COMPARISON OF RAINFALL ANALYSIS OF JAXA SATELLITE RAINFALL DATA ON STATIONS DATA IN JAMBI

Nova Susanti[1], Wandi[1], Nurhidayah[1], Arif Ma'rufi[2], Dewi Iriani[3] and Ahmad Fudholi[4]
[1]Program Studi Fisika, Fakultas Sains dan Teknologi, Universitas Jambi, Jl. Lintas Jambi - Muara Bulian Km., Mendalo Darat, Jambi Luar Kota, Kota Jambi, Jambi, Indonesia
[2]Stasiun Klimatologi Muaro Jambi, Badan Meteorologi Klimatologi dan Geofisika, Jalan Raya Jambi-Muara Bulian KM. Km, Muaro Jambi, Simpang Sungai Duren, Jambi, Kabupaten Muaro Jambi, Jambi, Indonesia
[3]Program Studi Pendidikan Matematika, Fakultas Keguruan dan Ilmu Pendidikan, Jl. Lintas Jambi - Muara Bulian Km., Mendalo Darat, Jambi Luar Kota, Kota Jambi, Jambi, Indonesia
[4]Solar Energy Research Institute, Universiti Kebangsaan Malaysia, Bangi Selangor, Malaysia
E-Mail: nova_fisikaunja@unja.ac.id

ABSTRACT

The availability of good rainfall data is a major factor in analyzing various phenomena related to rain. The rainfall data generated from the station is very accurate and reliable. However, it has various disadvantages such as incomplete data due to human error or measuring instruments, limitations in spatial resolution and availability in temporal scale. For this reason, there needs to be supporting rainfall data that can represent station data, especially in the Jambi area where good rainfall data is needed for various purposes. In this study validation of TRMM 3B42RT NASA and GSMAP JAXA satellite data on station observation data in Jambi. The method used is to compare the two satellite data with map making, graphs, and search for correlation values and RMSE to station data. After that, the best satellite data was selected to be compared with the data from 8 stations in Jambi to find out the distribution of data, graphics and the correlation and error values. From the study conducted, it was found that the rainfall value of the GSMAP JAXA satellite was closer to the station with a correlation value of 0.59 and an error of 98.75 mm/month. As for the comparison of GSMAP JAXA and data for 8 stations in the city of Jambi has a correlation range of 0.14-0.76 with an error value of 82.2- 172.27 mm/month.

Keywords: rainfall, station data, TRMM 3B42RT NASA, GSMAP JAXA.

INTRODUCTION

Rain is an atmospheric parameter that has broad applications both in the fields of hydrology, social, and in a variety of earth sciences [1]. Knowledge about rain becomes an important factor for various purposes of analyzing natural phenomena such as drought, floods, air resources management, agriculture and others. So that the process and results of the phenomenon can be achieved to the maximum, then the rainfall data used must be well available, both temporal (time available) and spatial.

Good rainfall data is a major factor in analyzing various phenomena related to rain. This is necessary so that the analysis process can be carried out effectively and efficiently resulting must be obtained from a good and questionable increase related to supporting natural phenomena. If the rainfall data is inaccurate, a high error value can be generated which can be obtained from the wrong conclusions and which results in losses from the inaccuracy of the analysis process that has been carried out in the research activities.

To get rainfall data, measurements can be done directly in the field with the application of rain instruments. Monitoring in this way is accurate and trustworthy, but there are also differences in spatial and global use because of the variability of high temporal and spatial rainfall caused by natural processes that actually vary. Finally, to get representative rainfall observation data (both quality and quantity, observation data) in a difficult place. Difficult to get rainfall data related to measuring instruments / measuring especially in the transfer area, so that it will be difficult to do analysis or analysis of water resources based on rainfall data somewhere does not need all the places that correspond to the manual or automatic rainfall station [2].

According to Triatmojo [3], the notion of precipitation is a derivative of air from the atmosphere to the surface of the earth which can consist of dew, snow, hail and rain. Precipitation occurs when the compilation of the atmosphere becomes saturated by water vapor so that it condenses air and falls to the surface of the earth. Therefore, fog and fog are not included as a form of suspension.

Based on its intensity, rainfall can be categorized in general in gathering hourly and daily. the category of rainfall per hour while four categories are light rain (1 to 5 mm/h), moderate rain (5-10 mm/h), heavy rain (10-20 mm/h) and very heavy rain (> 20 mm/h) [4].

Trofical Rainfall Measuring Mission (TRMM) is a joint mission between National Aeronautics and Space Administration (NASA) from the United States and National Space Development Agency (NASDA) from Japan, whose organization name is now changed to Japan Aerospace Exploration Agency (JAXA). The purpose of TRMM is to measure changes in rainfall and energy (latent heat condensation) in the Tropical and Subtropical regions. Estimated heat released into the atmosphere at different heights based on measurements can be used to improve the model of global atmospheric circulation. This model will then provide an estimated rainfall value on the TRMM satellite. TRMM is a device that measures radiation emitted by liquid or scattered by ice in clouds. This radiation is received as signals which can then be

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converted into rainfall. In general rainfall varies both temporally and spatially. This hydrological process takes place on a scale of time and place from 1 mm to 10,000 km spatially and from per second to hundreds of years temporally. The scale is defined as the characteristics of the region or time at which the rain occurred or the resolution of the area and the time at which measurements were taken [5-8].

Global Satellite Mapping of Precipitation (GSMAP) is a rainfall data product developed by Japan Science and Technology Agency in 2002 and then continued by JAXA since 2007 to produce global precipitation products with high spatial and temporal resolution [9]. GSMAP products are a combination of low orbit multi-satellite microwave radiometer data such as TRMM TMI, AQUA AMSRE, ADEOS II AMSRE and DMSP SSM/I and GEO infrared radiometer data. The brightness temperature at the microwave frequency as an input to the GSMAP system is converted to precipitation data. Combination techniques to obtain a resolution of 0.1 degree/1 hour with domains covering 60˚N to 60˚S are obtained using morphing techniques using infrared cloud vector transfer techniques and Kalman filters. This product is called GSMAP _MVK.

GSMAP _NRT is a GSMAP product that uses the same algorithm as GSMAP _MVK and after 4 hours of observation data can be obtained [10]. GSMAP _MVK data is available from March 2000 to December 2010 while GSMAP _NRT is available from October 2008 until now. The GSMAP project has objectives including to produce global precipitation maps with high resolution and precision from microwave satellite radiometer data, to develop a reliable microwave radiometer algorithm, and to create precipitation map techniques using multi satellite data.

This study aims to comparison of one satellite data with station observation data for rainfall in Jambi, Indonesia. At this stage satellite data is better than the station observation data in the period of 3 years (2016-2018) to validate the accuracy of satellite data against station data. The process is comparing one of the satellite data to the observation data by making a graph and temporal plot and the distribution plot and calculating the correlation coefficient and the root mean square error value

MATERIAL AND METHOD

This study was carried out for approximately 2 months at the Meteorology Climatology and Geophysics Agency (BMKG) Muaro Jambi Climatology Station having its address at Jalan Raya Jambi-Muaro Bulian KM. 18, Kabupaten Muaro Jambi, Jambi Province, Indonesia.

Tools and materials used in the study are: laptops with Microsoft Excel, GRADS, notepad, and ArcGIS 10.2.2 software. The material used is 8 station rainfall observations in Jambi, NASA TRMM 3B42RT satellite data, and JAXA GSMAP with a data period of 3 years (2016-2018).

NASA TRB 3B42RT data processing

In this stage, rainfall data is taken from NASA's TRMM 3B42RT data provider site, which can be directly downloaded from the site https://giovanni.gsfc.nasa.gov/giovanni/ by first logging in. Then 3B42RT type rainfall data is selected which has a spatial resolution of 0.25˚× 0.25˚ and a temporal resolution of 1 day. To get the rainfall data in accordance with the station to be investigated, coordinate adjustments are made and to get data for 3 years the time settings are chosen, namely from 2016 to 2018. Next, the plot data menu is selected and the rainfall value will be obtained in csv format. This data is then processed using Microsoft Excel Software and arranged according to the desired format for later use.

JAXA GSMAP data processing

To get GSMAP JAXA rainfall data, the process is carried out by downloading the data from the ftp: // hokushai.eorc.jaxa.jp site. To get rainfall data in accordance with the location of the station to be investigated, you can use the GRADS software. As for extracting the data, the control file (ctl) is used as follows:

```
DSET ^gsmap_nrt.%y4%m2%d2.0.1d.daily.00Z-23Z.dat
TITLE GSMaP_NRT 0.1deg Daily (00:00Z-23:59Z)
UNDEF -999.9
OPTIONS YREV LITTLE_ENDIAN TEMPLATE
XDEF   3600 LINEAR 0.05 0.1
YDEF   1200 LINEAR -59.95 0.1
tdef 1 levels 1013
VARS 1
precip 0 99 daily averaged precip(mm/hr)
ENDVARS
```

Then the data is processed and the rainfall values for each of the station location coordinates used in the study are stored in txt format. Data in this format is opened using the notepad application. The retrieved data is reprocessed using Microsoft Excel Software for use in the next step.

Comparison of NASA TRMM and GSMAP JAXA rainfall data

At this stage a selection of NASA TRMM NASA and GSMAP JAXA rain data is selected to choose which data is better for processing at a later stage. Testing is done by making a temporal plot and a scatter plot to see the consistency of the deviation. Another thing to do is to make rainfall maps for some cases in Jambi such as the phenomenon of rainfall that causes flooding. In addition, several comparisons were made with actual data. From the process carried out at this stage will get better rainfall data in representing station rainfall observations. The selected satellite data (NASA TRMM or GSMAP JAXA) will be processed in the next stage which will be used as comparative data to the observation station data in the city of Jambi which is a reference data in the study process.

Comparison of one satellite data with station observation data

At this stage satellite data is better than the station observation data in the period of 5 years (2013-2017) to validate the accuracy of satellite data against station data. The process is comparing one of the satellite data to the observation data by making a graph and temporal plot and the distribution plot and calculating the correlation coefficient and the root mean square error value. Then the results are analyzed to draw conclusions.

Correlation coefficient

The correlation coefficient that is often symbolized by the letter r is a statistical calculation to measure the linear relationship between two variables with interval values from -1 to 1. Values close to 1 indicate a strong positive relationship between two variables compared which means that if one variable increases then the other variables tend to increase following the same pattern. Conversely, if the value is close to -1, then there is a negative relationship between the two variables tested, which means that if the value of one variable increases, the value of the other variable tends to decrease opposite. A value of 0 indicates that the relationship that occurs is nonlinear or random.

According to Syaifullah [2] if the correlation coefficient value is greater the stronger the relationship between the two so that the estimated value pattern will be closer to the actual data pattern. The calculation process used is shown in equation (1).

$$r = \frac{\sum_{i=1}^{n}(X_i-\bar{X})(Y_i-\bar{Y})}{\sqrt{\sum_{i=1}^{n}(X_i-\bar{X})^2}\sqrt{\sum_{i=1}^{n}(Y_i-\bar{Y})^2}} \qquad (1)$$

where X_i and Y_i are the variables tested, $\bar{X}$ and $\bar{Y}$ are the average values of the sample.

Root mean square error

Root mean square error (RMSE) or often also called error is defined as the difference between the estimated value and the observed value. RMSE shows the level of estimation bias carried out by the estimation model. The value of RMSE can be found in equation (2).

$$\mathrm{RMSE} = \sqrt{\frac{\sum_{i=1}^{n}\left(y_i-y_i'\right)^2}{n}} \qquad (2)$$

where y_i is the estimated data, $y_i'$is the true value and n represents the total amount of data. If the RMSE value between the estimated value and the observation value is smaller, the smaller the difference between the two so the estimated value will be more accurate. To get more accurate data, the amount of calculated data is very decisive, meaning that the more data the RMSE value that has good accuracy can be achieved.

RESULTS AND DISCUSSIONS

Comparison between NASA TRMM (3B42RT) and JMMA TRMM (GSMAP_NRT)

To determine and select data that has a good representation with station rainfall data, at this stage a selection is made between NASA TRMM data (3B42RT) and TRMM JAXA (GSMAP_NRT). The method used in the selection is based on making daily rainfall maps, sampling data to determine the correlation value and the error and by looking at the time series graphs of each data used.

The first step is making a daily rainfall map. As according to Syaifullah [2], spatial analysis is needed to compare rainfall distribution patterns in several examples of rainfall cases. The data taken are daily rainfall data in 2016, 2017 and 2018 with the Jambi Province region for general analysis. In 2016 selected data on November 21, 2016 for postal data and November 20, 2016 for NASA TRMM data (3B42RT) and TRAX JAXA (GSMAP_NRT). The difference was caused by the difference in time systems used by the *BMKG* as the station data provider and JAXA and NASA as the satellite data provider. In this study, station data is used as a reference variable for other data. This means that from the two satellite data tested, the data closest to the station rainfall value will be selected to the next stage. For 2016 rainfall maps for station data, NASA TRMM (3B42RT), and TRMM JAXA (GSMAP_NRT).As for 2017 and 2018 also shows that the TRMM JAXA (GSMAP_NRT) rainfall data is closer to the station rainfall data. From the comparison of daily rainfall maps in the City of Jambi and surrounding areas in 2016, 2017 and 2018, it can be seen that the data generated from the JAXA TRMM satellite (GSMAP_NRT) is closer to the station data compared to NASA's TRMM satellite data (3B42RT). Therefore based on this method, TRAX JAXA (GSMAP_NRT) data is better for the next stage to choose.

Comparison of TRMM JAXA (GSMAP_NRT) with rainfall station in Jambi

The TRMM JAXA (GSMAP_NRT) and NASA TRMM (3B42RT) satellite data extracts are performed to see which data has the best representation of the observation data generated from the rain gauge station in Jambi. The first thing to see is the level of representation of the two satellite data to the station data. As explained in [11] that the diversity of data produced shows a good level of data representation. After the data is processed, it appears that the TRMM JAXA (GSMAP_NRT) satellite data is better. This is because the data is more varied than NASA's TRMM (3B42RT).

At this stage the analysis is carried out by comparing GSMAP_NRT data with measurement data generated from stations in the City of Jambi. The method used is to make a graph and scatter plot for each station in the city of Jambi. It also sought the correlation value and error value of each station as was done in previous studies [2]. At this stage the data used are daily bulk data over a 3-year period from 2016 to 2018. However, to facilitate

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analysis in research, the daily rainfall data is further processed into monthly data so that the data patterns will be easy to read. The number of rain stations studied consisted of 8 namely the names of Kota baru, Telanaipura, Stamet Jambi, Pelayangan, Danau teluk, Jambi timur, Pasar Jambi, and Jelutung.

Figure-1 shows JAXA and observation data comparison in 2016-2018 for station of Kota Baru, (a) monthly rainfall, (b) scatter plot. From Figure-1b, it can be seen that the rainfall value of JAXA data is slightly higher than the observation data. However, at some time such as November 2018 the observation data is much higher than the JAXA data. This is certainly due to the dynamic rainfall that occurs. The correlation value obtained is around 0.46 with an error value of 130.63 mm/month.

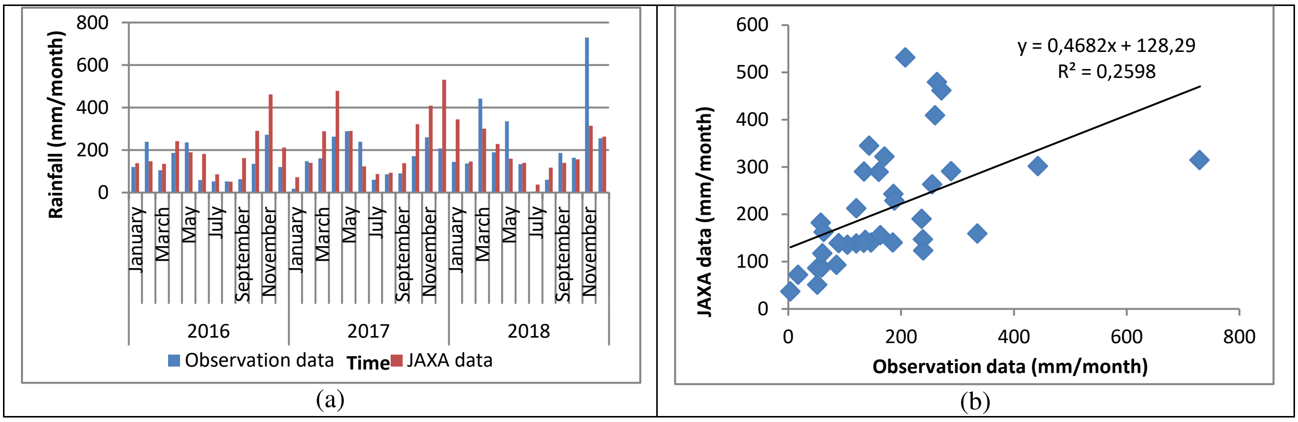

Figure-1. JAXA and observation data comparison in 2016-2018 for station of Kota Baru, (a) monthly rainfall, (b) scatter plot.

The analysis results for the Telanaipura station are shown in Figures 2a, b. It can be seen that the difference intensity of rainfall between the station and JAXA (GSMAP_NRT) in this area is different from time to time. The JAXA rainfall value tends to have a greater value than the station data including November 2016, April 2017, and December 2018. While the rainfall value for Telanaipura station also experienced a higher value than JAXA, including in May and November 2018. Overall the average value generated from JAXA satellites is higher than the station data, which are respectively with the intensity of 221 mm/month and 207 mm/month. From the results of the analysis of the correlation method the two data have a correlation coefficient of around 0.58 with an error value of about 107.1 mm/month.

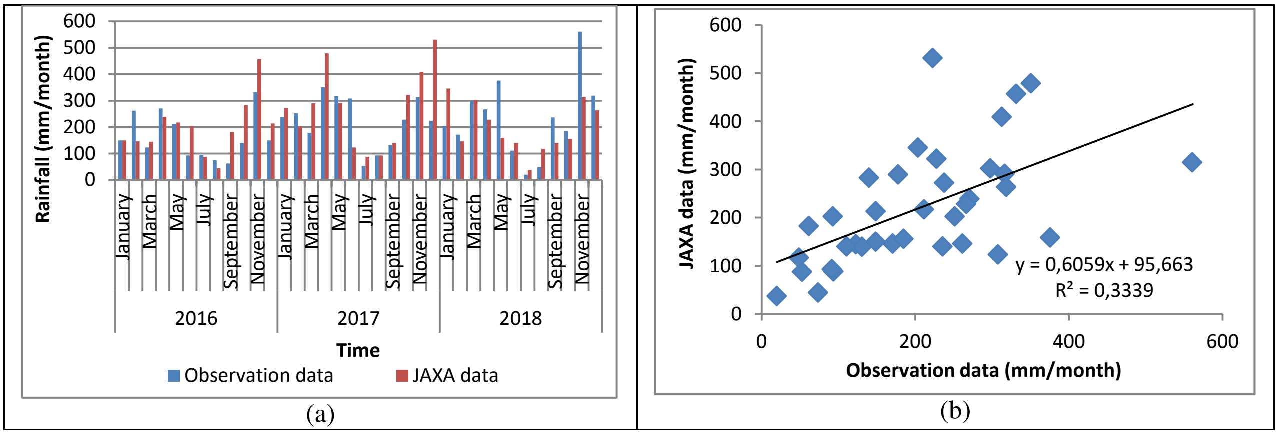

Figure-2. JAXA and observation data comparison in 2016-2018 for Telanaipura station, (a) monthly rainfall, (b) scatter plot.

Figure-3a, b shows JAXA and observation data comparison in 2016-2018 for station of Pasar Jambi, (a) monthly rainfall, (b) scatter plot. In this region there are significant differences in sometimes such as in November 2016, April 2017, and January 2018. However, overall the two data have a significant relationship. The graph shows that in the February-April time range there is blank data. This is because there are constraints on the rainfall instruments used so that data about rainfall in this time span cannot be obtained. From the results of correlation analysis obtained a relationship that has a fairly good level of significance with the value of the correlation coefficient reached 0.76 with an error of 133.25 mm/month.

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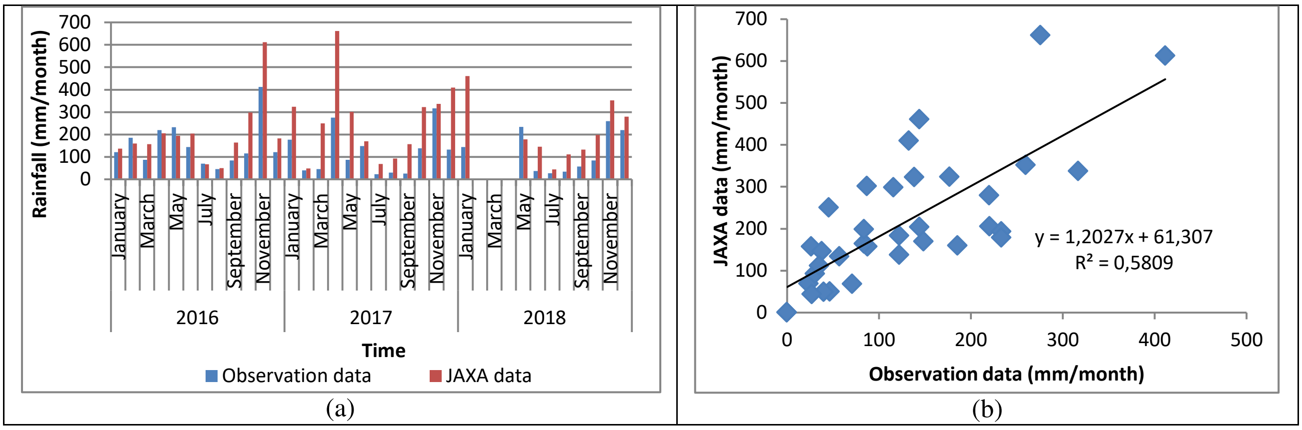

Figure-3. JAXA and observation data comparison in 2016-2018 for station of Pasar Jambi, (a) monthly rainfall, (b) scatter plot.

Overall the rainfall value of JAXA tends to be higher compared to the station of Stamet Jambi. Although overall JAXA data is higher, there are several months in which station data has a higher intensity value compared to JAXA satellite data. Values that have the most significant differences include those in May and November 2018. The results of the statistical correlation analysis between them show a relationship with a correlation coefficient around 0.57 and have an error value of 106.57 mm/month. For Pelayangan station, correlation analysis results obtained around 0.14 with an error value that reaches a range of 172.27 mm/month. For station of Danau Teluk, a correlation value of 0.46 is obtained with an error rate of 138.03 mm/month. For Jelatung station, the value of the difference resulting from the two data varies as well as the data in the other regions. However, the rainfall value from the JAXA satellite tends to be greater than the value generated from the Jelutung station or observation data. The value of postal data is greater than JAXA in May and November 2018 where the value of the difference occurs significantly. In terms of statistical analysis the relationship that occurs between the two data is quite good with a correlation coefficient of 0.62 and has an error of 103.52 mm/month.

From the series of data comparisons that have been done TRMM JAXA (GSMAP_NRT) satellite rainfall data can be used to represent station data in Jambi with a correlation value range between 0.14 to 0.76 and an error value of 82.2 mm/month to 172.27 mm/month. The use of this data as a substitute for station data depends on what problem is examined and how strong the desired relationship. In general, from the results that have been analyzed, the value of TRMM JAXA (GSMAP_NRT) rainfall has a pattern that follows the rainfall in Jambi. But there are some differences between one station with another both in the distribution of data and differences at certain times. This is because natural situations that are dynamic and in taking data often result in many errors both in terms of the instruments used and from the observer himself or human error.

CONCLUSIONS

From the study that has been done, it can be concluded that the rainfall data of TRMM JAXA satellite data (GSMAP_NRT) is better in the representation of station data in Jambi compared to NASA TRMM (3B42RT) with correlation values having a range of 0.14 to 0.76 and an error value of 82.2 mm/month to 172.27 mm/month.

The authors' recommendations in further study are (i) using rainfall data with more time span so that the relationship and the resulting value can be obtained as much as possible, (ii) conducting study experiments using other satellite data models so that it is possible to obtain better data in representing station rainfall data in the City of Jambi, and (iii) analyzing other atmospheric factors related to rainfall.

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REFERENCES

[1] Tapiador F. J., Turk F. J., Petersen W., Hou A. Y., Garcia-Ortega E., Machado L. A. T., Angelis C. F., Salio P., Kidd C., Huffman G. J., de Castro M. 2012. Global precipitation measurement: methods, datasets and applications. Atmos. Res. 104-105: 70-97, doi: 10.1016/j.atmosres. 2011.10.021.

[2] Syaifullah M. D. 2014. Validasi Data TRMM Terhadap Data Curah Hujan Aktual di Tiga Das di Indonesia. Jurnal Meteorologi dan Geofisika. 15(2): 109-118.

[3] Triatmojo Bambang. 2008. Hidrologi Terapan. Yogyakarta: Beta Offset.

[4] Badan Meteorologi, Klimatologi dan Geofisika. 2014. http://www.bmkg.go.id (accessed: 9 September 2018)

[5] Serway Raymond A., Jewett John W. 2010. Physics for Scientists and Engineers with Modern Physics eight edition. Brooks: Darmouth Publishing Inc.

[6] Collischonn B., Collischonn W., Tucci C. E. M. 2008. Daily Hydrologycal Modeling in The Amazon Basin Using TRMM Rainfall Estimates. Journal of Hydrology. 360, 207-216. doi: 10.1016/j.jhydrol.2008.07.032.

[7] Mantas V. M., Liu Z., Caro C., Pereira A. J. S. C. 2015. Validation of TRMM Multi-Satellite Precipitation Analysis (TMPA) Products in the Peruvian Andes. Atmospheric Research. 163, 132-145. doi: 10.1016/j.atmosres.2014.11.012

[8] Salvadore E., Bronders J., dan Batelaan O. Hydrological modelling of urbanized catchments: A review and future directions, J. Hydrol. 529, 61-81.

[9] Ushio T., Sasashige K., Kubota T., Shige S., Okamoto K., Aonashi K., *et al.* 2009. A Kalman filter approach to the global satellite mapping of precipitation (GSMaP) from combined passive microwave and Infrared radiometric data. Journal of Meteorological Society of Japan. (87A): 137-151.

[10] Earth Observation Research Center (EORC) dan Japan Aerospace Exploration Agency (JAXA). 2013. Global Rainfall Map in Near-Real-Time by JAXA Global Rainfall Watch (GSMaP_NRT) version 2.5, Tsukuba, Japan.

[11] Mamenun, Hidayat Pawitan, Ardhasena Sophaheluwakan. 2014. Validasi Dan Koreksi Data Satelit Trmm Pada Tiga Pola Hujan Di Indonesia. JURNAL METEOROLOGI DAN GEOFISIKA. 15(1): 13-23.