Observation of Chla from Satellites in Estuaries: A case study in Tampa Bay, USA

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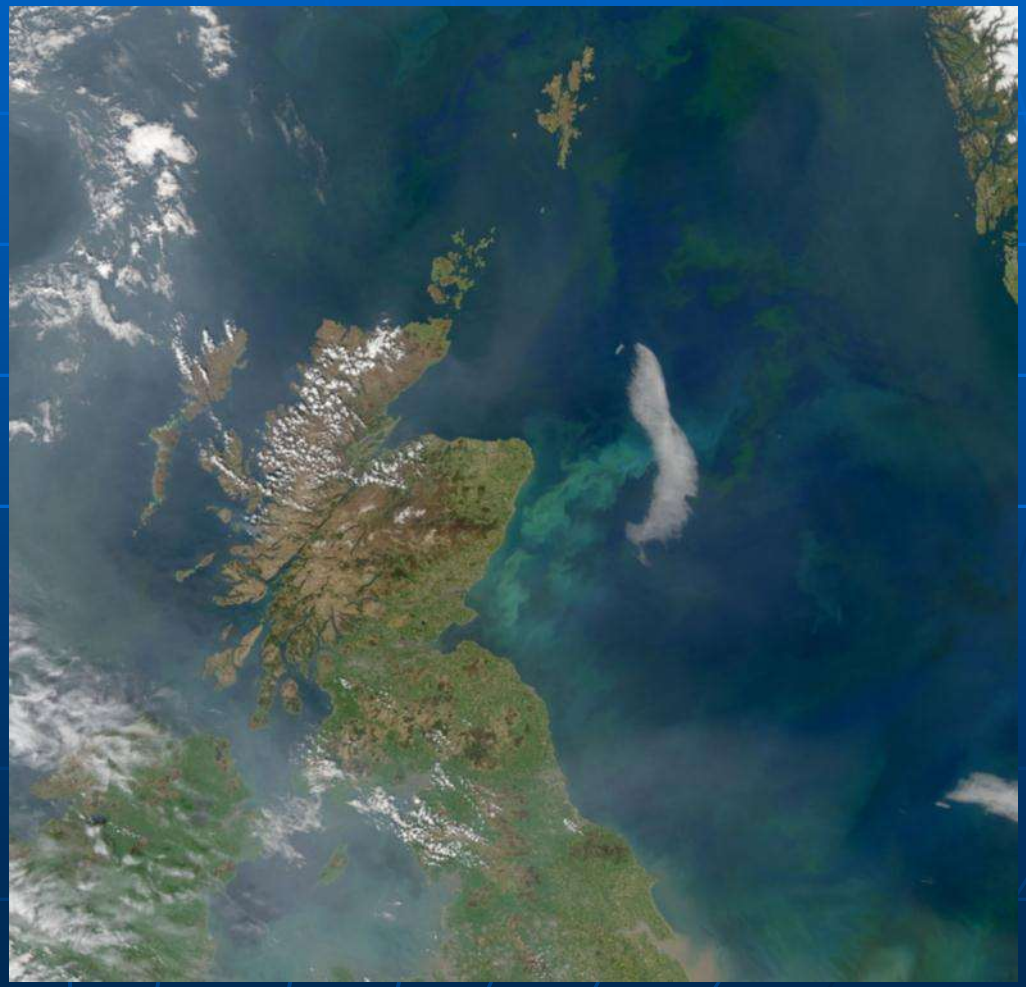
Red tide in coast and estuaries

MODIS RGB images

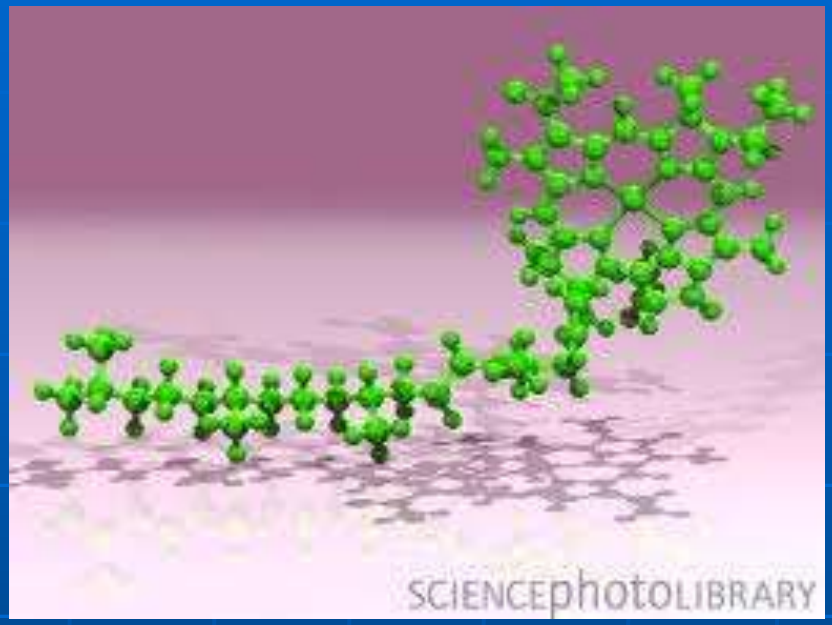
France's Bay of Biscay

Coastal of Scotland



Chlorophyll a (Chla)

an effective index of phytoplankton biomass

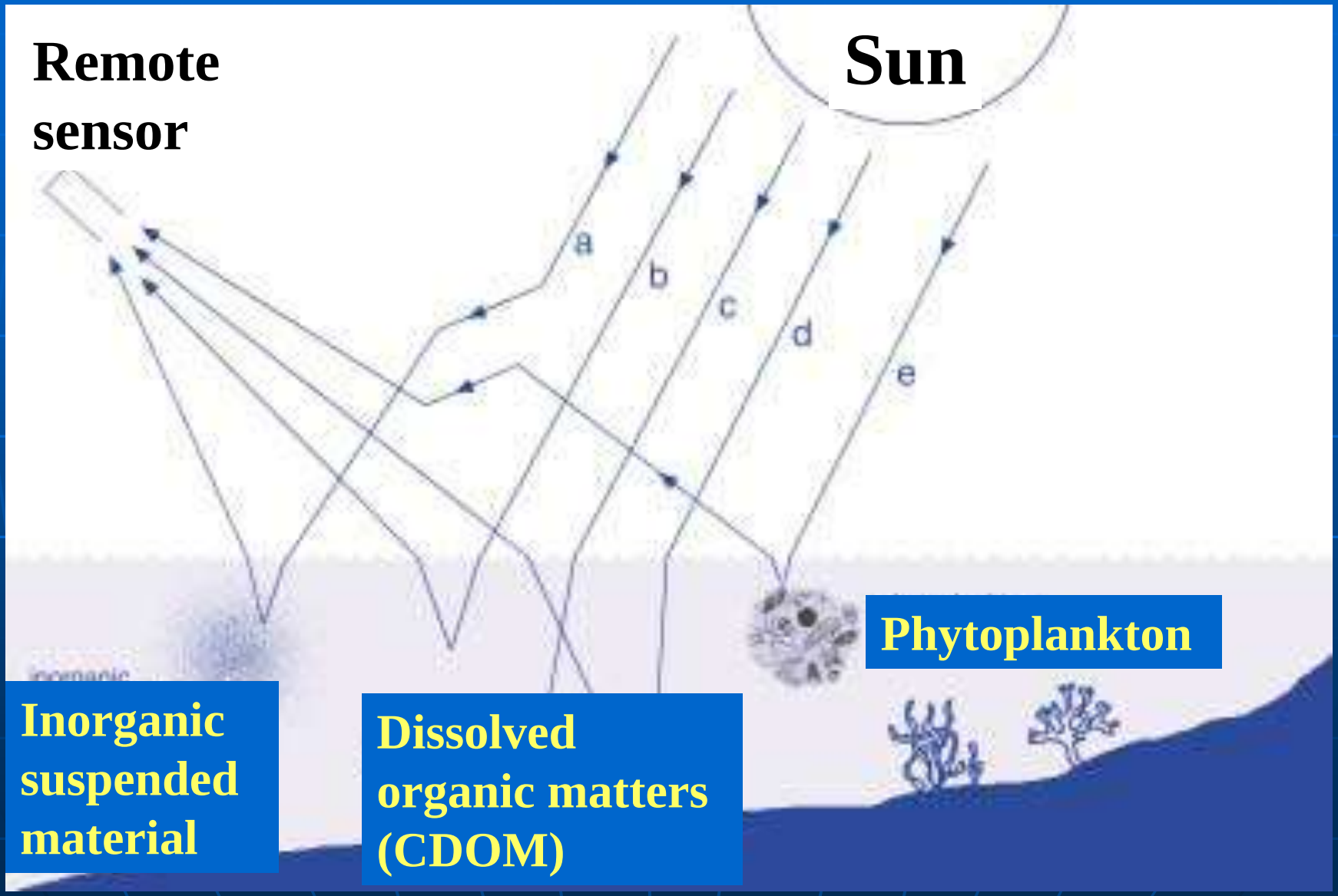


Observation of Chla from satellite is a great choice to monitor phytoplankton blooms in eutrophic waters

Outline

- Light environment in Tampa Bay
- Existing algorithm validation
- A new bio-optical algorithm
- Application of the new algorithm
- Extension of the new algorithm

Ocean Color Background



Ocean Color Background

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Tampa Bay:

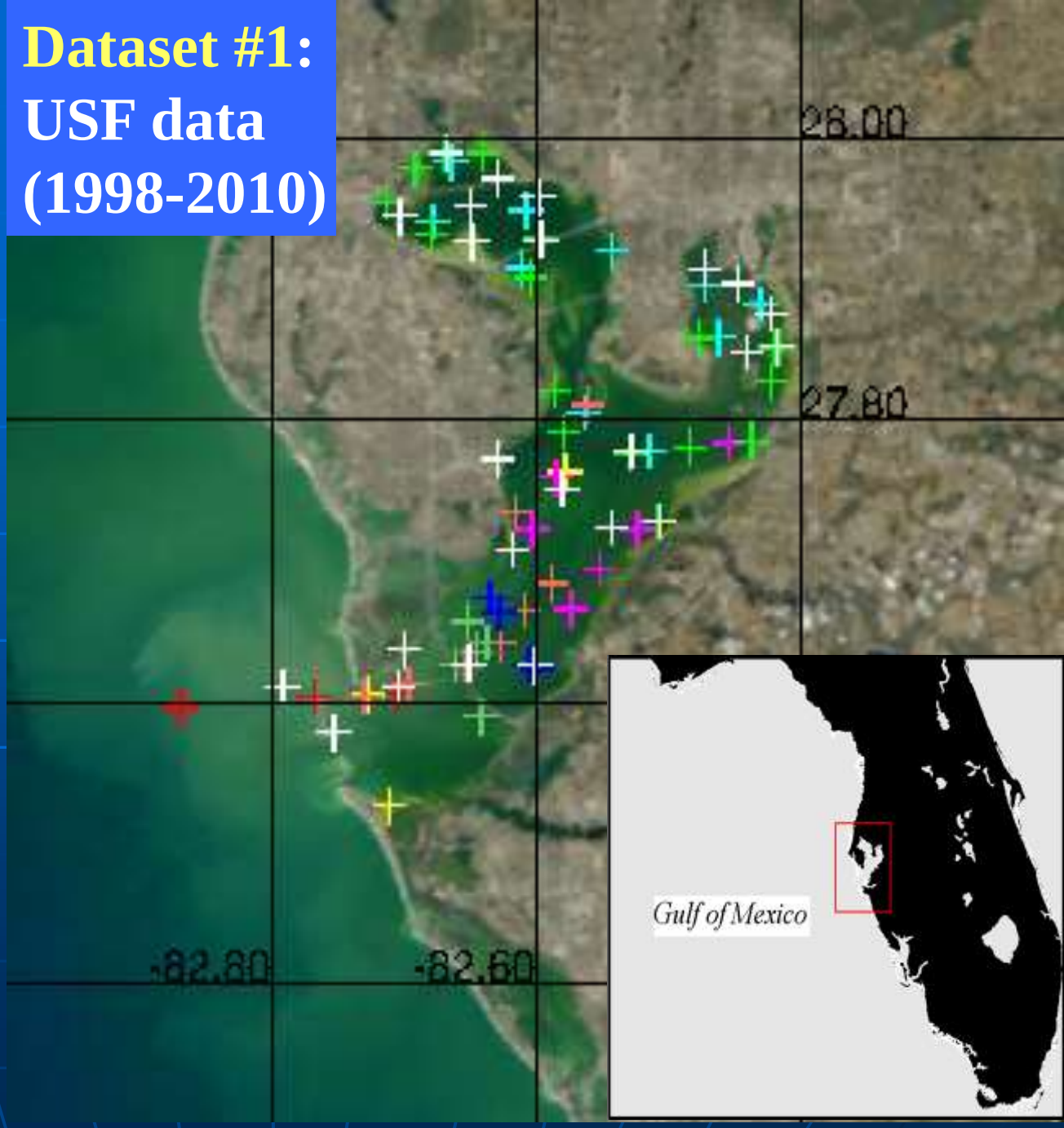
Surface area:

1000 km^2

Mean depth:

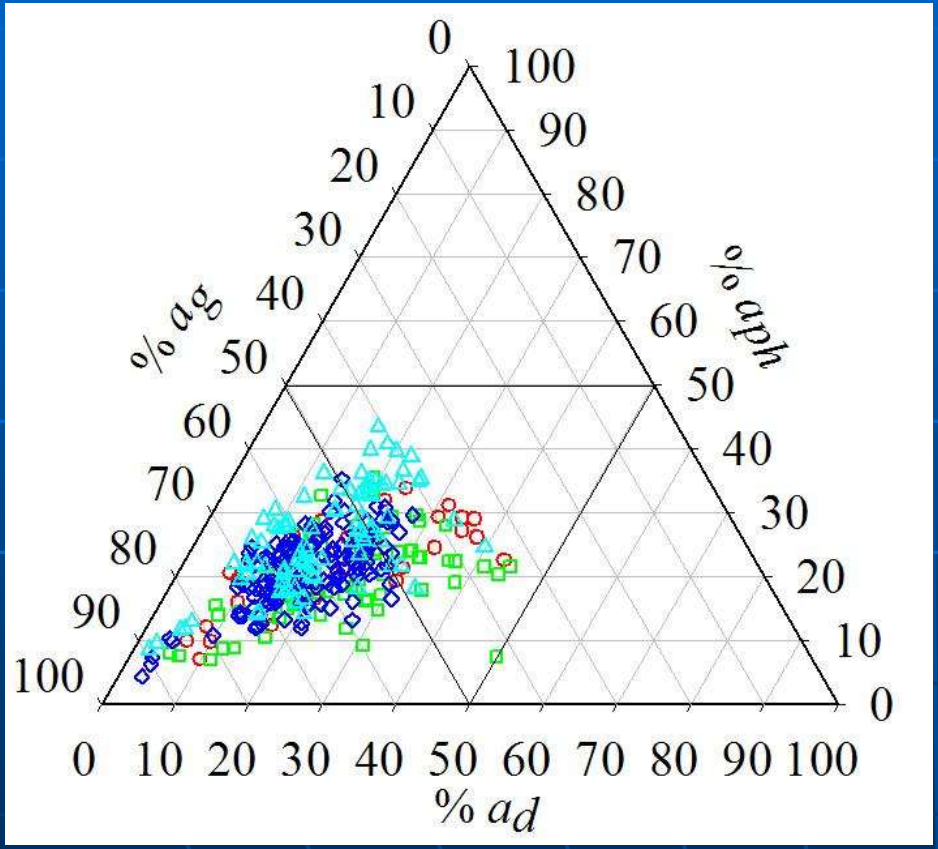
4 m

Dataset #1:
USF data (1998-2010)

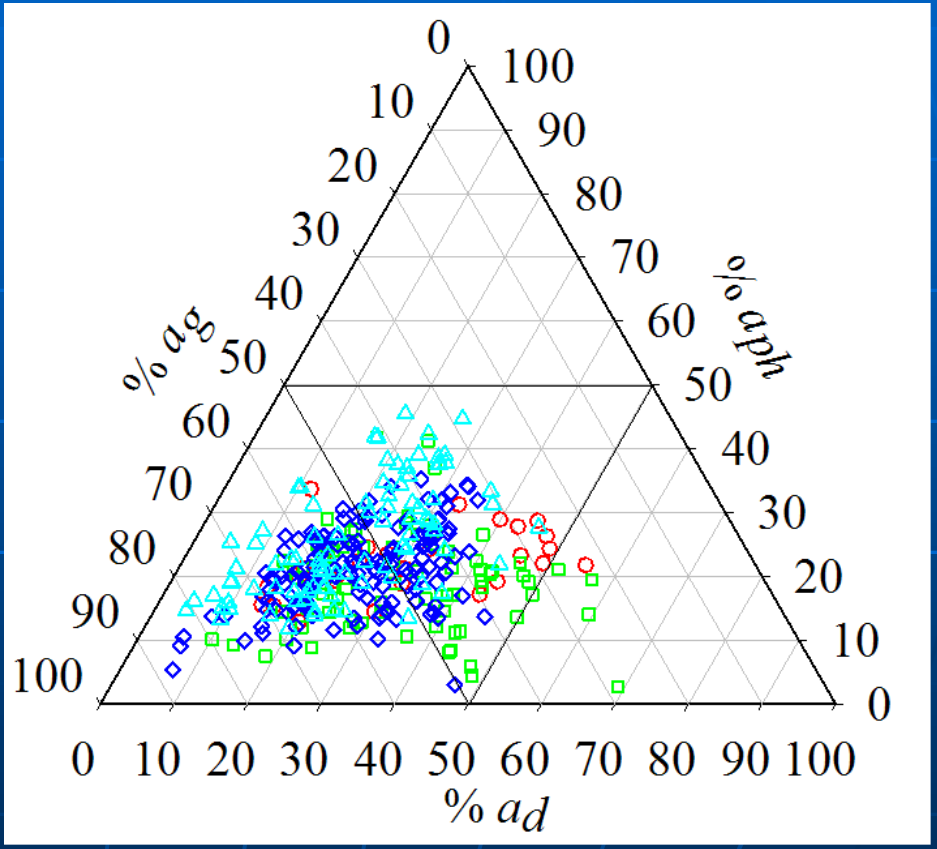


Light Environment (Le et al., 2012, ECSS)

443nm



555nm



Case 2: CDOM-dominated

Outline

- Light environment in Tampa Bay
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Algorithm validation (Le et al., 2013, RSE)

- Two-band ratio algorithm

  (Rrs665/Rrs710) (Ruddick, 2001)
- Three-band algorithm

  $(Rrs^{-1}665-Rrs^{-1}710)*Rrs730$ (Gitelson, 2005)
- Four-band algorithm

  $(Rrs^{-1}665-Rrs^{-1}710)/(Rrs^{-1}730-Rrs^{-1}710)$ (Le, 2009)
- Synthetic chlorophyll index

  SCI (Shen, 2010)

Band locations for several ocean color sensors

Sensor	Waveband locations
SeaWiFS (1997-2010)	412, 443, 490, 510, 555, 670, 765, 856
MODIS (2002-present)	412, 443, 488, 531, 547, 667, 678, 748, 869
MERIS (2002-2011)	412, 443, 490, 510, 560, 620, 665, 681, 709, 754, 860

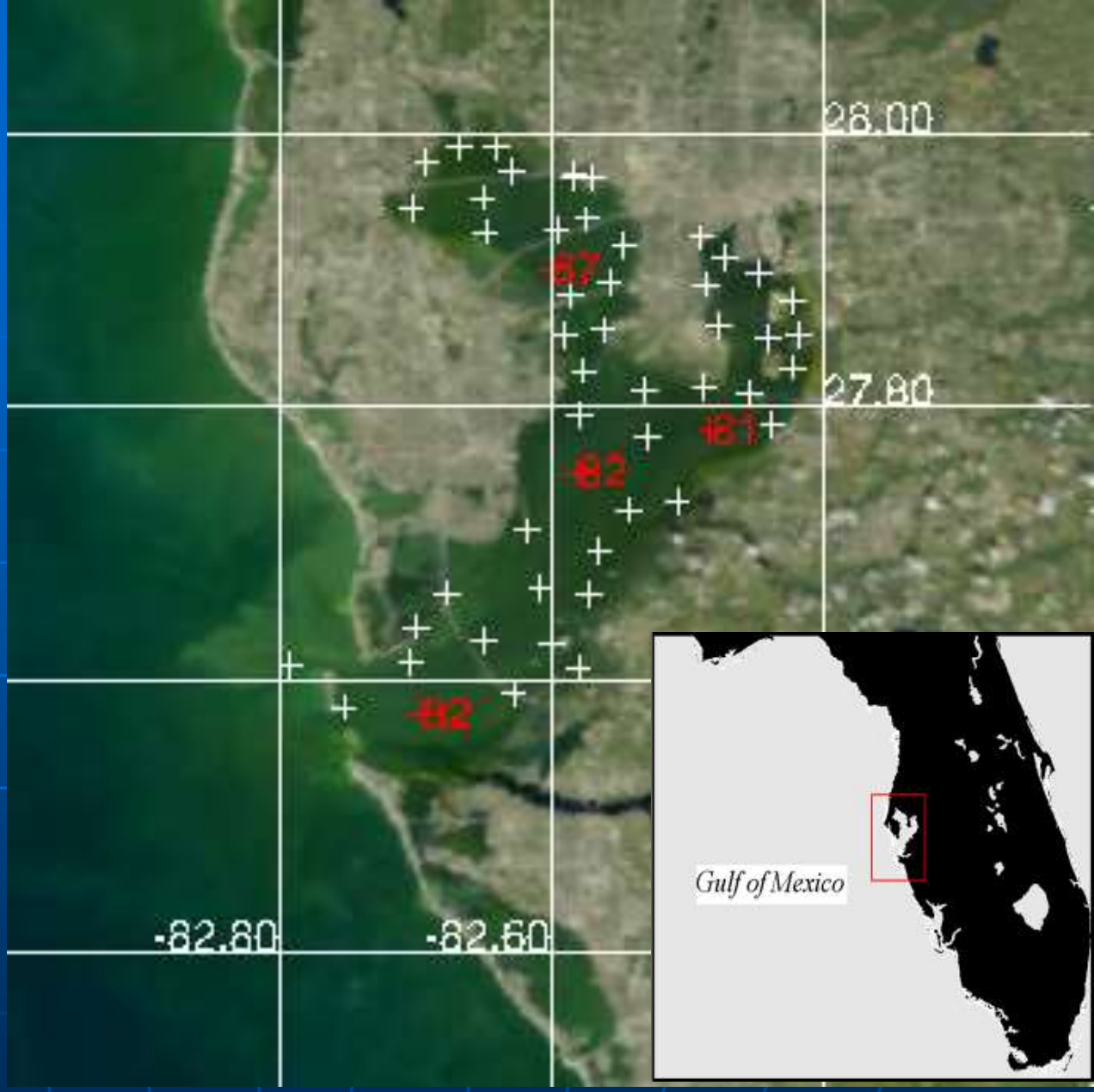
The potential of these algorithms applied to several ocean color sensors

	2-band	3-band	4-band	SCI
MERIS (2002-2011)	√	√	√	√
SeaWiFS (1997-2010)	√	×	×	×
MODIS (2002-present)	√	×	×	×

Can these algorithms be applied to satellite imagery?

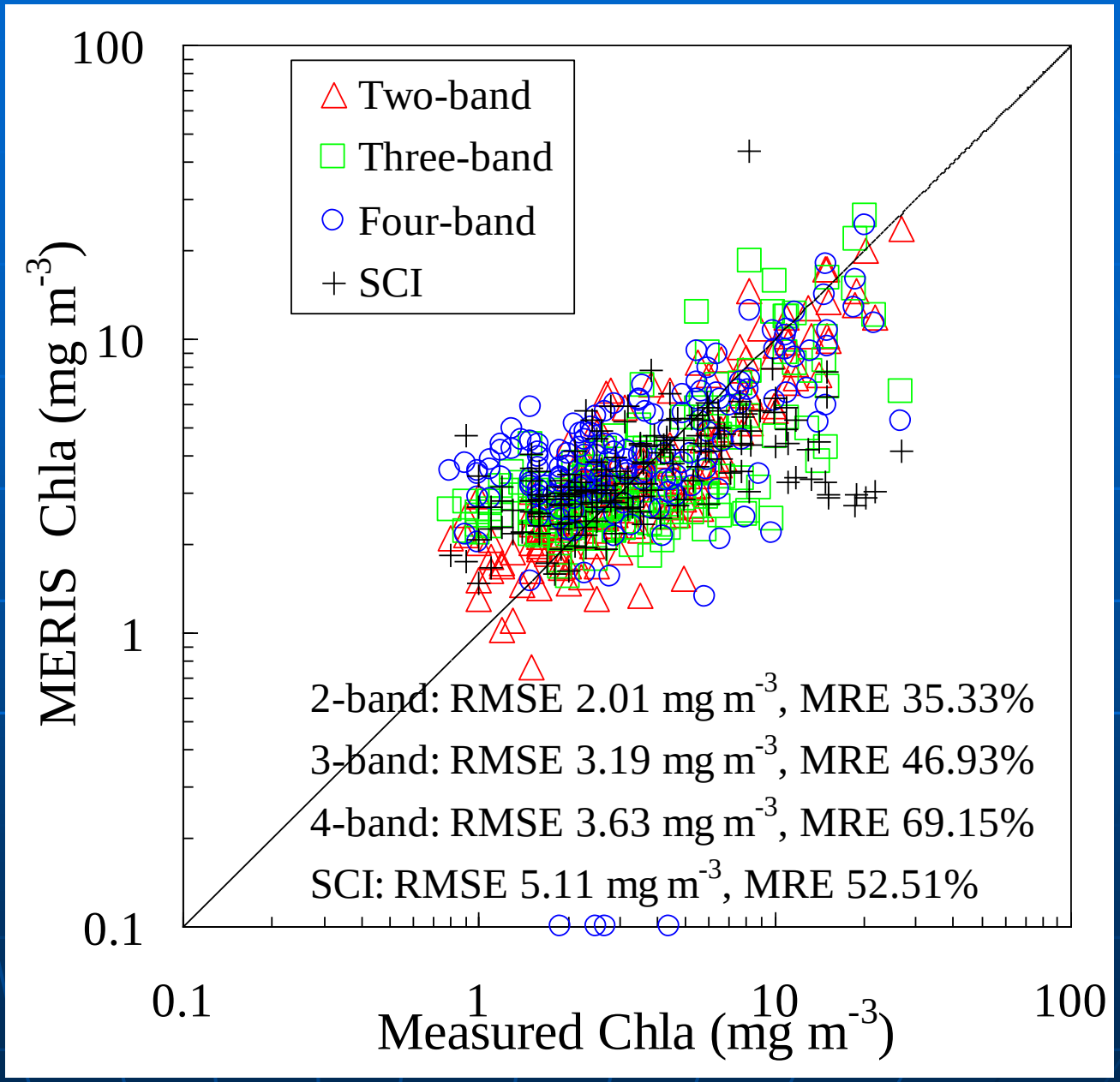
Dataset #2

EPCHC dataset
56 stations visited monthly
1974-2010

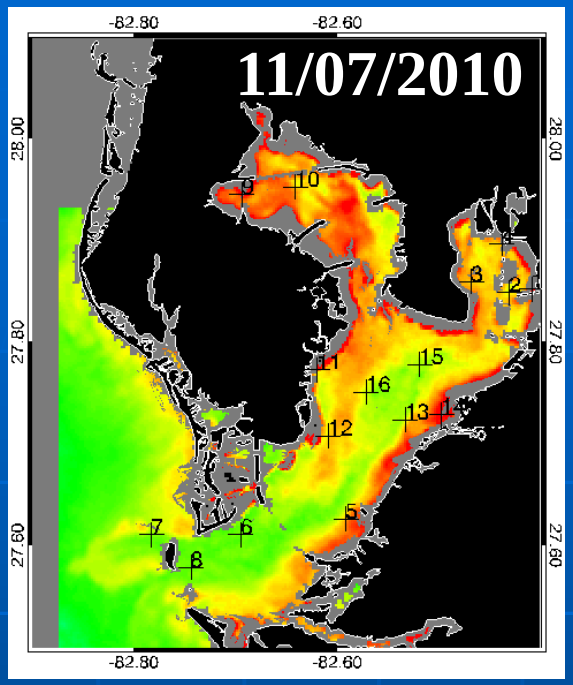


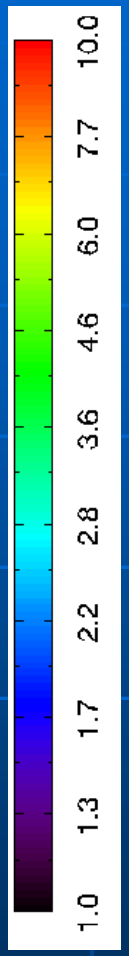
EPCHC: Environmental Protection Commission of Hillsborough County

MERIS:
Satellite data:
2009-2010
Chla data:
EPCHC

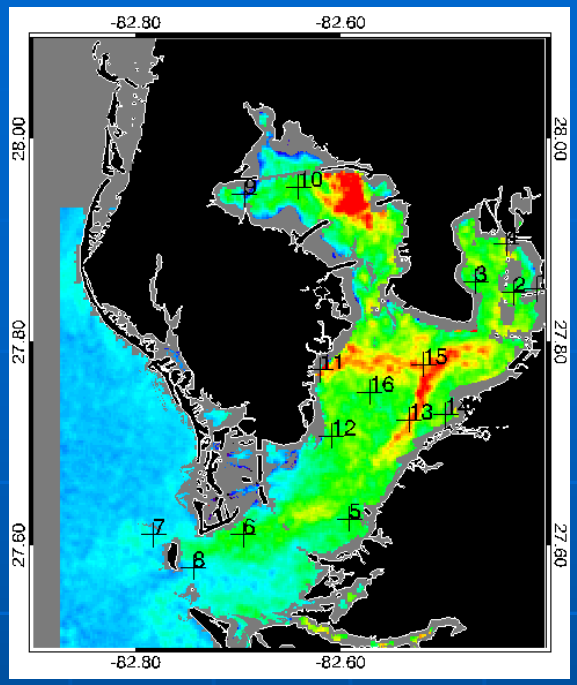


2-band

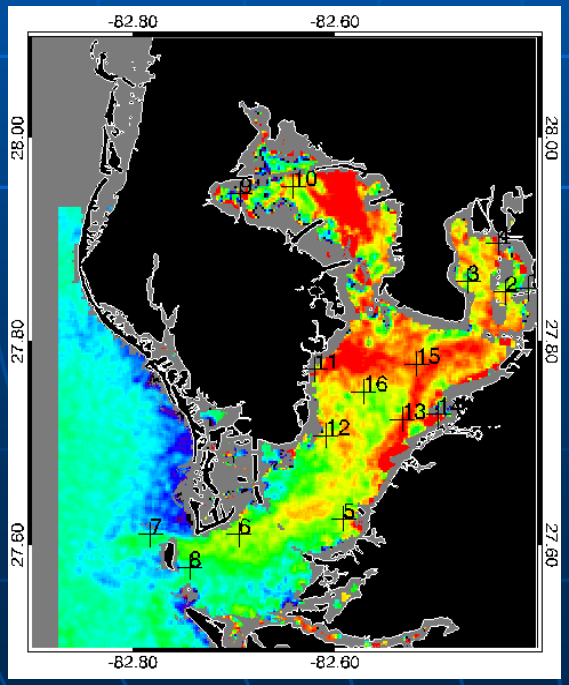




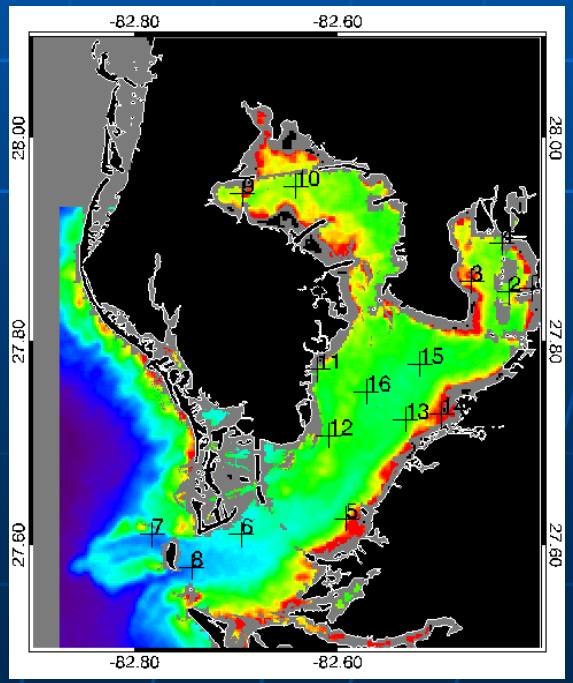
3-band



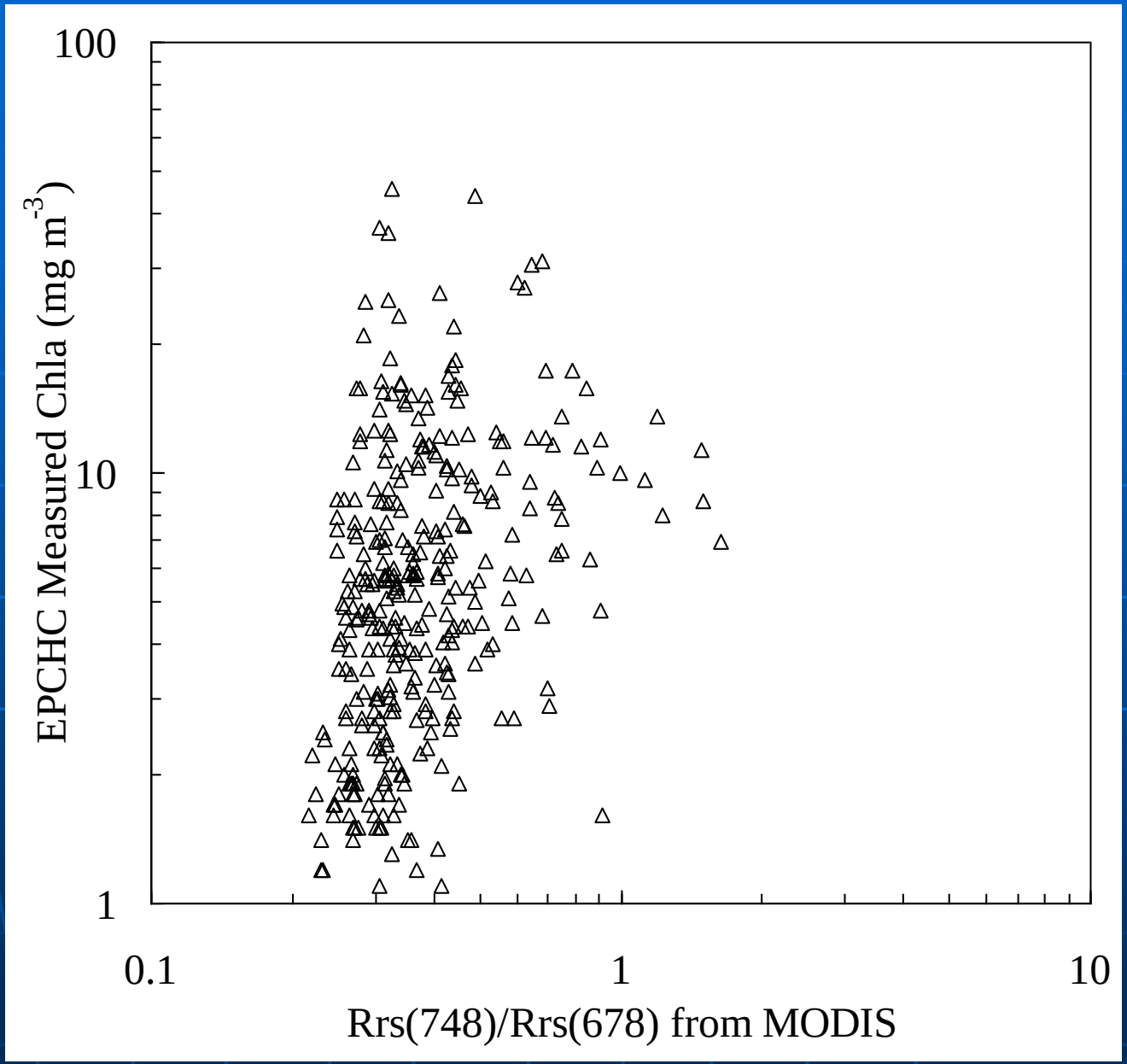
4-band



SCI



MODIS & SeaWiFS: Satellite data: 2002-2010 Chla data: EPCHC



The applicability of the four algorithm to several ocean color sensors

	2-band	3-band	4-band	SCI
MERIS (2002-2011)	√	×	×	×
SeaWiFS (1997-2010)	×	×	×	×
MODIS (2002-present)	×	×	×	×

What can we do for MODIS and SeaWiFS?

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A new algorithm (Le et al., 2013, PO)

RGCI--- Red Green Chla Index

For MODIS:

RGCI=Rrs(667)/Rrs(547)

For SeaWiFS:

RGCI=Rrs(670)/Rrs(555)

A new algorithm----RGCI

Calibration

Image data:

2004-2010

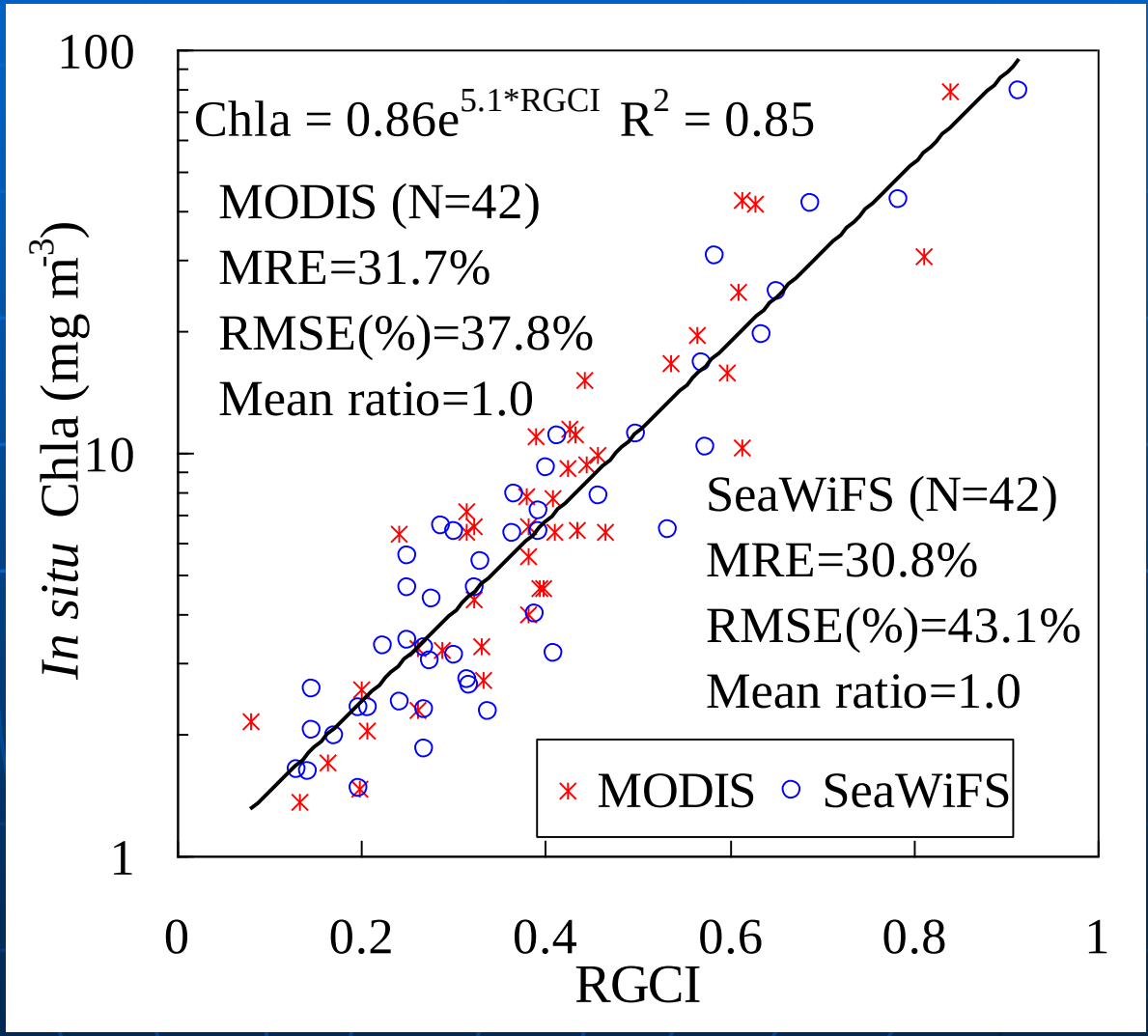
MODIS &

SeaWiFS

***In situ* data:**

Dataset #1

2004-2010



A new algorithm----RGCI

Validation

Image data:

MODIS

2002-2010

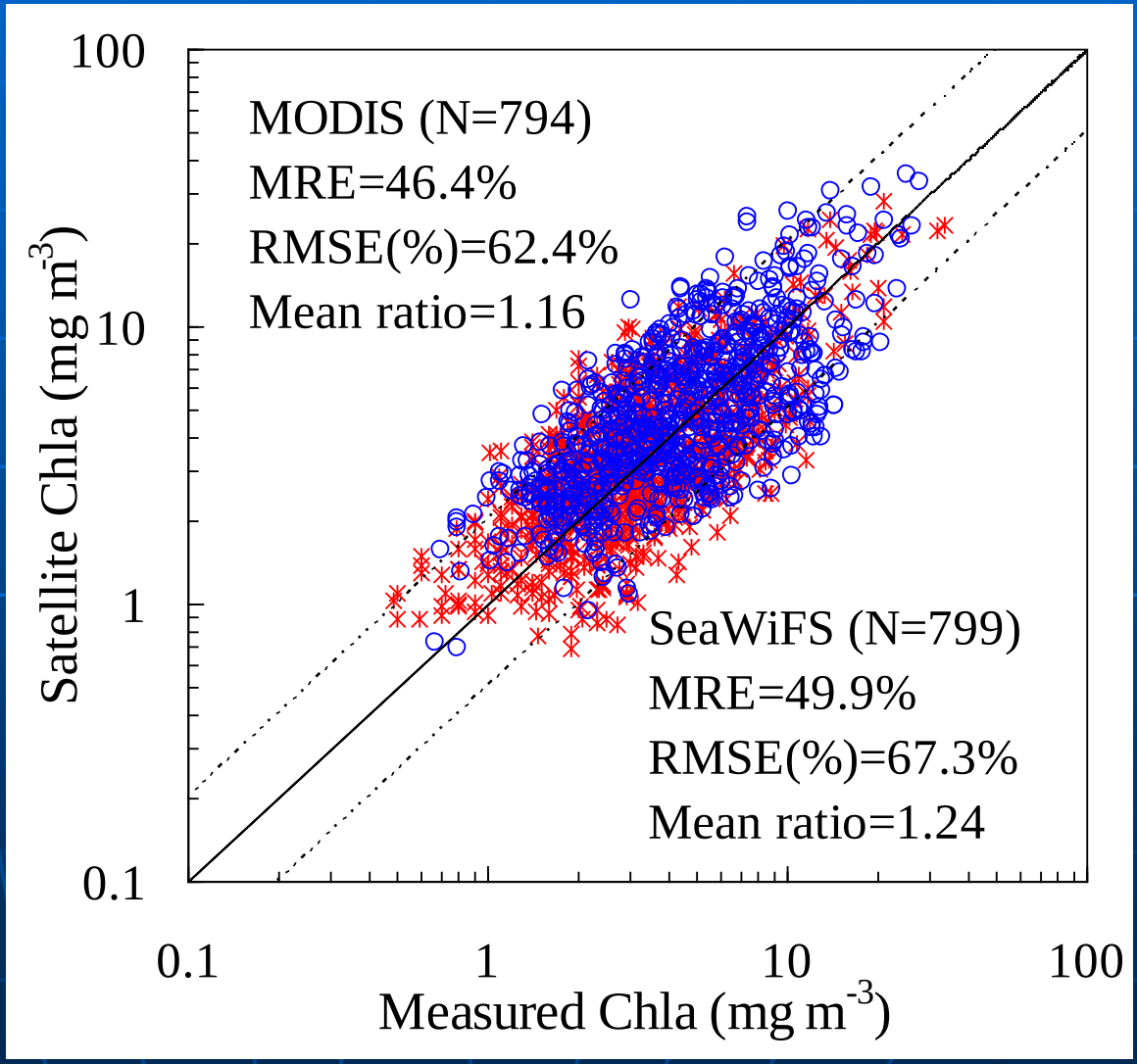
SeaWiFS

1998-2010

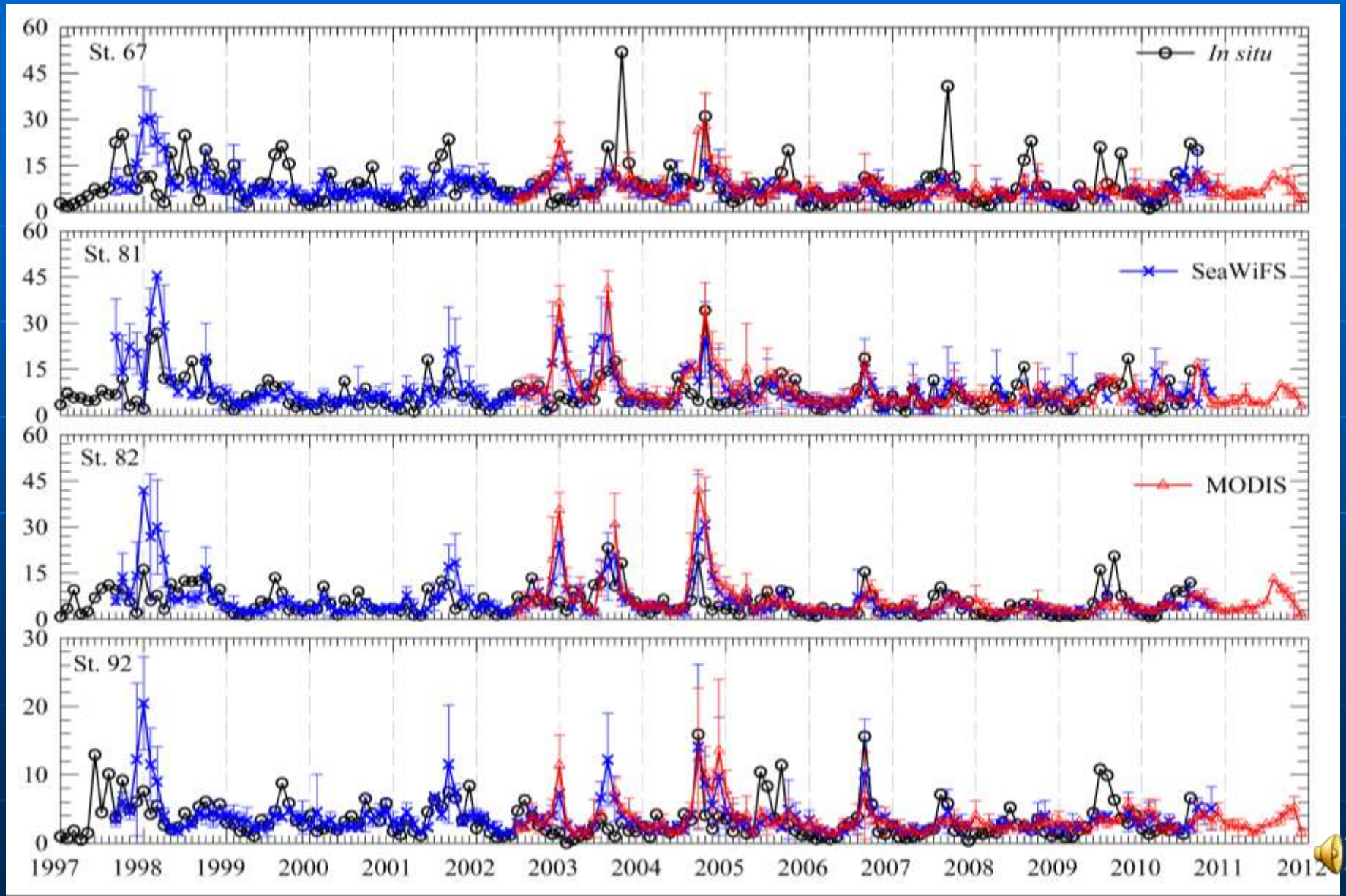
***In situ* data:**

Dataset #2

1998-2010



A new algorithm----RGCI



Yes, this RGCI algorithm can be applied to MODIS and SeaWiFS!

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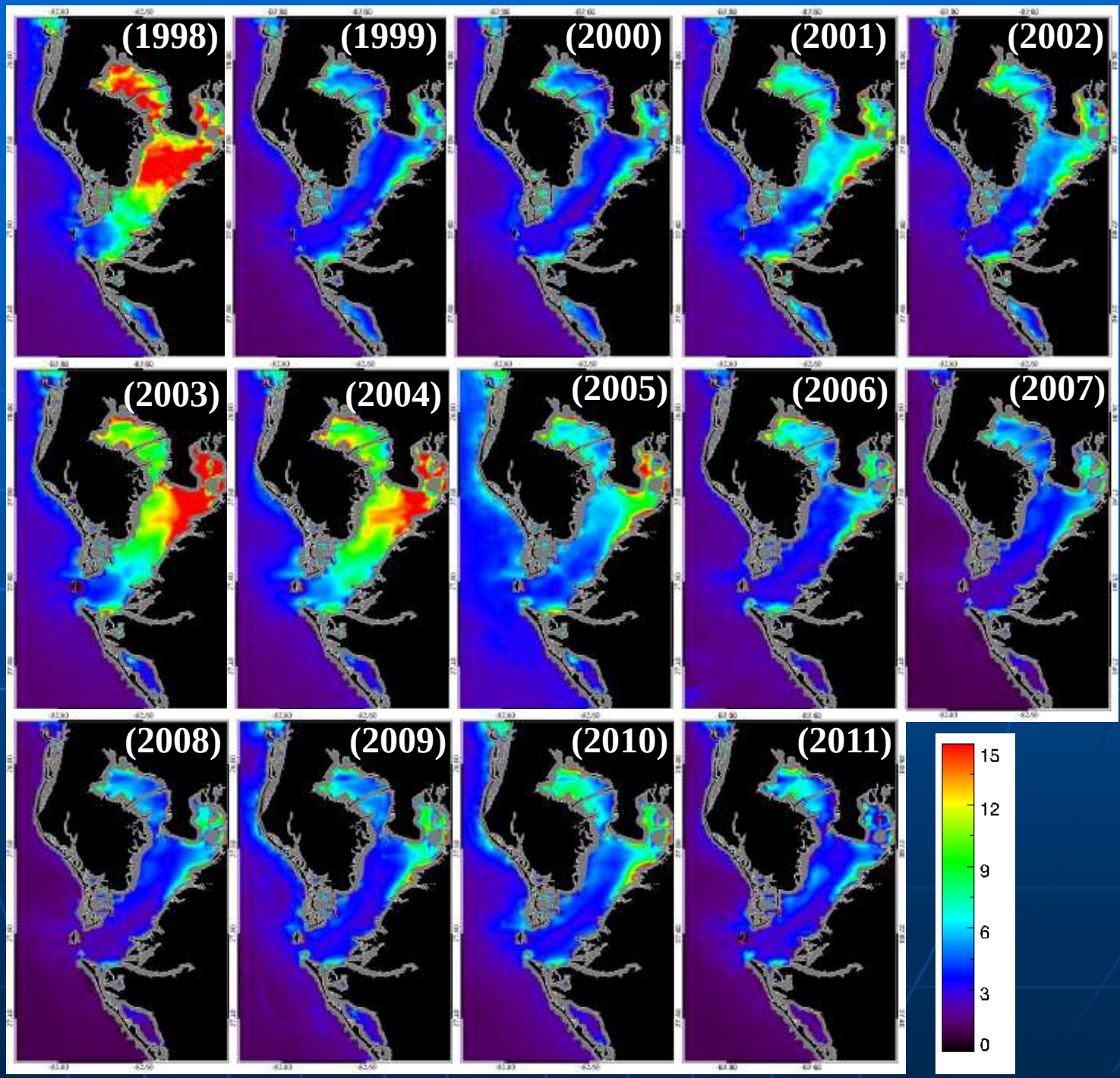
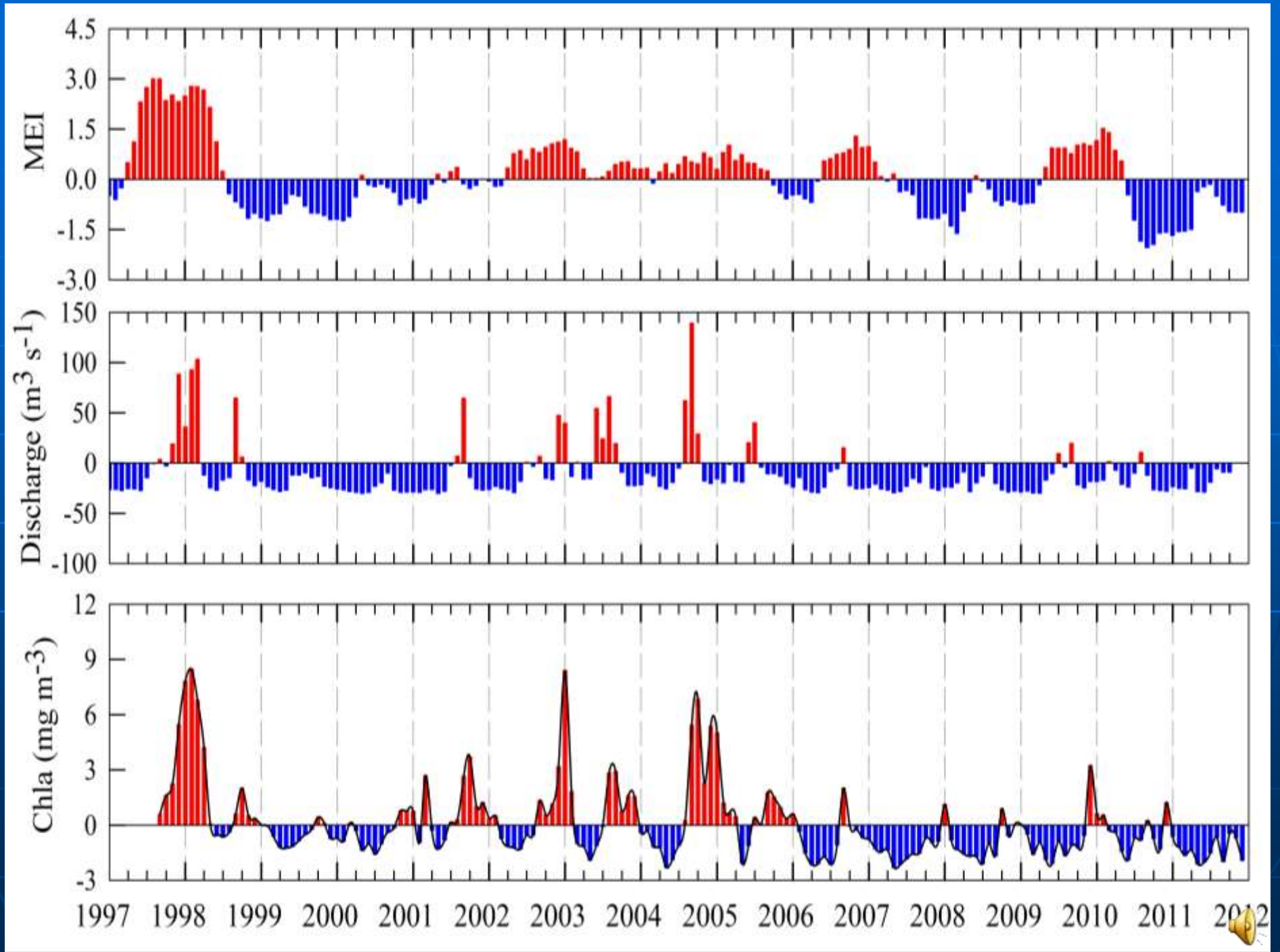
Annual mean Chla time series 1998-2011

Le et al., (2013, RSE)




MEI
4.5
3.0
1.5
0.0
-1.5
-3.0
Discharge (m3 s-1)
150
100
50
0
-50
-100
Chla (mg m-3)
12
9
6
3
0
-3
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012

Management Decision Matrix:

"Green" means stay on course

"Yellow" means caution and stay alert

"Red" means take action

Year	OTB	HB	MTB	LTB
1998	Yellow	Yellow	Red	Red
1999	Green	Green	Yellow	Green
2000	Green	Green	Green	Green
2001	Green	Green	Yellow	Yellow
2002	Green	Green	Yellow	Green
2003	Red	Red	Red	Yellow
2004	Yellow	Yellow	Yellow	Yellow
2005	Green	Yellow	Yellow	Yellow
2006	Green	Green	Green	Green
2007	Green	Green	Green	Green
2008	Green	Green	Green	Green
2009	Green	Green	Green	Green
2010	Green	Green	Green	Green
2011	Green	Green	Green	Green

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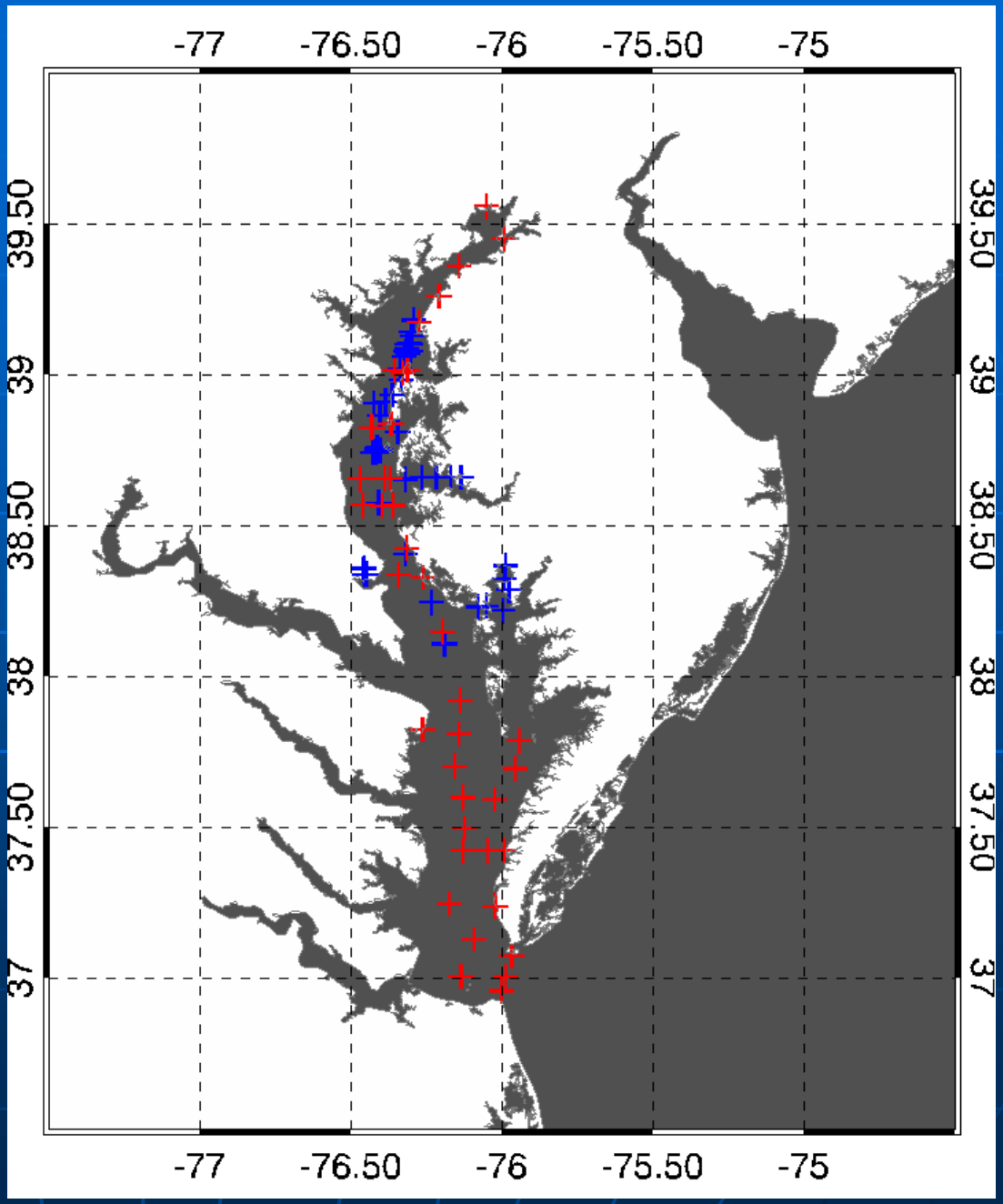
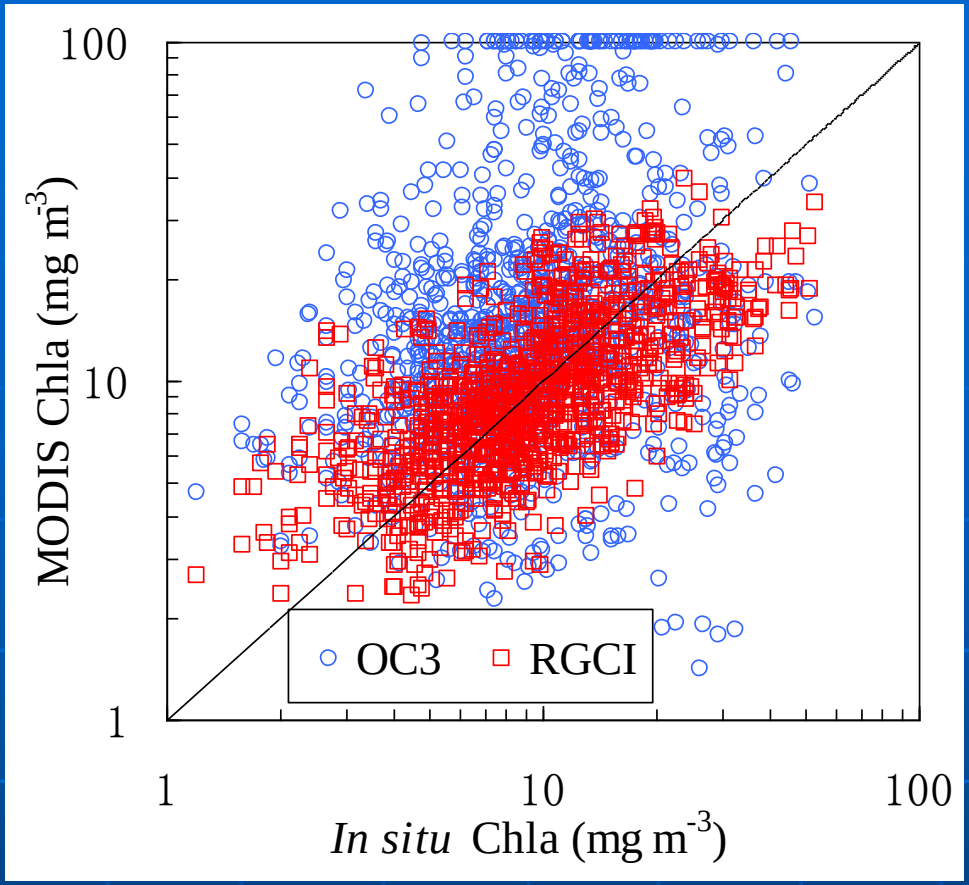
Dataset #3: Chesapeake Bay

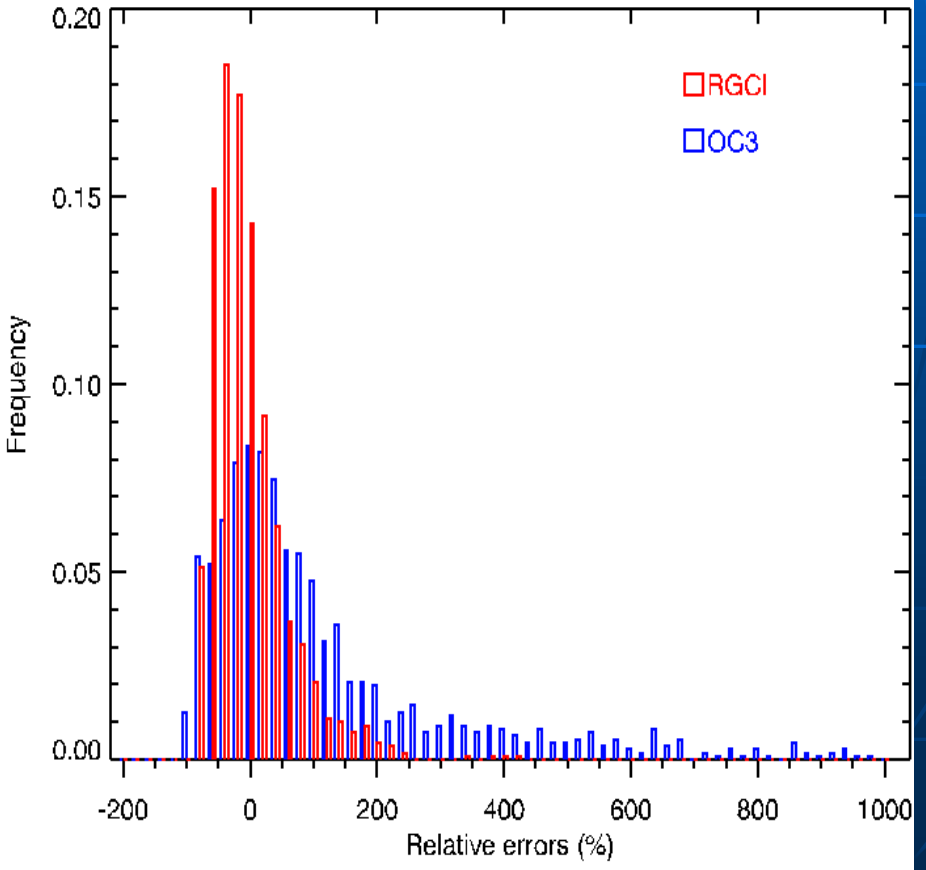
Surface area:
11,600 km^2
Mean depth:
7 m
Field collection:
49 stations
visited monthly
1996-2012
(Le et al., Prepared)



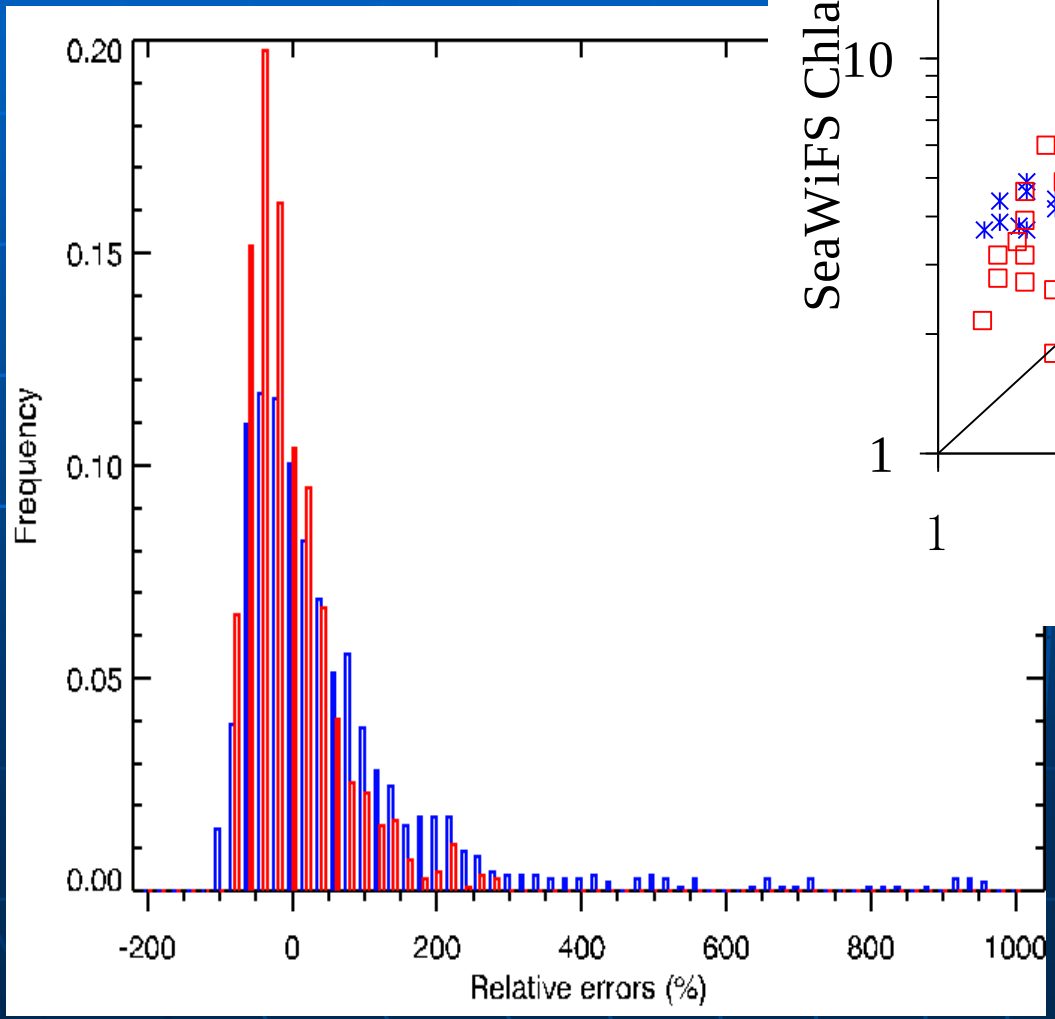


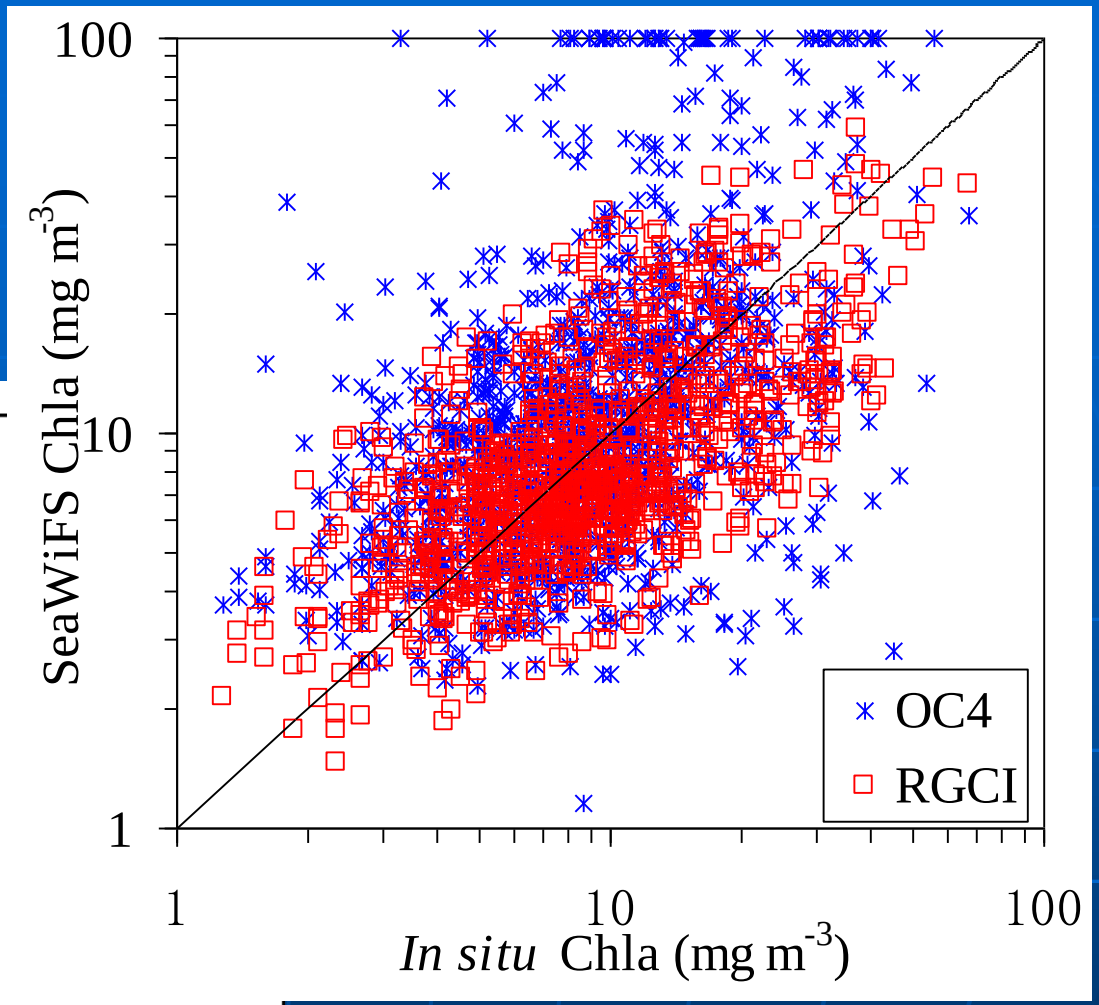
RGCI *vs* OC3 MODIS (Le et al, prepared)

Relative error distributions for the two algorithms



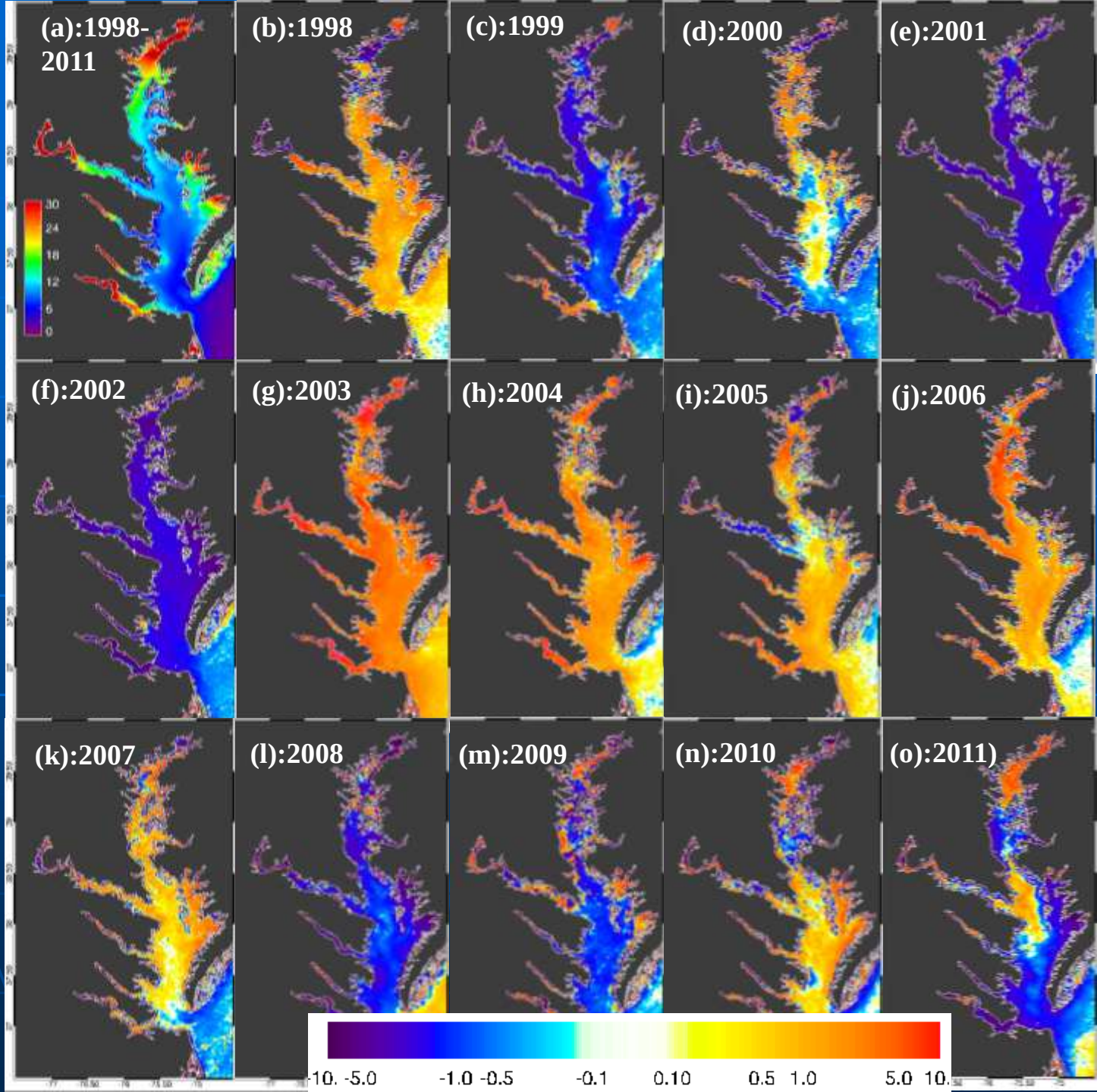
RGCI *vs* OC4
SeaWiFS





Relative error distributions for the two algorithms

Annual mean and anomaly Chla time series from 1998-2011 in Ch_Bay



Conclusions

- **Tampa Bay is a CDOM-rich Case 2 estuary**
- **All the validated algorithms can not be applied to MODIS and SeaWiFS imagery**
- **The new bio-optical algorithm (RGCI) has satisfied performance on MODIS and SeaWiFS**
- **Annual Chla variability in Tampa Bay is mainly controlled by climate variation**
- **The novel Chla algorithm (RGCI) has the potential to be applied to other turbid estuaries**

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- **Le et al. (2013).** Climate-driven chlorophyll a changes in a turbid estuary: observation from satellite**.** *Remote Sensing of Environment* http://dx.doi.org/10.1016/j.rse.2012.11.011**.**
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- **Le et al., (2009).** A four-band semi-analytical model for estimation chlorophyll a in highly turbid lakes: The case of Taihu Lake, China. *Remote Sensing of Environment*, 113: 1175-1182.
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