updated to v5.222D
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Earth Observation Research Center
Japan Aerospace Exploration Agency

Global Satellite Mapping of Precipitation Microwave-IR Combined Product (GSMaP_MVK) Data Format Description for Product Version 5

This document describes data format and information of Global Satellite Mapping of Precipitation (hereafter refers as GSMaP_MVK) for product version 5, which is a reanalysis of Global Rainfall Map in Near-Real-Time (GSMaP_NRT) distributed from JAXA/EORC. GSMaP_MVK and GSMaP_NRT were developed 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).

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	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 Rain Rate in text format [mm/hr]	ASCII, CSV format	Divided to 15 areas	---			See Section 4
5	Daily Rainfall [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 5
6						Daily (averaged from 12Z of the previous day to 11Z of the specified day)	
7	Daily Rainfall in text format [mm/hr]	ASCII, CSV format	Divided to 15 areas	---	0.1 x 0.1 degree grid box	Daily (averaged from 00Z to 23Z of the specified day)	See Section 6
8						Daily (averaged from 12Z of the previous day to 11Z of the specified day)	

2. Product/Algorithm Versions and Data Period

2.1. Version

Version of product and algorithms are denoted in following format.

Version: v**P**.**RSK.I**

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-IR combined algorithm; and
- **I**: inclement number of reprocessing.

Latest version of GSMaP_MVK is v5.222.1, indicates that product version is **5**, microwave imager algorithm version is **5.2**, microwave sounder version is **5.2**, microwave-IR combined version is **2,** and inclement number of reprocessing is **1**.

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 product version 5 is from **1 March 2000 to 30 November 2010** (data period will extend later).

2.3. FTP/web server

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

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

3.1. 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).

3.2. FTP Directory Information

Hourly Rain Rate data;	/standard/v5/hourly/**YYYY**/**MM**/**DD**/
Satellite Information Flag;	/standard/v5/sateinfo/**YYYY**/**MM**/**DD**/
Observation Time Flag;	/standard/v5/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;

Hourly Rain Rate data: gsmap_mvk.**YYYYMMDD**.**HHNN**.v**P.RSK.I**.dat
Satellite Information Flag: gsmap_mvk.**YYYYMMDD**.**HHNN**.v**P.RSK.I**.sateinfo.dat
Observation Time Flag: gsmap_mvk.**YYYYMMDD**.**HHNN**.v**P.RSK.I**.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.RSK.I: version of algorithms (see section 2 for details).

3.4. Data Format

Data format was same as current version of GSMaP_NRT, but slightly changed from previous version of GSMaP_MVK (version 4.8.4). Satellite Information Flag and Observation Time Flag are added for whole data period. History of version up is described in GSMaP_MVK_HISTORY.txt file 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).

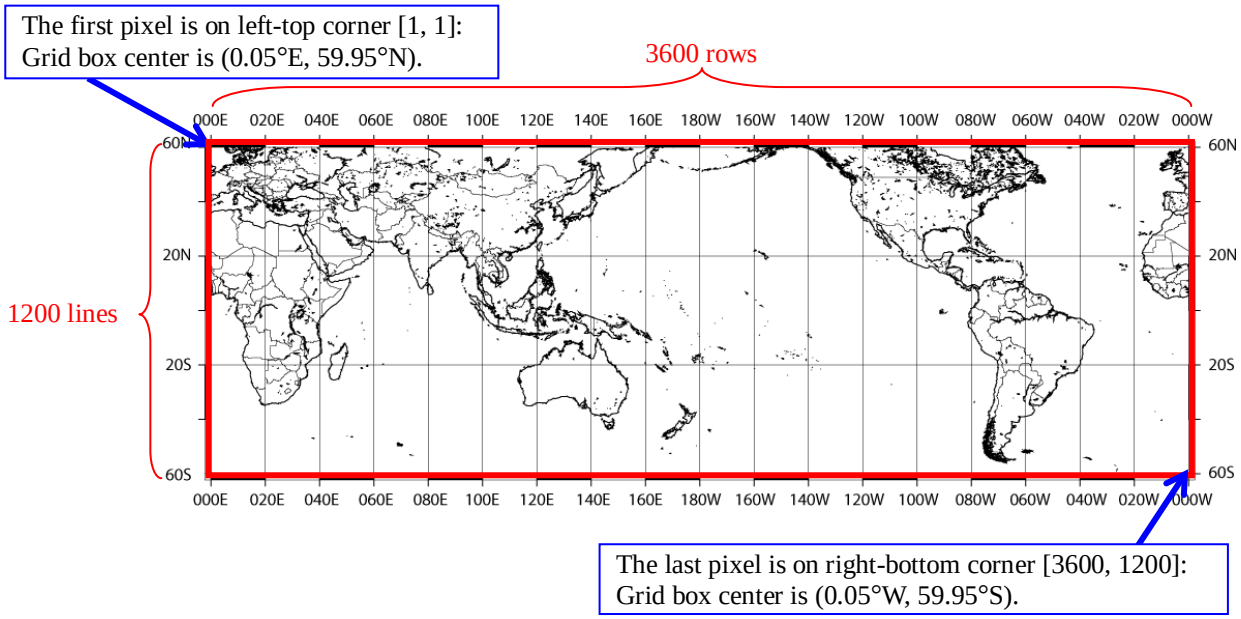

Figure 1 Data Coverage Map (Rain and Flag data)

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. If flag shows negative value, there is NO microwave radiometer observation. Following meanings are assigned to each bit in 32-bit integer (Table 3). Assigned bit to IR imager aboard Geo-stationary meteorological satellite is different to that of GSMaP_NRT, because GSMaP_MVK uses NOAA/CPC's Globally Merged IR data, which merges all available meteorological satellite data.

Table 3 Stored Values of Satellite Information Flag

Pixel Value		Description	
Value	**Bit**	**Sensor Category**	**Satellite/Sensor**
1	0	Microwave radiometer (imager/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-15/AMSU-A/B
256	8		NOAA-16/AMSU-A/B
512	9		NOAA-17/AMSU-A/B
1024	10		NOAA-18/AMSU-A/MHS
2048	11		NOAA-19/AMSU-A/MHS
4096	12		MetOp-A/AMSU-A/MHS
8192	13		DMSP-F18/SSMIS
16384	14		ADEOS-II/AMSR
32768	15		DMSP-F11/SSM/I
65536 − 536870912	16-29		not used
1073741824	30	Infrared Imager aboard Geo-stationary meteorological satellite	NOAA/CPC Globally Merged IR data
−(negative)	31	No microwave radiometer observation	

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 rainfall in text format (product (4))

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

4.2. FTP Directory Information

Data files are archived at following directories;

Hourly Data; /standard/v5/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.

4.3. File Naming Rules

Data files are named according to following rules;

Hourly Data;

gsmap_mvk_v**PRSKI_YYYYMMDD_HH**00_**XX_ZZZZZZ**.csv

where;

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

4.4. Area definition in text format

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

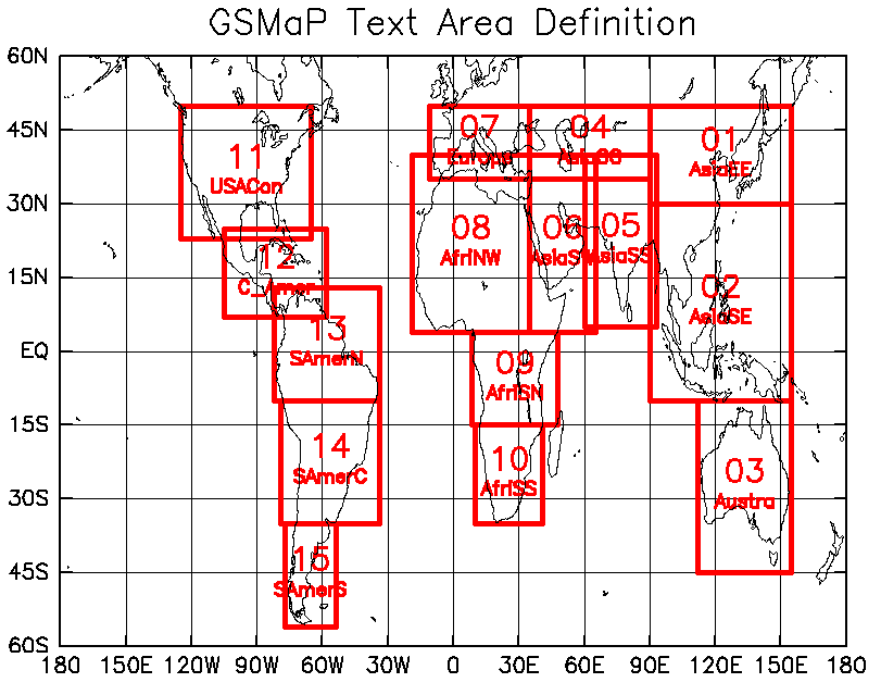

Figure 2 Definition of Text Area

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)

4.5. 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
49.95	89.95	0
49.85	89.95	0
49.75	89.95	0
49.65	89.95	0
…	…	…

Figure 3 Example of text format

4.6. File Size

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

5. Daily rainfall (products (5)-(6))

5.1. Basic Information

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: Global (60°N-60°S)

5.2. FTP Directory Information

Data files are archived at following directories;

Daily data (00Z-23Z average); /standard /v5/daily/00Z-23Z/**YYYYMM**/
Daily data (12Z-11Z average); /standard/v5/daily/p12Z-11Z/**YYYYMM**/

where;

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

5.3. File Naming Rules

Data files are named according to following rules;

Daily data (00Z-23Z average);
gsmap_mvk.**YYYYMMDD**.0.1d.daily.00Z-23Z.v**P.RSK**.**I**.dat
Daily data (12Z-11Z average);
gsmap_mvk.**YYYYMMDD**.0.1d.daily.p12Z-11Z.v**P.RSK**.**I**.dat

where;

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

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 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).

5.5. File Size

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

6. Daily rainfall in text format (products (7)-(8))

6.1. Basic Information

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:	18 areas

6.2. FTP Directory Information

Data files are archived at following directories;

Daily data (00Z-23Z average); /standard /v5/txt/daily/00Z-23Z/**XX_ZZZZZZ**/**YYYY**/**MM**/
Daily data (12Z-11Z average); /standard/v5/txt/daily/p12Z-11Z/**XX_ZZZZZZ**/**YYYY**/**MM**/

where;

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

6.3. File Naming Rules

Data files are named according to following rules;

Daily data (00Z-23Z average);

gsmap_mvk_v**PRSKI**_**YYYYMMDD**_daily_00Z-23Z_**XX_ZZZZZZ**.csv

Daily data (12Z-11Z average);

gsmap_mvk_v**PRSKI**_**YYYYMMDD**_daily_p12Z-11Z_**XX_ZZZZZZ**.csv

where;

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

6.4. Area definition in text format

Same as hourly text file. See section 4.4, Figure 2, and Table 5.

6.5. Data Format

Same as hourly text file. See section 4.5 and Figure 3.

6.6. File Size

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

7. Sample code

7.1. Sample Code Directory Information

Some sample codes are archived at following directory;

Data files are archived at following directories; /standard/v5/sample/

7.2. FORTRAN Sample Code

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

read_GSMaP_MVK_0.1deg.v5.f

7.3. 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.v5.pro

7.4. 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.v5.ctl
Satellite Information Flag:	GSMaP_MVK.hourly.sat.v5.ctl
Observation Time Flag:	GSMaP_MVK.hourly.time.v5.ctl
Daily data (00Z-23Z average);	GSMaP_MVK.daily.00Z-23Z.v5.ctl
Daily data (12Z-11Z average);	GSMaP_MVK.daily.p12Z-11Z.v5.ctl

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

8. Algorithm and references

8.1. Algorithm

The dataset of "Global Satellite Mapping of Precipitation (GSMaP_MVK)" is reanalysis version of GSMaP_NRT for meteorological and climate studies. List of papers describing the GSMaP algorithms are also found at Section 7.2 References, below.

8.2. 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.

(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.

(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.

(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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