ANALYSIS OF THE FACTOR WHICH GIVES INFLUENCE TO AVHRR NDVI DATA

Jong-geol Park and Ryutaro Tateishi
Center for Environmental Remote Sensing
Chiba University, Japan
amon@ceres.cr.chiba-u.ac.jp
tateishi@ceres.cr.chiba-u.ac.jp

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ABSTRACT

Land cover change of global scale from 1982 to 1993 was studied using NOAA Pathfinder AVHRR Land (PAL) data set. In order to reduce influence of clouds, the Temporal Window Operation (TWO) method was proposed for time series NDVI data. After the investigation of the relationship NDVI data and solar zenith angle (SZA), the result shows that NDVI data with SZA of larger than 60 degrees has more atmospheric effect. By analyzing average and standard deviation of temporal NDVI, areas with unstable NDVI were extracted. The unstable NDVI does not necessary mean land cover change. Further study is necessary to separate land cover changes and other causes in unstable NDVI.

1 INTROUCTION

Global data sets of land cover have a significant requirement for global biogeochemical and climate models (IGBP, 1994). Remotely sensed satellite data is an increasingly attractive source for deriving these data sets due to the resulting internal consistency, reproducibility, and coverage in locations where ground knowledge is spares (Townshend, 1992). Although global, continental, and regional land cover data sets have been derived from satellite data (Tucker et al., 1985), methods for deriving land cover from satellite data are still being in development. Many studies focused on using time series NDVI data and land surface "skin" bright temperature (TS) data of one year or more than one year to produce land cover map. But in some areas, NDVI and TS are easily changeable due to the characteristic of these regions. The major cause is cloud. Therefore, some methods, like Maximum Value Composite (MVC: Holben 1986), Maximum Value Interpolation (MVI: Taddei 1997), Temporal Window Operation (TWO: Park 1999), The Best Index Slope Extraction (BISE: Viovy 1992) have been used to reduce the influence of cloud. But, these methods cannot remove the influence of long term existing cloud. NDVI and TS also vary with the weather condition, which influences the change of vegetation. Tucker et al. (1991), 'Expansion and contraction of the Sahara desert', illustrated the uncertainty of this issue. Intuitively, it is not the boundaries of the Sahara as a geographical region. The fluctuation rather affects one of the many biophysical attributes defining a land-cover type, which responds to interannual variation in rainfall (Hellden 1991). On account of factors mentioned above, there is a great possibility of mis-classification of such areas.

The purpose of this study is to analyze the factors, which influence NDVI and TS greatly and to extract the areas where vegetation changes intensely with respect to weather conditions.

2 DATA

We used the NOAA/NASA Pathfinder AVHRR Land (PAL) data (James and Kalluri, 1994) for this study. The PAL data set includes daily and 10-day composites of 12 data layers at a spatial resolution 8 km. We extract 10-day composites of the following layers: NDVI, red reflectance (Channel 1: CH1), infrared reflectance (Channel 2: CH2), Channel 4 bright ness temperature, Channel 5 brightness temperature and Solar Zenith Angle (SZA). Land surface "skin" brightness temperature (TS) was derived from the thermal channels of the AVHRR by using the split-window technique (Price, 1984):
$TS = CH4 + 3.33 * (CH4 − CH5) − 273$,
TS is related, through the surface energy balance equation, to surface moisture availability and evapotranspiration, as a function of latent heat flux (Carlson et al., 1990).

3 AVERAGE AND STANDARD DEVIATION DATA SET FOR 12 YEARS

In order to extract vegetation change and land cover change using time series NDVI data set, a standard data set is necessary to compare with a posterior data set. Here, "a standard data set" means typical seasonal NDVI pattern which represent the pixel area. The influence by distortion factors such as volcanic ashes, abnormal weather and SZA to the
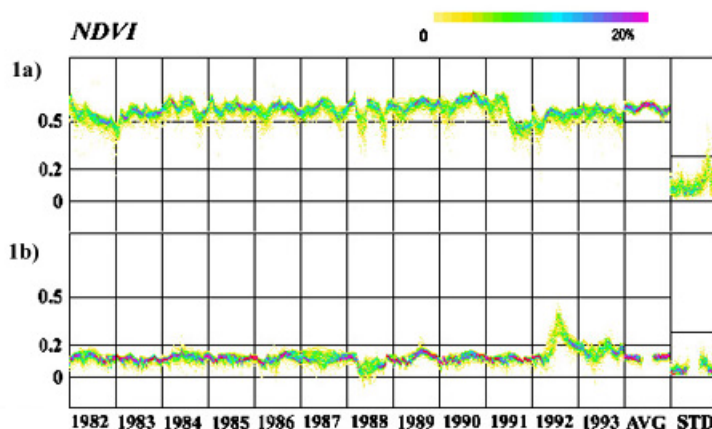
Figure 1. NDVI profile for twelve years

standard data set needs to be minimized. Thus, instead of using total average of the data of 12 years, for each pixel, the data of the same period of each year were arranged from low to high order, then the five years' data, i.e. from the second to sixth year were selected to calculate the average and standard deviation. NDVI has a characteristic of decreasing tendency with respect to the influence of cloud, volcanic ashes and SZA. Figure 1 a) is the NDVI profile of 12 years in the Brazilian Tropical Rain Forest area (70 pixels). The NDVI value is high, with a little change of NDVI during a year. But the observed NDVI value was low comparing to the other years for the influence of Mexico and Indonesian volcano eruption in 1982 and Philippine volcano eruption in 1991. And also there is the case that the NDVI value becomes extremely high by influence of abnormal weather. Figure 1 b) shows the desert area of Australian southern part. It is found that NDVI value was high by the influence of a great quantity of rain from March to May in 1992 (abnormal weather report' 94). In this study, as the NDVI data will not be used when SZA is larger than 60. If the NDVI data cannot be acquired more than 3 times for 12 years, the average data will not be calculated. Thus, the average data from June to July do not exist in figure 1 b).

4 STANDARD DEVIATION DATA AND AREA CHARACTERISTIC ON NDVI

From the average data, for each pixel, the period of maximum NDVI was utilized, and the average of the standard deviation data was calculated using five months' data from the peak of the NDVI (Figure 2). As a result, in desert area, there is no change of NDVI and the value of average standard deviation is low. High standard deviation value occurs on the shoreline although it is only 1 pixel.
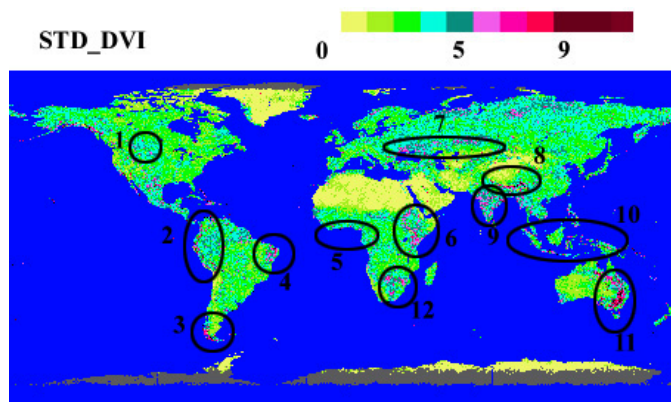

Figure 2. Standard deviation Image

The possible reasons include: 1) the cloud is easy to occur near shoreline area, 2) The ratio of the land and the sea changes in the pixel because the data is made from GAC (Global Area Coverage) with the of 4 km, 3) It is difficult to acquire the RMS error smaller than 1 pixel in geometric correction. Figure 3a) shows the average NDVI profile and standard deviation value of Amazon area for 12 years and five years, respectively, where NDVI is stable. The standard deviation value is small. But in Figure 3b) the change of NDVI is intense, and the standard deviation value is high. These areas mainly exist in the South American Cordillera de los Andes, Himalayas, Australian Great Dividing Range, Atlas Mountains of

Morocco, Ethiopia plateau, Indian Deacon, Brazilian eastern part, Africa southern part, Black sea peripheral, and south Argentinean beach. All the above-mentioned areas can be divided into three categories: 1) Areas where appearance frequency of clouds is high according to the topography, 2) Areas influenced by climate, 3) Areas influenced by other causes. Areas 1, 2, 6, 8, 10, 11, 12 in Figure 2 show the area where the appearance frequency of cloud is high according the topography. The NDVI data used in this study is corrected by the TWO (Park 1999) method in order to remove influence by clouds. But the areas mentioned above are not suited to be processed by the TWO method. Because these areas have more than two-month cloud period, while the TWO method assumes less cloud period.
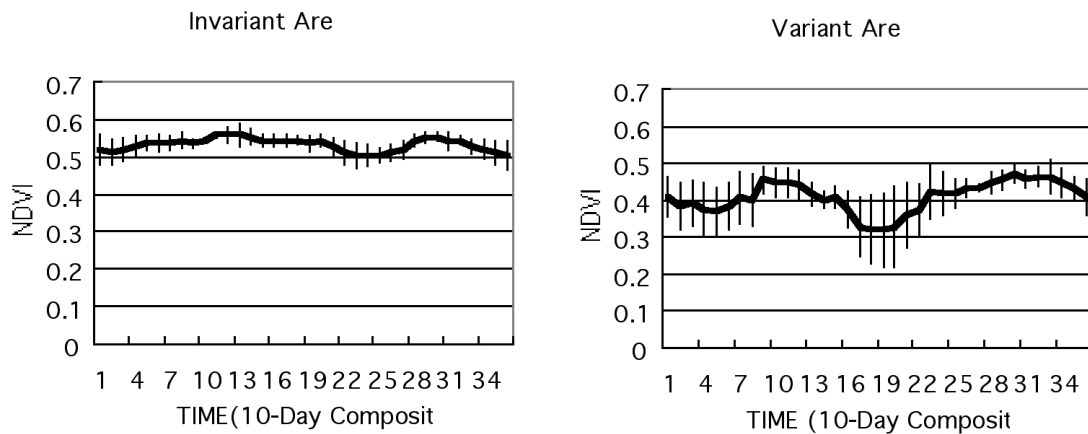

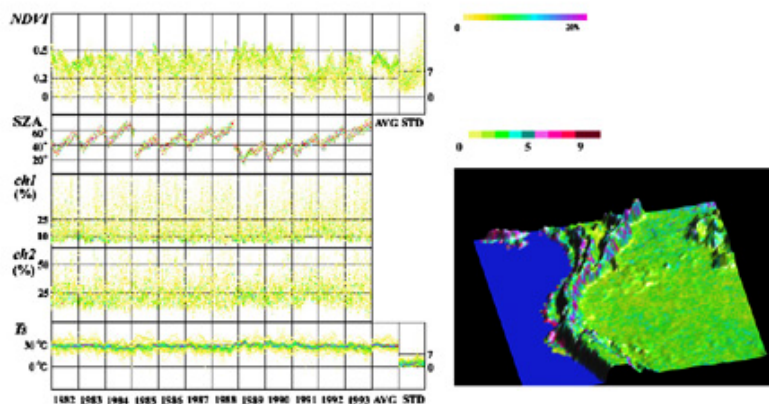Figure 3. Average NDVI profile and standard deviation value of Amazon area

Figure 4a. Profiles of NDVI, SZA, CH1, CH2, TS   Figure 4b. Bird's-eye view of area 2

Figure 4a) is the profiles of time series NDVI, Channel 1(Ch1), Channel 2 (Ch2) of South American Cordillera de los Andes (Figure 2: area 2). Since the influence by clouds to Ch1 and Ch2 data were not corrected, the observed reflectance has a high value and NDVI is low. Figure 4b) shows the bird's-eye view of elevation data, NDVI and average standard deviation. NDVI varies easily in the area, which have the appropriate condition of the incline, elevation and plants, and near the sea. Also NDVI varies easily in the area where a big mountain existed in low circumference. Figure 2: area 4, 9) shows the area influenced by the climate. In India and Indochina peninsula, the standard deviation value from June to August is larger than other periods because of the influence of monsoon. The area 4 also has a high standard deviation value. The climatic change is high this area, and the vegetation is also different from the neighboring side. Other areas are represented by area 3, 5, 7). The south coast of Argentinean is a Ryas coast and has the shoreline characteristic. It is considered that aerosol is the main factor influencing the change of NDVI in area 3. But there is few reference data, and it is difficult to grasp its relation correctly only from NOAA/AVHRR data. In the area of the Black sea outskirts, the standard deviation from autumn to spring is larger than in summer. It is thought that it is the influence by low frequency change of the atmosphere circulation. The change of each pixel was examined quantitatively for each year using the average and standard deviation data.

Where

$$GAP_i = \sum_{T=P-8}^{T=P+6} \left| \left(AVG_T - NDVI_{T+i} \right) / STD_T \right|$$

$$TOT_i = \sum_{T=P-8}^{T=P+6} \left(AVG_T - NDVI_{T+i} \right)$$

i: gap of the peak time (i= -2, -1, 0, 1, 2) unit: 10-day
GAP: Total value of season gap, AVG: Average NDVI value, STD: Standard deviation value of NDVI
TOT: Total change quantity, P: Peak time of AVG NDVI profile

For each pixel, matching was performed between the year profile and average profile. Here, as shown formula 1), the difference of the year data and average data is divided by the standard deviation value, then the absolute value of the results are summed and can be represented as the total value of seasonal gap (GAP). And the sum of the difference between the year and average data is expressed as Total change quantity (TOT). So the matching result represents the TOT value when the GAP value is the smallest. Figure 5a) shows TOT image of the areas abnormal weather distribution area shown in the synthesis change quantity image for 1983 years and abnormal weather report 1989 of Table 1). As a result we conclude that distribution of abnormal weather agrees with NDVI change well regionally.

5 CONCLOSIONS

This study was to analyze the factors which influence NDVI and TS largely, and to extract the areas where vegetation changes intensely with respect to weather conditions. By analyzing average and standard deviation of time series NDVI, areas where NDVI area not stable were extracted. Part of the cause of unstable NDVI were foune to be abnormal weathers. Further study to discriminate land cover change from other cause s including abnormal weather is necessary for global land cover change detection by global time series satellite data.

Asia	Southeast China	heavy rain (1-4)	
	South China	heavy rain (5-7)	
	Philippines, Indochina peninsula	drought (1-7)	
Europe	France	Intense heat / a gentle rain	
	Northern Europe	heavy rain (3-5)	
Africa	Southern Africa	drought	
	Ethiopia, Sudan	drought	
South America	Argentina, Paraguay, Brazil	heavy rain(1-6)	
	North America	Eastern America gentle rain	
	Central and southern America	heavy rain	
Oceania	Eastern Oceania	drought	

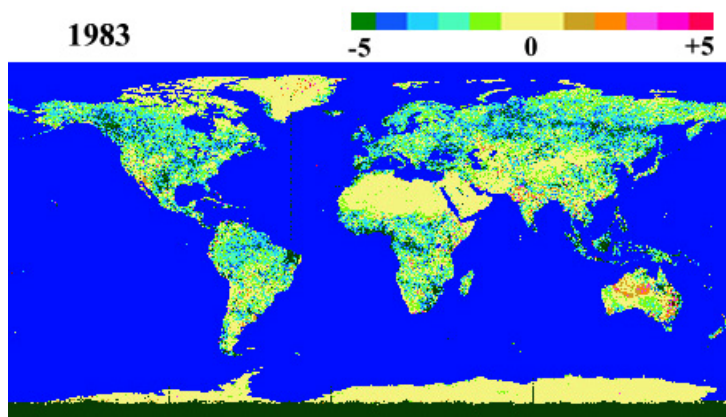*Table 1. Abnormal weather in 1983*

Figure 5. Total change quantity image in 1983

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