Bio-optical algorithm

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1. Attenuation
   a. Absorption coefficient
   b. Scattering coefficient
2. Bio-optical properties
   a. Chlorophyll-a concentration (Chl-a)
   b. Diffused attenuation coefficient (Kd)
   c. Colored dissolved organic matter (CDOM)
3. Problems for Case II waters
4. References

1. Attenuation

Attenuation = Absorption + Scattering

$$c(\lambda) = a(\lambda) + b(\lambda)$$

a. Absorption coefficient: a(λ)

$$a(\lambda) = a_{ph}(\lambda) + a_{SP}(\lambda) + a_{C}(\lambda) + a_{w}(\lambda)$$

phytoplankton, Suspended Particles, CDOM, sea water

b. Scattering coefficient: b(λ)

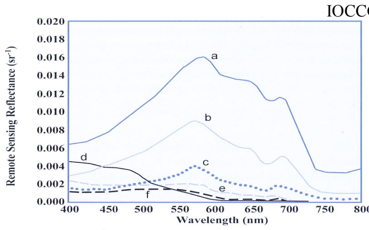
$$b(\lambda) = b_{ph}(\lambda) + b_{SP}(\lambda) + b_{w}(\lambda)$$

Particles (phytoplankton + Suspended Particles), sea water

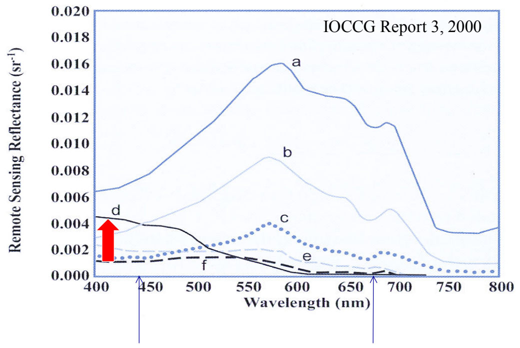
2. Bio-optical properties

a. Chlorophyll-a concentration

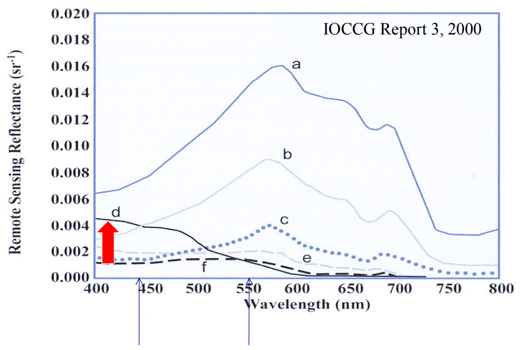
IOCCG Report 3, 2000



Case II	a.	Ext.High SP +	CDOM	
	b.	High SP +	CDOM	
	c.	Mod. SP +	CDOM	+ Phytoplankton
	e.	Low SP		+ Phytoplankton
Case I	d.			Low phytoplankton
	f.			Mod. phytoplankton

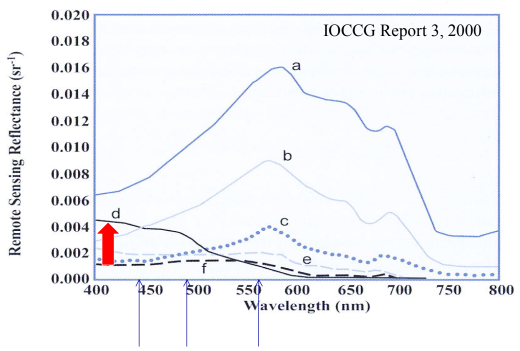


Absorption by chlorophyll-a at 440 and 670 nm
and increase of chlorophyll-a concentration



Chl-a = a $\{ nLw(\lambda_1) / nLw(\lambda_2) \}^b$

Gordon et al. (1981) λ_1=443, λ_2=555 nm



Chl-a = a $[\{ nLw(\lambda_1) + nLw(\lambda_2)\}/nLw(\lambda_3)]^b$

Kishino et al. (1995 and 1997) λ_1=443, λ_2=490, λ_2=565

O'Reilly et al., 1998, 2000

OC2 version 4 (OC2v4) Algorithm

$$C_a = 10^{(0.319 - 2.336R + 0.879R^2 - 0.135R^3)} - 0.071$$

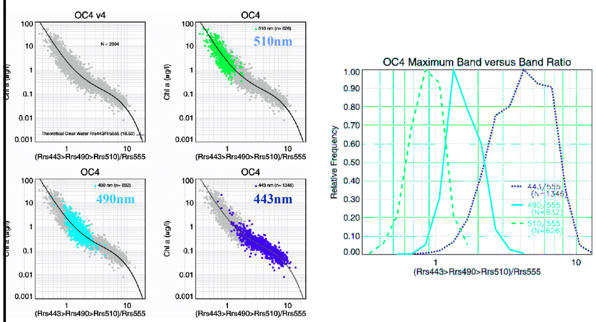
2 Band ratio $R = \frac{R_{rs}(490)}{R_{rs}(555)}$

OC4 version 4 (OC4v4) Algorithm

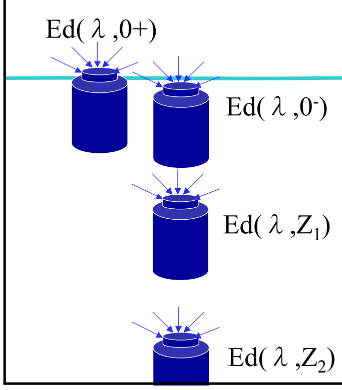
$$C_a = 10^{(0.366 - 3.067R + 1.930R^2 + 0.649R^3 - 1.532R^4)}$$

Maximum Band ratios $R = \frac{R_{rs}(443)}{R_{rs}(555)}$ $R = \frac{R_{rs}(490)}{R_{rs}(555)}$ $R = \frac{R_{rs}(510)}{R_{rs}(555)}$

Contribution of band ratio to range of chl-a



b. Diffused Attenuation Coefficient
(measurement of downwelling spectrum irradiance)



$E_d(\lambda, Z) = E_d(\lambda, 0^-)e^{-K(\lambda,}$

$K(\lambda, z)$: diffuse attenuation coefficient in per unit meters (m^{-1})

Diffuse Attenuation Coefficient

Austin and Petzold, 1981

$$K_d(490) = K_w(490) + a \{ L_w(\lambda_1) / L_w(\lambda_2)\}^b$$

$Kw(490)=0.022\ m^{-1}$, $\lambda_1=443$, $\lambda_2=550$ nm

Mueller, 2000

$$K_d(490) = 0.016 + a \{ nL_w(\lambda_1) / nL_w(\lambda_2)\}^b$$

$\lambda_1=490$, $\lambda_2=555$

c. Colored Dissolved Organic Matter (CDOM)

- **A strong absorber of ultraviolet radiation**
- **A precursor for many photochemical reactions**

(Johannessen et al., 2003)

- **Operational definition**
  the volume absorption coefficient at 300 nm relative to purified freshwater

(Kahru and Mitchell, 2001)

Colored Dissolved Organic Matter (CDOM)

Kahru and Mitchell, 2001

$$a_{CDOM(300)} = 10^{(a_0 + a_1 R)}$$

For SeaWiFS

R=log[nLw(443)/nLw(510)]

a = [-0.393,-0.872]

Colored Dissolved Organic Matter (CDOM)

Johannessen et al., 2003

$$\mathrm{Kd}_{(\lambda 0)}=a[\mathrm{Rs}_{(\lambda 1)}/\mathrm{Rs}_{(\lambda 2)}]^{b}$$

$$\mathrm{a}_{\mathrm{CDOM}(\lambda 0)}=c\ \mathrm{Kd}_{(\lambda 0)} - d$$

Ultraviolet bands; λ_0=323, 328, 380 nm
Visible bands; λ_1=412, λ_2=555 nm
a, b, c, d : constants

3. Problems for Case II water

Errors over the case II water

1.Atmospheric correction
- Negative radiance in the short wavelength
- Ambiguities in the water leaving radiance

2.Improvement of bio-optical algorithm
- Determination of chlorophyll-a,
- Determination of suspended particles,
- Determination of CDOM

4. References

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