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

P. Jeremy Werdell, Bryan A. Franz, Sean W. Bailey,
Lawrence W. Harding Jr., and Gene C. Feldman

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Outline

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

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

Algorithms

empirical (statistical) →

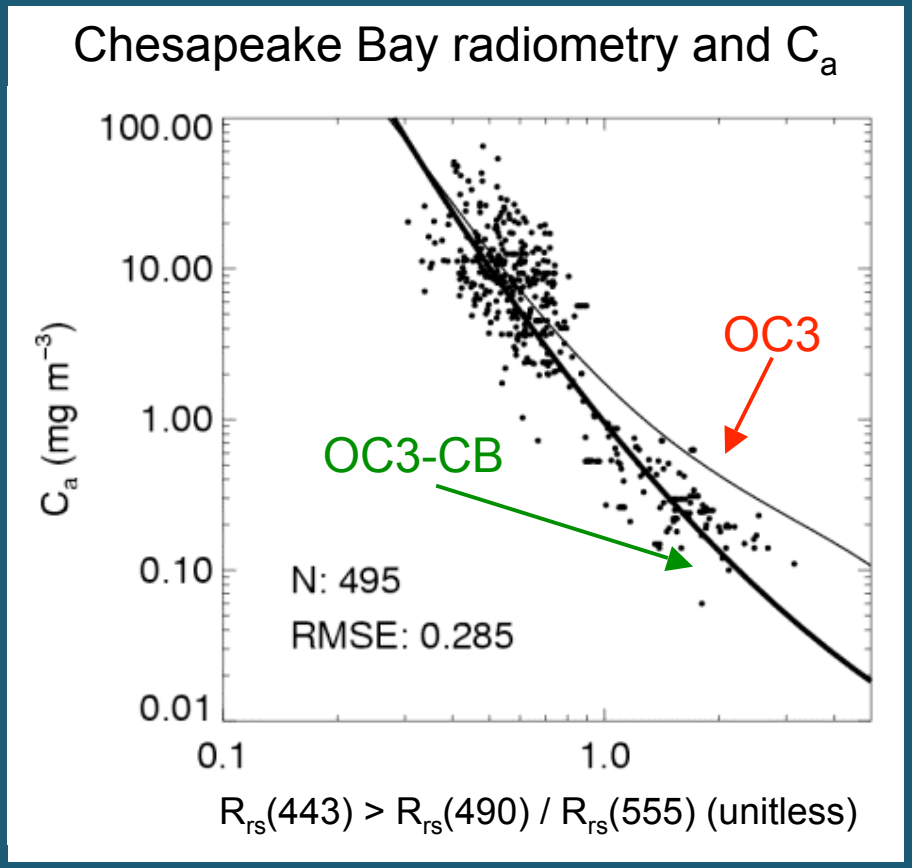
OC3 (O'Reilly 2000)

OC3-CB

semi-analytical

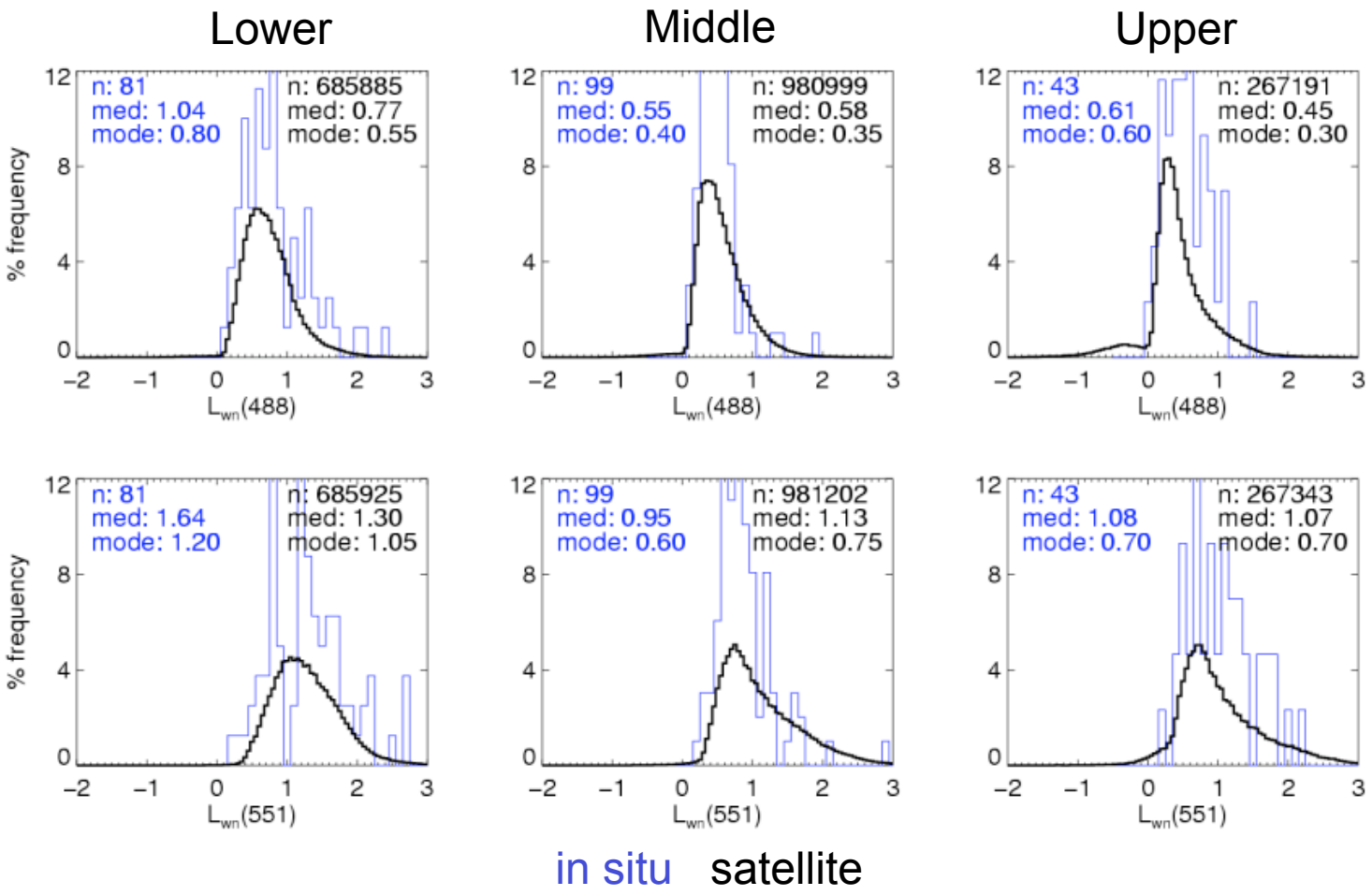
GSM (Maritorena 2002)

GSM-CB (Magnuson 2004)

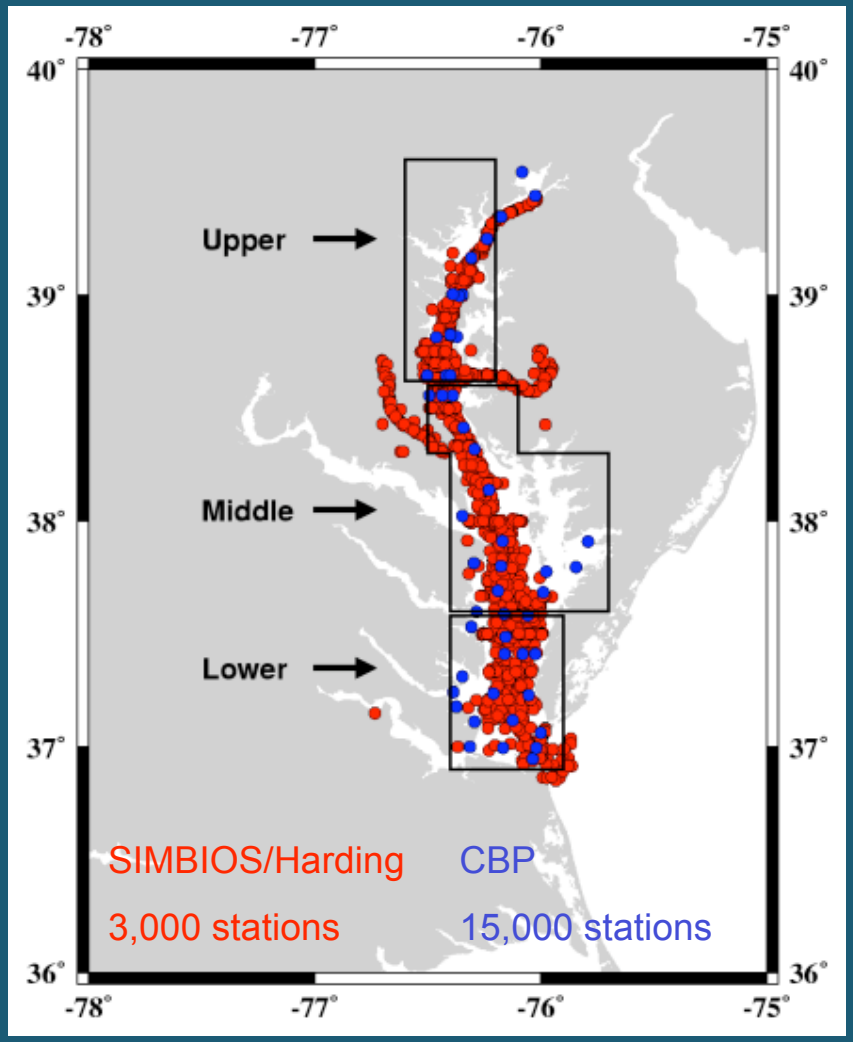


Satellite & In Situ Radiometric Comparisons

MODIS-Aqua L_{wn} distributions



C_a Ground Truth



Satellite Data Processing

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

goal is to consider only most reliable data

eliminate scenes with sat zenith > 54^{o}

require 25% of marine pixels to be cloud free

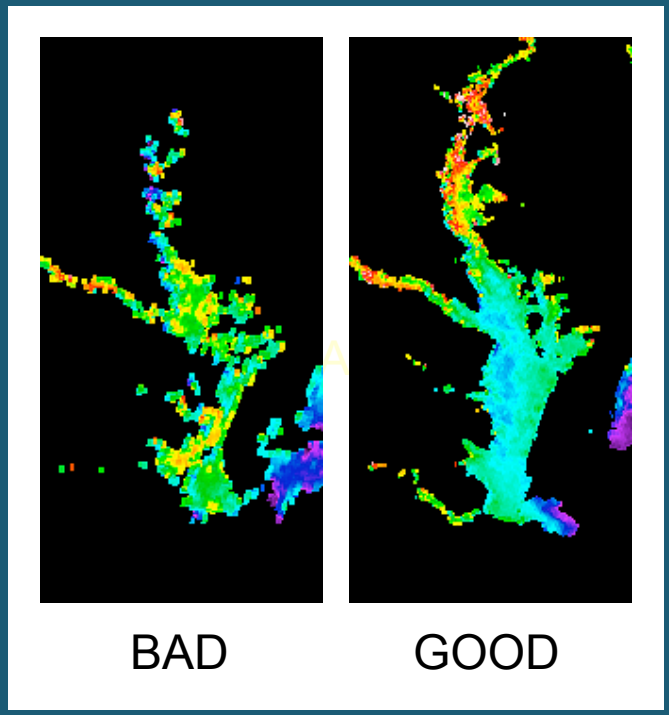
visual inspection

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

except for distribution analyses

require >200 valid pixels

per sub-region per scene



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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

spatial & temporal stratification

upper, middle, & lower Bay

winter, spring, summer, & fall

(defined in Magnuson 2004)

comparison to ground truth

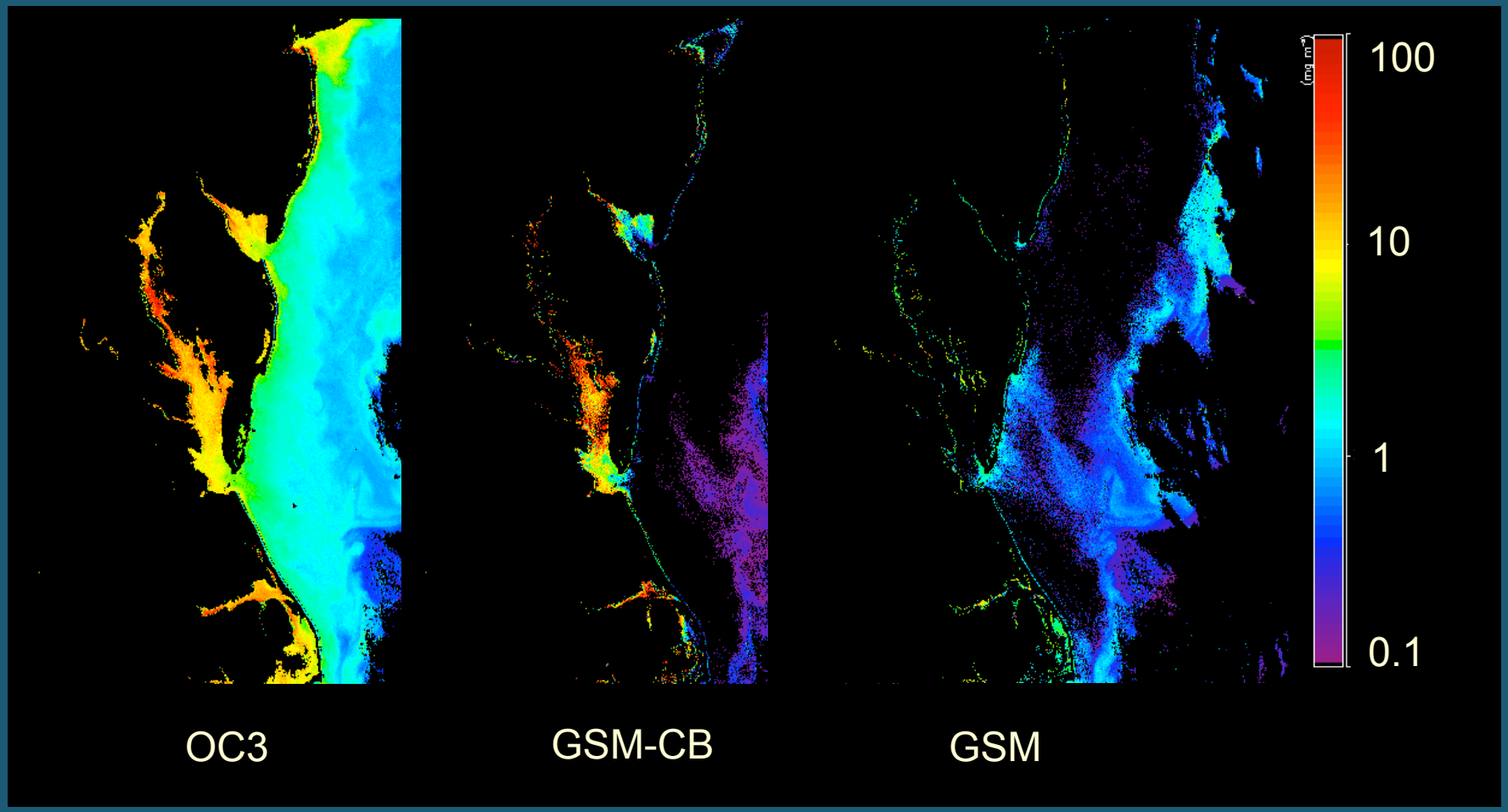
data distributions via histograms

time-series (monthly averages)

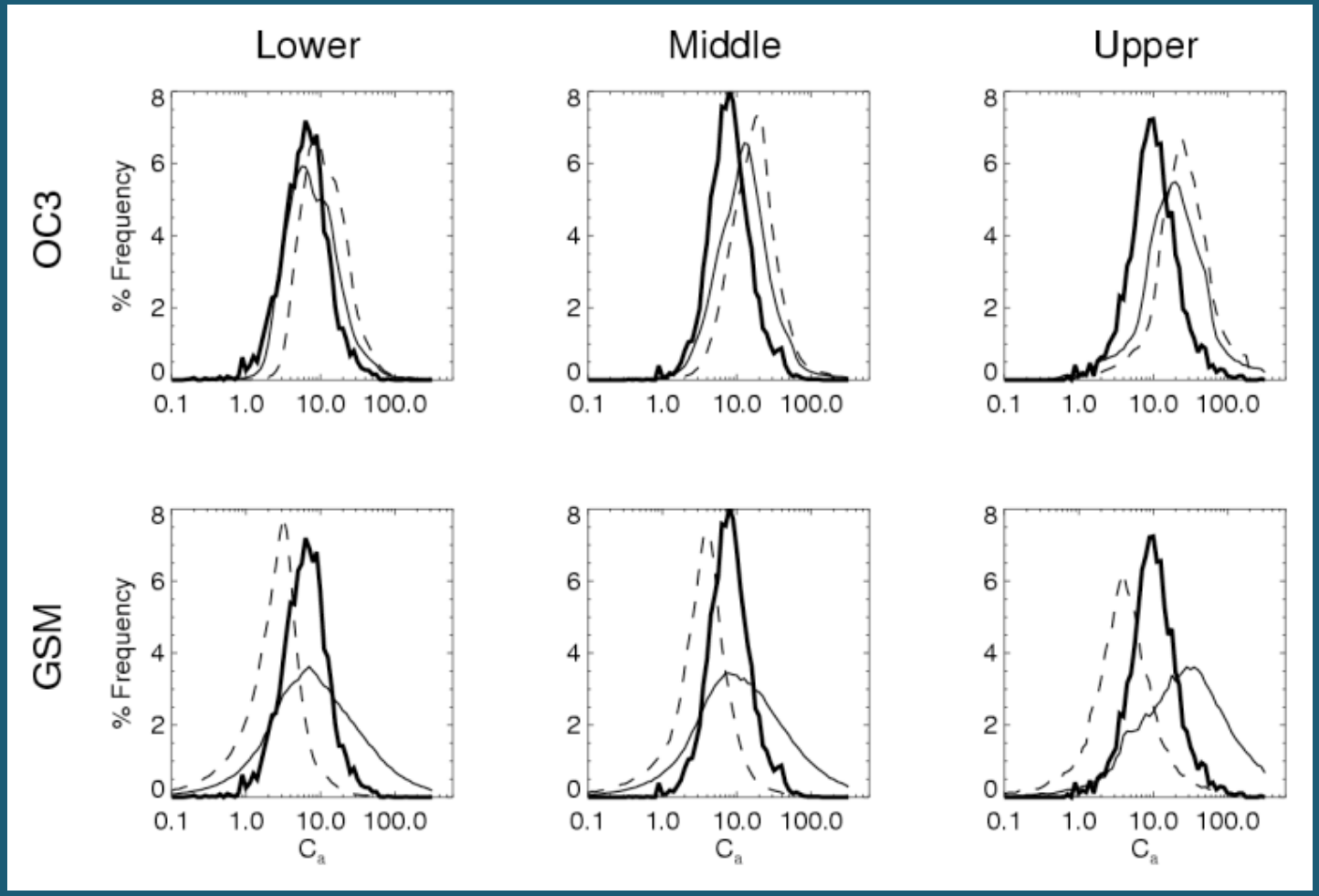
match-ups with Level-2 data

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

Spatial Coverage



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

absolute percent differences MODIS-Aqua & in situ C_a

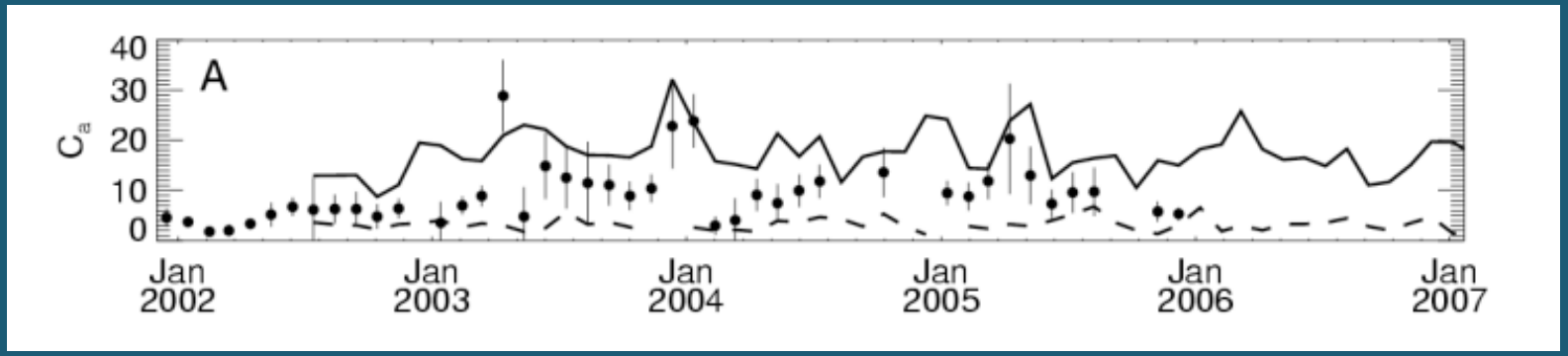
$$PD = 100\% \times \frac{|satellite - in\,situ|}{in\,situ}$$

using geometric means from seasonal & temporal distributions

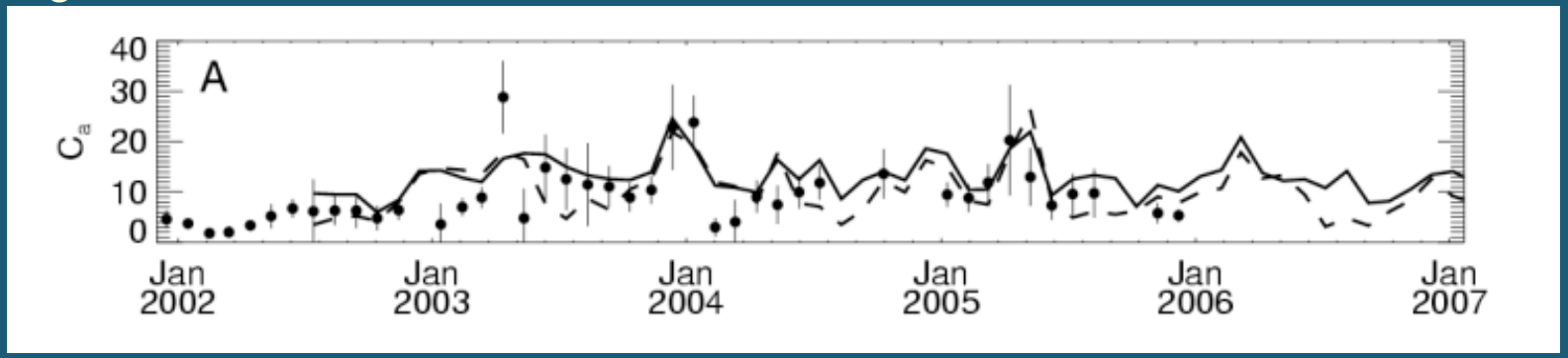
- ● lowest PD per scenario

Time-series - C_a

global



regional

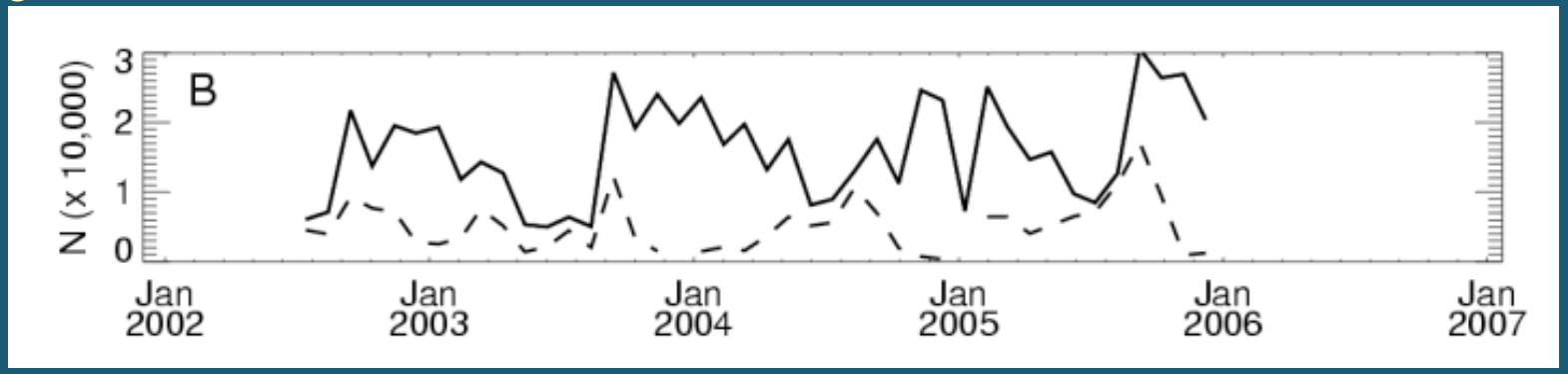


MODIS-Aqua, middle Bay

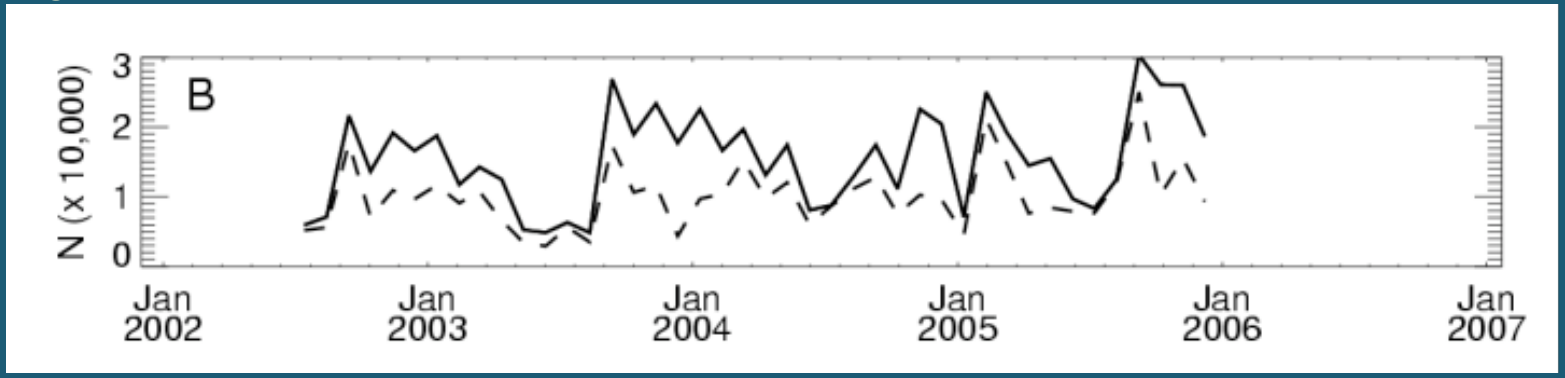
● in situ ----- GSM ——— OC3

Time-series - Coverage

global



regional

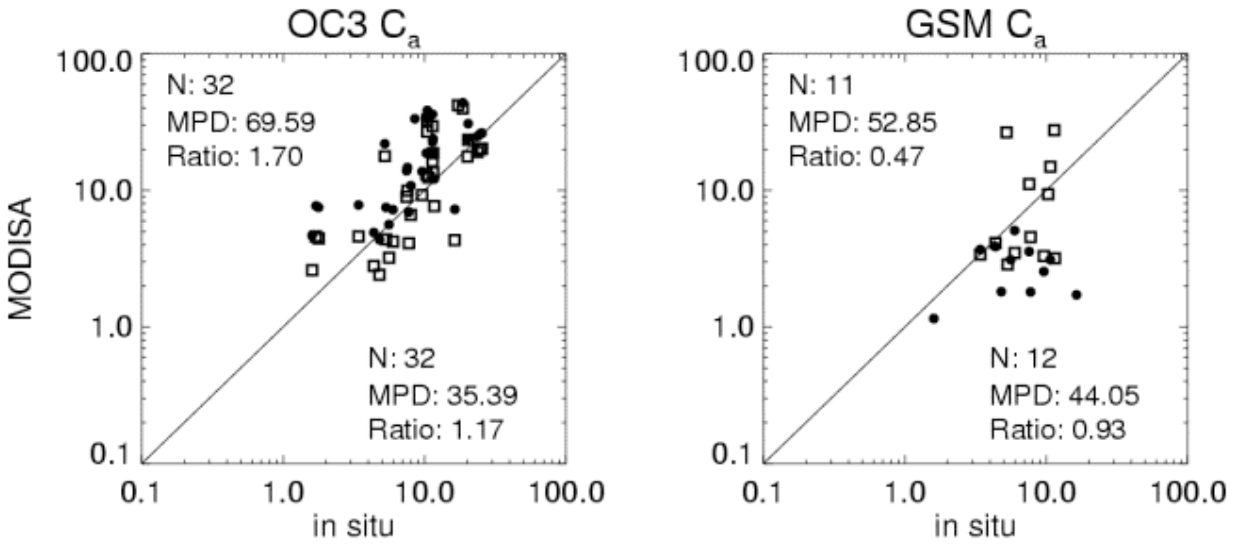


MODIS-Aqua, middle Bay

----- GSM ——— OC3

Level-2 Match-ups

MODIS-Aqua C_a match-ups, full mainstem Bay



- global
- regional

temporal coincidence +/- 3 hrs

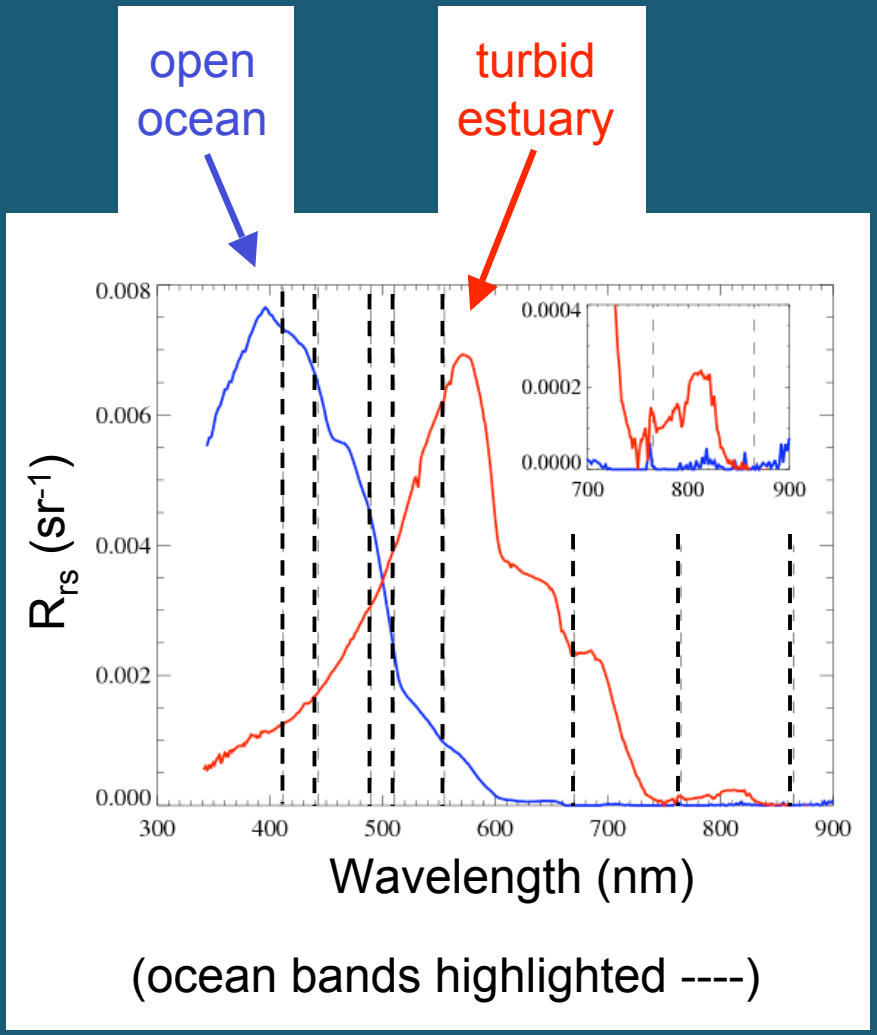
average of satellite 5 x 5 pixel box

exclusion criteria of Bailey & Werdell 2006

Challenges to Remote Sensing of Coastal Waters

- 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(NIR), model not a function of C_a
  - complicates correction for non-uniform subsurface light field (f/Q)
  - saturation of observed radiances
- anthropogenic emissions (NO_2 absorption)

Increased Spectral Resolution of MODIS



(ocean bands highlighted ----)

MODIS Land & Atmosphere Bands

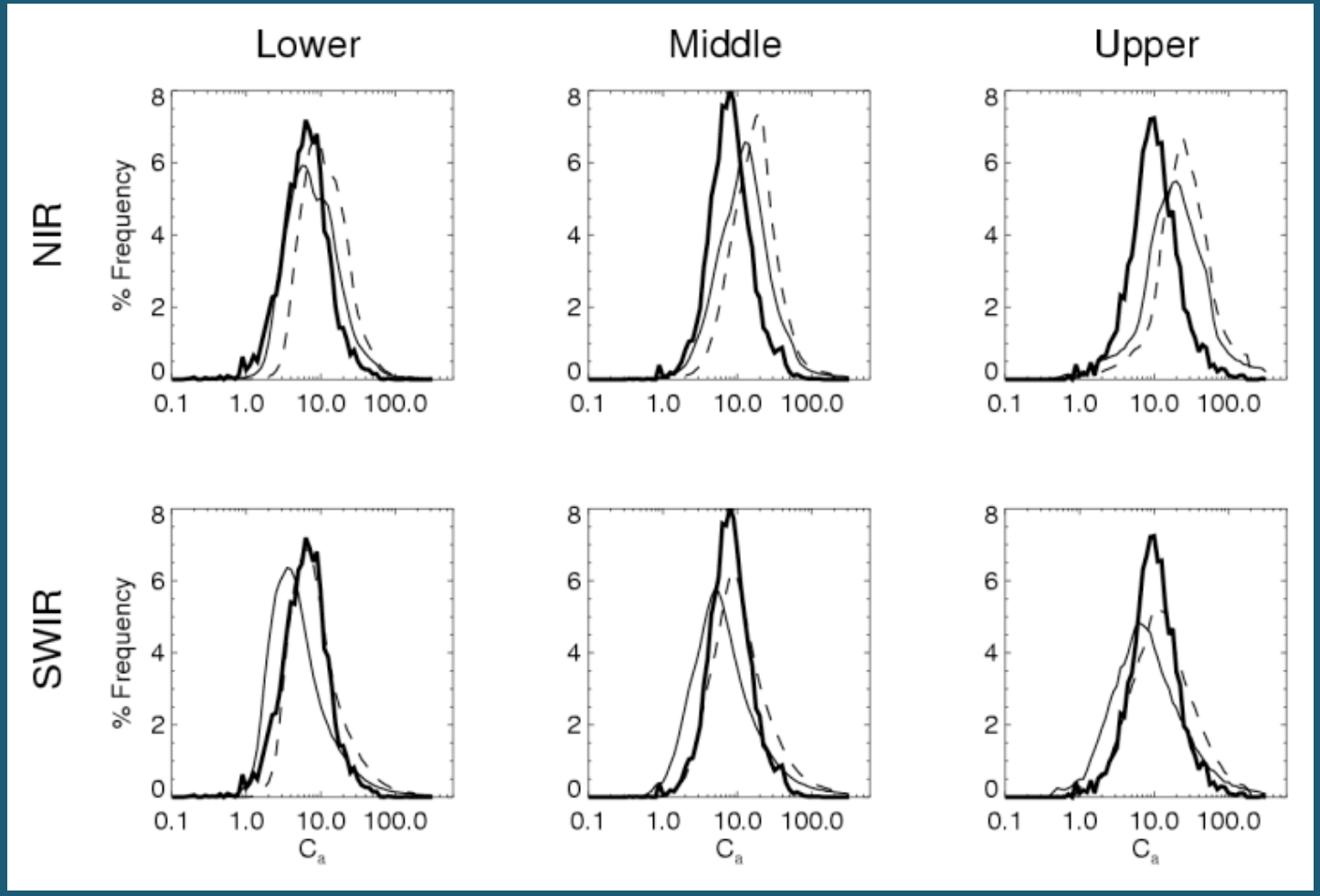
Band	λ (nm)	Resol.	Potential Use
1	645	250 m	turbidity, IOPs
2	859	250	aerosols
3	469	500	C_a, IOPs
4	555	500	C_a, IOPs
5	1240	500	aerosols
6	1640	500	aerosols
7	2130	500	aerosols

potential for alternative

bio-optical algorithms &

atmospheric correction approaches

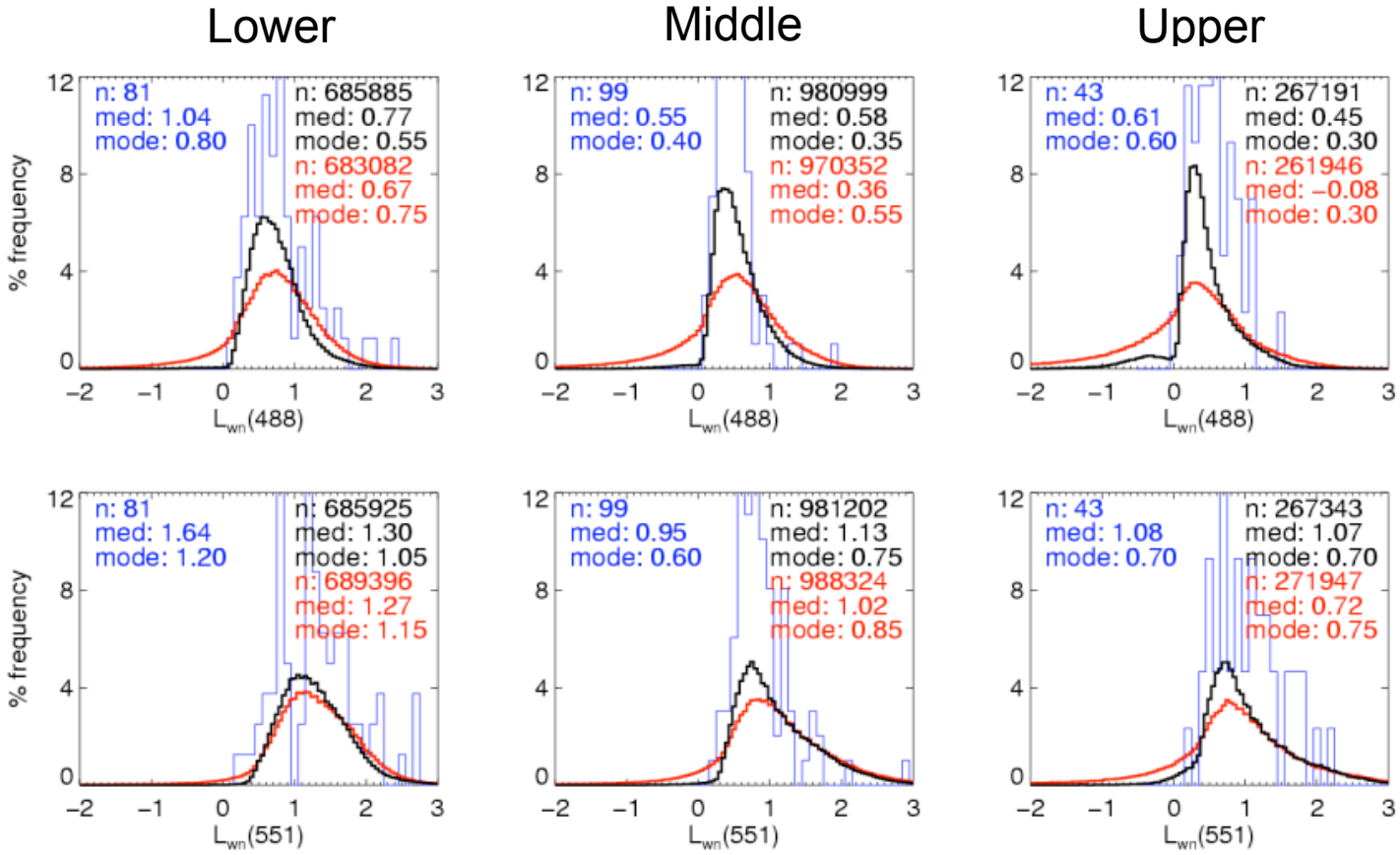
SWIR Atmospheric Correction



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

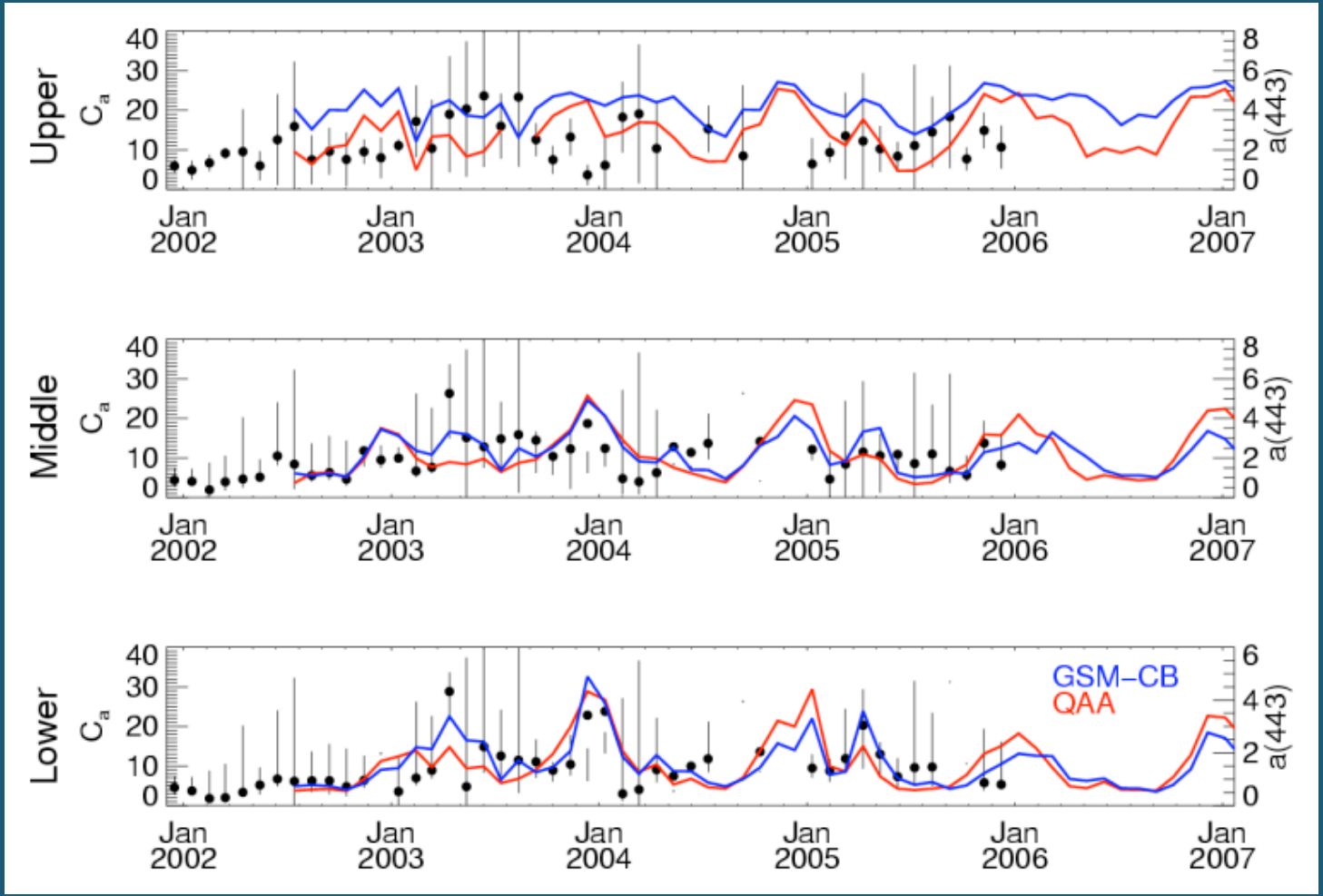
Level-2 Radiometric Comparisons

MODIS-Aqua L_{wn} distributions

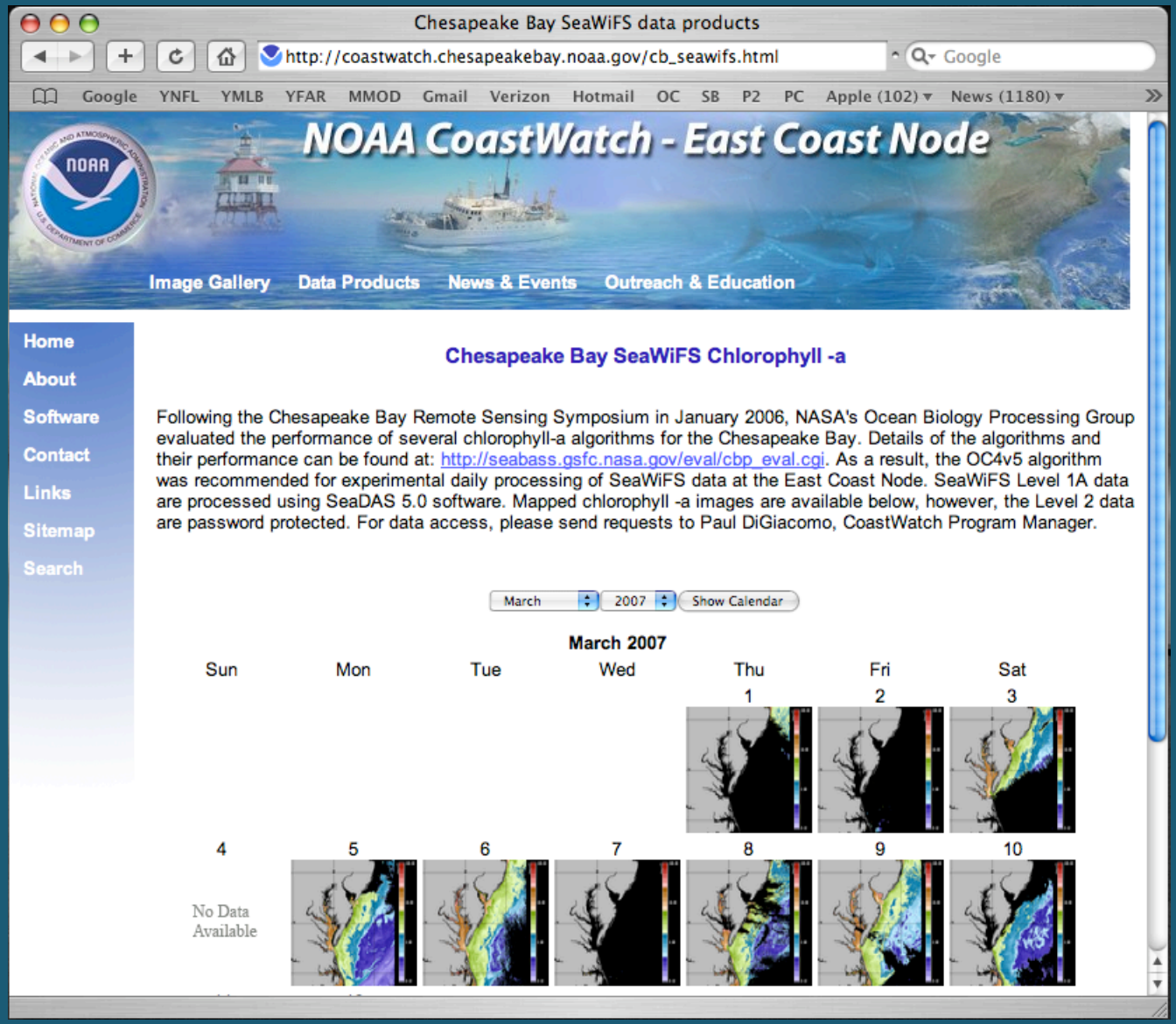


in situ satellite NIR satellite SWIR

MODIS-Aqua *a*(443) Time-series

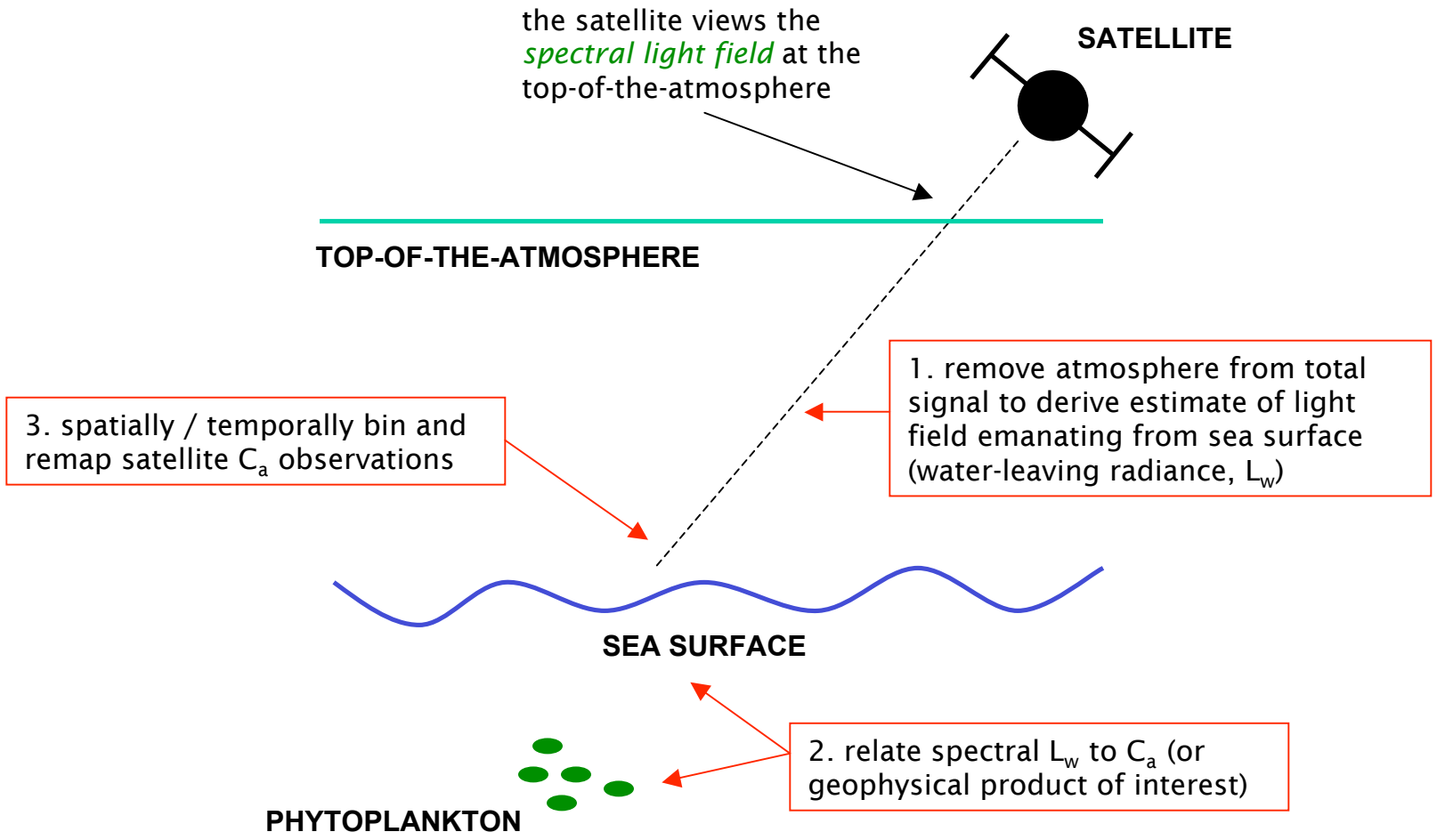


NOAA CoastWatch - East Coast Node



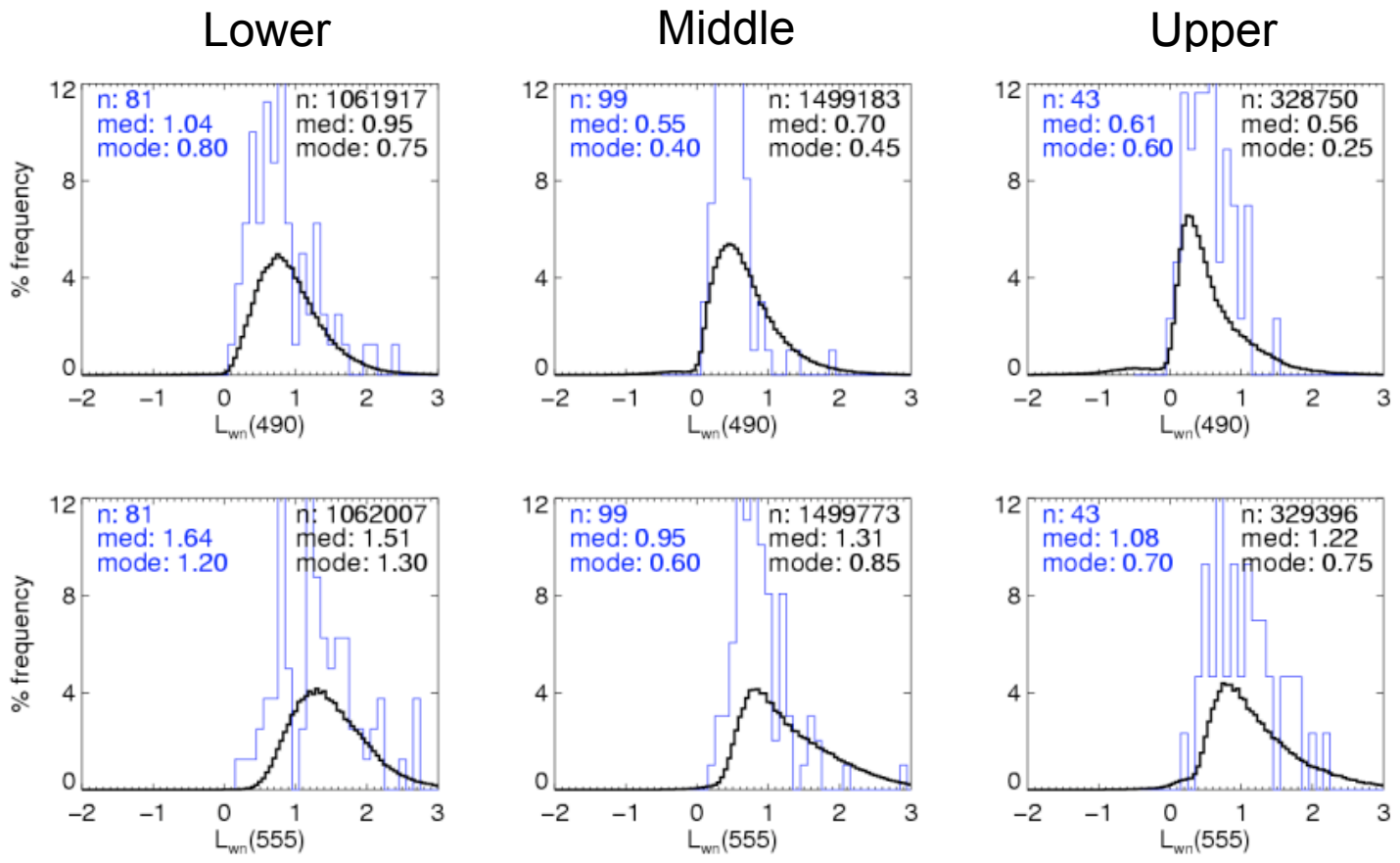

Thank You

Ocean Color Remote Sensing



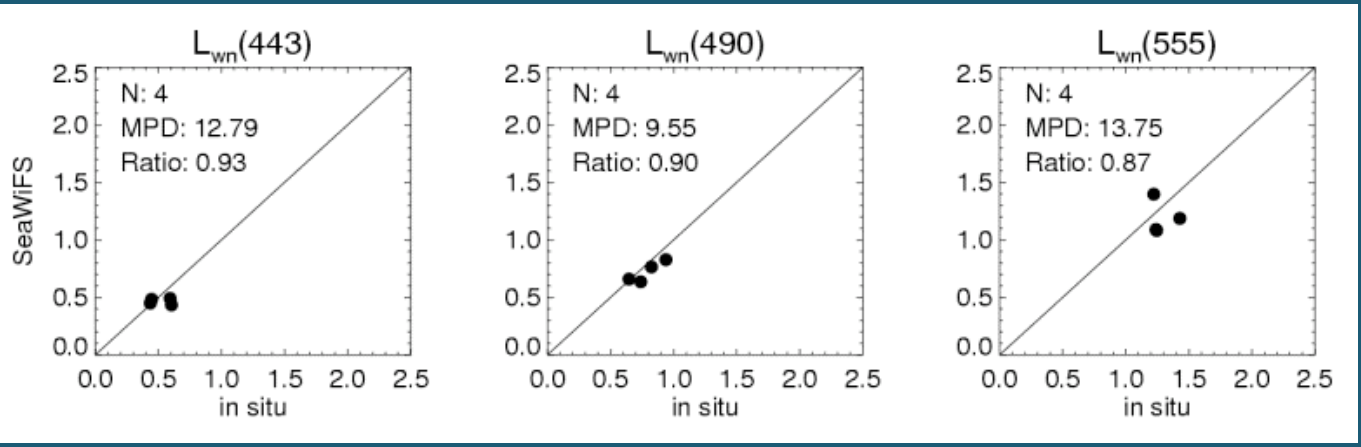
Level-2 Radiometric Match-ups

SeaWiFS L_{wn} distributions



Level-2 Radiometric Match-ups

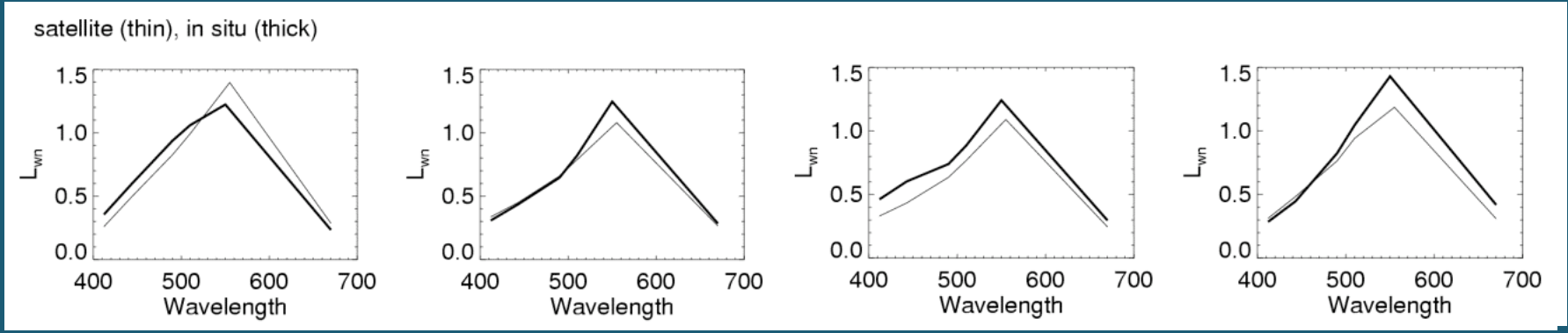
SeaWiFS L_{wn} match-ups, limited to middle & lower Bays



+/- 3-hrs

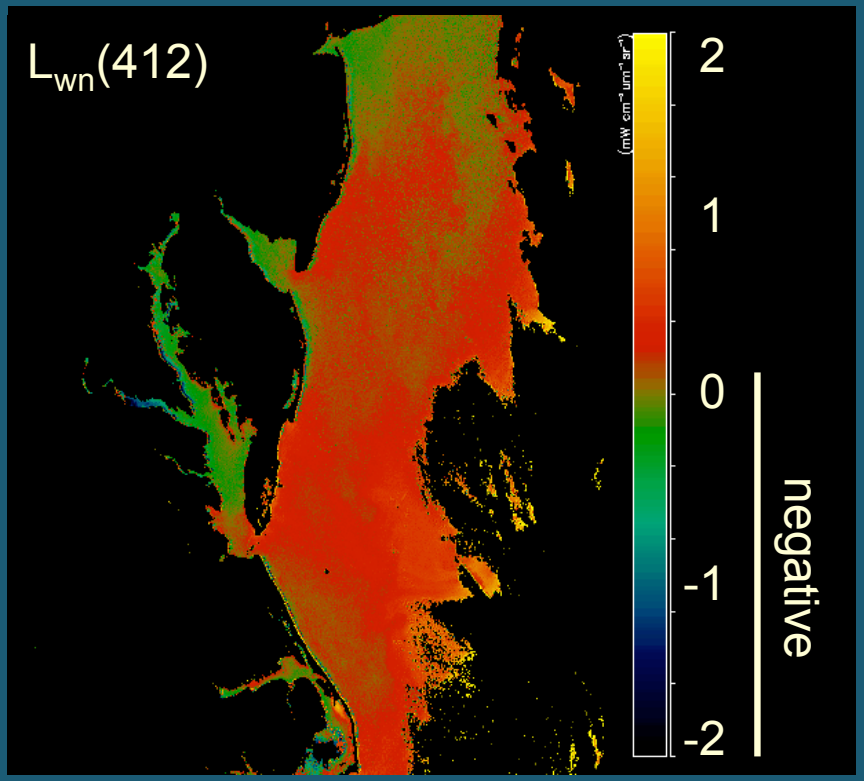
5 x 5 box

standard (global) exclusion criteria



Spatial Coverage

SeaWiFS, 18 April 2006



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