Validation of satellite precipitation estimates over Japan using the gauge-calibrated ground radar network

Nao Yoshida, Takuji Kubota, Kosuke Yamamoto (JAXA/EORC)

1. Introduction

- The Global Satellite Mapping of Precipitation (GSMaP) [Kubota et al. 2020] and Integrated Multi SatellitE Retrievals from GPM (IMERG) [Huffman et al., 2020] have been developed as a product of Global Precipitation Measurement (GPM) mission.
- Those products use passive microwave sensors and IR imagers for retrieving precipitation and gauges for calibration.
- Characteristics of those products have been validated using rain gauges in each country in previous studies [e.g., Yamaji et al., 2021; Tang et al., 2020; de Silva et al., 2023; Arabzadeh & Behrangi, 2021].
- In this study, we validate GSMaP and IMERG over Japan using the gauge-calibrated ground radar network data (Radar-AMeDAS) developed by the Japan Meteorological Agency [Makihara et al., 1996] as a true data.

2. Datasets and method

- Precipitation around Japan in 2022 measured by GSMaP and IMERG was compared. We use GSMaP NRT, GSMaP Gauge NRT, and IMERG Early Run as 4-hour latency precipitation data and GSMaP Gauge and IMERG Final Run as a gauge-calibrated precipitation data.
- **Fig.1** shows the area of Japan that was analyzed. The domain was limited to within 120km of radar observation sites.

Table1 Dataset of satellite-based precipitation and those latencies.

Latency	GSMaP	GSMaP Gauge (Gauge calibrated)	IMERG (Uncalibrated)	IMERG (Calibrated)
Realtime	GSMaP NOW	GSMaP Gauge NOW		
4 hour	GSMaP NRT	GSMaP Gauge NRT	Early Run	
12 hour			Late Run	
>3 days	GSMaP MVK	GSMaP Gauge	Final Run	Final Run
	Latency: 3 days		Latency: 3.5 month	

- 0.1x0.1 deg. resolution
- 1 hour resolution
- Gauge data: CPC (daily precipitation)
- V8 dataset is analyzed

- 0.1x0.1 deg. resolution
- 30 min. resolution
- Gauge data: GPCP (monthly precipitation)
- Early Run (v6) & Final Run (v7B) are analyzed

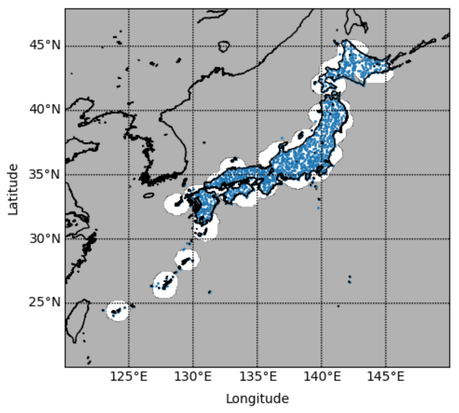

Fig.1 AMeDAS locations [JMA] and area which is applied for analysis. We have restricted the data within 120 km from the radar location.

3. Comparison using 4-hour latency datasets

- GSMaP Gauge NRT adjusts the precipitation rate compared to GSMaP NRT. GSMaP Gauge NRT has the most precise for annual mean precipitation rate.

Table2 Annual mean precipitation [mm/day]

GSMaP NRT	GSMaP Gauge NRT	IMERG Early Run	RA
4.52	**4.86**	4.76	**5.35**

Table3 Annual mean RMSE [mm/h]

GSMaP NRT	GSMaP Gauge NRT	IMERG Early Run
1.28	1.22	**1.11**

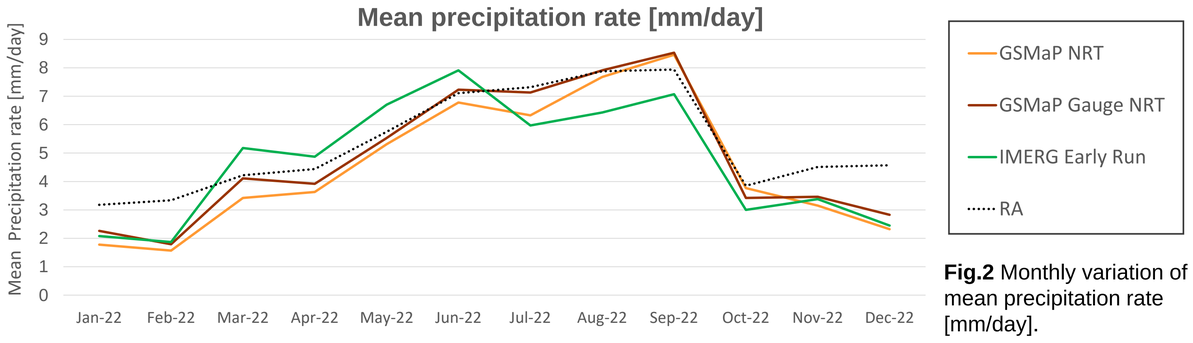

Fig.2 Monthly variation of mean precipitation rate [mm/day].

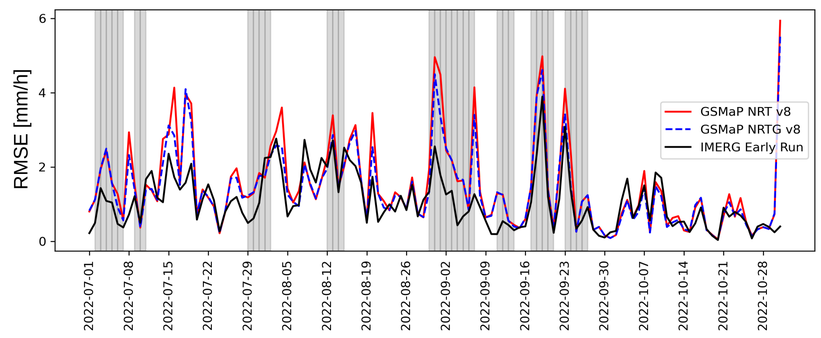

Fig.3 Daily variation of RMSE [mm/h] from July 1st to Oct 31st. Gray shade means typhoons were approaching around Japan.

- RMSE of IMERG is best. However, RMSEs of IMERG and GSMaP are comparable except for that in summer.
- RMSE of GSMaP tends to worsen especially heavy precipitation was observed (e.g. typhoon). GSMaP tends to overestimate the heavier precipitation over ocean observed by SSMI/S.

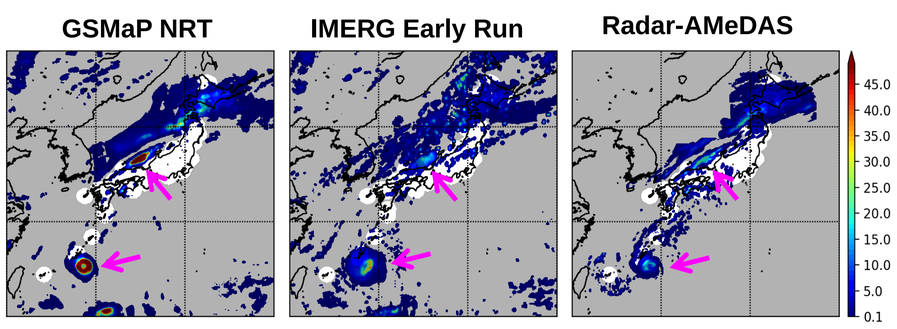

Fig.4 Mapping of Precipitation rate measured by satellite-based precipitation map and gauge-calibrated network data. All dataset measured in 07:00 – 07:59 on Aug. 31, 2022.

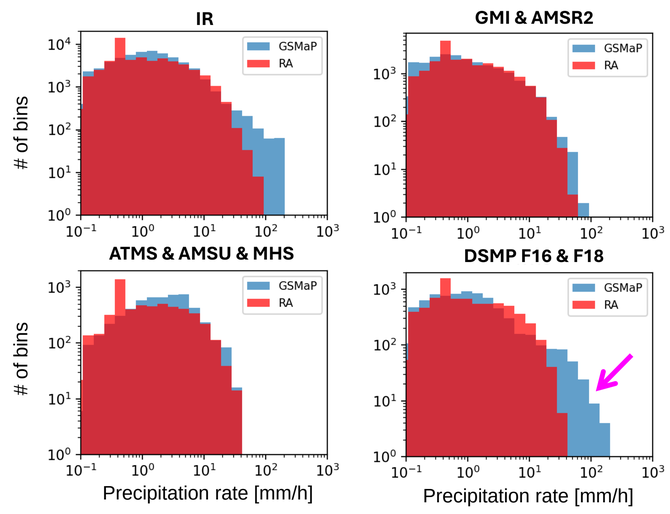

Fig.5 Histogram of precipitation rate retrieved by GSMaP NRT via each sensor over ocean in Aug. 2022. For reference, simultaneous Radar-AMeDAS dataset is also shown.

4. Comparison using gauge calibrated datasets

- IMERG is the most precise for annual mean precipitation rate.
- RMSE decreases as calibration by gauge and using longer latency dataset. GSMaP Gauge has better accuracy in RMSE.

Table4 Annual mean precipitation [mm/day]

GSMaP Gauge	IMERG Final Run	RA
4.78	**4.97**	**5.35**

Table5 Annual mean RMSE [mm/h]

GSMaP Gauge	IMERG Final Run
0.92	0.94

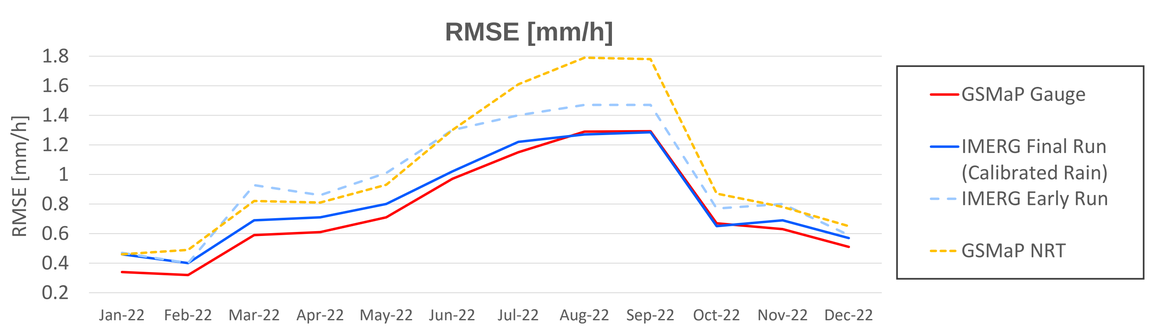

Fig.6 Monthly variation of RMSE [mm/h]. As a reference, RMSE of GSMaP NRT and IMERG Early Run are also shown.

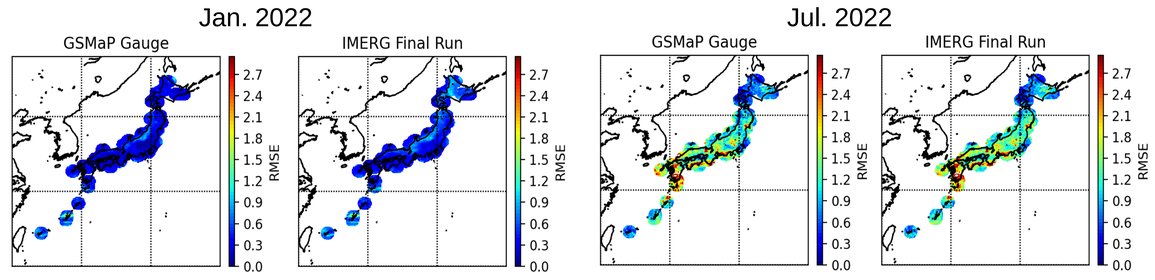

Fig.7 Mapping of RMSE measured each satellite-based precipitation map in Jan. 2022 (left) and July 2022 (right).

- RMSE and threat score (not shown here) of IMERG Final Run tend to worsen in winter. This is due to the low detectability of precipitation in winter by PMW, and IMERG cannot emerge precipitation by gauge calibration. RMSE in winter becomes larger compared to GSMaP over the north part of Japan.

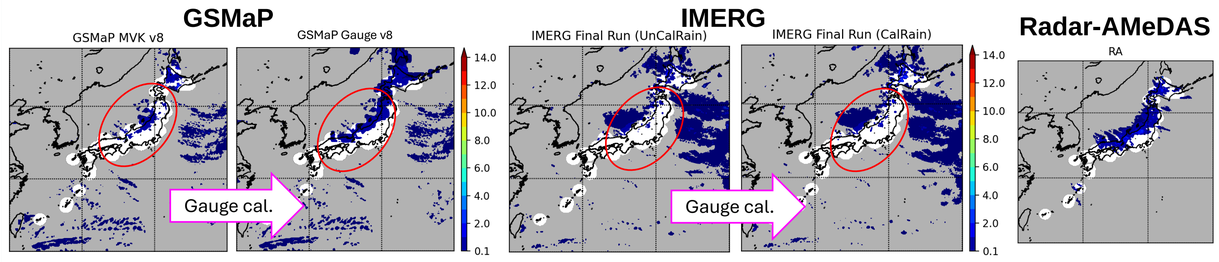

Fig.8 Mapping of precipitation rate measured by satellite-based precipitation map and gauge-calibrated network data. All dataset measured in 04:00 – 04:59 on Jan. 14, 2022.

5. Summary

- GSMaP and IMERG are compared with Radar-AMeDAS around Japan.
- Among GSMaP NRT, GSMaP Gauge NRT and IMERG Early Run, GSMaP Gauge NRT can estimate the most accurate precipitation rate. GSMaP has difficulty on retrieving the heavy precipitation over ocean by SSMI/S.
- Between GSMaP Gauge and IMERG Final Run (Calibrated Rain), IMERG Final Run has the most accurate annual precipitation rate. However, GSMaP Gauge has better RMSE. IMERG Final Run has low detectability of precipitation in winter, and it cause being worsen of RMSE in winter.

Reference

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