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Global Satellite Mapping of Precipitation Microwave-IR Combined Product (GSMaP_MVK) and Gauge-calibrated Rainfall Product (GSMaP_Gauge) Data Format Description for Product Version 7, Reanalysis Products (GSMaP_RNL), and Gauge-calibrated Reanalysis Product (GSMaP_Gauge_RNL) Data Format Description for Product Version 6

This document describes data format and information of Global Satellite Mapping of Precipitation Microwave-IR Combined Product (hereafter refers as GSMaP_MVK) for product version 7, which is a reanalysis version of Global Rainfall Map in Near-Real-Time (GSMaP_NRT) distributed from JAXA/EORC, and Gauge-calibrated Rainfall Product (GSMaP_Gauge). For the past period before March 1, 2014, we also produced Reanalysis Products (GSMaP_RNL) and Gauge-calibrated Reanalysis Product (GSMaP_Gauge_RNL). GSMaP_MVK, GSMaP_Gauge and GSMaP_NRT were developed for the Global Precipitation Measurement (GPM) mission based on activities of the GSMaP (Global Satellite Mapping of Precipitation) project, which was promoted for 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). The latest version of GSMaP algorithm (Ver.7) became one of the JAXA GPM products, and original data of GSMaP_NRT, GSMaP_MVK and GSMaP_Gauge in HDF5 format is distributed to the public through the JAXA G-Portal (https://www.gportal.jaxa.jp) as the GPM Global Rainfall Map product. GSMaP_RNL and GSMaP_Gauge_RNL use same algorithms as GSMaP_MVK and GSMaP_Gauge, respectively, but using the Japanese 55-year Reanalysis (JRA-55) data as ancillary data to produce continuous and homogeneous dataset for the past period from March 2000.

1. Products Overview

Table 1 Summary of GSMaP_MVK Products

No	Parameter [unit]	Data format	Coverage	Grid size	Horizontal resolution	Temporal resolution	Section
1	Hourly Rain Rate [mm/hr]	4-byte float plain binary, little-endian	Global (60°N-60°S)	3600 x 1200	0.1 x 0.1 degree grid box	Hourly (averaged from 00-minute to 59-minute of the specified hour. For example, 12:00-12:59Z for 12Z data)	See Section 3
2	Satellite Information Flag	4-byte singed integer plain binary, little-endian					
3	Observation Time Flag	4-byte float plain binary, little-endian					
4	Hourly Gauge-calibrated Rain Rate [mm/hr]	4-byte float plain binary, little-endian					See Section 4
5	Hourly Rain Rate & Gauge-calibrated Rain Rate in text format [mm/hr]	ASCII, CSV format	Divided to 15 areas	---			See Section 5
6	Daily Averaged Rain Rate [mm/hr]	4-byte float plain binary, little-endian	Global (60°N-60°S)	3600 x 1200		Daily (averaged from 00Z to 23Z of the specified day)	See Section 6
7						Daily (averaged from 12Z of the previous day to 11Z of the specified day)	
8	Daily Averaged Gauge-calibrated Rain Rate [mm/hr]					Same as 5	See Section 7
9						Same as 6	
10	Daily Averaged Rai Rate & Gauge-calibrated Rain Rate in text format [mm/hr]	ASCII, CSV format	Divided to 15 areas	---		Same as 5	See Section 8
11						Same as 6	

2. Product/Algorithm Versions and Data Period

2.1. Version

Version of product and algorithms are denoted in following format.

Version: **vP.RSKI.J**

where;

P: product version;
R: version of microwave imager algorithm (reset when product version is updated);
S: version of microwave sounder algorithm (reset when product version is updated);
K: version of microwave imager/sounder algorithm (reset when product version is updated);
I: version of microwave-IR combined algorithm (reset when product version is updated); and
J: inclement number of reprocessing.

For example, v6.5133.0 indicates that product version is **6**, microwave imager algorithm version is **6.5**, microwave sounder version is **6.1**, microwave imager/sounder version is **6.3**, microwave-IR combined version is **6.3,** and no inclement number.

Product version will be updated only when there are major updates in algorithms and reprocessing of whole period is done.

2.2. Data Period

Data period for GSMaP_MVK and GSMaP_Gauge product version 6 is currently **from 1 March 2014 to present**. Data will be updated operationally about three days after observation.
GSMaP_RNL and GSMaP_Gauge_RNL product version 6 covers the period from March 2000 to February 2014. Data will be updated in order when the processing completed.

2.3. FTP/web server

Password protected ftp server same as GSMaP Near Real Time Version (GSMaP_NRT).

3. Hourly Rain Rate (GSMaP_MVK, GSMaP_RNL) and Flag Files in Binary (products (1)-(3))

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

For GSMaP_MVK

Hourly Rain Rate data;	/standard/v7/hourly/**YYYY**/**MM**/**DD**/
Satellite Information Flag;	/standard/v7/sateinfo/**YYYY**/**MM**/**DD**/
Observation Time Flag;	/standard/v7/timeinfo/**YYYY**/**MM**/**DD**/

For GSMaP_RNL

Hourly Rain Rate data; /reanalysis/v6/hourly/**YYYY**/**MM**/**DD**/
Satellite Information Flag; /reanalysis/v6/sateinfo/**YYYY**/**MM**/**DD**/
Observation Time Flag; /reanalysis/v6/timeinfo/**YYYY**/**MM**/**DD**/

where;

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

3.3. File Naming Rules

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

For GSMaP_MVK

Hourly Rain Rate data: gsmap_mvk.**YYYYMMDD**.**HHNN**.v**P.RSKI**.**J**.dat
Satellite Information Flag: gsmap_mvk.**YYYYMMDD**.**HHNN**.v**P.RSKI**.**J**.sateinfo.dat
Observation Time Flag: gsmap_mvk.**YYYYMMDD**.**HHNN**.v**P.RSKI**.**J**.timeinfo.dat

For GSMaP_RNL

Hourly Rain Rate data: gsmap_rnl.**YYYYMMDD**.**HHNN**.v**P.RSKI**.**J**.dat
Satellite Information Flag: gsmap_rnl.**YYYYMMDD**.**HHNN**.v**P.RSKI**.**J**.sateinfo.dat
Observation Time Flag: gsmap_rnl.**YYYYMMDD**.**HHNN**.v**P.RSKI**.**J**.timeinfo.dat

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); and
P.RSKI.J: version of algorithms (see section 2 for details).

3.4. Data Format

Data format was same as current version of GSMaP_NRT, and previous version of GSMaP_MVK (Ver.6.5133.0). History of version up is described in GSMaP_MVK_HISTORY.txt file for GSMaP_MVK and GSMaP_RNL_HISTORY.txt file for GSMaP_RNL on the 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).

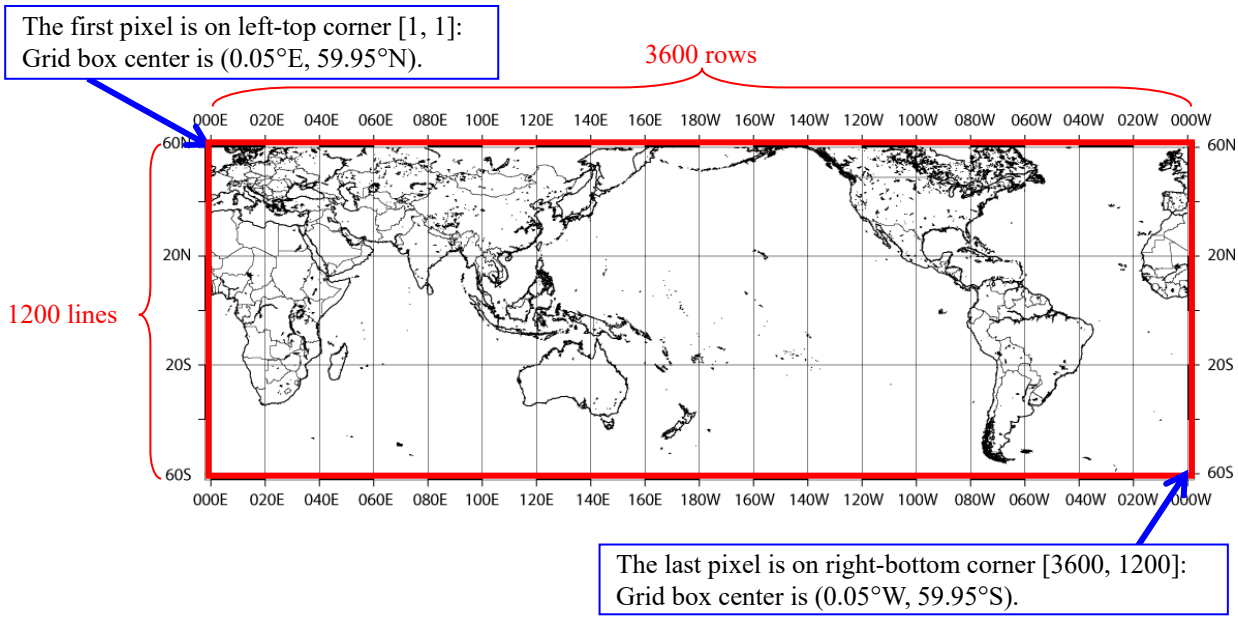

Figure 1 Data Coverage Map (Rain and Flag data)

3.5. Stored Value 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 Value 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.

3.6. Stored Value of Satellite Information Flag

"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).

Table 3 Stored Values of Satellite Information Flag

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

3.7. Stored Value of Observation Time Flag

"Observation Time Information Flag" are in 4-byte float plain binary format. The Flag indicates relative time of nearest microwave radiometer (imager/sounder) 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 and smaller than 1, 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.
$1 \leq X$	If value is equal or larger than 1, NO microwave radiometer observation is available at the pixel during time period of the file. X ($1 \leq X$) indicates relative observation time of coming 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, coming observation time of microwave radiometer at the pixel will be 3:30 UTC.
$X < 0$	If value is negative, NO microwave radiometer observation is available at the pixel during time period of the file. X ($X < 0$) 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)

3.8. File Size

Approximately 1.5 Mbyte (with gzip), and 17 Mbyte (uncompress) for each file.

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

4.1. 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).

4.2. FTP Directory Information

For GSMaP_Gauge

Hourly Rain Rate data; /standard/v7/gauge_hr/**YYYY**/**MM**/**DD**/

For GSMaP_Gauge_RNL

Hourly Rain Rate data; /reanalysis/v6/gauge_hr/**YYYY**/**MM**/**DD**/

where;

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

4.3. File Naming Rules

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

For GSMaP_Gauge

Hourly Gauge-calibrated Rain Rate data: gsmap_gauge.**YYYYMMDD**.**HHNN**.v**P.RSKI.J**.dat

For GSMaP_Gauge_RNL

Hourly Gauge-calibrated Rain Rate data:

gsmap_gauge_rnl.**YYYYMMDD**.**HHNN**.v**P.RSKI.J**.dat

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); and
P.RSKI.J: version of algorithms (see section 2 for details).

4.4. Data Format

Same as Hourly Rain Rate Data (product (1)). See Section 3.4.

4.5. Stored Value of Hourly Gauge-calibrated Rain Rate

Same as Hourly Rain Rate Data (product (1)). See Section 3.5.

4.6. File Size

Same as Hourly Rain Rate Data (product (1)). See Section 3.6.

5. Hourly Rain Rate (GSMaP_MVK, GSMaP_RNL) & Gauge-calibrated Rain Rate (GSMaP_Gauge, GSMaP_Gauge_RNL) in text format (product (5))

5.1. Basic Information

Hourly rain rate (GSMaP_MVK, GSMaP_RNL) and Gauge-calibrated rain rate (GSMaP_Gauge, GSMaP_Gauge_RNL) are stored in the same line.

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)
Domain: 15 areas

5.2. FTP Directory Information

Data files are archived at following directories;

For GSMaP_MVK and GSMaP_Gauge

Hourly Data; /standard/v7/txt/hourly/**XX_ZZZZZZ**/**YYYY**/**MM**/**DD**/

For GSMaP_RNL and GSMaP_Gauge_RNL

Hourly Data; /reanalysis/v6/txt/hourly/**XX_ZZZZZZ**/**YYYY**/**MM**/**DD**/

where;

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

5.3. File Naming Rules

Data files are named according to following rules;

For GSMaP_MVK and GSMaP_Gauge

Hourly Data;

gsmap_mvk_v**PRSKIJ_YYYYMMDD_HH**00_**XX_ZZZZZZ**.csv

For GSMaP_RNL and GSMaP_Gauge_RNL

Hourly Data;

gsmap_rnl_v**PRSKIJ_YYYYMMDD_HH**00_**XX_ZZZZZZ**.csv

where;

YYYY: 4-digit year;
MM: 2-digit month;
DD: 2-digit day;
HH: 2-digit hour;
PRSKIJ: version of algorithms (see section 2 for details); and
XX_ZZZZZZ: 9-digit area name.

5.4. Area definition in text format

15 areas are defined for Text format as in Figure 2.

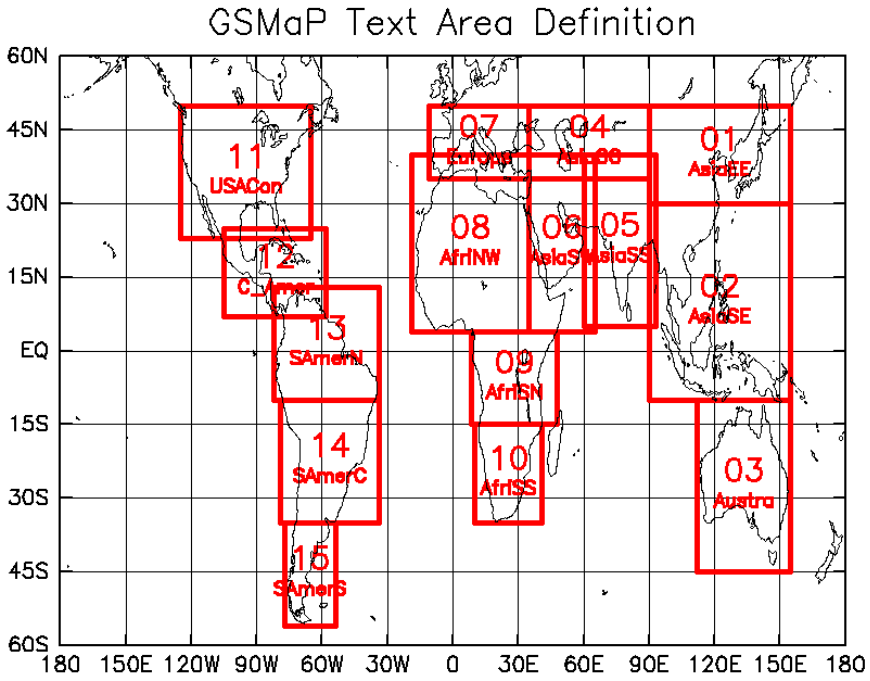

Figure 2 Definition of Text Area

Table 5 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)

5.5. Data Format

Text files are stored in CSV format (see Figure 3). 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 3 Example of text format

5.6. File Size

Approximately 100-700 Kbyte (with zip), and 1.0-5.5 Mbyte (uncompress) for each file.

6. Daily Averaged Rain Rate in Binary (products (6)-(7))

6.1. Basic Information

Daily averaged rain rate [mm/hr] of GSMaP_MVK and GSMaP_RNL (product (1)).

Temporal resolution:	24 hours average (daily average) Two definition of "daily"; a) 00Z-23Z average: from 00Z to 23Z of the day; and b) 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)

6.2. FTP Directory Information

Data files are archived at following directories;

For GSMap_MVK

Daily data (00Z-23Z average); /standard /v7/daily/00Z-23Z/**YYYYMM**/

Daily data (12Z-11Z average); /standard/v7/daily/p12Z-11Z/**YYYYMM**/

For GSMaP_RNL

Daily data (00Z-23Z average); /reanalysis /v6/daily/00Z-23Z/**YYYYMM**/

Daily data (12Z-11Z average); /reanalysis/v6/daily/p12Z-11Z/**YYYYMM**/

where;

YYYY: 4-digit year; and

MM: 2-digit month.

6.3. File Naming Rules

Data files are named according to following rules;

For GSMaP_MVK

Daily data (00Z-23Z average);

gsmap_mvk.**YYYYMMDD**.0.1d.daily.00Z-23Z.v**P.RSKI**.**J**.dat

Daily data (12Z-11Z average);

gsmap_mvk.**YYYYMMDD**.0.1d.daily.p12Z-11Z.v**P.RSKI**.**J**.dat

For GSMaP_RNL

Daily data (00Z-23Z average);

gsmap_rnl.**YYYYMMDD**.0.1d.daily.00Z-23Z.v**P.RSKI.J**.dat

Daily data (12Z-11Z average);

gsmap_rnl.**YYYYMMDD**.0.1d.daily.p12Z-11Z.v**P.RSKI.J**.dat

where;

YYYY: 4-digit year;
MM: 2-digit month;
DD: 2-digit day; and
P.RSKI.J: version of algorithms (see section 2 for details).

6.4. 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 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) is [0.05°E, 59.95°N] (See Figure 1).

6.5. File Size

Approximately 5 Mbyte (with gzip), and 17 Mbyte (uncompress) for each file.

7. Daily Averaged Gauge-calibrated Rain Rate in Binary (products (8)-(9))

7.1. Basic Information

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

Temporal resolution:	24 hours average (daily average) Two definition of "daily"; a) 00Z-23Z average: from 00Z to 23Z of the day; and b) 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)

7.2. FTP Directory Information

Data files are archived at following directories;

For GSMaP_Gauge

Daily data (00Z-23Z average); /standard /v7/gauge_dy/00Z-23Z/**YYYYMM**/
Daily data (12Z-11Z average); /standard/v7/gauge_dy/p12Z-11Z/**YYYYMM**/

For GSMaP_Gauge_RNL

Daily data (00Z-23Z average); /reanalysis /v6/gauge_dy/00Z-23Z/**YYYYMM**/
Daily data (12Z-11Z average); /reanalysis/v6/gauge_dy/p12Z-11Z/**YYYYMM**/

where;

YYYY: 4-digit year; and

MM: 2-digit month.

7.3. File Naming Rules

Data files are named according to following rules;

For GSMaP_Gauge

Daily data (00Z-23Z average);

gsmap_gauge.**YYYYMMDD**.0.1d.daily.00Z-23Z.v**P.RSKI**.**J**.dat

Daily data (12Z-11Z average);

gsmap_gauge.**YYYYMMDD**.0.1d.daily.p12Z-11Z.v**P.RSKI**.**J**.dat

For GSMaP_Gauge_RNL

Daily data (00Z-23Z average);

gsmap_gauge_rnl.**YYYYMMDD**.0.1d.daily.00Z-23Z.v**P.RSKI**.**J**.dat

Daily data (12Z-11Z average);

gsmap_gauge_rnl.**YYYYMMDD**.0.1d.daily.p12Z-11Z.v**P.RSKI**.**J**.dat

where;

YYYY: 4-digit year;

MM: 2-digit month;

DD: 2-digit day; and

P.RSKI.J: version of algorithms (see section 2 for details).

7.4. Data Format

Same as Daily Averaged Rain Rate Data (products (6)-(7)). See Section 6.4.

7.5. File Size

Same as Daily Averaged Rain Rate Data (products (6)-(7)). See Section 6.5.

8. Daily Averaged Rain Rate & Gauge-calibrated Rain Rate in text format (products (10)-(11))

8.1. Basic Information

Daily averaged rain rate (daily average of GSMaP_MVK and GSMaP_RNL) and gauge-calibrated rain rate (daily average of GSMaP_Gauge and GSMaP_Gauge_RNL) are stored in the same line.

Temporal resolution:	24 hours average (daily data) Two definition of "daily"; a) 00Z-23Z average: from 00Z to 23Z of the day; and b) 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:	15 areas

8.2. FTP Directory Information

Data files are archived at following directories;

For GSMaP_MVK and GSMaP_Gauge

Daily data (00Z-23Z average); /standard /v7/txt/daily/00Z-23Z/**XX_ZZZZZZ**/**YYYY**/**MM**/

Daily data (12Z-11Z average); /standard/v7/txt/daily/p12Z-11Z/**XX_ZZZZZZ**/**YYYY**/**MM**/

For GSMaP_RNL and GSMaP_Gauge_RNL

Daily data (00Z-23Z average); /reanalysis /v6/txt/daily/00Z-23Z/**XX_ZZZZZZ**/**YYYY**/**MM**/

Daily data (12Z-11Z average); /reanalysis/v6/txt/daily/p12Z-11Z/**XX_ZZZZZZ**/**YYYY**/**MM**/

where;

YYYY: 4-digit year;

MM: 2-digit month; and

XX_ZZZZZZ: 9-digit area name.

8.3. File Naming Rules

Data files are named according to following rules;

For GSMaP_MVK and GSMaP_Gauge

Daily data (00Z-23Z average);

gsmap_mvk_v**PRSKIJ_YYYYMMDD**_daily_00Z-23Z_**XX_ZZZZZZ**.csv

Daily data (12Z-11Z average);

gsmap_mvk_v**PRSKIJ_YYYYMMDD**_daily_p12Z-11Z_**XX_ZZZZZZ**.csv

For GSMaP_RNL and GSMaP_Gauge_RNL

Daily data (00Z-23Z average);

gsmap_rnl_v**PRSKIJ_YYYYMMDD**_daily_00Z-23Z_**XX_ZZZZZZ**.csv

Daily data (12Z-11Z average);

gsmap_rnl_v**PRSKIJ_YYYYMMDD**_daily_p12Z-11Z_**XX_ZZZZZZ**.csv

where;

YYYY: 4-digit year;

MM: 2-digit month;

DD: 2-digit day;

PRSKIJ: version of algorithms (see section 2 for details); and

XX_ZZZZZZ: 9-digit area name.

8.4. Area definition in text format

Same as hourly text file. See section 5.4, Figure 2, and Table 5.

8.5. Data Format

Same as hourly text file. See section 5.5 and Figure 3.

8.6. File Size

Approximately 100-700 Kbyte (with zip), and 1.0-5.5 Mbyte (uncompress) for each file.

9. Sample code

9.1. Sample Code Directory Information

Some sample codes for GSMaP_MVK are archived at following directory. You can apply same sample code prepared for GSMaP_MVK to GSMaP_Gauge, GSMaP_RNL, or GSMaP_Gauge_RNL, but please replace input file name as appropriate.

Data files are archived at following directories; `/standard/v7/sample/`

9.2. FORTRAN Sample Code

FORTRAN sample code to read hourly rain rate data (product (1), plain binary) is archived as;

`read_GSMaP_MVK_0.1deg.v7.f`

9.3. IDL Sample Code

Sample code for Interactive Data Language (IDL) to read hourly rain rate data (product (1), plain binary) is archived as;

`GSMaP_MVK_sample.v7.pro`

9.4. GrADS Control File

Sample control files of the Grid Analysis and Display System (GrADS) for each product are also archived as follows;

Hourly Rain Rate data:	`GSMaP_MVK.hourly.rain.v7.ctl`
Satellite Information Flag:	`GSMaP_MVK.hourly.sat.v7.ctl`
Observation Time Flag:	`GSMaP_MVK.hourly.time.v7.ctl`
Hourly Gauge-calibrated Rain Rate data:	`GSMaP_MVK.gauge_hr.rain.v7.ctl`
Daily data (00Z-23Z average);	`GSMaP_MVK.daily.00Z-23Z.v7.ctl`
Daily data (12Z-11Z average);	`GSMaP_MVK.daily.p12Z-11Z.v7.ctl`

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

10. Algorithm and references

10.1. 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 10.2.

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

10.2. References

Papers describing the GSMaP project and algorithms 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, Geophysical Monograph 206" (Edited by V. Lakshmi)*, American Geophysical Union, 27-42.

M.K. Yamamoto, and S. Shige, 2014: 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 GSMaP Project Website:
http://sharaku.eorc.jaxa.jp/GSMaP_crest/html/publications.html

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