

Analysis of Rainfall Data based on GSMaP and TRMM towards Observations Data in Yogyakarta

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Abstract. In reality, to obtain a complete and representative rainfall observations data in a particular area is quite difficult. Therefore, to complement the existence of rainfall data, satellite data is used, so the rainfall data can got by us for a region that has limited equipment, then the characteristics of rainfall can knew by us in that region. The purpose of this study is to analyzed the validity of GSMaP (Global Satellite Mapping of Precipitation) and TRMM (Tropical Rainfall Measuring Mission) data with in-situ rainfall data in Yogyakarta during the period (2012-2016). The method used is to process GSMaP and TRMM data into daily, decade, monthly, and seasonal data to compare with in situ data and perform statistical tests. Based on the results it can be seen that during the observation period for DJF (December-January-February), the highest GSMaP and TRMM rainfall correlations occur in decade-1 and decade-3 respectively. In MAM (March-April-May), GSMaP (decade-2) and TRMM (decade-1), while in JJA (June-July-August) for GSMaP (decade-2) and TRMM (decade-3), and in SON (September-October-November) for GSMaP (decade-3) and TRMM (decade-2). Therefore it can be concluded that the correlation between GSMaP and TRMM with in situ data, the best occurs on average in decade-2 and decade-3.

1. Introduction

To obtain a complete and representative rainfall observation data are quite difficult, because of the their variation and incomplete data availability. To overcome this problem, one of them used satellite data that has high spatial and temporal resolution such as GSMaP (Global Satellite Mapping of Precipitation) and TRMM (Tropical Rainfall Measuring Mission), therefore satellite technology can obtain rainfall data for a region with limited equipment and can study the rainfall characteristics in that area [1].

Notable amount of researches using GSMaP and TRMM data were previously conducted [2-6]. Among them, validation research and comparison between satellites for rainfall estimates in Colombia [7] which resulted in good enough validation for daily rainfall in the area. Best results were obtained in the eastern plains of Colombia, and the product performance was relatively low on the Pacific coast. In comparing the various satellites, it appears that PERSIANN and GSMaP-MVK (GSMaP Moving Vector with Kalman filter) show poor performances. While CMORPH (the Climate Precipitation Center Morphing) and GSMaP-MVK + show the best performance among the products evaluated in



the study here. Then a study of comparative evaluation of GSMaP rainfall data well with other satellite data, modeling and observational data conducted in America [8], which concludes that overall, GSMaP performance is better compared to other four satellite-based data, with slightly better probability during the season hot compared during winter. But the study in the African river basin [9] compares six satellite performance and in general the performance of GPROF 6.0 and GSMaP-MKV is not very accurate, and RFE 2.0 and TRMM_3B42 are accurate. In the East African region [10], which states that the convective stability of the atmosphere above East Africa is controlled by the relatively cold airflow of the Indian Ocean off the coast. During the rainy season, sea surface temperature (SST) increases (and hottest in the rainy season). As a result, the air flowing into East Africa becomes less stable, and this analysis can be used to help understand the overwhelmingly tropical rainfall of East Africa commonly found in models. Then to conduct flood evaluation that occurred in Kyushu-Japan [11], data model (Generalized Additive Models) for correction bias GSMaP_MVK data was used. The results of this study show that the GSMaP data bias correction is accurate enough with a bias of more than 50%. Furthermore, the TRMM data evaluation study was conducted in Nepal [12] stating that the use of TRMM data could be to determine the source of water. Then research in China [13] uses data from CMORPH compared with GSMaP that can show variability in diurnal rainfall.

To complement the existence of representative rainfall data, in this research rainfall data from satellite GSMaP and TRMM_3B42 were used and validated further using in situ data. This research are expected to obtain rainfall data for the area without accessible tools and can study rainfall characteristic in a region, especially Yogyakarta and its surroundings.

2. Materials and Methods

Data used in this research are rainfall data generated by GSMaP_NRT, TRMM, (see Table 1), and surface observation data for Yogyakarta area (7.8°S, 110.21°E) in 2012-2016. TRMM data used in the below table is level-3 (3B42RT) which are downloaded from FTP facility [14], with a spatial resolution of 0.25°x 0.25° and temporal resolution every 3 hours. In addition, JAXA (Japan Aerospace Exploration Agency) has also produced TRMM data with better format and quality [15, 16]. As a prototype of GPM (Global Precipitation Measurement), JAXA has developed a near-real-time data processing system and deploys it through the internet site.

Table 1. Data characteristic of GSMaP_NRT and TRMM_3B42RT taken from FTP facility

Parameter	GSMaP_NRT	3B42_RT
Product	JAXA	NASA
Spatial Res	0,10° Lat/Lon	0,25° Lat/Lon
Temporal Res	1 hour	3 hours

The algorithm developed based on the project of GSMaP so it has known as GSMaP_NRT (GSMaP near real time). Table 1 shows the characteristic tables of both types of TRMM data from both NASA (3B42RT) and from JAXA (GSMaP_NRT). Viewed from spatial or temporal resolution then GSMaP_NRT is better than 3B42RT. The next analysis is to analyze the correlation between GSMaP, TRMM results, and in situ data with statistical calculations using linear regression equations.

3. Results and discussion

The results of this study support the previous research results expressed by [1, 7, 8] which analyzes two types of NASA TRMM data types (3B42RT) and TRMM Jaxa (GSMaP_NRT) for watersheds. From those studies it is shown that the Jaxa TRMM is closer to observational data than the NASA TRMM. Meanwhile, from this research the general analysis results show that the GSMaP rainfall

value has a pattern that follows the in situ rainfall compared to the TRMM although the value tends to be below the estimates, and the results of this study also support the previous research result [9, 11, 13].

The next step of the research we analyzed the temporal distribution of the average daily rainfall that displayed on a seasonal basis. Based on the results it can be seen that in DJF month maximum daily rainfall obtained from GSMaP_NRT data is 46,64 mm, TRMM of 0,2 mm and in situ is 52 mm, as shown in Figure 2 (left). While Figure 2 (right) shows the average daily rainfall seasonally for the MAM month, where the maximum daily rainfall of GSMaP_NRT data is 29.98 mm, TRMM of 4.95 mm and in situ of 18 mm.

Figure 1 below shows the average seasonal spatial distribution of rainfall from GSMaP_NRT (a) and TRMM_3B42RT (b) for December-January-February (DJF) in 2012-2016 in Yogyakarta and surrounding areas. Based on the results seen that rainfall generated from GSMaP reaches 350 mm, then for TRMM only reaches 50 mm, while in situ data is 341.6 mm, thus rainfall generated from GSMaP is closer to in situ compared to TRMM.

To complete the results of this study, analyzed rainfall in MAM, where the spatial distribution of seasonal average rainfall from GSMaP reaches 250 mm, then for TRMM only reaches 100 mm, while from in situ data for 211.2 mm. Meanwhile for JJA, from GSMaP about 50 mm and for TRMM reach 150 mm, while from in situ data equal to 68,5 mm. For SON, from GSMaP is 200 mm, then for TRMM reach 50 mm, while from in situ data is 232,5 mm. Thus based on these results it is seen that the rainfall generated from GSMaP is closer to in situ data than that generated from TRMM.

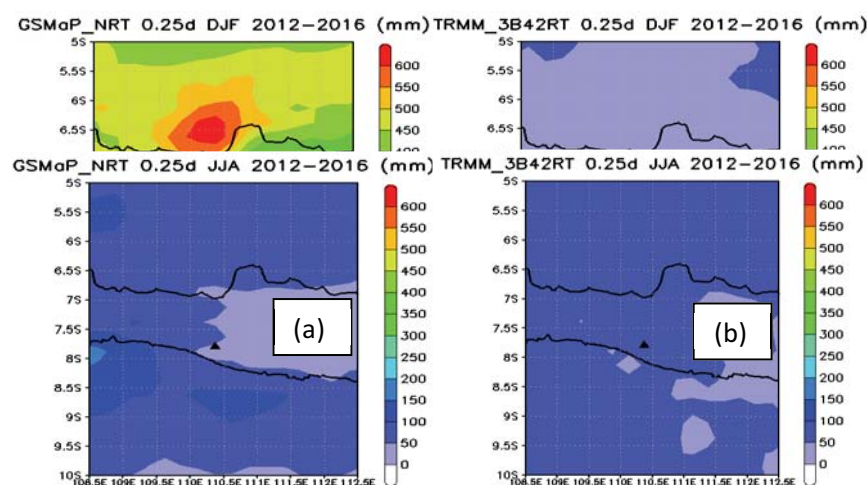


Figure 1. Spatial distribution of seasonal rainfall from *GSMaP* (a) and *TRMM* (b) for *DJF* and *JJA* for 2012-2016 at Yogyakarta. Rainfall with the smallest intensity is marked in blue, and the largest with red.

From the daily average pattern, the distribution of the GSMaP pattern is more similar to the in situ pattern, and it appears that the average daily appearance of the GSMaP pattern is one day earlier than in situ, whereas for TRMM the pattern distribution does not look similar to the in situ pattern, and the intensity always smaller. Meanwhile the daily rainfall and intensity patterns of GSMaP are closer to the in situ rainfall pattern compared to the TRMM.

Other results were analyze for JJA and SON, and it based on the results showed that in the month of precipitation the maximum daily average of GSMaP was 17.69 mm, TRMM 0.5 mm, and in situ

0.25 mm. For the month of maximum daily average daily rainfall of GSMaP of 19.65 mm, TRMM 0.15 mm, and in situ 3.3 mm. Overall, it shows that the magnitude of the GSMaP rainfall is closer to the in situ rainfall value than the TRMM that tends to be below the in situ value.

For comparison, another result mentioned by [17]. **Figure 4** shows monthly mean precipitation averaged over 10 years (December 2000 to November 2010) in Singapore. These studies confirmed that The satellite-borne precipitation can generally capture a temporal variation of rain gauge data in monthly time scale, although GSMaP has discrepancies in winter time. Figure 4b presents long-term annual and seasonal mean precipitation derived from satellite-derived and ground-based rainfall. Observation shows no distinct seasons but relatively low rainfall in summer season. Satellite data are capable of estimating the seasonal- and annual-basis precipitation features appeared in station observation. Overall, satellite-derived precipitation agrees well against the gauge precipitation at coarser time scale.

In further analysis, the first ten days in a month was defined as decade-1, the second ten days as decade-2 and the third ten days as decade-3 and comparing GSMaP and TRMM data with in situ data through statistical analysis as shown in **Figure 5**. GSMaP and TRMM correlations with in situ for decade-1 on DJF of 0.57 and 0.22 respectively.

Another result of GSMaP and TRMM data correlation with in situ data as can be seen in **Figure 7** for GSMaP (left) and TRMM (right). The GSMaP and TRMM correlations with in situ for decade-3 on DJF is 0.57 and 0.22 respectively.

The statistically correlated analyzes were processed for each decade-1, decade-2, and decade-3 for each season (DJF, MAM, JJA, and SON). From ten days rainfall analysis it has seen that during the observation period for DJF, the highest correlation between GSMaP and TRMM with in situ occurs in decade-1 and decade-3 respectively. In MAM, GSMaP (decade-2) and TRMM (decade-1), while in JJA GSMaP (decade-2) and TRMM (decade-3), and on SON GSMaP (decade-3) and TRMM (decade-2). Therefore it can be concluded that the correlation between GSMaP and TRMM with in situ data, the best occurs on average is in decade-2 and decade-3 and the complete results can be seen in **Table 2**.

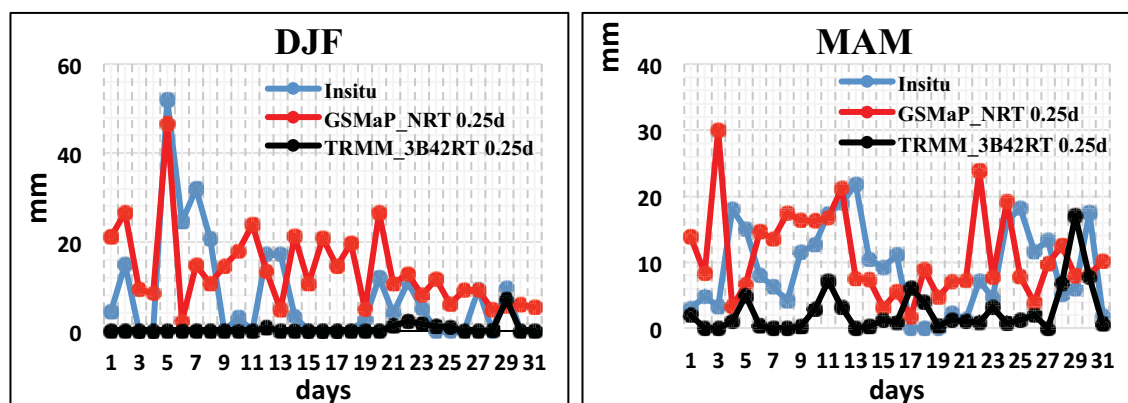


Figure 2. Temporal distribution of average seasonal rainfall from GSMaP, TRMM, and in situ for DJF and MAM for 2012-2016 at Yogyakarta.

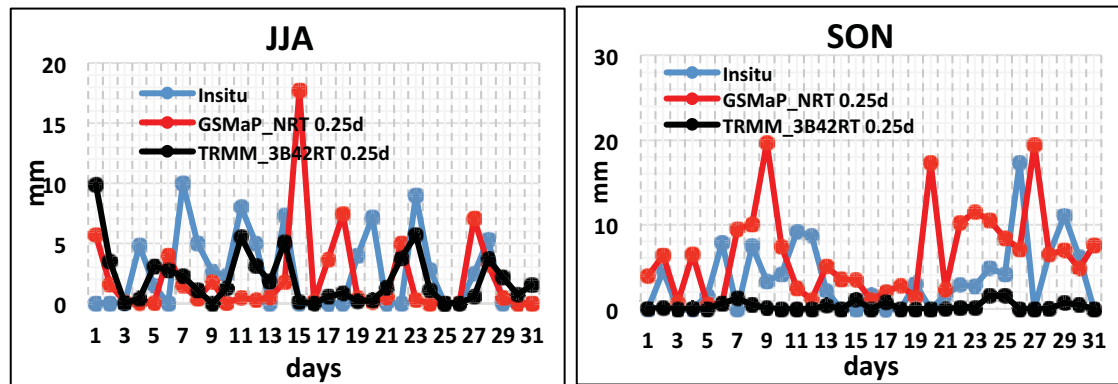


Figure 3. Temporal distribution of average seasonal rainfall from GSMaP, TRMM, and in situ for JJA and SON for 2012-2016 at Yogyakarta.

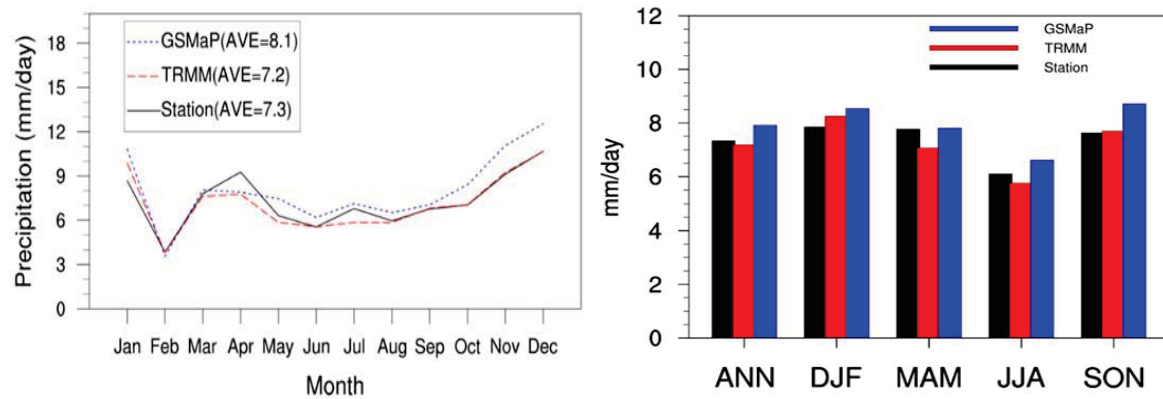


Figure 4. Long-term monthly mean precipitation (mm/day) derived from station (black solid line), TRMM TMAP-3B42 (red line) and GSMaP (blue dotted line) in Singapore (a). Long-term annual and monthly mean precipitation (mm/day) derived from station (black), TRMM TMAP-3B42 (red) and GSMaP (blue) (b). Note : ANN is annual, DJF is December-January-February, MAM is March-April-May, JJA is June-July-August, and SON is September-October-November.

The GSMaP and TRMM data correlation with in situ data as can be seen in **Figure 6** for GSMaP (left) and TRMM (right). The GSMaP and TRMM correlations with in situ for Decade-2 on DJF is 0.25 and 0.56 respectively.

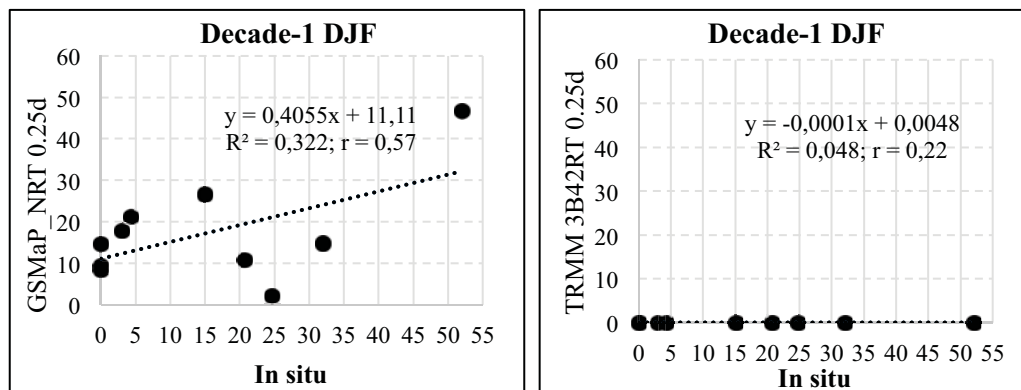


Figure 5. Distribution of correlations for decade-1 on DJF between GSMaP and in situ (left) and TRMM (right) data for 2012-2016 at Yogyakarta.

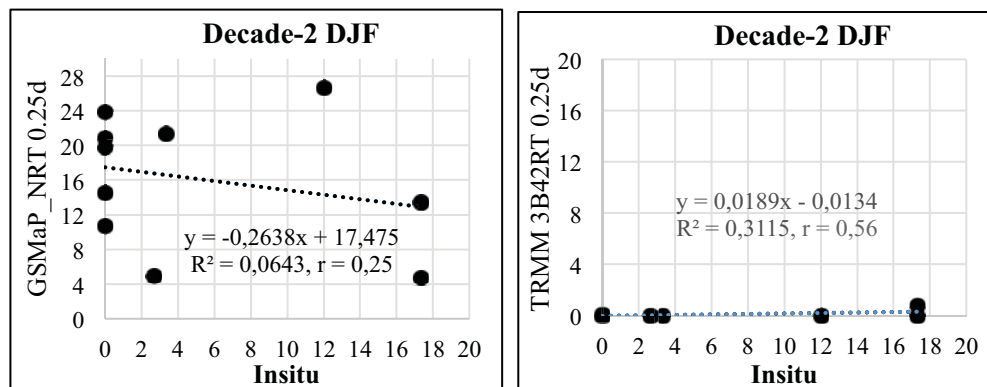


Figure 6. Distribution of correlations for decade-2 on DJF between GSMaP and in situ (left) and TRMM (right) data for 2012-2016 at Yogyakarta.

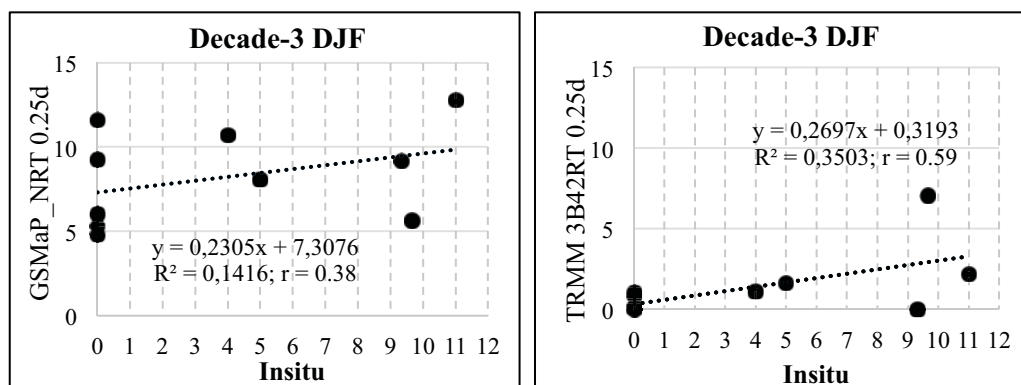


Figure 7. Distribution of correlation for decade-3 on DJF between GSMaP and in situ data (left) and TRMM (right) for 2012-2016 at Yogyakarta.

Tabel 2. Correlation coefficient of rainfall between GSMaP_NRT, TRMM_3B42RT with in situ data for Decade-1, Decade-2, Decade-3, in 2012-2016 at Yogyakarta.

	DJF		MAM		JJA		SON	
	GSMaP	TRMM	GSMaP	TRMM	GSMaP	TRMM	GSMaP	TRMM
Decade-1	0.57	0.22	0.60	0.53	0.32	0.31	0.10	0.16
Decade-2	0.25	0.56	0.60	0.06	0.46	0.67	0.32	0.37
Decade-3	0.37	0.59	0.03	0.11	0.11	0.72	0.33	0.06

4. Conclusions

From daily rainfall analysis results for each season it was seen that the rainfall generated from GSMaP_NRT is closer to in situ data than that generated from TRMM_3B43RT. While from data analysis of ten days rainfall seen that during observation period for DJF, GSMaP and TRMM highest correlation with in situ data occurs in decade-2 and decade-3, ie 0,56 and 0,59 respectively. On MAM, GSMaP (decade-2) is 0,60 and TRMM (decade-1) is 0,53, while on JJA GSMaP (decade-2) is 0,46 and TRMM (decade-3) 0,72, and in SON GSMaP (decade-3) is 0,33 and TRMM (decade -2) is 0,32. Therefore it can be concluded that the correlation between GSMaP and TRMM with in situ data, the best occurred on average in decade-1 and decade-2.

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