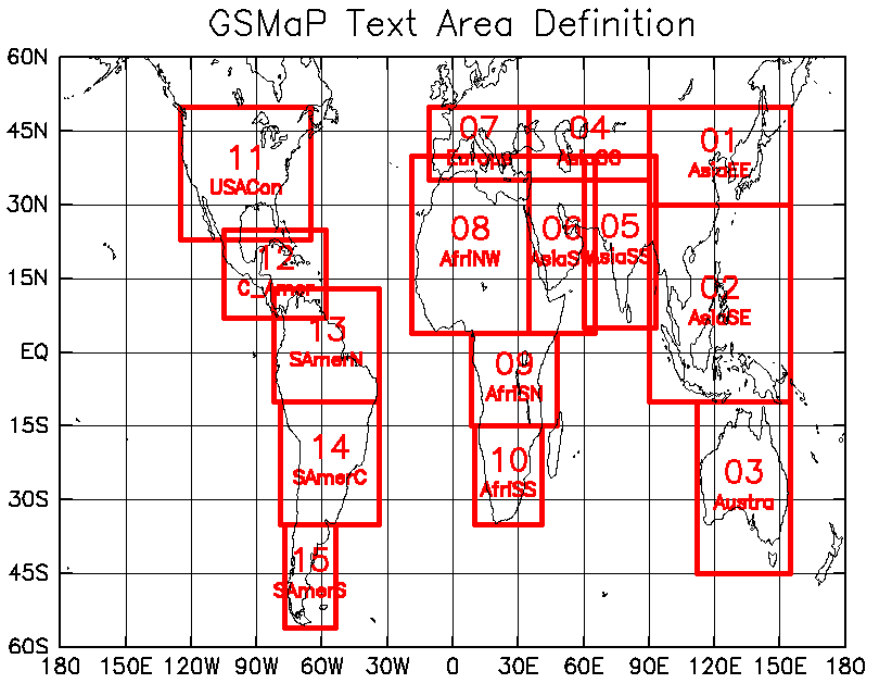

Figure 3 Definition of new Text Area

Table 6 Corner latitude and longitude of each area

Area name	Longitude (W)	Longitude (E)	Latitude (S)	Latitude (N)	Description
01_AsiaEE	90	155	30	50	East Asia
02_AsiaSE	90	155	-10	30	South East Asia
03_Austra	112	155	-45	-10	Australia
04_AsiaCC	35	90	35	50	Central Asia
05_AsiaSS	60	93	5	40	South Asia
06_AsiaSW	35	65	4	40	Arabian Penisula and East Africa
07_Europe	-11	35	35	50	Europe
08_AfriNW	-19	35	4	40	North West and Central Africa
09_AfriSN	8.5	48	-15	4	Southern Africa (North)
10_AfriSS	10	41	-35	-15	Southern Africa (South)
11_USACon	-125	-65	23	50	USA (Contiguous)
12_C_Amer	-105	-58	7	25	Central America
13_SAmerN	-82	-34	-10	13	South America (North)
14_SAmerC	-79	-34	-35	-10	South America (Central)
15_SAmerS	-77	-54	-56	-35	South America (South)

4.5. Data Format

Text files are stored in CSV format (see Figure 4). Unit is [mm/hr]. Data with missing value are omitted.
All text files are archived with compressed using “zip”.
This data format is available in the ArcGIS (ESRI ArcMap 10.0), verified by Mr. Fujioka (ICHARM).

Lat	Lon	RainRate	Gauge-calibratedRain
49.95	89.95	0	0
49.85	89.95	0	0
49.65	89.95	1.1	1.5
……			

Figure 4 Example of text format

4.6. File Size

Approximately 200 Kbyte (with zip), and 1.6 Mbyte (uncompress) for each file.

5. Daily rainfall in 0.25-deg (products (7)-(8))

5.1. Basic Information

Temporal resolution: 24 hours average (daily data)
Two definition of “daily”:
00Z-23Z average: from 00Z to 23Z of the day
12Z-11Z average: from 12Z of the previous day to 11Z of the day
Grid resolution: 0.25 degrees latitude/longitude grid (25km at the equator)
Domain: Global (60°N-60°S)
Data latency: 4 hours after the end of accumulation period
Data archived period: File will be removed when reanalysis data (GSMaP_MVK) is uploaded (about 3days).

5.2. FTP Directory Information

Data files are archived at following directories;

Daily data (00Z-23Z average);

/realtime_ver/**VV**/daily/00Z-23Z/**YYYYMM**/

Daily data (12Z-11Z average);

/realtime_ver/**VV**/daily/p12Z-11Z/**YYYYMM**/

where;

YYYY: 4-digit year;
MM: 2-digit month; and
VV: 2-digit Algorithm version.

5.3. File Naming Rules

Data files are named according to following rules;

Daily data (00Z-23Z average);

gsmap_nrt.**YYYYMMDD**.0.25d.daily.00Z-23Z.dat

Daily data (12Z-11Z average);

gsmap_nrt.**YYYYMMDD**.0.25d.daily.p12Z-11Z.dat

where;

YYYY: 4-digit year;
MM: 2-digit month; and
DD: 2-digit day.

5.4. Data Format

All binary files are produced in little-endian byte order platform, and archived with compressed using “gzip”. Unit is [mm/hr]. Missing value is -999.9.

Grid of those files consists of 1440 x 480 pixels, which are longitude-latitude elements corresponding to a 0.25 x 0.25 degree grid that covers the global region from 60°N to 60°S. The center longitude and latitude of the first pixel [1, 1] (left top corner) is [0.125°E, 59.875°N].

5.5. GrADS Control File

Sample control files of the Grid Analysis and Display System (GrADS) for each product are also available from ftp server.

Daily data (00Z-23Z average);

/realtime_ver/**VV**/daily/00Z-23Z/GSMaP_NRT.daily.00Z-23Z.ctl

Daily data (12Z-11Z average);

/realtime_ver/**VV**/daily/p12Z-11Z/GSMaP_NRT.daily.p12Z-11Z.ctl

where;

VV: 2-digit Algorithm version.

About usage of GrADS tool, please see GrADS home page (http://grads.iges.org/grads/head.html).

5.6. File Size

Approximately 800 Kbyte (with gzip), and 2.7 Mbyte (uncompress) for each file.

6. Gauge-calibrated rainfall in 0.25-deg (products (9)-(10))

6.1. Basic Information

Daily averaged rain rate [mm/hr] of GSMaP_Gauge (product (4)).

Temporal resolution:	24 hours average (daily data) Two definition of "daily": 00Z-23Z average: from 00Z to 23Z of the day 12Z-11Z average: from 12Z of the previous day to 11Z of the day
Grid resolution:	0.25 degrees latitude/longitude grid (25km at the equator)
Domain:	Global (60°N-60°S)
Data latency:	4 hours after the end of accumulation period

6.2. FTP Directory Information

Data files are archived at following directories;

Daily data (00Z-23Z average);

/realtime_ver/**VV**/gauge_dy/00Z-23Z/**YYYYMM**/

Daily data (12Z-11Z average);

/realtime_ver/**VV**/gauge_dy/p12Z-11Z/**YYYYMM**/

where;

YYYY: 4-digit year;
MM: 2-digit month; and
VV: 2-digit Algorithm version.

6.3. File Naming Rules

Data files are named according to following rules;

Daily data (00Z-23Z average);

gsmap_gauge.**YYYYMMDD**.0.25d.daily.00Z-23Z.dat

Daily data (12Z-11Z average);

gsmap_gauge.**YYYYMMDD**.0.25d.daily.p12Z-11Z.dat

where;

YYYY: 4-digit year;
MM: 2-digit month; and
DD: 2-digit day.

6.4. Data Format

Same as Daily rainfall in 0.25-deg (product (7)-(8)). See Section 5.4.

6.5. GrADS Control File

Sample control files of the Grid Analysis and Display System (GrADS) for each product are also available from ftp server.

Daily data (00Z-23Z average);

/realtime_ver/**VV**/gauge_dy/00Z-23Z/GSMaP_GAUGE.daily.00Z-23Z.ctl

Daily data (12Z-11Z average);

/realtime_ver/**VV**/gauge_dy/p12Z-11Z/GSMaP_GAUGE.daily.p12Z-11Z.ctl

where;

VV: 2-digit Algorithm version.

About usage of GrADS tool, please see GrADS home page (http://grads.iges.org/grads/head.html).

6.6. File Size

Approximately 800 Kbyte (with gzip), and 2.7 Mbyte (uncompress) for each file.

7. Daily rainfall in 0.1-deg (products (11)-(12))

7.1. Basic Information

Temporal resolution:	24 hours average (daily data) Two definition of "daily": 00Z-23Z average: from 00Z to 23Z of the day 12Z-11Z average: from 12Z of the previous day to 11Z of the day
Grid resolution:	0.1 degrees latitude/longitude grid (10km at the equator)
Domain:	Global (60°N-60°S)
Data latency:	4 hours after the end of accumulation period
Data archived period:	File will be removed when reanalysis data (GSMaP_MVK) is uploaded (about 3days).

7.2. FTP Directory Information

Data files are archived at following directories;

Daily data (00Z-23Z average);

/realtime_ver/**VV**/daily0.1/00Z-23Z/**YYYYMM**/

Daily data (12Z-11Z average);

/realtime_ver/**VV**/daily0.1/p12Z-11Z/**YYYYMM**/

where;

YYYY: 4-digit year;

MM: 2-digit month; and

VV: 2-digit Algorithm version.

7.3. File Naming Rules

Data files are named according to following rules;

Daily data (00Z-23Z average);

gsmap_nrt.**YYYYMMDD**.0.1d.daily.00Z-23Z.dat

Daily data (12Z-11Z average);

gsmap_nrt.**YYYYMMDD**.0.1d.daily.p12Z-11Z.dat

where;

YYYY: 4-digit year;
MM: 2-digit month; and
DD: 2-digit day.

7.4. Data Format

All binary files are produced in little-endian byte order platform, and archived with compressed using "gzip". Unit is [mm/hr]. Missing value is -999.9.

Grid of those files consists of 3600 x 1200 pixels, which are longitude-latitude elements corresponding to a 0.1 x 0.1 degree grid that covers the global region from 60°N to 60°S. The center longitude and latitude of the first pixel [1, 1] (left top corner) is [0.05°E, 59.95°N].

7.5. GrADS Control File

Sample control files of the Grid Analysis and Display System (GrADS) for each product are also available from ftp server.

Daily data (00Z-23Z average);

/realtime_ver/**VV**/daily0.1/00Z-23Z/GSMaP_NRT.daily0.1.00Z-23Z.ctl

Daily data (12Z-11Z average);

/realtime_ver/**VV**/daily0.1/p12Z-11Z/GSMaP_NRT.daily0.1.p12Z-11Z.ctl

where;

VV: 2-digit Algorithm version.

About usage of GrADS tool, please see GrADS home page (http://grads.iges.org/grads/head.html).

7.6. File Size

Approximately 800 Kbyte (with gzip), and 17 Mbyte (uncompress) for each file.

8. Gauge-calibrated rainfall in 0.1-deg (products (13)-(14))

8.1. Basic Information

Daily averaged rain rate [mm/hr] of GSMaP_Gauge (product (4)).

Temporal resolution:	24 hours average (daily data) Two definition of "daily": 00Z-23Z average: from 00Z to 23Z of the day 12Z-11Z average: from 12Z of the previous day to 11Z of the day
Grid resolution:	0.1 degrees latitude/longitude grid (10km at the equator)
Domain:	Global (60°N-60°S)

Data latency: 4 hours after the end of accumulation period

Data archived period: File will be removed when reanalysis data (GSMaP_MVK) is uploaded (about 3days).

8.2. FTP Directory Information

Data files are archived at following directories;

Daily data (00Z-23Z average);

/realtime_ver/**VV**/gauge_dy0.1/00Z-23Z/**YYYYMM**/

Daily data (12Z-11Z average);

/realtime_ver/**VV**/gauge_dy0.1/p12Z-11Z/**YYYYMM**/

where;

YYYY: 4-digit year;
MM: 2-digit month; and
VV: 2-digit Algorithm version.

8.3. File Naming Rules

Data files are named according to following rules;

Daily data (00Z-23Z average);

gsmap_gauge.**YYYYMMDD**.0.1d.daily.00Z-23Z.dat

Daily data (12Z-11Z average);

gsmap_gauge.**YYYYMMDD**.0.1d.daily.p12Z-11Z.dat

where;

YYYY: 4-digit year;
MM: 2-digit month; and
DD: 2-digit day.

8.4. Data Format

Same as Daily rainfall in 0.1-deg (product (11)-(12)). See Section 7.4.

8.5. GrADS Control File

Sample control files of the Grid Analysis and Display System (GrADS) for each product are also available from ftp server.

Daily data (00Z-23Z average);

/realtime_ver/**VV**/gauge_dy0.1/00Z-23Z/GSMaP_GAUGE.daily0.1.00Z-23Z.ctl

Daily data (12Z-11Z average);

/realtime_ver/**VV**/gauge_dy0.1/p12Z-11Z/GSMaP_GAUGE.daily0.1.p12Z-11Z.ctl

where;

VV: 2-digit Algorithm version.

About usage of GrADS tool, please see GrADS home page (http://grads.iges.org/grads/head.html).

8.6. File Size

Approximately 800 Kbyte (with gzip), and 17 Mbyte (uncompress) for each file.

9. Algorithm and references

9.1. Algorithm

The dataset of "Global Rainfall Map in Near Real Time" is near-real-time version of GSMaP algorithm. Details of the latest GSMaP algorithm are described in following documents and references in Section 6.2.

- Global Satellite Mapping of Precipitation (GSMaP) for GPM: Algorithm Theoretical Basis Document (ATBD)" (http://www.eorc.jaxa.jp/GPM/doc/algorithm_e.htm)..

9.2. References

Papers describing the GSMaP project and algorithm are as follows.

(About GSMaP project)

K. Okamoto, T. Iguchi, N. Takahashi, K. Iwanami and T. Ushio, 2005: The global satellite mapping of precipitation (GSMaP) project. *25th IGARSS Proceedings*, 3414-3416.

K. Okamoto, T. Iguchi, N. Takahashi, T. Ushio, J. Awaka, S. Shige, and T. Kubota, 2007: High precision and high resolution global precipitation map from satellite data. *ISAP 2007 Proceedings*, 506-509.

T. Kubota, S. Shige, H. Hashizume, K. Aonashi, N. Takahashi, S. Seto, M. Hirose, Y. N. Takayabu, K. Nakagawa, K. Iwanami, T. Ushio, M. Kachi, and K. Okamoto, 2007: Global Precipitation Map using Satelliteborne Microwave Radiometers by the GSMaP Project : Production and Validation. *IEEE Trans. Geosci. Remote Sens.*, **45(7)**, 2259-2275.

(About microwave imager algorithm)

K. Aonashi, J. Awaka, M. Hirose, T. Kozu, T. Kubota, G. Liu, S. Shige, S., Kida, S. Seto, N. Takahashi, and Y. N. Takayabu, 2009: GSMaP passive, microwave precipitation retrieval algorithm: Algorithm description and validation. *J. Meteor. Soc. Japan*, **87A**, 119-136.

A. Taniguchi, S. Shige, M. K. Yamamoto, T. Mega, S. Kida, T. Kubota, M. Kachi, T. Ushio, and K. Aonashi, 2013: Improvement of high-resolution satellite rainfall product for Typhoon Morakot (2009) over Taiwan. *J. Hydrometeor.*, **14**, 1859-1871.

S. Shige, M.K. Yamamoto, and A. Taniguchi, 2014. Improvement of TMI rain retrieval over the Indian Subcontinent. *Chapter for "Remote Sensing of the Terrestrial Water Cycle" (Edited by Venkat Lakshmi et al.)*, Wiley Online Library, DOI: 10.1002/9781118872086, 27-42.

M.K. Yamamoto, and S. Shige, 2015: Implementation of an orographic/nonorographic rainfall classification scheme in the GSMaP algorithm for microwave radiometers. *Atmos. Res.,* **163**, 36–47.

(About microwave sounder algorithm)

S. Shige, T. Yamamoto, T. Tsukiyama, S. Kida, H. Ashiwake, T. Kubota, S. Seto, K. Aonashi and K. Okamoto, 2009: The GSMaP precipitation retrieval algorithm for microwave sounders. Part I: Over-ocean algorithm. *IEEE Trans. Geosci. Remote Sens*, **47**, 3084-3097.

S. Kida, S. Shige, and T. Manabe, 2010: Comparison of rain fractions over tropical and sub-tropical ocean obtained from precipitation retrieval algorithms for microwave sounders. *J. Geophys. Res.*, **115**, D24101, doi:10.1029/2010JD014279.

S. Kida, T. Kubota, M. Kachi, S. Shige, and R. Oki, 2012: Development of precipitation retrieval algorithm over land for a satellite-borne microwave sounder. *Proc. of IGARSS 2012*, 342-345.

(About microwave imager/sounder algorithm)

T. Kubota, S. Shige, M. Kachi, and K. Aonashi. 2011: Development of SSMIS rain retrieval algorithm in the GSMaP project. *Proc 28th ISTS*, 2011-n-46.

(About microwave-IR combined algorithm)

T. Ushio, T. Kubota, S. Shige, K. Okamoto, K. Aonashi, T. Inoue, N., Takahashi, T. Iguchi, M. Kachi, R. Oki, T. Morimoto, and Z. Kawasaki, 2009: A Kalman filter approach to the Global Satellite Mapping of Precipitation (GSMaP) from combined passive microwave and infrared radiometric data. *J. Meteor. Soc. Japan*, **87A**, 137-151.

T. Ushio, T. Tashima, T. Kubota, and M. Kachi, 2013: Gauge Adjusted Global Satellite Mapping of Precipitation (GSMaP_Gauge), *Proc. 29th ISTS*, 2013-n-48.

(About NRT system)

M. Kachi, T. Kubota, T. Ushio, S. Shige, S. Kida, K. Aonashi, and K. Okamoto, 2011: Development and utilization of "JAXA Global Rainfall Watch" system. *IEEJ Transactions on Fundamentals and Materials*, **131**, 729-737. (In Japanese with English abstract)

T. Ushio, and M. Kachi, 2009: Kalman filtering application for the Global Satellite Mapping of Precipitation (GSMaP). *Chapter for "Satellite Rainfall Applications for Surface Hydrology" (Editedy by Mekonnen Gebremichael and Faisal Hossain)*, Springer, ISBN978-9048129140, 105-123.

Additional related papers are listed on the JST/CREST GSMaP Project Website
http://sharaku.eorc.jaxa.jp/GSMaP_crest/html/publications.html

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