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Is TRMM product good proxy for gauge precipitation over peat land area of the South Sumatera?

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Abstract. The Tropical Precipitation Measuring Mission (TRMM) provides daily precipitation data covering the tropical region. In this study, data from the TRMM were compared with those obtained from direct measurement using an integrated observation system namely *SE*nsor*y* data transmission *S*ervice *A*ssisted by *M*idori *E*ngineering laboratory(SESAME). The SESAME directly measures and records the ground water level, soil moisture, skin temperature and precipitation in the peatland area. There are four SESAME stations used in this study, two stations located at the Peatland Hydrological Unit (PHU) of the Saleh River and the other two are located at the PHU of the Lumpur Riverfor validating the TRMM precipitation data. The analysis indicates that the precipitation data obtained from the TRMM have significant correlation with those recorded by the SESAME. The coefficient correlations at those PHU Saleh River I, PHU Saleh River II, PHU Lumpur River I and PHU Lumpur River II are 0.52, 0.48, 0.53 and 0.52, respectively. Meanwhile, the root mean square errors (RMSEs) of the TRMM relative to SESAME data at those four stations are 1.88 mm/d, 2.62 mm/d, 1.53 mm/d and 2.31 mm/d, respectively. Therefore, the TRMM product is a good proxy for gauge precipitation over the peatland area of the South Sumatera.

1. Introduction

Precipitation is defined any products of condensation of atmospheric water favor that falls from to the earth, for example rain, snow and hail.It is one of the most important hydrology parameters and has a large influence in the supply of fresh water.In addition, precipitation also has a significant impact on the economic and environmental conditions of an area[1-4].

Rain gauge is one of a common tool for measuring precipitation. However, its spatial distribution is sparse and it cannot cover a wide area. From the last few decades, satellite remote sensing has been used for the measurement of precipitation, including the TRMM satellites. Although satellite measurement covers a wide area, its spatial and temporal accuracy might not significant. Therefore, evaluation of the satellite remote sensing data using ground station is required[5-7].

In order to obtain ground-based measurement data, an in-situ measurement system for hydrological and climatological parameters has been developed. This system is called *SE*nsor*y* data transmission *S*ervice *A*ssisted by *M*idori *E*ngineering laboratory(SESAME) system. In the South Sumatra, this system was installed at 8 locations in the Peatland Hydrological Unit (PHU)[8].

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This study is designed to evaluate the TRMM precipitation data by comparing withthe SESAME data obtained in the peatland area of South Sumatera. In particular, this study is intended to address the following question:

a. What is the correlation between TRMM precipitation data and the SESAME precipitation data?
b. Is the TRMM results good for precipitation measuring over peat land area of the South Sumatera?

2. Data

This study used the TRMM 3 hours precipitation datafor a period of 1 July 2017 to 31 March 2018. In addition, the SESAME data observed from 4 locations:PHU Sungai Lumpur 1, PHU Sungai Lumpur 2, PHU Sungai Saleh 1, and PHU Sungai Saleh 2 for a period of 1 July 2017 to 31 March 2018. The locations of this study shown in Figure 1.

PHU Lumpur River 1	PHU Lumpur River 2	PHU Saleh River 1	PHU Saleh River 2
			
-3.1436443, 105.1843584	-2.9106579, 105.0824855	-3.4583709, 104.9209707	-2.6768524,105.1434387

Figure 1. Locations of the SESAME stations used in this study.

2.1. SESAME (SEnsory data transmission Service Assisted by Midori Engineering laboratory)

The SESAME is a system for measuring hydrological and climatological parameters and it was designed for the peatland area in Indonesia. The parameters measured are surface temperature, ground water level (GWL), soil moisture, and precipitation. The system measures data using sensors, records and disseminates them through mobile communication networks, then processes and transmits data, and finally provides output that can be analyzed and transmited to the users[8]. In Indonesia, this system has been installed in 17 locations of peatland area, 8 of which are in the South Sumatra**.**

2.2. TRMM(Tropical Precipitation Measuring Mission)

The TRMM satellite was developed by the National Aeronautics and Space Administration (NASA) and the Japan Aerospace Exploration Agency (JAXA. The TRMM satellite has started the measurements in 1997 [9]. The satellite brings 5 channels of PR (Precipitation Radar), TMI (TRMM Microwave Channel), VIRS (Visible an Infrared Channel), CERES (Clouds and the Earth's Radiant Energy System), and LIS (Lightening Imaging Sensor). In particular the PR and TMI channels have missions in measuring theprecipitation. Both channels are able to observe rain structures and play an important role in knowing the mechanisms of global climate change and monitoring of environmental variations.

The TRMM precipitation data have been available since 1998 [9,10]. The data have 3 levels [10]. Level 1 provides raw data butit has been calibrated and corrected geometrically. Level 2 contains images of original precipitation at the same spatial resolution when the satellite passes through the recorded area. Level 3 provides processed data which are ready to use. In this study, we used the TRMM data level 3, with a spatial resolution of 0.25 ° x 0.25 ° and temporal resolution of 3 hours.

3. Methodology

This research was conducted at 4 (four) stations, namely the PHU Sungai Lumpur 1, the PHU Sungai Lumpur 2, the PHU Sungai Saleh 1 and the PHU Sungai Saleh 2.In order to evaluate the TRMM precipiation data, a statistical analysis has been conducted, namely the linear regression, linear correlation and standard errors analyses [11-13].

3.1. Linier regression
In this study, a simple linier regression analysis was used to find are lationship between two continuous variables, namely the precipitation data from the SESAME and those from the TRMM satellite. The SESAME data are as the dependent variables, while the independent variable is the TRMM data. The general form of linier regressionis:

$$y = a + bx, \quad (1)$$

$$a = \frac{(\sum y \sum x^2) - (\sum x \sum xy)}{N(\sum x^2)(\sum x)^2}, \quad (2)$$

$$b = \frac{N(\sum xy) - (\sum x \sum y)}{N(\sum x^2)(\sum x)^2}, \quad (3)$$

where y is a dependent variable, x is a independent variable, a is intercept and b is slope.

3.2. Linier correlation
The linear correlation is used to determine how closely the relationship between two or more variables. The calculation of correlation coefficient for two variablesis determined by:

$$r_{xy} = \frac{1}{N-1} \sum_{i=1}^{N} \frac{(xi-x)-(yi-y)}{s_x s_y}, \quad (4)$$

where s_x and s_y are standard deviation for each variables (x, y). If the correlation coefficient $r = \pm 1$, then the two variables (x,y) clusters along a straight line and they have a perfect correlation. Note that the positive (+) value means that the two variables are "in-phase". Meanwhile, the negative (–) value means that the two variables are "out-of-phase". For$r$ = 0, the two variables are scattered randomly on the graph and there is little or no relationship between the variables.

3.3. Standard errors

3.3.1. Mean Bias Error(MBE). The MBE value indicates a systematic error estimation. Apositive (negative) value means that the estimation is greater (smaller) than the real measurement. The MBE is calculated by:

$$MBE = \frac{i}{N} \sum_{i=1}^{N} (xi - yi) \quad (5)$$

3.3.2. Root mean square error (RMSE). RMSE values indicate random errors from satellite data.

$$RMSE = \sqrt{\left(\frac{i}{N} \sum_{i=1}^{N} \{xi - (MBE) - yi\}^2\right)} \quad (6)$$

3.3.3. Mean absolute error (MAE). MAE value indicate the accuracy of estimate with the average error in unit of the same size as the original.

$$MAE = \frac{i}{N} \sum_{i=1}^{N} |xi - yi| \quad (7)$$

Where *xi* is the estimated value (TRMM data), *yi* is the value of in-situ measurement (SESAME data), and N is the number of data used.

4. Result and discussion
A graph of precipitation data recorded by SESAME and TRMM over a period of 1 July 2017 to 31 March 2018 is shown in Figure 2 below:

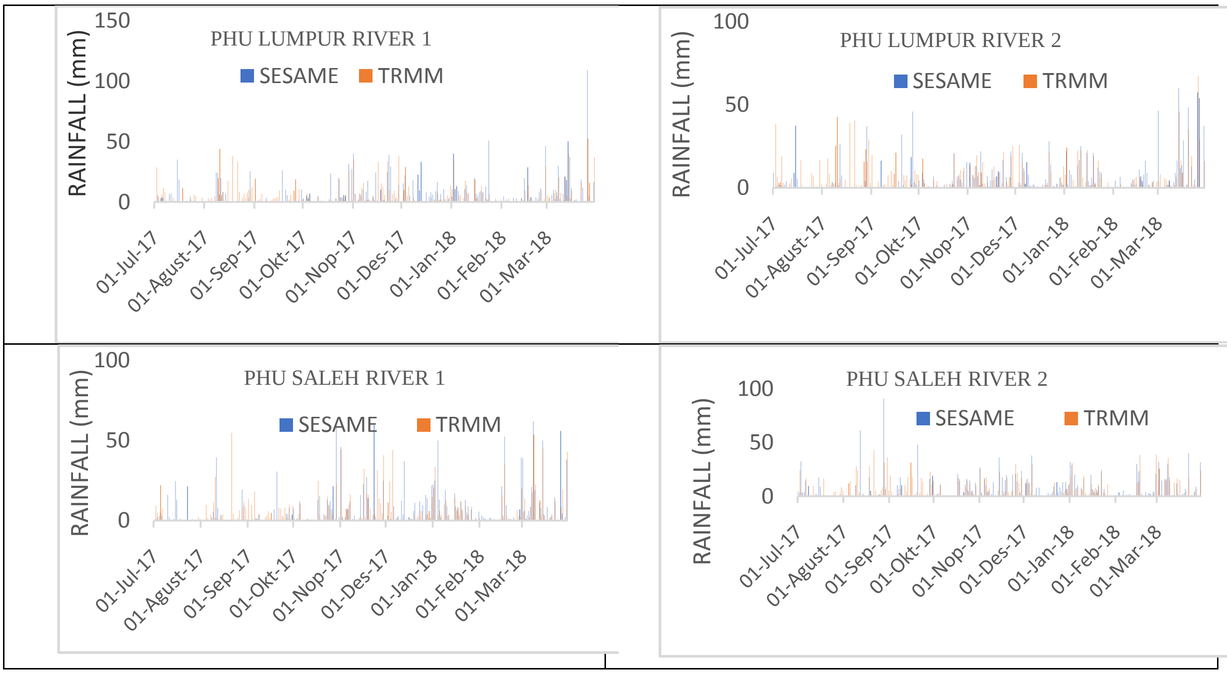

Figure 2. The graph comparison of precipitation SESAME data and TRMM satellite data on four location of research.

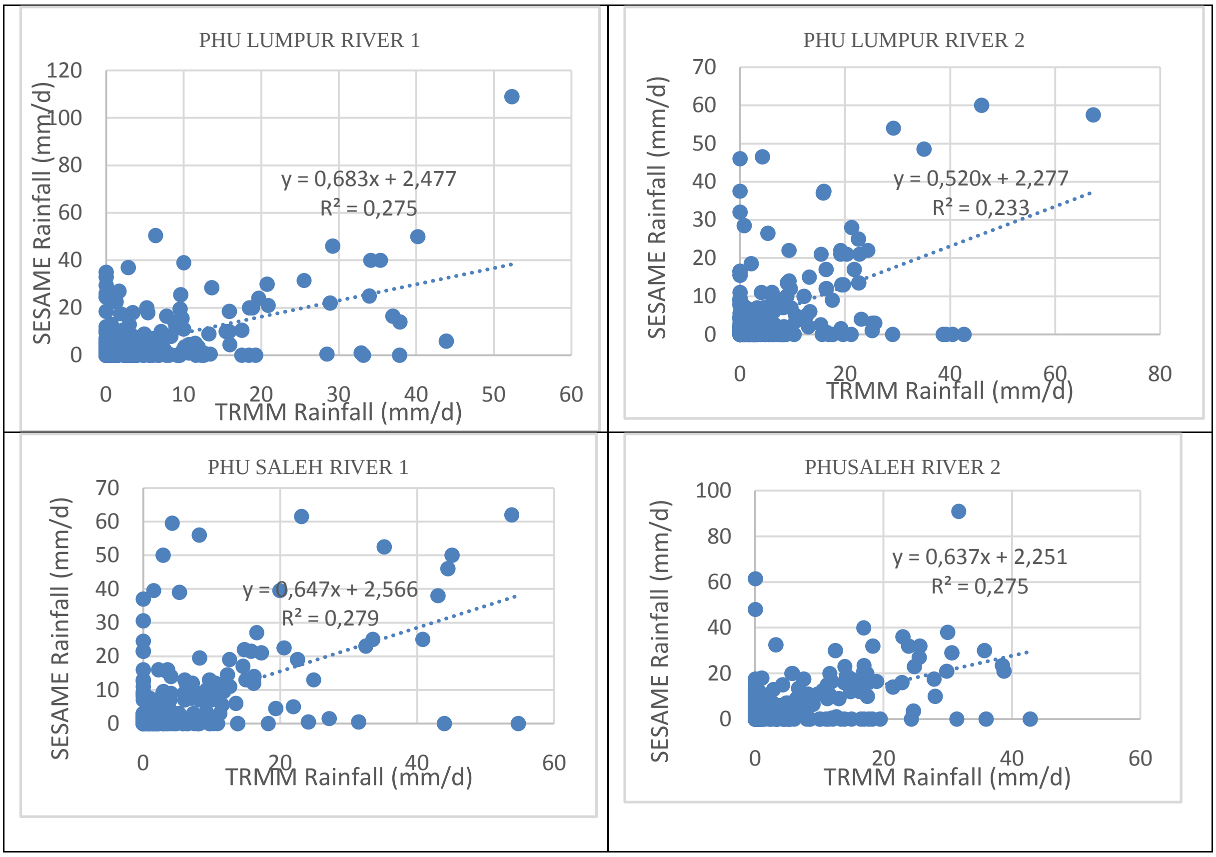

Figure 3. The graph linier regression of precipitation SESAME and TRMM satellite onfour location of research.

It was calculated the precipitation correlation and errors between the SESAME data and the TRMM data using equation 1 until 7. Figure 3 shows the scatter plot of daily precipitation correlation between the SESAME data and TRMM data at the PHU Lumpur River 1, PHU Lumpur River 2, PHU Saleh River 1, and PHU Lumpur Saleh 2 for a period 1 July 2017 to 31March 2018.

Table 1 shows the correlation coefficient and error of precipitation SESAME and TRMM satellite on location of research: PHU Lumpur River 1, PHU Lumpur River 2, PHU Saleh River 1, and PHU Saleh River 2. The results shows that the coefficient correlations of TRMM precipitation and SESAME precipitation for 4 research locations were 0.52, 0.48, 0.53 and 0.52, respectively. The root mean square errors (RMSEs) of the TRMM relative to SESAME data were 1.88 mm/d, 2.62 mm/d, 1.53 mm/d and 2.31 mm/d, respectively. So that, the TRMM precipitation data and SESAME precipitation data has a strong correlation.

Table 1. The correlation coefficient and error of precipitation SESAME and TRMM satellite on four location of research.

Parameter	PHU Lumpur River 1	PHU Lumpur River 2	PHU Saleh River 1	PHU Saleh River 2
r	0.52	0.48	0.53	0.52
MBE	-0.027	-0.95037	-0.04744	-0.00212
RSME	1.883058	2.617391	1.534115	2.305494
MAE	3.846557	3.7637	3.592344	3.686813

5. Conclusion

The analysis shows that the precipitation data from TRMM weather satellite is significantly correlated with the observed precipitation data from the SESAME. Therefore, it could be concluded that TRMM product is good proxy for gauge precipitation over peat land area of the South Sumatera.

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