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

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Global Rainfall Map Realtime version (GSMaP_NOW) Data Format Description

This document describes data format and information of Global Rainfall Map Realtime version (hereafter refers as GSMaP_NOW) is a quasi-realtime version of "JAXA Global Rainfall Watch (GSMaP_NRT)", which provides global rainfall map 4-hour after observation.

GSMaP_NOW is a rainfall map over the geostationary satellite "Himawari" observation area, using passive microwave observations that are available within half-hour after observation (GMI, AMSR2 near Japan, and AMSU direct receiving data), and applying half-hour extrapolation of rainfall map toward future direction by using cloud moving vector from the geostationary satellite “Himawari”. This allows us to estimate "quasi-realtime" hourly rainfall map at every half-hour.

Since GSMaP_NOW uses less passive microwave radiometer data as input compared to that of GSMaP_NRT, its data accuracy tends to be worse qualitatively. Furthermore, GSMaP_NOW at "current hour" is estimated by extrapolating half-hour by cloud moving vector, so data accuracy may become worse. Early validation result of data accuracy of GSMaP_NOW is available from http://sharaku.eorc.jaxa.jp/GSMaP_NOW/.

Product Overview

Table 1 Summary of GSMaP_NOW 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), but missing outside of “Himawari” area	3600 x 1200	0.1 degree grid box	Hourly	/now/latest/ /now/GrADS/latest/ /now/GrADS/archive/
2	Observation Time Flag	4-byte float plain binary, little-endian					/now/timeinfo/ /now/GrADS/timeinfo/
3	Hourly Rain Rate in text format [mm/h]	ASCII, CSV format	5 areas over land within “Himawari” area	--			/now/txt/**XX_ZZZZZZ**/

Note: There is some lack of data.

XX_ZZZZZZ: area name (9-digit).

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

1.1. Basic Information

Temporal resolution: 1 hour (hourly data), but updated half-hourly

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), but missing values are currently stored to the pixels outside of geostationary satellite "Himawari" observation area (63.9°E-134.1°W, 60°N-60°S)

Data latency: 0-hour after observation

Archive: Only 24-hour data is archived.

1.2. FTP Directory Information

Hourly Rain Rate data;
Latest 24 hour data: /now/latest/
Observation Time Flag: /now/timeinfo/

For GrADS users;
Hourly Rain Rate data;
Latest 24 hour data: /now/GrADS/latest/
Archive data: /now/GrADS/archive/YYYY/MM/DD/
Observation Time Flag; /now/GraDS/timeinfo/YYYY/MM/DD/

where;
YYYY: 4-digit year of start time;
MM: 2-digit month of start time;
DD: 2-digit day of start time;

1.3. File Naming Rules

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

Hourly Rain Rate data: gsmap_now.**YYYYMMDD**.**HHNN**_**hhnn**.dat
Observation Time Flag: gsmap_now.**YYYYMMDD**.**HHNN**_**hhnn**.timeinfo.dat
For GrADS users;
Hourly Rain Rate data: gsmap_now.**YYYYMMDD**.**HHNN**.dat
Observation Time Flag: gsmap_now.**YYYYMMDD**.**HHNN**.timeinfo.dat

where;
YYYY: 4-digit year of start time;
MM: 2-digit month of start time;
DD: 2-digit day of start time;
HH: 2-digit hour of start time;
NN: 2-digit minute of start time;
hh: 2-digit hour of end time; and
nn: 2-digit minute of end time.

1.4. Data Format

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).

1.5. 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.

1.6. 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 (**HHNN** in file name). Values are stored as indicated in Table 3.

Table 3 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 (**HHNN**) = "0100" 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 (**HHNN**) = "0100" 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)

1.7. 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: /now/sample/GSMaP_NOW.hourly.rain.ctl
Observation Time Flag: /now/sample/GSMaP_NOW.hourly.time.ctl

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

1.8. File Size

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

2. Hourly rainfall in text format (product (3))

2.1. Basic Information

Temporal resolution:	1 hour (hourly data), but updated half-hourly.
Grid resolution:	0.1 degrees latitude/longitude grid (10km at the equator)
Domain:	5 areas (see 2.4), but missing values are currently stored to the pixels outside of geostationary satellite “Himawari” observation area (63.9°E-134.1°W, 60°N-60°S).
Data latency:	0-hour after observation
Archive:	Only 24-hour data is archived.

2.2. FTP Directory Information

Data files are archived at following directories;

Hourly Data; /now/txt/**XX_ZZZZZZ**/

where;

XX_ZZZZZZ: 9-digit area name.

2.3. File Naming Rules

Data files are named according to following rules;

Hourly Data; gsmap_now.**YYYYMMDD_HHNN_hhnn_XX_ZZZZZZ**.csv

where;

YYYY: 4-digit year of start time;
MM: 2-digit month of start time;
DD: 2-digit day of start time;
HH: 2-digit hour of start time;
NN: 2-digit minute of start time;
hh: 2-digit hour of end time;
nn: 2-digit minute of end time; and
XX_ZZZZZZ: 9-digit area name.

2.4. Area definition in text format

5 areas are defined for Text format as in Figure 1.

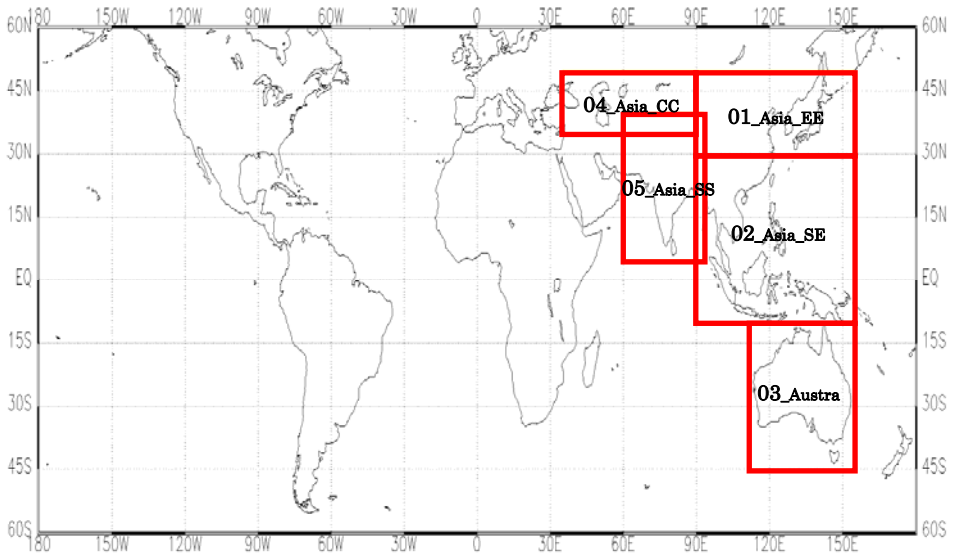

Figure 1 Definition of new Text Area

Table 4 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

2.5. Data Format

Text files are stored in CSV format (see Figure 2). 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 2 Example of text format

2.6. File Size

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

3. Algorithm and references

3.1. Algorithm

The dataset of “Global Rainfall Map Nowcast version” is quasi-realtime version of GSMaP algorithm. GSMaP_NOW produces rainfall map over the area of geostationary satellite "Himawari", using passive microwave observations that are available within half-hour after observation (GMI, AMSR2 near Japan, and AMSU direct receiving data). Furthermore, half-hour extrapolation of rainfall map toward future direction by using cloud moving vector from the geostationary satellite allows us to estimate "current" hourly rainfall map at every half-hour.

Details of the latest GSMaP algorithm are described in following documents and references in Section 3.2.

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

3.2. 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. *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, 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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