An Algorithm for Coastal Water and the Status of its Implementation into the MODIS Processing Stream

by

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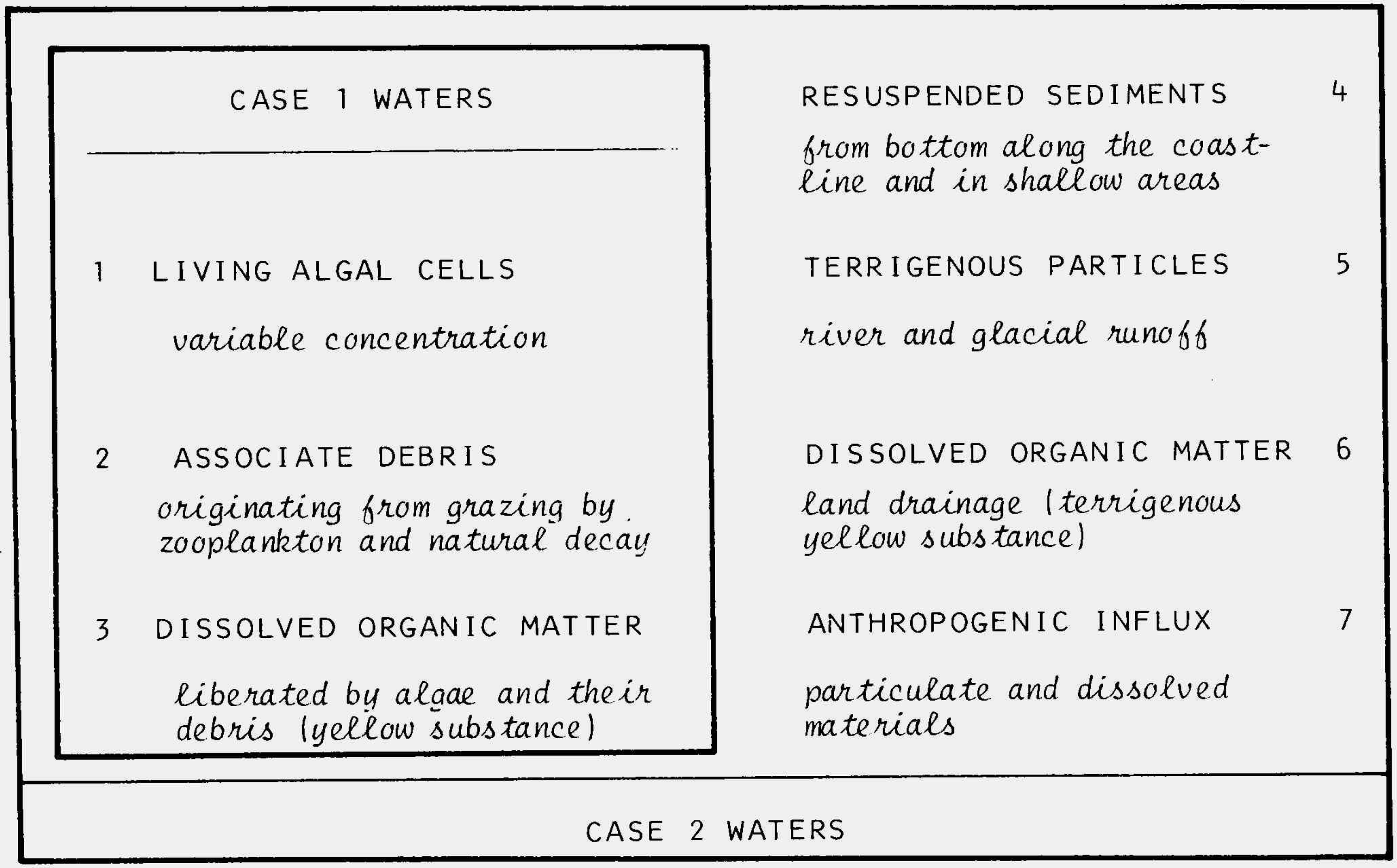


(Gordon and Morel, 1983)

Atmospheric Correction

$$\rho_t(\lambda) = \rho_r(\lambda) + \rho_A(\lambda) + t_v(\lambda) t_s(\lambda) \rho_w(\lambda)$$

Case 1 waters:

- $\rho_w(765) \approx \rho_w(865) \approx 0$, $\Rightarrow$ NIR can be used to assess the aerosol influence.

Case 2 waters:

- ρ_w(NIR) $\neq$ $\Rightarrow$ no bands "tailor made" for assessing the aerosol.
- Case 2 waters contain large quantities of dissolved organic material that influence ρ_t in a manner similar to strongly-absorbing aerosols.
- Strongly absorbing aerosols are often found near the coast.

Approach for Case 2 waters: model $\rho_A(\lambda)$ and $\rho_w(\lambda)$, and then use spectral optimization to find the best values of the model parameters.

The Aerosol Model

Uses a Junge Power -Law Size Distribution :

$$\frac{dN}{dD} = \frac{K}{D^{\nu+1}}$$

$$\frac{dN}{dD} = 0 \qquad D < D_0,$$

$$D_0 \leq D \leq D_1,$$

$$D_1 \leq D \leq D_2,$$

$$D > D_2,$$

D_0 = 0.06 μm, D_1 = 0.20 μm, and D_2 = 20 μm.

Mie theory is used to compute aerosol properties

- $m = m_r - im_i$, where m_r is either 1.50 or 1.333, and m_i = 0, 0.001, 0.003, 0.010, 0.030, and 0.040.

$$\rho_A(G,\lambda,m_r,m_i,\nu) = a(G,\lambda,m_r,m_i,\nu)\tau(\lambda) + b(G,\lambda,m_r,m_i,\nu)\tau^2(\lambda) + c(G,\lambda,m_r,m_i,\nu)\tau^3(\lambda) + d(G,\lambda,m_r,m_i,\nu)\tau^4(\lambda)$$

- ν ranges from 2.0 to 4.5 in steps of 0.5.

- 72 separate aerosol models (2 values of $m_r \times$ 6 values of $m_i \times$ 6 values of ν).

- Interpolate to essentially give a continuum of models.

The Water Model
(Garver and Siegel, 1997)

$$\rho_w = \rho_w(b_b/(a+b_b))$$

$$a = a_w + a_{ph} + a_{cdm}$$
$$b_b = b_{bw} + b_{bp}$$

$$a_{ph}(\lambda) = a_{ph0}(\lambda)\ C$$
$$a_{cdm}(\lambda) = a_{cdm}(443)\ \exp[-S(\lambda - 443)\}]$$
$$b_{bp}(\lambda) = b_b(443)\ [443/\lambda]^n$$

$$\rho_w = \rho_w(\lambda, C, a_{cdm}(443), b_{bp}(443))$$

Note, the parameters $a_{ph0}(\lambda)$, S, and n are provided by fitting the model to experimental data. For Case 1 waters, S = 0.0206 nm^{-1} and n = 1.03 (Maritorena, *et al.*, 2002).

The Optimization

$$\hat{\rho}_{Aw}(G,\lambda,m_r,m_i,\nu,\tau_a,C,a_{cdm}(443),b_{bp}(443)) \equiv \hat{\rho}_A(G,\lambda,m_r,m_i,\nu,\tau_a)$$
$$+\hat{t}_v(G,\lambda,m_r,m_i,\nu,\tau_a)\hat{t}_s(G,\lambda,m_r,m_i,\nu,\tau_a)\ \hat{\rho}_w(\lambda,C,a_{cdm}(443),b_{bp}(443)).$$
$$\rho_{Aw}(G,\lambda,measured) \equiv \rho_A(G,\lambda)+t_v(G,\lambda)t_s(G,\lambda)\rho_w(\lambda)$$

$$\rho_t(\lambda)=\rho_r(\lambda)+\rho_A(\lambda)+t_v(\lambda)t_s(\lambda)\rho_w(\lambda)$$

The modeled counterpart of

Assuming $\rho_A(765)$ and $\rho_A(865) = 0$ gives estimation of the parameters ν and τ_a as functions of m_r and m_i, i.e., $\nu(m_r,m_i)$ and $\tau_a(m_r,m_i)$.

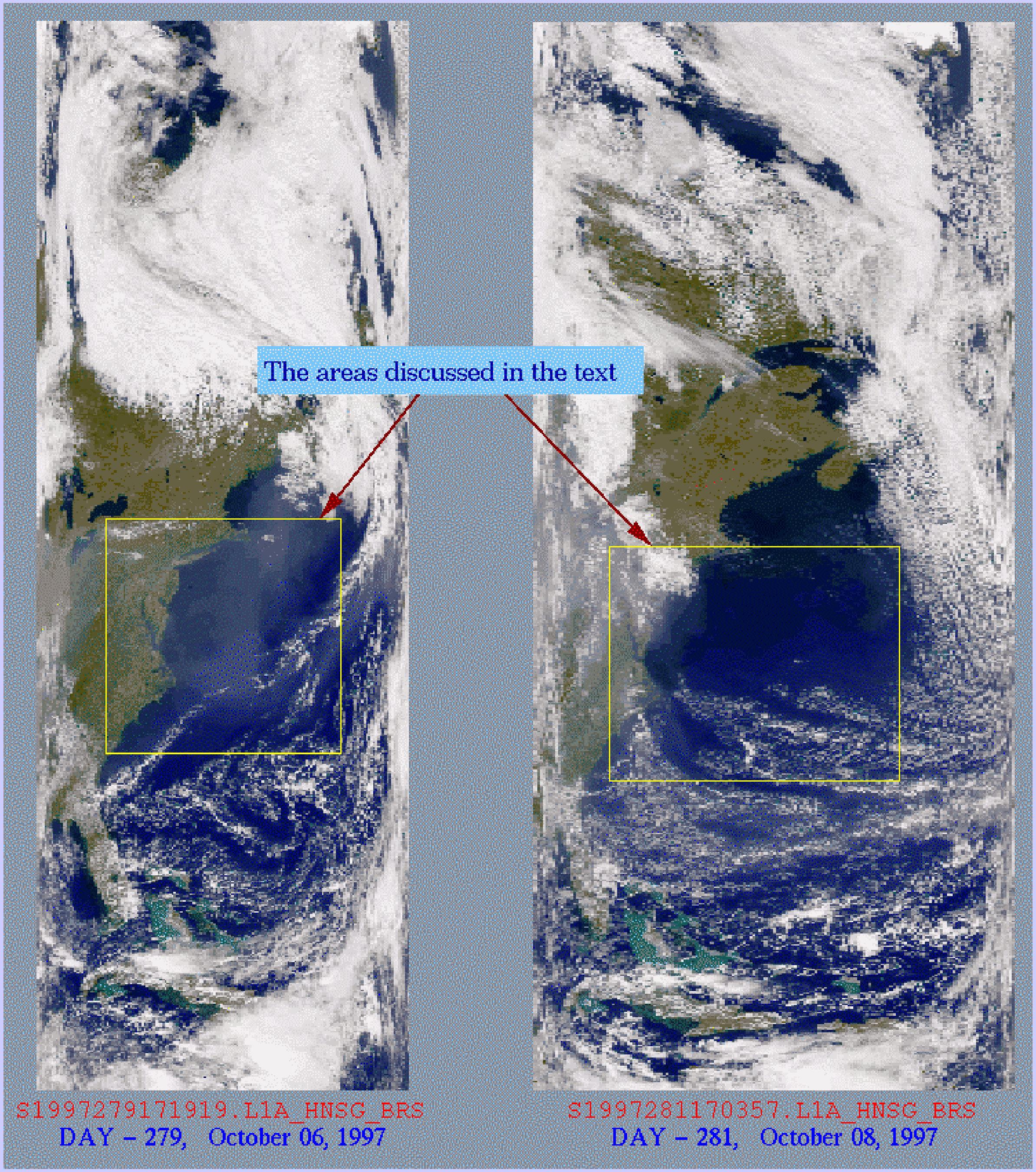
Given the constraints $\nu(m_r,m_i)$ and $\tau_a(m_r,m_i)$ we minimize the quantity

$$\sum_{\lambda}\left\{\hat{\rho}_{Aw}(G,\lambda_i,m_r,m_i,\nu,\tau_a,C,a_{cdm}(443),b_{bp}(443)) - \rho_{Aw}(G,\lambda_i,measured)\right\}^2$$

In effect, we have optimized for 7 parameters:

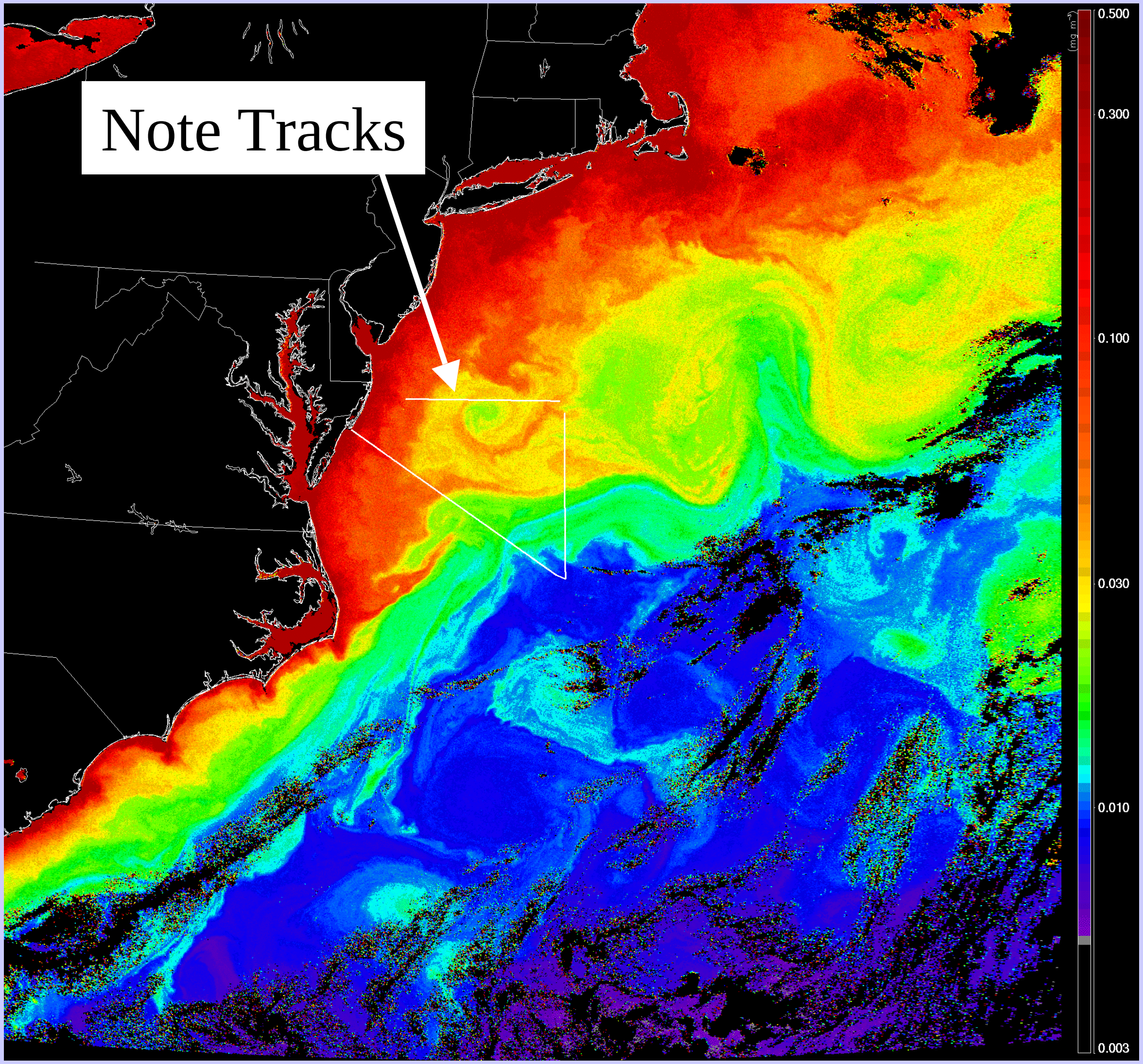
C, $a_{cdm}(443)$, $b_{bp}(443)$, ν, τ_a, m_r, and m_i;

This is generally all that is needed in Case 1 waters.

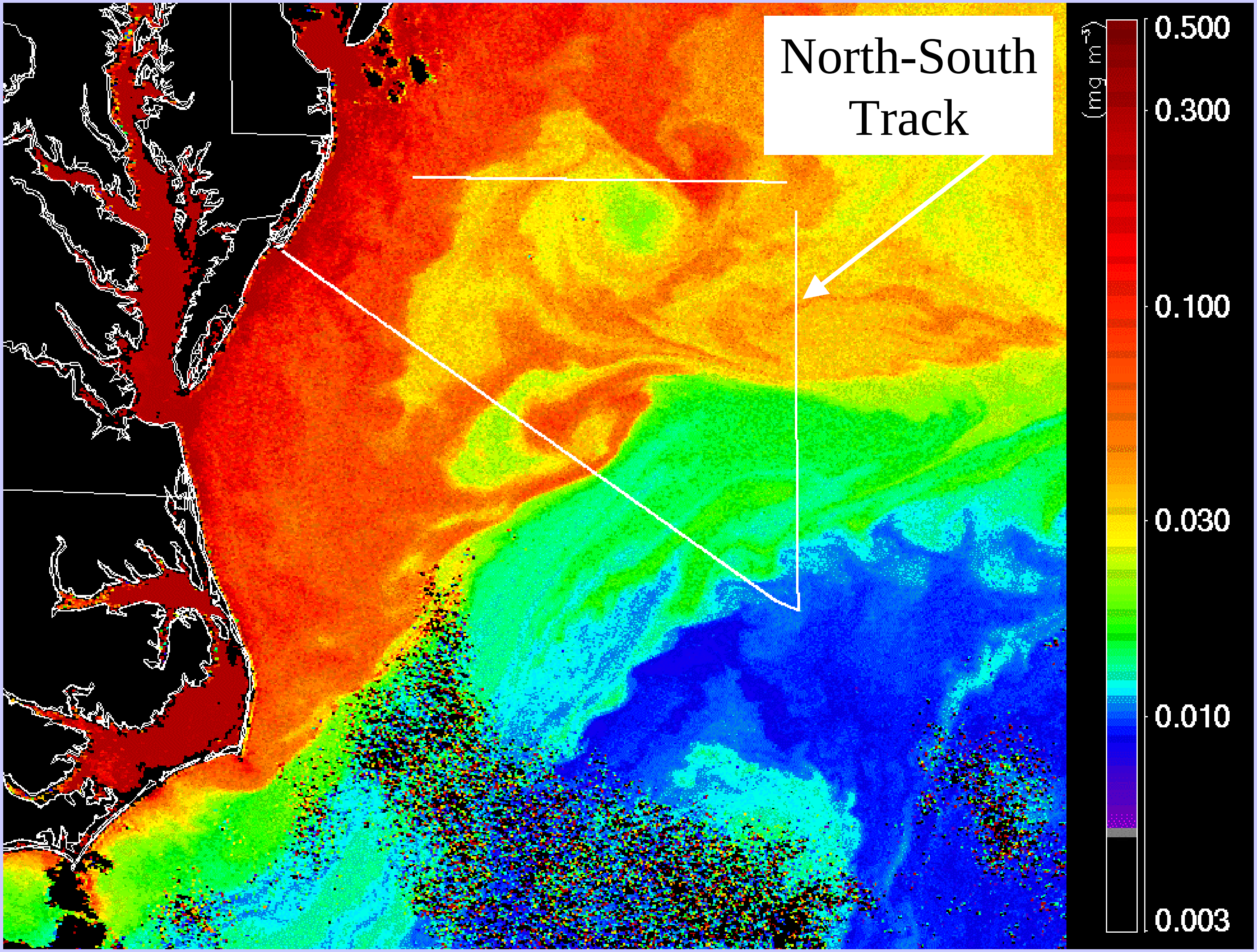

The areas discussed in the text
S1997279171919.L1A_HNSG_BRS
DAY – 279, October 06, 1997
S1997281170357.L1A_HNSG_BRS
DAY – 281, October 08, 1997

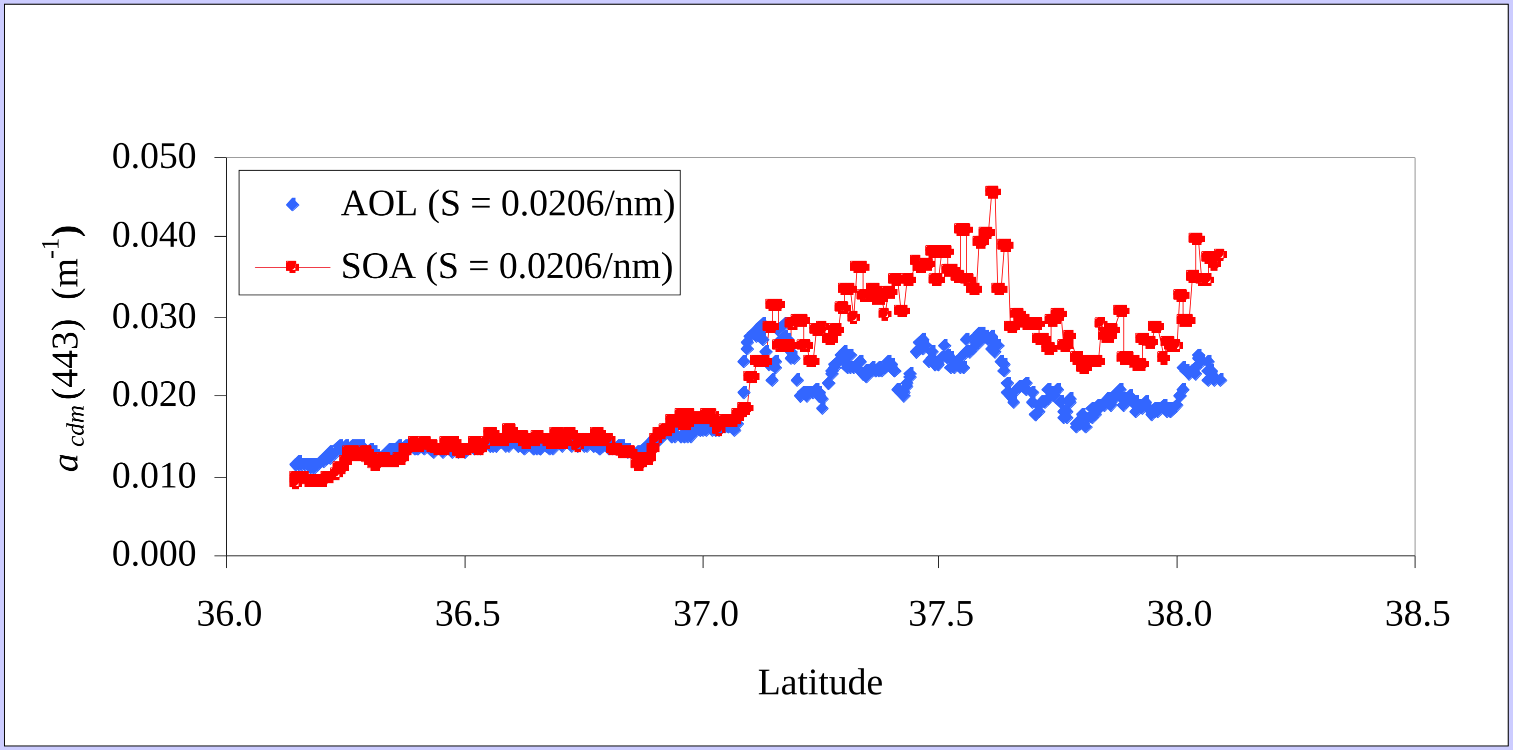
To validate this algorithm, we use the SeaWiFS image from Day 279 (left on previous slide) and compare the retrievals of a_{cdm} from the algorithm with estimates of a_{CDOM} from the AOL. The AOL measurements are made along the triangular path drawn on the nex t two images.

SOA $a_{cdm}(443)$ (m^{-1})



SOA $a_{cdm}(443)$ (m^{-1})

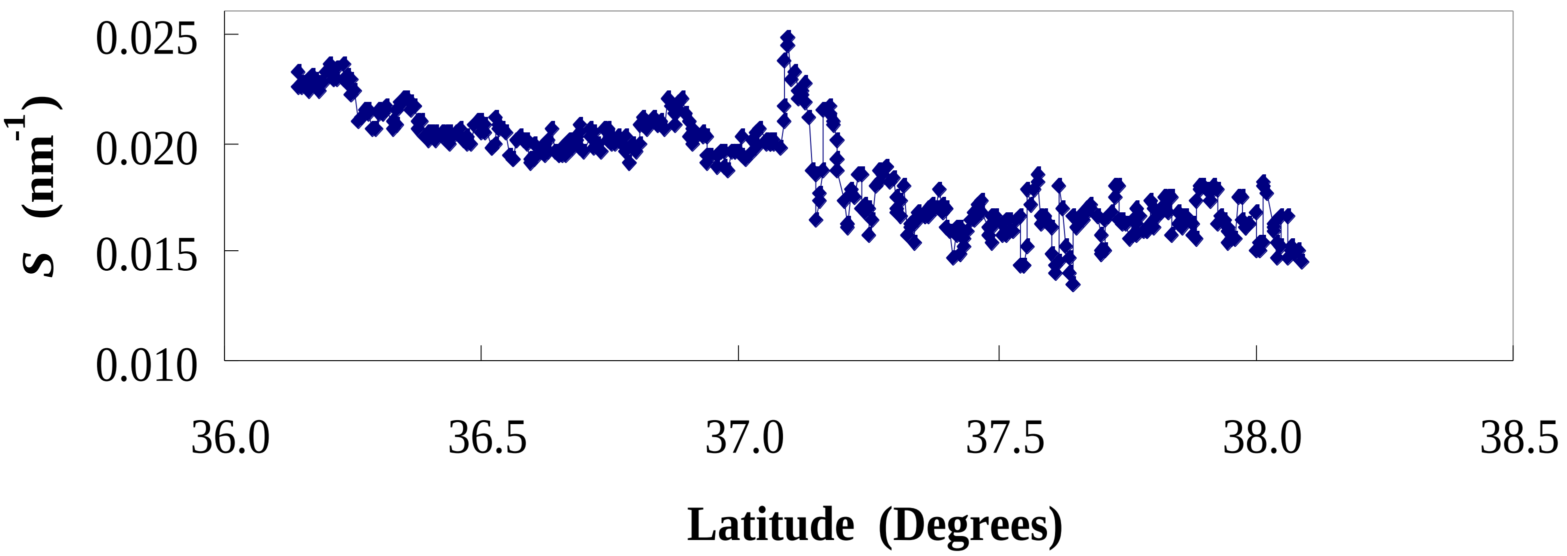




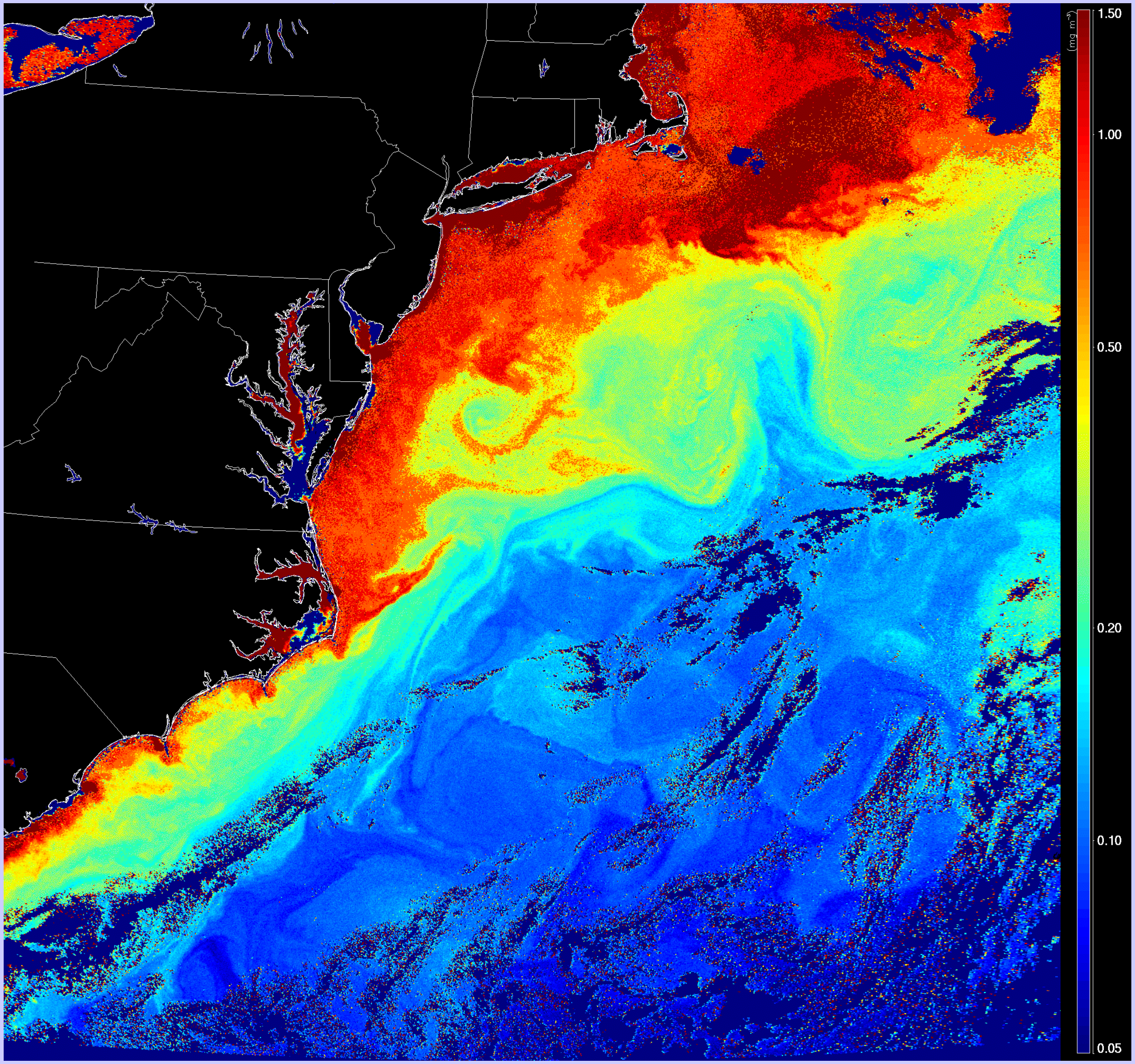
Comparison of SOA and AOL a_{cdm}(443) along the North-South Track

The value of S required to bring the SOA retrieved $a_{cdm}(443)$ into confluence with the AOL-retrieved $a_{CDOM}(443)$ at each point along the track the track was determined and shown in the next slide. The resulting S values show a clear trend of decreasing into the mesotrophic waters as would be expected (Green and Blough, 1994). Similar results are found for the other two tracks.

Required "*S*" for Exact AOL-SOA Agreement Along North-South Track



SOA *Chl a* (mg/m^3)



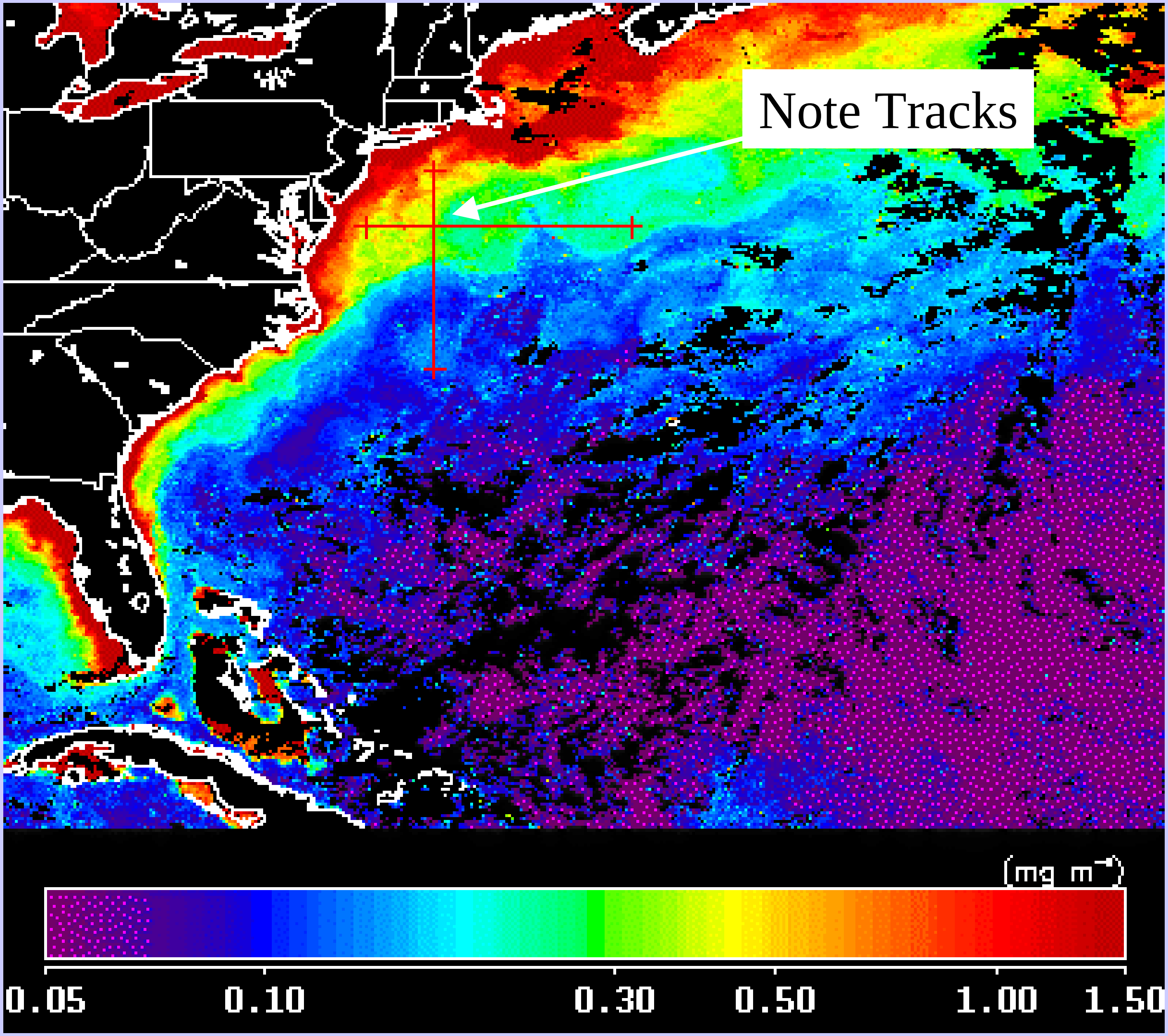
1.50

1.00

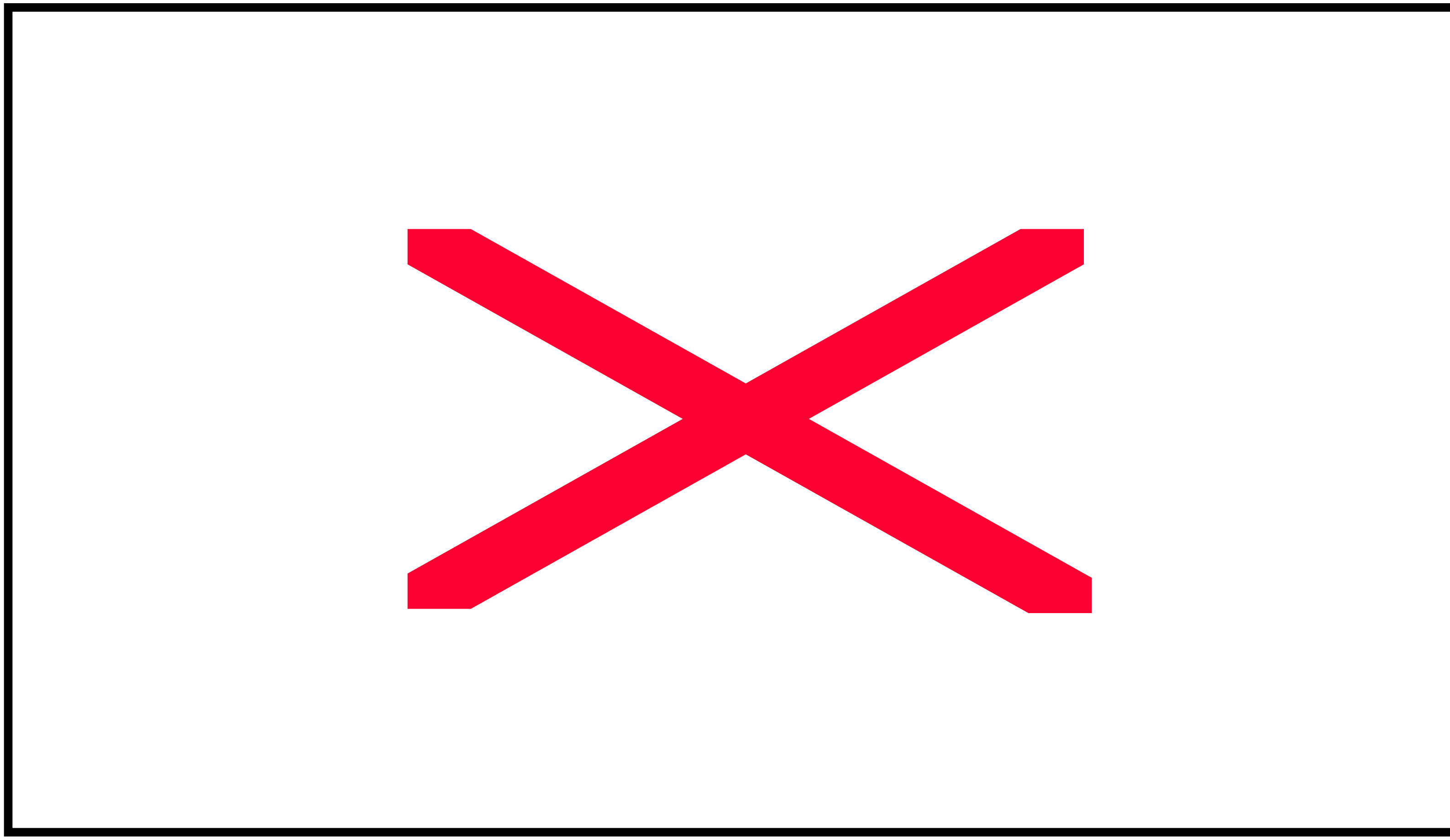
0.50

0.10

SeaWiFS 8-day mean *Chl a*

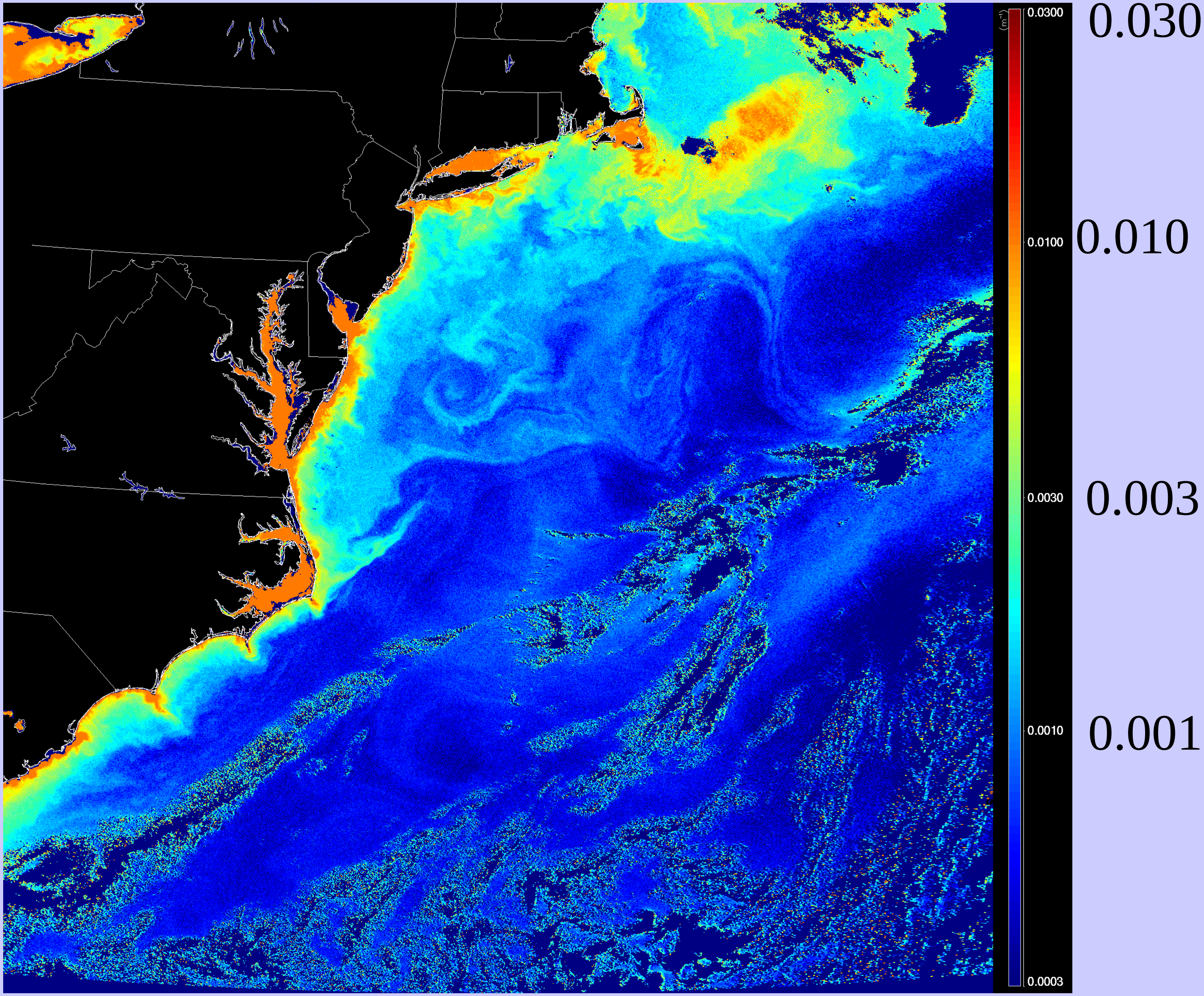


Comparison with SeaWiFS

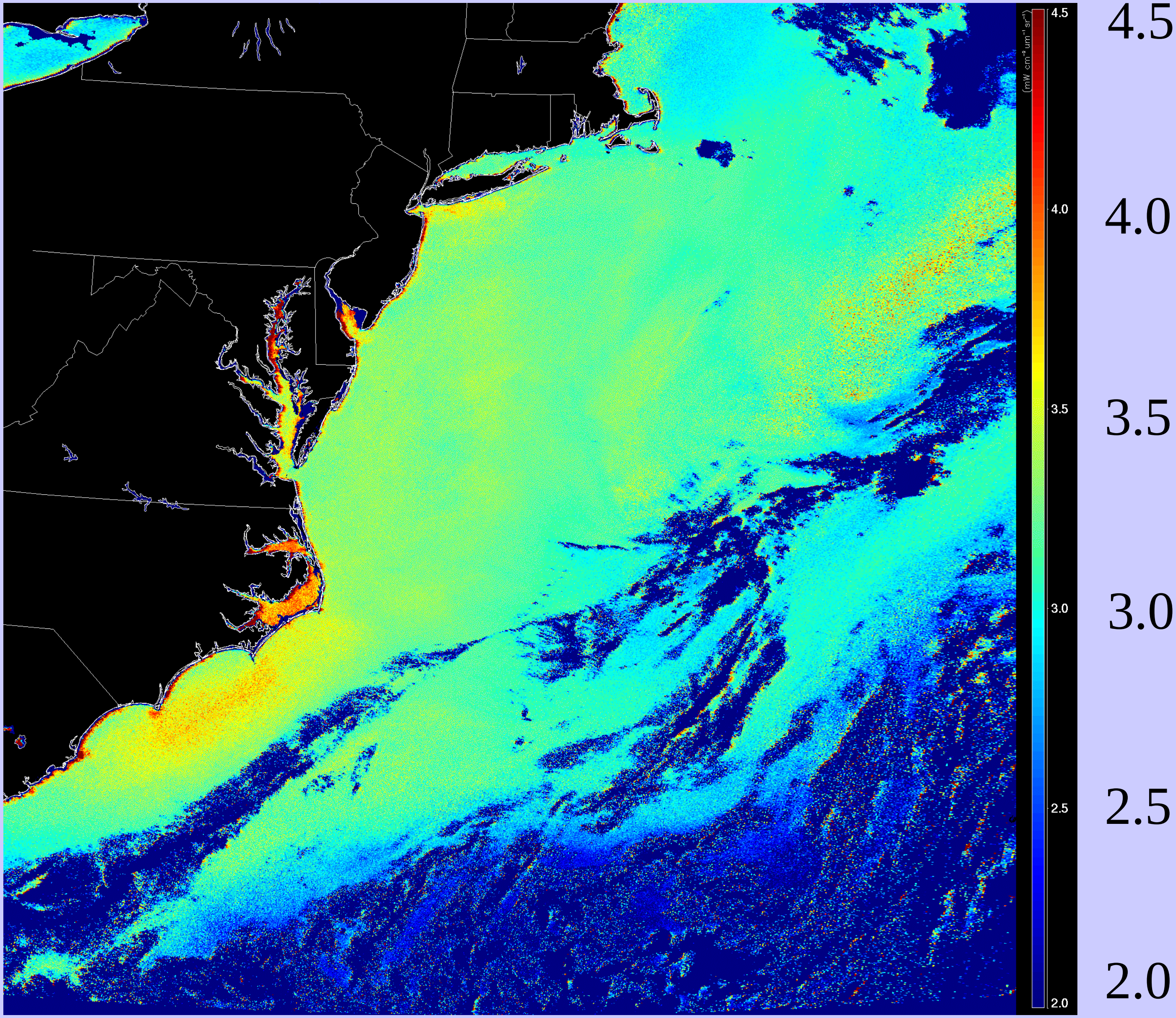


Comparison with SeaWiFS

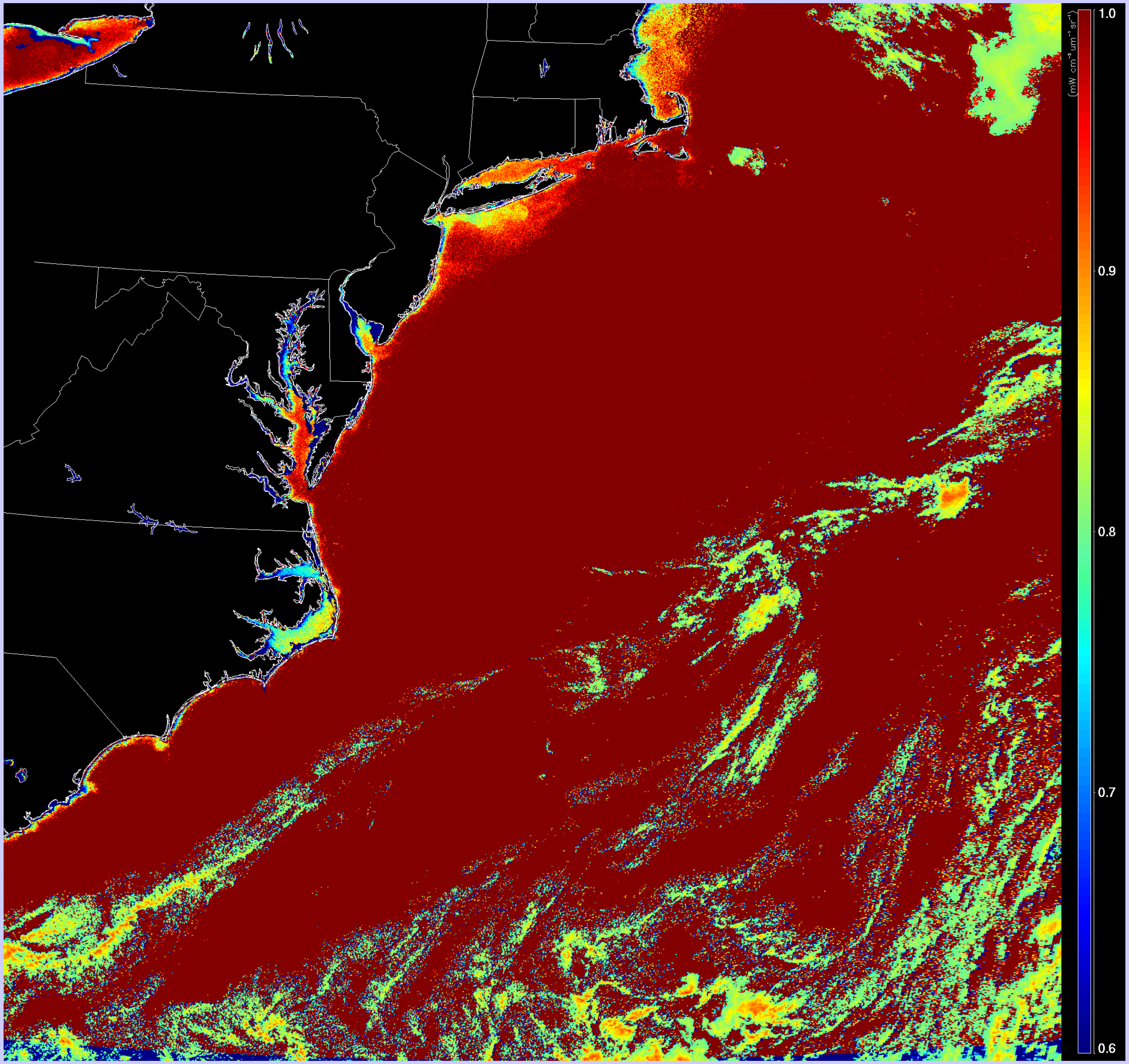
$b_{bp}(443)$ (m^{-1})



ν



ω_0



1.0

0.9

0.8

0.7

0.6

Extension to Case 2 Waters

- In Case 2 waters, we operate the algorithm as in Case 1 waters, i.e., assuming that $\rho_w(NIR) = 0$.

- Then we use the retrieved values of C, $a_{cdm}(443)$, and $b_{bp}(443)$ to provide an estimate of ρ_w in the NIR, and the retrieved values of ν, τ_a, m_r, and m_i to estimate t_v and t_s and the NIR.

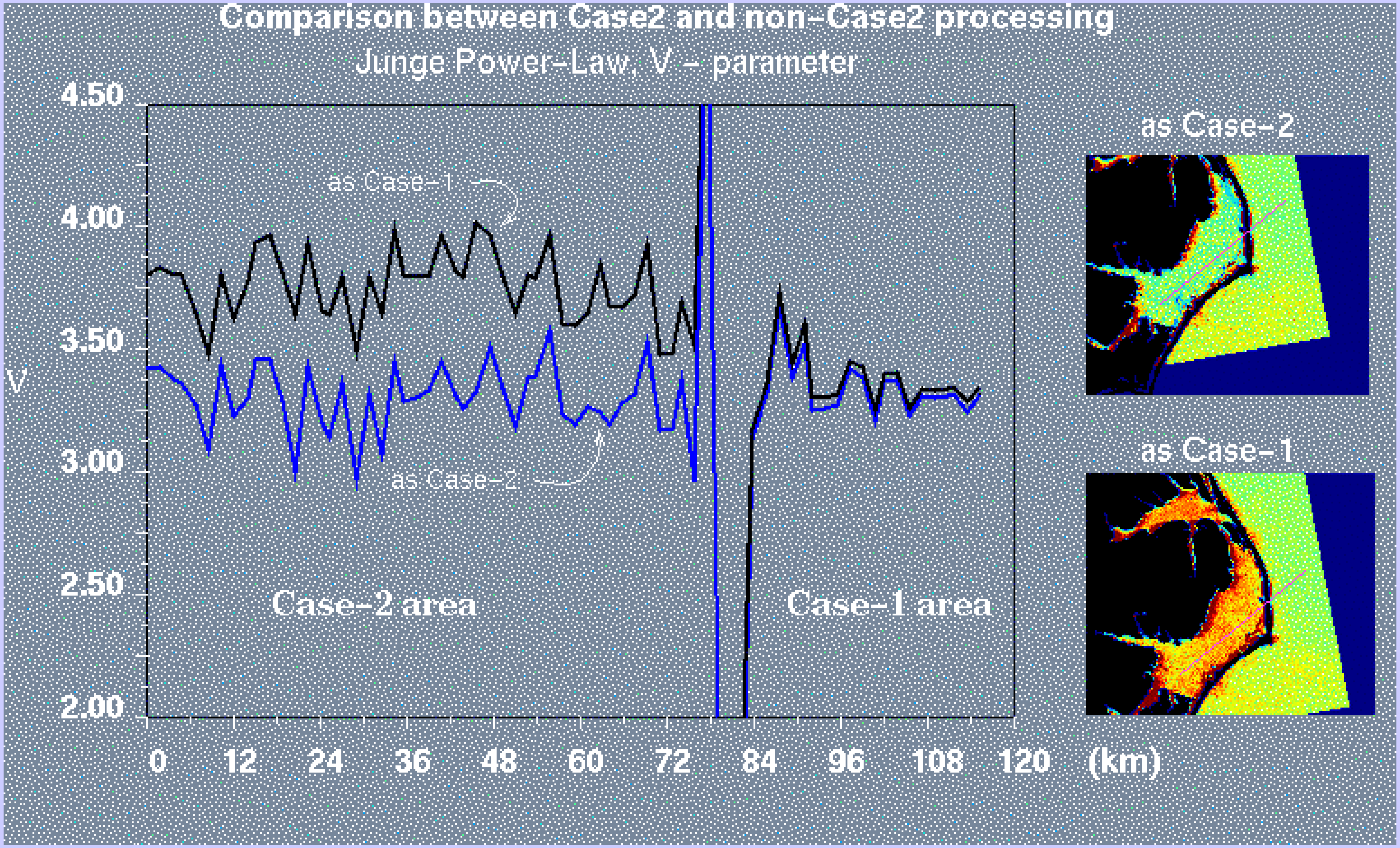
- These estimates are subtracted from the total, i.e.,

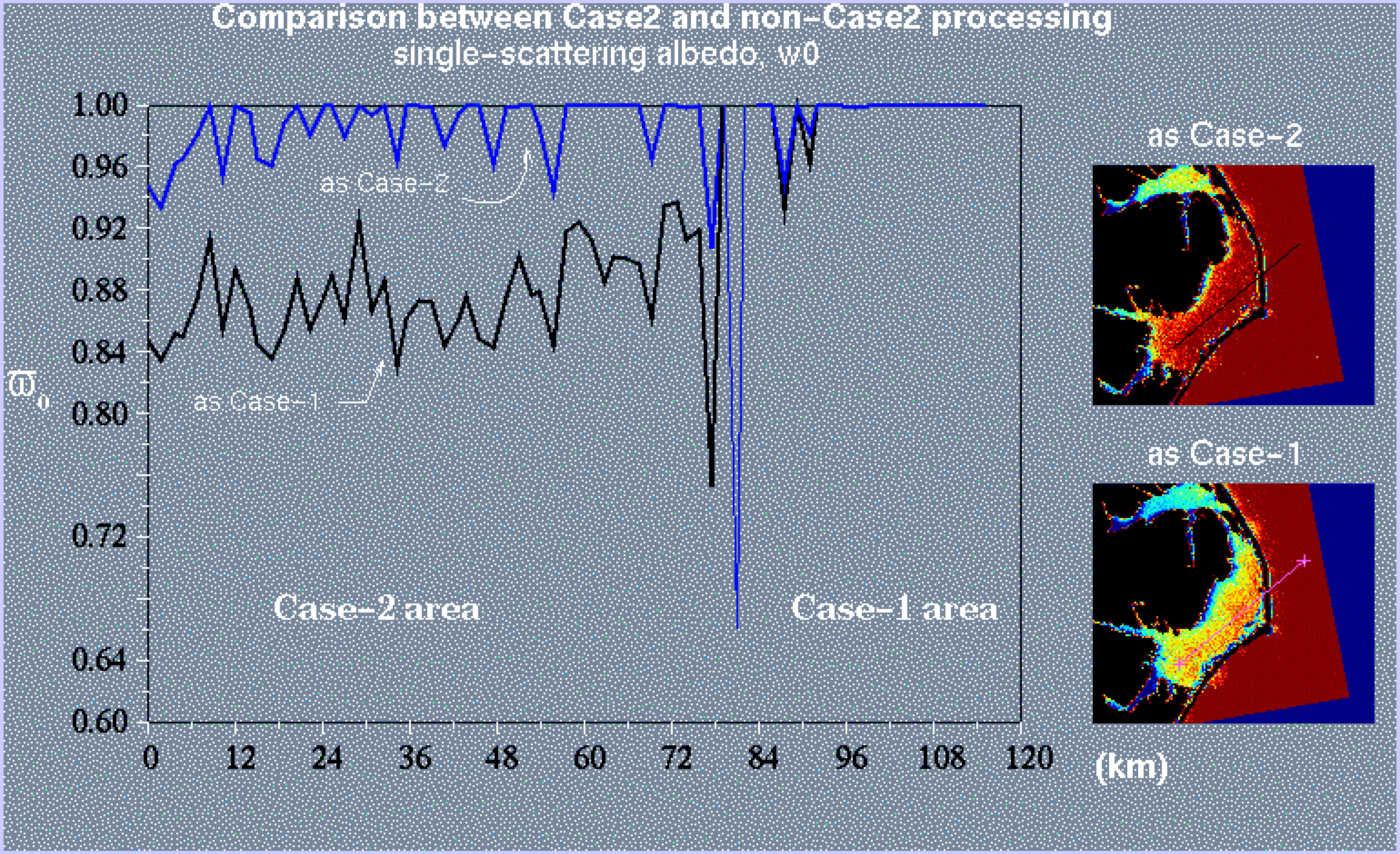
$$\rho_t(\lambda_{NIR}) - t_v(\lambda_{NIR})t_s(\lambda_{NIR})\rho_w(\lambda_{NIR}) = \rho_r(\lambda_{NIR}) + \rho_A(\lambda_{NIR}).$$

- The $\nu - \tau_a$, portion of the algorithm is then operated with

$$\rho_t(\lambda_{NIR}) - t_v(\lambda_{NIR})t_s(\lambda_{NIR})\rho_w(\lambda_{NIR}),$$

  instead of $\rho_t(\lambda_{NIR})$, to estimate new constraints $\nu(m_r,m_i)$ and $\tau_a(m_r,m_i)$, and to initiate a new optimization, etc.


Comparison between Case2 and non-Case2 processing
Junge Power-Law, V - parameter
4.50
4.00
3.50
3.00
2.50
2.00
V
as Case-1
as Case-2
Case-2 area
Case-1 area
0
12
24
36
48
60
72
84
96
108
120
(km)
as Case-2
as Case-1


Comparison between Case2 and non-Case2 processing
single-scattering albedo, w0
1.00
0.96
0.92
0.88
0.84
0.80
0.72
0.64
0.60
ϖ_0
as Case-2
as Case-1
Case-2 area
Case-1 area
0
12
24
36
48
60
72
84
96
108
120
(km)
as Case-2
as Case-1

Incorporation into the MODIS Code : A Status Report

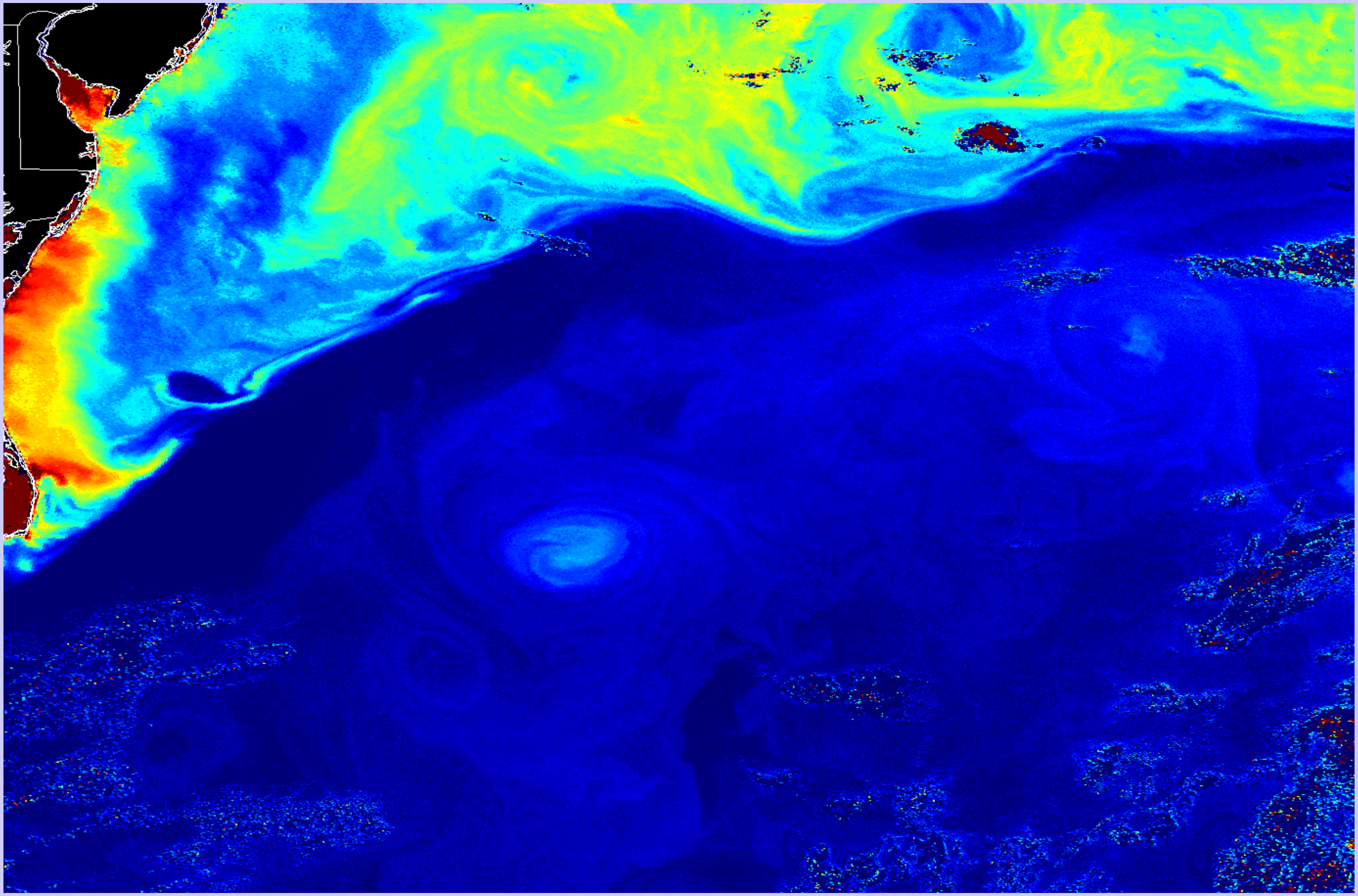
Processing philosophy

- Spectral Optimization Algorithm is slow, so at present we must restrict application to sub -granuals.

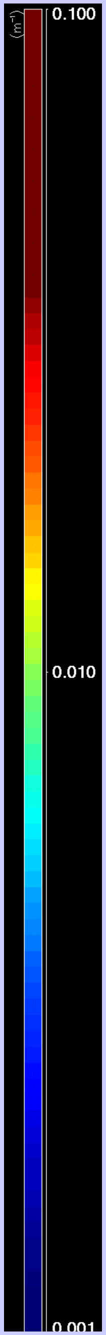
- Unlike the Case 1 $\rho_w(\lambda)$ model, the Case 2 $\rho_w(\lambda)$ model will most likely be site specific, i.e., the parameters in the GS97 model $\{a_{ph0}(\lambda), S, \text{and } n\}$ will depend on the target location.

- Our goal is to provide processing code that can be used for any location, given model parameters for that location. Individual investigators must supply $a_{ph0}(\lambda)$, S, and n.

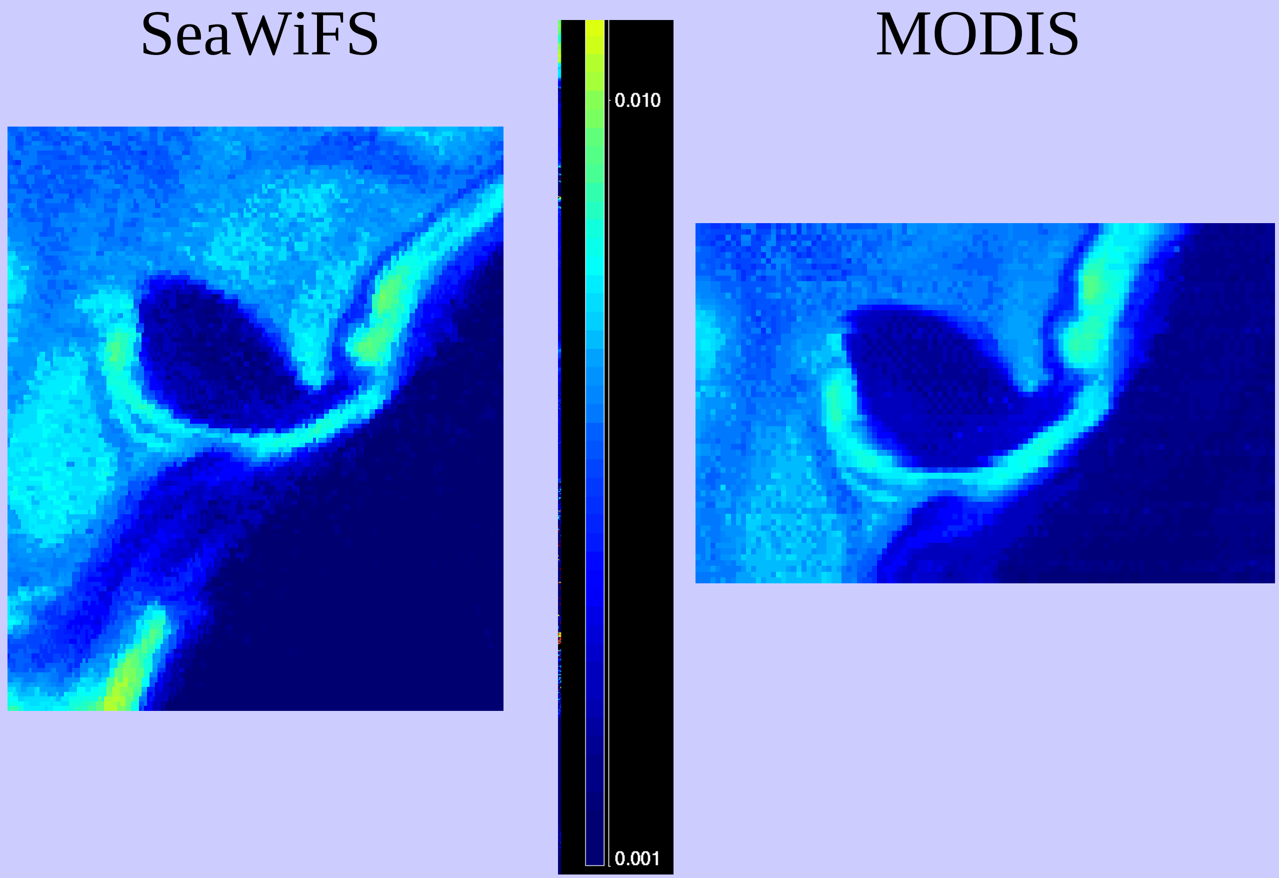
$b_{bp}\,(m^{-1})$



SeaWiFS

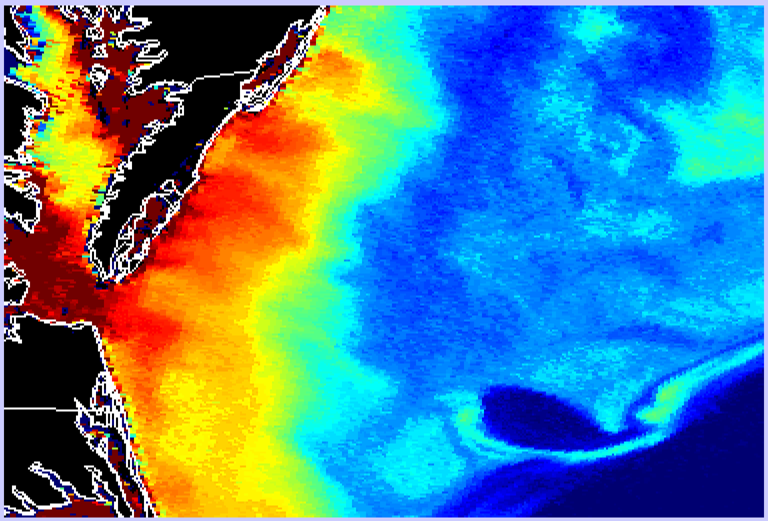


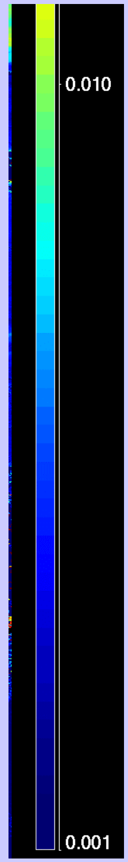
b_{bp} (m^{-1})



b_{bp} (m^{-1})

SeaWiFS





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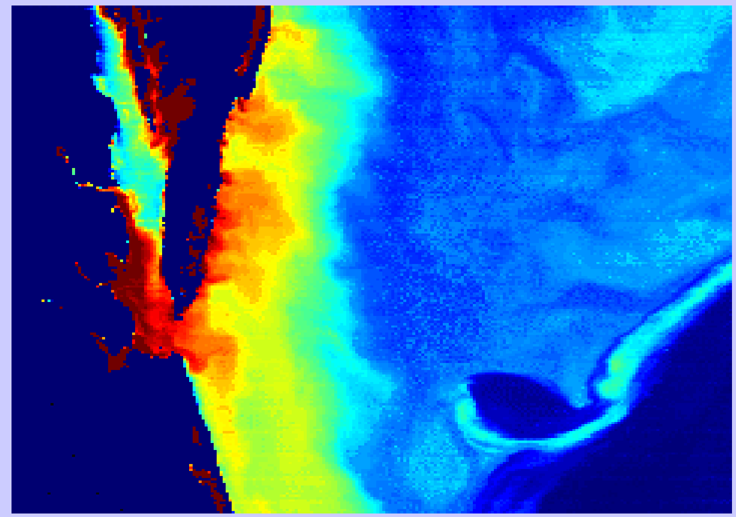
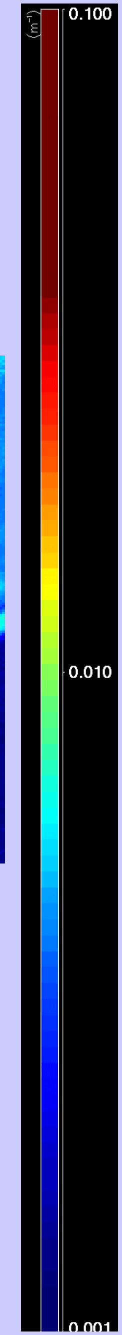
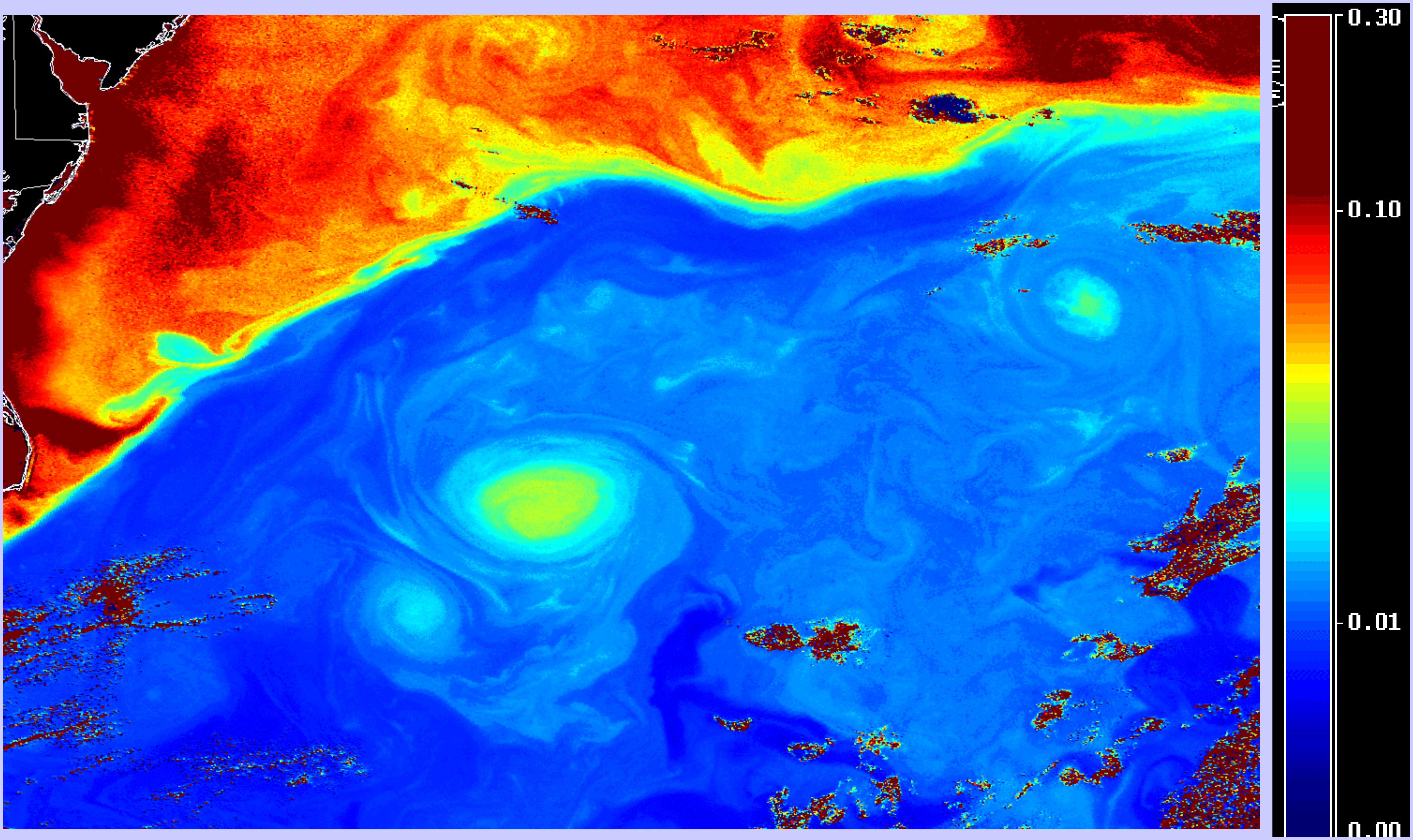




a_{cdm} (m^{-1})

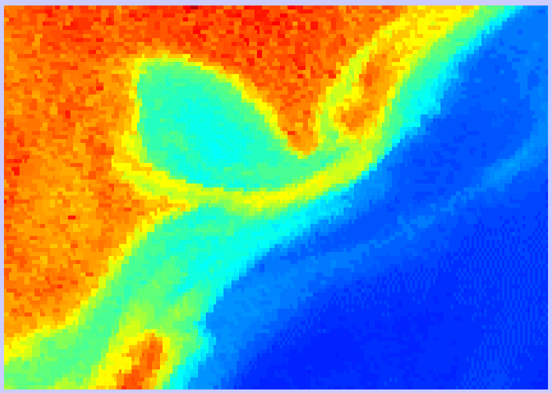


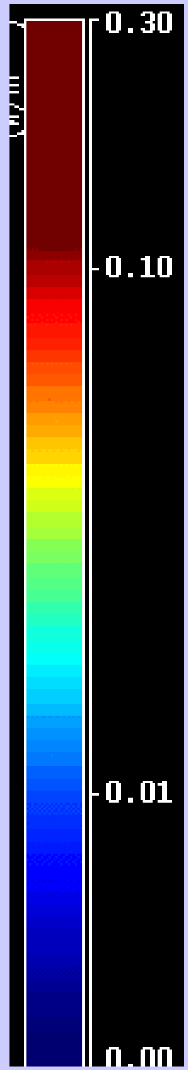
SeaWiFS

0.003

a_{cdm} (m^{-1})

SeaWiFS





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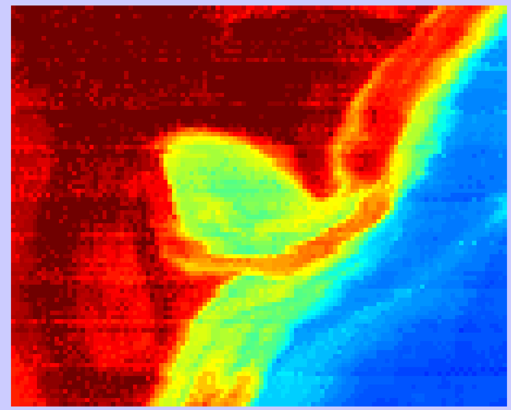
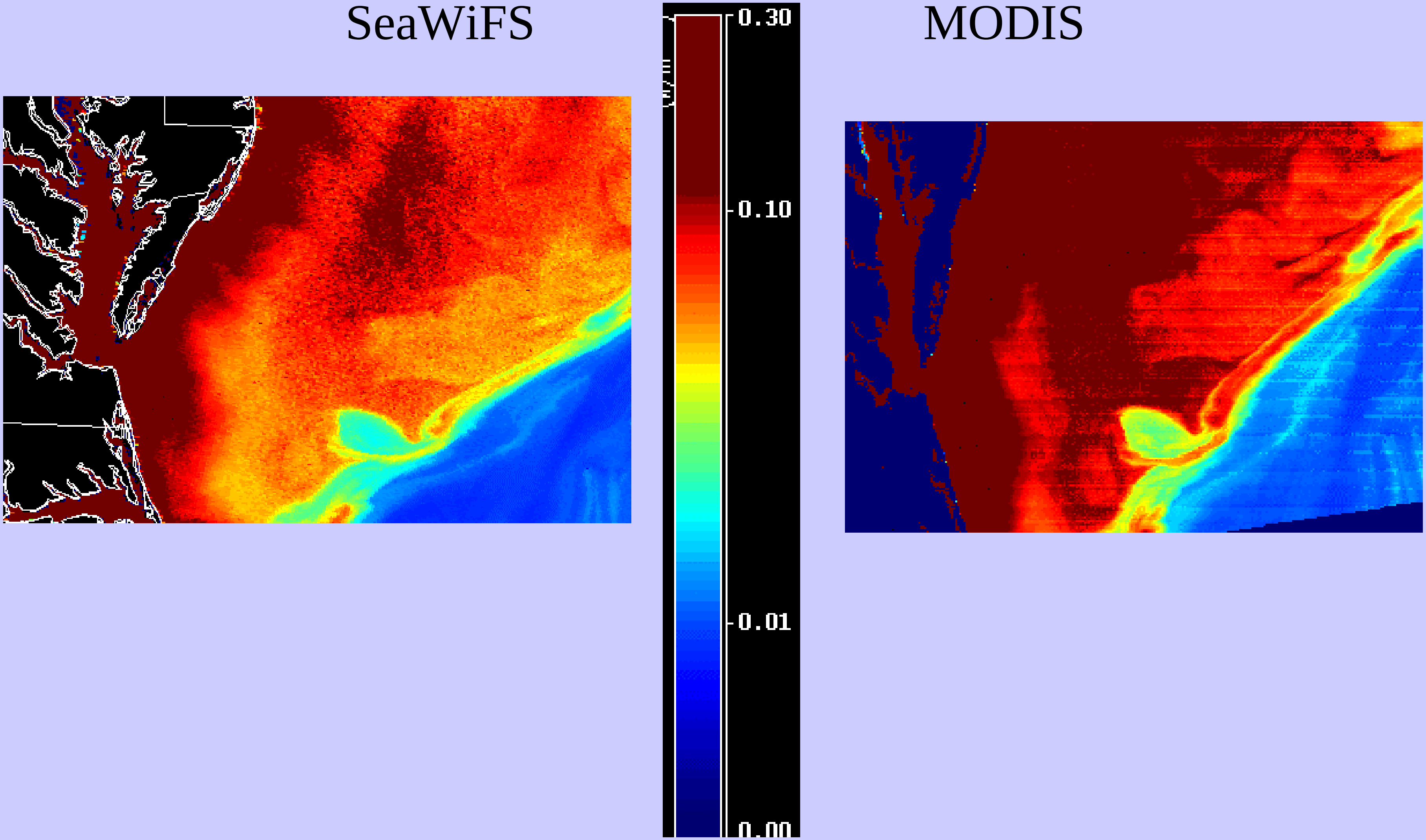
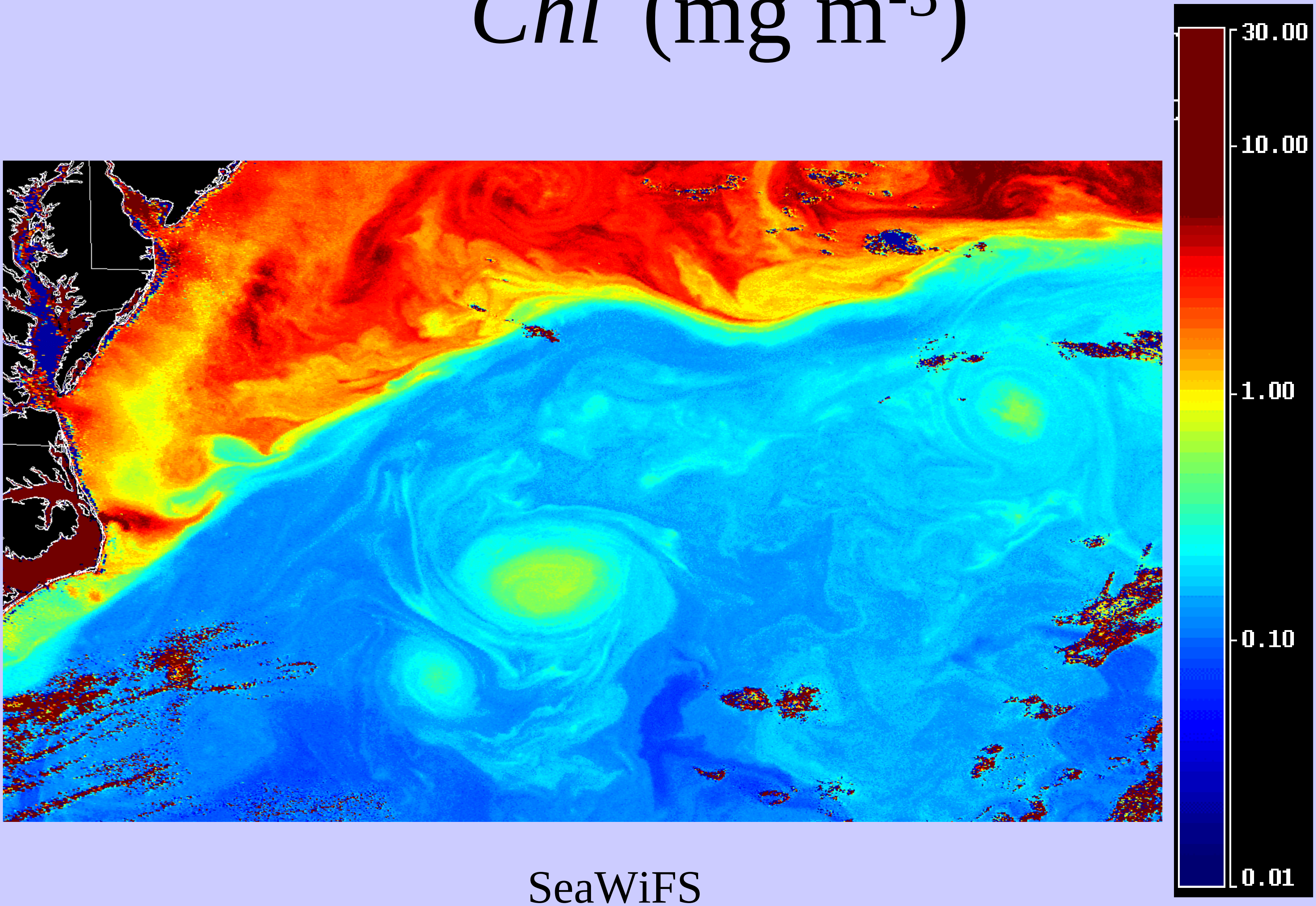


$a_{cdm}\,(m^{-1})$

SeaWiFS MODIS

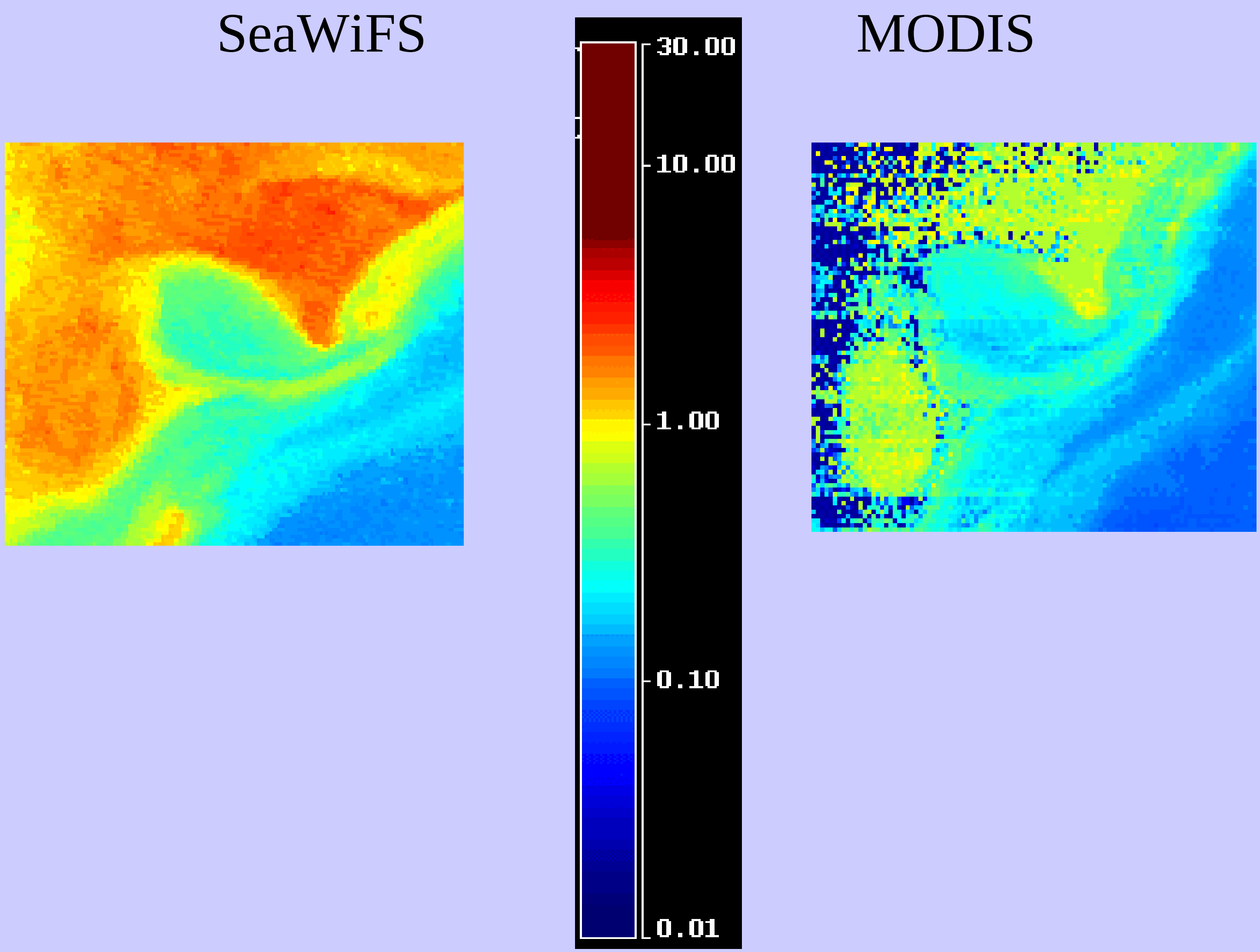


Chl (mg m^{-3})



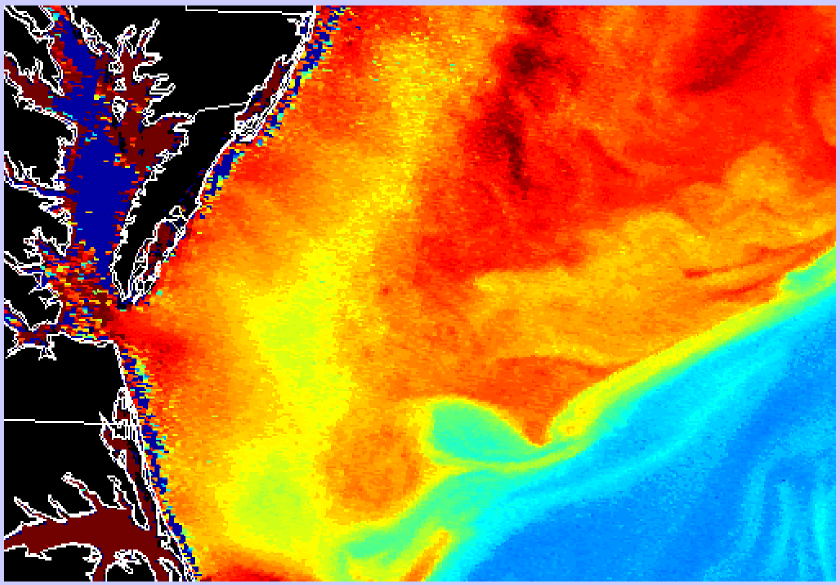
SeaWiFS

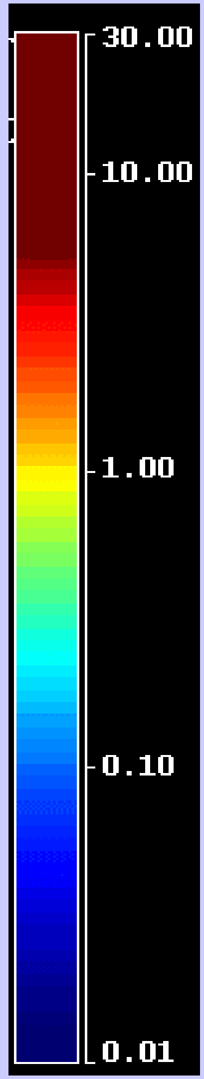
Chl (mg m^{-3})



Chl (mg m^{-3})

SeaWiFS





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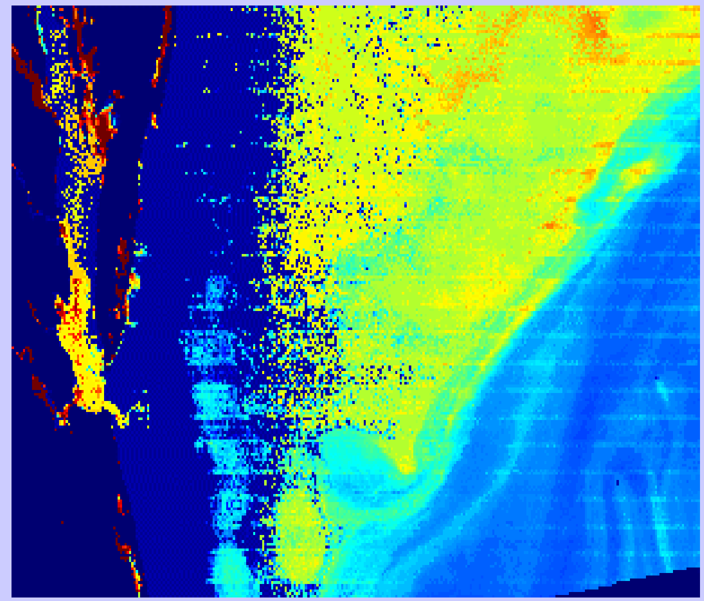

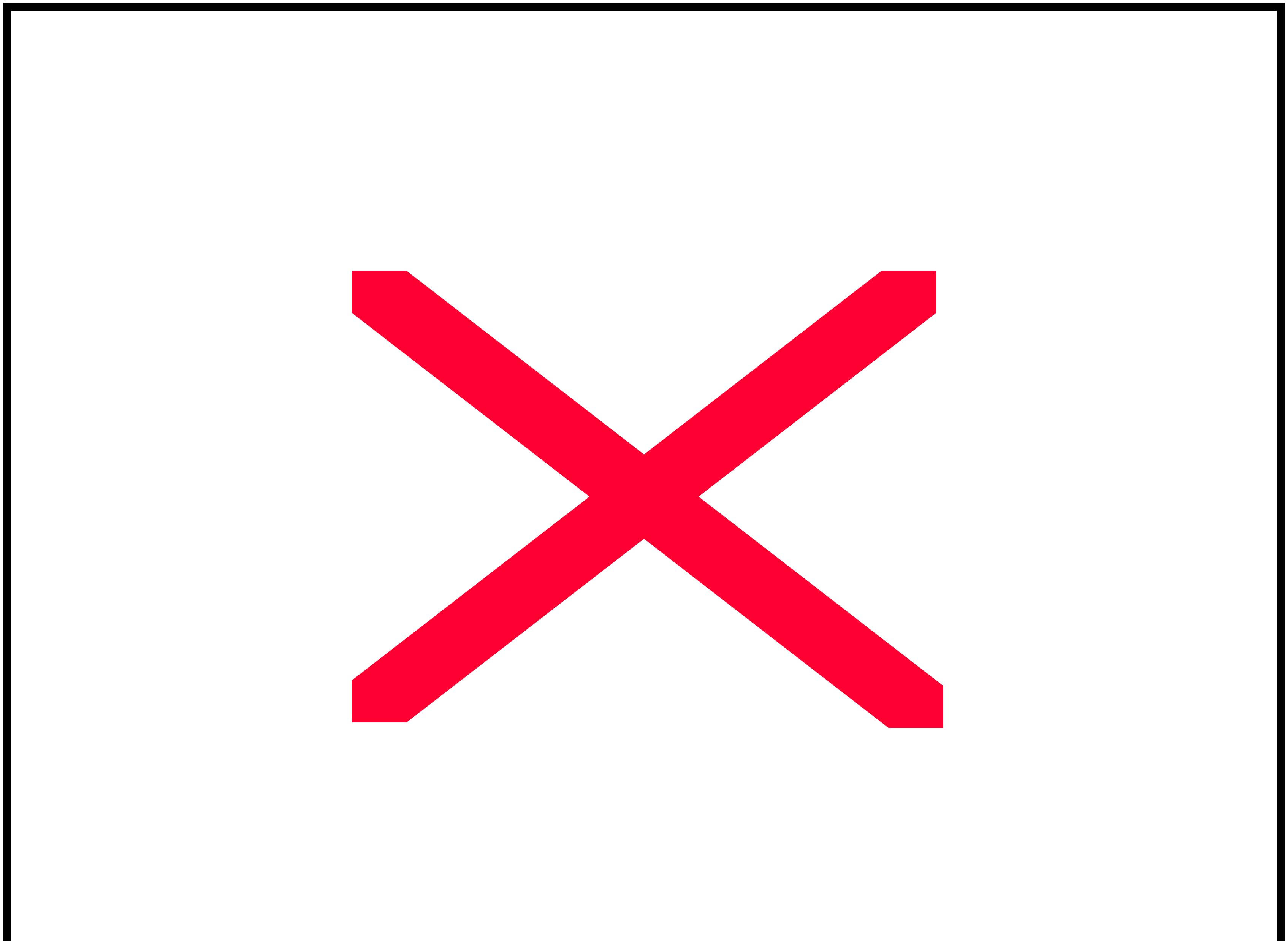

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