

# Approach for the long-term spatial and temporal evaluation of ocean color satellite data products in a coastal environment

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# Outline

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develop an approach for working with the community to rapidly evaluate **long-term regional time-series** of satellite ocean color data products

demonstrated via a **Chesapeake Bay  $C_a$  algorithm** round robin initiated by the Chesapeake Bay Program, executed by the NASA OBPG, with additional participation by NOAA, the U. of Maryland, and Old Dominion U.

the approach is **independent** of the data product and region of interest

# CBP $C_a$ Round Robin

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## empirical (statistical) approaches

OC4	operational SeaWiFS (versions 4 and 5)
OC3	operational MODIS
OC2	
OC3-ODU	tuned to Bay (ODU)
OC3-CB	tuned to Bay (SeaBASS)
Clark	tuned to Bay (NOAA)
Carder	operational VIIRS

## semi-analytical approaches

GSM01	
GSM01-CB	tuned to Bay (UMD)

RESULTS ONLINE: [http://seabass.gsfc.nasa.gov/cgi-bin/cbp\\_eval.cgi](http://seabass.gsfc.nasa.gov/cgi-bin/cbp_eval.cgi)

# Algorithms

empirical (statistical) →

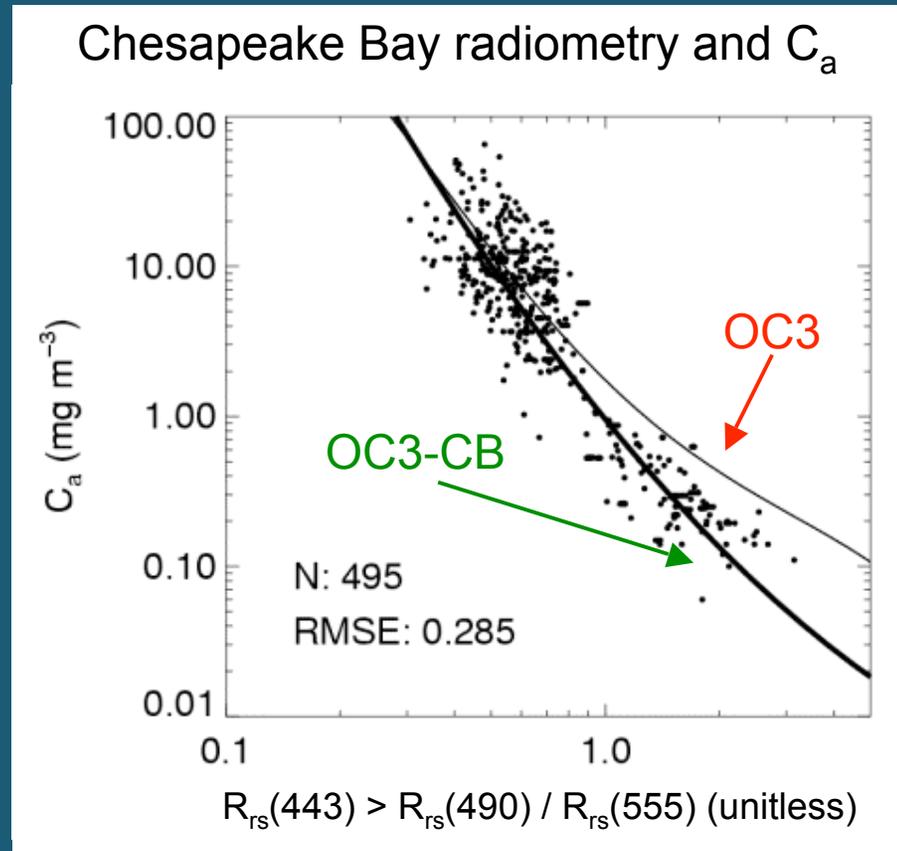
OC3 (O'Reilly 2000)

OC3-CB

semi-analytical

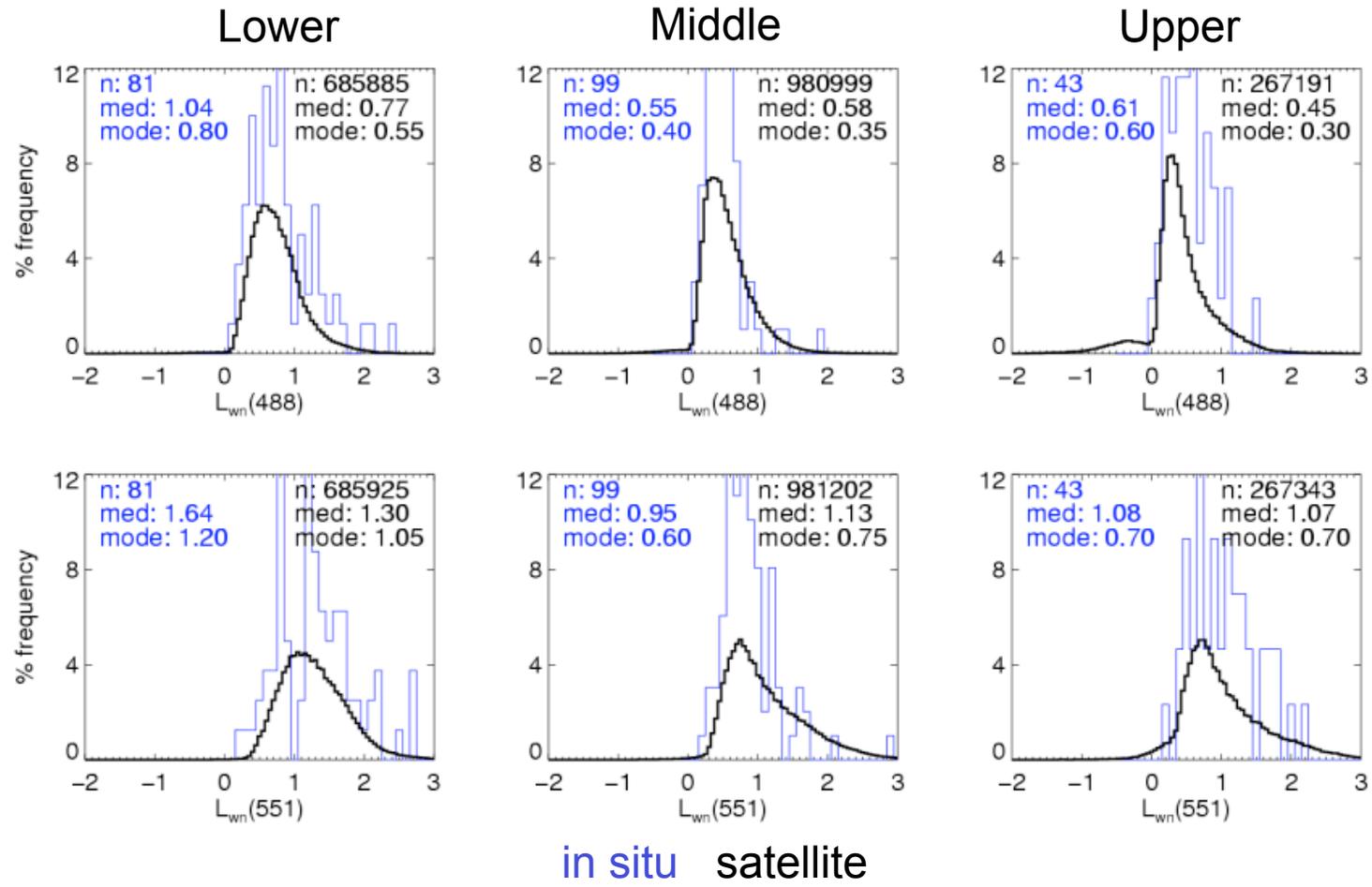
GSM (Maritorena 2002)

GSM-CB (Magnuson 2004)

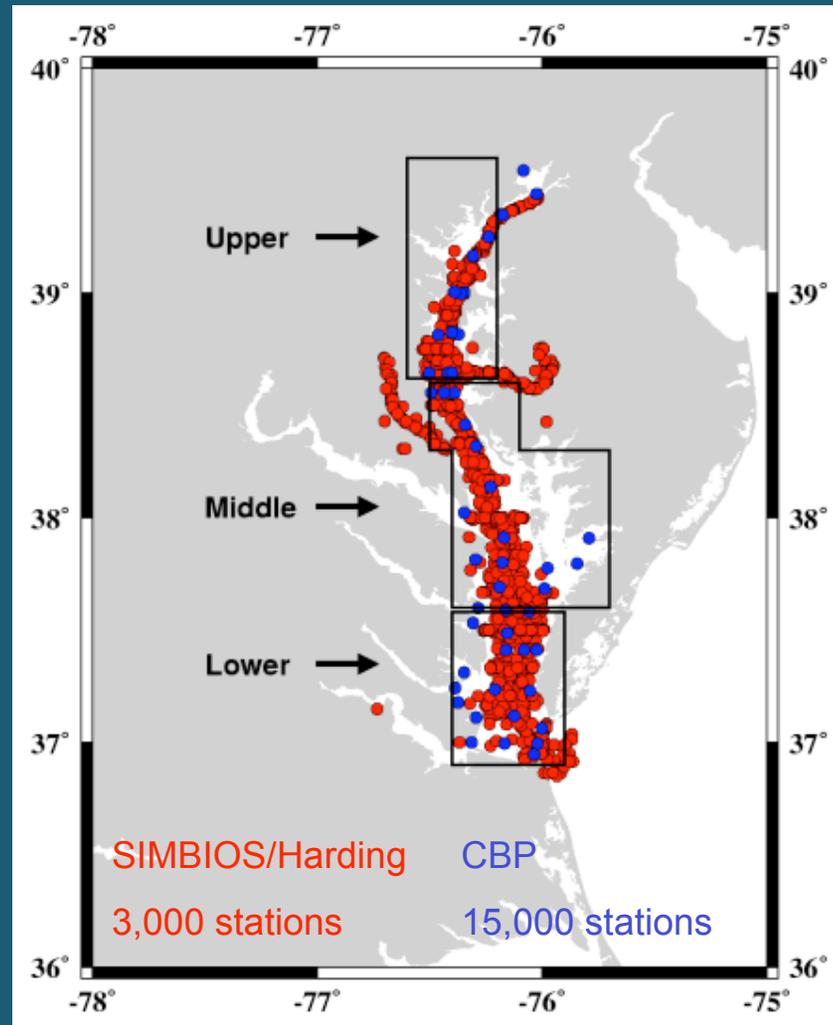


# Satellite & In Situ Radiometric Comparisons

## MODIS-Aqua $L_{wn}$ distributions



# $C_a$ Ground Truth



# Satellite Data Processing

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3,000 MODIS-Aqua and 6,200 SeaWiFS extracted Level-1A files  
processed using MSL12 version 5.6.2  
one Level-2 file per candidate  $C_a$  algorithm  
 $L_{wn}(\lambda)$ ,  $K_d(490)$ , AOT(865),  $a(443)$ ,  $b_b(510)$  also generated  
statistical and visual QC applied

# Quality Control

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goal is to consider only most reliable data

eliminate scenes with sat zenith  $> 54^\circ$

require 25% of marine pixels to be cloud free

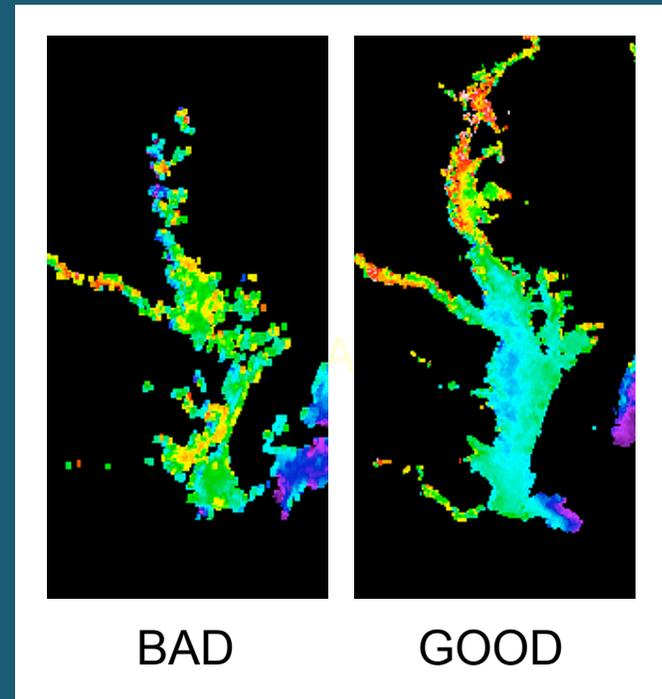
visual inspection

consider only  $0.1 < C_a < 100 \text{ mg m}^{-3}$

except for distribution analyses

require  $>200$  valid pixels

per sub-region per scene



# Satellite Data Processing

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statistical and visual QC applied

1,107 SeaWiFS scenes from Sep 1997 to Mar 2007

537 MODIS-Aqua scenes from Jun 2002 to Mar 2007

nine days of data per month for each sensor

# Validation

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## spatial & temporal stratification

upper, middle, & lower Bay

winter, spring, summer, & fall

(defined in Magnuson 2004)

## comparison to ground truth

data distributions via histograms

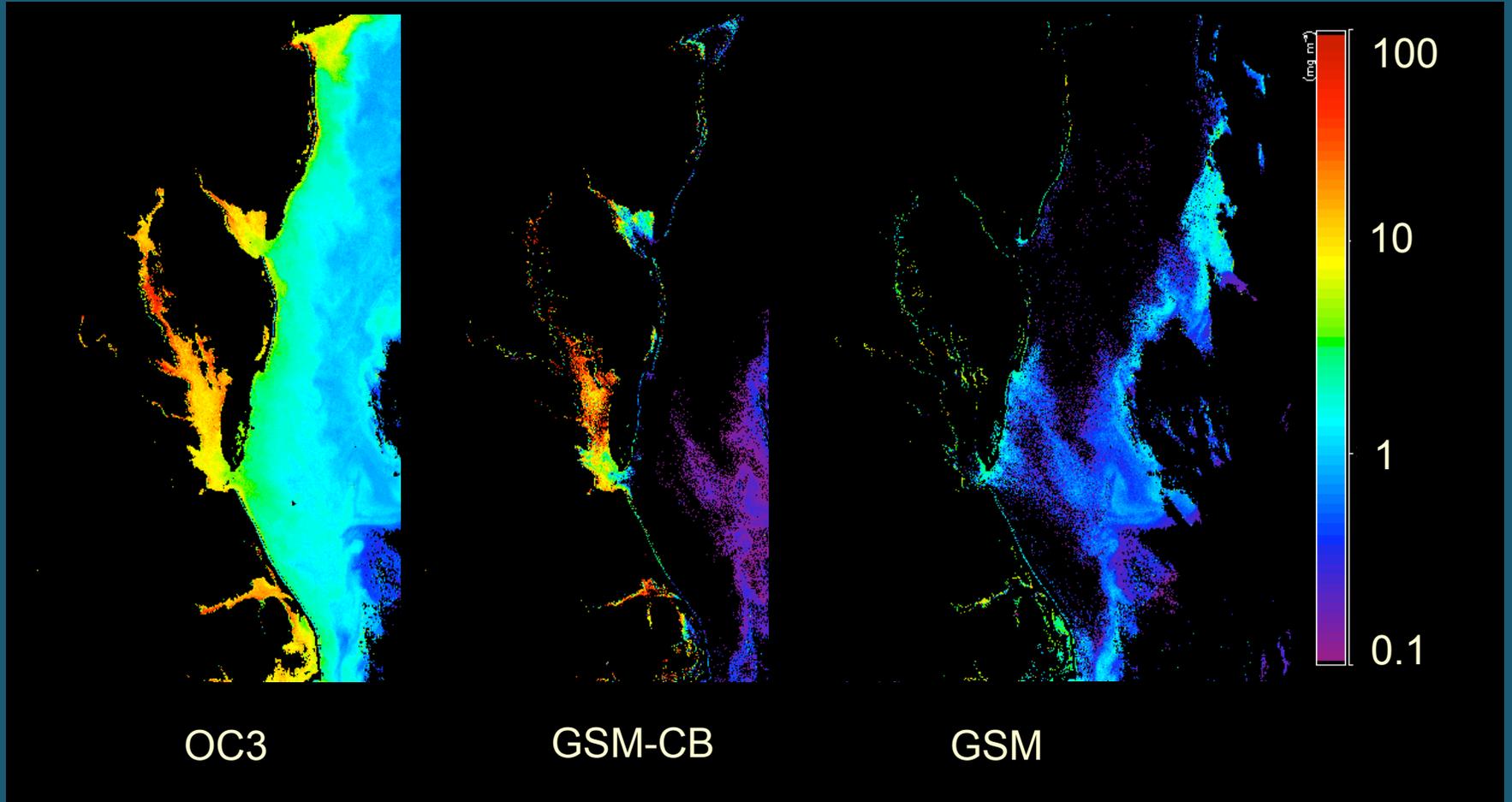
time-series (monthly averages)

match-ups with Level-2 data

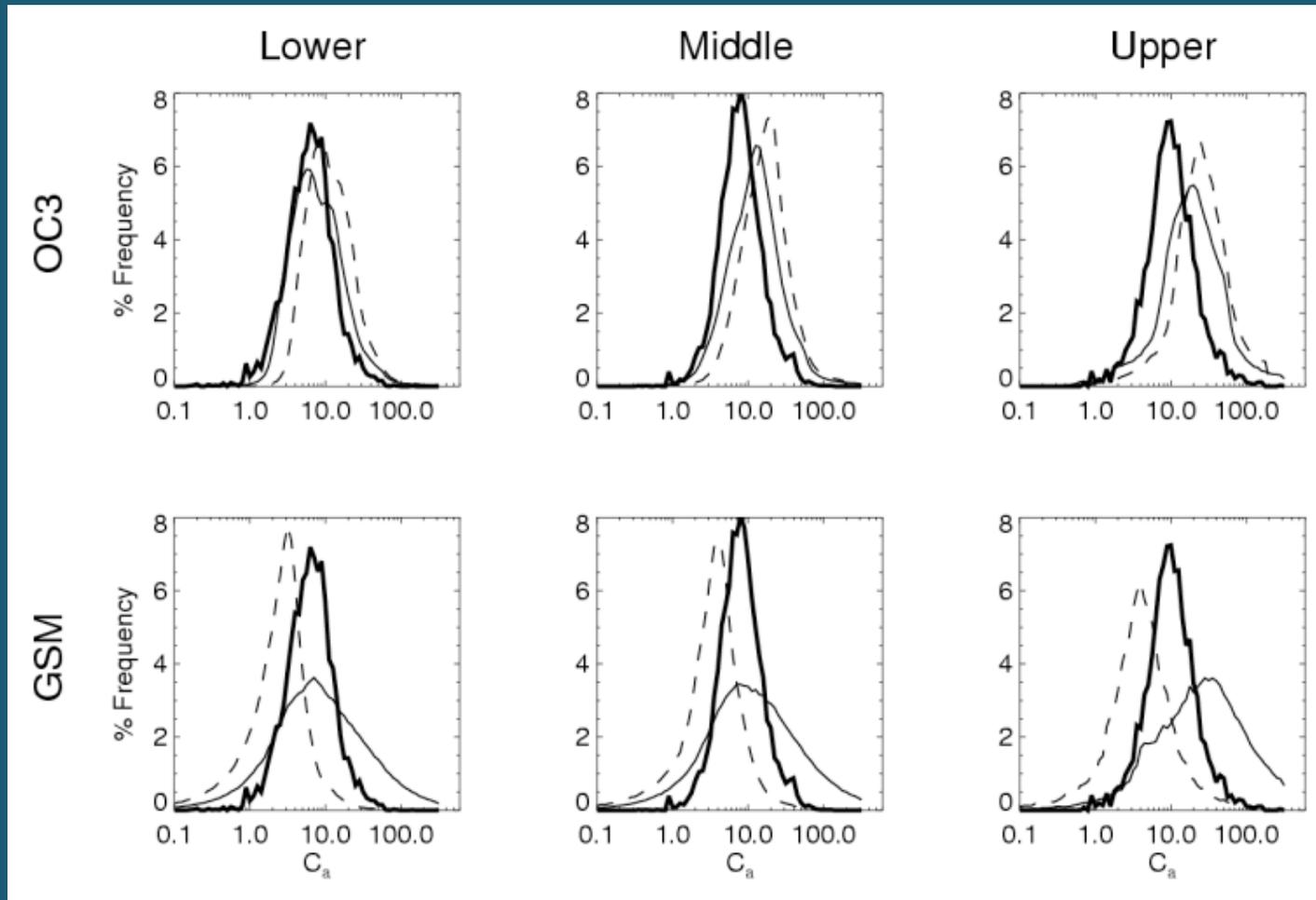
**trade-offs in specific coverage needs and accuracy requirements** drive the selection of the best algorithm(s) and processing approach(es)

# Spatial Coverage

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# Distributions



MODIS-Aqua, all seasons



in situ



global



regional

# Distributions

		N	OC3	OC3-CB	GSM	GSM-CB
Upper Bay	Spring	1208	85.7	63.8	85.2	<b>63.4</b> ●
	Summer	1364	44.4	20.8	119.2	<b>3.3</b> ●
	Fall	374	100.6	75.0	<b>64.6</b> ●	82.4
	Winter	717	91.7	68.2	79.9	<b>62.8</b> ●
Middle Bay	Spring	1752	65.4	39.8	104.0	<b>33.9</b> ●
	Summer	1986	51.3	<b>24.6</b> ●	78.5	58.1
	Fall	808	76.3	45.1	87.8	<b>24.7</b> ●
	Winter	1268	91.0	65.4	85.9	<b>45.4</b> ●
Lower Bay	Spring	1993	65.7	<b>33.0</b> ●	95.6	38.1
	Summer	2532	45.2	<b>10.6</b> ●	75.6	58.5
	Fall	1142	45.6	<b>6.1</b> ●	115.9	9.4
	Winter	1537	85.6	54.2	111.5	<b>45.9</b> ●

absolute percent differences  
MODIS-Aqua & in situ  $C_a$

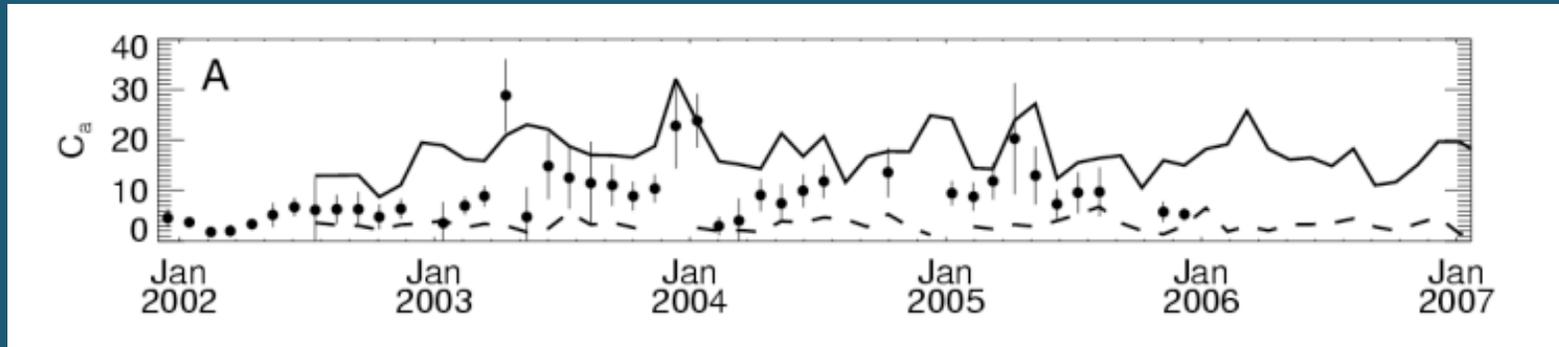
$$PD = 100\% \times \frac{|satellite - in\ situ|}{in\ situ}$$

using geometric means  
from seasonal & temporal  
distributions

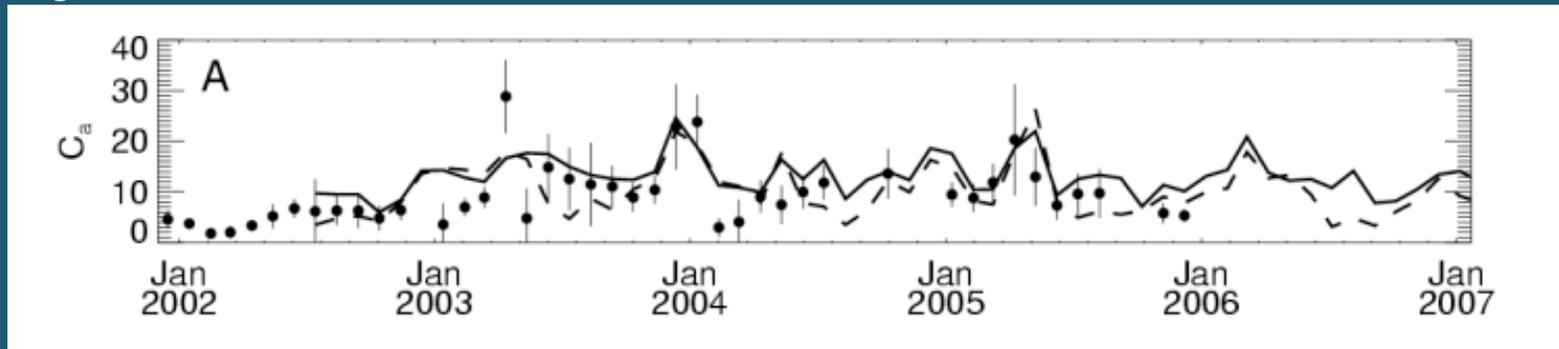
- lowest PD per scenario

# Time-series - $C_a$

global



regional

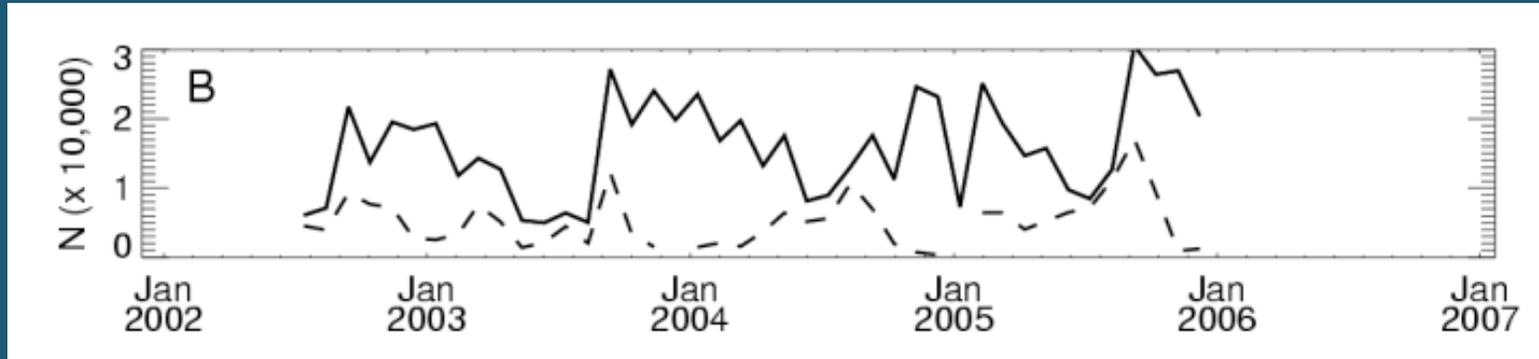


MODIS-Aqua, middle Bay

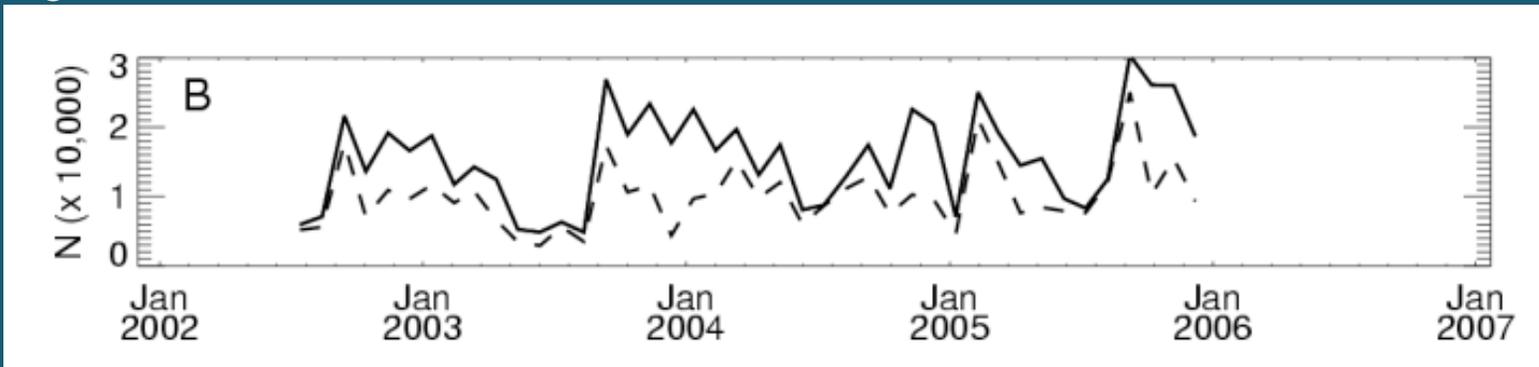
● in situ    - - - - GSM    ——— OC3

# Time-series - Coverage

global



regional

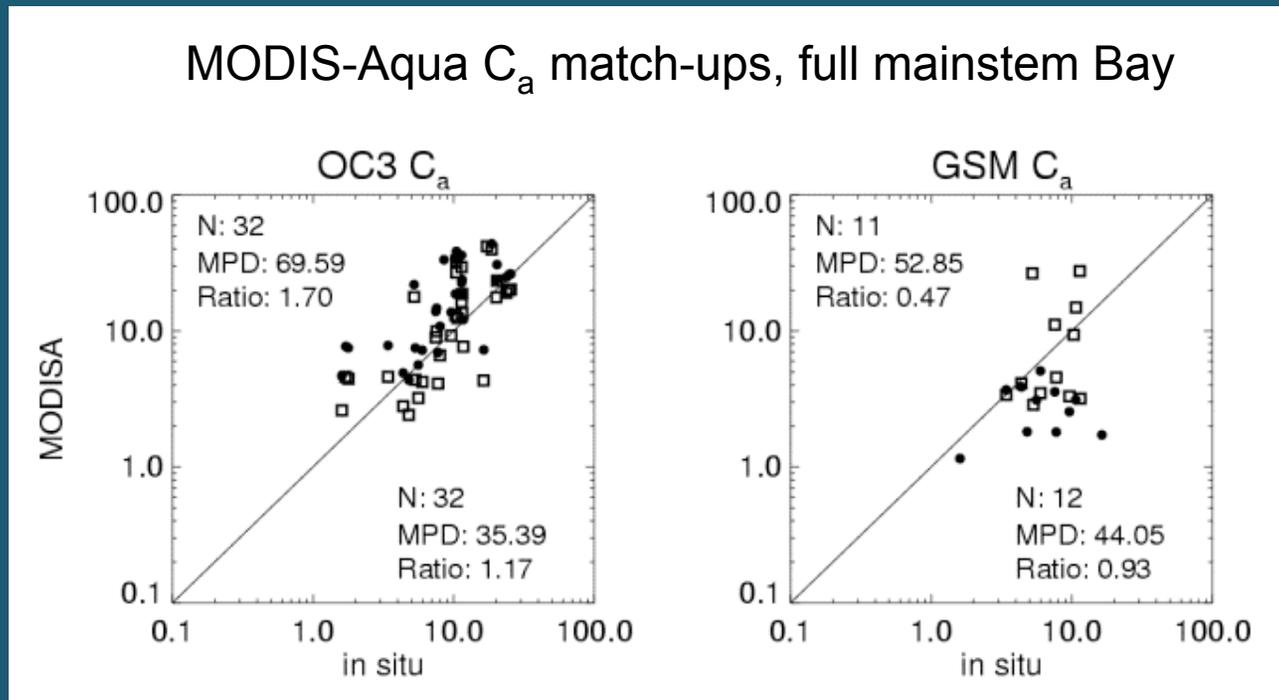


MODIS-Aqua, middle Bay

----- GSM    ——— OC3

# Level-2 Match-ups

## MODIS-Aqua $C_a$ match-ups, full mainstem Bay



- global
- regional

temporal coincidence +/- 3 hrs

average of satellite 5 x 5 pixel box

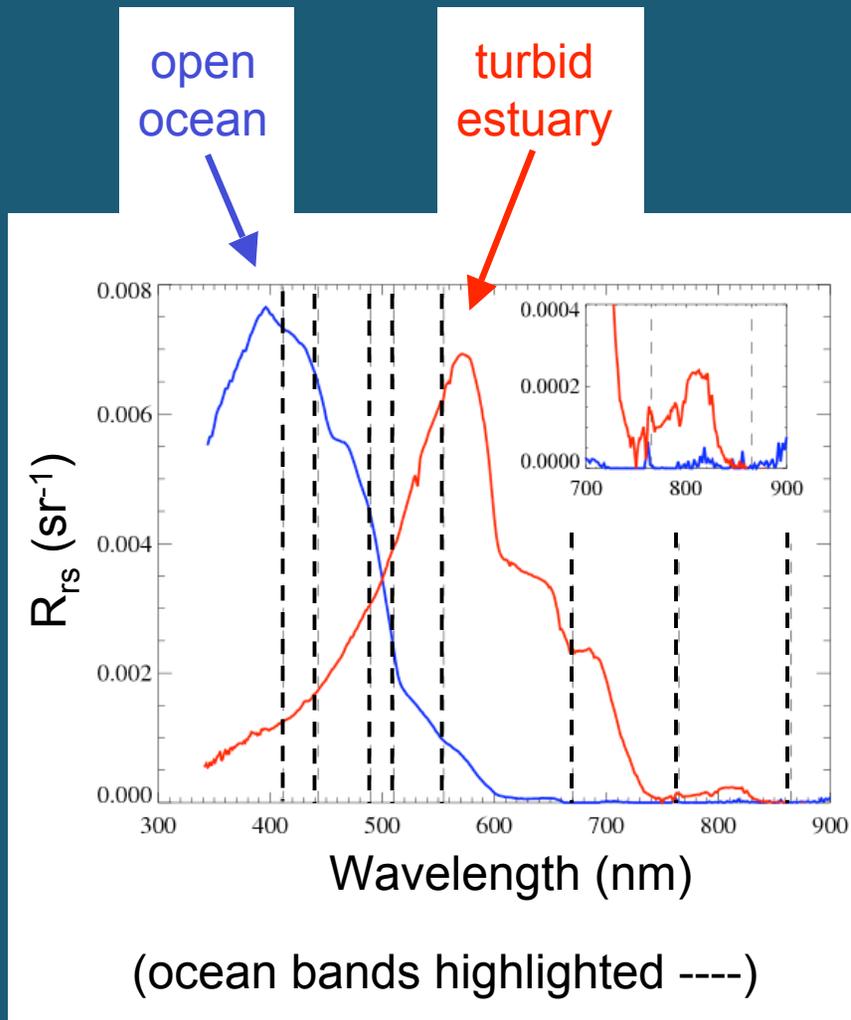
exclusion criteria of Bailey & Werdell 2006

# Challenges to Remote Sensing of Coastal Waters

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- temporal and spatial variability
  - limitations of satellite sensor resolution and repeat frequency
  - validity of ancillary data (reference SST, wind)
  - varied resolution requirements and binning options
- straylight contamination from land
- non-maritime aerosols (dust, pollution)
  - region-specific models required
  - absorbing aerosols
- suspended sediments and CDOM
  - complicates estimation of  $L_w(\text{NIR})$ , model not a function of  $C_a$
  - complicates correction for non-uniform subsurface light field ( $f/Q$ )
  - saturation of observed radiances
- anthropogenic emissions ( $\text{NO}_2$  absorption)

# Increased Spectral Resolution of MODIS

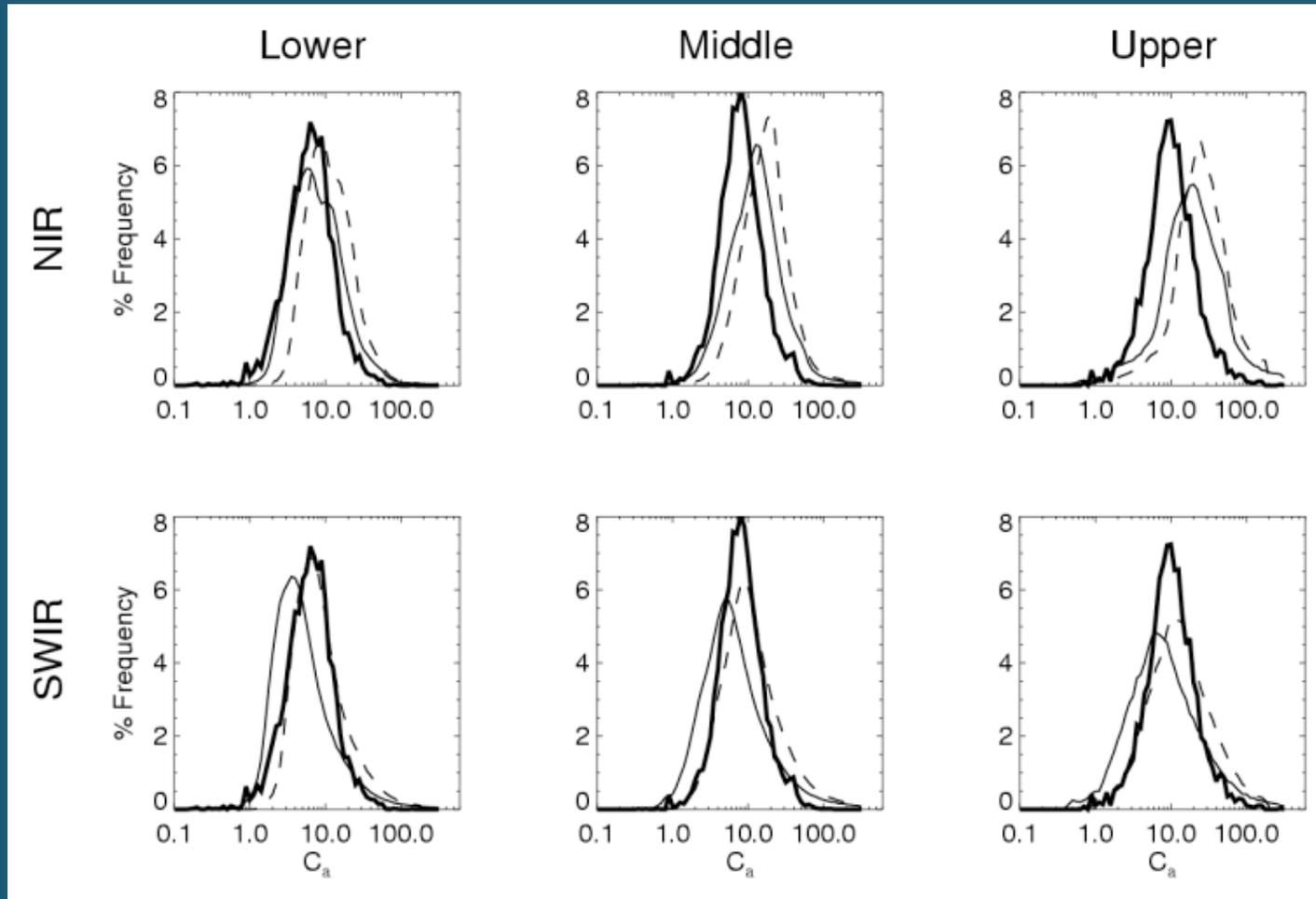


## MODIS Land & Atmosphere Bands

Band	$\lambda$ (nm)	Resol.	Potential Use
1	645	250 m	turbidity, IOPs
2	859	250	aerosols
3	469	500	$C_a$ , IOPs
4	555	500	$C_a$ , IOPs
5	1240	500	aerosols
6	1640	500	aerosols
7	2130	500	aerosols

potential for alternative  
 bio-optical algorithms &  
 atmospheric correction approaches

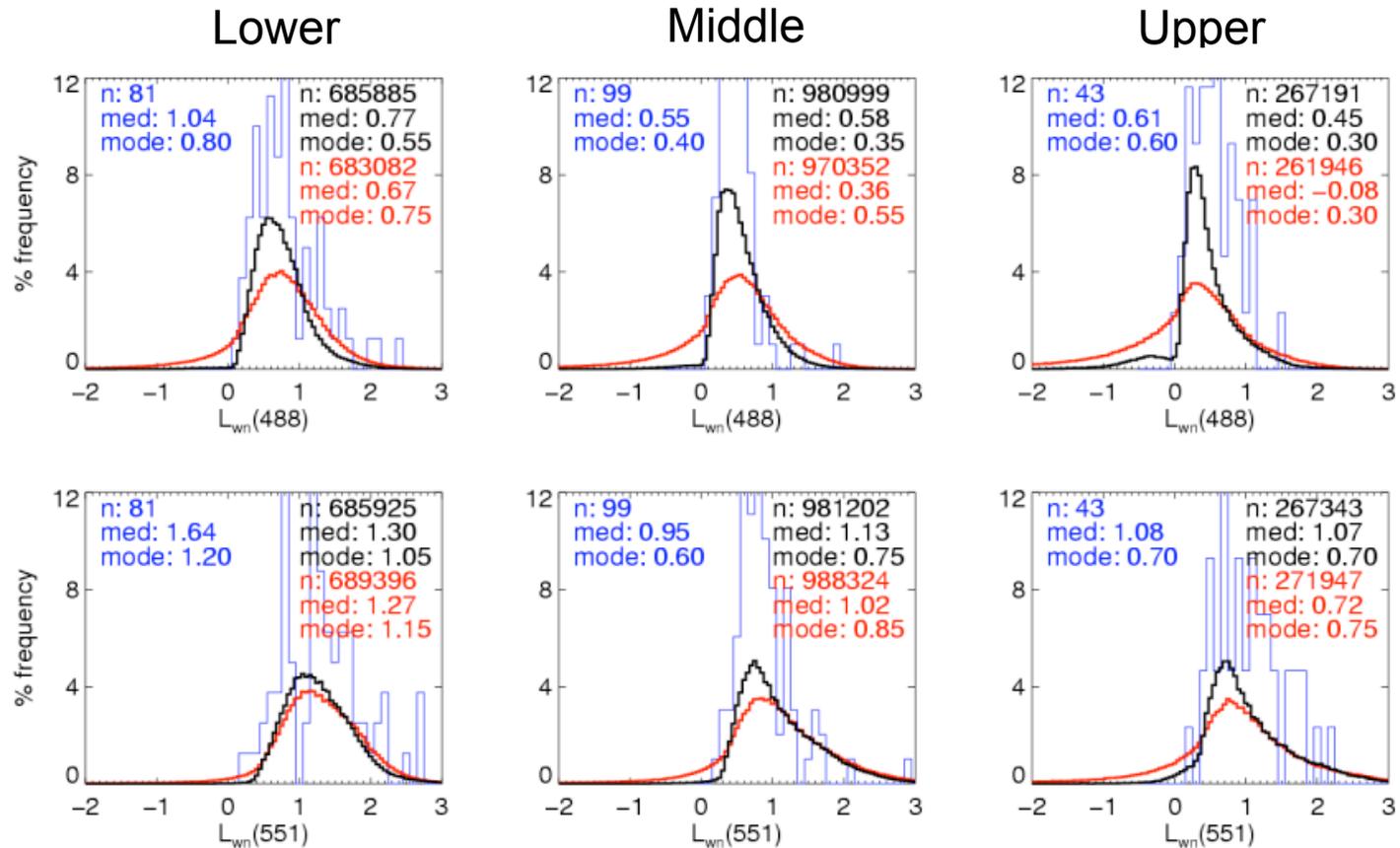
# SWIR Atmospheric Correction



MODIS-Aqua OC3, all seasons — in situ - - - - global — regional

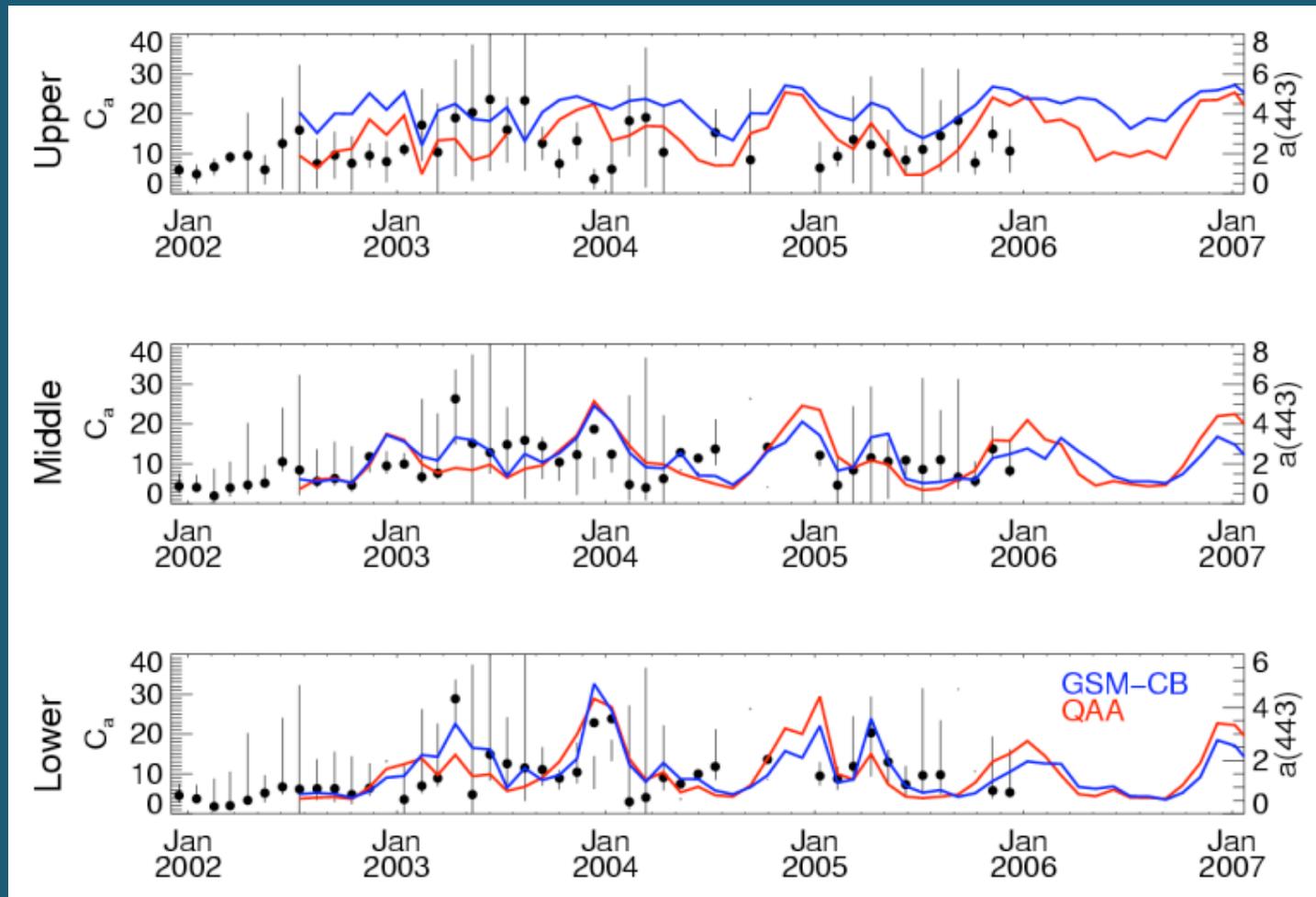
# Level-2 Radiometric Comparisons

## MODIS-Aqua $L_{wn}$ distributions



in situ    satellite NIR    satellite SWIR

# MODIS-Aqua $a(443)$ Time-series



# NOAA CoastWatch - East Coast Node

Chesapeake Bay SeaWiFS data products

http://coastwatch.chesapeakebay.noaa.gov/cb\_seawifs.html

NOAA CoastWatch - East Coast Node

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### Chesapeake Bay SeaWiFS Chlorophyll -a

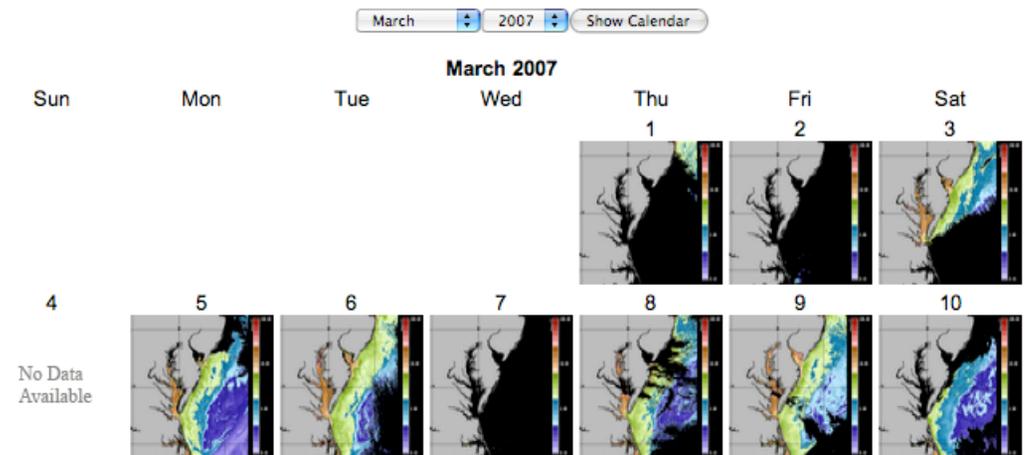
Following the Chesapeake Bay Remote Sensing Symposium in January 2006, NASA's Ocean Biology Processing Group evaluated the performance of several chlorophyll-a algorithms for the Chesapeake Bay. Details of the algorithms and their performance can be found at: [http://seabass.gsfc.nasa.gov/eval/cbp\\_eval.cgi](http://seabass.gsfc.nasa.gov/eval/cbp_eval.cgi). As a result, the OC4v5 algorithm was recommended for experimental daily processing of SeaWiFS data at the East Coast Node. SeaWiFS Level 1A data are processed using SeaDAS 5.0 software. Mapped chlorophyll -a images are available below, however, the Level 2 data are password protected. For data access, please send requests to Paul DiGiacomo, CoastWatch Program Manager.

March 2007

Sun Mon Tue Wed Thu 1 Fri 2 Sat 3

4 5 6 7 8 9 10

No Data Available



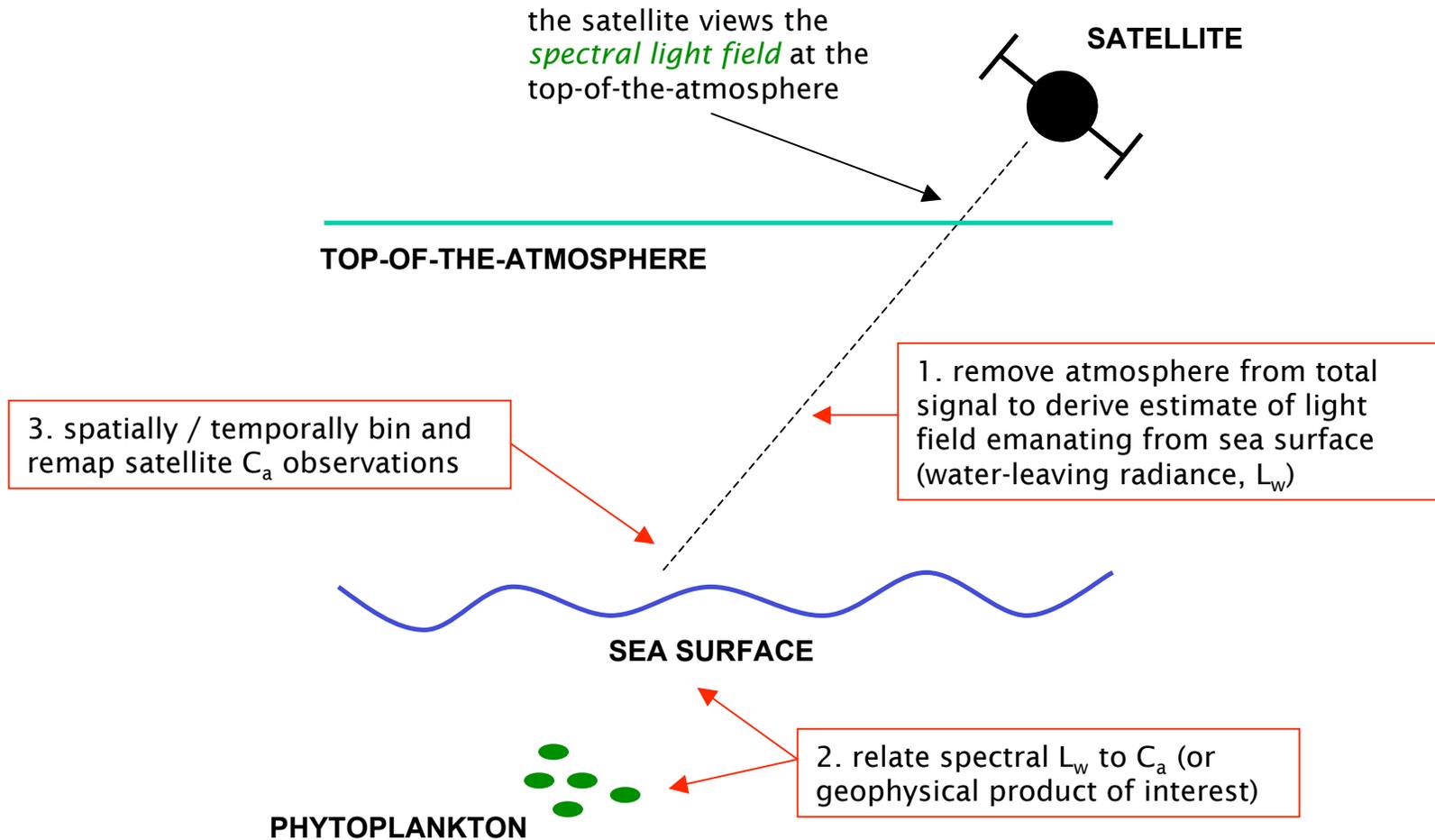
The screenshot displays a web browser window with the URL [http://coastwatch.chesapeakebay.noaa.gov/cb\\_seawifs.html](http://coastwatch.chesapeakebay.noaa.gov/cb_seawifs.html). The page features the NOAA logo and a navigation menu. The main content area is titled "Chesapeake Bay SeaWiFS Chlorophyll -a" and contains a paragraph of text explaining the data processing and availability. Below the text is a calendar for March 2007, showing a grid of 10 days (March 1-10) with corresponding SeaWiFS Chlorophyll-a maps. The maps are color-coded, with a color scale on the right of each map. The maps for March 1-3 and 5-10 are visible, while the map for March 4 is labeled "No Data Available".



# Thank You

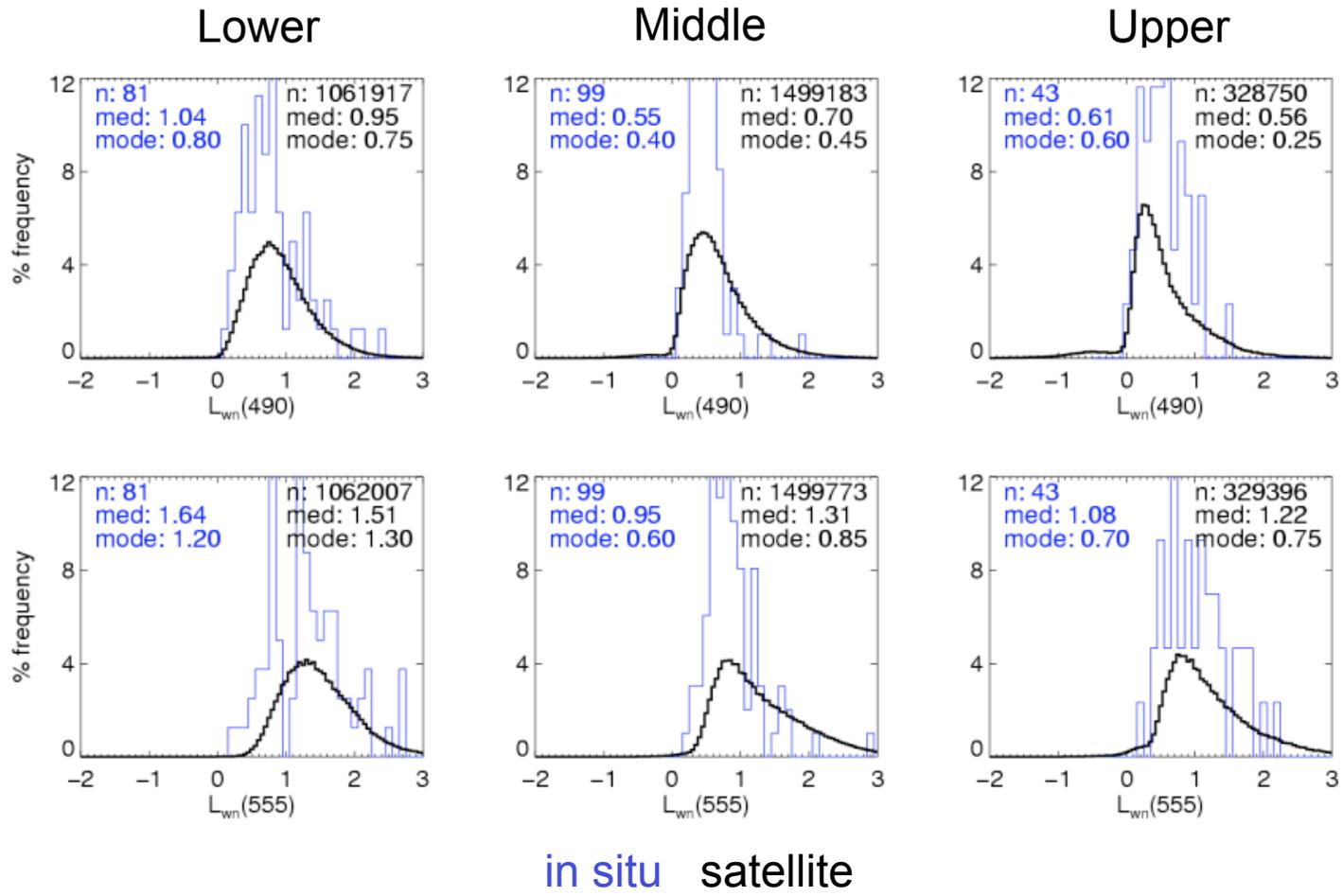
Coastal Ocean Remote Sensing, SPIE Optics + Photonics, San Diego, CA, 26 Aug 2007

# Ocean Color Remote Sensing



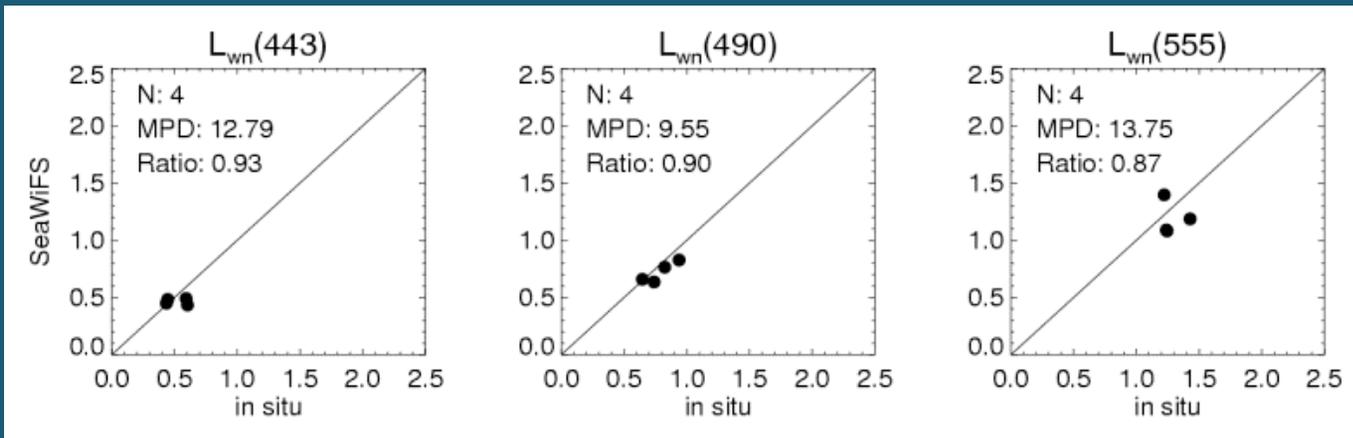
# Level-2 Radiometric Match-ups

## SeaWiFS $L_{wn}$ distributions



# Level-2 Radiometric Match-ups

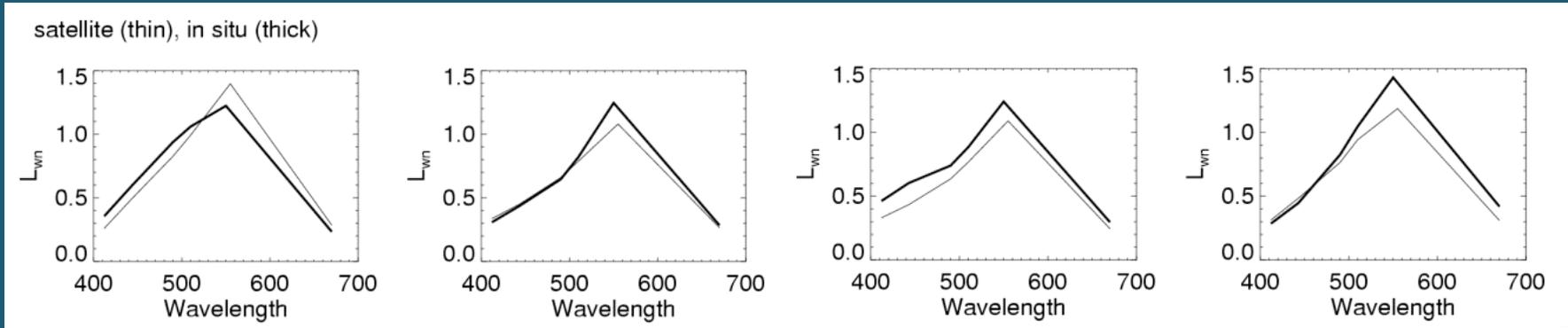
SeaWiFS  $L_{wn}$  match-ups, limited to middle & lower Bays



+/- 3-hrs

5 x 5 box

standard (global)  
exclusion criteria

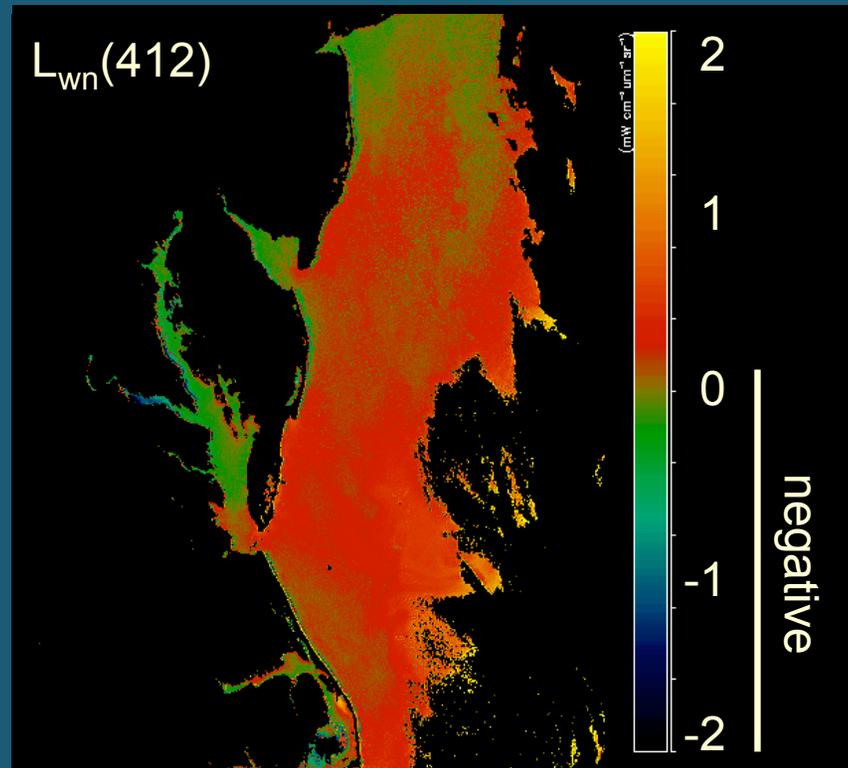


# Spatial Coverage

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SeaWiFS, 18 April 2006



# MODIS-Aqua $b_b(531)$ Time-series

