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INDIRECT EFFECT OF LAND COVER TOWARD ON CLOUD OPTICAL THICKNESS OVER INDONESIA

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Abstract

Land surface changes (land cover) and local climate in atmospheric phenomenon such as clouds formation and properties have influenced by converting Earth's surface system. The aim of this reaseach is to investigate the indirect effect of land cover on cloud optical thickness over land in Indonesia with concern in annual and seasonal by MODIS images from january 2003 to december 2016, using the climatologies algorithm approach and vegetation index or normalized difference vegetation index (NDVI). The Earth's hydrological cycle is complex system describing the mutual relationship between Earth's surface and the atmospheric component, as a consequence, small changes to one part of the system can accrue to have larger effects on the other system as a whole. NDVI and cloud optical thickness obviously allocated in wet season than dry season, with fluctuated in uphill and downhill polynomial. According to wet season, downhill line of cloud optical thickness ware detected as mean value on every November during 14 years. At 1 percent of NDVI fluctuation declined two times of optical depth otherwise. Absolute result in wet season may be due to more stable and homogeneous data variability. Least sunlight for vegetation growth and the least amount of evapotranspiration energy, less cloud forms.

Keywords: Land cover, Cloud Optical Thickness, MODIS

A. Introduction

The role of Earth's surface in local climate through the continuously surface energy balance of transpiration, evaporation, and evapotranspiration. Approximately 70 percent of the Earth's surface is covered by water, and 30% the remaining of Earth's surface recognize as land. It also exists for all types of landforms on earth that include mountains, forests, urban areas, glaciers, desserts, etc. A recent study that published since 1973 untill 2016 implies the forests have a better ability to maintain good air quality stability (Diener & Mudu, 2021). However, an estimated 178 million hectares of forest reconstruct to make the other land uses since 1990 to 2020 (FAO, 2020). Therefore, land surface properties have been continuously changing overtime. This fact will refer to their role in the changing nature of the land. Climate change occurs because of the changes in global emissions come from the land sector, land surface temperature, air pressure, wind, rainfall and humidity (Duveiller, et. al. 2018). The above changes are related to the changes in the environment, the changing environment issue in Indonesia and in the world is a very sensitive matter, such as forest fires (which continued until now), floods, air pollution, waste disposal plant, land use change, including the implementation of spatial plans that is not accordingly, so that the land use changes (Wu, et. al. 2013).

On the other hand, Cloud is one of the significant portions dominate the Earth's surface energy balance by lead to warming or cooling Earth's surface depending on the reflect and absorbing the energy from sun into space or from surface to space. Clouds, the crucial part of the atmospheric layer, directly interact with global aspects of the climate system. Better understanding of increasing or decreasing the incoming or outgoing solar radiation may lead to generalizing the current conditions. This information asserts the cloud response has a clout on heating and cooling mechanism on Earth, especially in land surface (Voigt, et. al., 2020).

Indonesia, one of the country cases, is the permanent alter from the forest and may even breakthrough from 2001 to 2012 from 0.1 growing to 0.8 area in millions of hectares due to agriculture, logging, forest-to-palm oil planting, and etc (Margono, 2014). The indirect effect of deforestation on the environment and climate change is unbalancing Earth's system by increasing the concentration of greenhouse gases into the atmosphere (FAO, 2020). Indonesia is most complex terrestrial ecosystem all of Asia extending 5,000 km along equator and spanning two major bio-geographical realms, Indo-Malaya and Australasia with seven major bio-geographic regions in Indonesia, centered on the major island and groups and their surrounding seas, such as Sumatra and Kalimantan. Indonesia has total forest area around 88,495,000 ha or 48,8 percent of land area. Deforestation, clearance, or clearing is the cutting or burning down of all the trees in an area or forest converted to a non-forest use (Williams, et. al. 2020).

Land surface properties could be accumulated from vegetation indication approach by Normalized difference vegetation index (NDVI) where this vegetation index could be a parameter to effectively characterize bio-physical/ biochemical states and processes from vegetated surfaces by "greenness" profile inscribing what the condition occurs (Didan, 2015). On the other hand, clouds factor is made of more distinguish character depend on cloud characteristics include how visible the ground is as viewed from outer space as it is blocked by the clouds. By observing with land surface factor and cloud characteristics, the correlation between each other can be modulated indirect effects. In principle there are two approaches such as ground-based and satellite assessment. However, to represent in terms of all accurately, ground-based measurement is still uncertainty measure and limitation of data.

The empirical assessment is necessary to define above subject so-called remote sensing assessment. Remote sensing is the best approximation to decipher this problem which provides some advantages such as easily processing, widely cover area, and periodically observation, etc. The concept of remote sensing refers to collect and interpret of the information about the environment and the surface of the earth from a distance, primarily by sensing radiation that is naturally emitted or reflected by the earth's surface or from the atmosphere, or by sensing signals transmitted from a device and reflected back is remote sensing description (ESRI, 2017).

Effect caused by the phenomenon of the changing of land surface and cloud characteristics is urgency of this research. So, the objective of this research is to investigate the indirect effect of land cover on cloud optical thickness over land in Indonesia with concern in annual and seasonal by MODIS images from january 2003 to december 2016, using the climatologies algorithm aprroach. The further analysis, cloud component describes cloud optical thickness will analysis with NDVI changes.

B. Methodology

Based on the occurence of the phenoma, the forest loss calculation mechanism is obtained by the vegetation index approach, interacting with the forest landscape. The vegetation index is driven by the implementation of vegetation transformation depending on two or more spectral bands. There are several vegetation indices based on their usefulness. One of the most widely used is the Normalized Difference Vegetation Index (NDVI). Concept of NDVI is designed by the reflectance of wavelengths of light of the visible and near infrared wavelength, two of the bands with sensitivity wavelengths ranging from 0.55 – 0.70 and 0.73 – 1.0 micrometers, respectively.

The characterization of NDVI class depends on the probability of the wavelength intensity of the NDVI range value from +1.0 to -1.0. More index of NDVI value indices as an area that has more radiation reflected in deference of wavelengths intensity. Slight differences between the wavelengths of intensity mean the vegetation may be identified as grassland, tundra or desert. Figure 1 depicts the example of the concept of the reflectance of vegetation index (NDVI). For vegetation index product, MOD13C2, NDVI extract as land surface properties parameter. NDVI parameter has a complete paramters name CMG_0_05_Deg_Monthly_NDVI. The example of the concept of the reflectance of vegetation index (NDVI) based on MODIS (Didan, 2015).

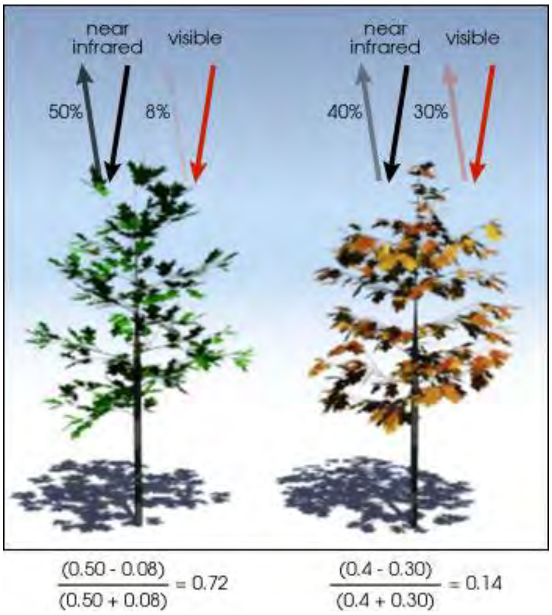

Figure 1. Illustration of the vegetation reflectance for NDVI (Illustration by Robert Simmon). (Source: Weier & Herring, 2000)

The formula of the density of wavelengths radiation represents [1] consider

$$NDVI = \frac{(Surface\ Reflectance-1)}{(Surface\ Reflectance+1)} = \frac{(\rho_{NIR}-\rho_R)}{(\rho_{NIR}+\rho_R)} \quad (1)$$

Where ρ_{NIR} is the near infrared (NIR) reflectance and ρ_R is the Red (Red) reflectance.
Cloud optical thickness can be written in terms of the

$$\tau = \int_h^{\infty} K_{ext} \rho dh' (2)$$

Where τ represents cloud optical thickness. K_{ext} is the extinction coefficient per unit mass. ρ is the atmospheric density at height h'.

Accordingly, multiple clouds in the atmospheric layer are adequately accounted for $\tau = 0$ on the top of atmosphere and $\tau = \tau_0$ on the bottom. We are using the mean value of MOD08_M3 and MOD08_M3 for cloud_optical_thickness_mean_mean. Particularly during scattering of cloud layer, Rayleigh optical depth is necessary to determined the given wavelength and composition. Occurence and number of Rayleigh optical depth is necessary to calculate only the total number of molecules per unit area in the column above the site, and this depends on some components such as pressure, angle, etc (Hubanks, 2018).

In these terms, climatology is also defined as the average of each particular month. There are numerous climatological functions that compute daily and monthly climatologies; calculate anomalies from the climatologies; remove monthly and daily annual cycles, and, calculate interannual variabilities.

$$d_{m,n} = x_{m,n} - x_{(m,n)-1} (3)$$

$$a_{i,j,m,n} = x_{i,j,m,n} - \frac{\sum_{n=2003}^{2016} x_{i,j,m,n}}{14} (4)$$

Where $d_{m,n}$ is the differences between current monthly mean value $x_{m,n}$ to previous monthly mean value $x_{(m,n)-1}$, subscript m, n refers to from the fixed month and year for which the climatology is computed, respectively. $a_{i,j,m,n}$ is the deviation of the monthly values $x_{m,n}$from the sprecific monthly grid cell climatology subscript i, j refers to the ith row and jth column of the model grid.

The Fisher Z-Transformation is a way to transform the sampling distribution of Pearson's r (i.e. the correlation coefficient) becomes normally distributed. The "z" in Fisher Z stands for a z-score [43]. Fisher's z-transformation of r is defined as

$$z = \frac{1}{2}\ln\left(\frac{1+r}{1-r}\right) = \arctan h\,(r) \quad (5)$$

Where ln is the natural logarithm function and $\arctan h$ is the inverse hyperbolic tangent function. If (X, Y) has a bivariate normal distribution with correlation $\rho$and the pairs (X_i, Y_i) are independent and identically distributed, then$z$ is approximately normally distributed with mean.

$$\frac{1}{2}ln\left(\frac{1+\rho}{1-\rho}\right) \quad (6)$$

$$\frac{1}{\sqrt{N-3}} \quad (7)$$

where $N$is the sample size, and $\rho$is the true correlation coefficient.

C. Findings and Discussion

1. Findings

The results of the standard deviation of COT parameter variable and surface properties from January 2003 to December 2016 are presented in Figure 2. This image shows the fluctuation of the mean value of each individual parameters depends on 14 years of the time series. Monthly variation is a point in the x-axis and y-axis is index value in each specific case of NDVI and cloud parameters. We would like to evaluate all the parameters in the domain to look for the annual cycle rendency. The NDVI values range from 0.73 to 0.82 which means this value is close to +1 indicating the highest possible green leaf density. Cloud optical thickness has valuesin the range 7 to 12, which are correlated to extinction of radiation.

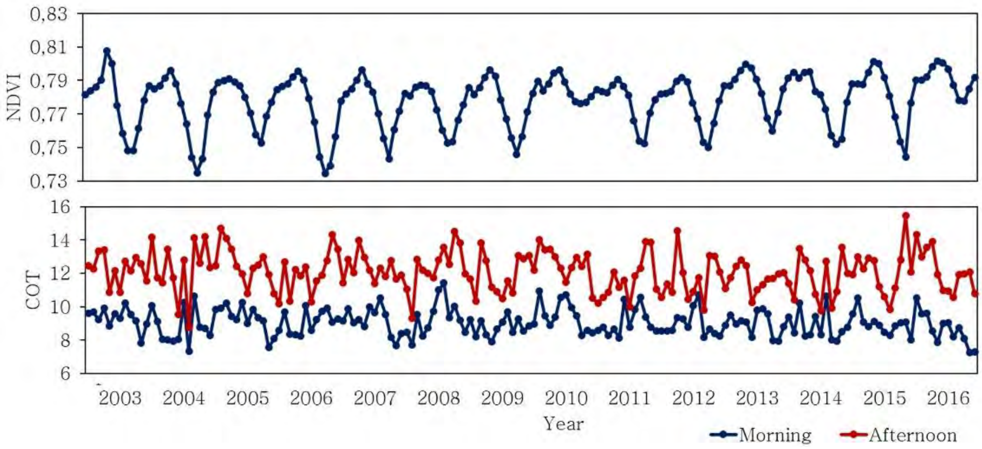

Figure 2. The graph of land properties (i.e., NDVI) and cloud optical thickness from MODIS Terra (Morning) and MODIS Aqua (Afternoon) start from January 2003 to December 2017. Blue line depict MODIS Terra and Red line depict MODIS Aqua. (Tampubolon, et. al. 2020)

The annual and seasonal mean regional distribution of NDVI and cloud optical thickness, separated morning and afternoon. Regarding annual and seasonal, the cloud optical thickness is smaller size in morning than the afternoon, reflecting denser of particle size can be seen on Figure 3. Significance of cloud optical thickness distribution was more stable in wet season of than dry season (Igel, et al. 2018). Figure 4 shows slightly falling trend of delta NDVI towards delta cloud optical thickness. Decreasing 0.01 of delta NDVI (1% change of NDVI) smaller a cloud's optical thickness, which relate to cloud ability to absorbing more sunlight. It may result in positive feedback associated with changes in cloud cover.

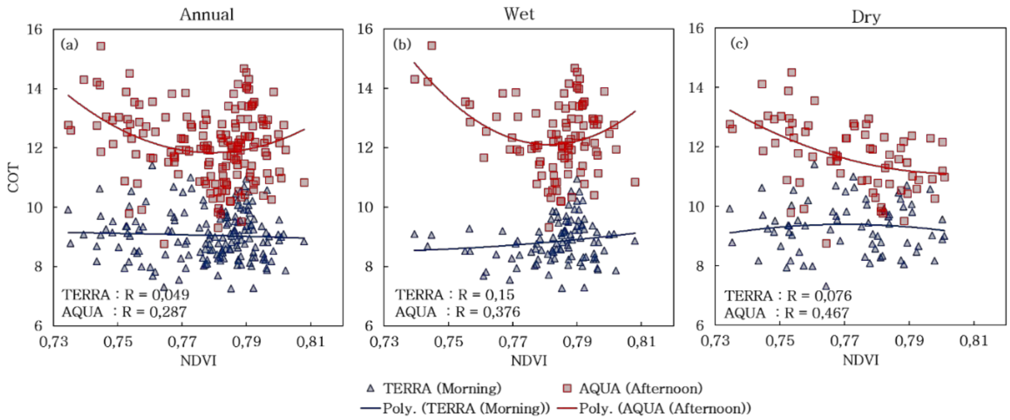

Figure 3. Scatter plots between NDVI versus cloud optical thickness for (a) Annual; (b) Wet season; and (c) Dry season retrieval result of TERRA (Morning) and AQUA (Afternoon) MODIS data from January 2003 until December 2016. Blue rectangle creates a visual symbolize of TERRA (Morning) MODIS data and red box creates a visual of symbolize of Aqua (Afternoon) MODIS data.

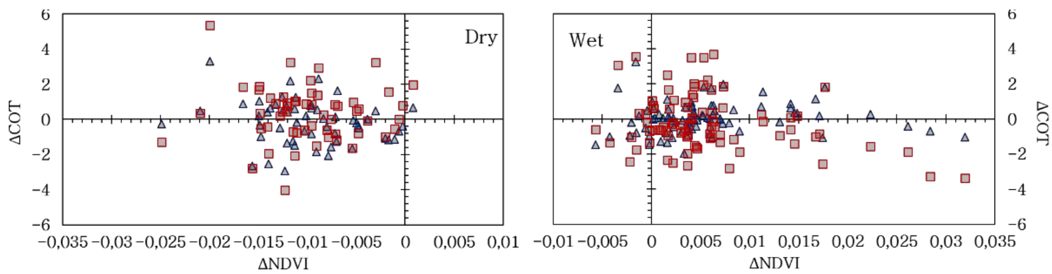

Figure 4. Scatter plots between ΔNDVI versus optical thickness of TERRA (Morning) and AQUA (Afternoon) MODIS data from January 2003 until December 2016 in wet and dry season.

D. Conclusion

All statistics of distribution of relationship between NDVI and cloud optical thickness obviously allocated in wet season than dry season, with fluctuated in uphill and downhill polynomial. According to wet season, downhill line of cloud optical thickness ware detected as mean value on every November during 14 years. At 1 percent of NDVI fluctuation declined two times of optical depth otherwise. Absolute result in wet season may be due to more stable and homogeneous data variability. Least sunlight for vegetation growth and the least amount of evapotranspiration energy, less cloud forms.

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