Estimation of vegetation water content using MODIS data for the assessment of fire risk forest in Viet Nam.

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Abstract.

Estimation of vegetation water content from local to global scale is central to the understanding of biomass burning processes. Several attempts to estimate vegetation water content on the basis of satellite remote sensing data have relied on empirical relationships between vegetation greenness/status and vegetation water content. However, some assumptions made to relate vegetation greenness and vegetation status to the vegetation moisture content are not applicable to all types of vegetation. This thesis was based on the results of researches on sensitivity of vegetation water content and other factors (biophysical, soil, atmosphere, illumination and viewing position) on reflectance simulated at different levels (leaf, canopy, top of atmosphere) in the electromagnetic spectrum range between 400 and 2500 nm. The results allow identification of capacity using MODIS data to specify wavelengths sensitive to vegetation water content. Some researches were established some new index, one of them called Global Vegetation Moisture Index (GVMI), is developed specifically for the SPOT-VEGETATION sensor to retrieve vegetation water content. The index uses a combination of the Short Wave Infrared (SWIR) channel and the Near-Infrared (NIR) channel rectified for contamination by atmospheric effects using the BLUE channel. Simulated GVMI values are related to vegetation water content expressed in terms of Equivalent Water Thickness at canopy level (EWT canopy). From the result of this researches and capacity to develope MODIS data in Viet Nam allowed to apply remote sensing technology in term of forecasting fire risk forest in Viet Nam. The result of thesis have indicated the relation between reflection of ratio channel Sort Wave Infrared and Near Infrared of TERRA MODIS and estimation of water vegetation content almost types of forest in Viet Nam, specially relation with fire forest season and humidity, temperature status. Some detail results and further researches is discussed.

List of Acronyms

EFAST: Extended Fourier Amplitude Sensitivity Test
EWT: Equivalent Water Thickness (leaf level)
LOPEX93: Leaf Optical Properties Experiment 93
MODIS: Moderate-Resolution Imaging Spectroradiometer
NIR: Near-Infrared
SPOT: Système Pour l'Observation de la Terre
SWIR: Short Wave Infrared

1. Introduction

Viet Nam, that has tropical climate nation, in which it devides into four seasons at North and two seasons at South of Viet Nam. However, dry season often appear duration on November of last year to March and April of next year. At that time, rainfall is very low, number of dry day lasts many and even once or two months. A part from that., Viet Nam with land surface is very complex, three and fourth is mountain, spreads as latitude, thus there are so many types of forest in different areas belonging to its position. Addition, climate of Viet Nam has been worse changed, recently, temperature of atmosphere increases, disaster as storm, flood, especially fire forest occur frequently and seriously. Because of these reasons, the risk of fire forest will be high in dry season. And in the fact that, Viet Nam has had so may fire forest affairs, recently. Duration of 1998 –2000 year, there are 2108 affairs, about 23,000 ha forest had been lost. According to Forest Agencies, there has been 1,413 fire forest annually, 3,616 ha natural forest and 3,032 ha artificial forest lost in Viet Nam. Table 1 show the statistical fire forest data duration of 1992-2001 in Viet Nam.

Table 1. The statistical fire forest data during 1992-2001 in Viet Nam.

Years	Sum of fire forest affairs	Natural fired forest area (ha)	Artificial fire forest area (ha)	Sum of fire forest area (ha)	Note
1992	1.467	6.995,5	2.339,8	9.335,3	
1993	4.428	3.165,2	3.200, 0	6.365,0	
1994	2.337	4.226,6	4.120,0	8.321,6	
1995	850	6.080,0	3.600,0	9.684,0	
1996	2.551	6.540,0	6.196,0	12.758,0	
1997	309	307,0	1.054,0	1.361,0	
1998	1.685	6.893,7	7.918,8	15.276,5	5.122 ha Bushes
1999	185	902,8	236,5	1.139,5	
2000	244	654,7	205,5	850,2	
2001	256	391,0	1.454,4	1.845,4	
Sum	14.132	36.160,5	30.325,0	66.845,5	

Resource: Forest Protection Department of Viet Nam

In frond of that status, Government and Official units has been implemented many methods to reduce fire forest and environment and health affects. However, fire forest has been tending to complex and difficult to control, especially on fire forest season. Consequently, group of researcher has been worked on this thesis for assistance of forecast early the fire forest on macro area.

2. Methodology

Remote sensing technology has been more popular applications in Viet Nam. However, in the vegetation cover, these applications implemented in statistics, investigation the areas. Some studies researched on statistics of fired forest spots but the results had restricted. Thus, the thesis has implemented study on remote sensing technology to detect status of water vegetation content in order to assess and support fire forest forecast activities.

2.1 Single channel analysis

The use of the red and near-infrared (NIR) channels provides complementary information to distinguish between bright soil (high reflectance in both the NIR and Red bands) and sparse vegetation (low reflectance in the Red). However, it is still difficult to distinguish dark soil from sparse vegetation. The solution proposed by the Locust Group is to use complementary information provided by the SPOT-VEGETATION short-wave infrared (SWIR) channel (located at 1.6 µm). The SWIR is sensitive to water in the soil and vegetation [2]. On a 10-day composite image, the soil usually dries more quickly than the vegetation leading to SWIR reflectance values of soil that are higher than the SWIR reflectance values of vegetation. By analyzing each single channel Red, NIR and SWIR, the user can identify the properties of the vegetation from the bare soils. By comparing the reflectance values of the single channels within the surrounding background, the officer can decide whether a pixel can be classified as vegetation or bare soil.

2.2 Calculation of water vegetation content by SWIR/NIR ratio channel of TERRA – MODIS.

An EFAST sensitivity analysis was performed to compare the single wavelength SWIR and NIR sensitivity to EWT with the Simple Ratio (Eq. 1). Results (Table 2) show that the simple ratio is more sensitive to EWT variations than SWIR/ NIR the single wavelengths. EWT accounts for 86.7% of Simple Ratio variations while only accounting for 36.4% of reflectance variation at 1600 nm. The simple ratio between SWIR and NIR could therefore be used as a first approximation to retrieve vegetation water content at leaf level (Ceccato, 2001).

Table 2: Sensitivity analysis of single wavelength (1600 nm: SWIR, 820 nm: NIR) and Simple Ratio to EWT, N (Leaf internal structure) and Cm (Leaf dry matter content), (Ceccato, 2001).

Factors	Reflectance values at 1600 nm	Reflectance values at 820 nm	Ratio (1600nm/820nm)
EWT	36.4%	0.0%	86.7%
N	41.1%	74.4%	5.8%
Cm	22.5%	25.6%	7.5%

Thus, we applied parameters in the condition of Viet Nam by SWIR/NIR (Channel 2/channel 6) simple ratio channel of TERRA - MODIS. The detail following:

$$y = 0.666 + \frac{1.0052}{1+1159x} - 6.976x \quad (1)$$

where y is the SWIR/NIR reflectance value of TERRA - MODIS, x is the EWT – Equivalent Water Thickness (g H2O/cm2).

And, the result of study is discussed on the next section below.

3. Results and discussion.

According to equation 1, EWT was defined in the range 0 – 700 g H2O/cm2, so we were uncertainly divided into 6 levels following table 3, below:

Table 3. Table of legend and division water content at leafs level.

Colours	Symbol	Content	Legends
	Ko_xd	unknown	No forest area
	Ratkho	Very dry region	1-50 g H_2O/m^2
	kho	Dry region	51-100 g H_2O/m^2
	hoikho	A little dry region	101-200 g H_2O/m^2
	hoiam	Normal region	201-300 g H_2O/m^2
	am	Wet region	301-400 g H_2O/m^2
	Am uot	Very wet region	401- 700 g H_2O/m^2

The result of study was indicated that the dynamic of EWT at leaf level on dry season and wet season. Through processing MODIS data of 11 months in 2002 covered Viet Nam ‘s territory. So, on this section, we present the result of 3 specific representative months for dry season (fire forest season): January, February and March and wet season: September, October and November in Viet Nam. The detail result show on figures below:

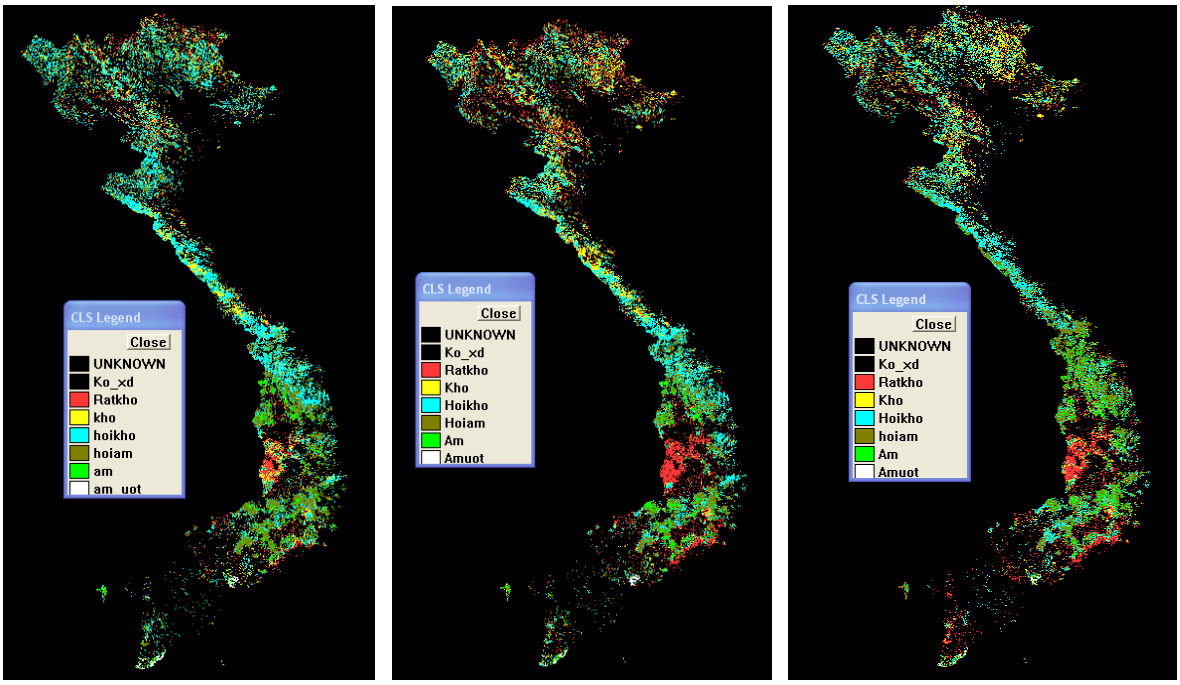

Figure 1. EWT at leaf level on the forest area on the dry season (fire forest season) in Viet Nam for the SWIR/NIR of TERRA-MODIS covered Viet Nam on January, February and March in 2002.

On the figure 1, red regions represents very dry area, amount of water at leaf level is about 1-50 g H2O/m2. Especially, analyzing Dipterocarpacea forest area in Tay Nguyen/South of Viet Nam show that, the temperature atmosphere is high, humidity is very low, dry days can last for months, thus water of trees lost, leading to leaf left and dry status, fire risk forest is very high during this time. In the fact that, many fire forest affairs is occurred in this region annually, especially on the peak every March and April. For others region in Viet Nam as West North of North of Viet Nam, some areas in the Middle had similar results logical rule in the Tay Nguyen region.

In the wet season, rain fall level is high over the country, the humidity is very high, trees growth very fast, water of vegetation content is always rich. This manifest clearly on figure 2 below:

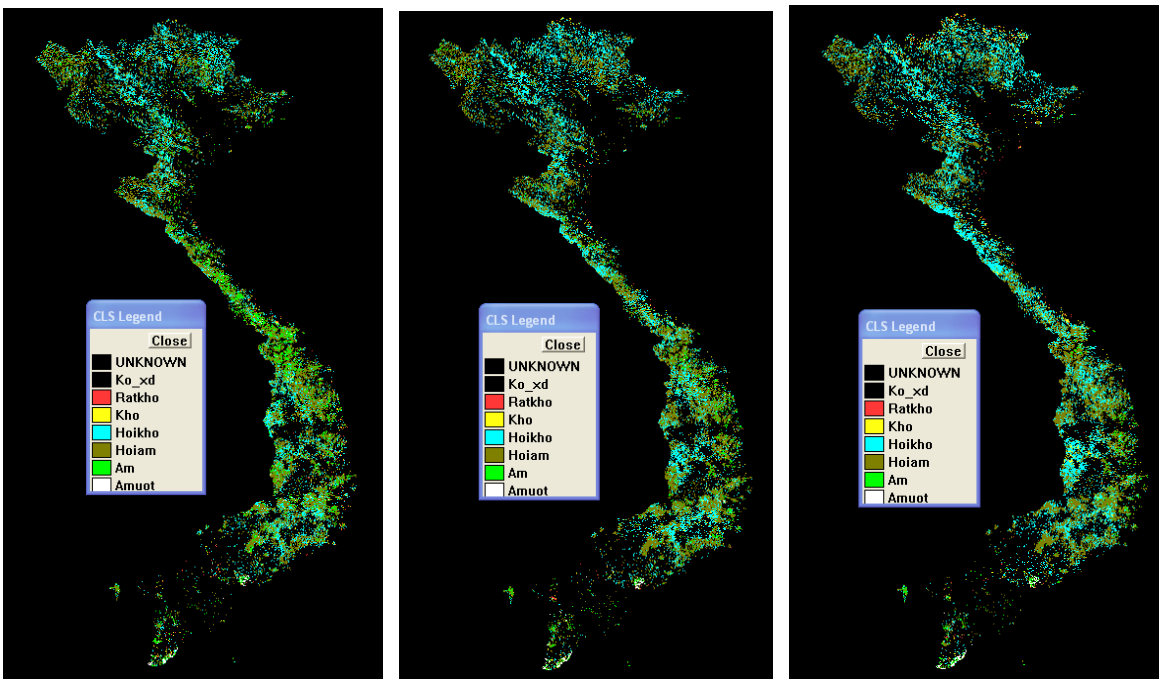

Figure 2. EWT at leaf level on the forest area on the wet season: August, September and November in Viet Nam for the SWIR/NIR of TERRA-MODIS covered Viet Nam on August, September and November in 2002.

On the figure 2, there is no symbol to show lack of vegetation water content, thus all part of tree imported water enough, however, including leafs level. Thought, there has no red or yellow appeared, blue and white covered demonstrating that water content on the trees will be much. So, the risk of fire forest was difficult to happen duration of it.

4. Conclusion.

Consequently, using MODIS data can detect, monitoring the state of trees, especially can assess vegetation water content at leafs level. Then it can be used to forecast the dry level of forest area. If this data and other materials as meteorological and fields data cooperate, it will be possible to establish station of forecasting fire forest on the macro area, quickly and very useful and economical for control of fire forest agencies in Viet Nam.

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