Validation of GSMaP Passive Microwave Precipitation Retrievals and improvement by Revised Method of Microwave Rainfall Normalization

Nao Yoshida, Takuji Kubota, Munehisa K. Yamamoto (JAXA/EORC)

1. Introduction

- The Global Satellite Mapping of Precipitation (GSMaP) [Kubota et al. 2020] has been developed as a product of Global Precipitation Measurement (GPM) mission. GSMaP algorithm flow is Fig. 1. There is a discrepancy of precipitation rate among PMW sensors, thus Method of Microwave Rainfall Normalization (MMN) module is implemented [Yamamoto and Kubota, 2022].

PMW algorithm → Normalization module (MMN) → PMW-IR algorithm → Gauge-adjusted algorithm

Fig.1 Algorithm flow of GSMaP (v8).

- In the current GSMaP algorithm, normalization is calculated based on the CDF of zonal mean monthly rainfall. Reference is GMI or TMI [Yamamoto and Kubota, 2022].
- Our previous study showed GSMaP tends to large RMSE during summer and the time when the rain intensity > 30 mm/h. In addition, SSMIS tends to overestimate precipitation rate over ocean in the summer (Fig. 2). We found that the MMN module increased the SSMIS precipitation rate by a factor of 1.1 to 1.5 (Fig. 3) [Yoshida et al., submitted].
- In this study, we applied a new MMN method to GSMaP v8 algorithm [Kubota et al., 2026] and validate its result.

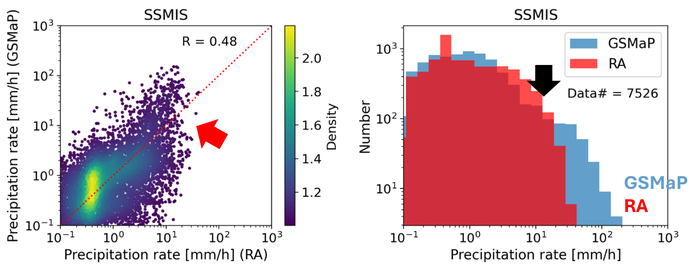

Fig. 2 Scatter plot and histogram of precipitation rate over sea by GSMaP and Radar-AMeDAS. Sensor is SSMIS/F16.

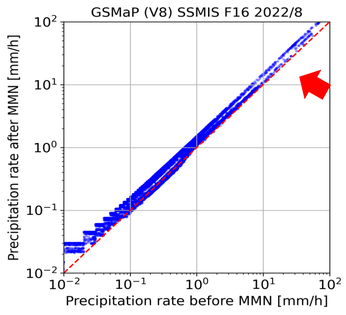

Fig. 3 Scatter plot of before and after MMN precipitation rate. Sensor is SSMIS/F16.

2. New MMN method

- In this study, a method to corrections using the average and standard deviation [Bouwer et al., 2004] was applied. Thus, expected to adjust the PMW precipitation rate to average value of reference. The new proposed MMN does not apply the linear normalization for more than 99 percentile precipitation.

$$SRE_{cor} = (SRE_0 - \mu_{SRE})\tau_f + \mu_{OBS}$$

$$\left(\mu_f = \frac{\mu_{OBS}}{\mu_{SRE}}, \quad \tau_f = \frac{\tau_{OBS}}{\tau_{SRE}} \right)$$

μ: average, τ: standard deviation,
OBS: Reference (GMI), SRE: Other sensors

MMN correction is applied for following conditions, which are the same as Yamamoto and Kubota, 2022.
- Precipitation rate > 0 mm/h,
- Non-orographic conditions, and
- Less snow probability（< 50%）.

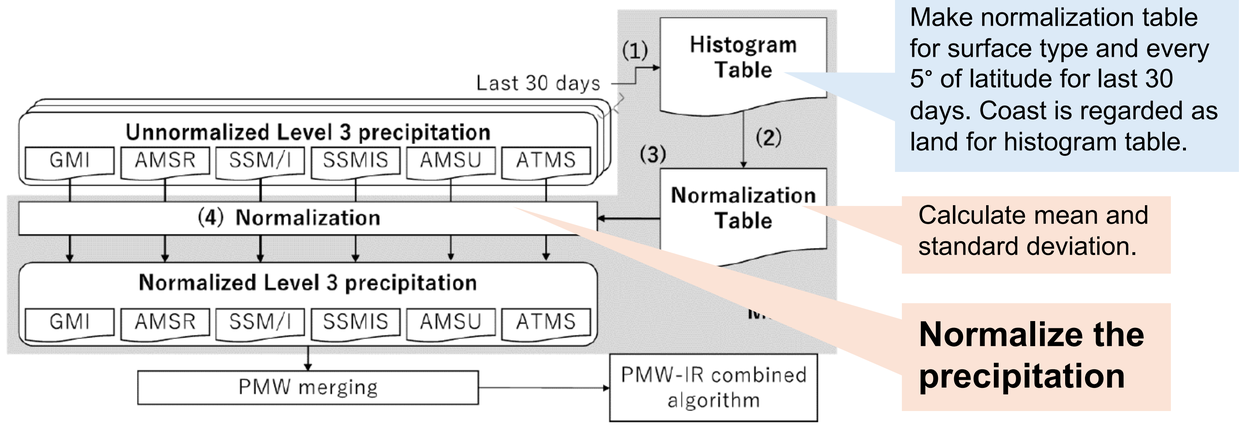

Fig.4 Flow of MMN module [Yamamoto and Kubota, 2022].

3. Dataset

- The results of new MMN are validated using the retrieval data of GMI (L3) and the gauge-calibrated ground radar network data (Radar-AMeDAS, RA) developed by Japan Meteorological Agency [Makihara et al., 1996]. Dataset is Aug. 2022.
- Original RA data has 1.0 km grid resolution, but it was resampled in 0.1 deg. resolution, which is the same resolution of GSMaP data. Validation area is limited within 120 km from the radar location.

4. Result

●Global precipitation and Zonal mean

- New MMN method works well globally (Figs. 5 and 6).
- Over ocean, slight underestimation trend in the tropics and southern mid-latitudes compared to GMI before MMN but it was corrected. Over land, slight underestimation trend in tropics before MMN, but it was corrected.

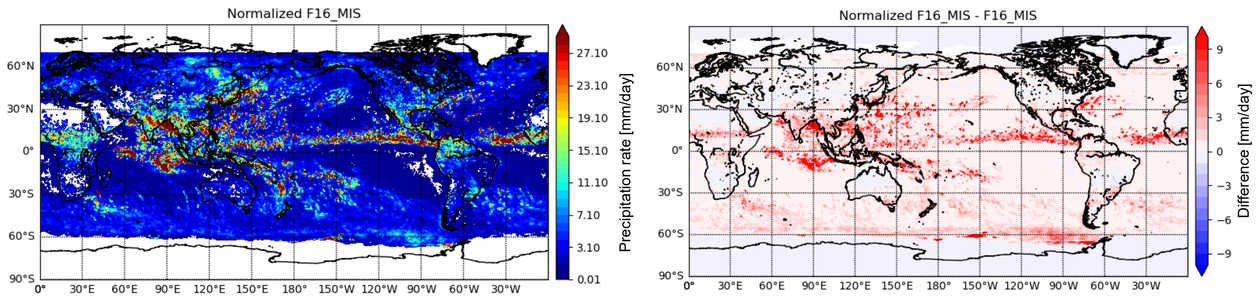

Fig. 6 Global precipitation map of new MMN correction (left) and differences between original SSMIS/F16 precipitation and normalized precipitation (right).

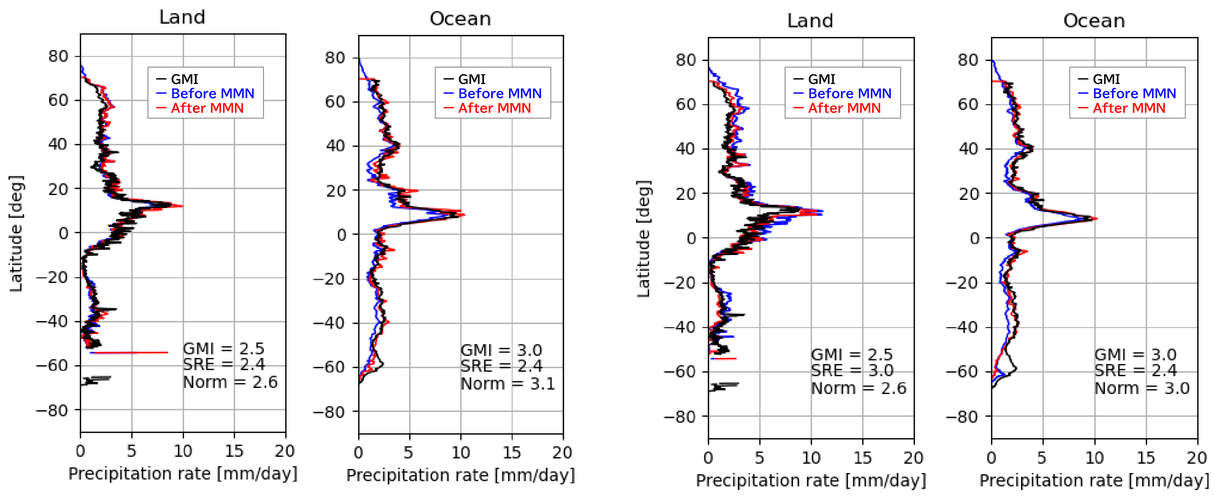

Fig. 6 Zonal mean rainfall amount between GMI and PMW sensors. (Left) SSMIS/F16. (Right) NOAA19. GMI (black), before (blue) and after (red) MMN correction.

●Validation around Japan (RMSE and Mean error)

- In the case of SSMIS F16, Improvements of RMSE and mean error (ME) are obtained in the new MMN (Fig. 7).
  RMSE：2.10 (v8) → 1.86 (New)　　ME：0.03 (v8) → -0.01 (New)
- Table shows the result for other PMW sensors. The improvement of RMSE is clear for SSMIS. In the case of Aug. 2022, the improvement of RMSE in MHS sensors are limited but ME is improved. Therefore, we consider new MMN works well and bias can be mitigated.

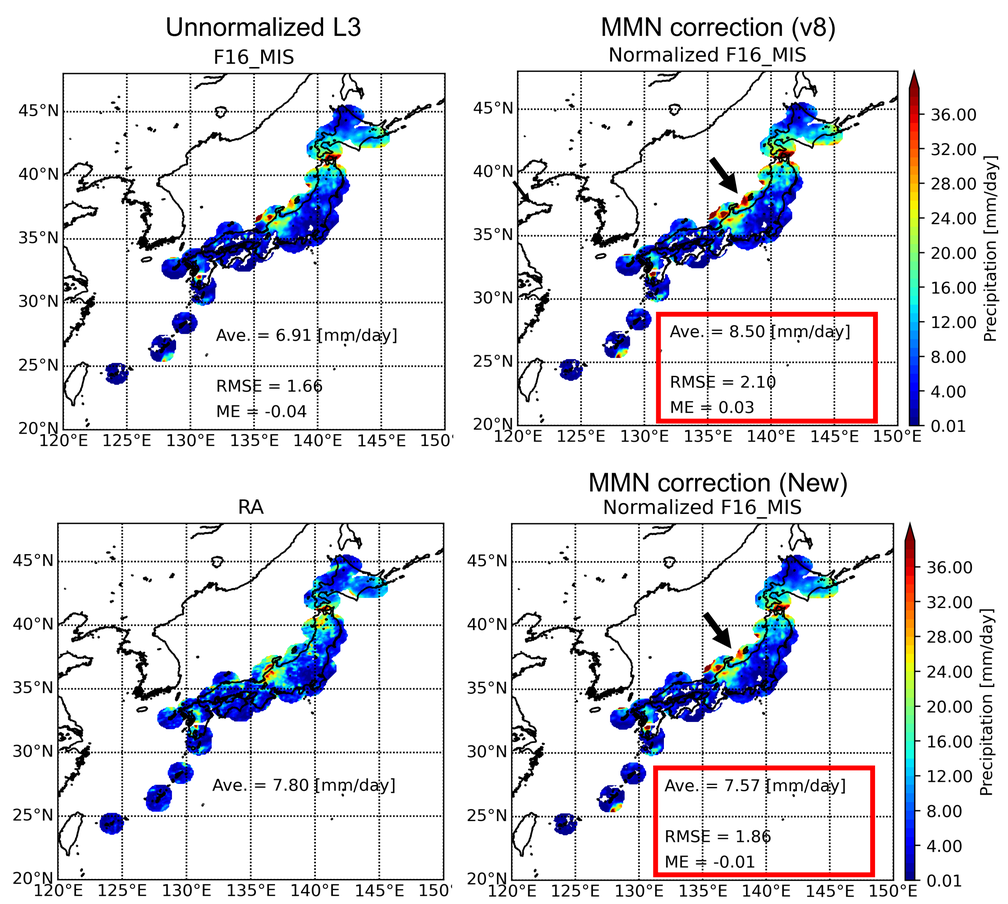

Fig. 7 Map of monthly mean precipitation rate of SSMIS/F16 in 2022/8 around Japan.

Table Change of RMSE and ME using MMN method (v8 and new) among PMW sensors.

	RMSE			ME		
	Unnormalized L3	v8	New	Unnormalized L3	v8	New
SSMIS/F16	1.66	2.10	**1.86**	-0.04	0.03	**-0.01**
SSMIS/F18	1.50	1.88	**1.69**	-0.06	**0.02**	-0.04
NOAA19	1.43	**1.44**	1.49	-0.05	-0.04	**-0.02**
Metop-B	1.30	**1.32**	1.39	-0.04	-0.02	**0.01**
Metop-C	1.30	**1.36**	1.59	-0.02	**0.00**	0.04
GPM-core/GMI	**1.89**			**-0.03**		

5. Summary

- New MMN method based on Bouwer et al. (2004), which uses average and standard deviation of precipitation rate, has been applied to GSMaP v8 and its validation has been tested.
- New MMN method works well globally and RMSE and ME around Japan are improved with the new MMN. Especially, the new MMN has an impact to SSMIS retrieval. Thus, we consider that the bias between PMW sensors can be mitigated.
- Major version up of GSMaP (v9) is planned in Autumn 2026 and new MMN is planned to be included.

Reference

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