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

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Data Format Description for
Global Rainfall Map Realtime version (GSMaP_NOW) and Gauge-calibrated Rainfall Product (GSMaP_Gauge_NOW)

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 area, using passive microwave observations that are available within a half-hour after observation (GMI, AMSR2 near Japan, and AMSU direct receiving data), and applying a half-hour extrapolation of rainfall map toward future direction by using cloud moving vector from the geostationary satellite. 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/.

Contents

1. Product Overview

Table 1 Summary of GSMaP_NOW Products

No	Parameter [unit]	Data format	Coverage	Grid size	Horizontal resolution	Temporal resolution	FTP directory	Section
(1)	Hourly Rain Rate [mm/hr]	4-byte float plain binary, little-endian	Global (60°N-60°S)	3600 x 1200	0.1 degree grid box	Hourly	/now/latest/ /now/half_hour/	See Section 2
(2)	Hourly Gauge-calibrated Rain Rate [mm/hr]						/now/latest/ /now/half_hour_G/	See Section 3
(3)	Hourly Rain Rate & Gauge-calibrated Rain Rate in text format [mm/hr]	ASCII, CSV format	Divided to 15 areas	--			/now/txt/**XX_ZZZZZZ**/	See Section 4
(4)	Hourly Rain Rate & Gauge-calibrated Rain Rate in NetCDF format [mm/hr]	NetCDF	Global (60°N-60°S)	3600 x 1800 (FillValue over the area of 60°N-90°N and 60°S-90°S)			Latest 24-hr: /now/latest/ Archive: /now/netcdf/**YYYY**/**MM**/**DD**/	See Section 5
(5)	Major flags and corresponding Hourly Rain Rate in NetCDF format [mm/hr]							

Note: There is some lack of data.

XX_ZZZZZZ: area name (9-digit).

2. Hourly Rainfall in Binary (products (1))

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).
	Latitude and longitude of the first grid [1, 1] is [59.95°N, 0.05°E].
Domain:	Global (60°N-60°S)
Data latency:	0-hour after observation
Archive:	Since March 29, 2017 (not re-processed).

**Please note that the quality of the GSMaP_NOW has changed several times because of the algorithm update. Please see a document "/now/GSMaP_NOW_HISTORY.txt" in the ftp site.*

2.2. FTP Directory Information

Latest 24 hour data:

Hourly Rain Rate data; /now/latest/

Archive data:

Hourly Rain Rate data; /now/half_hour/**YYYY**/**MM**/**DD**/

where;

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

2.3. File Naming Rules

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

Latest 24 hour data:

Hourly Rain Rate data; gsmap_now.**YYYYMMDD**.**HHNN_hhnn**.dat
(For GrADS users) gsmap_now.**YYYYMMDD**.**HHNN**.dat

Archive data:

Hourly Rain Rate data; gsmap_now.**YYYYMMDD**.**HHNN**.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.

2.4. 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).

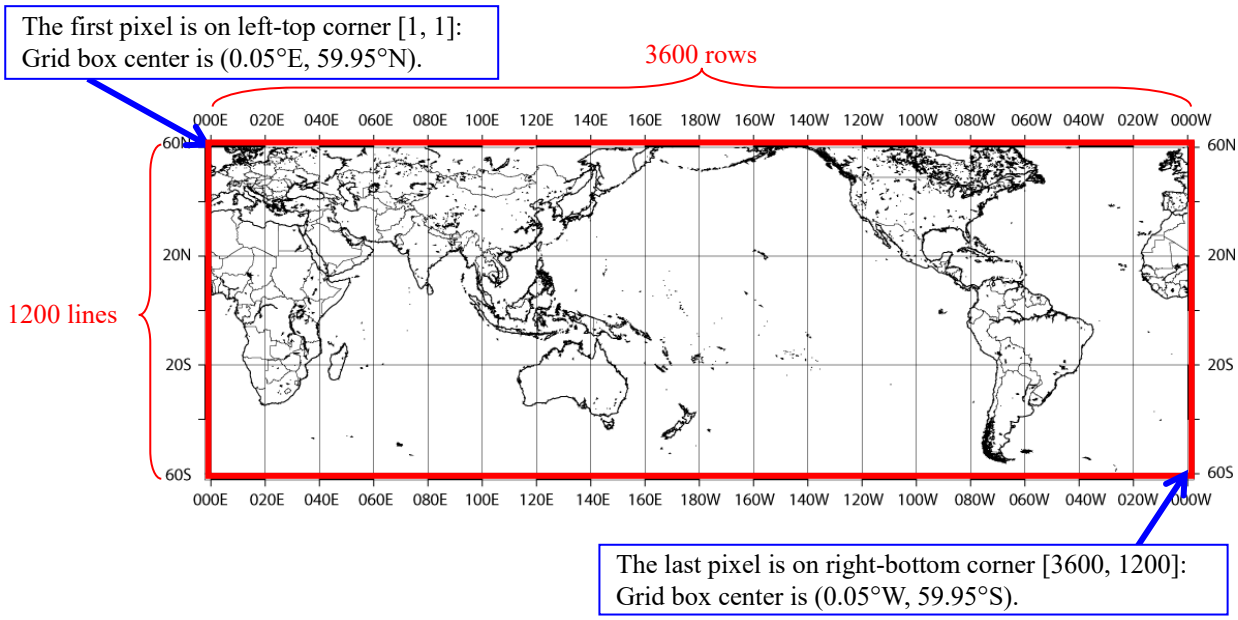

Figure 1 Data Coverage Map (Rain and Flag data)

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.

2.6. GrADS Control File

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

Hourly Rain Rate data: /now/sample/GSMaP_NOW.hourly.rain.ctl

About usage of GrADS tool, please see GrADS home page (http://cola.gmu.edu/grads/grads.php).

2.7. File Size

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

3. Hourly Gauge-calibrated Rain Rate (GSMaP_Gauge_NOW) in Binary (product (2))

3.1. 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).
Data latency:	0-hour after observation
Data archived period:	Since June 27, 2019 (not re-processed).

**Please note that the quality of the GSMaP_Gauge_NOW has changed several times because of the algorithm update. Please see a document "/now/GSMaP_NOW_HISTORY.txt" in the ftp site.*

3.2. FTP Directory Information

Hourly Gauge-calibrated Rain Rate data;

Latest 24 hour data:	/now/latest/
Archive:	/now/half_hour_G/**YYYY**/**MM**/**DD**/

where;

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

3.3. File Naming Rules

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

Hourly Gauge-calibrated Rain Rate data;

Latest 24 hour data;	gsmap_gauge_now.**YYYYMMDD**.**HHNN_hhnn**.dat
(For GrADS users)	gsmap_gauge_now.**YYYYMMDD**.**HHNN**.dat
Archive data;	gsmap_gauge_now.**YYYYMMDD**.**HHNN**.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.

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.

3.7. GrADS Control File

You can use same sample code prepared for Hourly Rain Rate (2.6). Please replace input file name as appropriate.

4. Hourly Rain Rate (GSMaP_NOW) & Gauge-calibrated Rain Rate (GSMaP_Gauge_NOW) in text format (product (3))

4.1. 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:	15 areas (see 4.4).
Data latency:	0-hour after observation
Archive:	Only 24-hour data is archived.

4.2. FTP Directory Information

Data files are archived at following directories;

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

where;

XX_ZZZZZZ: 9-digit area name.

4.3. 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.

4.4. Area definition in text format

15 areas are defined for Text format as gray-shaded areas in Figure 2. In addition to the 15 areas, data for Island outside the defined areas is prepared in “island” directory.

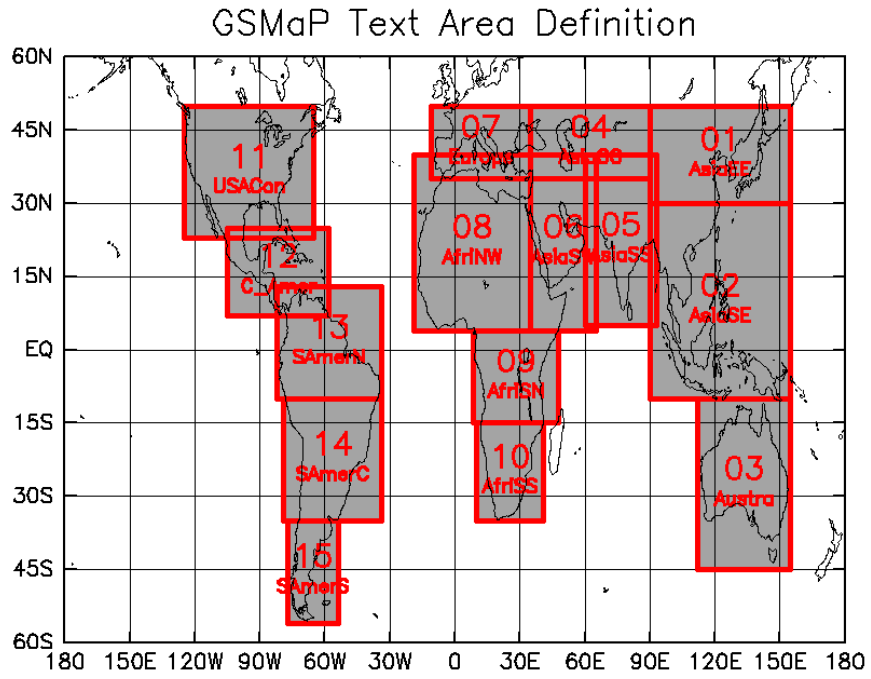

Figure 2 Definition of Text Area

Table 3 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 Peninsula 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	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

4.6. File Size

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

5. Hourly Rain Rate (GSMaP_NOW), Gauge-calibrated Rain Rate (GSMaP_Gauge_NOW), and Major Flags in NetCDF format (products (4)-(5))

5.1. Basic Information

There are two kinds of NetCDF product provided from the ftp site.

Product (4) as "Hourly Rain Rate & Gauge-calibrated Rain Rate" is same as product (1) and product (2) except for the format of NetCDF and adding latitude and longitude information. Users who would like to use real time rainfall data can use this simple NetCDF data (product (4)). Please see Table 4.

Table 4 Stored variables in "Hourly Rain Rate & Gauge-calibrated Rain Rate" (product (4))

Variable [unit]	Long Name	Type	Grid Size	Horizontal resolution	Temporal resolution	Subsection
Latitude [degrees north]	Latitude	float	3600 x 1800 (FillValue over the area of 60°N-90°N and 60°S-90°S)	0.1 x 0.1 degree grid box	Hourly	-
Longitude [degrees east]	Longitude	float				-
hourlyPrecipRate [mm/hr]	precip_now	float				See section 5.5
hourlyPrecipRateGC* [mm/hr]	precip_gauge_now	float				See section 5.6

*GC: Gauge-calibrated

As the other NetCDF product, product (5) as "Major flags and corresponding Hourly Rain Rate" is mainly for users who would like to use the additional information of time, satellite, reliability, and so on.

In the algorithm of GSMaP_NOW, a rainfall map is generated over the area, using passive microwave observations that are available within a half-hour after observation (GMI, AMSR2 near Japan, and AMSU direct receiving data), and applying a half-hour extrapolation of rainfall map toward future direction by using cloud

moving vector from the geostationary satellite. The product (5) stores the information BEFORE the extrapolation of rainfall map toward future direction.

Table 5 Stored variables in "Major flags and corresponding Hourly Rain Rate" (product (5))

Variable [unit]	Long Name	Type	Grid Size	Horizontal resolution	Temporal resolution	Subsection
Latitude [degrees north]	Latitude	float	3600 x 1800 (FillValue over the area of 60°N-90°N and 60°S-90°S)	0.2 x 0.1 degree grid box	Hourly	-
Longitude [degrees east]	Longitude	float				-
hourlyPrecipRate [mm/hr]	precip_RT	float				See section 5.7
hourlyPrecipRateGC* [mm/hr]	precip_gauge_RT	float				See section 5.8
snowProbability [percent]	snowprob_RT	short				See section 5.9
observationTimeFlag [N/A]	timeinfo_RT	float				See section 5.10
satelliteInfoFlag [N/A]	sateinfo_RT	int64				See section 5.11
reliabilityFlag [N/A]	reliability_RT	byte				See section 5.12
orographicRainFlag [N/A]	oroginfo_RT	int				See section 5.13
Surface Type [N/A]	surfaceType_RT	short				See section 5.14

*GC: Gauge-calibrated

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

Grid resolution: 0.1 degrees latitude/longitude grid (10km at the equator).

Domain: Grid size is 3600 x 1800 (90°N-90°S), however, effective data is only in 60°N-60°S, and the area of 60°N-90°N and 60°S-90°S are masked out (fillValue).

Data latency:

0-hour after observation for "Hourly Rain Rate & Gauge-calibrated Rain Rate" (product (4))

0.5-hour after observation for "Major flags and corresponding Hourly Rain Rate" (product (5))

Data archived period: Since December 6, 2021.

5.2. FTP Directory Information

Hourly Gauge-calibrated Rain Rate data;

Latest 24 hour data: /now/latest/

Archive: /now/netcdf/**YYYY**/**MM**/**DD**/

where;

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

5.3. File Naming Rules

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

Hourly Rain Rate & Gauge-calibrated Rain Rate (product (4));

gsmap_now_rain.**YYYYMMDD**.**HHNN**.nc

Major flags and corresponding Hourly Rain Rate (product (5));

gsmap_now_flag.**YYYYMMDD**.**HHNN**.nc

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; and
NN: 2-digit minute of start time.

5.4. Data Format

Products in NetCDF format are produced with grid size 3600 x 1800, which are longitude-latitude elements corresponding to a 0.1° x 0.1° grid that covers the global region from 90°N to 90°S. However, the effective data is only in 60°N-60°S, and the area of 60°N-90°N and 60°S-90°S are masked out (fillValue).

5.5. Stored Values of "precip_now"

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

5.6. Stored Values of "precip_gauge_now"

Same values as Hourly Gauge-calibrated Rain Rate Data (product (2), and same definition as Hourly Rain Rate Data (product (1)). See Section 2.5.

5.7. Stored Values of "precip_RT"

As explained in Section 5.1, "precip_RT" is Hourly Rain Rate data BEFORE the extrapolation. The definition is same as Hourly Rain Rate Data (product(1)). See Section 2.5.

5.8. Stored Values of "precip_gauge_RT"

As explained in Section 5.1, "precip_RT" is Hourly Gauge-calibrated Rain Rate data BEFORE the extrapolation. The definition is same as Hourly Rain Rate Data (product(1)). See Section 2.5.

5.9. Stored Values of "snowprob_RT"

"snowprob_RT" is the probability ratio of snow fall in percent. If value is more than 50 (%), there is a high possibility that it is snowfall. Values range is from 0 to 100 %. Missing value is defined as -9999.

5.10. Stored Values of "timeinfo_RT"

"timeinfo_RT" is the flag indicating 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 6.

Table 6 Stored Values of Observation Time Flag

Value	Description
X ≤ 0.5	X 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**) = "0130" and X = 0.2, observation time of the pixel will be 01:42 UTC.
X = −999	No microwave observation (Missing)

5.11. Stored Values of "sateinfo_RT"

"sateinfo_RT" is the flag indicating all satellite/sensor which are used in estimation of rainfall at each pixel during one-hour time period. Following meanings are assigned to each bit in 32-bit integer (Table 7).

Table 7 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	not used
4	2		GPM-Core/GMI
8	3		not used
16	4		not used
32	5		not used
64	6		not used
128	7		GCOM-W1/AMSR2
256	8		not used
512	9		not used
1024	10		not used
2048	11		not used
4096	12		not used
8192	13		not used
16384	14		DMSP-F16/SSM/I
32768	15		not used
65536	16		DMSP-F18/SSM/I
131072	17		not used
262144	18		not used
524288	19		not used
1048576	20		not used
2097152	21		not used
4194304	22		not used
8388608	23		NOAA-19/AMSU-A/B
16777216	24		NPP/ATMS
33554432	25		JPSS-1/ATMS
67108864	26		not used
134217728	27		MetOp-B/AMSU-A/MHS
268435456	28		MetOp-C/AMSU-A/MHS
	29−31		Spare

5.12. Stored Values of "reliability_RT"

"reliability_RT" is the flag showing reliability of the estimation of hourly rain rate at each pixel. Reliability at each pixel is represented by 10 levels (1, 2, 3, 4, 5, 6, 7, 8, 9, and 10), and 10 is the best (most reliable), and 1 the worst (most unreliable).

5.13. Stored Values of "oroginfo_RT"

"oroginfo_RT" is the flag indicating the number of pixels of orographic condition.
When "oroginfo_RT" is greater than zero,

oroginfo_RT%8: orographic rain condition (stable type)
(oroginfo_RT/16)%8: orographic rain condition (neutral type)
(oroginfo_RT/256)%8: orographic rain condition (unstable type)

5.14. Stored Values of "surfaceType_RT"

"surfaceType_RT" is the flag for land surface type.

0: Ocean
1: Coast
2: Land
-4: Sea Ice
-8: Low Temperate

5.15. File Size

Approximately 5 Mbyte for each file.

5.16. Python Sample Code

Sample code of the Python for the product are also available from ftp server. Please replace input file name as appropriate.

Hourly Rain Rate data: /now/sample/readGSMaP_netcdf.py

6. Algorithm and references

6.1. Algorithm

. GSMaP_NOW produces rainfall map over the area of geostationary satellite "Himawari" and "Meteosat", using passive microwave observations that are available within a half-hour after observation (GMI, AMSR2 near Japan, and AMSU direct receiving data). Furthermore, a half-hour extrapolation of rainfall map toward future direction by using cloud moving vector from the geostationary satellites 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 6.2.

- Global Satellite Mapping of Precipitation (GSMaP) for GPM: Algorithm Theoretical Basis Document (ATBD)" (https://sharaku.eorc.jaxa.jp/GSMaP/faq/GSMaP_faq15.html)

6.2. References

Papers describing the GSMaP project and algorithm are as follows.

- Kubota, T., K. Aonashi, T. Ushio, S. Shige, Y. N. Takayabu, M. Kachi, Y. Arai, T. Tashima, T. Masaki, N. Kawamoto, T. Mega, M. K. Yamamoto, A. Hamada, M. Yamaji, G. Liu and R. Oki 2020: Global Satellite Mapping of Precipitation (GSMaP) products in the GPM era, Satellite precipitation measurement, Springer, https://doi.org/10.1007/978-3-030-24568-9_20.

(Major papers related to GSMaP algorithms)

- Kubota, T., 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**, No. 7, 2259-2275, https://doi.org/10.1109/TGRS.2007.895337.

- Aonashi, K., 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, https://doi.org/10.2151/jmsj.87A.119.

- 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, https://doi.org/10.2151/jmsj.87A.137.

- Mega, T., T. Ushio, M. T. Matsuda, T. Kubota, M. Kachi, and R. Oki, 2019: Gauge-adjusted global satellite mapping of precipitation. *IEEE Trans. Geosci. Remote Sens.*, **57.4**, 1928-1935, https://doi.org/10.1109/TGRS.2018.2870199.

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