# STUDY ON THE DEVELOPMENT OF $a_{\mathrm{dom}}$ ESTIMATION ALGORITHM BY EMPIRICAL METHOD FOR GOCI OCEAN COLOR SENSOR

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**ABSTRACT** This study uses empirical method to estimate absorption coefficient of colored dissolved organic matter ($a_{\mathrm{dom}}$) from GOCI satellite data with the relationship between band ratio of remote sensing reflectance ($R_{rs}$) and $a_{\mathrm{dom}}$. For development of $a_{\mathrm{dom}}$ estimation algorithm, the used data is in-situ data about ocean optical properties in the around seawater area of the Korean Peninsula during 1998 – 2005. The relationship of $R_{rs}(412)/R_{rs}(555)$, $R_{rs}(443)/R_{rs}(555)$, $R_{rs}(490)/R_{rs}(555)$, $R_{rs}(510)/R_{rs}(555)$ and $a_{\mathrm{dom}}(412)$ showed $R^2$ values of 0.707, 0.707, 0.597 and 0.552, respectively. The spectrum of $a_{\mathrm{dom}}(\lambda)$ is shape of exponential function $a_{\mathrm{dom}}(\lambda)$ value decreases with increasing wavelength. For estimation of $a_{\mathrm{dom}}(412)$ from satellite data, we developed an algorithm from the relationship of $a_{\mathrm{dom}}(412)$ and $R_{rs}(412)/R_{rs}(555)$. This algorithm was employed on SeaWiFS imagery to estimate $a_{\mathrm{dom}}(412)$ in the South Sea, East Sea, Yellow Sea and northern East China Sea areas. Also, SeaDAS-derived $a_{dg}(412)$ from same SeaWiFS imagery, These $a_{dg}(412)$ was then compared with in-situ and empirical-algorithm-derived $a_{\mathrm{dom}}(412)$, but these values were different. We think two points that such different values are caused by discrepancy related to failure of standard atmospheric correction scheme, the other are caused by error related to definition of $a_{\mathrm{dom}}(412)$ and $a_{dg}(412)$.

**KEY WORDS:** GOCI, absorption coefficient of colored dissolved organic matter ($a_{\mathrm{dom}}$), remote sensing reflectance ($R_{rs}$), ocean color, SeaWiFS, inherent optical property (IOP)

## 1. INTRODUCTION

The atmosphere, land, oceans, and sediments interact in the coastal environment through sometimes contrasting processes that result in the burial, destruction of old and formation of new organic carbon. Colored dissolved organic matter (CDOM), a large fraction of the organic matter pool in rivers, interferes with remote sensing determinations of chlorophyll concentrations that are needed to estimate primary productivity (Muller-Karger *et al.*, 1989) and, in many instances, is the most important factor controlling light penetration in coastal waters (Del Castillo *et al.*, 1999). Kalle (1966) originally coined the term Gelbstoff from the German yellow substance. Others have suggested names like gilvin (Kirk, 1994) and chromophoric dissolved organic matter. Here it will be referred to as CDOM.

CDOM is defined operationally by the method used to separate suspended and dissolved material. The two most common methods are filtration through glass-fiber filters (GF/F 0.7 ㎛) and polycarbonate or polysulfone menbranes (0.2 ㎛). Both methods have their advantages and disadvantages. GF/F filters allow passage of some bacteria, viruses, and colloids, which are not considered dissolved materials. However, GF/F filters can be ashed (500℃), reducing the possibility of sample contamination. Membrane filters exclude more suspended particles, but are difficult to clean. In blue waters, the concentration of suspended particles is so low that filtration for dissolved organic carbon (DOC) and CDOM measurements may be unnecessary and risky as samples could get contaminated during the procedure. However, in coastal environments, filtration is necessary and the differences in CDOM content between GF/F and membrane filtrates can be significant (Del Castillo, unpublished data). There is a final consideration. Bio-optics research strives to account for the contribution of all light-absorbing species in water. The method most commonly used for measuring absorption by particles (alive and dead) involves capture of the particles unto GF/F filters. If membrane filters are used to obtain CDOM samples, a fraction of organic material will not be accounted for. The significance of this fraction should be evaluated before making a decision on which CDOM filtration method will be used.

The influence of CDOM is not limited to coastal areas adjacent to a river mouth. Large rivers can broadcast their influence into waters that are normally considered oligothrophic. Muller-Karger et al. (1989) documented how the Orinoco River plume enters the estern Caribbean, almost reaching the southern coast of Puerto Rico. Del Castillo et al. (2001) documented an intrusion of the Mississippi River plume into normally oligothrophic waters of the Gulf of Mexico. In both cases, large amounts of terrigenous organic carbon were injected thousands of miles into the ocean, and the presence of

CDOM contributed to erroneous remote sensing estimates of chlorophyll by ocean color satellite sensors.

CDOM is the principal light-absorbing constituent of the DOM pool in seawater, far exceeding the contributions of discrete dissolved organic or inorganic chromophores. Absorption spectra are broad and unstructured, and typically decrease with increasing wavelength in an exponential fashion. Thus workers have typically fit these spectra to the expression,

$$a_{dom}(\lambda) = a_{dom}(\lambda_0)e^{-S(\lambda-\lambda_0)} \qquad (1)$$

where $a_{dom}(\lambda)$ and $a_{dom}(\lambda_0)$ are the absorption coefficients at wavelength $\lambda$ and reference wavelength $\lambda_0$ , respectively, and $S$ defines how rapidly the absorption decreases with increasing wavelength (Bricaud *et al.*, 1981; Zepp and Schlotzhauer, 1981; Carder *et al.*, 1989; Blough *et al.*, 1993; Green and Blough, 1994). The fitting of absorption data to Eq. (1) has proved quite useful as a simple means to characterize CDOM spectra rapidly; in most cases, this equation approximates the spectral dependence very well.

In this study, we researched to estimate the absorption coefficients of CDOM ( $a_{dom}$ ) using empirical method for GOCI (Geostaionary Ocean Color Imager) ocean color sensor.

## 2. METERIAL AND METHODS

### 2.1 Field Measurements

Remote sensing reflectance ( $R_{rs}$ ) was measured from 400nm to 750nm at 1nm intervals with a field dual spectroradiometer (ASD Inc.). Absorption coefficients of CDOM ( $a_{dom}$ ) was measured *in-situ*. $a_{dom}$ was measured at the same wavelengths as those of the $R_{rs}$ . The measurements were obtained in CASE-II turbid water and in CASE-I clear water, around the Korea Peninsula from 1998 to 2005 (Figure 1).

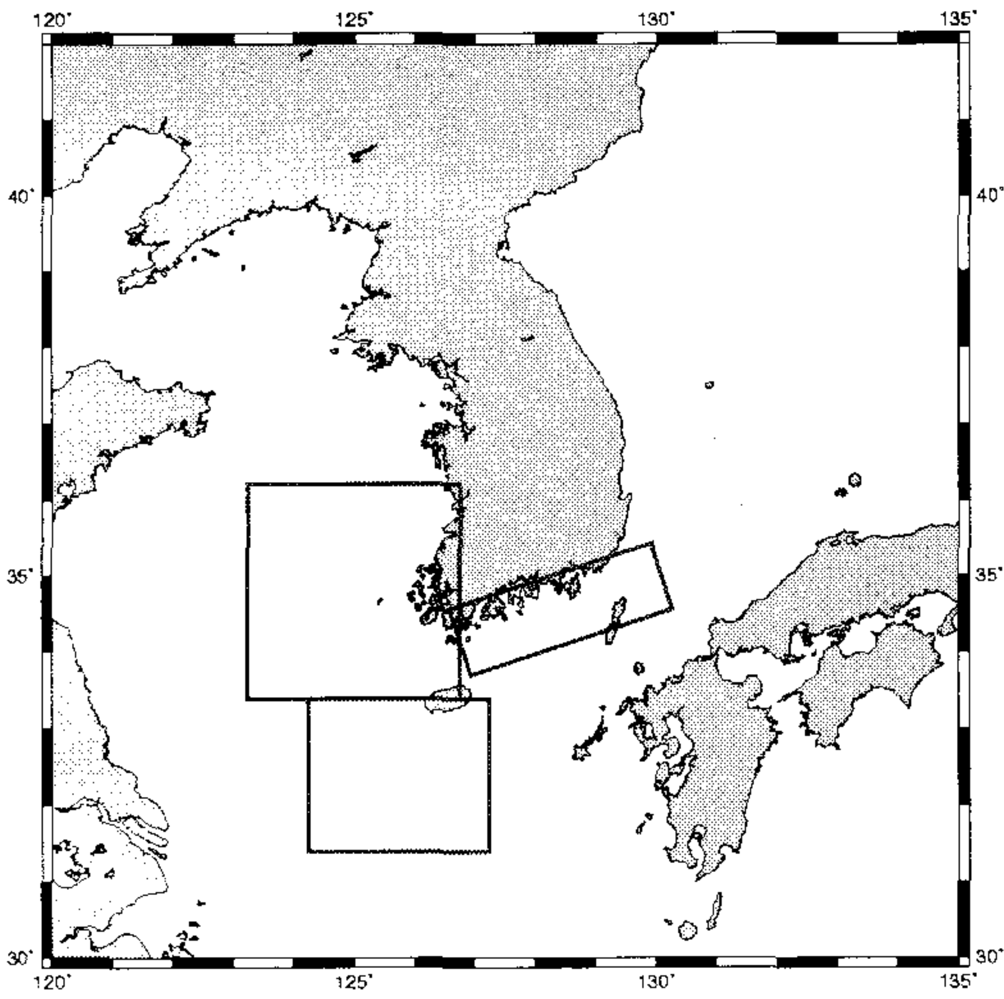

Figure 1. Map of *in-situ* area (red box area).

### 2.2 Calculation of *in-situ* $a_{dom}$

Measurements of spectral absorption of the soluble material in seawater or the colored dissolved organic matter (CDOM) have been obtained in diverse oceanic and coastal waters using spectrophotometers with 10 ㎝ pathlength optical cells. Seawater samples are filtered through pre-rinsed 0.45 ㎛ membrane filters, and the optical density spectra $OD_{dom}(\lambda)$ of the filtrate relative to purified water are obtained using a spectrophotometer. Necessary care should be taken during handling of the seawater samples to avoid contamination and photo-degradation. Absorption coefficients of CDOM ( $a_{dom}$ ) are calculated as

$$a_{dom}(\lambda) = \frac{2.303 \times OD_{dom}(\lambda)}{0.1}[m^{-1}] \qquad (2)$$

where 0.1 is the pathlength of the 10 ㎝ optical cell (unit m), 2.303 is the conversion factor between $\log_{10}$ and $\ln$, and $OD_{dom}(\lambda)$ is the optical density relative to pure water.

### 2.3 Calculation of *in-situ* $R_{rs}$

The optical measurements were carried out by using a portable dual UV/VNIR spectroradiometer (Analysis spectral Devices, ASD Inc.) with the spectral range of 350 – 1050 ㎚. The five water leaving radiance spectra ( $L_w$ ) are averaged and corrected for the sky light reflection and the air-sea effects.

$$L_w(\lambda) = L_{wT}(\lambda) - F_r(\lambda) \times L_{sky}(\lambda) \qquad (3)$$

where $L_{wT}(\lambda)$ is the total radiance, $L_{sky}(\lambda)$ is the sky radiance, and $F_r(\lambda)$ is the fresnel reflectance. The values of $L_{sky}(\lambda)$ were obtained from the sky radiometer and $F_r(\lambda)$ value was assumed to be constant 0.025 (Austin, 1974). In fact, $F_r(\lambda)$ varies with viewing geometry, sky conditions (clear, partially and densely cloudy), sea surface roughness due to wind, and is wavelength-dependent under a cloudy sky (Mobley, 1999). Remote sensing reflectance ($R_{rs}$) is calculated as

$$R_{rs}(\lambda) = \frac{L_w(\lambda)}{E_d(\lambda)}[sr^{-1}] \qquad (4)$$

where $L_w(\lambda)$ is the water leaving radiance obtained from Eq. (3), and $E_d(\lambda)$ is the downwelling irradiance obtained from RCR (Reflective Cosine Receptor) of ASD dual spectroradiometer.

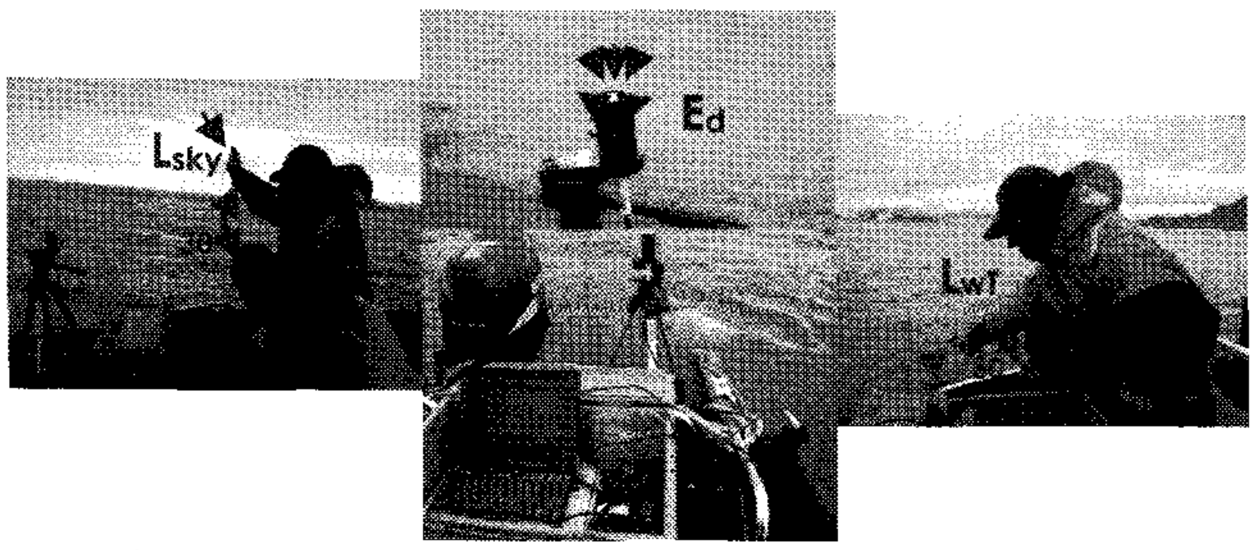

Figure 2. Measurements of AOPs (Apparent Optical Properties) using Fieldspec Pro Dual UV/VNIR Spectroradiometer of ASD Inc.

## 3. RESULT

Figure 3, 4, 5, and 6 are appeared relationship between $a_{dom}(412)$ and $R_{rs}(412)/R_{rs}(555)$, $R_{rs}(443)/R_{rs}(555)$, $R_{rs}(490)/R_{rs}(555)$, $R_{rs}(510)/R_{rs}(555)$, respectively.

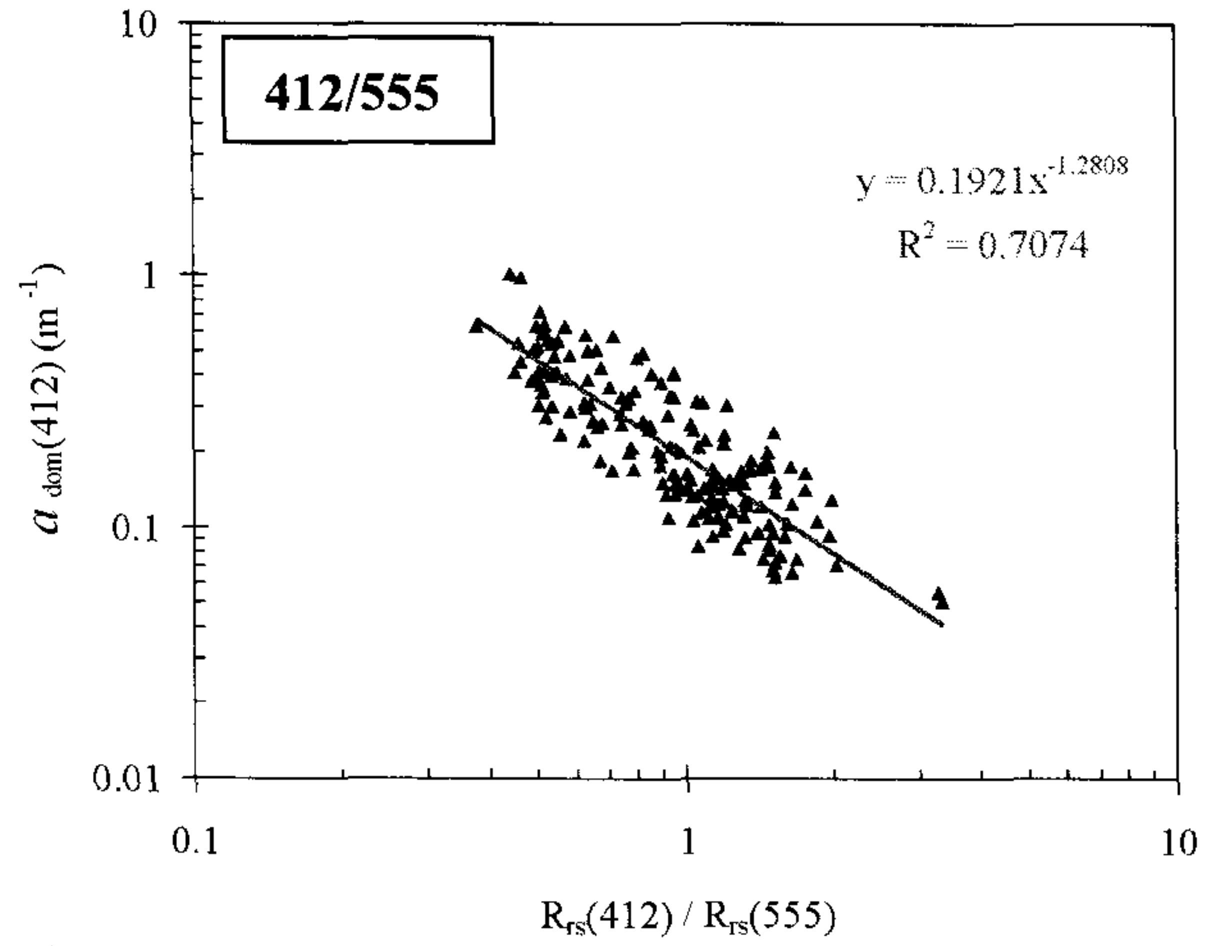

Figure 3. Relationship between $a_{dom}(412)$ and band ratio of $R_{rs}(412)/R_{rs}(555)$.

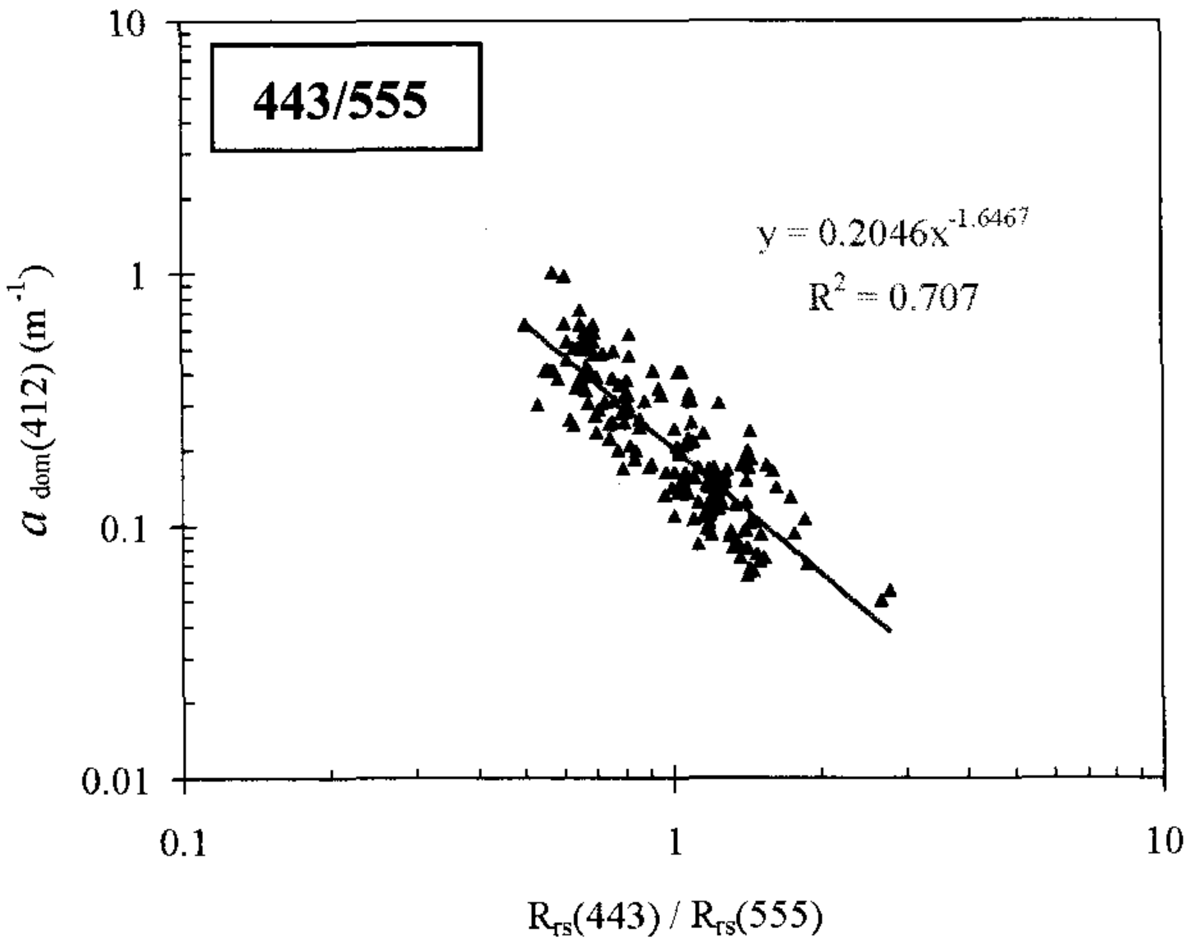

Figure 4. Relationship between $a_{dom}(412)$ and band ratio of $R_{rs}(443)/R_{rs}(555)$.

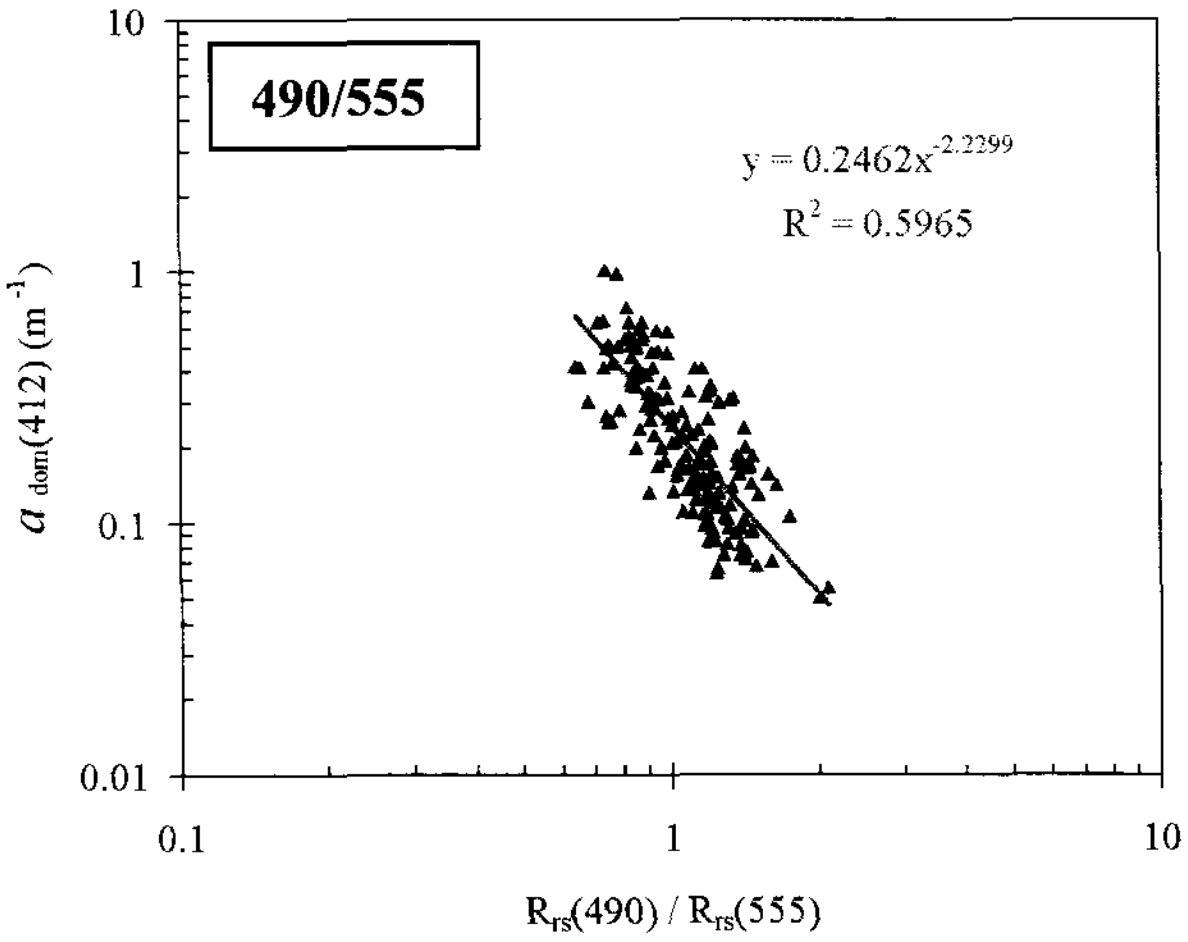

Figure 5. Relationship between $a_{dom}(412)$ and band ratio of $R_{rs}(490)/R_{rs}(555)$.

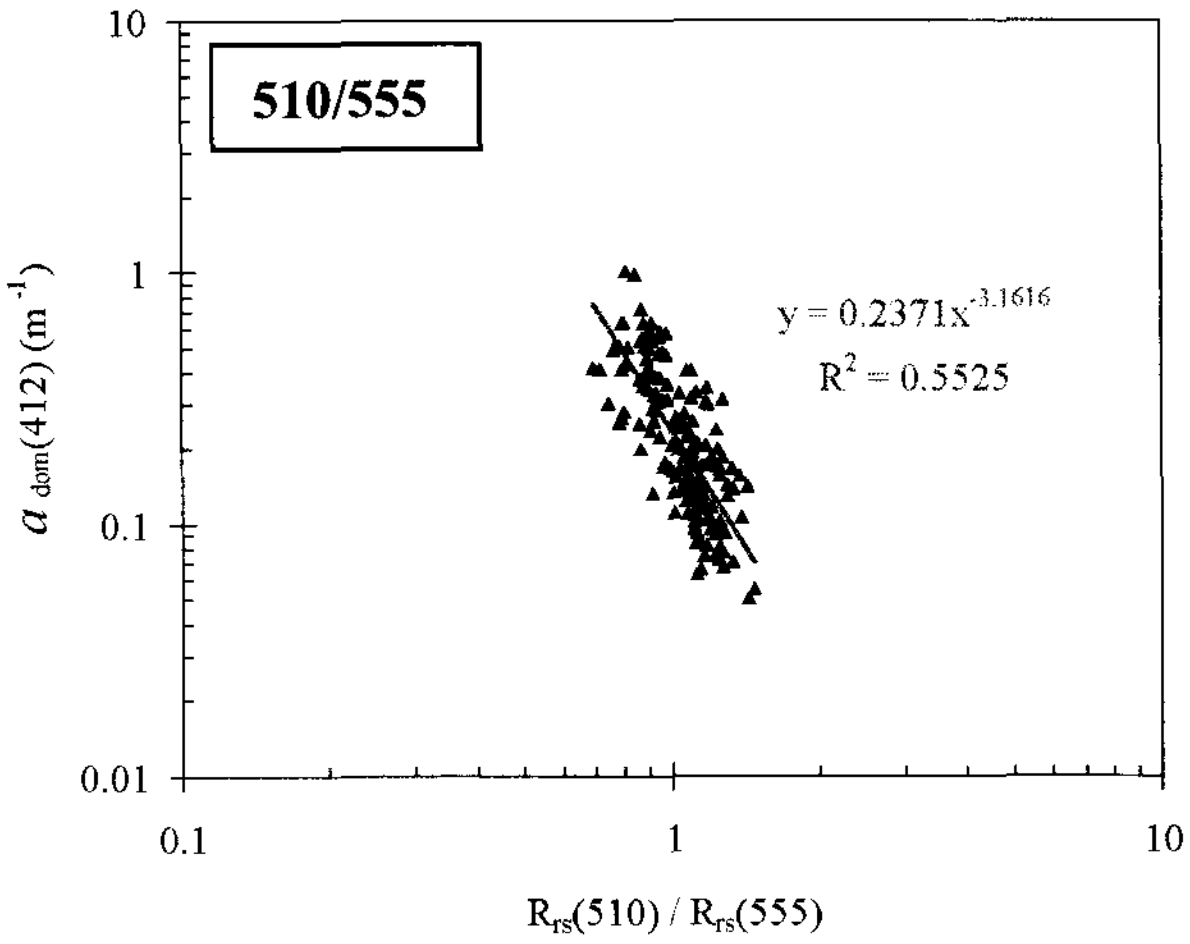

Figure 6. Relationship between $a_{dom}(412)$ and band ratio of $R_{rs}(510)/R_{rs}(555)$.

## 4. CONCLUSIONS

The relationship of $R_{rs}(412)/R_{rs}(555)$, $R_{rs}(443)/R_{rs}(555)$, $R_{rs}(490)/R_{rs}(555)$, $R_{rs}(510)/R_{rs}(555)$ and $a_{dom}(412)$

showed $R^2$ values of 0.707, 0.707, 0.597 and 0.552, respectively. The spectrum of $a_{\mathrm{dom}}(\lambda)$ is shape of exponential function $a_{\mathrm{dom}}(\lambda)$ value decreases with increasing wavelength. Wavelength of 443 nm is maximum absorption band of chlorophyll.

For estimation of $a_{\mathrm{dom}}(412)$ from satellite data, we developed an algorithm from the relationship of $a_{\mathrm{dom}}(412)$ and $R_{rs}(412)/R_{rs}(555)$. The equation is as follows.

$$a_{dom}(412) = 0.192 \times \left(\frac{R_{rs}(412)}{R_{rs}(555)}\right)^{-1.281} [m^{-1}] \quad (5)$$

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