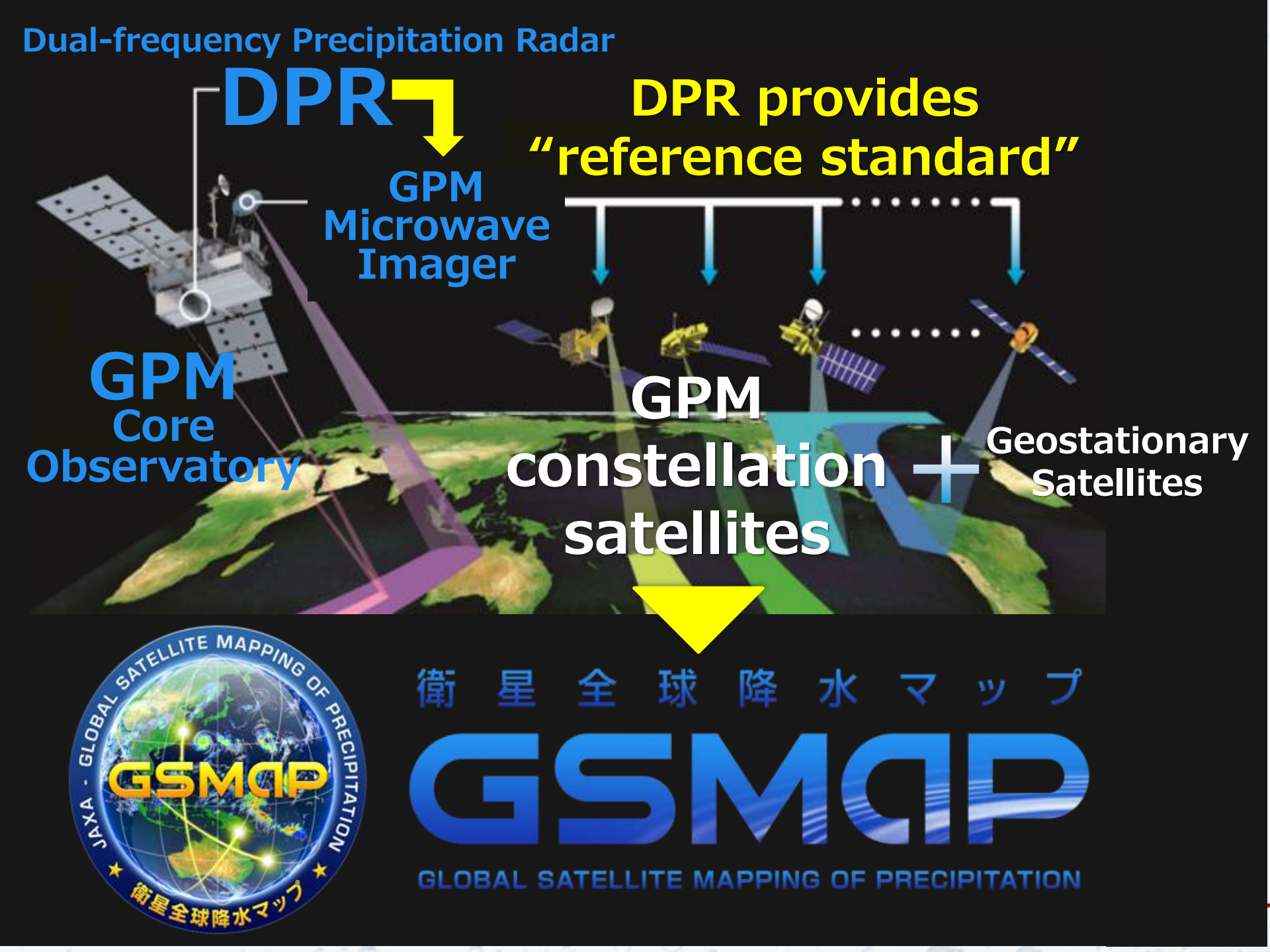
GSMaP

GLOBAL SATELLITE MAPPING OF PRECIPITATION

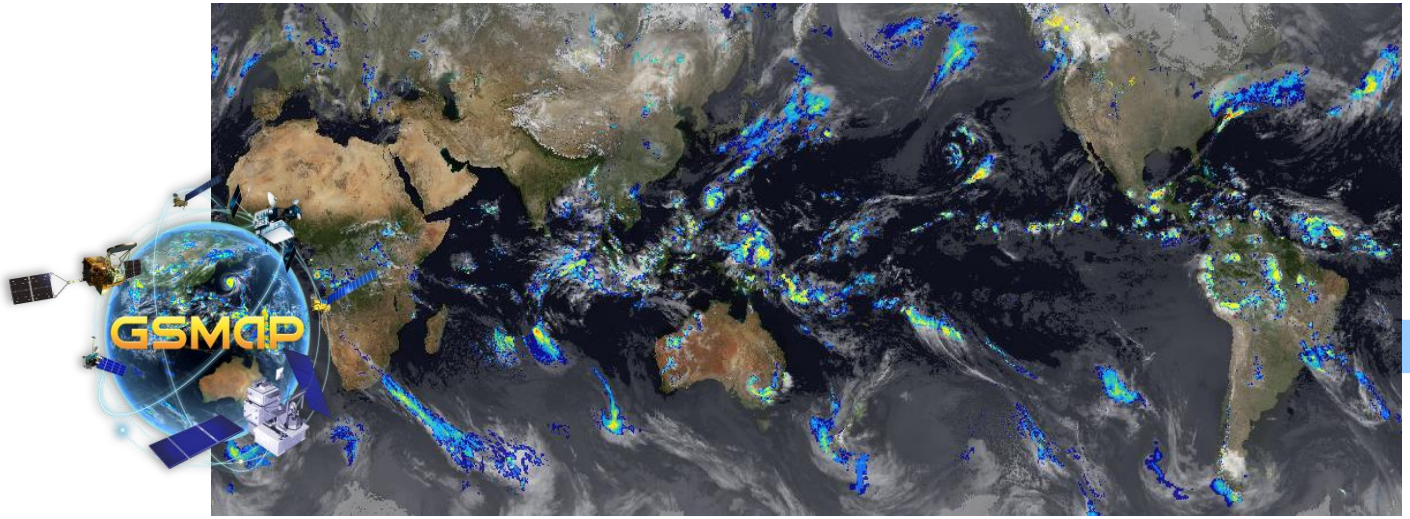
GSMaP new version (v8) updated in Dec. 2021

Japan Aerospace Exploration Agency
Earth Observation Research Center

JAXA


Dual-frequency Precipitation Radar
DPR
GPM Microwave Imager
DPR provides "reference standard"
GPM Core Observatory
GPM constellation satellites
+
Geostationary Satellites
JAXA - GLOBAL SATELLITE MAPPING OF PRECIPITATION
GSMaP
衛星全球降水マップ
GSMaP
GLOBAL SATELLITE MAPPING OF PRECIPITATION

GSMaP applications



衛星全球降水マップ
GSMaP
GLOBAL SATELLITE MAPPING OF PRECIPITATION

Statistics!
Realtime!
Long-term!

- 0.1 deg lat/lon
- Hourly rain rate
- Since March 2000 to present (just now)

Broad utilization fields of GSMaP!

JAXA

GSMaP updates

- GSMaP is planning the major updates in Dec. 2021.

Date	Product version	Algorithm Version
Sep. 2014	V03	v6
Jan. 2017	V04	v7
Dec. 2021	**V05**	**v8**

  - A review paper of GPM-GSMaP V03 & V04: Kubota et al. (2020), https://doi.org/10.1007/978-3-030-24568-9_20

- GPM-GSMaP V05 (algorithm version 8) is available from:
  - G-Portal https://gportal.jaxa.jp/gpr/?lang=en
    HDF, Global-scale txt, NetCDF, GeoTiff format
  - JAXA Rainfall Watch https://sharaku.eorc.jaxa.jp/GSMaP/index.htm
    Binary, region-subset txt, NetCDF format

Features in the new version

See Appendix for detail information

Passive microwave (PMW) algorithm

- Retrievals extended to the pole-to-pole (PMW only)
- Update of Database
  - ✓ Frozen precipitation depth will be newly installed in V05, presented by Dr. Aonashi at 2019 PMM Science Team Meeting.
- Heavy Orographic Rainfall Retrievals
  - ✓ A basic idea was presented by Prof. Shige at 2019 PMM Science Team Meeting.
- Several improvements in PMW retrieval technique

Normalization module for PMW retrievals

Newly installed in V05, described in Yamamoto and Kubota (2020, https://doi.org/10.1109/IGARSS39084.2020.9324451)

PMW-IR Combined algorithm

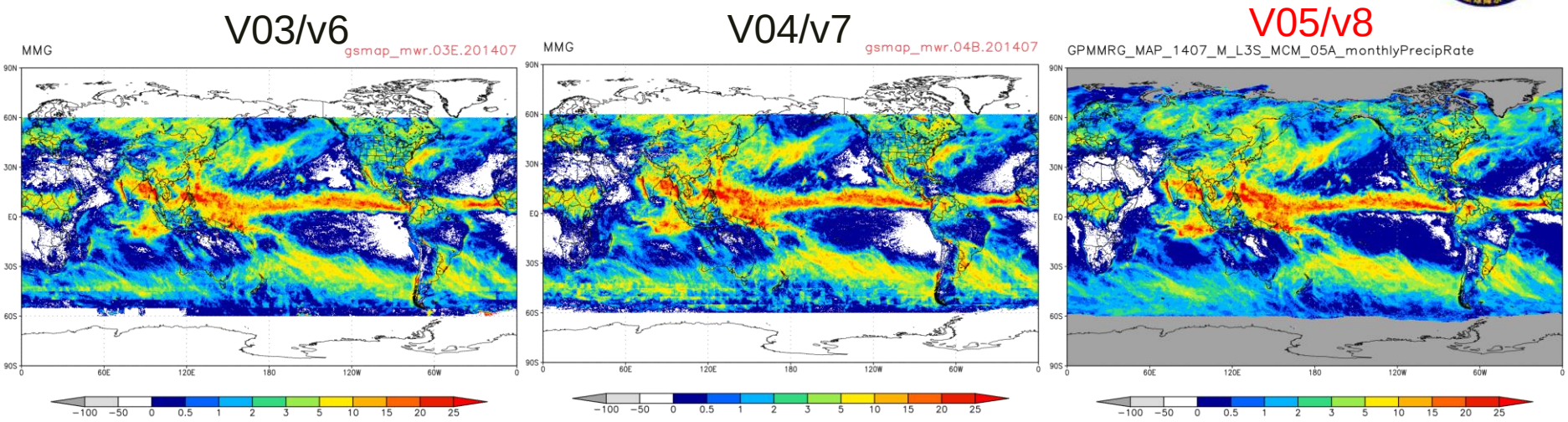
A basic idea is using morphing and Kalman filter (Ushio et al. 2009). In addition, histogram matching method by Hirose et al. (2021) will be implemented in V05.

Hirose et al., 2021: Histogram Matching to Improve Homogeneity in Satellite Merged Precipitation Products, *IEEE GRSL*, *accepted*.

Gauge-adjustment algorithm

A basic idea is adjustment using the NOAA CPC Global Unified Gauge-Based Analysis of Daily Precipitation (Mega et al. 2019). Artificial patterns appeared in V04 will be mitigated in V05.

Features in the new version



Domain of the GSMaP V03/v6 and V04/v7 is from 60S to 60N

➡ In GSMaP V05/v8, the retrieval domain is extended to pole-to-pole*.

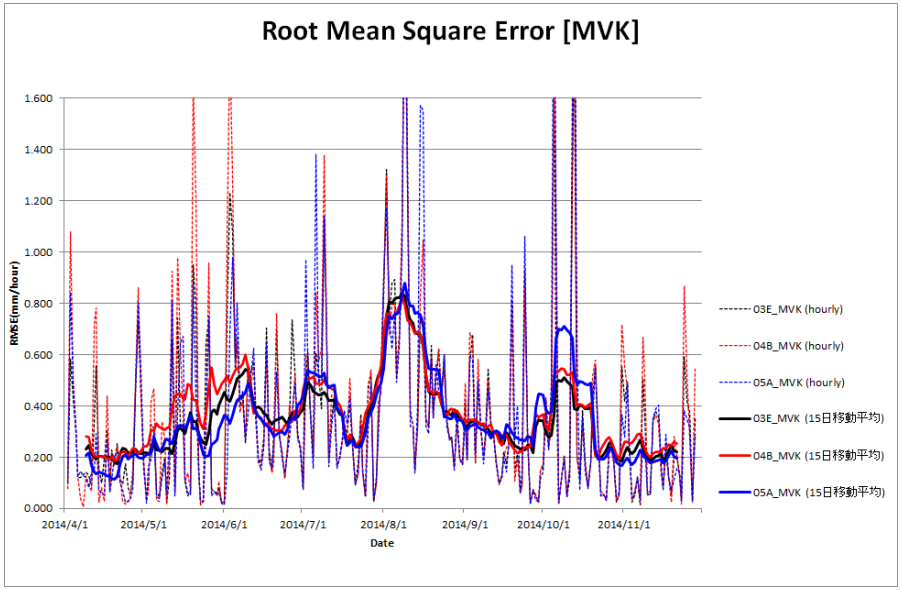
* Retrieval domain has been extended to the poles only when passive microwave radiometer passes. The PMW-IR combined algorithm will be available in next version.

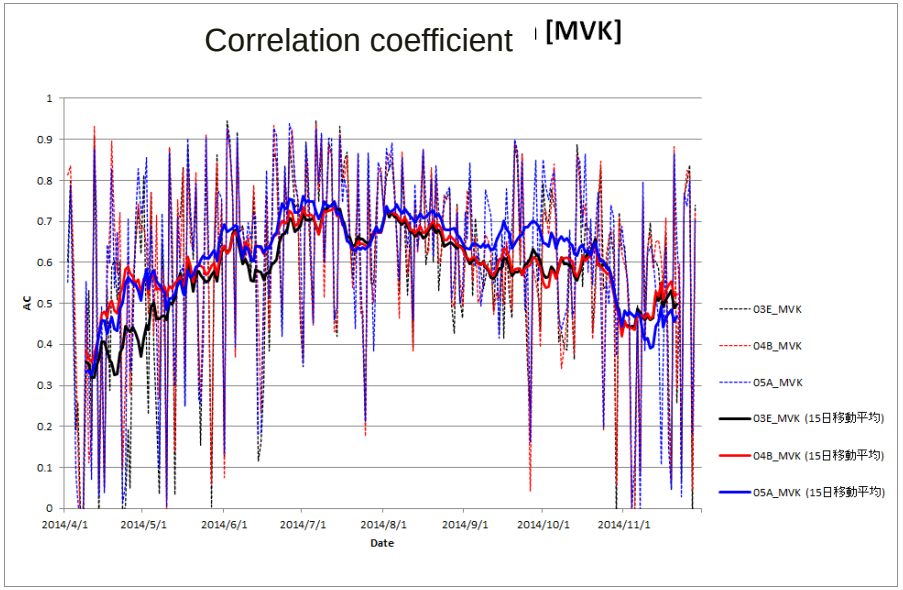
* The values over sea ice and Greenland are still missing in V05/v8 due to the difficulty of estimation.

- Due to the polar extension, precipitation in the high latitudes of Eurasia and Alaska can now be estimated.
- Algorithm-derived unnatural grid pattern in the southern mid-latitude ocean has been eliminated.
- Overestimation near the Chilean coast (Andes Mountains) is improved in V05/v8.

Validation over the Japan

- Preliminary validation results using the gauge-adjustment ground radar data over the Japan (land) confirmed better results in V05 satellite only products.



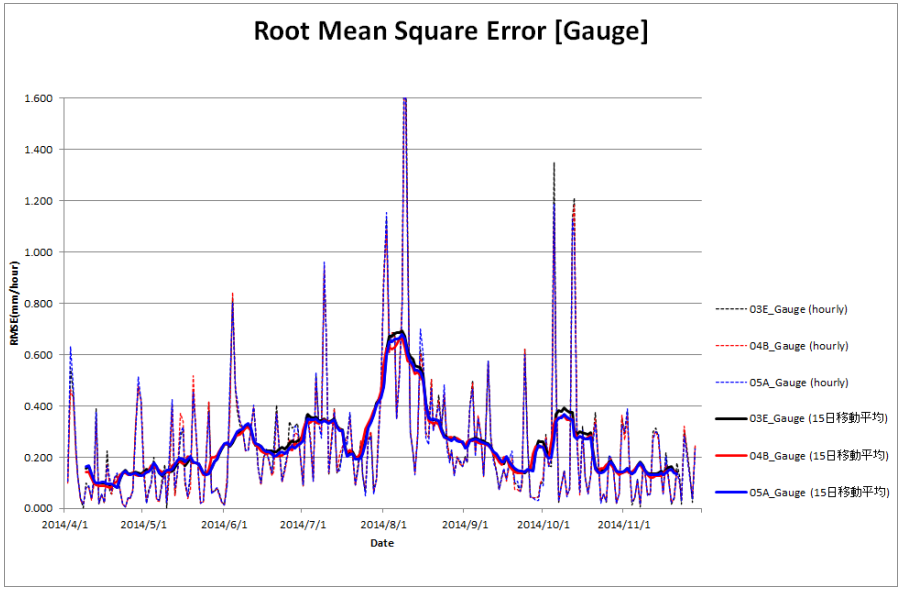


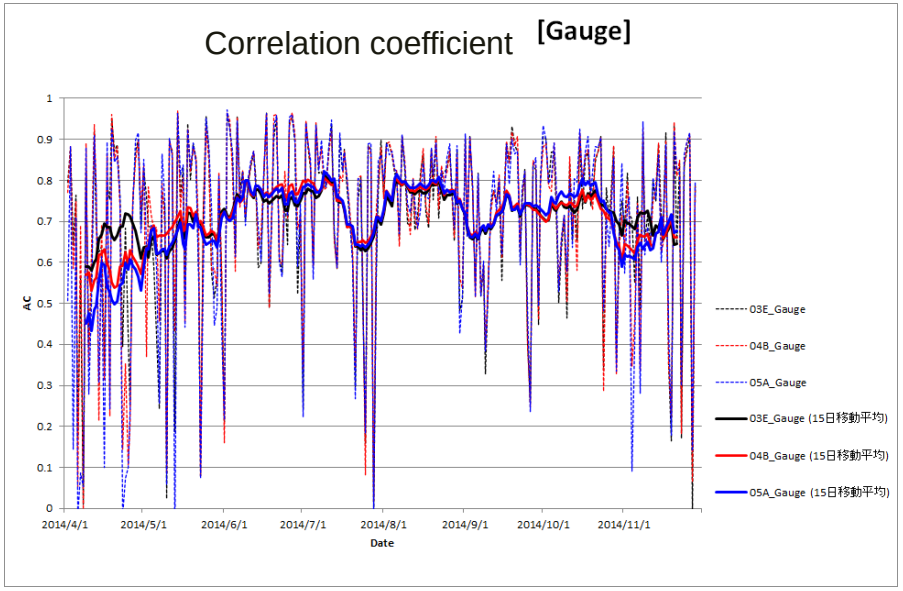
Apr-Nov 2014 mean RMSE
V03/v6 GSMaP_MVK 0.345 mm/h
V04/v7 GSMaP_MVK 0.371 mm/h
V05/v8 GSMaP_MVK 0.348 mm/h

Apr-Nov 2014 mean CC
V03/v6 GSMaP_MVK 0.573
V04/v7 GSMaP_MVK 0.594
V05/v8 GSMaP_MVK 0.605

Validation over the Japan

- In gauge-adjustment products, skills shown in the validation were similar among the past, current coming versions.





Apr-Nov 2014 mean RMSE

V03/v6 GSMaP_Gauge 0.246 mm/h

V04/v7 GSMaP_Gauge 0.240 mm/h

V05/v8 GSMaP_Gauge 0.241 mm/h

Apr-Nov 2014 mean CC

V03/v6 GSMaP_Gauge 0.710

V04/v7 GSMaP_Gauge 0.707

V05/v8 GSMaP_Gauge 0.696

Various GSMaP products

	3-day latency	4-hour latency	0-hour latency
Satellite -basis	**GSMaP MVK** (Standard) Since March 2000	**GSMaP NRT** (Near-real-time) Since March 2000	**GSMaP NOW** (Realtime) Since January 2015
Gauge-adjusted	**GSMaP Gauge** (Gauge-adjusted standard) Since March 2000	**GSMaP Gauge NRT** (Gauge-adjusted Near-real-time) Since March 2000	**GSMaP Gauge NOW** (Gauge-adjusted Realtime) Since June 2019

Better accuracy ☺
Relatively worse latency ☹

Relatively worse accuracy ☹
Better latency ☺

Applications

Agriculture/ Food security	Climate monitoring	Disaster management/ Flood abalysis	Weather monitoring

Data formats

- The provider differs depending on the type and format of the product as shown in the table below.

	NOW Gauge_NOW	NRT Gauge_NRT	MVK Gauge
G-Portal https://gportal.jaxa.jp/gpr/?lang=ja		HDF Global-scale, txt	HDF Global-scale, txt NetCDF GeoTIFF
"JAXA Rainfall Watch" website/ftpsite https://sharaku.eorc.jaxa.jp/GSMaP/index_j.htm	Binary Region-subset,txt NetCDF	Binary Region-subset,txt NetCDF	Binary Region-subset,txt

In the new GSMaP version (v8), GSMaP NRT, Gauge_NRT, NOW, and Gauge_NOW in NetCDF format is newly available.

NetCDF format – NRT and Gauge_NRT

In the new GSMaP version (v8), GSMaP in NetCDF format is available.

Parameter [unit]	Type	Grid Size	Horizontal resolution	Temporal resolution
Latitude	Float	3600 x 1800	0.1 x 0.1 degree grid box	Hourly
Longitude	Float			
Hourly Rain Rate [mm/hr]	Float			
Hourly Gauge-calibrated Rain Rate [mm/hr]	Float			
Snow Probability	Short			
Observation Time Flag	Float			
Reliability Flag	Signed char			

Descriptions of the parameter is in the document at

https://sharaku.eorc.jaxa.jp/GSMaP/document/new/DataFormatDescription_NRT8.pdf

NetCDF format – NOW and Gauge_NOW

In the new GSMaP version (v8), GSMaP in NetCDF format is available.

Parameter [unit]	Type	Grid Size	Horizontal resolution	Temporal resolution
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	Float			
Hourly Rain Rate [mm/hr]	Float			
Hourly Gauge-calibrated Rain Rate [mm/hr]	Float			

In addition to the major variables listed above, flags are also available in NetCDF format. Please see the document below.

https://sharaku.eorc.jaxa.jp/GSMaP/document/new/DataFormatDescription_NOW.pdf

Other infomation

- Users' guide
  https://sharaku.eorc.jaxa.jp/GSMaP/guide.html

- FAQ
  https://sharaku.eorc.jaxa.jp/GSMaP/faq/GSMaP_faq_list.html

- Documents (format specifications, release note etc.)
  https://www.eorc.jaxa.jp/GPM/en/gsmap.html

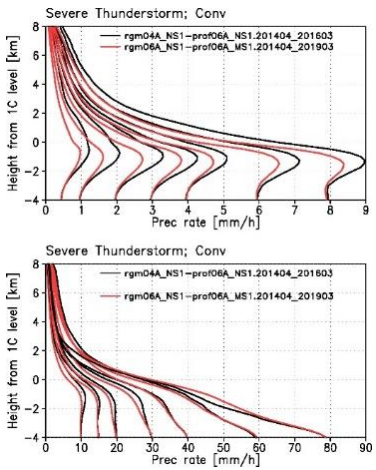
Appendix:

Summary for improvements in GPM V05

- The following improvements are expected in GPM-GSMaP V05 (algorithm version 8) released in Apr. 2021.
- Improvements of passive microwave (PMW) algorithm
  - Retrievals extended to the pole-to-pole
  - Update of Database
  - Heavy Orographic Rainfall Retrievals
  - PMW retrieval technique
  - Normalization module for PMW retrievals
  - PMW-IR Combined algorithm
    - Implementation of histogram matching method by Hirose et al. (2021)
  - Gauge-adjustment algorithm
    - Based upon Mega et al. (2019), and artificial patterns appeared in V04 will be mitigated in V05 (presented by Prof. Ushio).

Improvements in GPM-GSMaP V05 (1)

- Updates of Database in PMW algorithm
  - Precipitation profile database
    - V04: 2-year KuPR V04A data
    - V05: 5-year DPR(MS) V06A data (by Prof. Hamada)



Example of **2-year KuPR V04A** vs **5 year- DPR (MS) V06A**

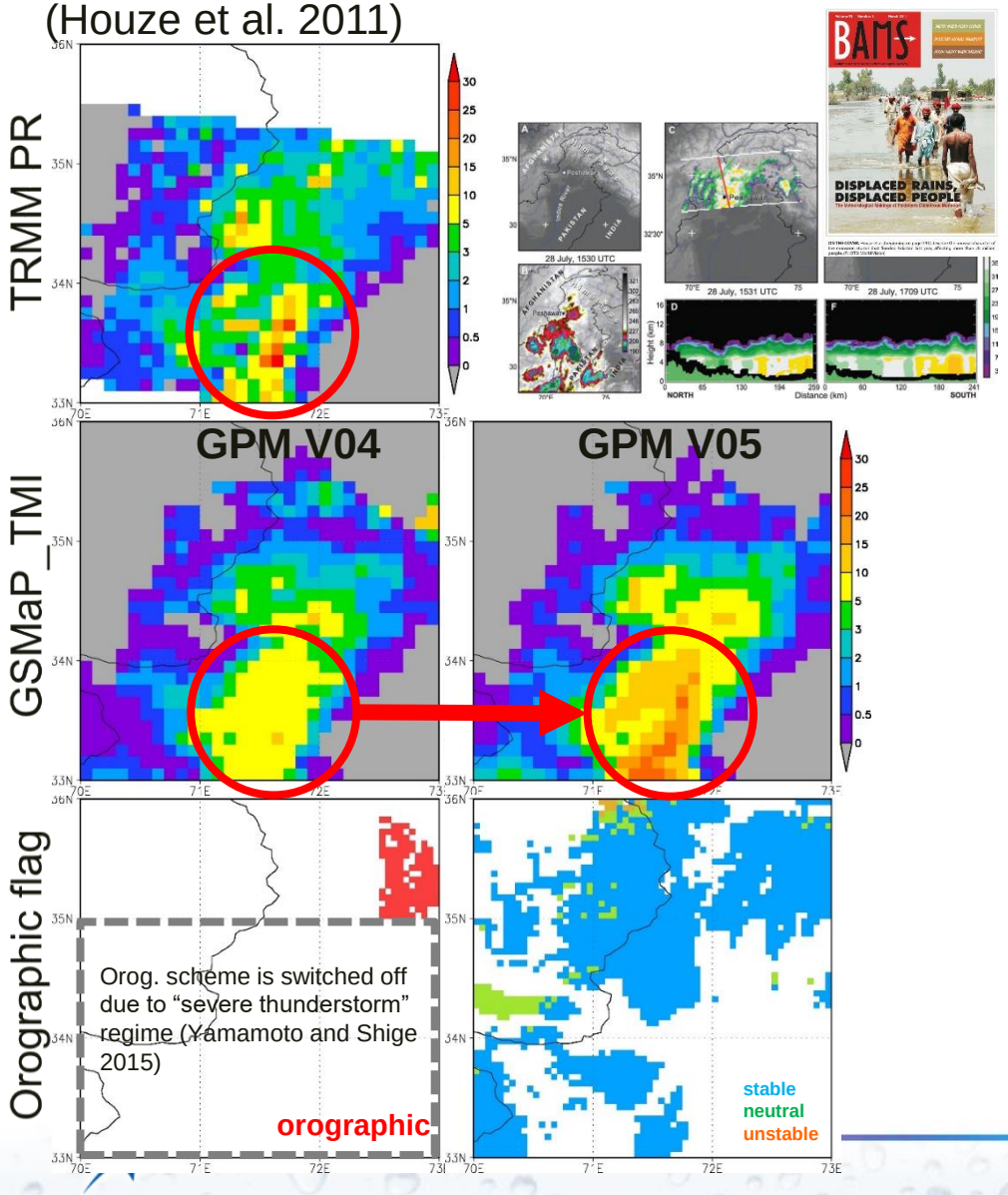
  - Precip/no-precip classification
    - V04: 2-year KuPR & GMI combined method (Seto et al. 2016)
    - V05: 5-year KuPR & GMI combined method (by Dr. M. K. Yamamoto)
  - Surface emissivity
    - V04: Furuzawa et al. (2012) using TMI & PR
    - V05: Furuzawa et al. (2012)+TELSEM (Aires et al. 2011)
  - Frozen precipitation depth
    - Newly installed in V05, presented by Dr. Aonashi at 2019 PMM Science Team Meeting.

Improvements in GPM-GSMaP V05 (2)

- PMW retrieval technique
  - Retrievals derived from more sensors
    - MHS(Metop-C) & ATMS (Suomi-NPP/ATMS, NOAA-20/ATMS)
  - Retrievals extended to the pole-to-pole
    - PMW retrievals only (no PMW-IR combined in 60deg-pole)
  - Dynamic land/ocean classification
    - A technique of Mega and Shige (2016) is applied to all PMW sensors.
  - Snowfall retrievals
    - Refinements of technique based upon Sims and Liu (2015) and Liu and Seo (2013) using CloudSat-DPR-GMI data
    - Improvements of screening in surface snow/sea ice
  - Precipitation detections
    - Improvements of coastal detection in MWS algorithms
- Improvements of Heavy Orographic Rainfall Retrievals
  - See the following slide by Prof. Shige (because this was skipped in his yesterday presentation).

Orographic/nonorographic rainfall classification scheme in V05 (by Prof. Shige)

Pakistan Heavy rainfall event in 28 Jul. 2010
(Houze et al. 2011)



Issues of orographic rainfall scheme in GPM V04:

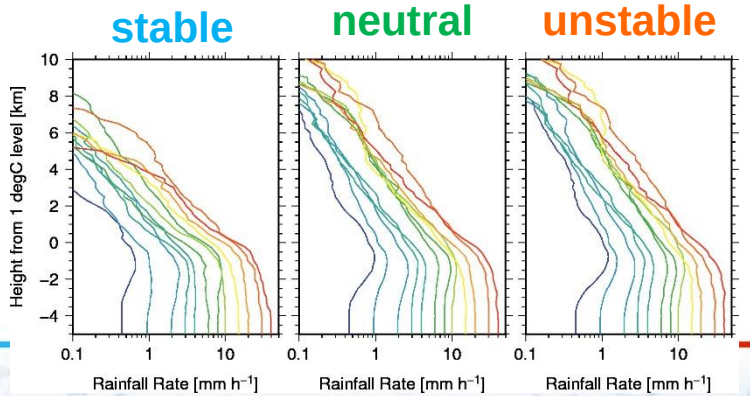
Switching off of the scheme over the regions with strong lightning activity results in underestimation of warm orographic rainfall such as Pakistan Heavy rainfall event in 28 Jul. 2010.

↓

Low-level static stability (Shige and Kummerow 2016) enable the scheme to detect warm orographic rainfall over the regions with strong lightning activity

- Stable upslope: -5.5 < dTv/dz
- Neutral upslope: -6.5 < dTv/dz ≤ -5.5
- Unstable upslope: dTv/dz ≤ -6.5

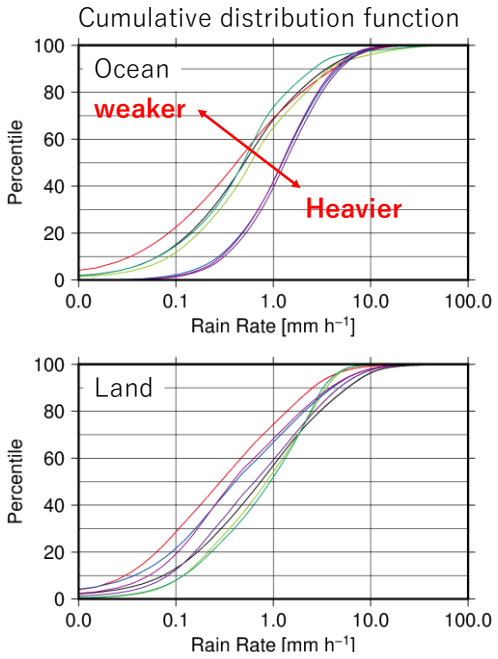
dTv/dz: raplse rate of virtual temperature < 1.5 km above surface [K km^{-1}]



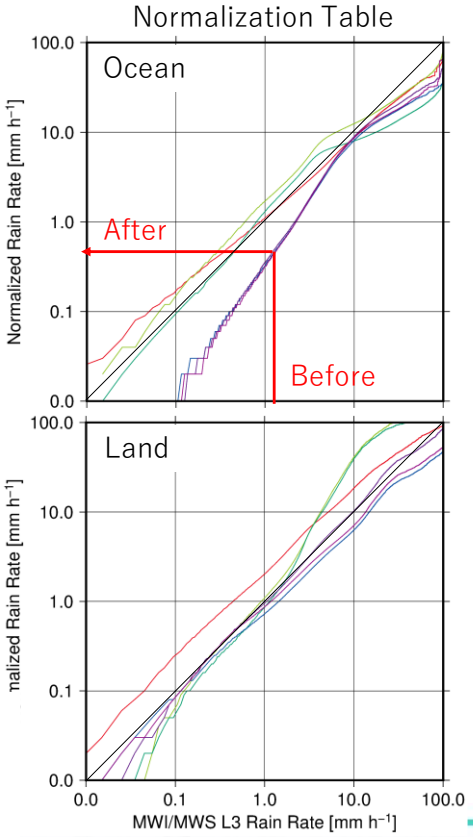
Improvements in GPM-GSMaP V05 (3)

- Normalization module for PMW retrievals (by Dr. M. K. Yamamoto)
  - Newly installed in V05, described in Yamamoto and Kubota (2020)

1. Rain-rate CDF calculated for every sensor

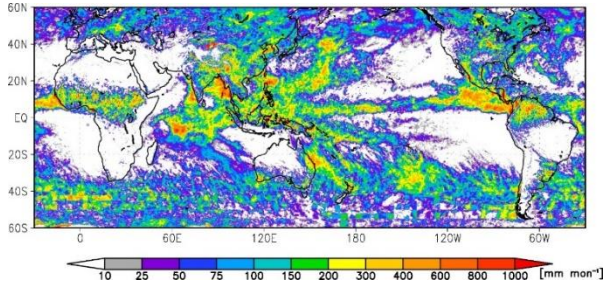


2. Normalization table derived with reference to TMI/GMI

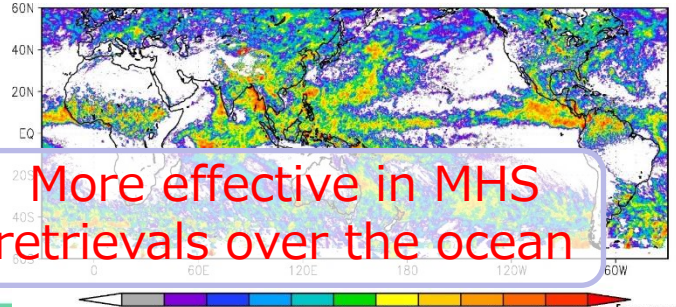


3. Application of the table to PMW retrievals

Mean rainfall applied by the method (F16_SSMIS, July 2008)



Mean rainfall applied by the method (N18_MHS, July 2008)



More effective in MHS retrievals over the ocean

M. K. Yamamoto and T. Kubota, 2020: Development of rainfall normalization module for GSMaP microwave imagers and sounders, *Proc. IGARSS2020*.

Improvements in GPM-GSMaP V05

- PMW-IR Combined algorithm
  - Implementation of histogram matching method by Hirose et al. (2021)

Histogram matching method

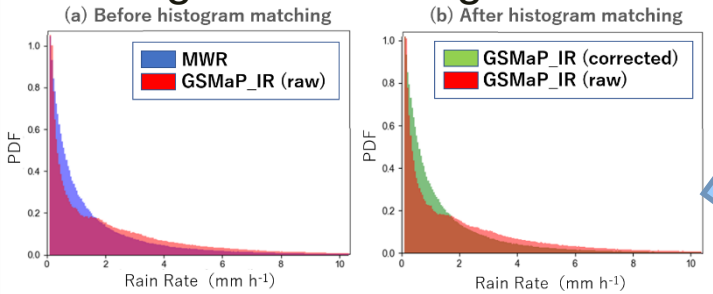


Fig. 1: (a) A rain rate histogram of MWR is shown in blue PDF and that of GSMaP_IR is shown in red PDF. (b) Same as (a), but green PDF shows a rain rate histogram of GSMaP_IR after applying histogram matching.

Mitigations of spatial gaps between PMW and IR retrievals

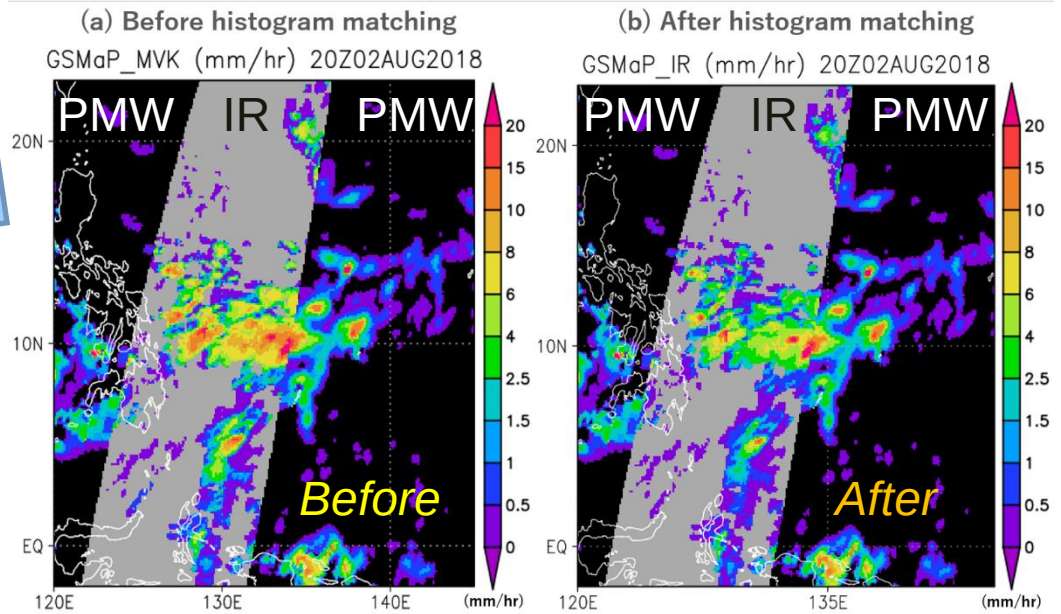


Fig. 3: (a) Snapshot of GSMaP_MVK, black areas are observed by MWR and gray areas are interpolated by GEO IR. (b) same as (a), but histogram correction has been applied.

Mitigations of zonally averaged biases between PMW and IR retrievals

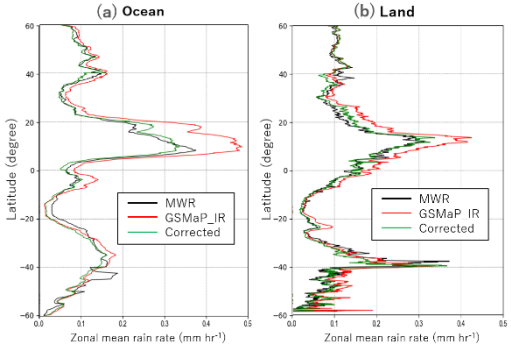


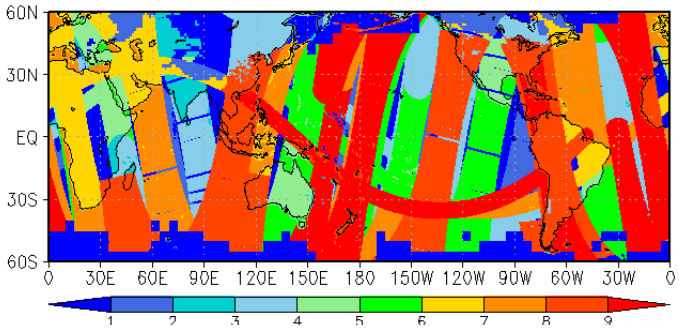
Fig. 6: Zonal mean rain rate (a) over ocean, (b) over land. Black lines show MWR reuslts, red lines show GSMaP_IR results and green lines show those after applying histogram matching.

Hirose et al., 2021: Histogram Matching to Improve Homogeneity in Satellite Merged Precipitation Products, *IEEE GRSL*, *accepted*.

Validation efforts: “Reliability Characterization”

- A reliability flag has been available in the GSMaP since May 2017 because user communities strongly requested a measure of the reliability for the precipitation estimates.
  - 10 levels (10 being the best and 1 the worst) considering surface type reliability, low temperature reliability, and MVK propagation reliability.
- Yamaji et al. (2021, *JMSJ*) was published in June 2021.
  - https://doi.org/10.2151/jmsj.2021-033
  - described the reliability flag and verified the effectiveness by classifying the GSMaP skills with reference to ground radar data around Japan.

A snapshot of the reliability flag for GSMaP_NRT



M. Yamaji, T. Kubota, and M. K, Yamamoto, 2020b: An Approach to Reliability Characterization of GSMaP Near-Real-Time Precipitation Product, *J. Meteor. Soc. Japan*. https://doi.org/10.2151/jmsj.2021-033

Seasonal march of thread score for each level of the flag