VOL. 15, NO. 4, FEBRUARY 2020 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

AN EVALUATION OF MODIS GLOBAL EVAPOTRANSPIRATION PRODUCT (MOD16A2) AS TERRESTRIAL EVAPOTRANSPIRATION STUDY IN MANOKWARI - WEST PAPUA - INDONESIA

Arif Faisol[1], Indarto Indarto[2], Elida Novita[2] and Budi Yono Budiyono[3]
[1]Faculty of Agricultural Technology, Papua University, Manokwari, Indonesia
[2]Faculty of Agricultural Technology, Jember University, Jember, Indonesia
[3]Faculty of Agriculture, Papua University, Manokwari, Indonesia
E-Mail: indarto.ftp@unej.ac.id

ABSTRACT

MODIS global evapotranspiration was used widely in the world as terrestrial evapotranspiration for agriculture. This research aimed to evaluate the performance of MODIS global evapotranspiration product as terrestrial evapotranspiration in West Papua. A total of 32 MODIS global evapotranspiration image recording from 2016 to2018 were used. Four (4) statistical parameters, i.e., mean error (ME), root mean square error (RMSE), relative bias (RBIAS), and mean bias factor (MBIAS) are used to compare value from MODIS Global evapotranspiration product and value of evapotranspiration calculated by climatological data. The results show that MODIS global evapotranspiration value tends to overestimate and have lower deviation than climate data analysis. Statistical analysis present the ME = 0.43 mm/day, RMSE = 0.57 mm/day, RBIAS = 0.18, and MBIAS = 0.85. Based on statistical performance, MODIS global evapotranspiration can estimate evapotranspiration in Manokwari - West Papua with reasonable accuracy.

Keywords: MODIS global evapotranspiration, terrestrial evapotranspiration, precision agriculture.

1. INTRODUCTION

Precision Agriculture has been a significant issue over the last three decades to aid plant agriculture. Precision agriculture is an approach to farm management that uses information technology to ensure that the crops and soil receive what they need for optimum productivity. Precision agriculture defined as the management of spatial and temporal variability in the fields using information and communication technologies [1]. Pierce and Nowak [2]define precision agriculture as the application of technologies and principle to manage spatial and temporal variability associated with all aspects of agricultural production.The main objectives of precision agriculture are to increase the profitability of crop production and to reduce the negative environmental impact by adjusting application rates of agricultural inputs according to local needs [2].

Evapotranspiration is one of the parameters in precision agriculture. Evapotranspiration (ET) is the amount of water released to the atmosphere from ground surfaces, intercepts canopy precipitation through evaporation and plant transpiration.

Three (3)methods for interpreting evapotranspiration data have known, i.e., (1) measurement, (2) pan-evaporation, and (3) climate analysis [3]. However, these methods have some inconvenient. The estimation of evapotranspiration is only for the local area. The limit number of the meteorological station availablein Indonesia restricts the applicability ofdata for climatic analysis. According to BMKG, the number of climatological stations in Indonesia in 2018 is 1197[4] with un-evenly distributed.

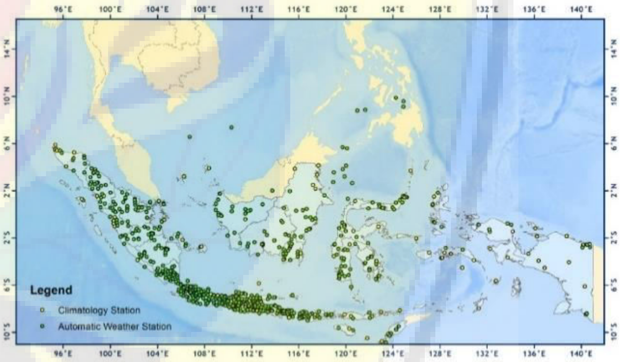


Figure-1. Distribution of climatological stations in Indonesia [4].

The Utilization of remote sensing technology is expected to be an alternative solution. Remote sensing provides a cost-effective method to estimate evapotranspiration at regional to global scales.Some research works have a concern with theapplication of remotely sensed image to generate evapotranspiration information.For example the works reported by Tsoumi *et al.*[5]in Greece and Trezza *et al.* [6] in Mexico. Those studies show that the accuracy of evapotranspiration data estimated depends on the radiometric quality and spatial resolution [5][6][7].

Several institutions in the world provided evapotranspiration based on remote sensing data. National Aeronautics Space Administration (NASA) [8], European Space Agency (ESA) [8], U.S Geological Survey (USGS) [9], and Department of Civil Engineering - Indian Institute of Science [10] provide evapotranspiration data in the form of satellite imagery. MODIS global terrestrial evapotranspiration product (MOD16A2) is one of RS data for evapotranspiration measurement.

Several studies showed that MODIS global terrestrial evapotranspiration product can estimate evapotranspiration with reasonable accuracy [11][12][13][14][15]. Furthermore, research conducted by Courault *et al.*[16], Jiang *et al.* [17] and Kalma *et al.* [18] show that deviation of MODIS global terrestrial evapotranspiration is between 10% - to 30% compared to measurement and observation [16][17][18].This study evaluates the MODIS global terrestrial evapotranspiration product in Manokwari- West Papua - Indonesia.

2. METHODS

This research is conducted in Manokwari- West Papua - Indonesia. Generally, the main stages of this research:

2.1 Data inventory

MODIS global terrestrial evapotranspiration (MOD16A2) for area of interest around Manokwari City were collected. As much as 32 scenesfrom periods of 2016 to 2018were collected.Furthermore climatological data from local meteorological stations are also collected and uses for statistical calculations.

2.2 Information extraction

The purpose of this stage is to extract evapotranspiration information from MOD16A2. The evapotranspiration information extraction process is done using the HEG Tool released by NASA[8].

2.3 Statistical evaluation

The five (5) statistical test,i.e.mean error (ME), root mean square error (RMSE), relative bias (RBIAS), and mean bias factor (MBIAS) are used to compare satellite data and local measurement data. The calcul using equations (1) to (5) as follow:

$$ME = \frac{1}{n}\sum_{i=1}^{n}(yi - xi) \quad (1)$$

$$\mathrm{RMSE} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(yi - xi)^2} \quad (2)$$

$$RBIAS = \frac{\sum_{i=1}^{n}(yi-xi)}{\sum_{i=1}^{n} xi} \quad (3)$$

$$MBIAS = \frac{\sum_{i=1}^{n} xi}{\sum_{i=1}^{n} yi} \quad (4)$$

Where:
ME = mean error (mm.day^{-1}),
RMSE = root mean square error,
RBIAS = relative bias,
MBIAS = mean bias factor,
yi = satellite évapotranspiration (mm.day^{-1}),
$\overline{yi}$ = average satellite évapotranspiration (mm.day^{-1}),
xi = climate evapotranspiration (mm.day^{-1}),
$\overline{xi}$= =averaged climate evapotranspiration (mm.day^{-1}),
SD_{yi} =standard deviation of satellite evapotranspiration (mm.day^{-1}),
SD_{xi} =standard deviation of climate data processing (mm.day^{-1}), and
n = amount of data.

The perfect value of mean error (ME) = 0, relative bias (RBIAS) = 0, mean bias factor (MBIAS) = 1, and root mean square error (RMSE) = 0 [19].

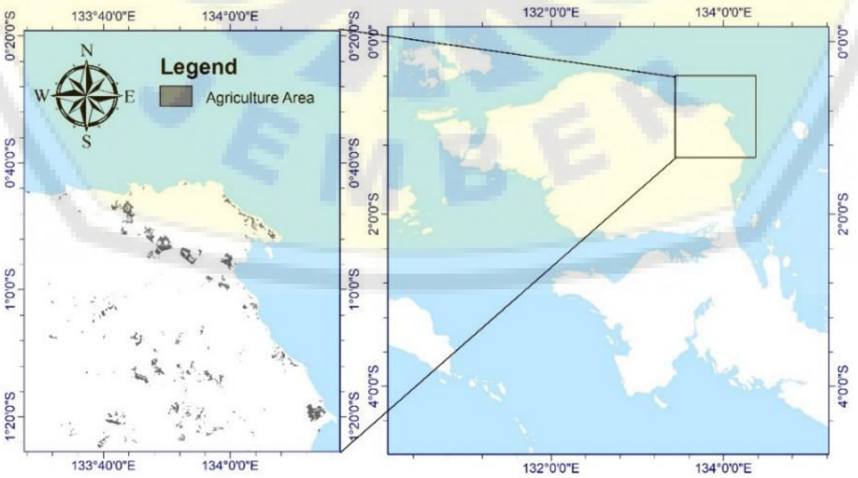


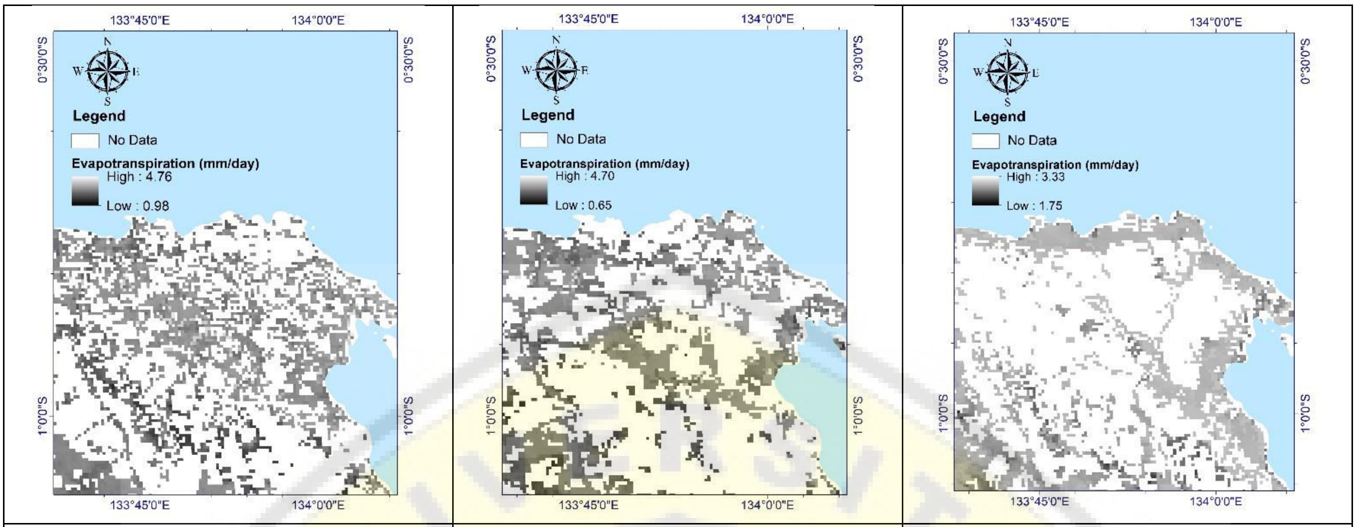
Figure-2. Study Area.

3. RESULTS AND DISCUSSIONS

Spatial distribution of evapotranspiration derived from MODIS global terrestrial evapotranspiration (MOD16A2) for the areaof interest is show in Figure-3. Furthermore, two colour histograms of Figure-4 visualised the comparison of evapotranspiration value derived from MODIS image and the value that calculated from climate data analysis.

ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com



(a) (b) (c)

Figure-3. Evapotranspiration distribution in Manokwari – West Papua based on MODIS global terrestrial evapotranspiration: (a) 19 May 2016, (b) 06 May 2017, (c) 11 July 2018.

It is show that evapotranspiration value derived from satellite (MOD16A2) is slightly higher than the value calculated from climate data. Then Table-1 present the summary of statistical analysis results of the evapotranspiration value's comparation that derived from MODIS and calculated from climatic data.

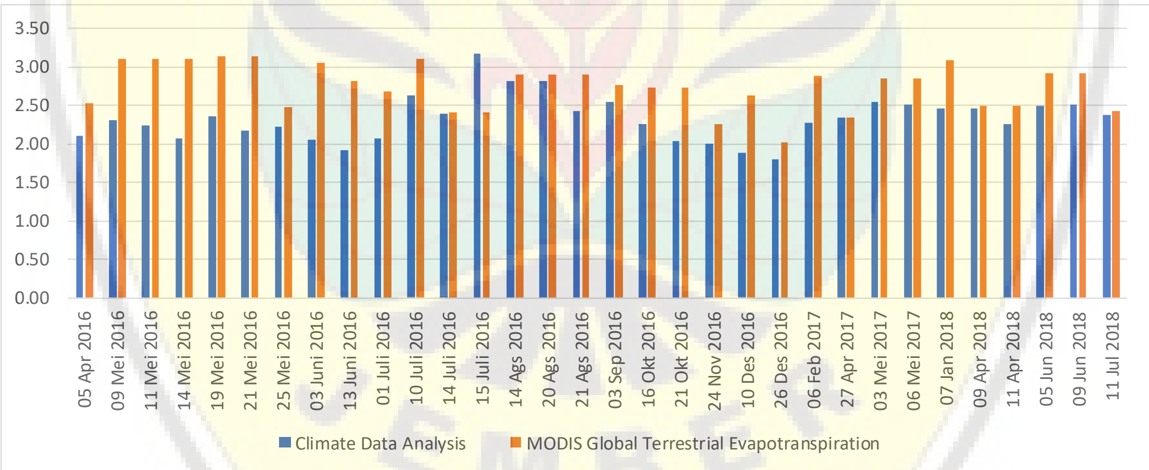


Figure-4. Comparison of Evapotranspiration value between MODIS(MOD16A2) and climate data analysis.

Table-1. Statistical evaluation.

Index	Value
Mean Error (mm/day)	0.43
Relative Bias	0.18
Mean Bias Factor	0.85
Root Mean Square Error	0.57

Based on the result of statistical analysis we can conclude that MODIS global terrestrial evapotranspiration (MOD16A2) have a good performance with reasonable accuracy compared with climate data analysis.

4. CONCLUSIONS

MODIS global terrestrial evapotranspiration has a good performance with reasonable accuracy compared with climate data analysis, so MODIS global terrestrial evapotranspiration product can be used as an alternative solution to generate evapotranspiration information in Manokwari- West Papua.

ACKNOWLEDGEMENT

The authors would like thanks to RISTEKDIKTI - Ministry of Research, Technology and Higher Education that financed this research by Penelitian Kerjasama Antar Perguruan Tinggi (PKPT) grant, Papua University as author agency, and Jember University as partner college.

REFERENCES

[1] S. Fountas, K. Aggelopoulou and T. A. Gemtos. 2016. Precision Agriculture: Crop Management for Improved Productivity and Reduced Environmental Impact or Improved Sustainability in Supply Chain Management for Sustainable Food Network, 1st ed., Chichester: John Wiley & Sons, Ltd. pp. 41-65.

[2] F. J. Pierce and P. Nowak 1999. Aspect of Precision Agriculture. Adv. Agron.67: 1-85.

[3] R. G. Allen, L. S. Pereira, D. Raes, and M. Smith. 1998. Fao Irrigation and Drainage Paper No 56 : Crop Evapotranspiration, 1st ed. Rome: FAO.

[4] BMKG. 2018. Metadata Stasiun. [Online]. Available: https://dataonline.bmkg.go.id/home. [Accessed: 28-Feb-2018].

[5] Tsouni A., Kontoes C., Koutsoyiannis D., Elias P., Mamassis N., Sensing R., … Penteli P. 2008. Estimation of Actual Evapotranspiration by Remote Sensing: Application in Thessaly Plain, Greece. Sensors. 8: 3586-3600.

[6] R. Trezza, R. G. Allen and M. Tasumi. 2013. Estimation of Actual Evapotranspiration along the Middle Rio Grande of New Mexico Using MODIS and Landsat Imagery with the METRIC Model. Remote Sens. 5: 5397-5423.

[7] Reyes-gonzález A., Kjaersgaard J., Trooien T., Hay C., Ahiablame L., Nacional I. &Agr D. I. 2018. Estimation of Crop Evapotranspiration Using Satellite Remote Sensing-Based Vegetation Index. Hindawi. 2018: 12.

[8] DAAC. 2019. Evapotranspiration. [Online]. Available: https://ladsweb.modaps.eosdis.nasa.gov/missions-and-measurements/products/evapotranspiration/. [Accessed: 06-Mar-2019].

[9] Water Environment Federation. 2019. USGS Releases Map of U.S Evapotranspiration Rates.

[10] Assimilation of Multi-satellite data at Berambadi watershed for Hydrology And land Surface experiment (AMBHAS). 2019. Generation of Evapotranspiration (ET) Product for India.

[11] A. L. Aguilar, H. Flores, G. Crespo, M. I. Mar, I. Campos and A. Calera. 2018. Performance Assessment of MOD16 in Evapotranspiration Evaluation in Northwestern Mexico. Water. 10(901): 14.

[12] R. D. Q. Miranda, J. D. Galvíncio, M. Soelma, B. De Moura, C. A. Jones and R. Srinivasan. 2017. Reliability of MODIS Evapotranspiration Products for Heterogeneous Dry Forest : A Study Case of Caatinga. Adv. Meteorol. No. 14.

[13] N. C. S. Shekar and L. Nandagiri. 2016. Actual Evapotranspiration Estimation Using a Penman-Monteith Model. Int'l J. Adv. Agric. Environ. Engg. 3(1): 161-164.

[14] H. W. Kim, K. Hwang, Q. Mu, S. O. Lee, and M. Choi. 2012. Validation of MODIS 16 Global Terrestrial Evapotranspiration Products in Various Climates and Land Cover Types in Asia Validation of MODIS 16 Global Terrestrial Evapotranspiration Products in Various Climates and Land Cover Types in Asia. J. Civ. Eng. 16(August): 229-238.

[15] Q. Mu, M. Zhao, and S. W. Running. 2011. Remote Sensing of Environment Improvements to a MODIS global terrestrial evapotranspiration algorithm. Remote Sens. Environ. 115(8): 1781-1800.

[16] D. Courault, B. Seguin, and A. Olioso. 2005. Review on Estimation of Evapotranspiration from Remote Sensing Data : from Empirical to Numerical Modeling Approaches. Irrig. Drain. Syst. 19: 223-249.

[17] L. Jiang, S. Islam and T. N. Carlson. 2004. Uncertainties in Latent Heat Flux Measurement and estimation : implications for using a simplified approach with remote sensing data. Can. J. Remote Sens. 30(5): 769-787.

[18] J. D. Kalma, T. R. McVicar and M. F. McCabe. 2008. Estimating Land Surface Evaporation : A Review of Methods Using Remotely Sensed Surface Temperature Data. Surv. Geophys. 29: 421-469.

[19] E. Omranian, H. O. Sharif, and A. A. Tvakoly 2018. How Well Can Global Precipitation Measurement (GPM) Capture Hurricanes? Case Study : Hurricane Harvey. Remote Sens. p. 14.