Global Precipitation Measurement (GPM)
GSMaP Product V04
(Algorithm version 7)
Release Note

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

Jan. 2017

GPM-GSMaP V04 (Algorithm version 7)

- The GSMaP products was updated to Product version 04 (V04A)/Algorithm version 7 on 17th Jan., 2017.
  - The data from March 2014 will be reprocessed by the end of Mar. 2017. After that, the data from Mar. 2000 will be reprocessed.
- There are following improvements in V04 from V03.
  1. Improvement of GSMaP algorithm using GPM/DPR observations as database (DB)
  2. Improvement of the algorithm over the high latitudes by implementation of snowfall estimation method and NOAA multisensor snow/ice cover maps
  3. Improvement of gauge-correction method in both near-real-time and standard products
  4. Improvement of orographic rain correction method
  5. Improvement of weak rain detection over the ocean by considering cloud liquid water

GPM-GSMaP Product list

Standard product (Latency: 3 days)

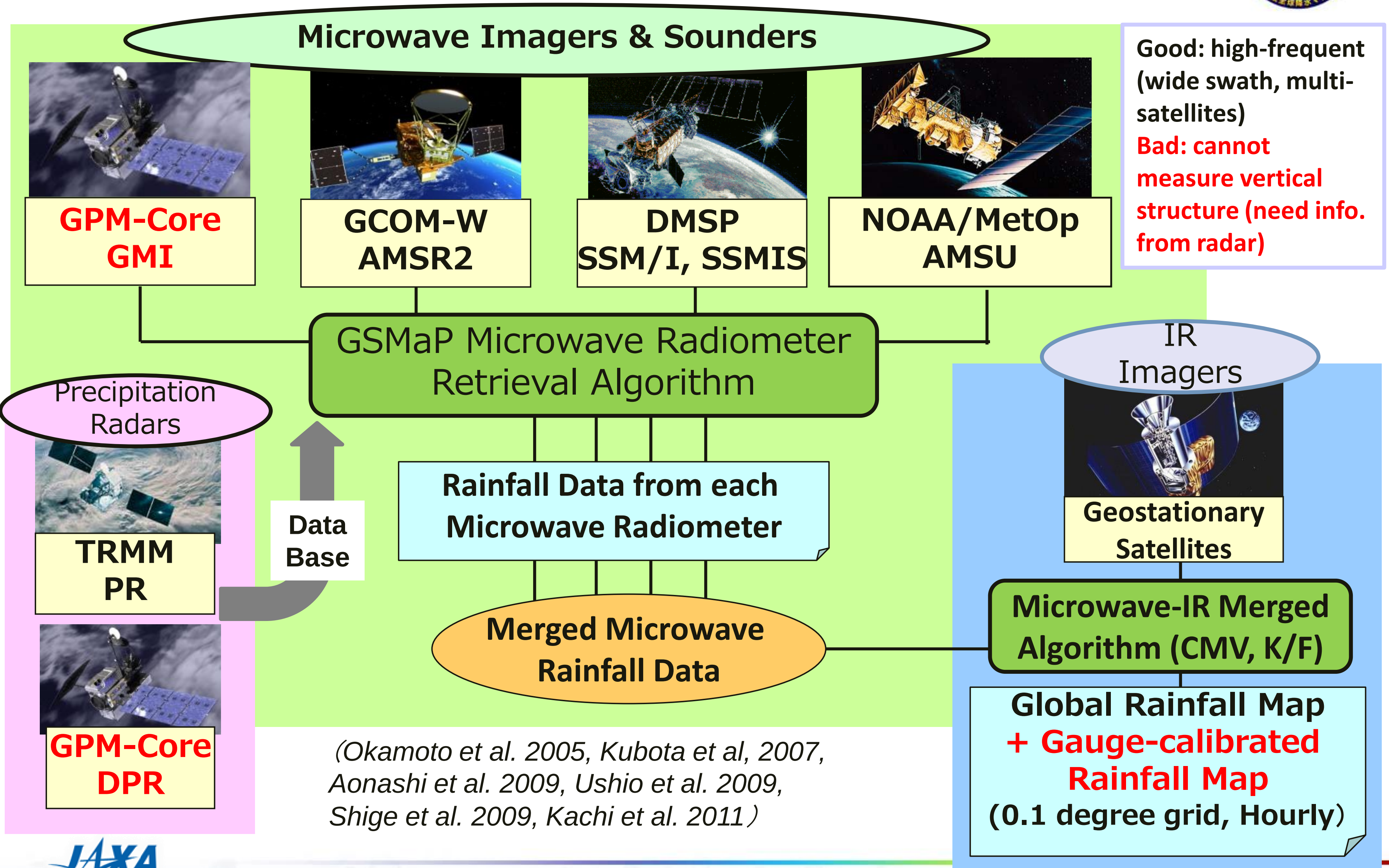
Product name	Variables	Horizontal resolution	Temporal resolution	Latency	Correction
L3 GSMaP Hourly	Hourly Precip Rate (**GSMaP_MVK**)	0.1×0.1 deg.lat/lon	1 hour	3 days	None
	Gauge-adjusted Hourly Precip Rate (**GSMaP_Gauge**)				adjusted by daily rain gauges (NOAA CPC Gauge-Based Analysis, Chen et al. 2008)

Near-real-time product (Latency: 4 hours)

Product name	Variables	Horizontal resolution	Temporal resolution	Latency	Correction
L3R GSMaP Hourly	Hourly Precip Rate (**GSMaP_NRT**)	0.1×0.1 deg.lat/lon	1 hour	4 hours	None
	Gauge-adjusted Hourly Precip Rate (GSMaP_Gauge_NRT)				Correction by empirical coefficients

GPM-GSMaP data is now available from JAXA G-portal (https://www.gportal.jaxa.jp) as well as current GSMaP web site (http://sharaku.eorc.jaxa.jp/GSMaP/).

Overview of GSMaP Algorithm



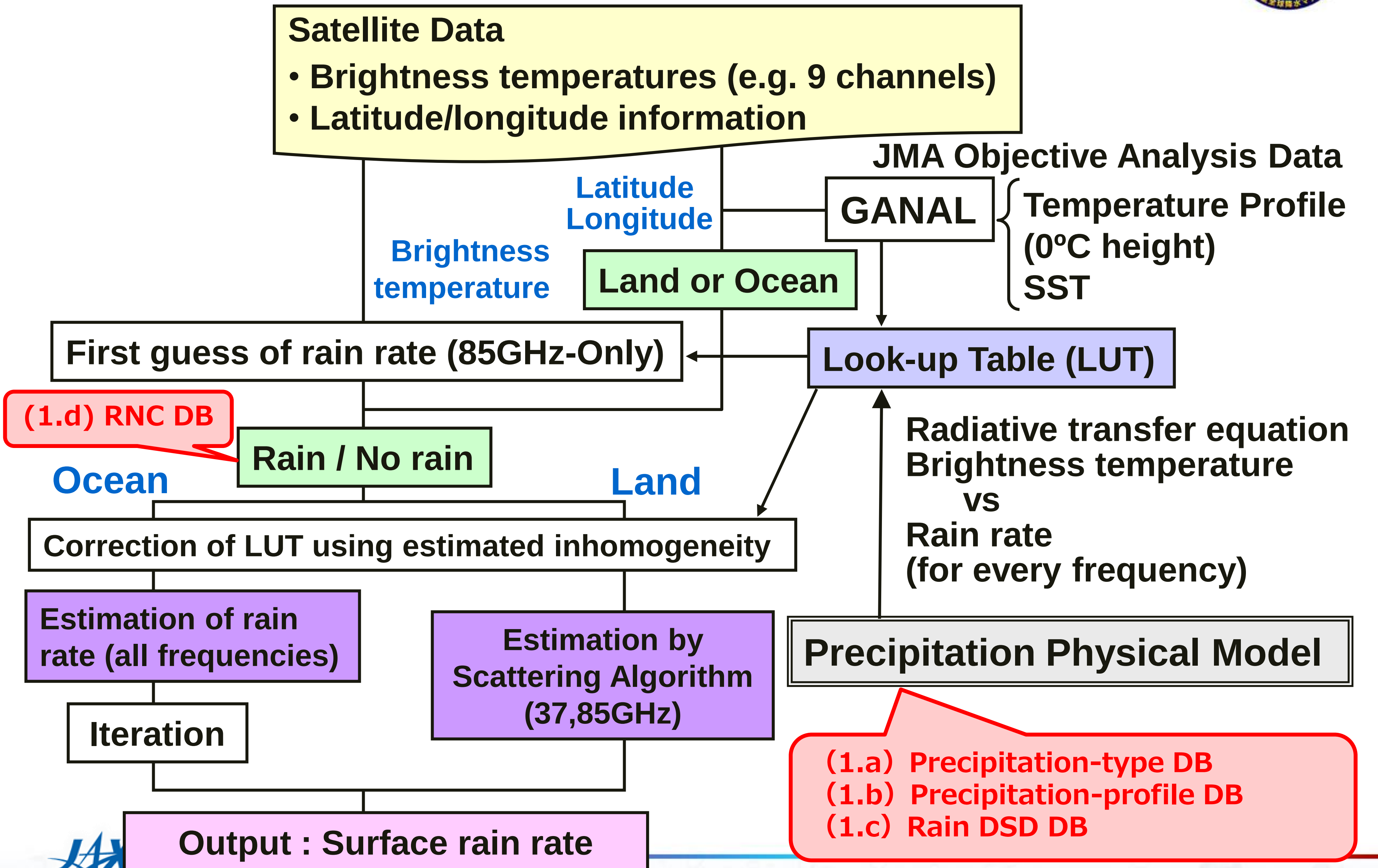
(Okamoto et al. 2005, Kubota et al, 2007, Aonashi et al. 2009, Ushio et al. 2009, Shige et al. 2009, Kachi et al. 2011)

http://sharaku.eorc.jaxa.jp/GSMaP/

(1) Utilization of GPM/DPR DB

- In the GSMaP algorithm, following DBs are used in the precipitation estimation. From the V04, DBs constructed from the GPM/DPR observations are integrated into the algorithms.
  - Precipitation physical model for calculation of Look-up tables
    - (1.a) Precipitation-type DB (by Hamada and Takayabu, Univ. Tokyo)
    - (1.b) Precipitation-profile DB (by Hamada and Takayabu, Univ. Tokyo)
    - (1.c) Rain Drop Size Distribution (DSD) DB (by Yamaji and Kubota, JAXA/EORC)
  - (1.d) Rain/No-rain classification (RNC) DB (by Seto, Nagasaki Univ.)
- Here, the DBs were made by the GPM/DPR data during 2-year period from Apr. 2014 to Mar. 2016.
  - GPM/KuPR data were used in the DB because more sample numbers were necessary, due to such small data accumulation (just 2 years).
  - The GPM/DPR dual-frequency product will be used in future algorithms.

Flowchart of GSMaP MWR algorithm



DBs used in the GSMaP_MWR algorithm: Precipitation Types and Profiles from TRMM PR

(Takayabu 2008)

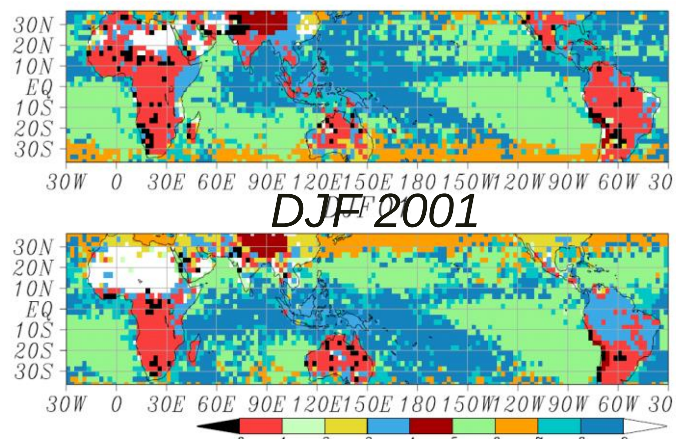
Classification of Precipitation Type

Precipitation type DB

2.5º grid
Every 3 months
10 types (land × 6, ocean × 4)

Stratiform pixel ratio
Stratiform rain ratio
Precipitation area
Rain top height
Rain intensity

JJA 2001



(Land)
0: Severe Thunderstorm
1: Afternoon Shower
2: Shallow
3: Ext-trop Frontal Systems
4: Organized
5: High Land

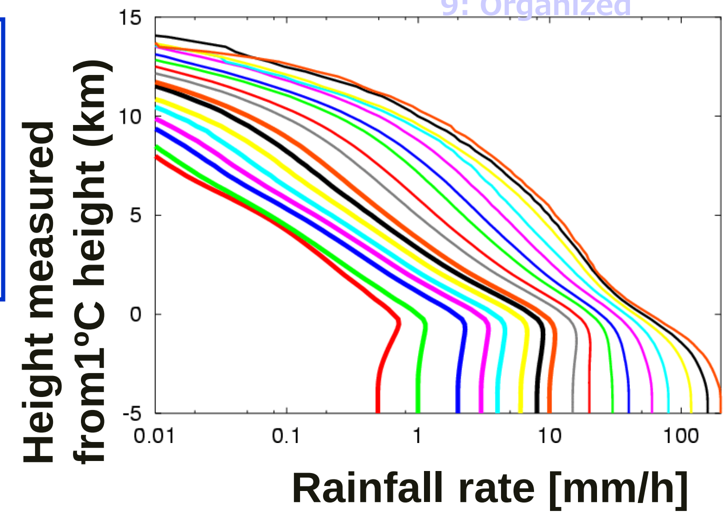
(Ocean)
6: Shallow
7:Ext-trop Frontal Systems
8:Transition Z.
9: Organized

Profile for each type

Precipitation profile DB

Classified by precipitation type and surface rainfall rate

Profiles : Type-1 Afternoon shower type (LAND)

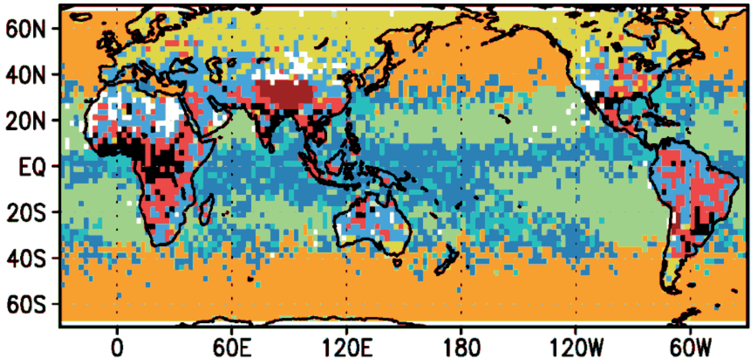


Rainfall rate profiles classified by rainfall rate (Type-1)
0.5, 1, 2, 3, 4, 6, 8, 10, 15, 20, 30, 40, 60, 80, 120, 160, 200 mm/h

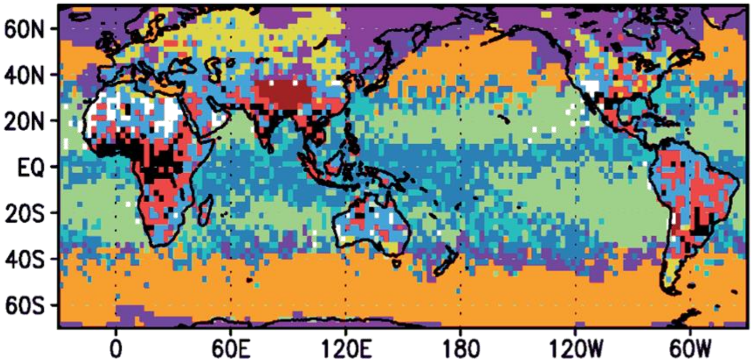
(1.a & 1.b) Precipitation Type & Profile DB

- 40-65 degrees of latitudes correspond to areas outside of the TRMM coverage, and of the first observation by spaceborne precipitation radar.
- →Development of new methods for classification of mid-high latitude precipitation types with global objective analysis (Hamada and Takayabu, Univ. of Tokyo)

Pre-versions
Due to a limitation of the TRMM coverage, one type, that is, "Extratropical frontal systems" was categorized in the mid/high latitude precipitation.



Current version
The mid/high latitude precipitation-type was divided into Extratropical frontal systems and Stationary types

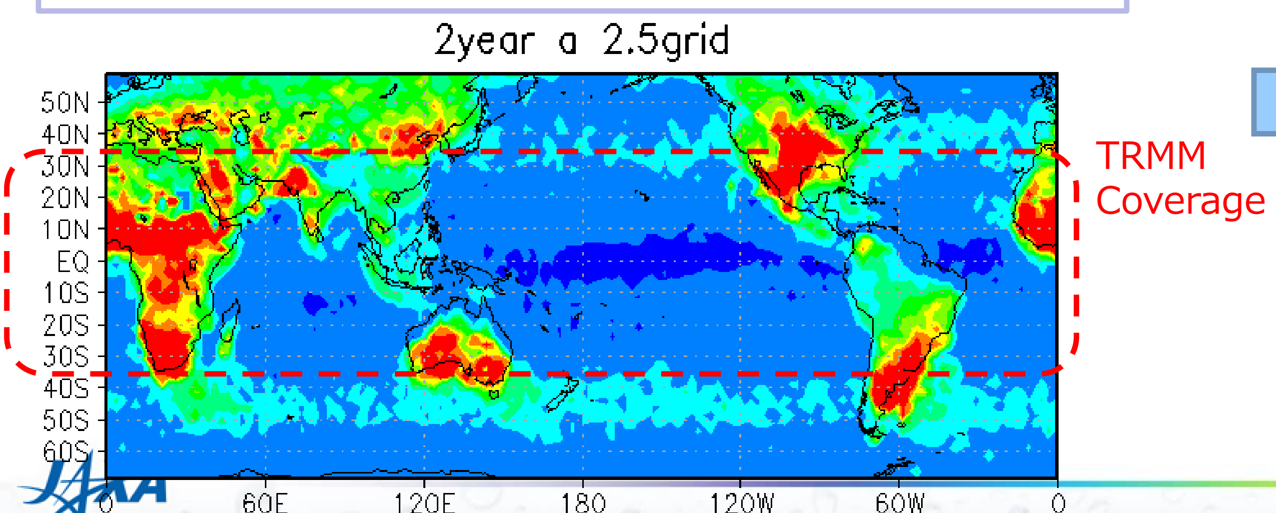


(Before) "Extratropical frontal systems"→
(After) "Extratropical frontal systems" & "Stationary"

(1.c) DSD DB

- Development of DSD DB based upon the GPM/DPR
  - The method by Kozu et al. (2009) and Aonashi et al. (2009) using the TRMM/PR data was applied to the GPM/KuPR data, which leads to expansion to 40-60 degrees of latitudes (Yamaji and Kubota, JAXA/EORC)
  - In future DB, the GPM/DPR Dual-frequency product will be used.

Horizontal distribution of "a" in $Z=aR^b$ for convective precipitation, derived from 2 year-data of the GPM/KuPR



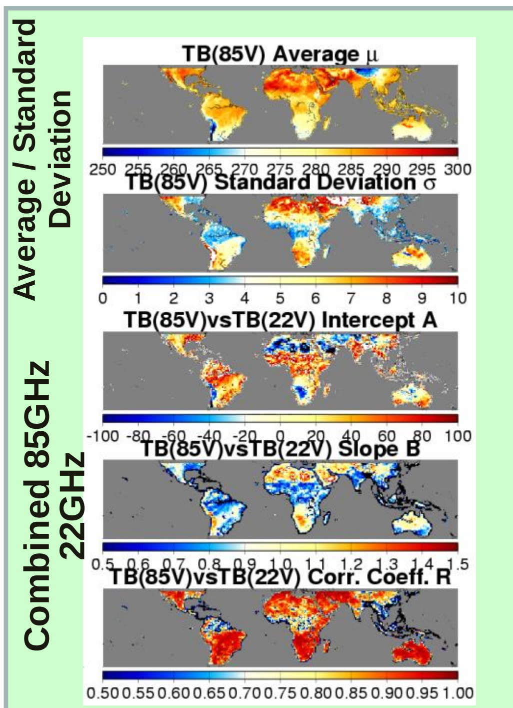
"a" value was averaged in each precipitation type, and used in the RTM calculation for the construction of the Look-up table.

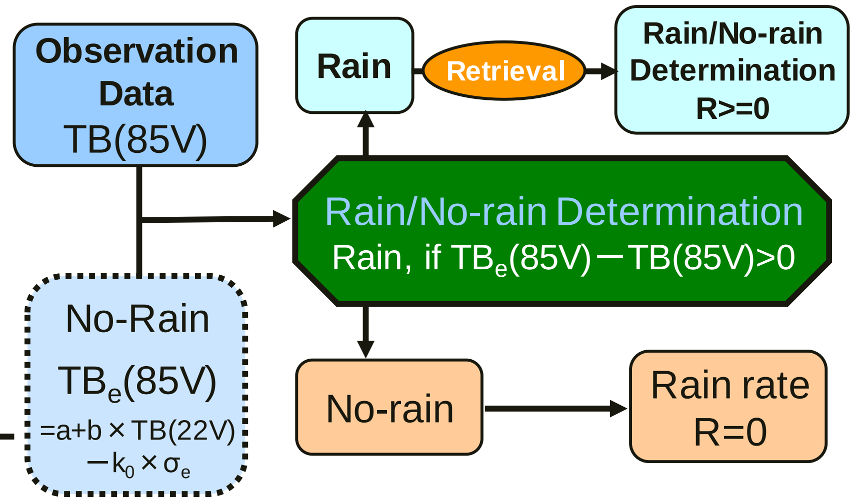
(1.d) RNC DB

- Development of RNC DB based upon the GPM
  - Seto et al. (2005)'s method for the TRMM/PR & TMI data was applied to the GPM/DPR & GMI data, which leads to expansion to 40-60 degrees of latitudes (Seto, Nagasaki Univ.)

Concept of Seto et al. (2005)'s method

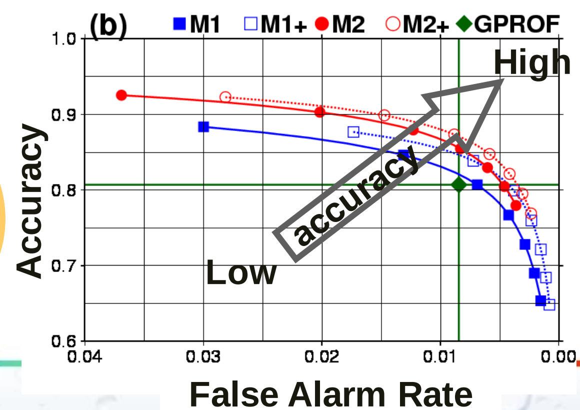
Database of Brightness Temperature with No Rain





Results

Rain/No-rain determination accuracy becomes better than that of GPROF



(2) Improvement of the algorithm over the high latitudes

- (2) Improvement of the algorithm over the high latitudes (by Kubota, JAXA/EORC)
  - (a) Implementation of snowfall estimation method
    - There were no snowfall estimates in previous GSMaP products.
    - In V04 (algorithm version 7), Snow-Rain Separation method (Sims and Liu 2015) and Snowfall estimation method(Liu and Seo 2013) were integrated into the GSMaP algorithm for the GMI and the SSMIS.
  - (b) Implementation of NOAA multisensor snow/ice cover maps (autosnow)
    - By using the autosnow data, wrong estimates related to the surface snow & the sea ice were mitigated.
    - This effects not only the GMI and the SSMIS, but also other sensors such as the AMSR2.

Flowchart of Prof. Liu’s code for snowfall estimate in the GMI

CloudSat-GPM Coincidence Dataset
by Joe Turk/JPL

Classification of snow/rain (Sims and Liu 2015)

↓ snow

Retrieval

↓

- Snowfall Probability
- Snowfall Rate

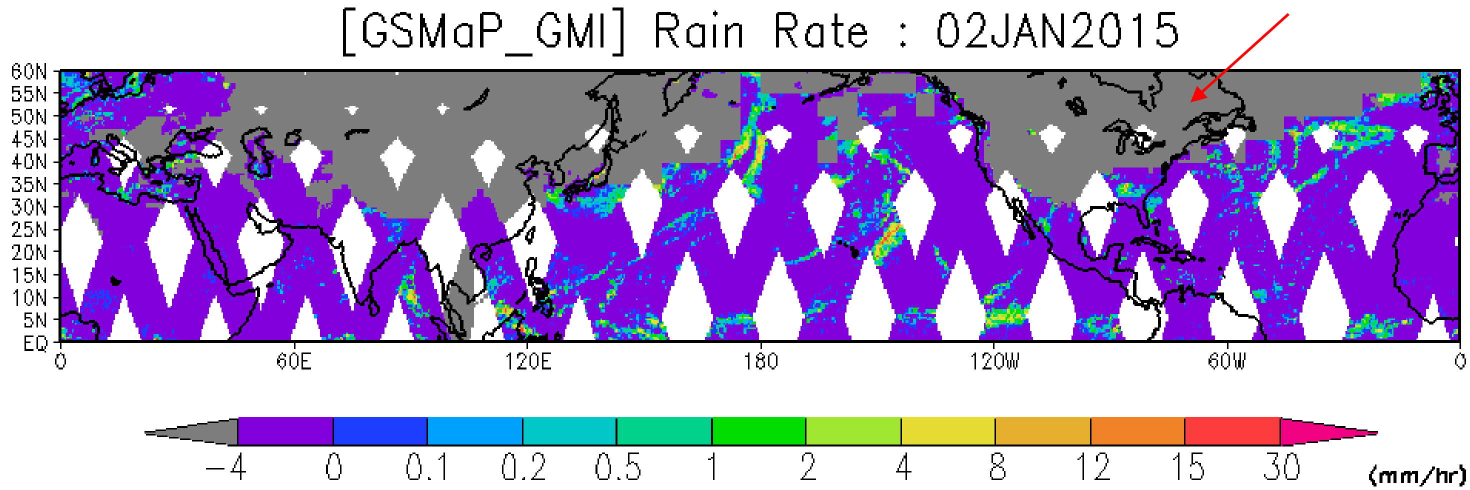
<u>Look-up table for snow regime</u>

- Based upon Liu and Seo (2013)
- Project observed TBs to the first 3 PCs
- In the 3-d EOF space, using GMI-CloudSat/KuPR matchups, compute the probability of snowfall (CloudSat near-surface dBZe>-15) and snowfall rate

Example of implementation of the snowfall estimation method

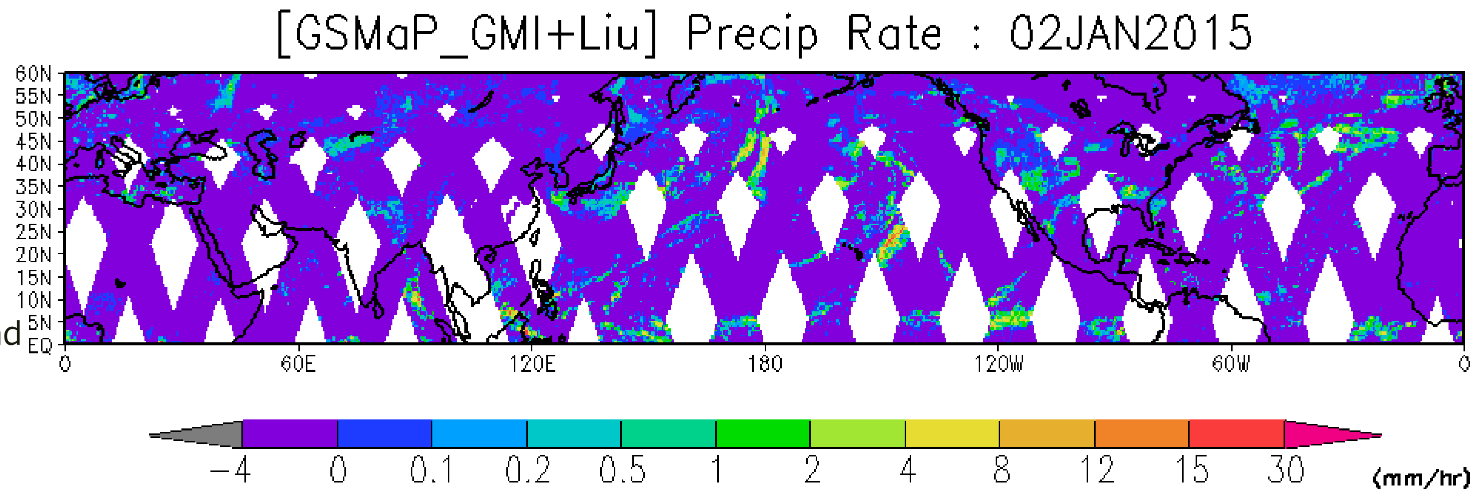
Grey: Missing value

GSMaP V03



GSMaP V04 test

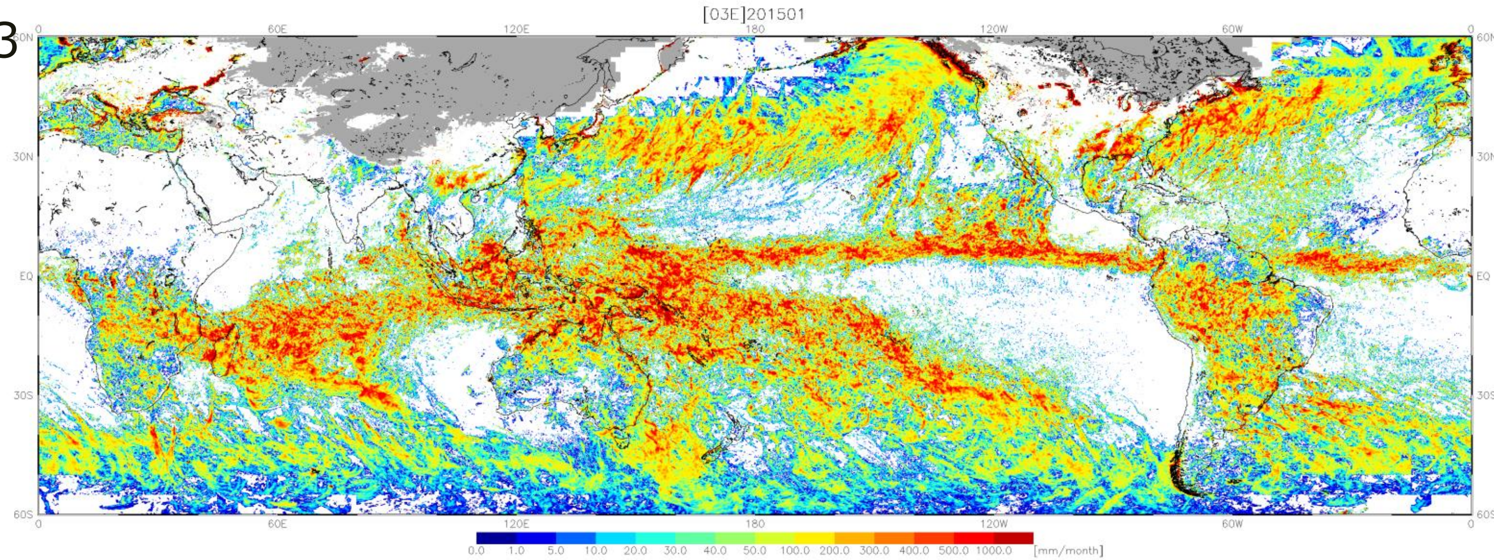
- Snow-Rain Separation method (Sims and Liu 2015)
- Snowfall estimation (Liu and Seo 2013)



Changes from V03 to V04 for the GMI retrievals on Jan. 2015

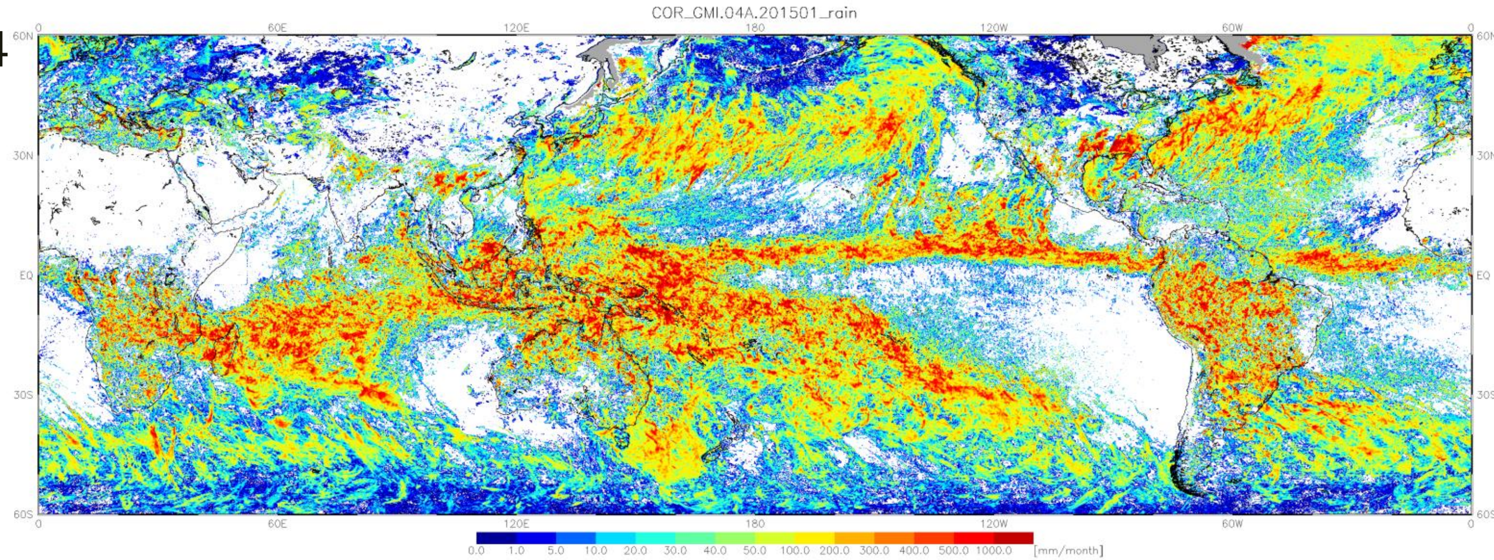
GSMaP_GMI V03 (Jan 2015)

- Lack of detections of snowfall in the Eurasian Continent and North American Continent



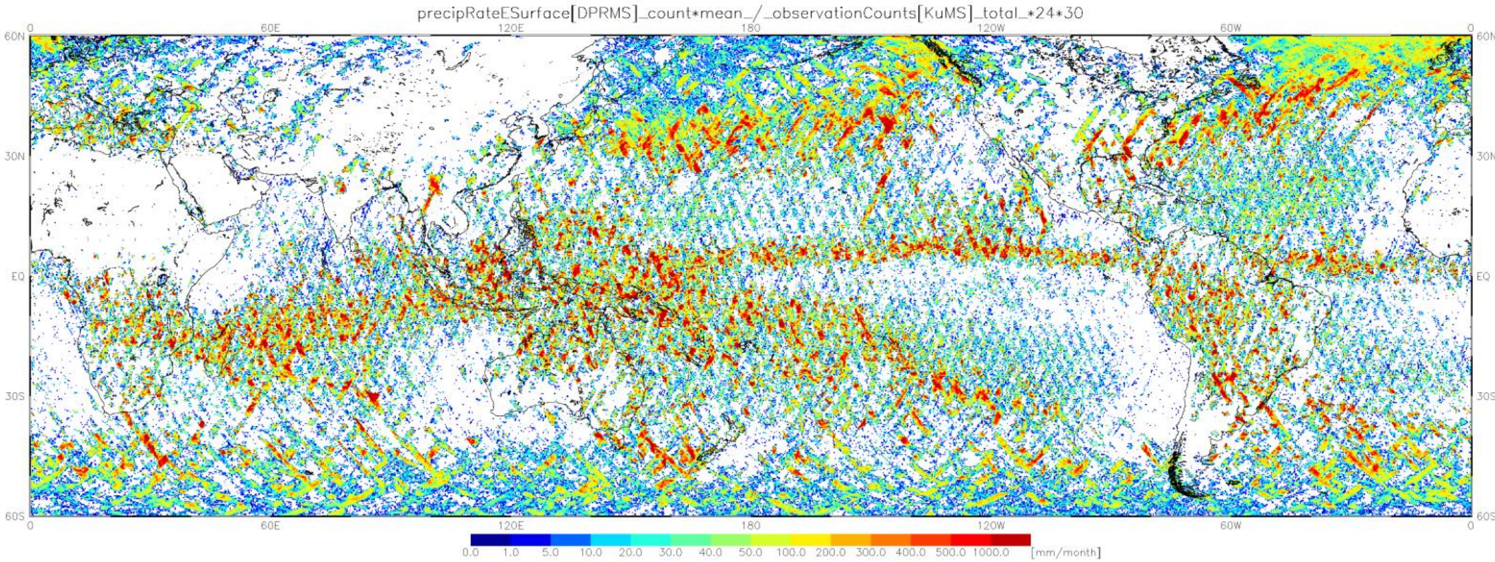
GSMaP_GMI V04 (Jan 2015)

- There were detections of snowfall in the Western Eurasian Continent and North-West American Continent

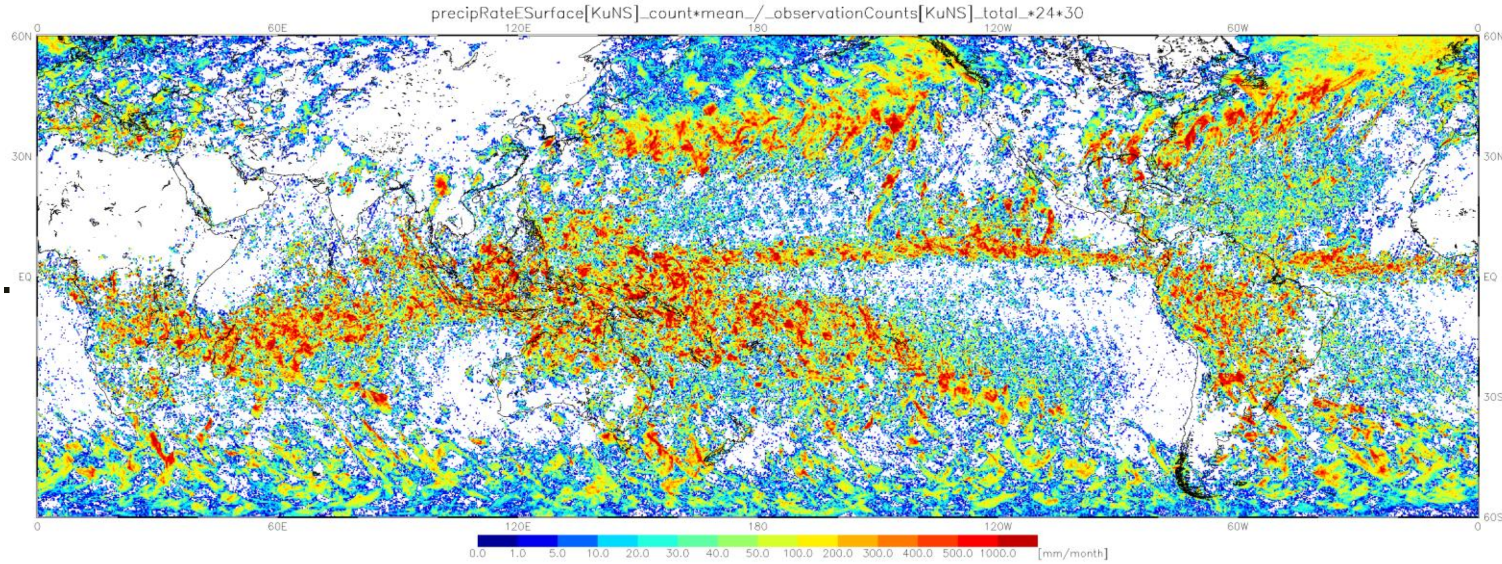


Comparison with reference to the GPM/DPR on Jan. 2015

Surface precipitation amount of the GPM/DPR Dual-frequency product on Jan. 2015



Surface precipitation amount of the GPM/KuPR product on Jan. 2015



Horizontal pattern of the GSMaP_GMI V04 retrievals were similar to that of the GPM/DPR.

Improvement of other components

- 3) Improvement of gauge-correction method in both near-real-time and standard products
  - Developed by Ushio and Mega (Osaka Univ.)
  - In the near-real-time product, the method was changed substantially.
  - In the standard product, the method was modified and the current method is not applied in the gauge-sparse region such as in Central Africa.

- 4) Improvement of orographic rain correction method
  - Developed by Shige and Yamamoto (Kyoto Univ.)
  - See Yamamoto and Shige (2015).

- 5) Improvement of weak rain detection over the ocean by considering cloud liquid water
  - Developed by Aonashi (JMA/MRI)
  - Effects are larger over the subtropical ocean.

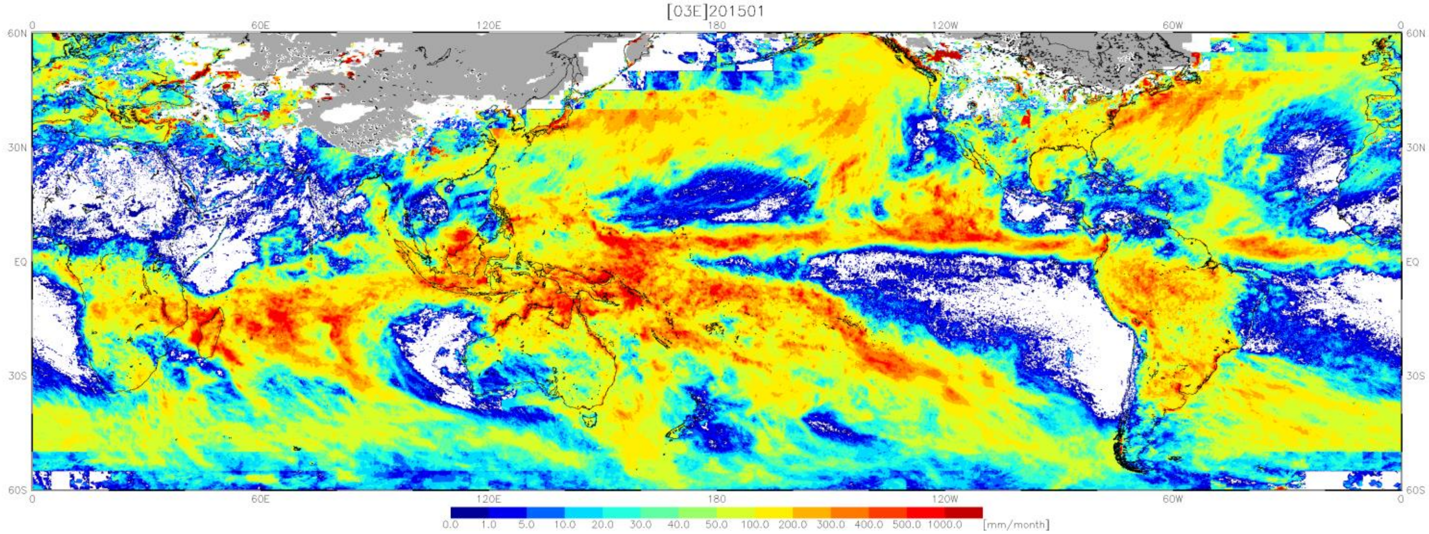
Summary of algorithm improvements in V04 (algorithm version 7)

Name	Details	Effects
Utilization of GPM/DPR data	Precipitation-type DB Precipitation-profile DB Rain DSD DB	Larger effects, in particular, over the areas outside the TRMM coverage
	RNC DB	
High latitudes	Implementation of snowfall estimation method	Larger effects, in particular, over the low temperature areas
	Implementation of NOAA autosnow data	Larger effects, in particular, over the snow cover and the sea-ice
Others	Gauge-correction method in the near-real-time product	Globally higher accuracy
	Gauge-correction method in the standard product	Larger effects, in particular, over the gauge-sparse areas such as Central Africa
	Orographic rain correction method	Larger effects over coastal moist monsoon region
	Weak rain detection over the ocean	Larger effects over subtropical ocean

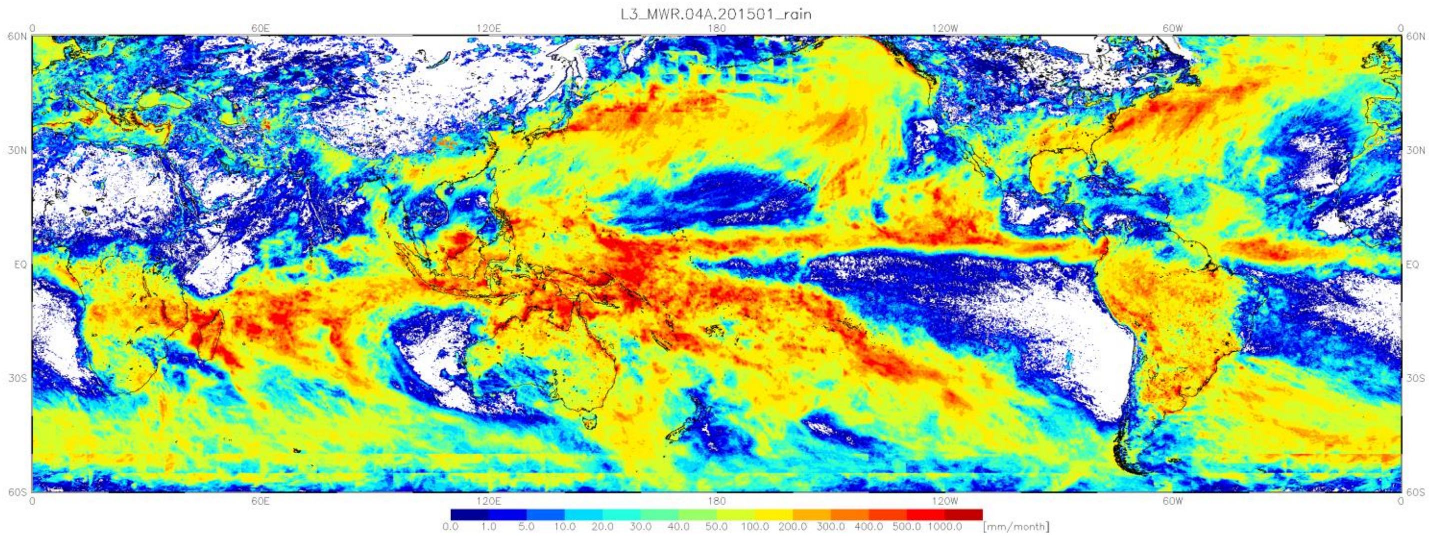
Evaluation results of V04 (1)

Horizontal distribution of V03 vs. V04for MWR-merged precipitation amount (Jan. 2015)

V03

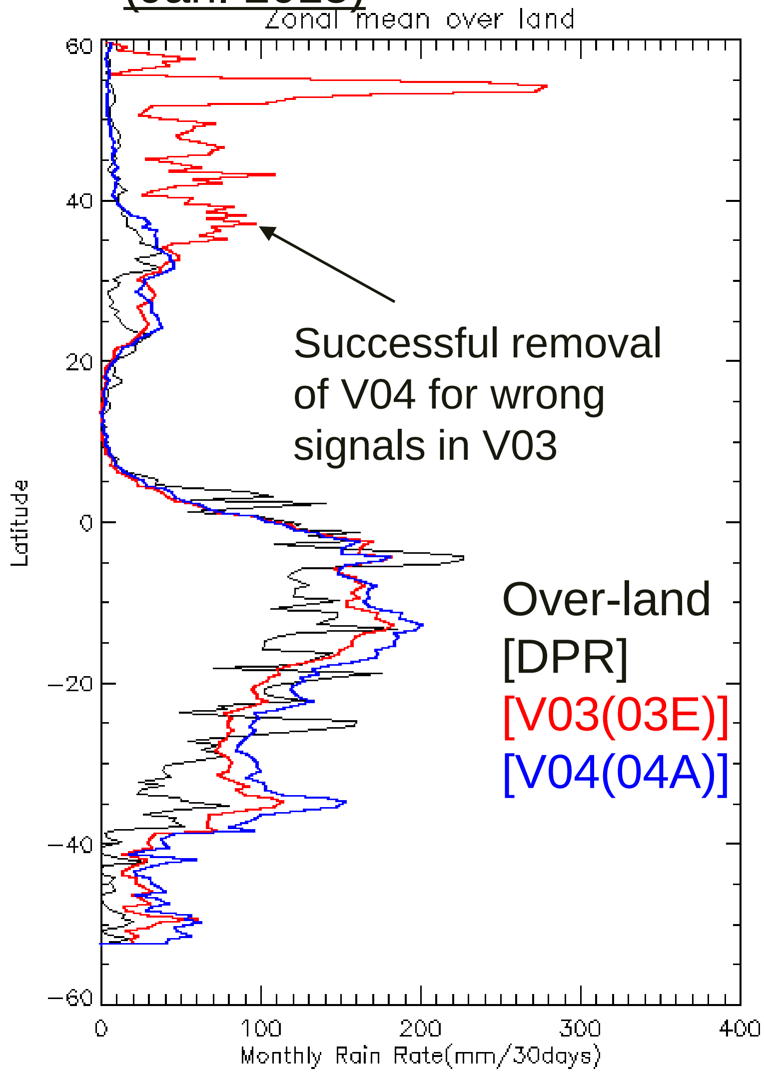


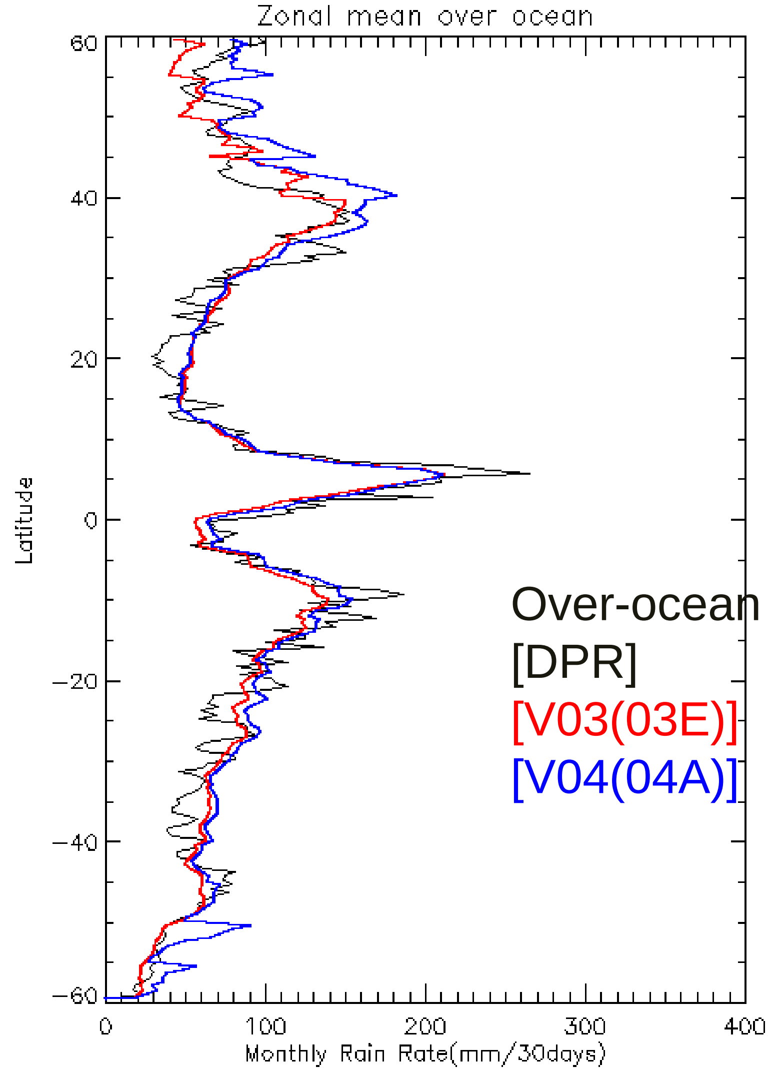
V04
test



Evaluation results of V04 (2)

Zonal mean of V03 vs. V04for MWR-merged precipitation amount (Jan. 2015)

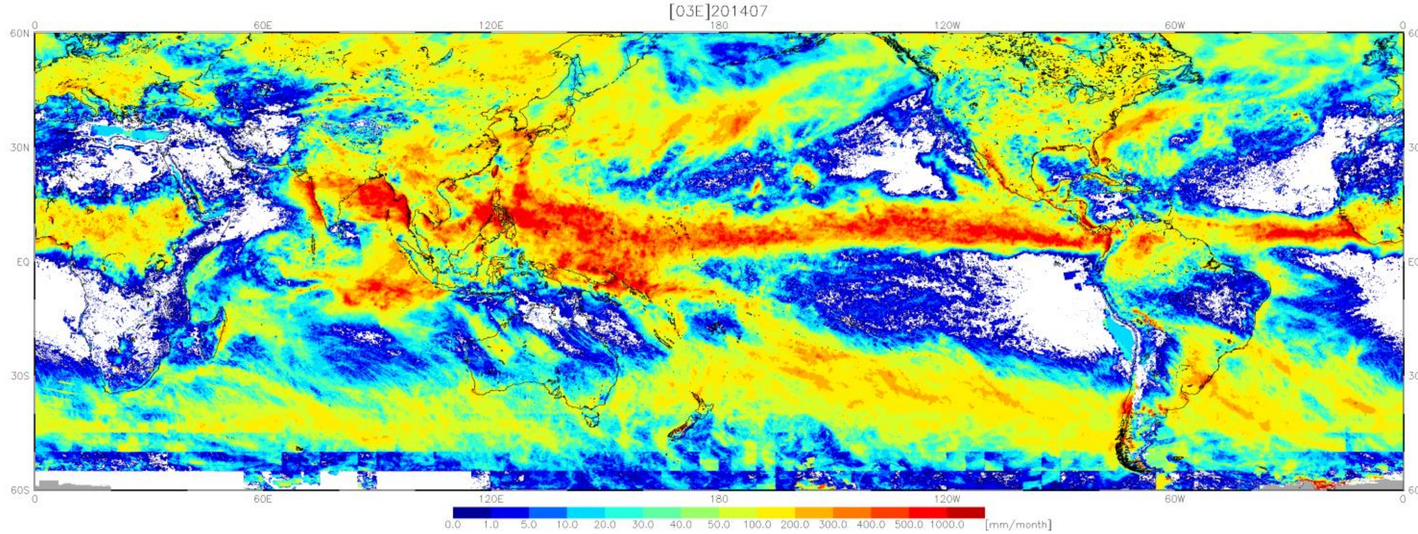




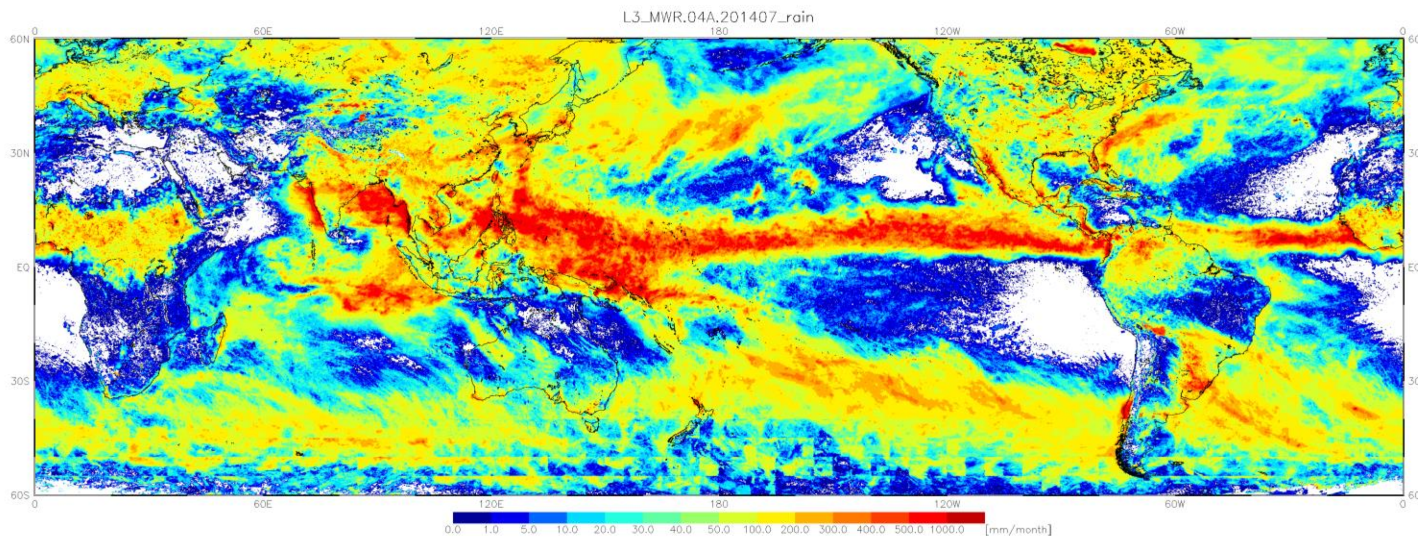
Evaluation results of V04 (3)

Horizontal distribution of V03 vs. V04for MWR-merged precipitation amount (Jul. 2014)

V03

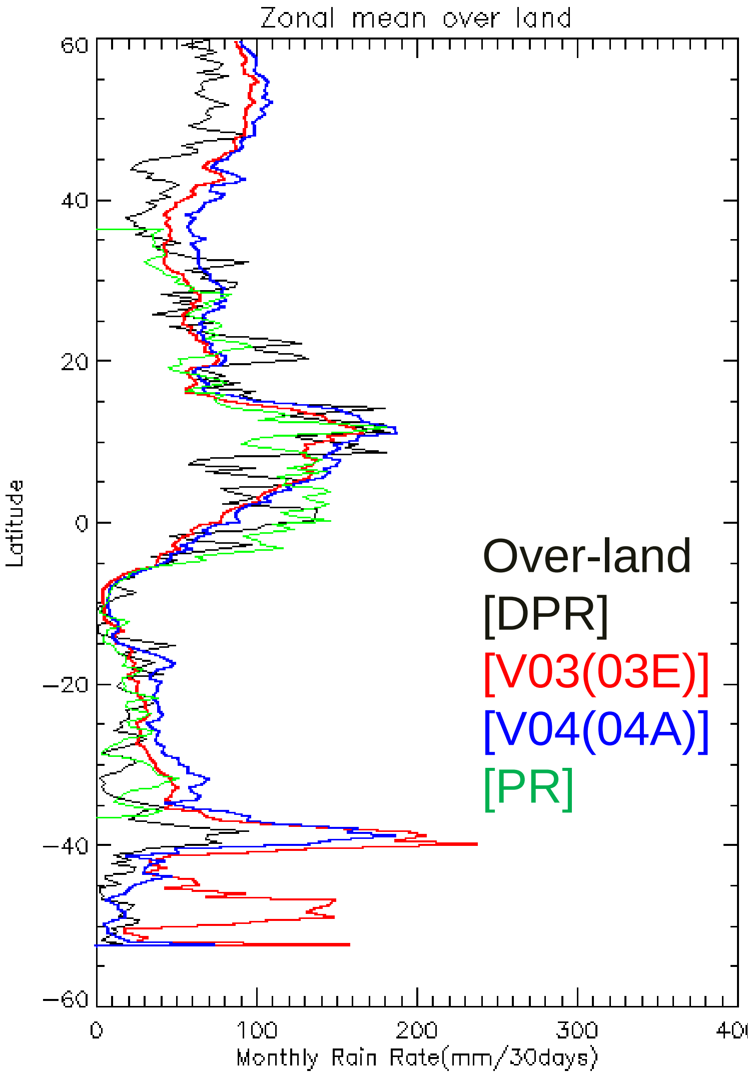


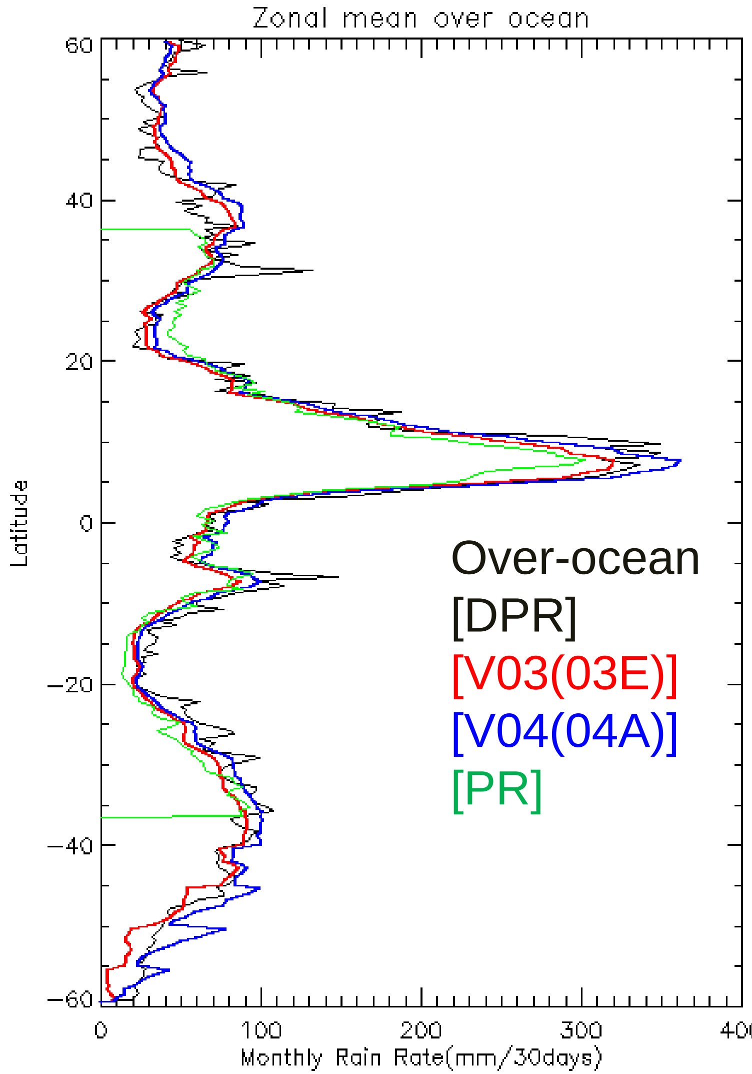
V04



Evaluation results of V04 (4)

Zonal mean of V03 vs. V04for MWR-merged precipitation amount (Jul. 2014)

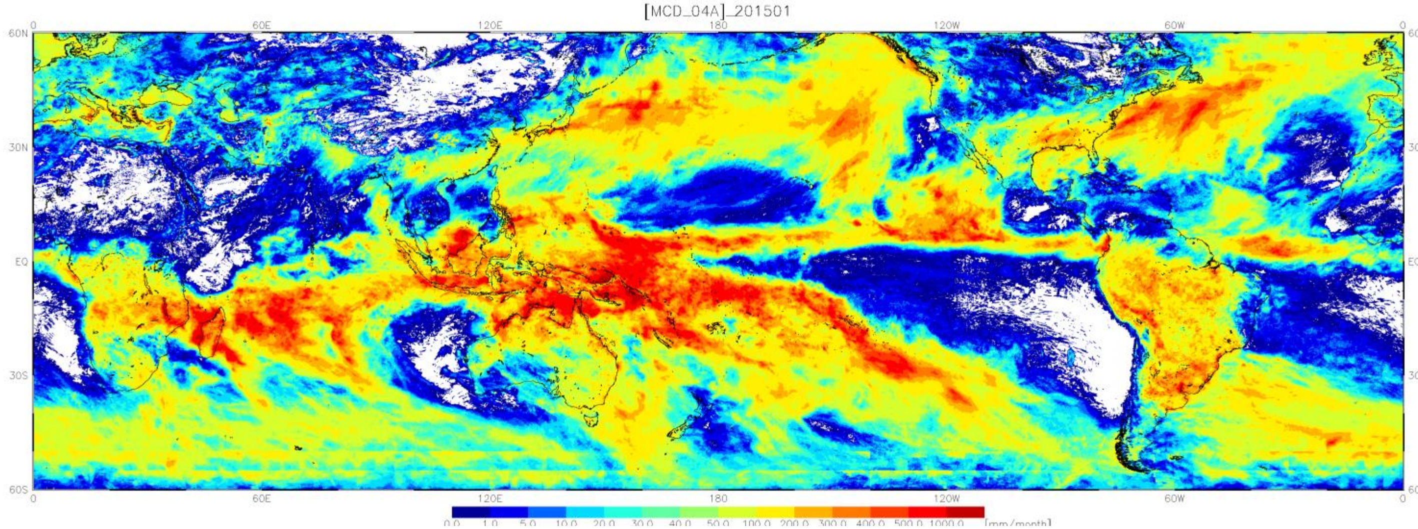




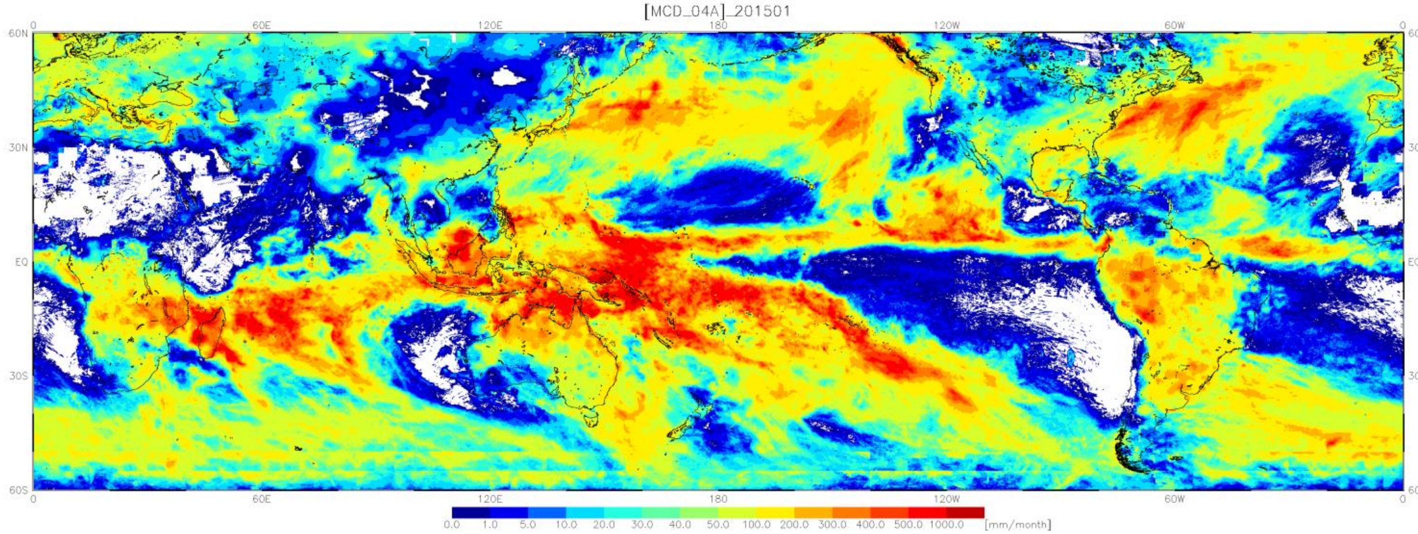
Evaluation results of V04 (5)

<u>Horizontal distribution of V04 for the standard products (Jan. 2015)</u>

GSMaP_MVK (without the gauge correction)

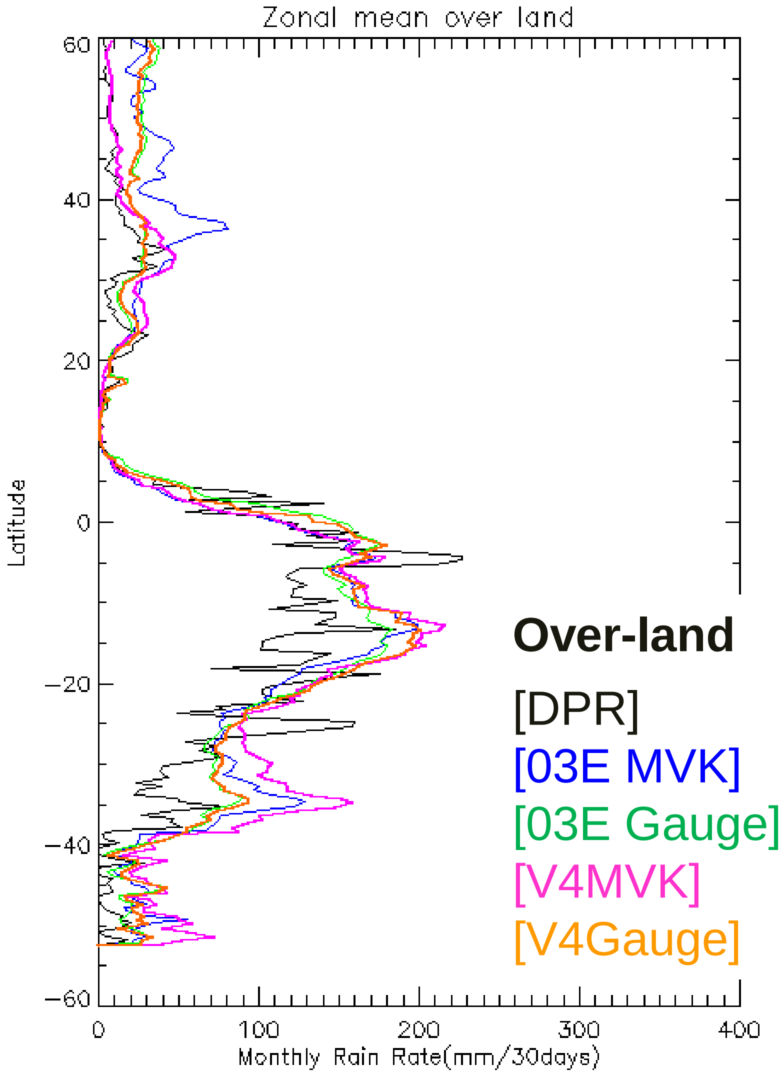


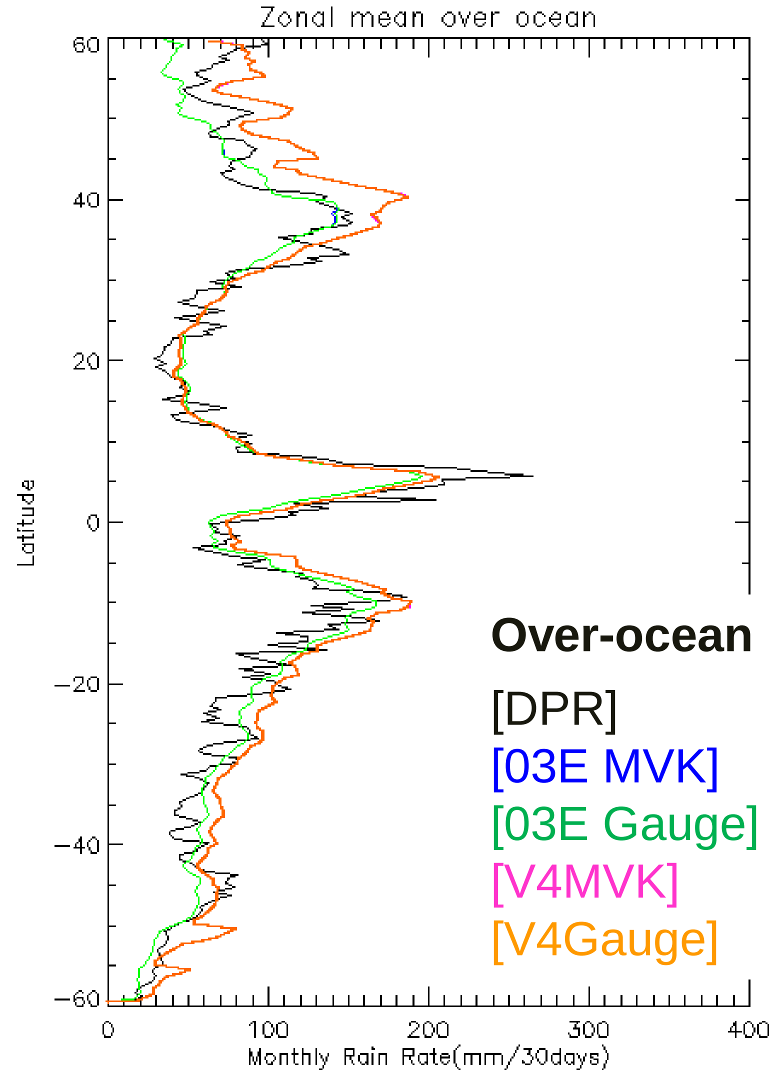
GSMaP_Gauge (with the gauge correction)



Evaluation results of V04 (6)

Zonal mean of V03 vs. V04for the standard products (Jan. 2015)

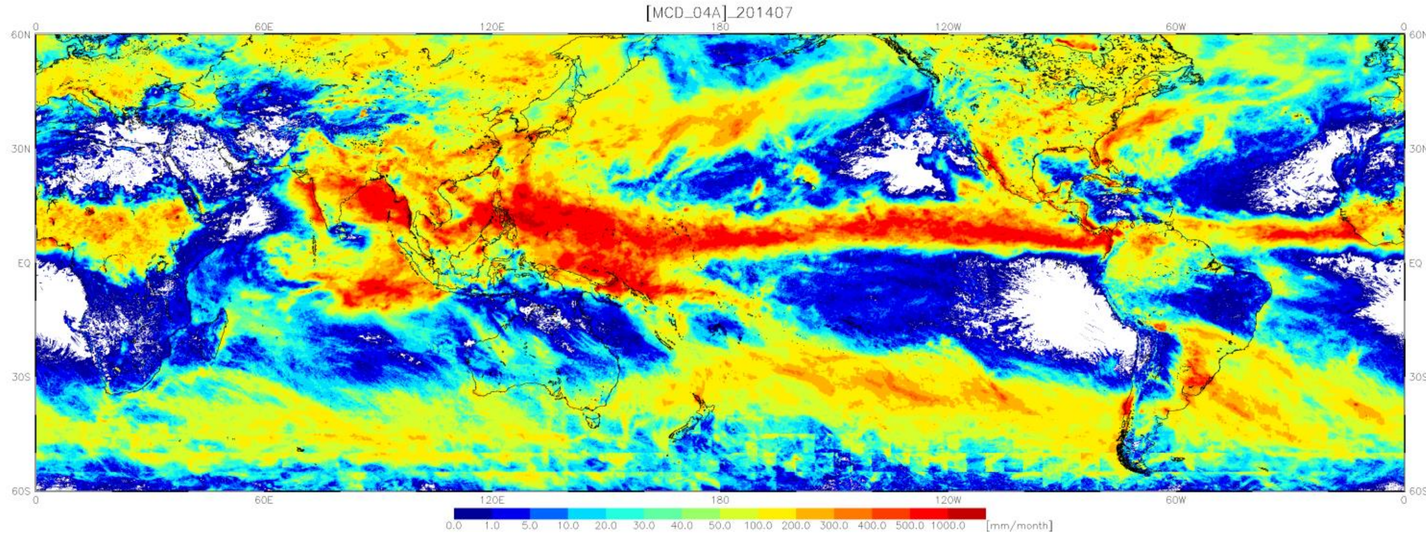




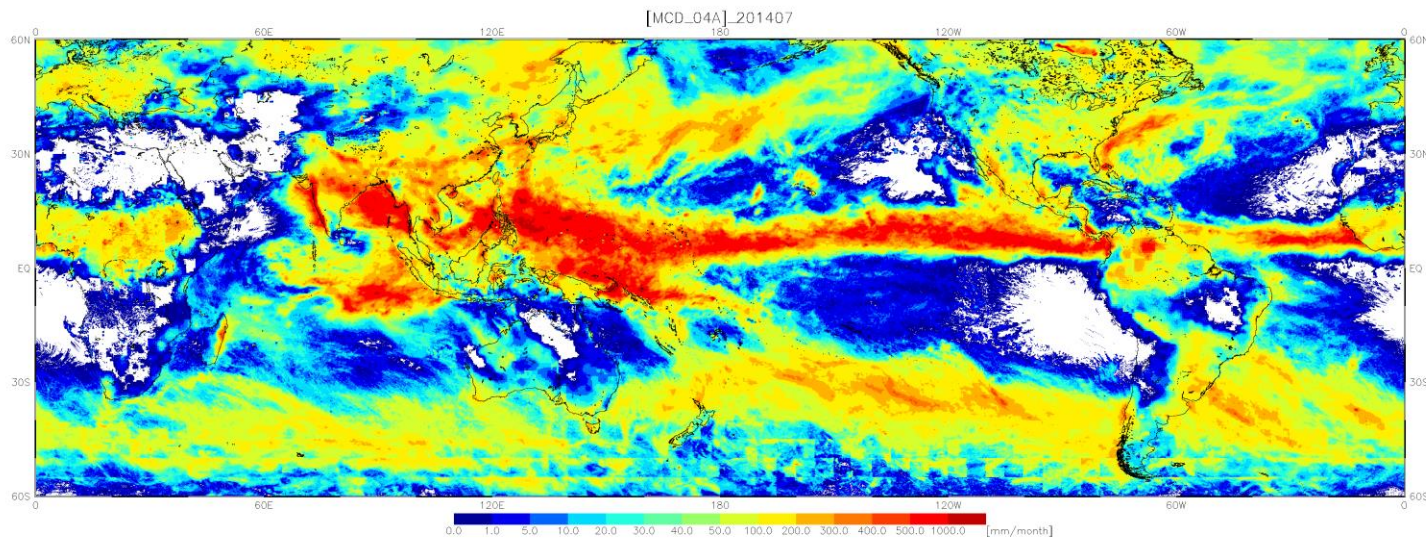
Evaluation results of V04 (7)

Horizontal distribution of V04 for the standard products (Jul. 2014)

GSMaP_MVK (without the gauge correction)

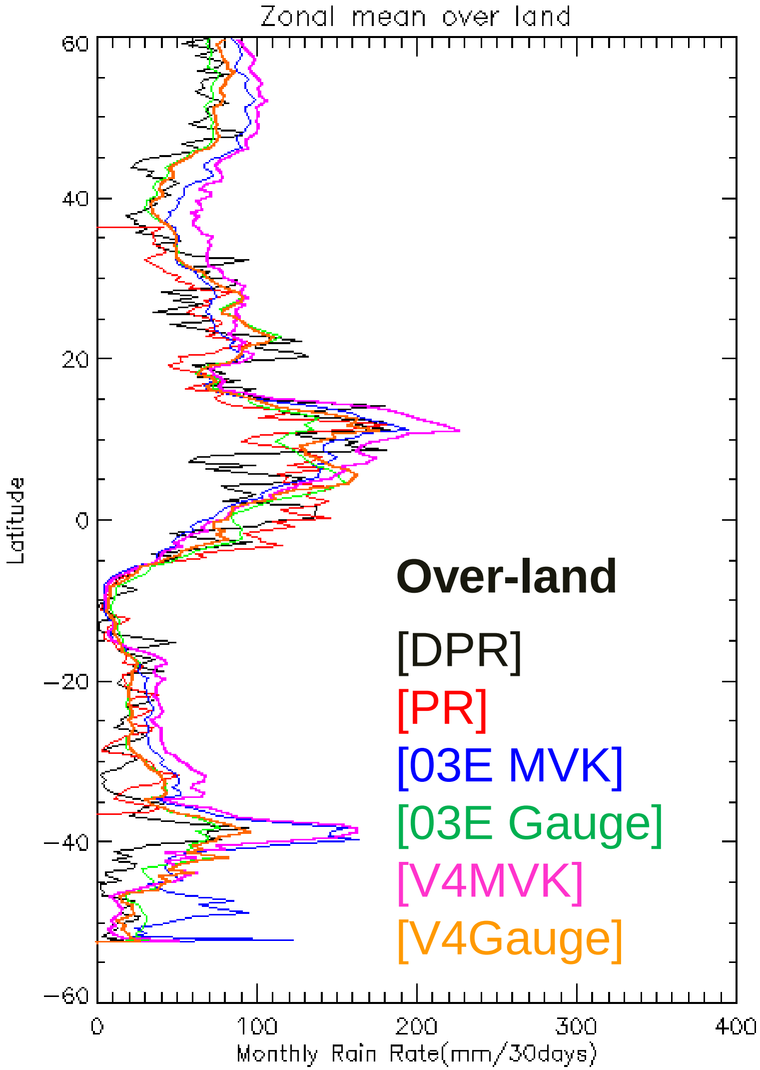


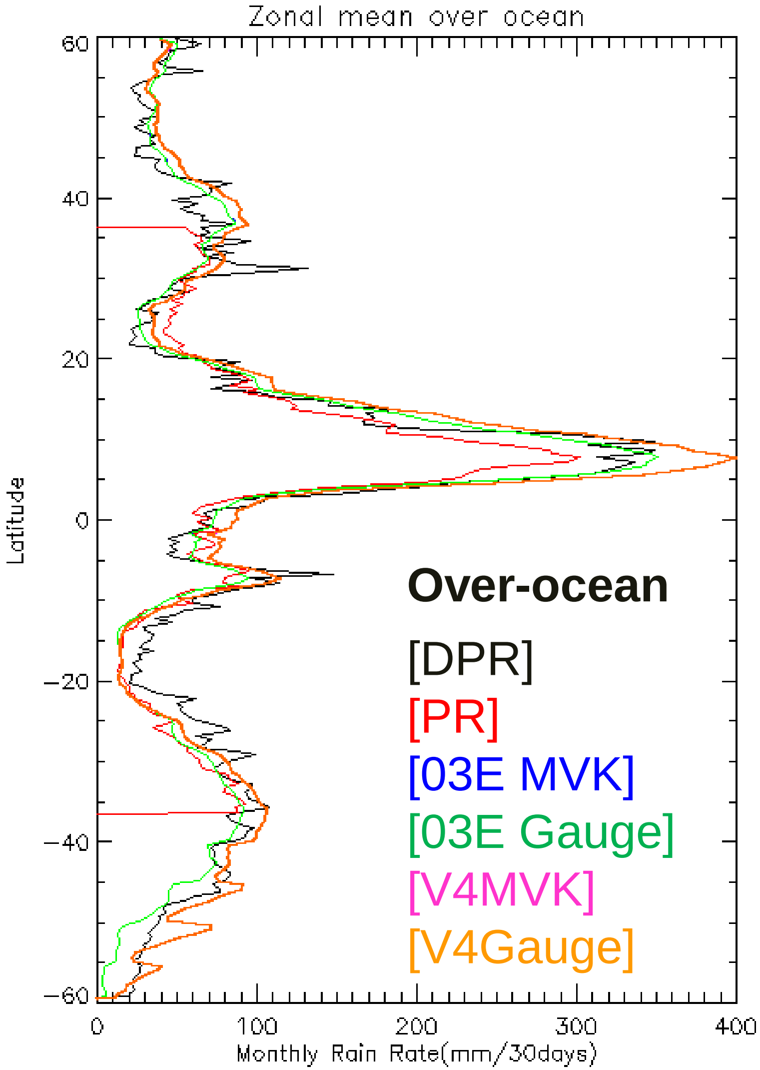
GSMaP_Gauge (with the gauge correction)



Evaluation results of V04 (8)

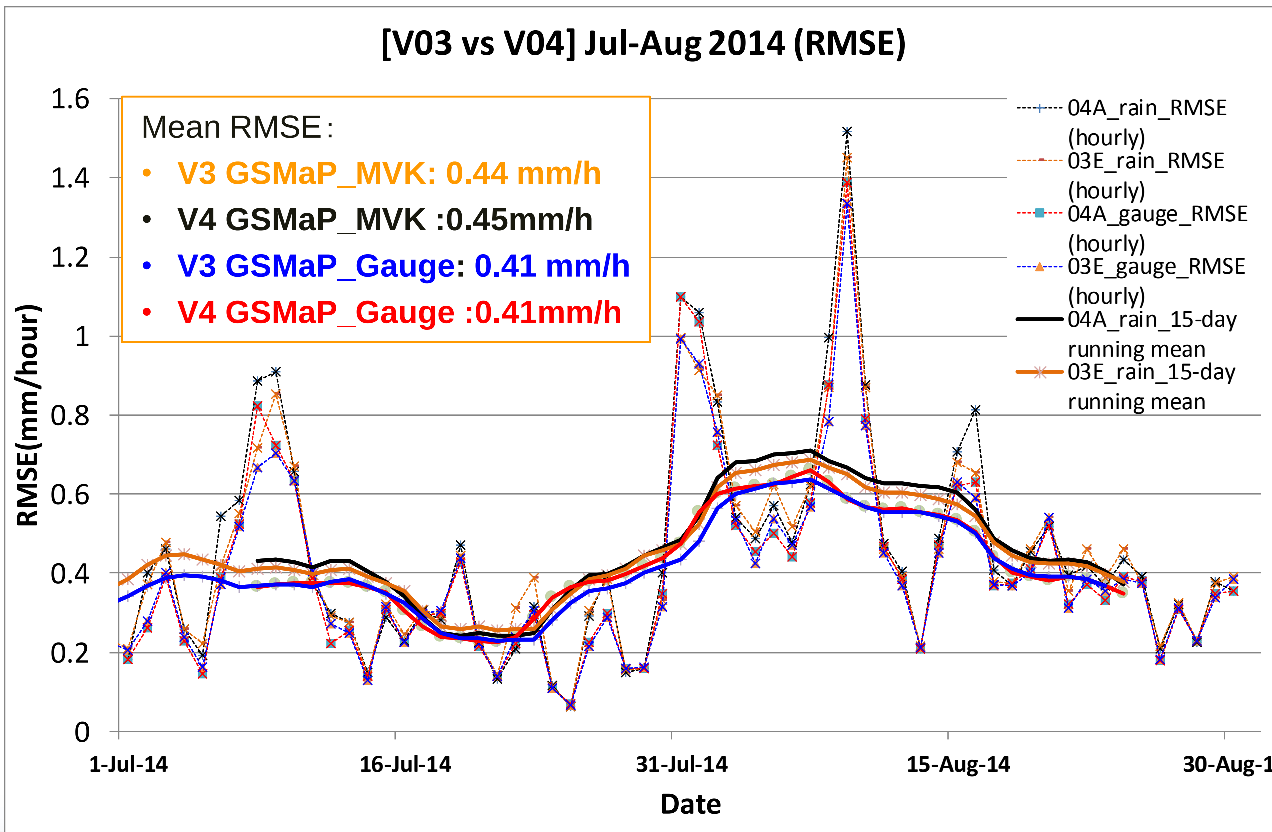
Zonal mean of V03 vs. V04for the standard products (Jul. 2014)





Early validation results of V04

- Validation with the ground-radar data around Japan
  - GSMaP standard products were compared by Root Square Mean Error (RMSE) with reference to JMA's Radar-AMeDAS (gauge-calibrated radar analysis rainfall) around Japan in <u>0.25 degree grid</u> and <u>daily accumulation</u> for the period from Jul. 1, 2014 to Aug. 31, 2014.



Solid: daily values
Dashed: 15day-running mean

V3 GSMaP_MVK
V3 GSMaP_Gauge
V4 GSMaP_MVK
V4 GSMaP_Gauge