

# **An Overview of NASA Ocean Color Data Products**

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**University of South Florida**

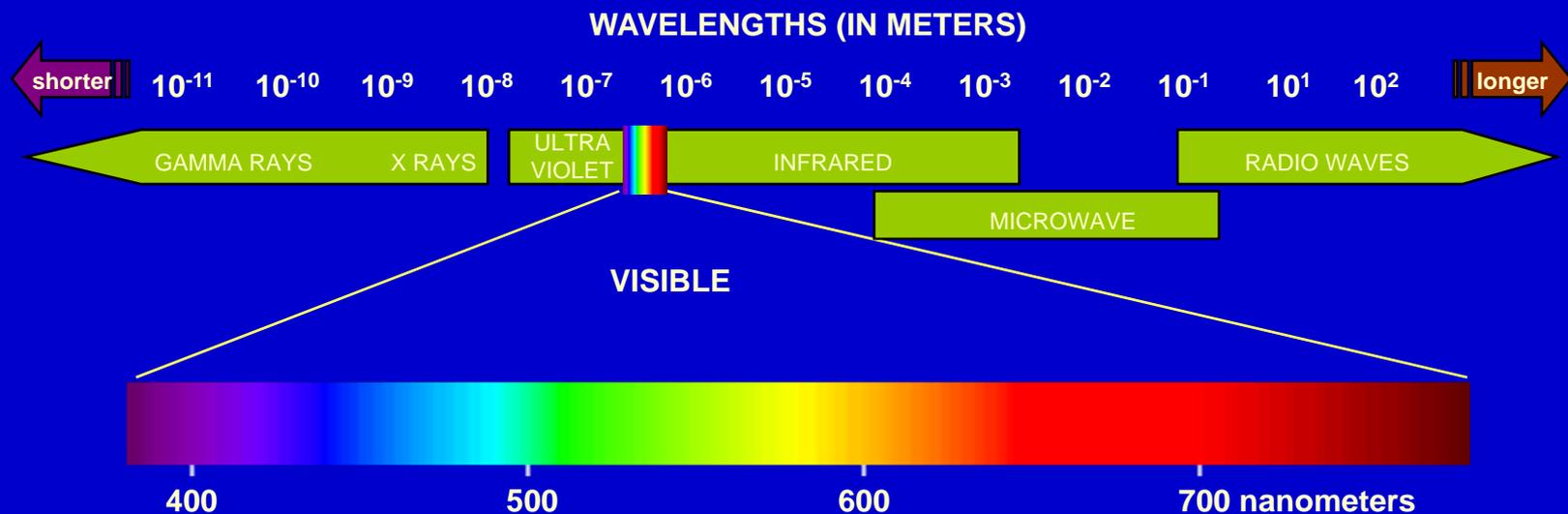
**hu@marine.usf.edu**

# Topics

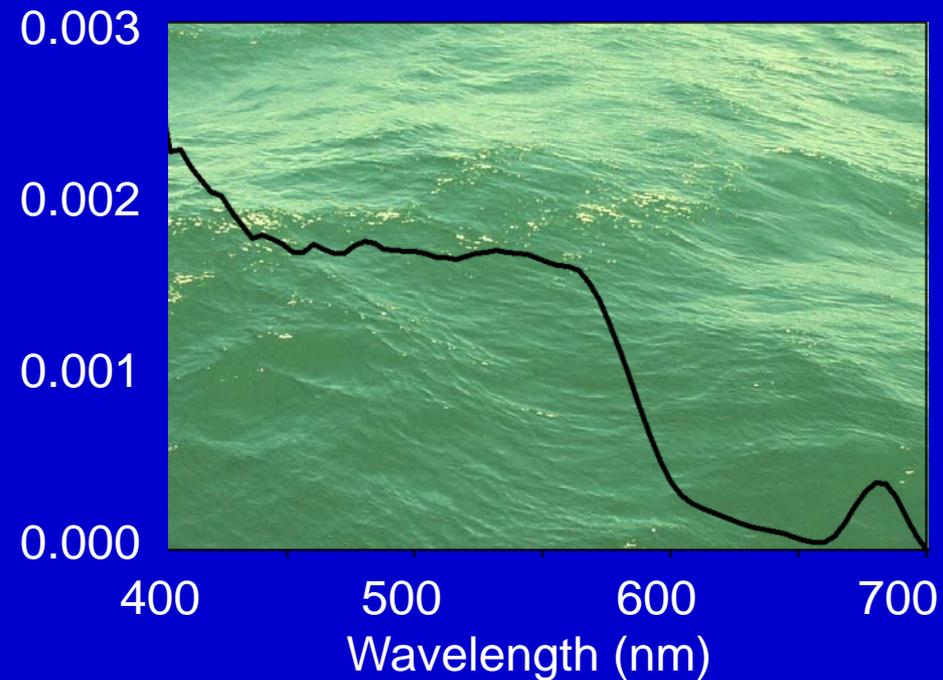
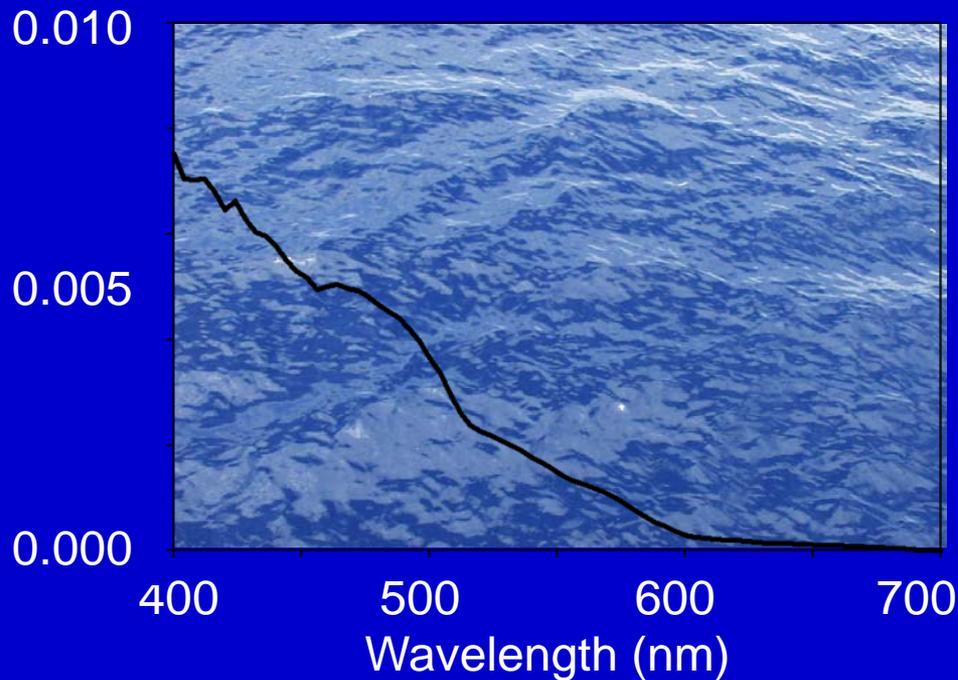
- 1. Principles and History**
- 2. Current Status**
- 3. Examples**
- 4. What's Next?**

# Optical Remote Sensing: The science of light propagation

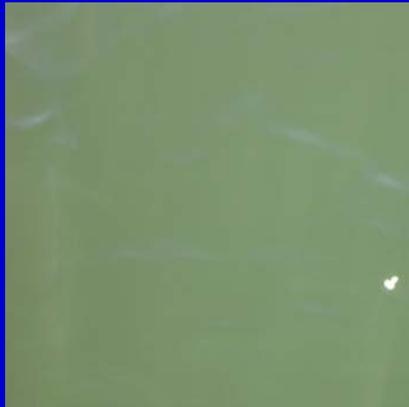
## Electromagnetic Spectrum



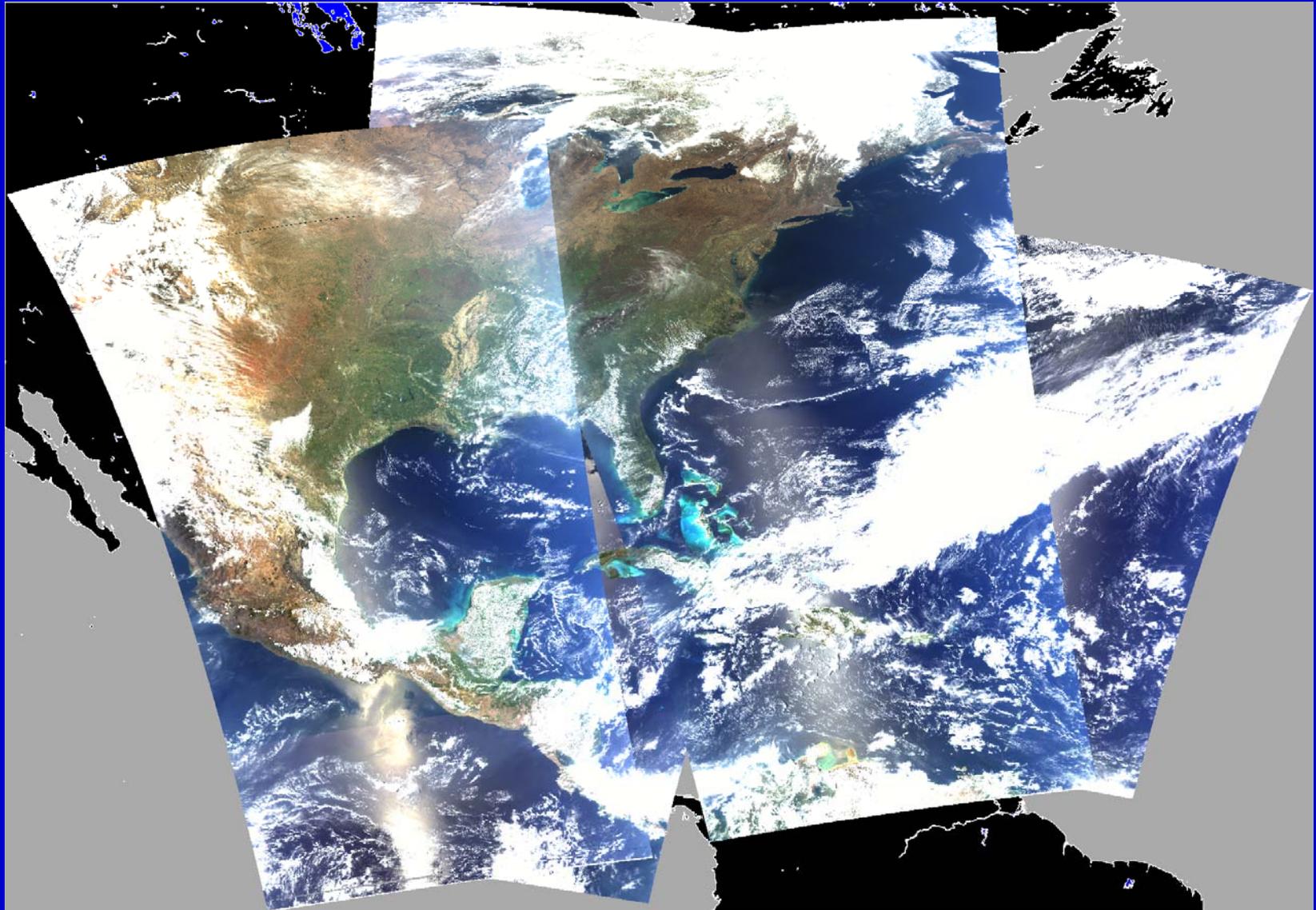
# Optical Remote Sensing: Principles



# The Beauty of Ocean Color

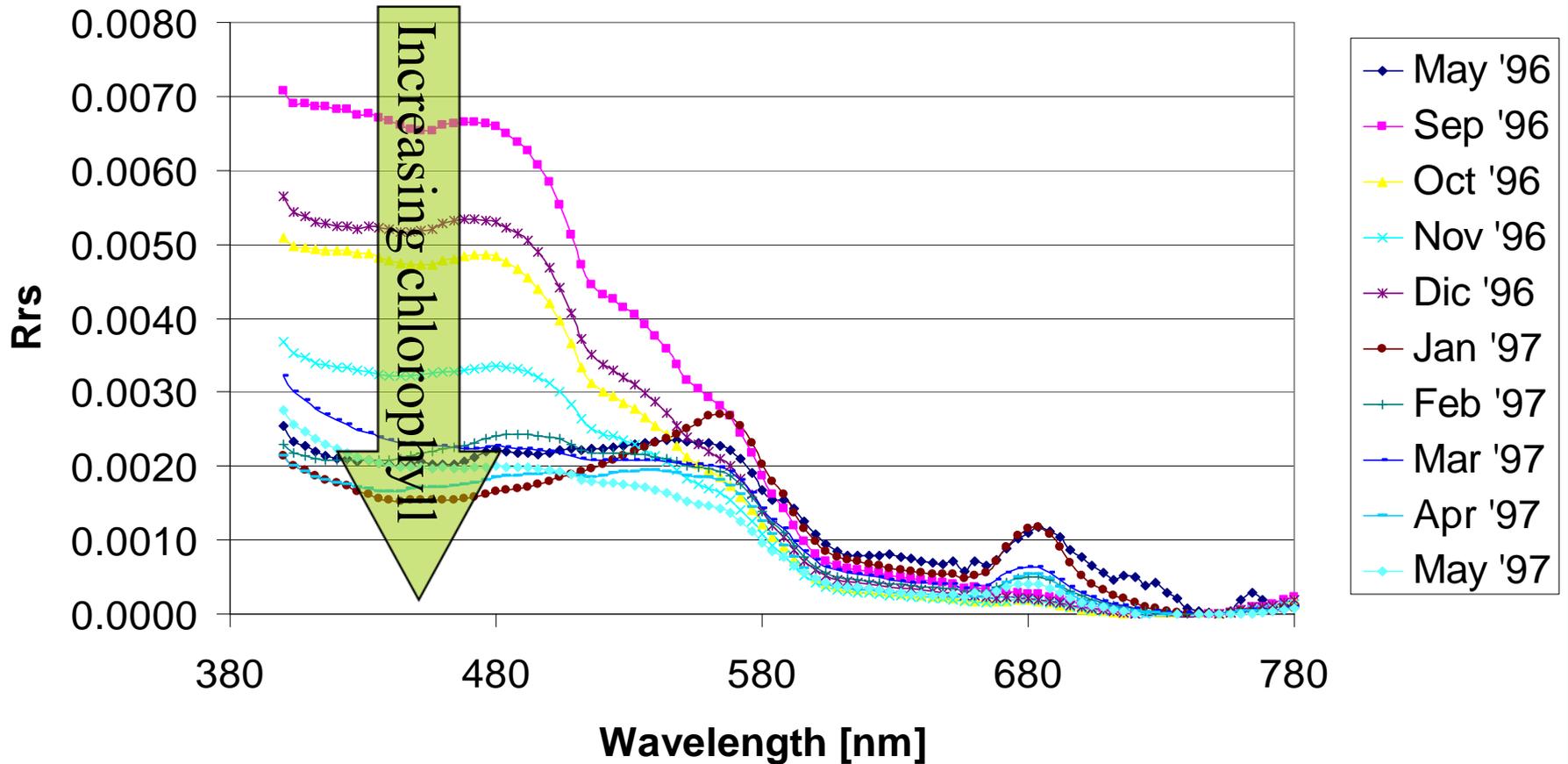


# The Beauty of Remote Sensing

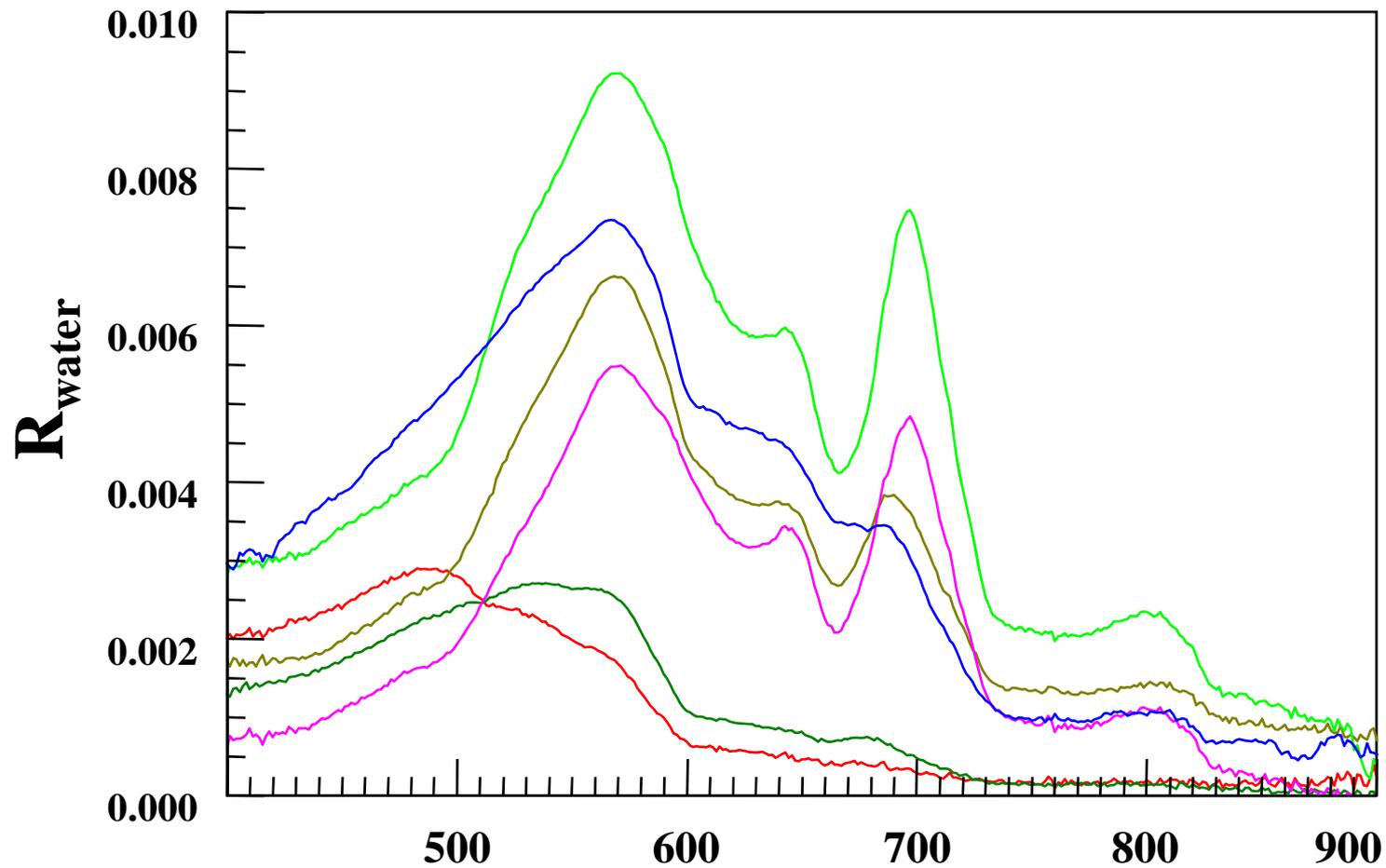


# Simple Interpretation

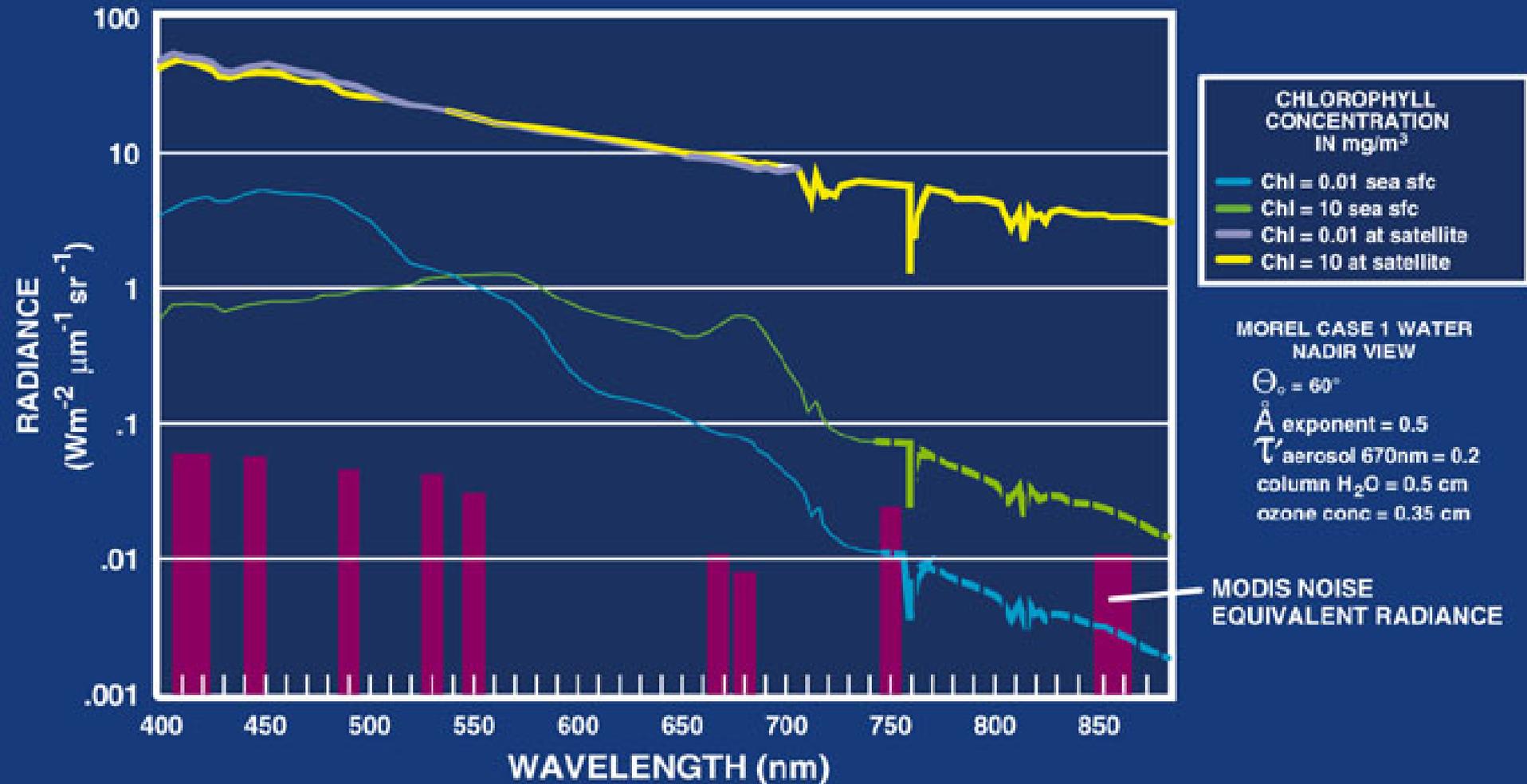
## Remote Sensing Reflectance



# Complex Interpretation

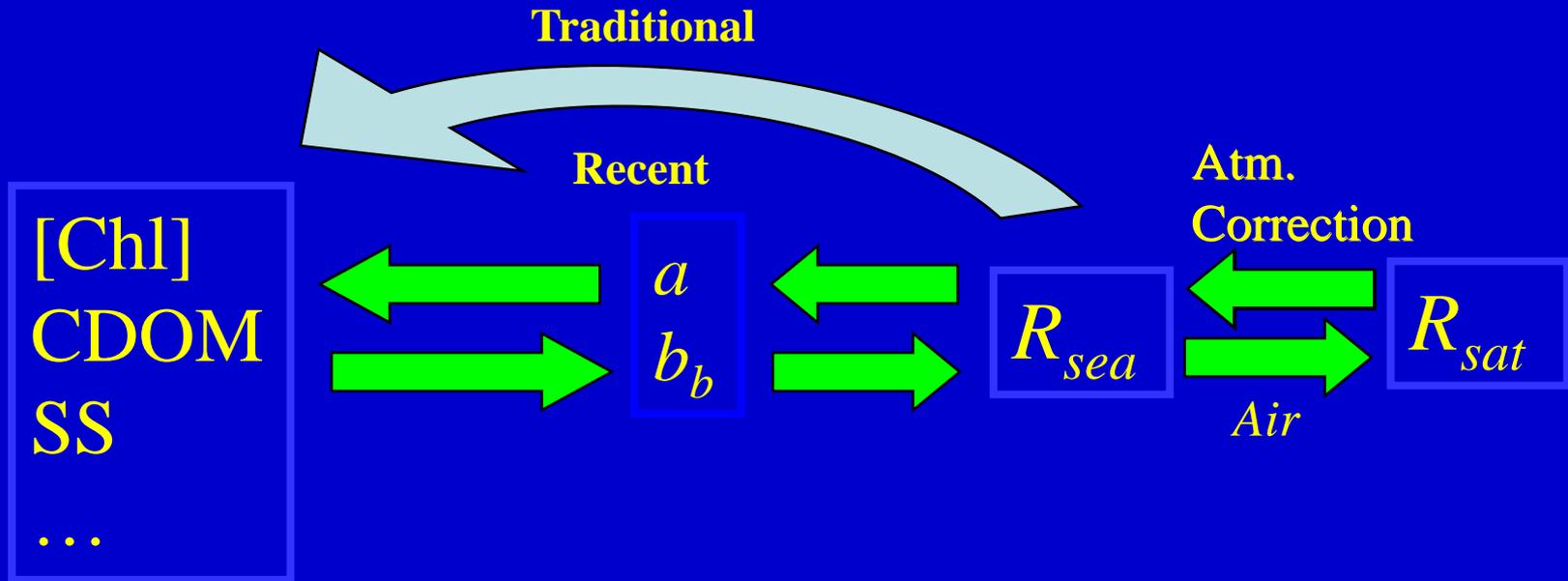


# Satellite vs Surface Observation



Gordon (1983)

# Forward and Inversion Algorithms



$$R_{sea} = f(a_p, a_d, a_{CDOM}, b_{bp})$$

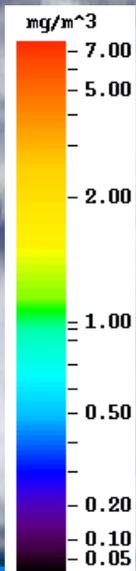
A satellite image of Earth showing a coastline and a large body of water. The image is tilted. A red text overlay 'R\_sat' is centered on the image. The text 'R' is larger and bold, with 'sat' in a smaller font size below it.

**R**<sub>sat</sub>

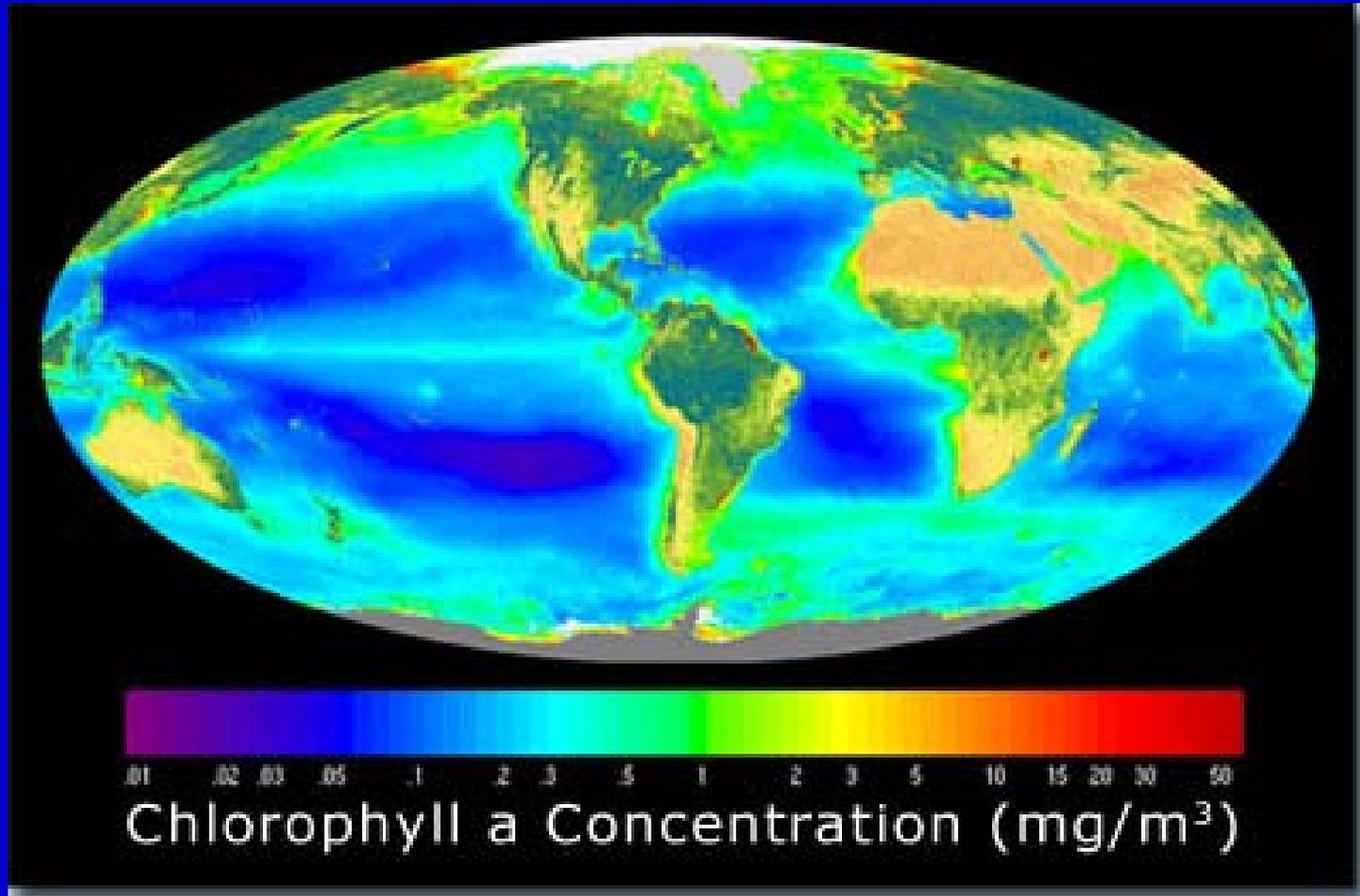
A satellite image of a coastal region, likely the Mediterranean Sea, showing a large body of water with a prominent white and grey cloud pattern. The landmasses are visible in shades of green and brown. A red label 'R\_sea' is overlaid on the image, positioned in the center-left area.

$R_{sea}$

Chl



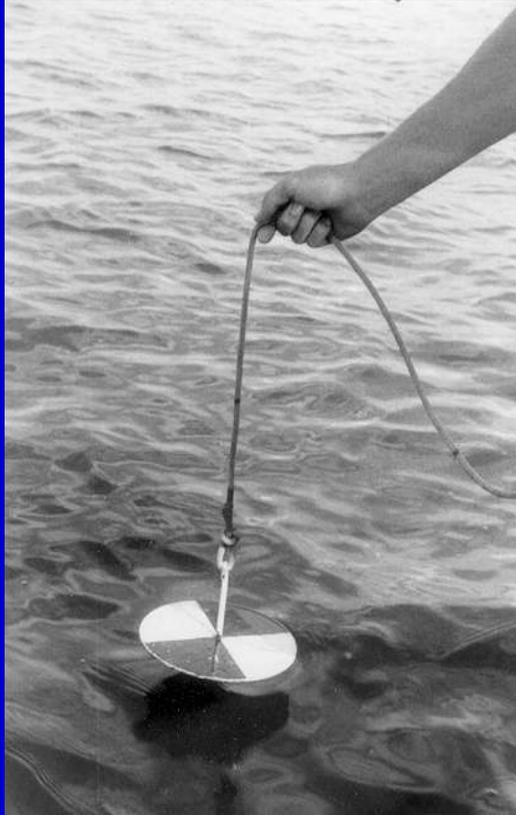
# Mean Chl (9/1997 – 8/2000)



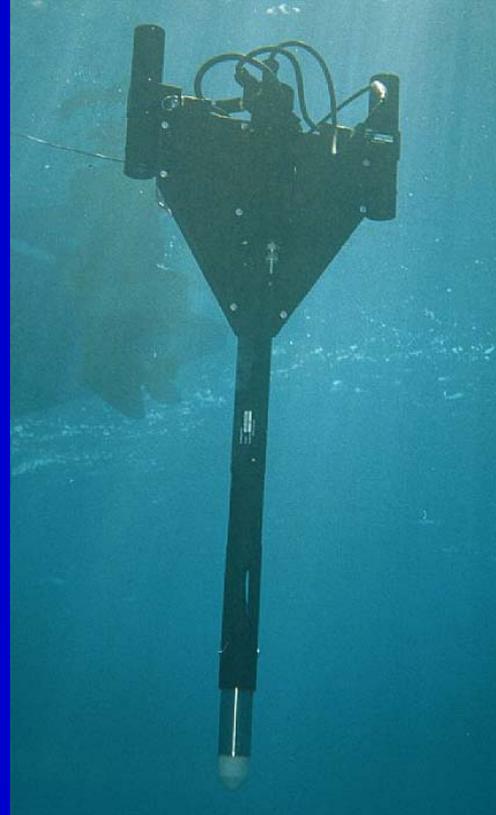
Source: NASA/GSFC

# A Little History

1950's



Today



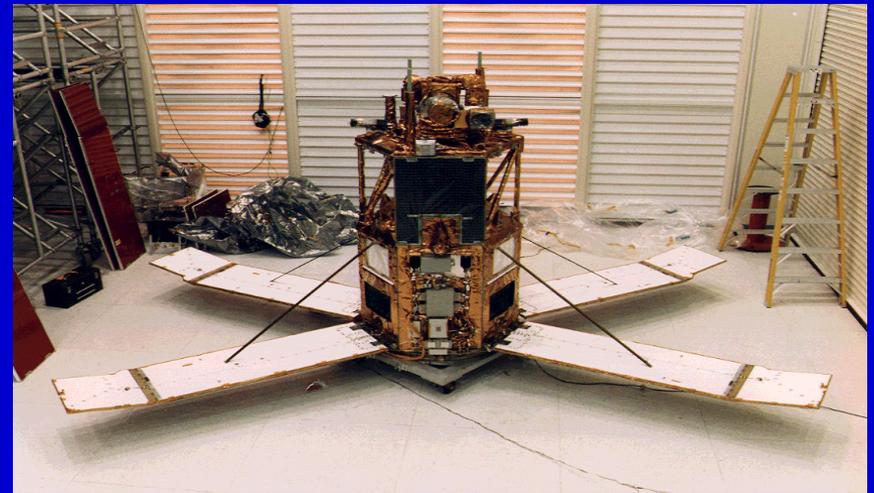
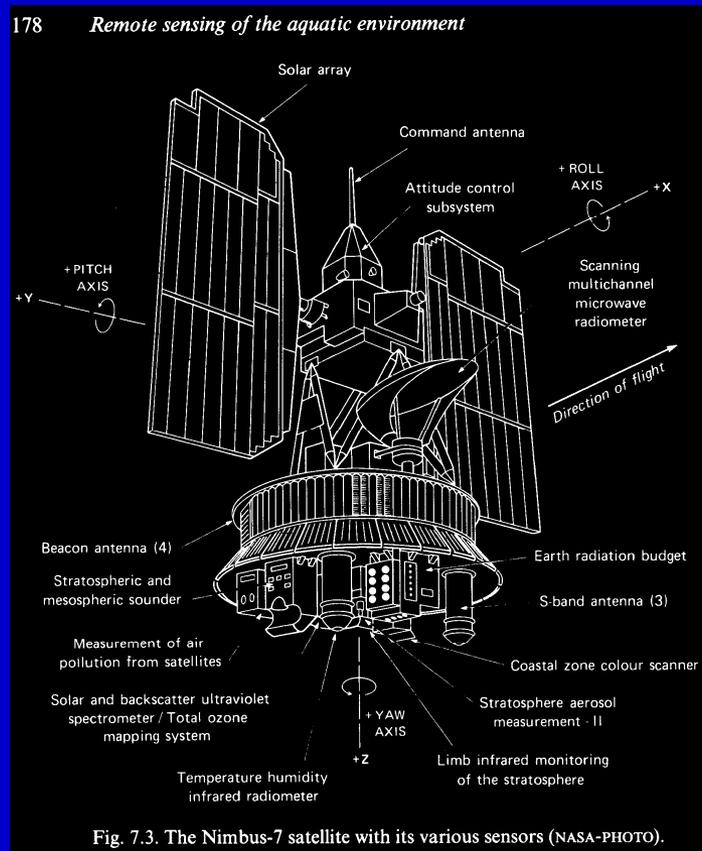
# Today's Gears



# Satellite Instruments

CZCS on NIMBUS-7  
(1978-1986)

SeaWiFS on Orbview-2  
(1997 – present)

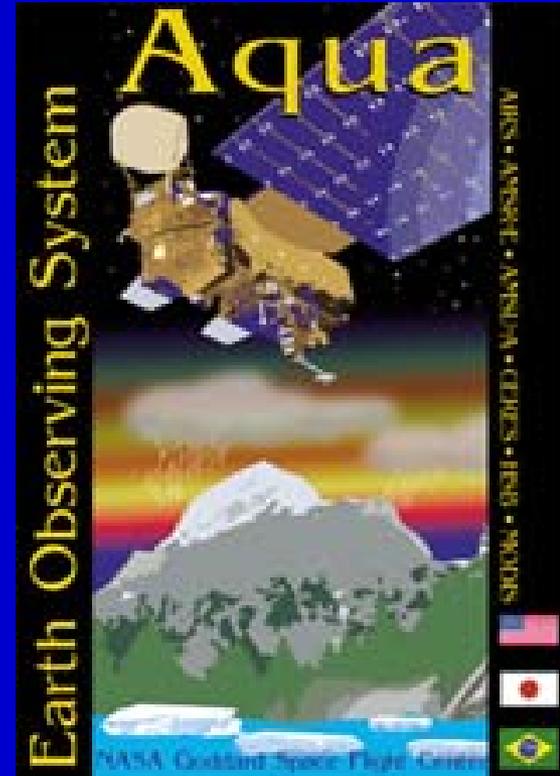


# Satellite Instruments

MODIS on Terra  
(1999-present)



MODIS on Aqua  
(2002 – present)



## Computing Power

- **1970s: First CZCS image in a month**
- **Today: 10-year SeaWiFS archive in 2 days**

## Algorithms

- **1970s: Subtraction, ratio, etc.**
- **Today: Semi-analytical, optimization, etc.**

## Data/Image Availability

- **1970s: Barely anywhere**
- **Today: Free everywhere**

## Peer Recognition

- **1970s: One image deserves publishing in Science**
- **Today: Images without story published nowhere**

# What data products?

- **Spectral reflectance**
- **Chlorophyll-a concentration**
- **Surface irradiance**
- **Attenuation coefficient**
- **Backscattering coefficient**
- **CDOM absorption coefficient**
- **Euphotic depth**
- **Total suspended sediments**
- **Fluorescence line height**
- **.....**

# Where?

- **NASA (global archive)**
- **Regional (customized for GOM)**

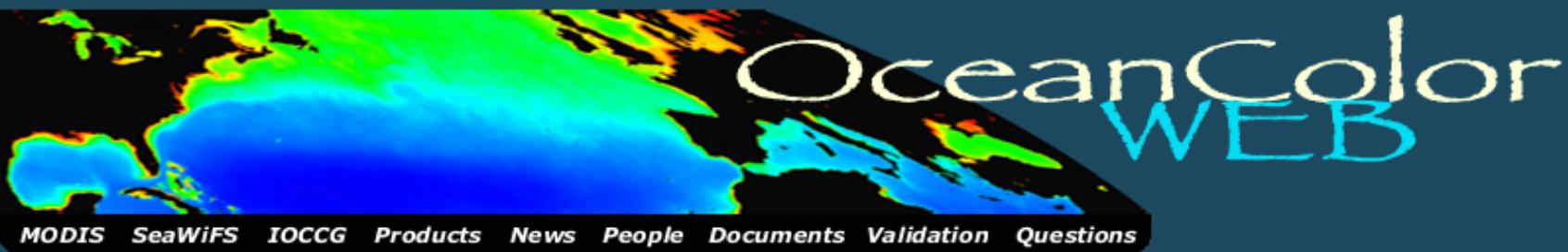
<http://oceancolor.gsfc.nasa.gov>

OceanColor Home Page - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://oceancolor.gsfc.nasa.gov/

Google



**MODIS SeaWiFS IOCCG Products News People Documents Validation Questions**

### Data Access

#### Data Production and Distribution Status

 We have started receiving MODIS data again, but now SeaWiFS has gone into safe haven. Investigation is under way.

*NOTE: FTP connections must be made in PASSIVE mode*

#### Level 1 and 2 Browser

Visually search the ocean color data archive. Directly download or order data from a single file to an entire mission.

#### Level 3 Browser

Browse the entire global ocean color

### Ocean Color Web Feature

Recent topics and imagery of interest to the OceanColor community.

#### The Congo River Plume



### Support Services

#### SeaDAS

A comprehensive image analysis package for the processing, display, analysis, and quality control of ocean color data.

#### SeaBASS

An archive of *in situ* oceanographic atmospheric data for use in algorithm development and satellite data product validation.

#### Registration for support services

- [Data access and Subscriptions](#)
- [Forgotten password](#)
- [Email change](#)
- [SeaWiFS Access Authorization](#)

# http://reason.gsfc.nasa.gov/Giovanni/

**Giovanni - Ocean Color Radiometry Online Visualization and Analysis - Mozilla Firefox**

File Edit View History Bookmarks Tools Help

http://gdata1.sci.gsfc.nasa.gov/daac-bin/G3/gui.cgi?instance\_id=ocean\_mo



Area of Interest: West: -180 North: 90 South: -90 East: 180 Update Map

### Parameters

Display:  Data Product Info  Climatology Info  Units  Only Parameters with Climatology

Analysis Options:  Parameter  Climatology  Anomaly [Show Notes...](#)

SeaWiFS(1997/09/01 - 2009/07/01)

Parameter	Data Product Info		
<input type="checkbox"/> Aerosol optical thickness at 865 nm	SWFMOT865.005	SeaWiFS	1997/09 - 2009/07
<input type="checkbox"/> Angstrom coefficient 510 to 865 nm	SWFMOA510.005	SeaWiFS	1997/09 - 2009/07
<input type="checkbox"/> Chlorophyll a concentration	SWFMOCHLO.005	SeaWiFS	1997/09 - 2009/07
<input type="checkbox"/> Diffuse attenuation coefficient at 490 nm	SWFMOK490.005	SeaWiFS	1997/09 - 2009/07
<input type="checkbox"/> Epsilon of aerosol correction at 765 and 865 nm	SWFMOEPS78.005	SeaWiFS	1997/09 - 2009/07

<http://www7333.nrlssc.navy.mil/imagery/image>

[ryMenu2.html](http://www7333.nrlssc.navy.mil/imagery/image)

File Edit View History Bookmarks Tools Help

http://www7333.nrlssc.navy.mil/imagery/imageMenu2.html

Harmful Algal BloomS Observing... Naval Research Laboratory - Co... http://www73...yMenu2.html

## Imagery Products Search Parameters

### File Types

NRL SeaWiFS Level-3 Mosaic

### Areas Of Interest

GulfOfMexico

### Starting Time

25 September 2005

### Ending Time

16 October 2005

### Products

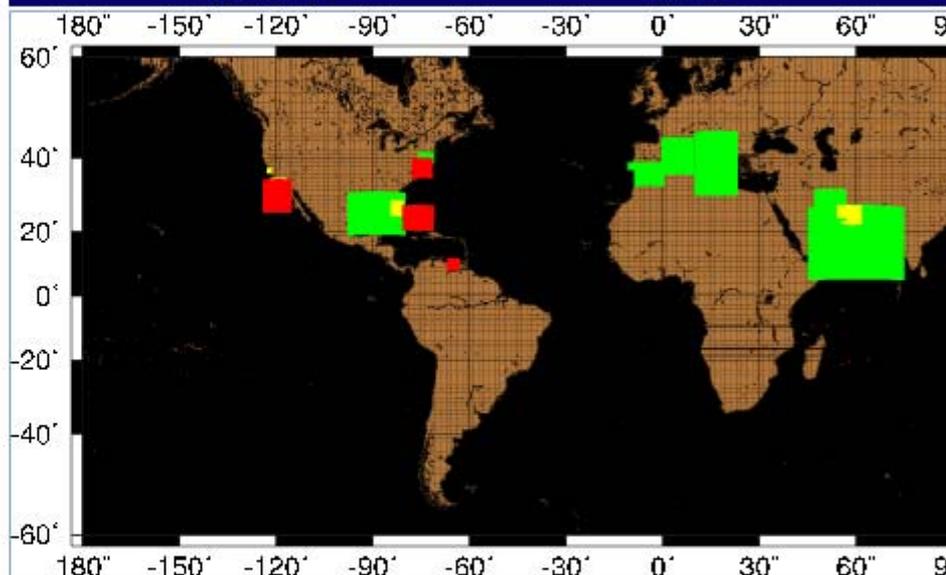
Search

## Additional Filtering Parameters

Cloud Coverage

[SeaWiFS](#)

[Modis](#)



## NRL-Code7333 Optical Products-Imagery

Developmental Products

1. MODIS Lake Products

# http://habsos.noaa.gov/

**Harmful Algal Bloom Mapping System - Mozilla Firefox**

File Edit View History Bookmarks Tools Help

http://www.ncddc.noaa.gov/website/HABSOS\_nrt/viewer.htm

Harmful Algal Blooms Observing System

**HABSOS**  
HARMFUL ALGAL BLOOMS OBSERVING SYSTEM

About The Data | NRL 7 Day Animations | Feedback | Help

**NAVIGATION**

**DATA INFORMATION**

**OUTPUT**

**LAYERS/LEGEND**

- Event Reports (<= 30 days)
- FWRI Cell Counts
- DET Cell Counts

**Refresh Map**

Auto Refresh

**View Data By Date**  
03-Nov-2009 to 03-Dec-2009

Filter FWRI Cell Counts Data ( 164 records)

Filter DET Cell Counts Data ( 0 records)

**Add Imagery/Model Data To Display:**  
Imagery available for Gulf of Mexico only  
Models available for Gulf of Mexico and Caribbean only

Imagery Products

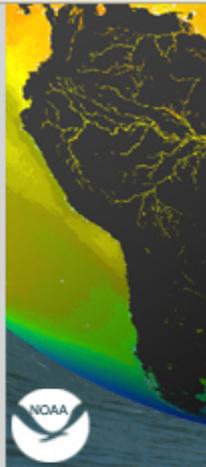
Chlorophyll-a Anomaly (PM)

02-Dec-2009 (1 Day Ago)

Search

NOAA Coastal Data Development Center  
Lon: 86° 24'W Lat: 31° 3'N

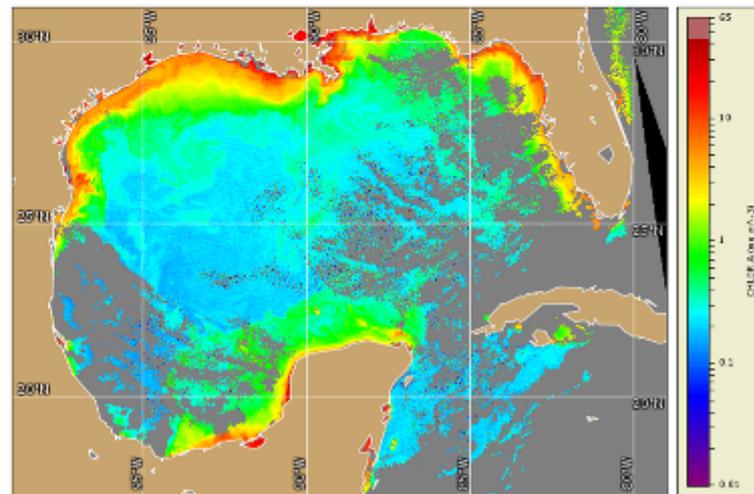
United States | Florida | Submit



using NOAA's Comprehensive Large Array-data Stewardship System (CLASS). Under the new NOAA Data Center-CLASS relationship, CLASS will focus on information technology in support of the archive (ingest, archival storage and access) while NODC is responsible for the overall archive services, including preservation planning, scientific stewardship, documentation and metadata management. An archive team consisting of representatives from CoastWatch, NODC and CLASS is currently working to fulfill the archive requirements for these products. One of these requirements is the completion of the NODC Submission Information Form (SIF), which contains detailed descriptions of the products as well as information about data submission and dissemination, and links to other relevant documentation. While this is a living document, the most current version of the CoastWatch L2 ocean color SIF is available [here](#).

### Ocean Color Product Information

The L2 ocean color products generated by CoastWatch from SeaWiFS, MODIS and MERIS data consist primarily of spatial information on chlorophyll-a concentration, as well as turbidity (reflectance), covering 13 CoastWatch regions globally. Products derived from all three sensors have approximately 1 km-per-pixel resolution, and will be delivered as both daily and 61-day composites. All files will be in CoastWatch Hierarchical Data Format (HDF). For more detailed information about these products, refer to the SIF in the section above.



CoastWatch ocean color for Gulf of Mexico from MODIS Aqua, 2008/12/02

While more interoperable connections are being established between CLASS and NODC information

## Storms

*There is presently no significant tropical storm activity*

[Recent Seasonal Activity](#)

[Tropical Outlook & Discussion](#)

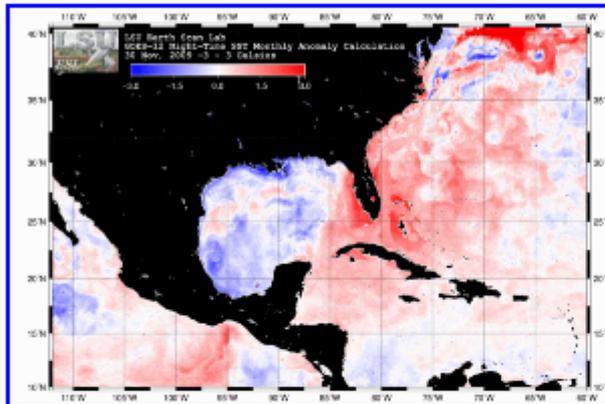
[2008 Hurricane Season](#)



[Image of the Month](#)

[Related LSU Sites](#)

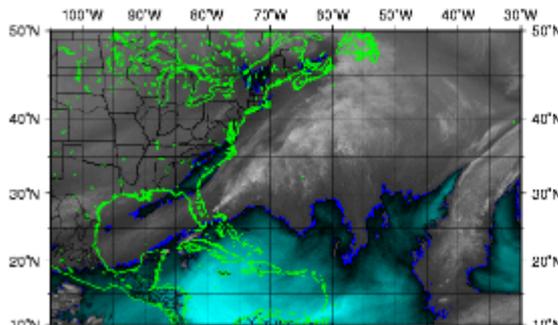
[Coastal Studies Institute](#)



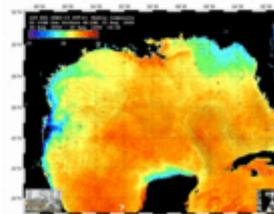
**GOES-12 Monthly Composite SST Anomaly**  
Calculated from 11-year mean, November 2009



## Recent Atmospheric Imagery



## Recent Ocean Temperatures



**Gulf Loop Current and Surface Temperatures**

[Links to imagery](#)  
[Research](#)

<http://gulf-coast.lsu.edu/>

GCIS - Latest CHLO image from MODIS-Aqua - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://gulf-coast.lsu.edu/aqua\_chlo.html

GCIS - La Reload current page

COASTAL STUDIES INSTITUTE  
LOUISIANA STATE UNIVERSITY / BATON ROUGE, LOUISIANA  
**WAVCIS**

Gulf-Coast Information System  
**GCIS**

OCEANOGRAPHY & COASTAL SCIENCES  
LOUISIANA STATE UNIVERSITY

Home

Satellite Data

Coastal Model

GIS

Field Data

Links

Latest Chlorophyll Concentration Map from MODIS - Aqua

Historical Data

Click [here](#) to see the last 12-day data on Gulf of Mexico.

(mg m<sup>-3</sup>) 64.00  
10.00

Done

<http://modis.marine.usf.edu/weekly/gcoos/>

[gcoos.index.html](http://modis.marine.usf.edu/weekly/gcoos/gcoos.index.html)

gcoos - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://modis.marine.usf.edu/weekly/gcoos/gcoos.index.html

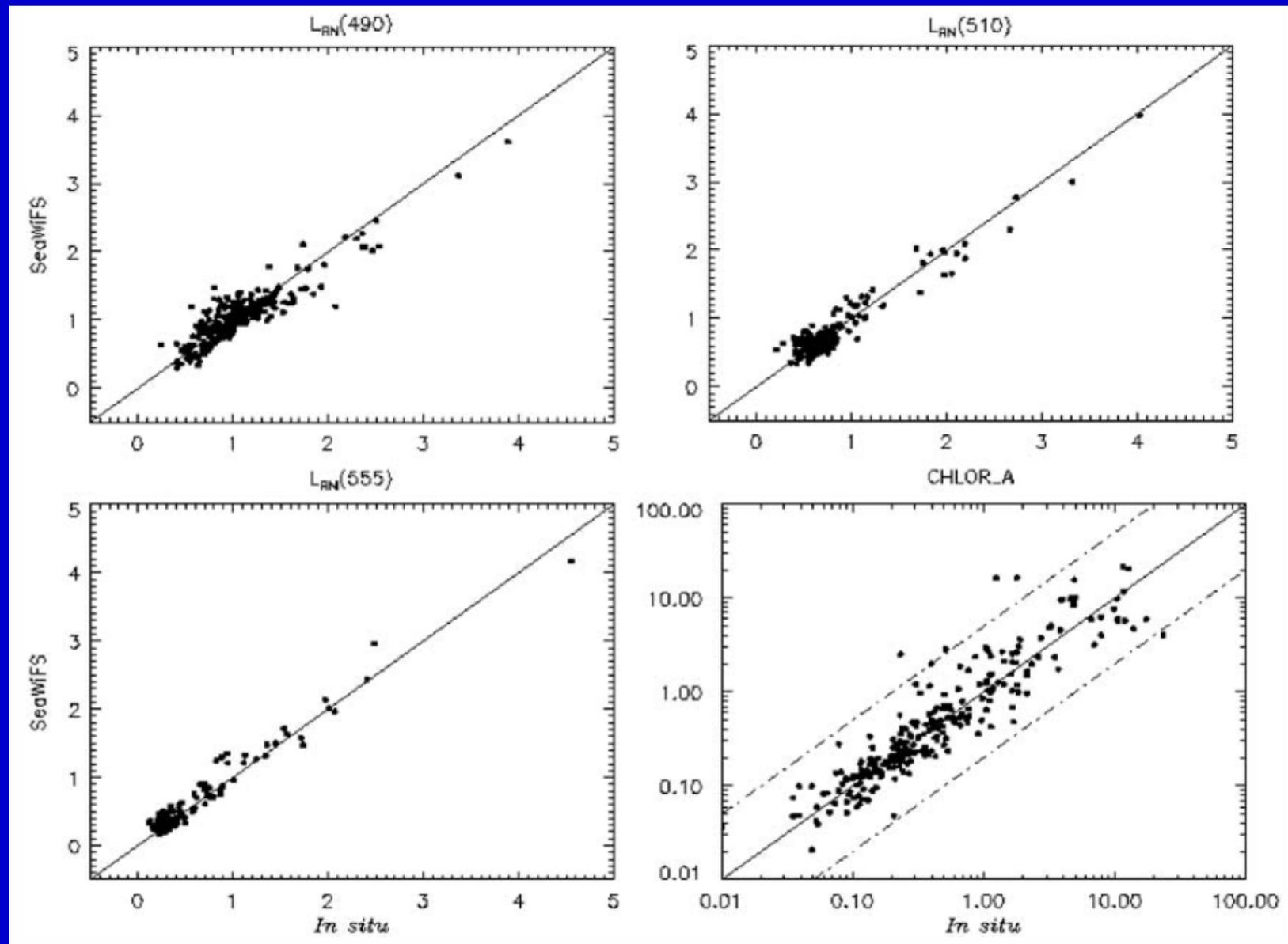
Harmful Algal Blooms Observing... Naval Research Laboratory - Co... USF MODIS Mapped Products...

2009

December							November							October						
Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat
		<a href="#">1</a>	<a href="#">2</a>	<a href="#">3</a>	4	5	<a href="#">1</a>	<a href="#">2</a>	<a href="#">3</a>	<a href="#">4</a>	<a href="#">5</a>	<a href="#">6</a>	<a href="#">7</a>					<a href="#">1</a>	<a href="#">2</a>	<a href="#">3</a>
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September							August							July						
Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat
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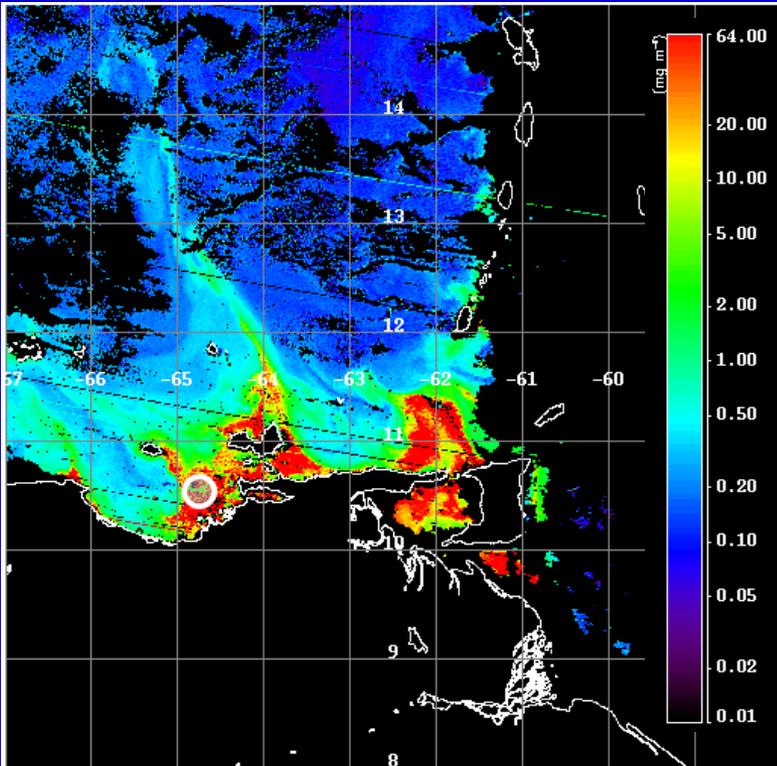
**How shall we trust these products?**

# Global Oceans

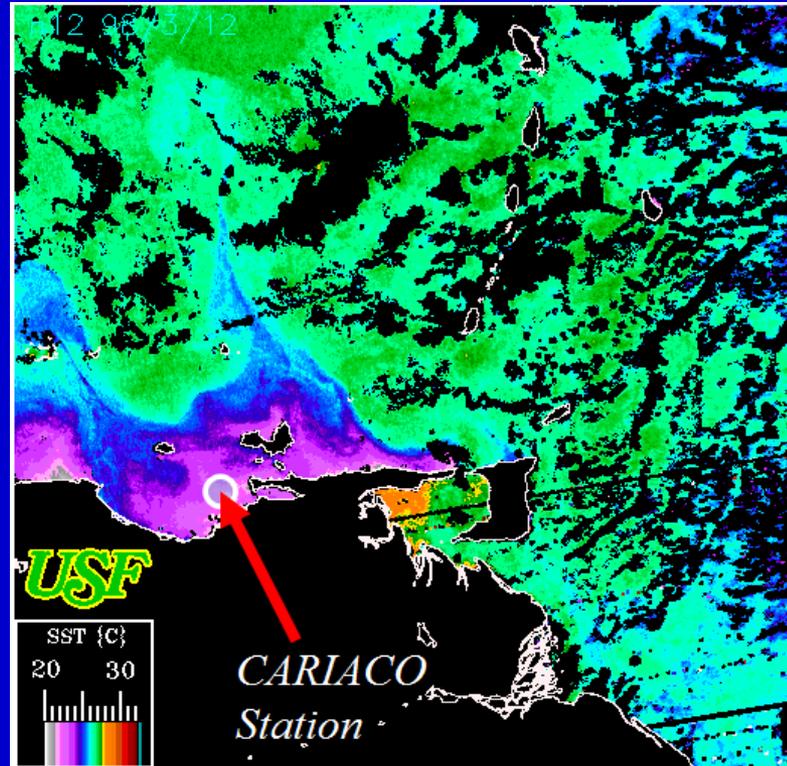


McClain et al., (2004, DSR-II)

# Upwelling and River Plume



**SeaWiFS (Chlorophyll a)**  
**15 March 1998**

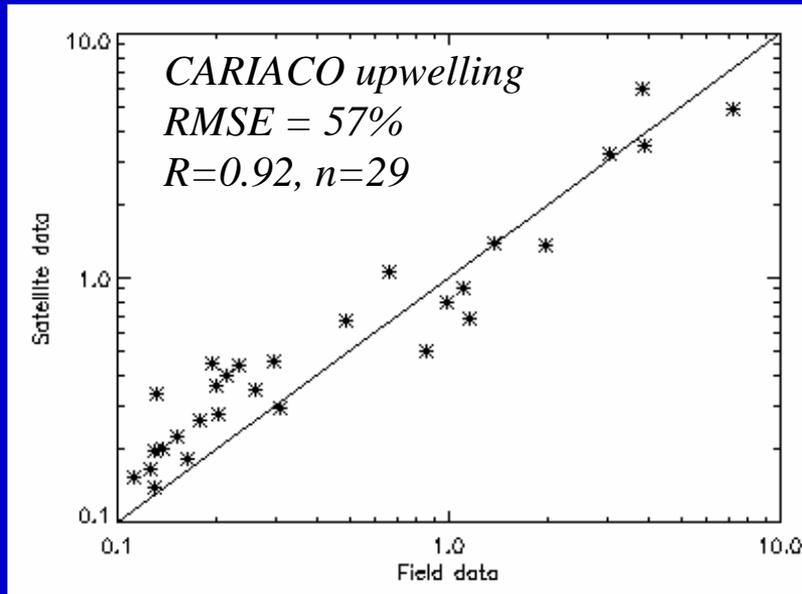


**AVHRR (SST)**  
**12 March 1998**

From Muller-Karger (2001, EOS)

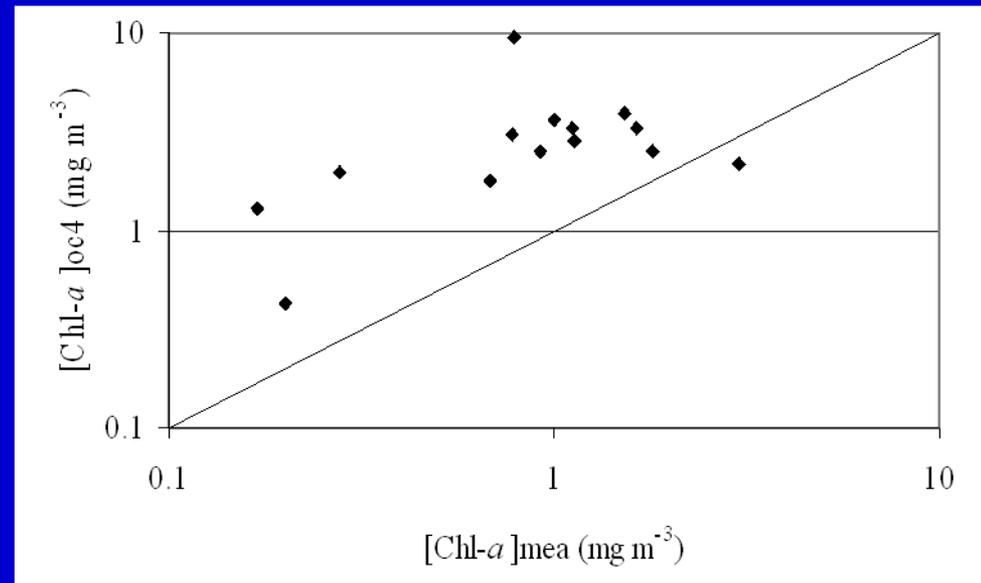
# Upwelling and River Plume

CARIACO upwelling:  
RMSE = 57%



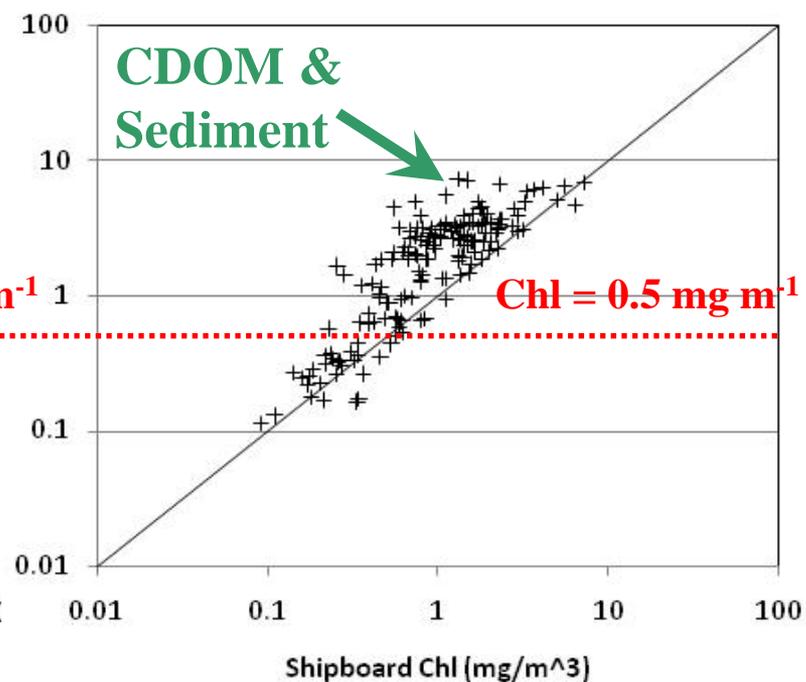
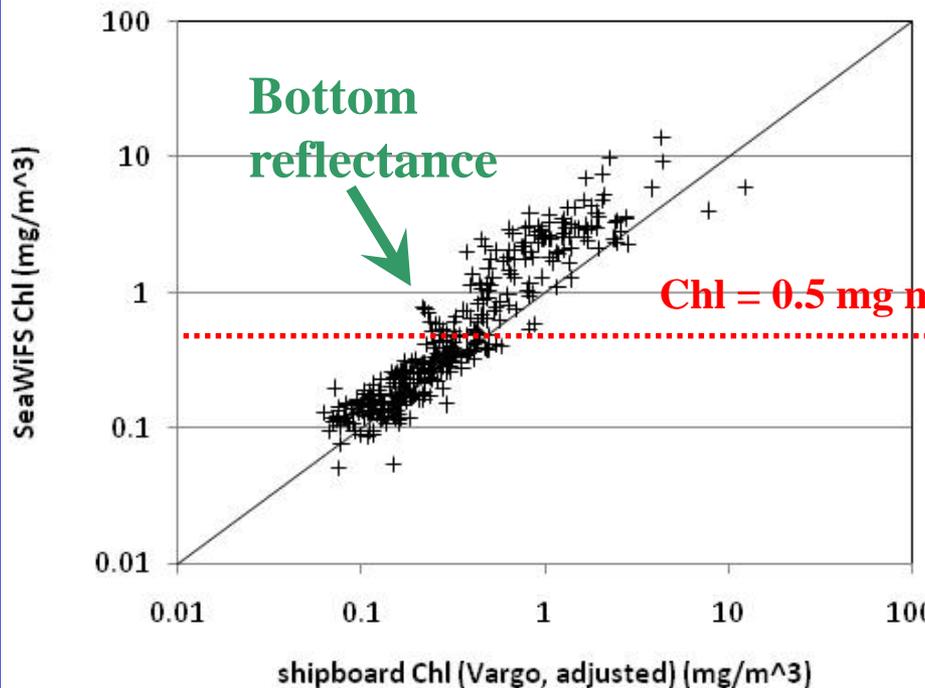
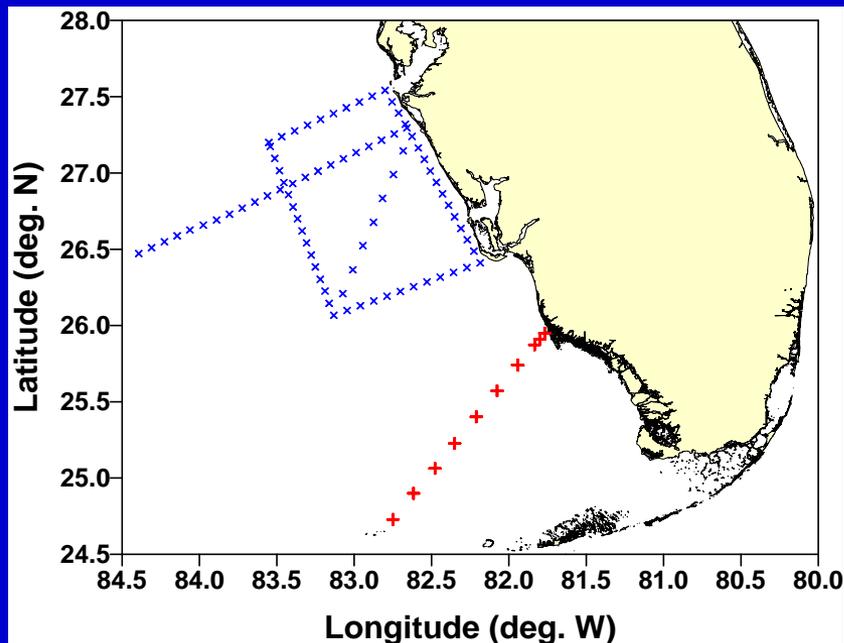
Unpublished data

Orinoco plume:  
RMSE > 150%



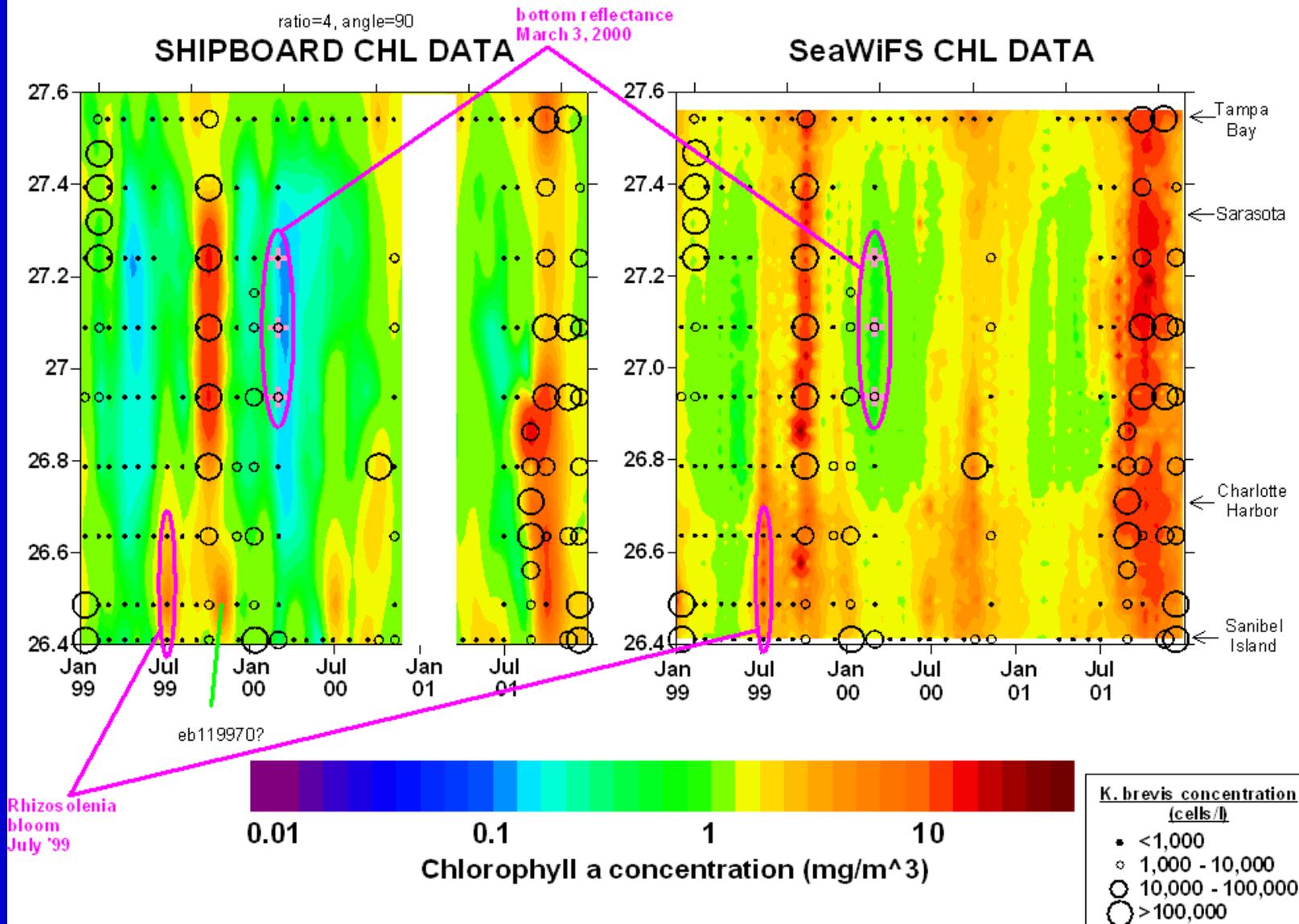
Odriozola et al. (2007, CSR)

# Florida Coastal Water



# 10-m Isobath, West Florida

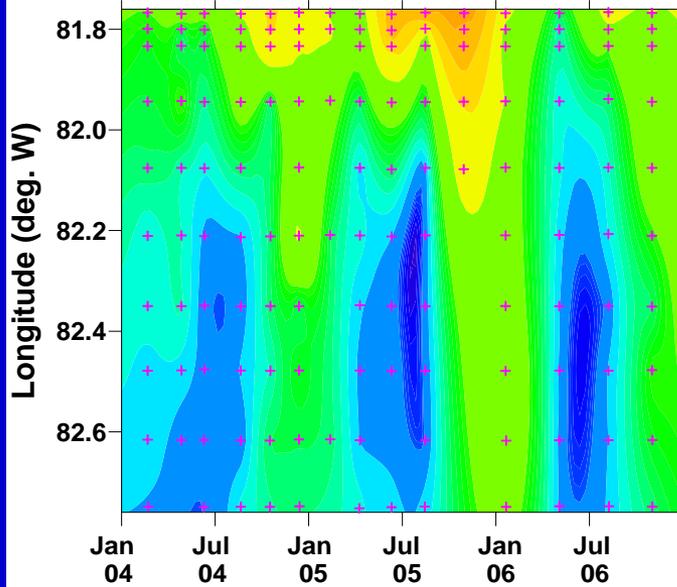
## 10m isobath (Stations 51, 70-83, 1)



# Cross-shelf, West Florida

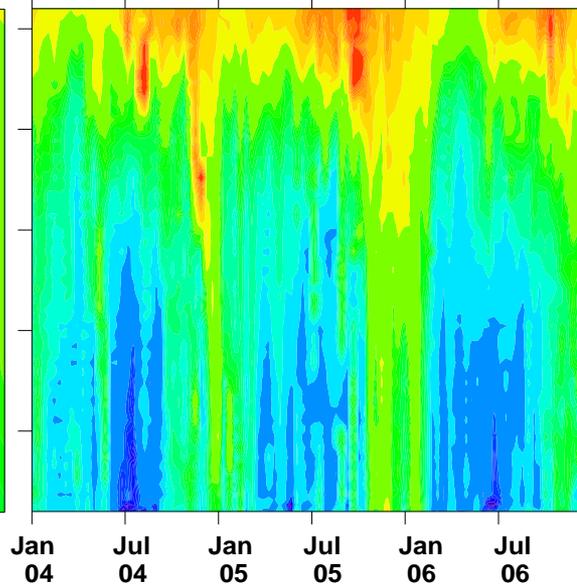
## SHIPBOARD CHL

ratio=4, angle=90



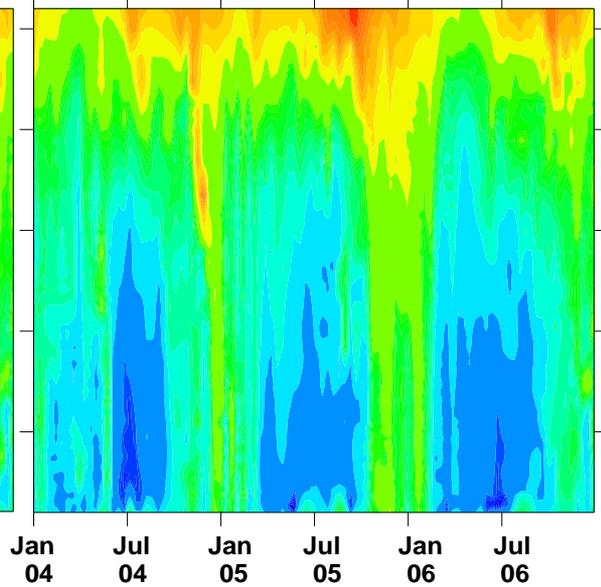
## SeaWiFS CHL

ratio=4, angle=90



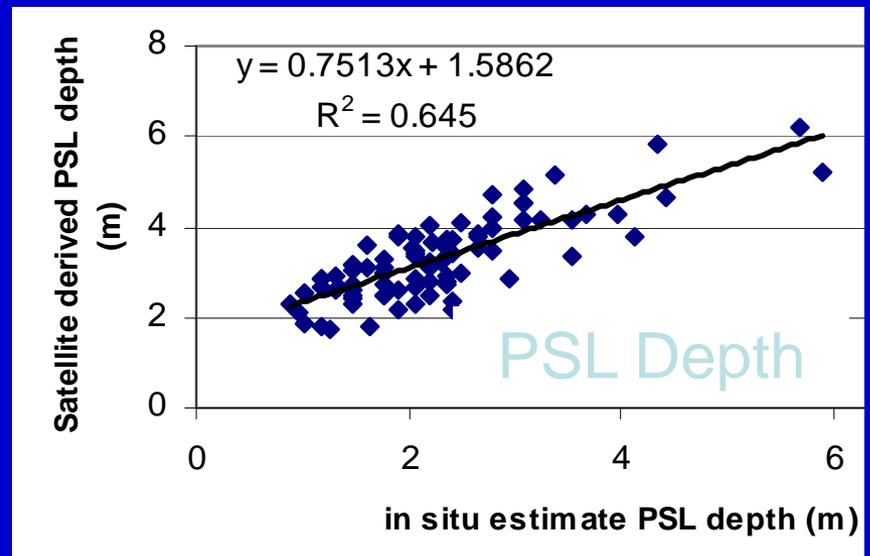
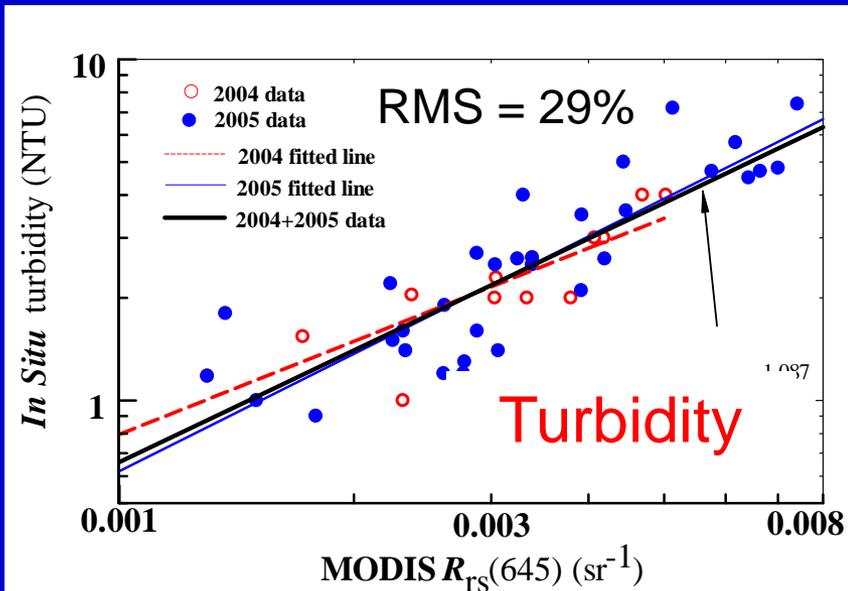
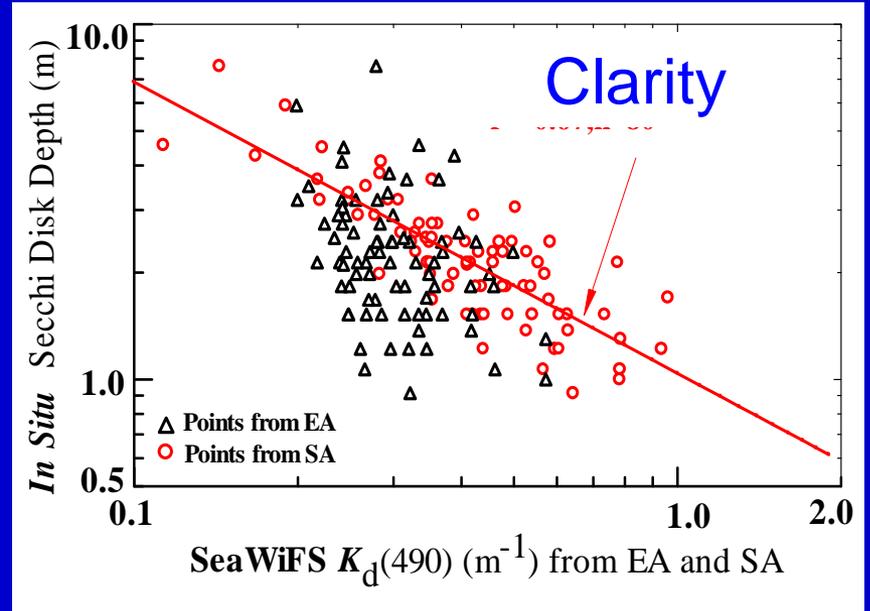
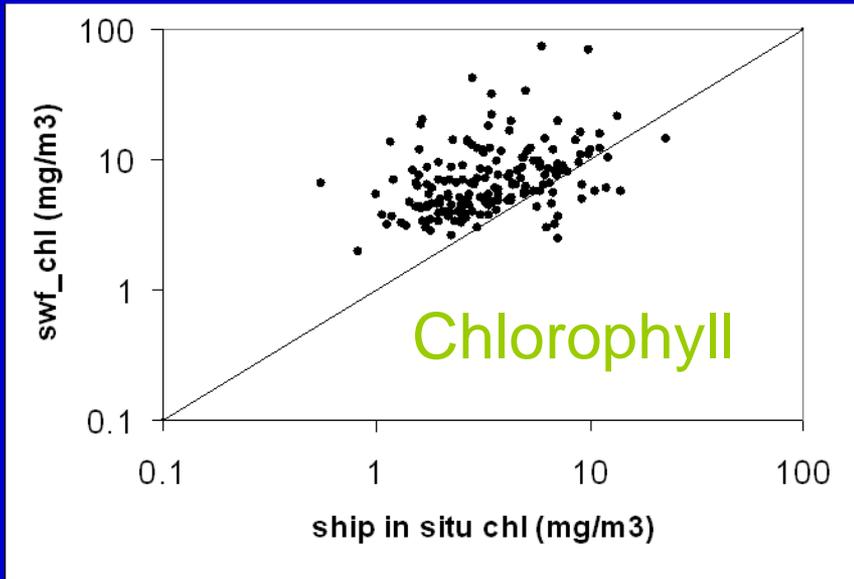
## MODIS (Aqua) CHL

ratio=4, angle=90



Chlorophyll a concentration (mg/m<sup>3</sup>)

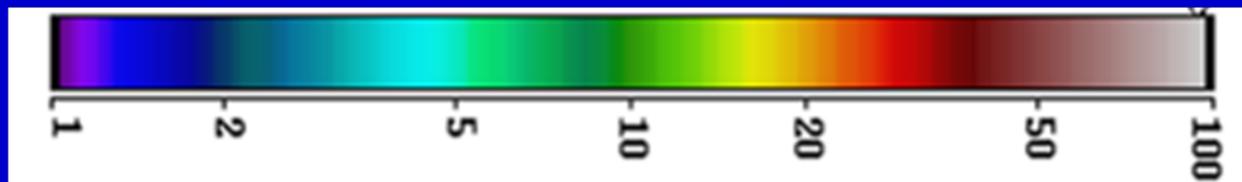
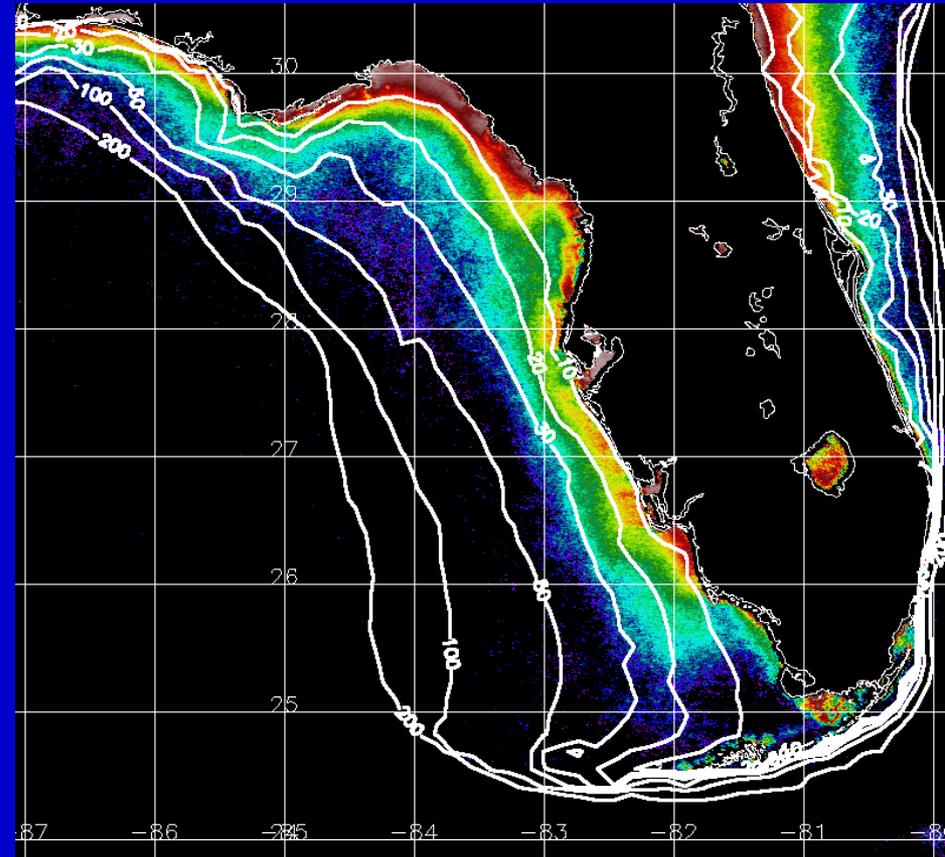
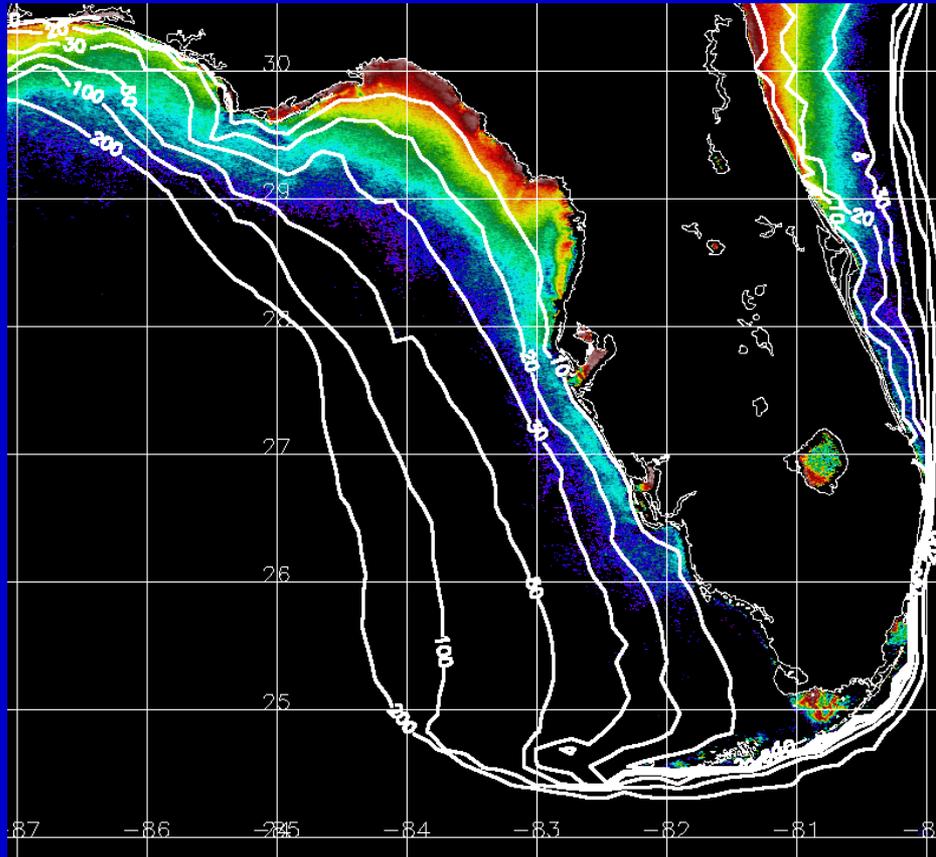
# Tampa Bay, Florida



# Percentage of Negative Lw (1998-2007)

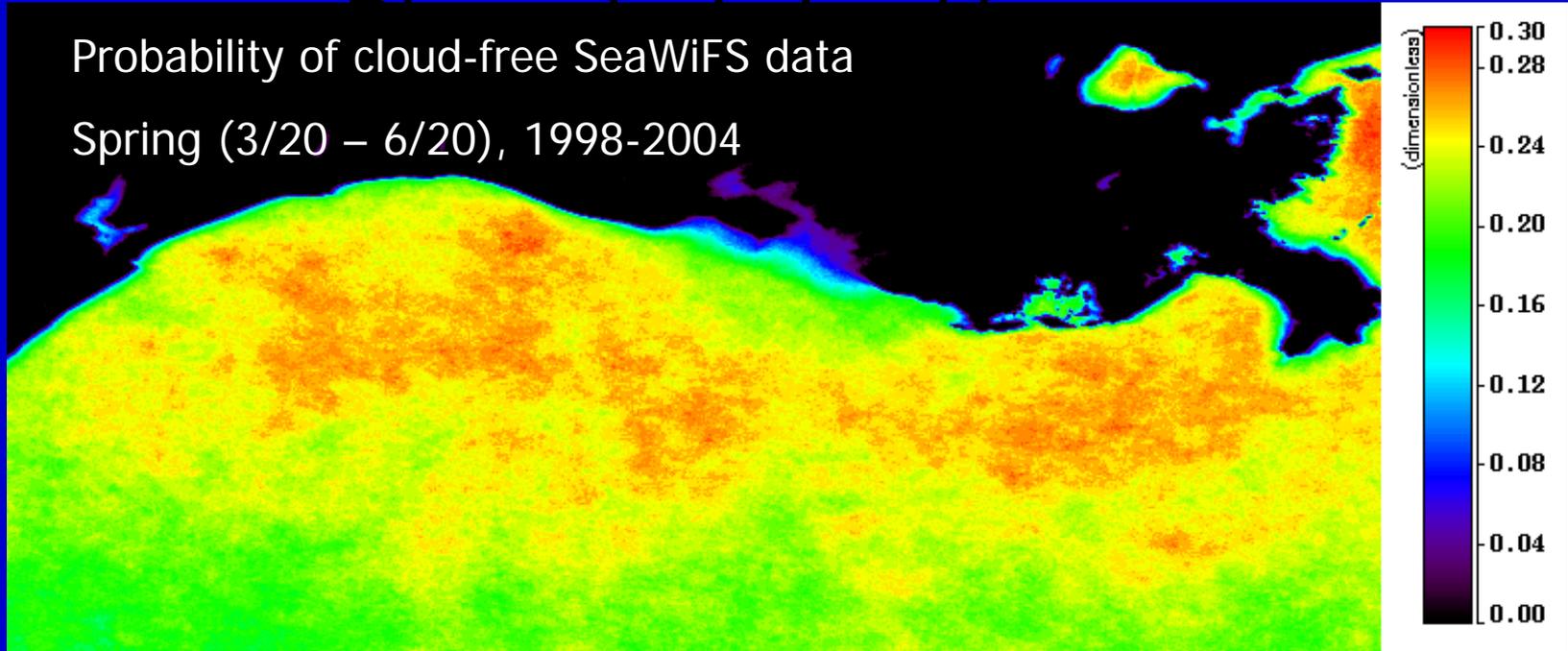
Spring

Autumn



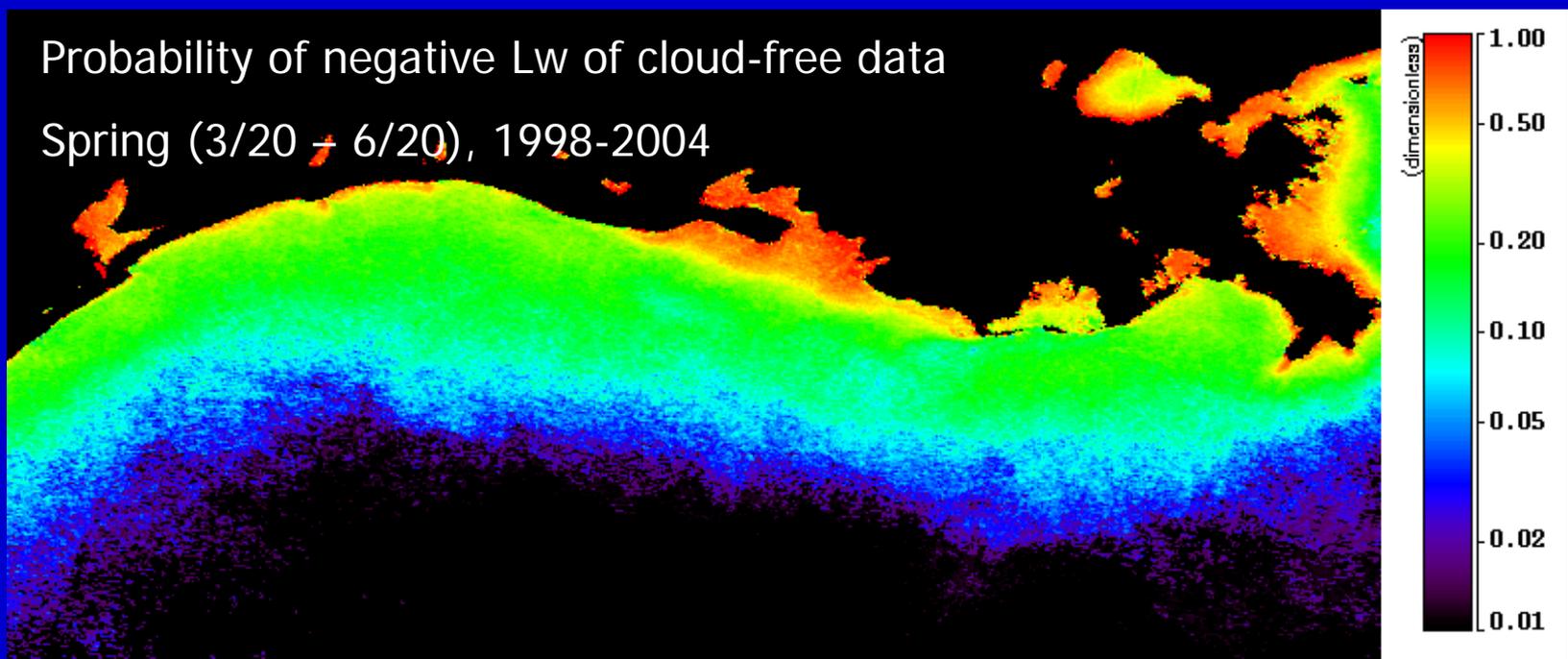
Probability of cloud-free SeaWiFS data

Spring (3/20 – 6/20), 1998-2004



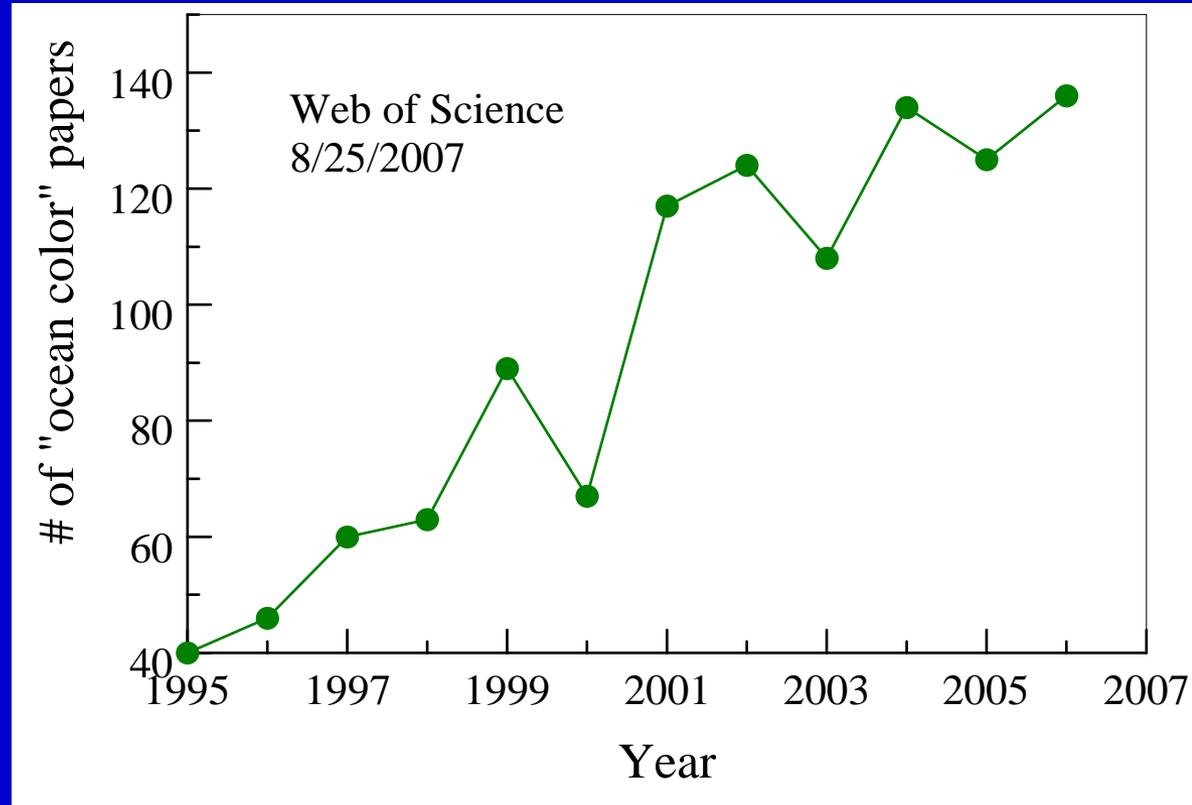
Probability of negative Lw of cloud-free data

Spring (3/20 – 6/20), 1998-2004



# “Ocean color” in Research

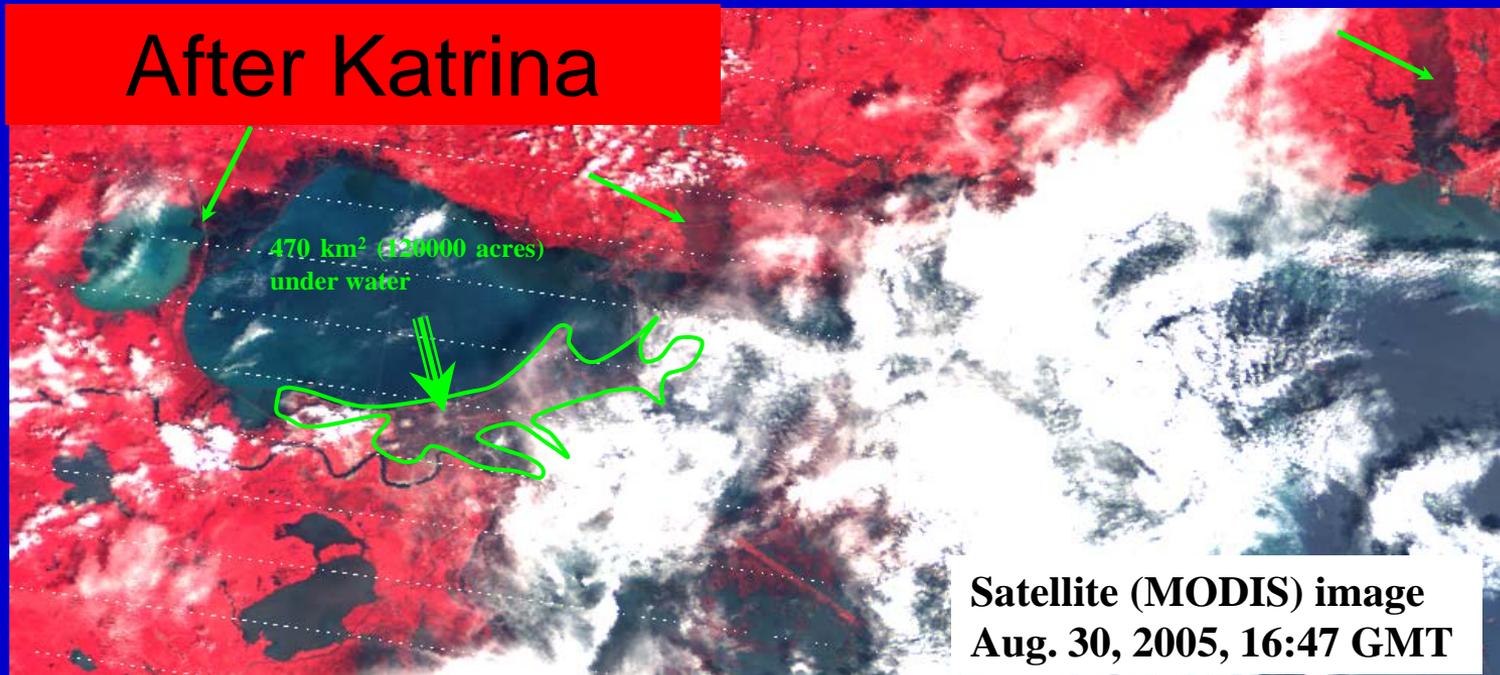
1. Carbon Cycle
2. Climate
3. Ecology and Fishery
4. Oceanography



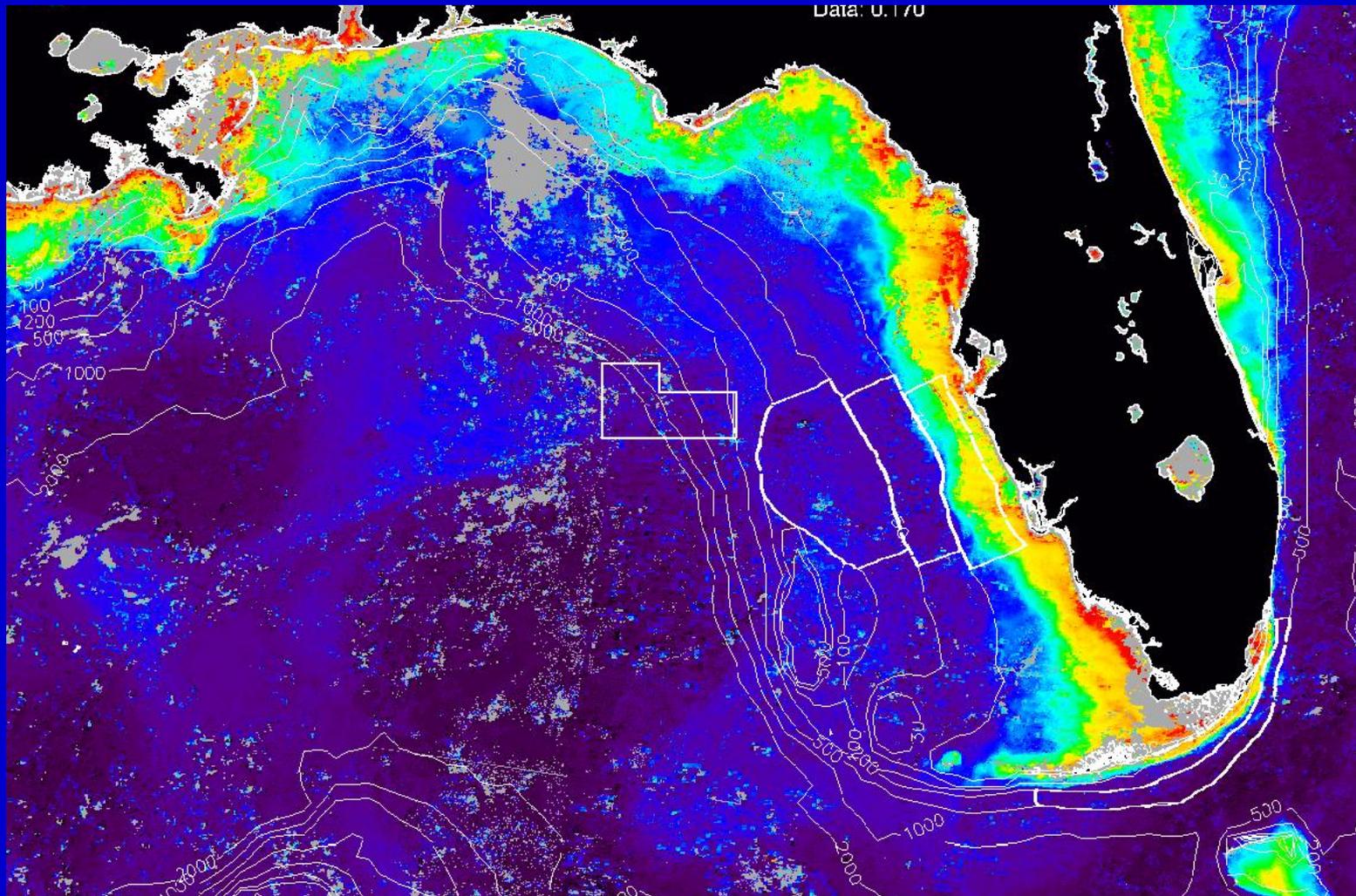
# Before Katrina



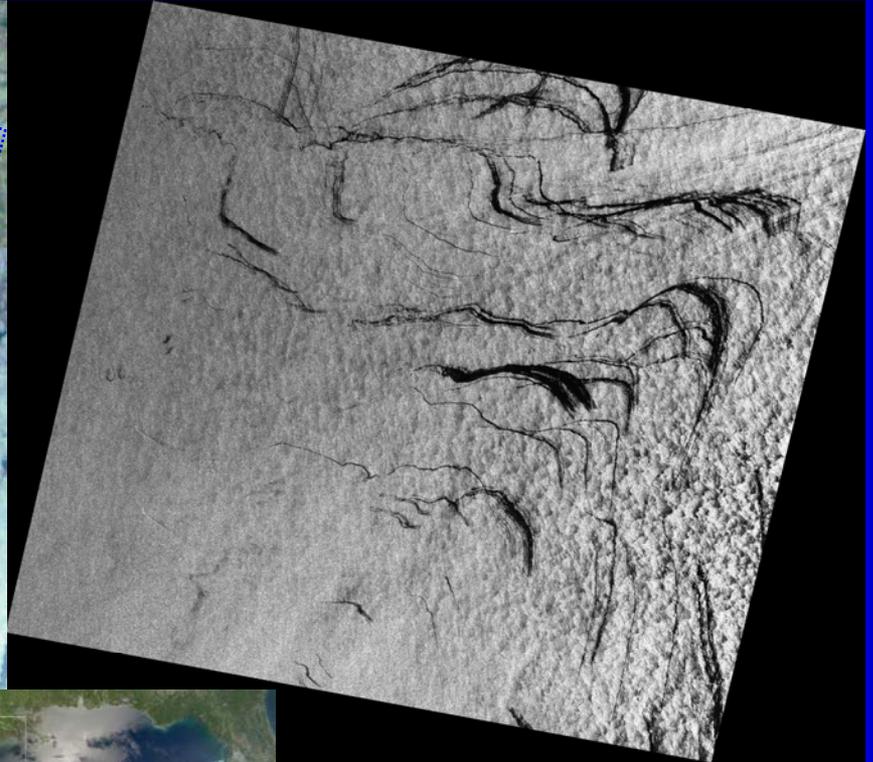
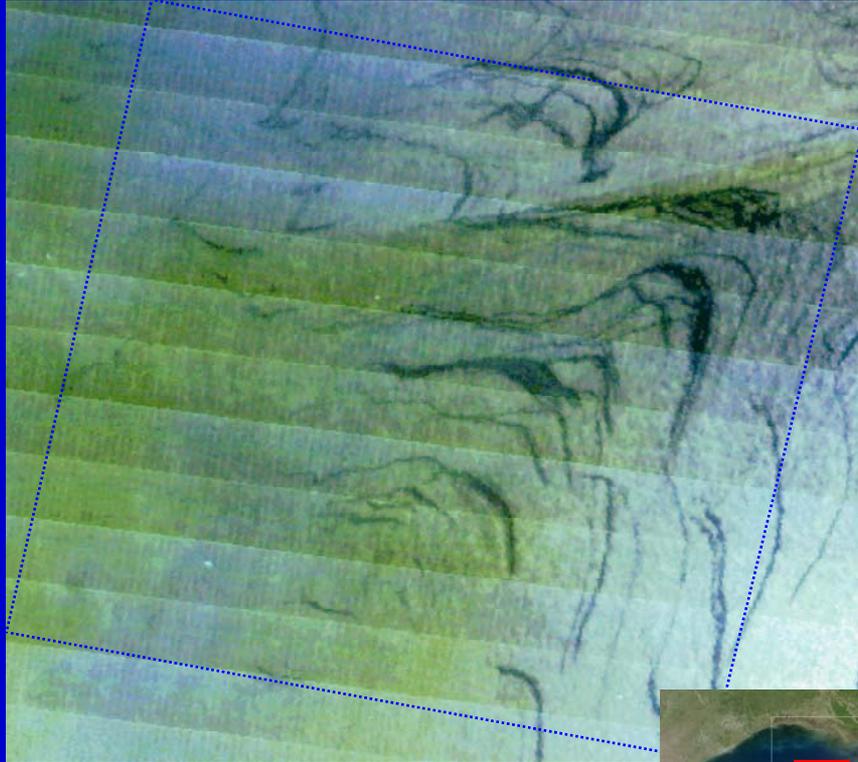
# After Katrina



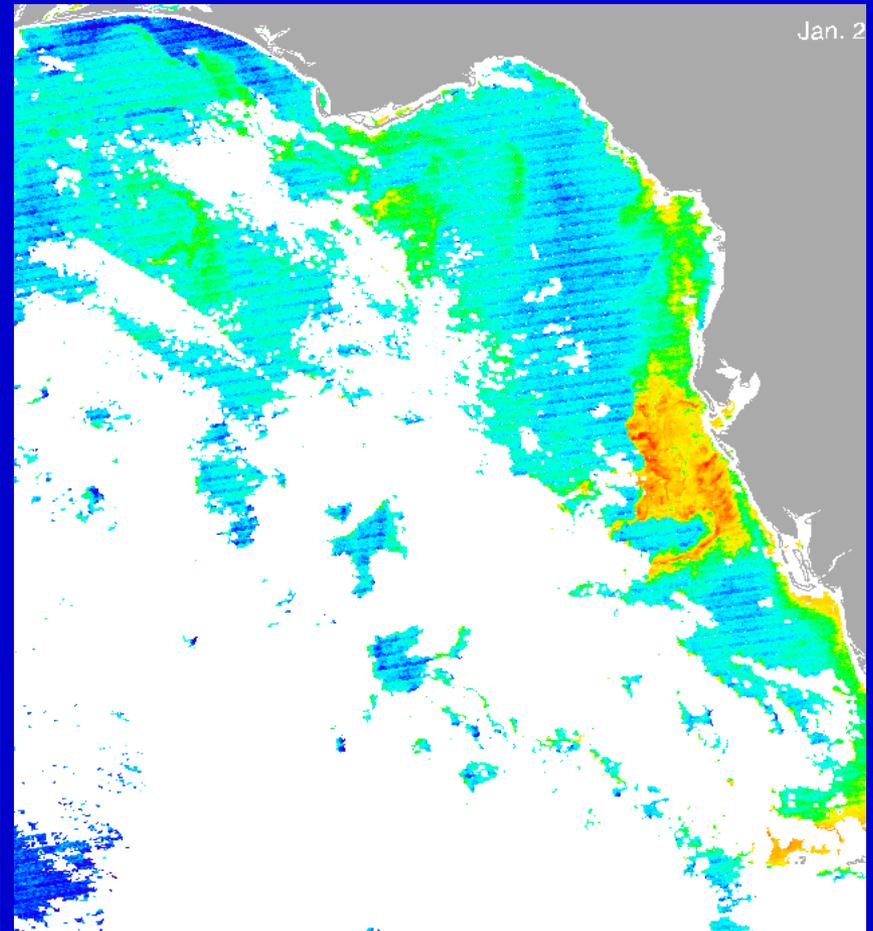
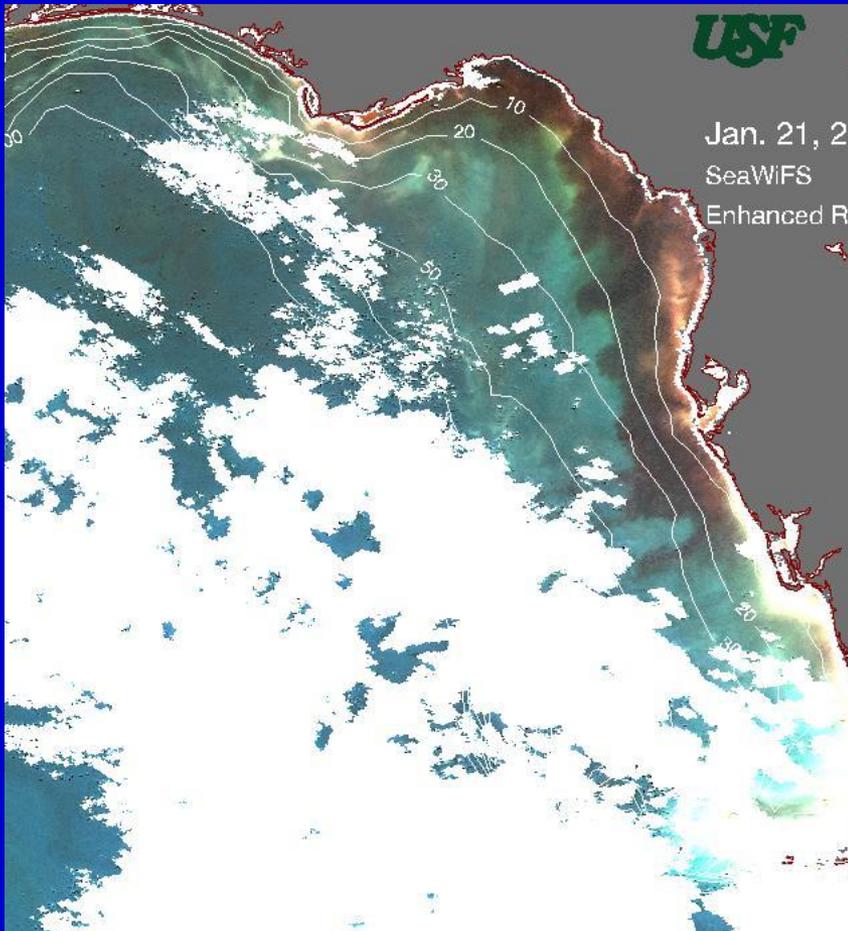
# Wastewater Management



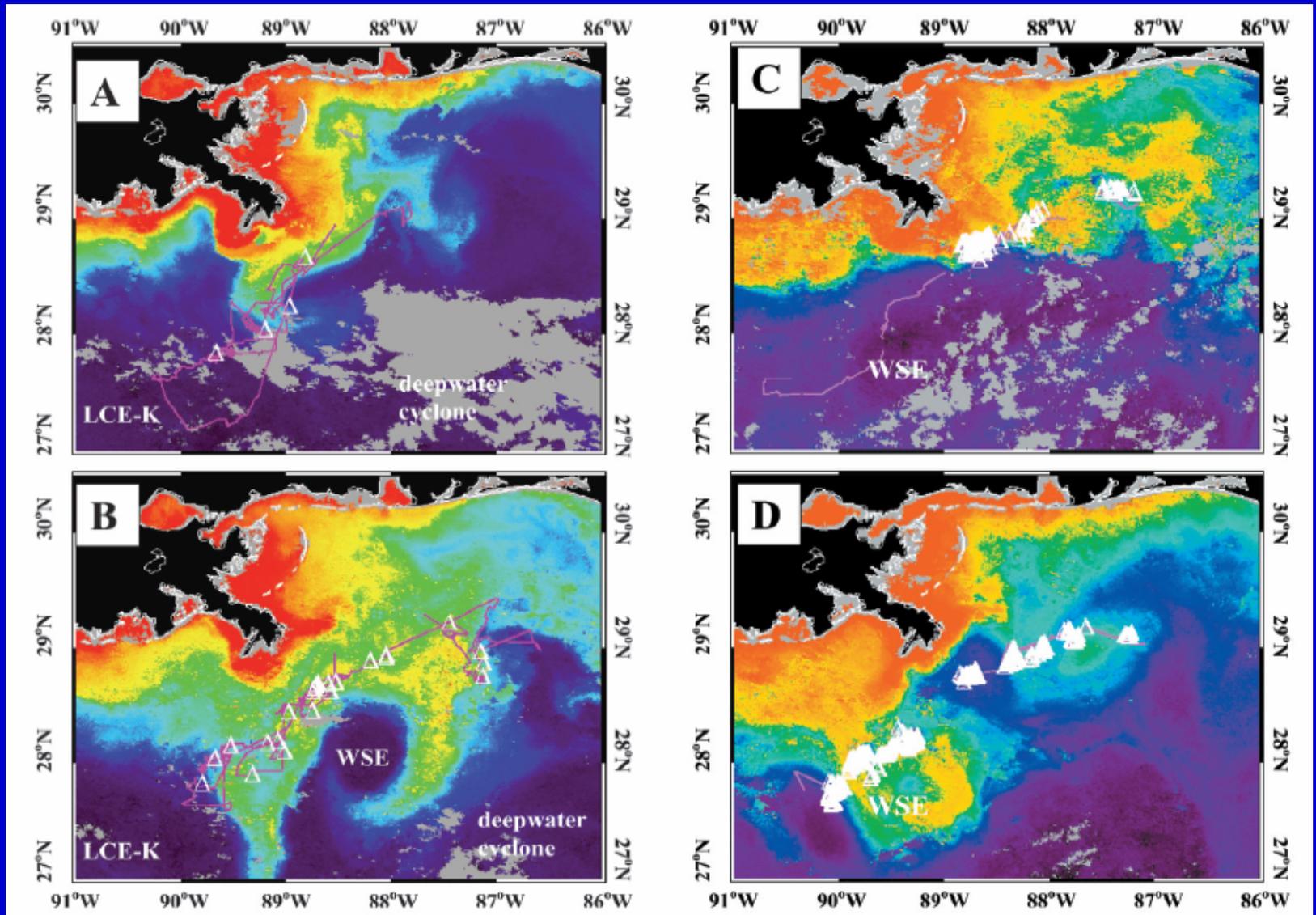
# Oil Search



# Plume or Bloom

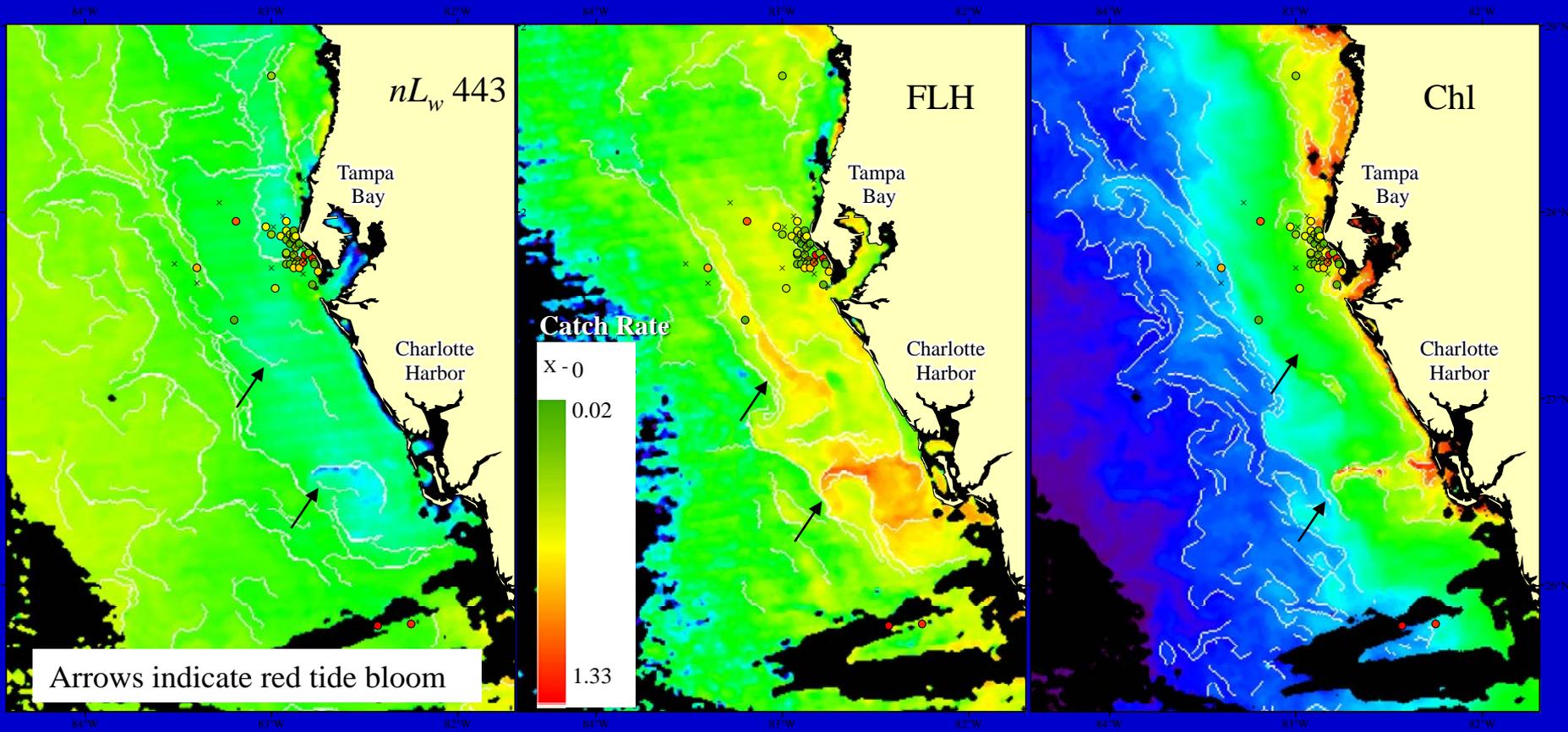


# Whale Locations



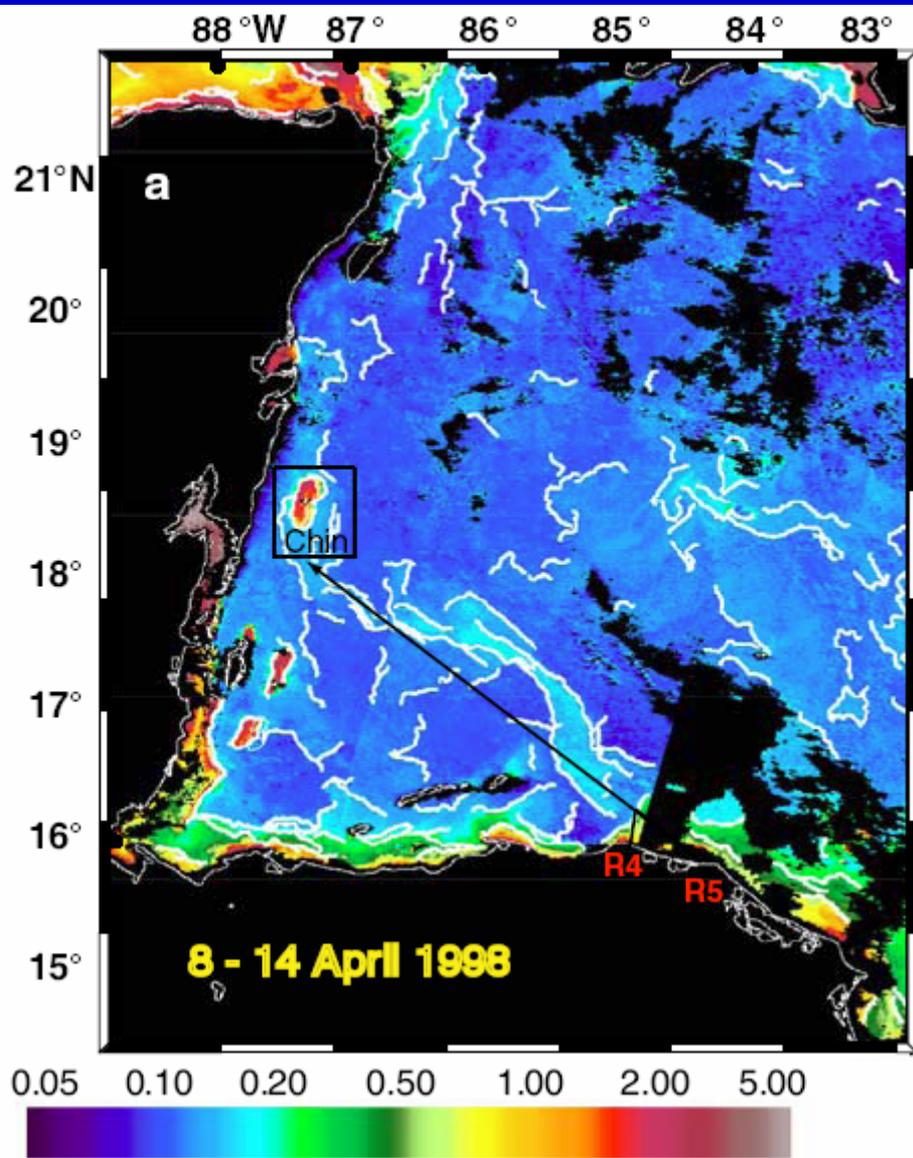
Biggs et al. (2006, AGU monograph)

# Fronts and Fish



Wall et al., (2009)

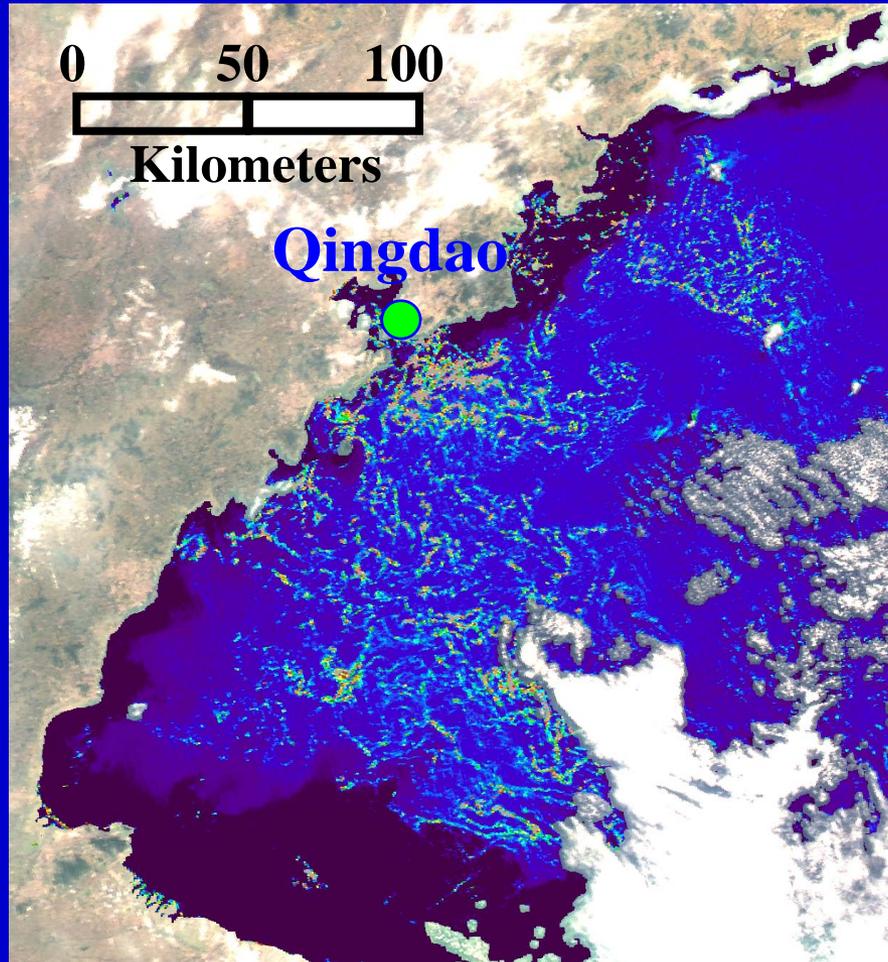
# Coral Reef Connectivity



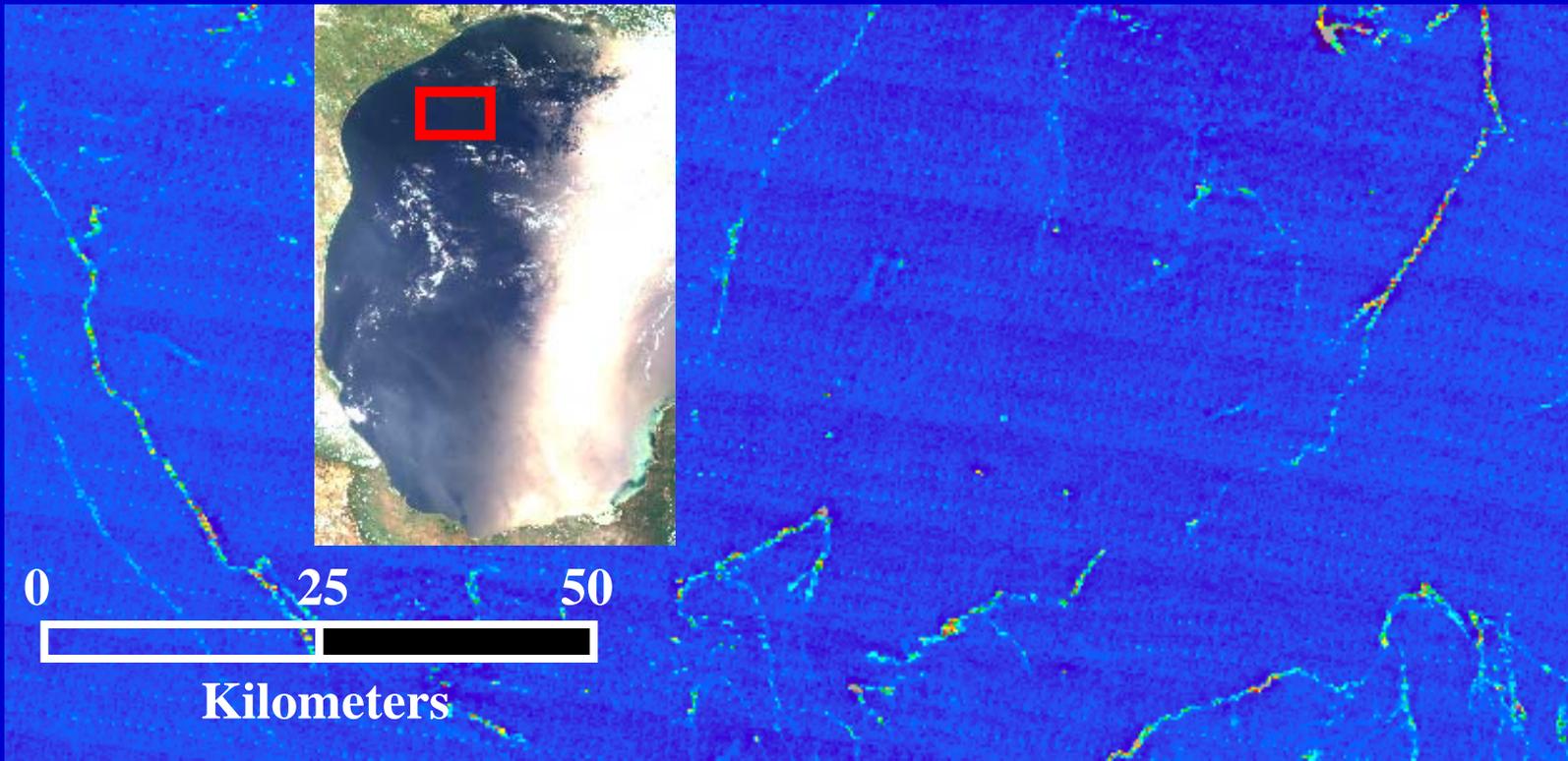
	BR1	BR2	BR3	TF	GLO	LH	Chin	COZ	GUA	ROA	UTI
Ulúa River (R1)	285	4	2	4	81	19	0	0	0	0	0
Cangrejal River (R2)	0	0	0	0	18	7	3	0	0	0	0
Aguán River (R3)	0	0	0	1	5	9	6	0	0	0	0
Sico Tinto River (R4)	0	0	0	0	0	5	23	6	0	0	0
Patuca River (R5)	0	0	0	0	0	0	1	1	0	0	0
Nicaragua (NIC)	0	0	0	0	0	0	0	1	0	0	0
Barrier Reef South (BR1)				1	5	0	0	0	0	0	0
Barrier Reef Middle (BR2)				108	116	6	0	0	0	0	0
Barrier Reef North (BR3)				114	1	4	1	0	0	0	0
Turneffe Atoll (TF)					81	8	11	0	0	0	0
Glovers Atoll (GLO)						50	0	0	0	0	0
Lighthouse (LH)							5	0	0	0	0
Chinchoro (Chin)								8	0	0	0
Cozumel (COZ)									0	0	0
Guanaja (GUA)										0	0
Roatán											0
Utila											

Soto et al. (2009)

# Green Tides



# Sargassum Pollution



# What's Next

## 1. Increase usage

User-friendly products

Involvement of end-users

## 2. Improve quality

Accuracy

Resolution

## 3. Inter-disciplinary

## 4. Increase \$

# Acknowledgements

- NASA, NOAA, EPA, USGS, NSF
- Florida DEP, FWCC
- Numerous collaborators