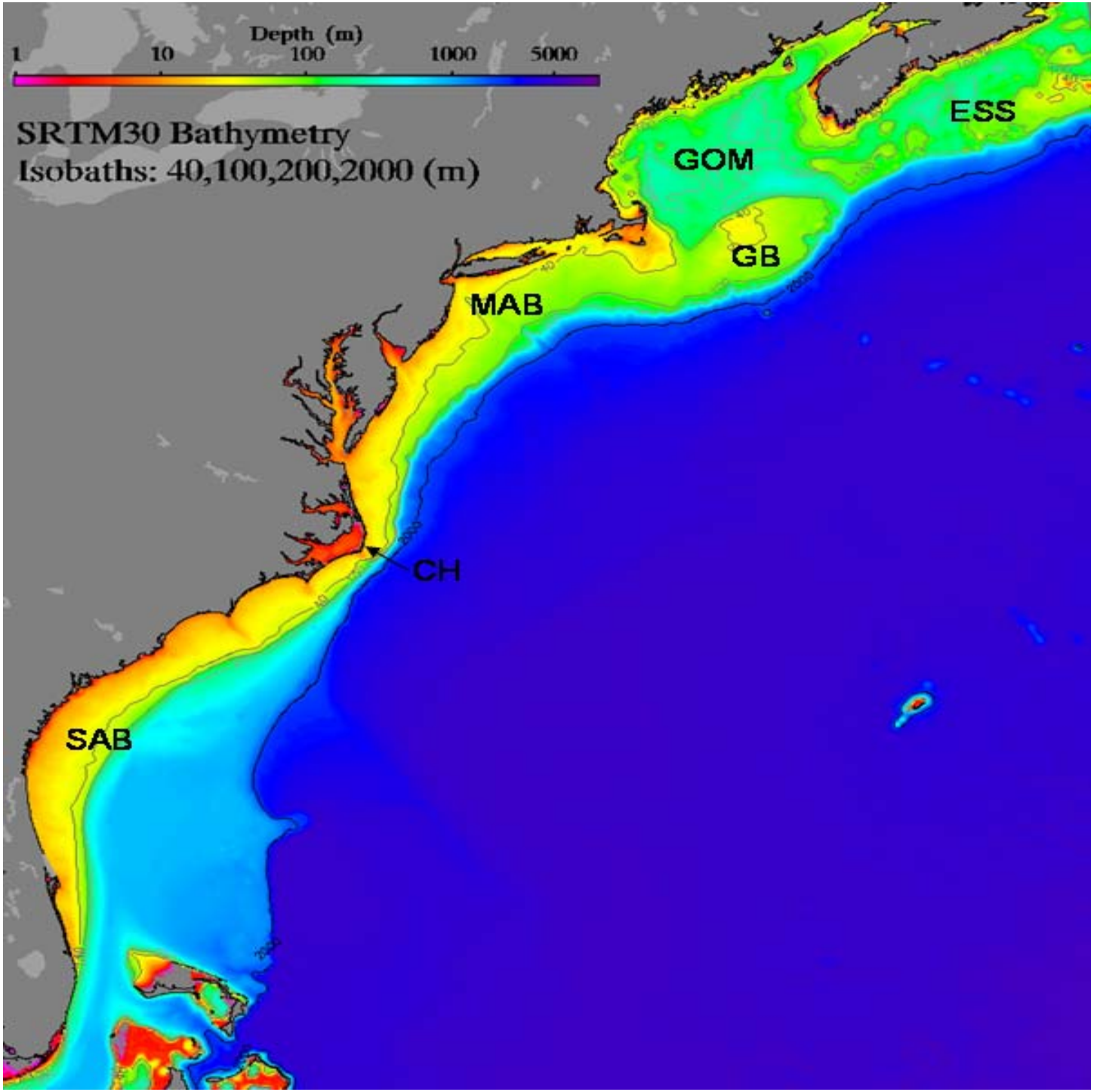
ECoS
East Coast
Satellite
Data
Analyses

O'Reilly
McClain
Signorini
Mannino



Topics

- **Status of Satellite-Derived Products and Climatologies**
- **Internal Consistency and Reasonableness of 'new' Satellite Products:**
  - **POC Clark**
  - **A_CDOM(355) Mannino**
  - **DOC Mannino**
- **Seasonal Cycles, Inter-Annual Anomalies and Trends in Chlorophyll and SST in Continental Shelf Water off the US East Coast (O'Reilly, McClain, Signorini, Belkin)**
- **Primary Production Estimates for the East Coast (including the SAB)**
- **New Primary Production Model (Marra & O'Reilly)**

Satellite-Derived Data: US ECoS

- A variety of satellite-derived measurements are being used to quantify and understand:
  - Regional,
  - Seasonal,
  - Inter-annual and
  - Climate-related

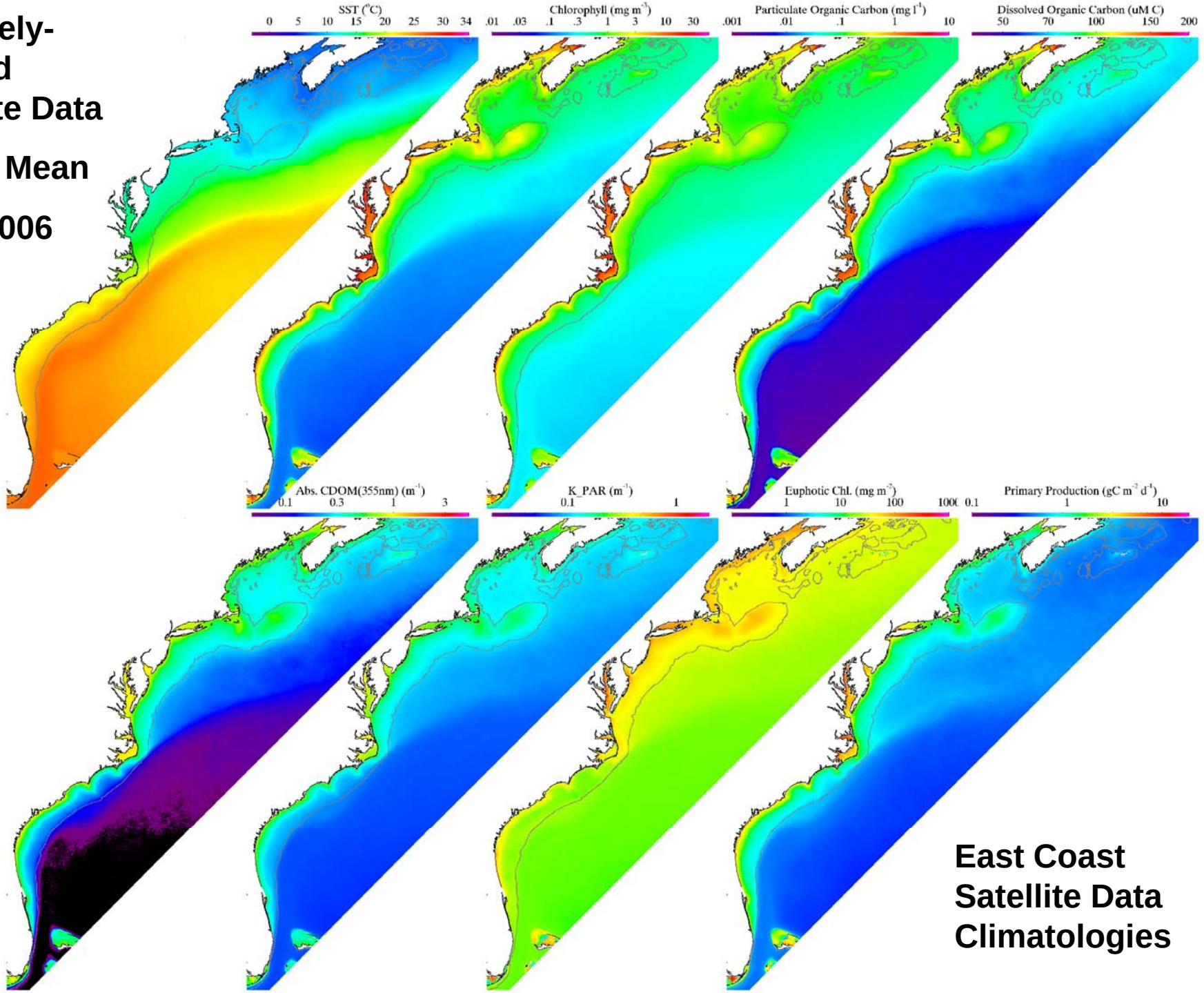
Variability of phytoplankton biomass and organic carbon production.

- Import/Export of particulate (POC) & dissolved organic carbon (DOC) via Estuaries, Warm Core Rings, Gulf Stream Advection at C. Hatteras.
- The satellite time series are particularly well suited for assessments of inter-annual and long term climate-related changes because they are spatially and temporally comprehensive and have a high degree of consistency in their accuracy and precision over time.
- Define statistical subareas (oceanographic subunits)
- Climatological comparisons with the coupled circulation-biogeochemical model to determine how well the model captures the mean condition, the dynamic range over seasonal time scales, and the regional differences in the timing of minima and maxima such as spring and fall phytoplankton blooms.

Remotely-Sensed Satellite Data

9-Year Mean

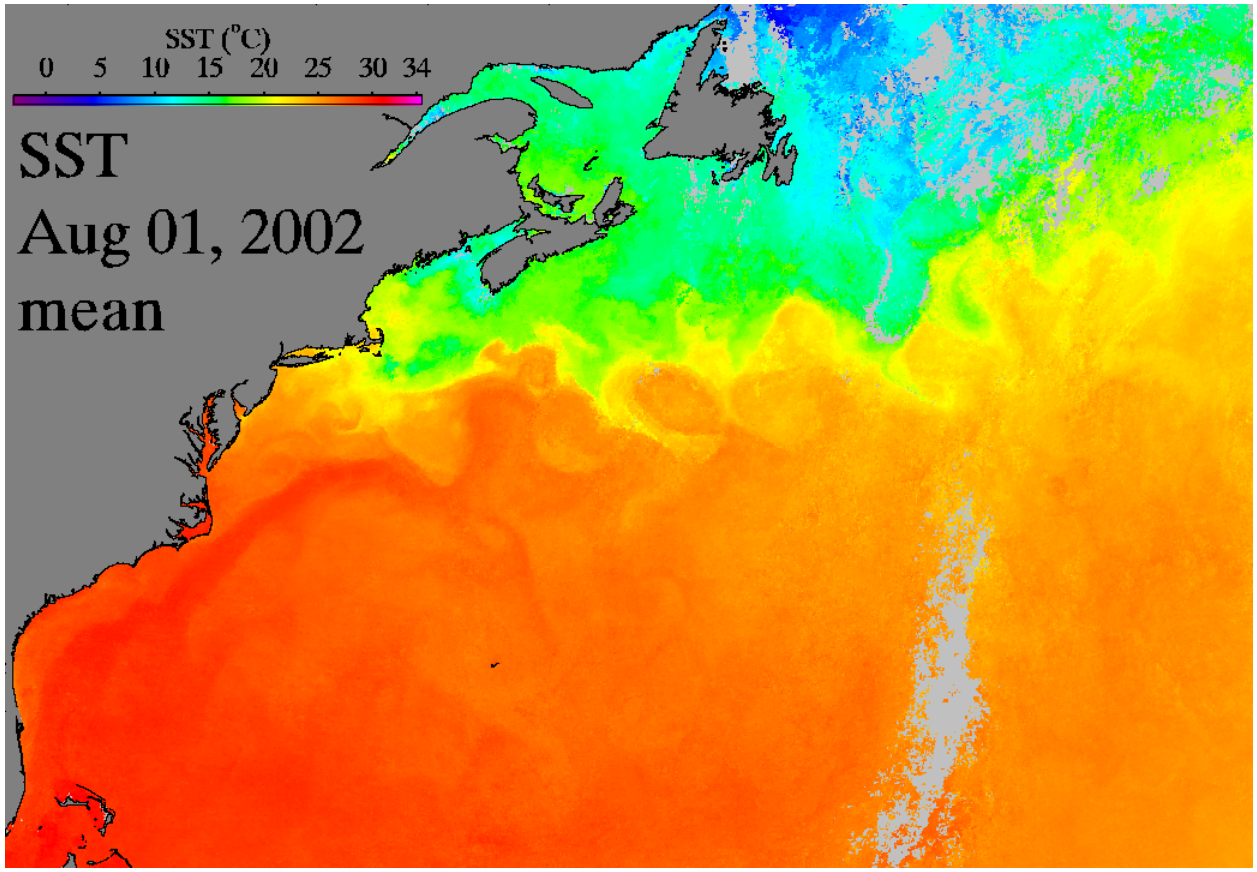
1998-2006



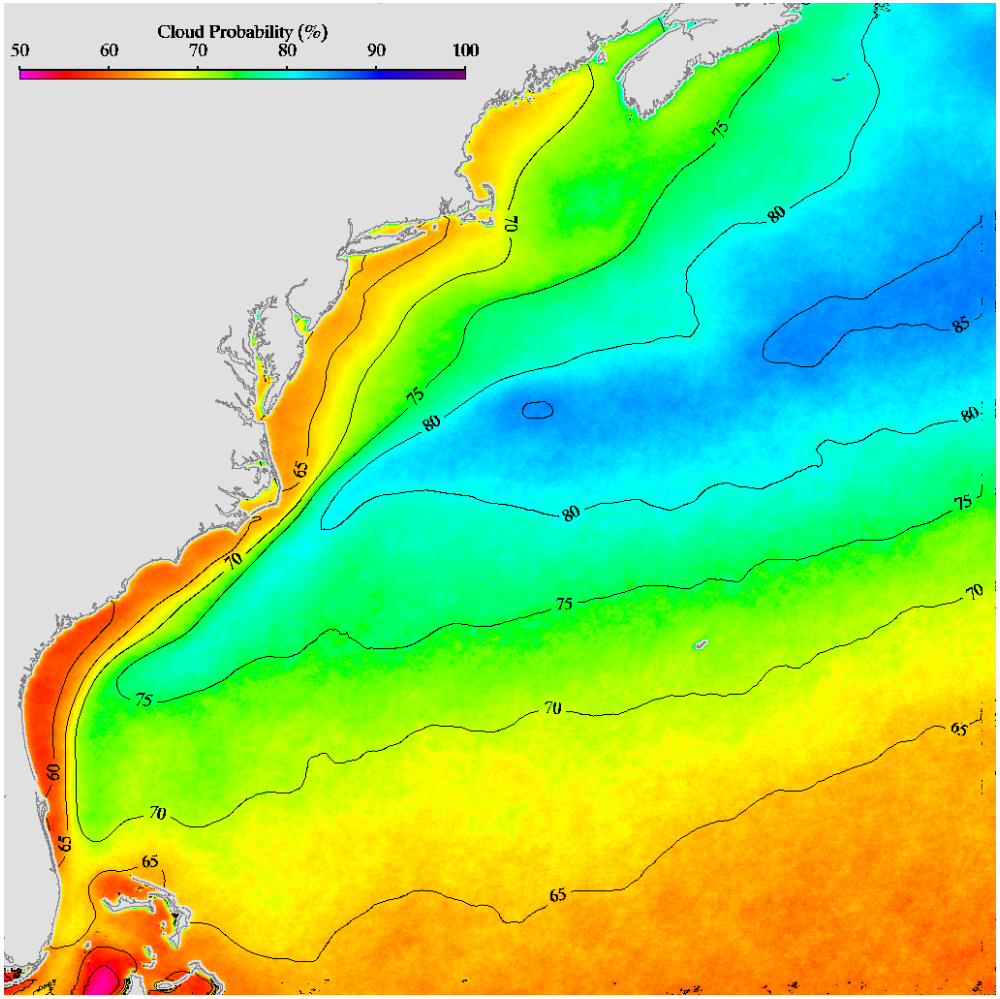
East Coast Satellite Data Climatologies

Sea Surface Temperature
- Merged Product -

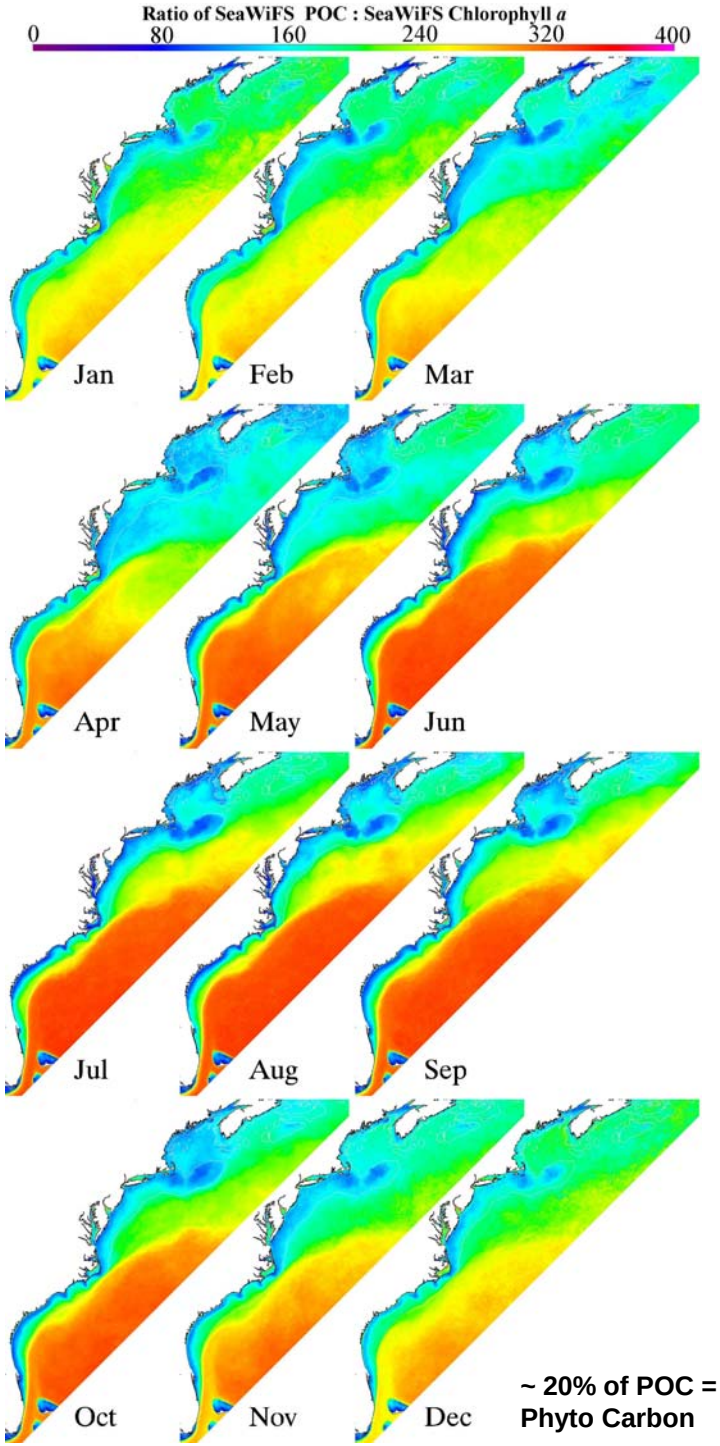
- **SST derived from multiple satellites to remove clouds**
- **Sources include: Pathfinder (AVHRR), MODIS Aqua, MODIS Terra, and GOES**



Credit: J. O'Reilly, C. Orphanides, T. Ducas

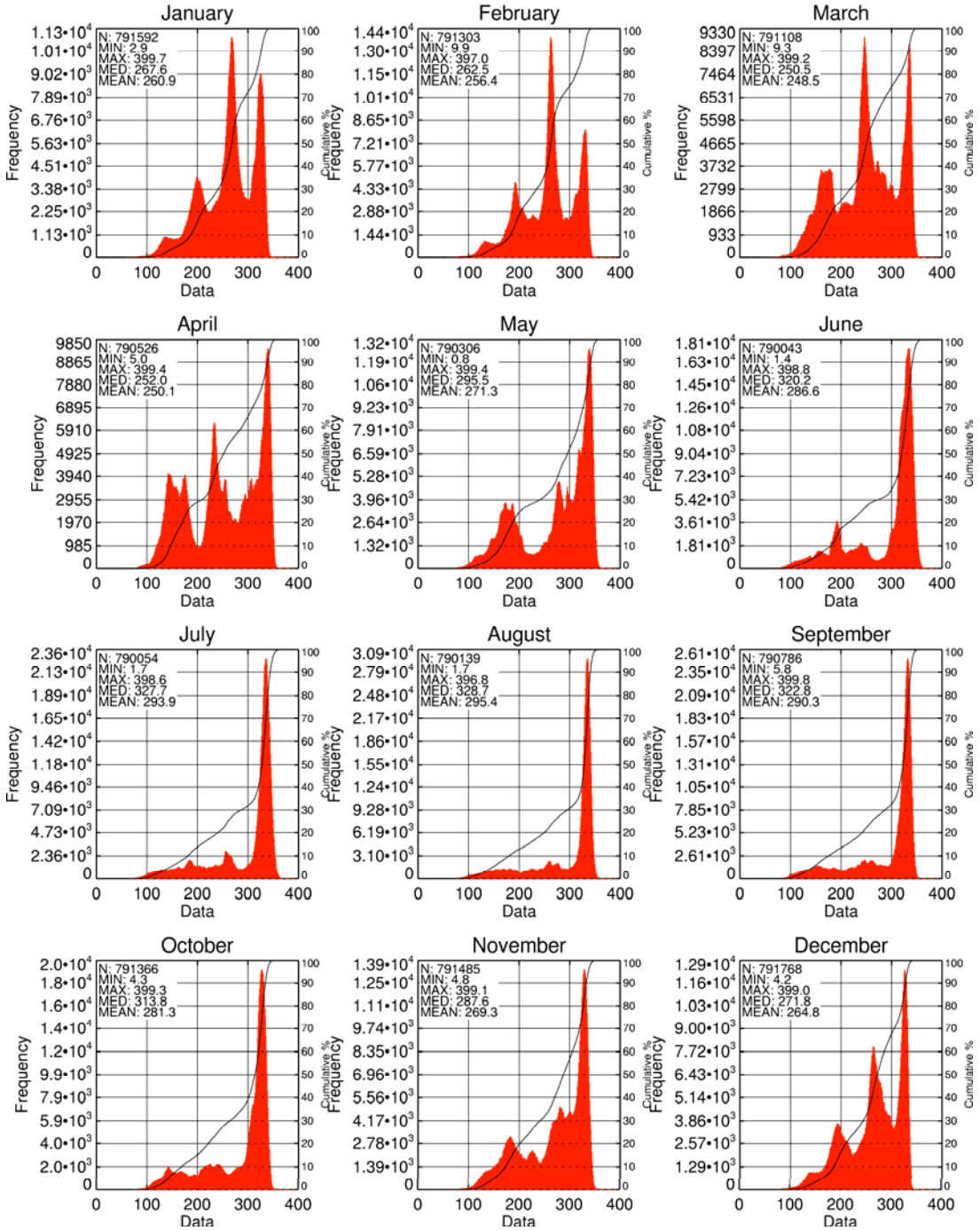


Cloud Probability. The mean probability (percent) of cloud cover based on all MLAC SeaWiFS scenes (Sept. 1997-Dec. 2006). The mean probability was computed by averaging the twelve monthly mean probabilities (O'Reilly, McClain, Signorini & Belkin)



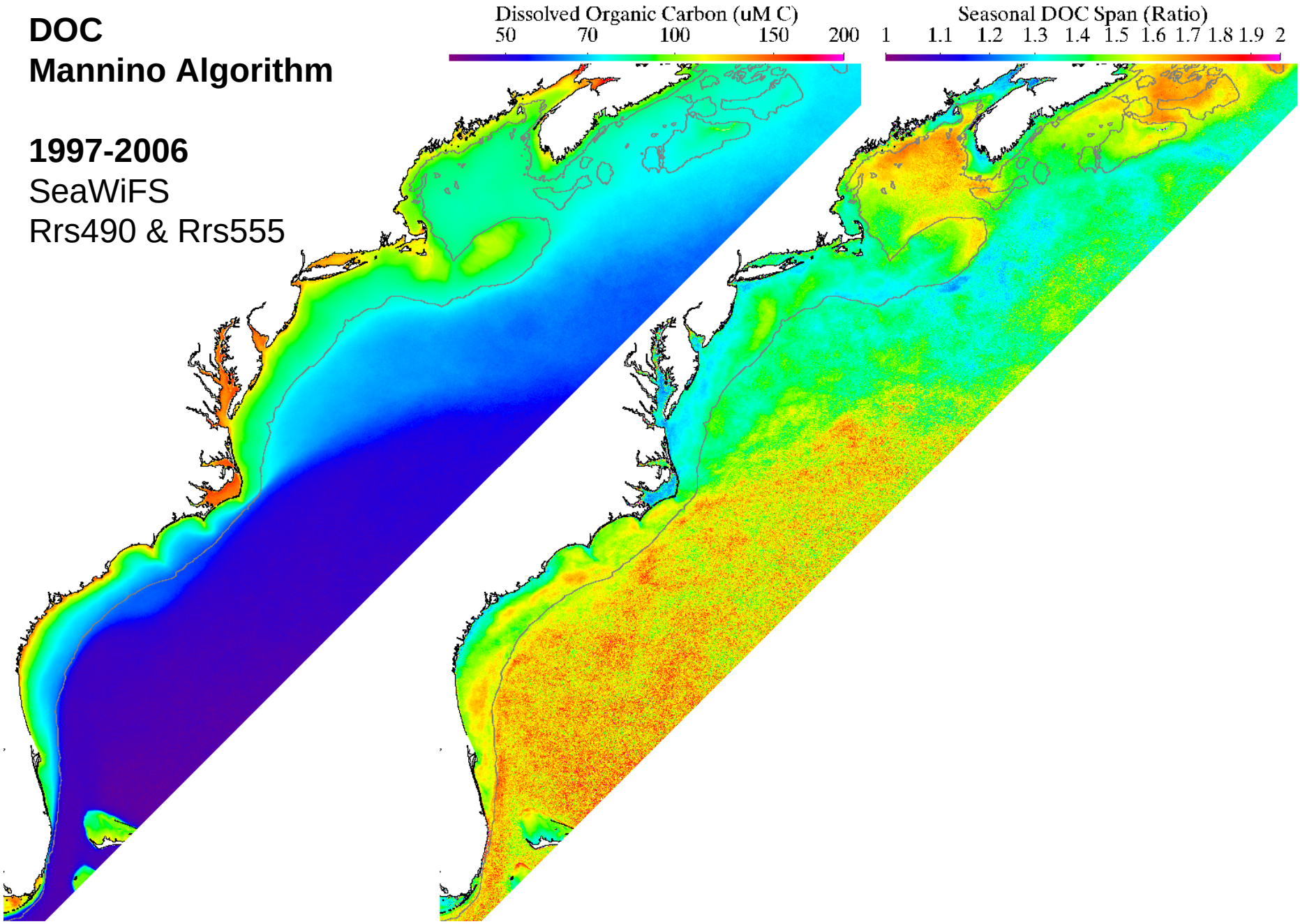
~ 20% of POC = Phyto Carbon

SeaWiFS POC : Chlorophyll (East Coast Map)

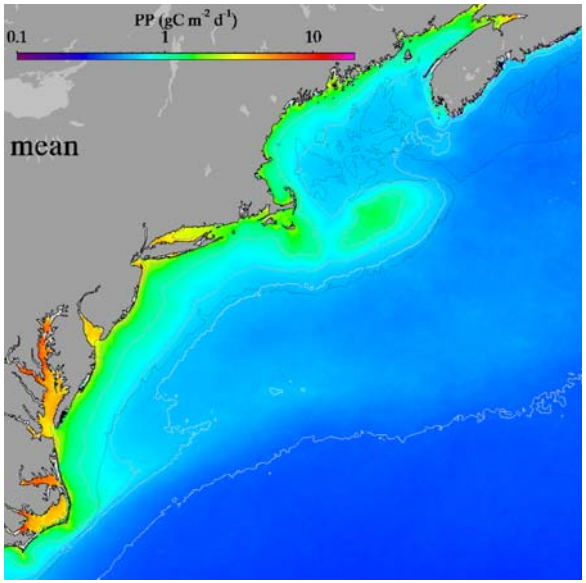


DOC
Mannino Algorithm

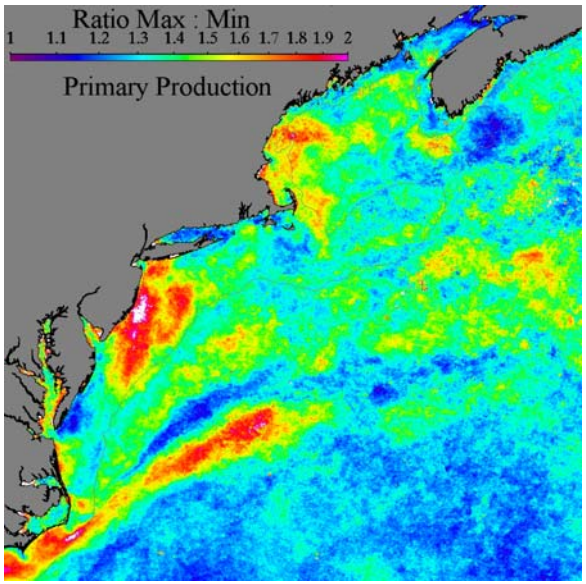
1997-2006
SeaWiFS
Rrs490 & Rrs555

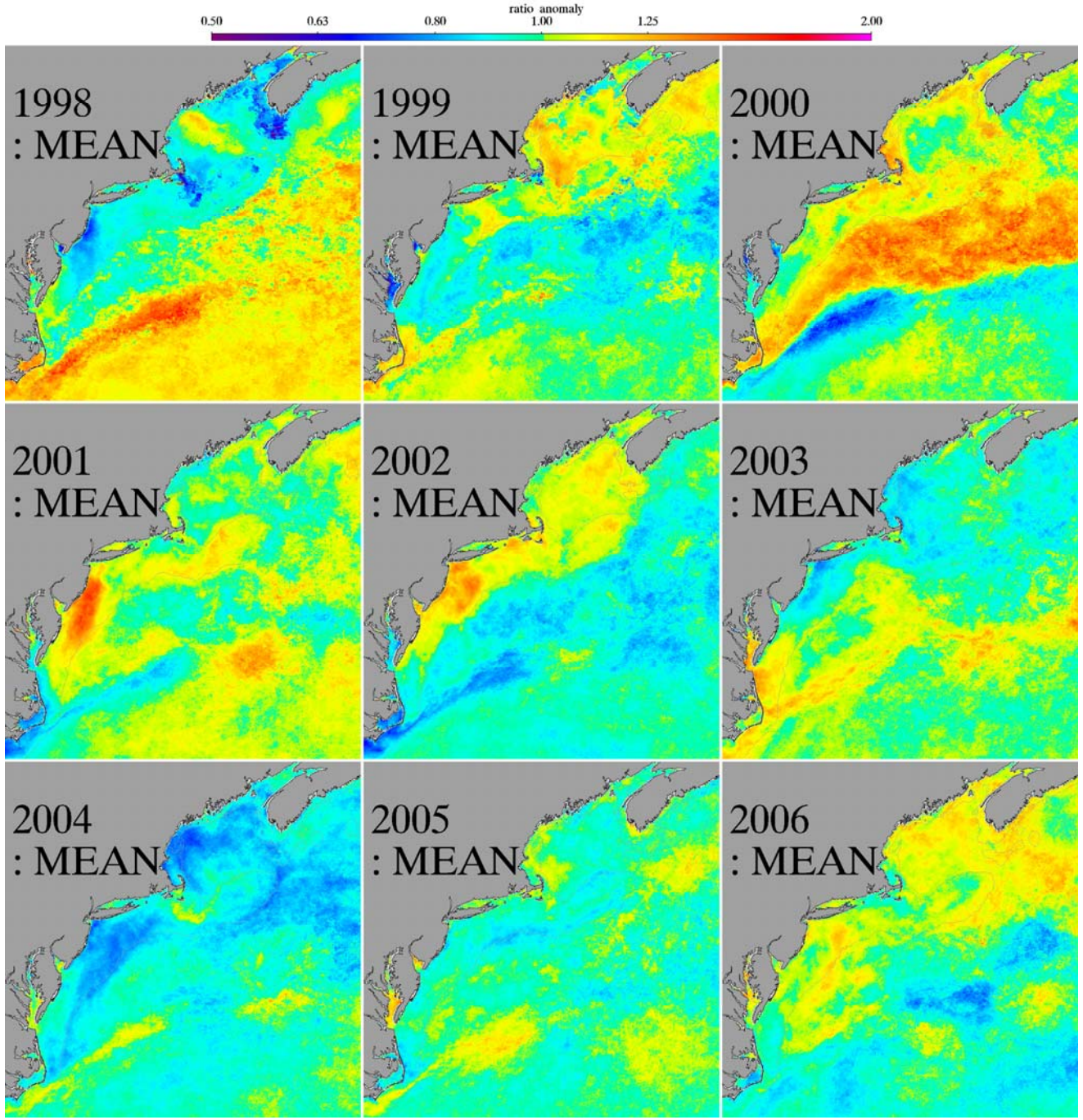


Mean Primary Production (1998 2006)



Inter-Annual Variability

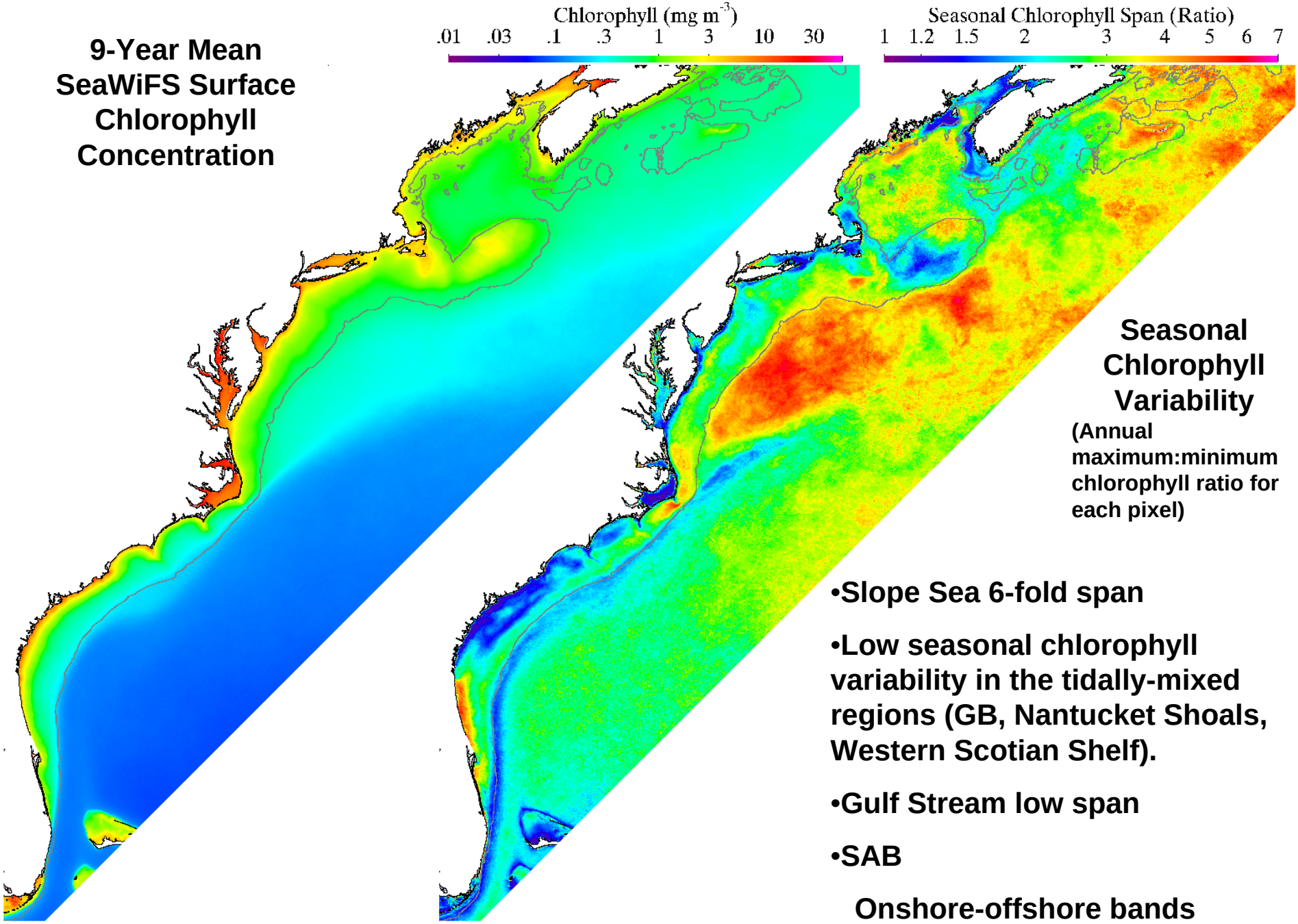




Seasonal Cycles, Inter-Annual Anomalies, and Trends in Satellite-Derrived Chlorophyll and SST in Continental Shelf Water off the US East Coast

O'Reilly, McClain, Signorini, Belkin

9-Year Mean SeaWiFS Surface Chlorophyll Concentration



Seasonal Chlorophyll Variability

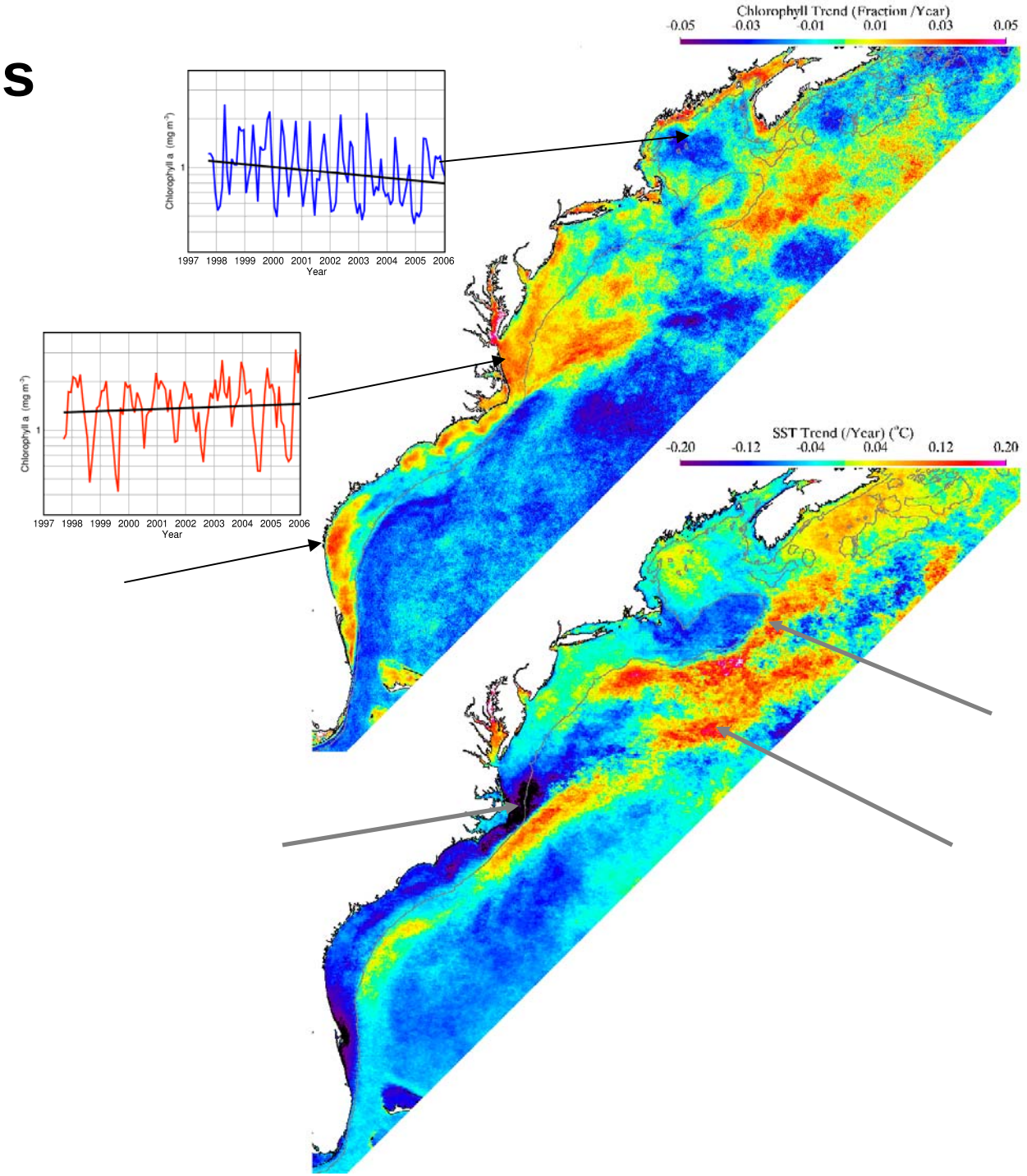
(Annual maximum:minimum chlorophyll ratio for each pixel)

- **Slope Sea 6-fold span**
- **Low seasonal chlorophyll variability in the tidally-mixed regions (GB, Nantucket Shoals, Western Scotian Shelf).**
- **Gulf Stream low span**
- **SAB**
  - **Onshore-offshore bands**
  - **N-S delineation at Jacksonville**

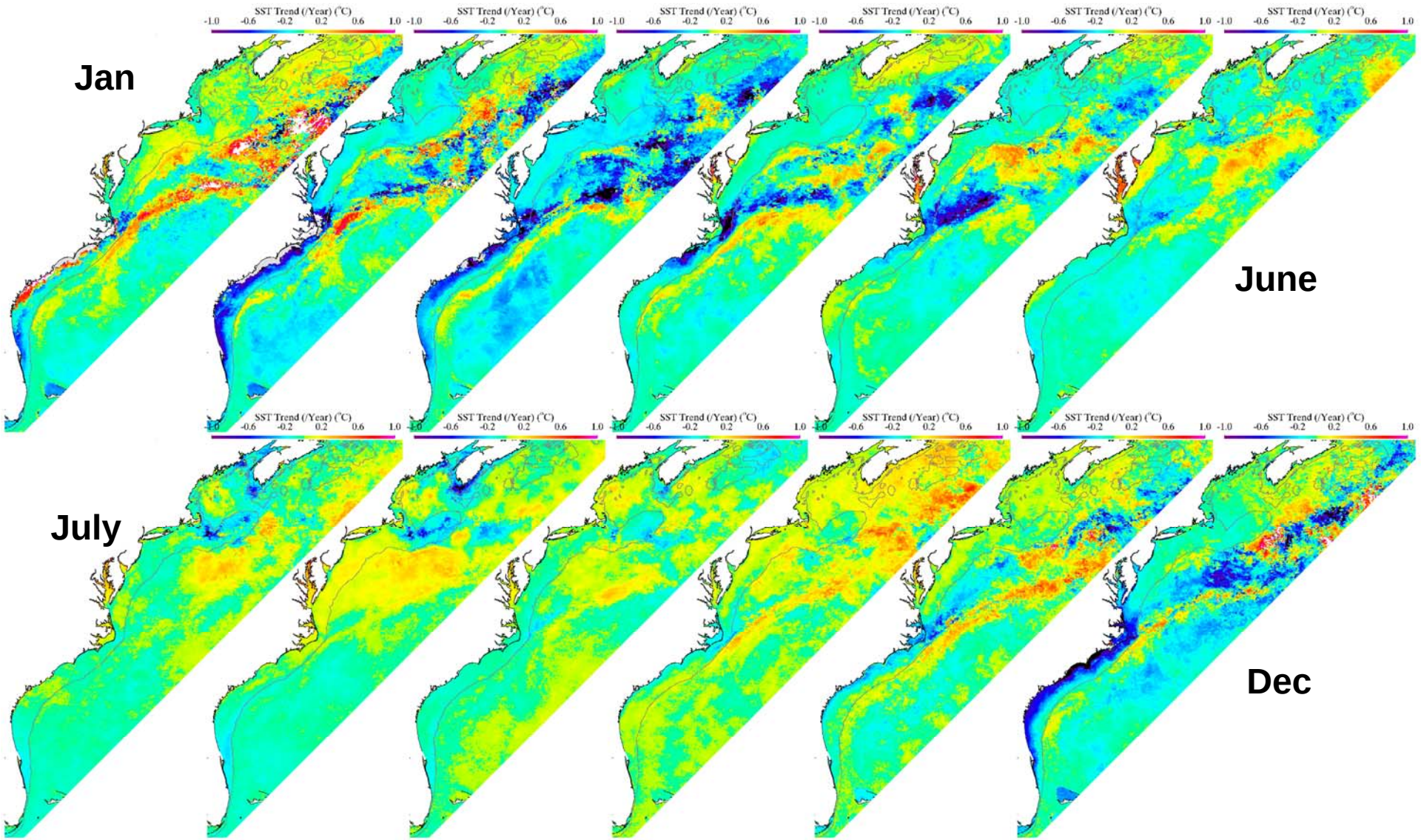
Long Term Trends

- 1998-2006
- The trend (change per year) for SST (lower) and chl (upper) based on the slope from a linear regression of monthly SST and chlorophyll anomalies versus the time period from September 1997 throught Dec 2006

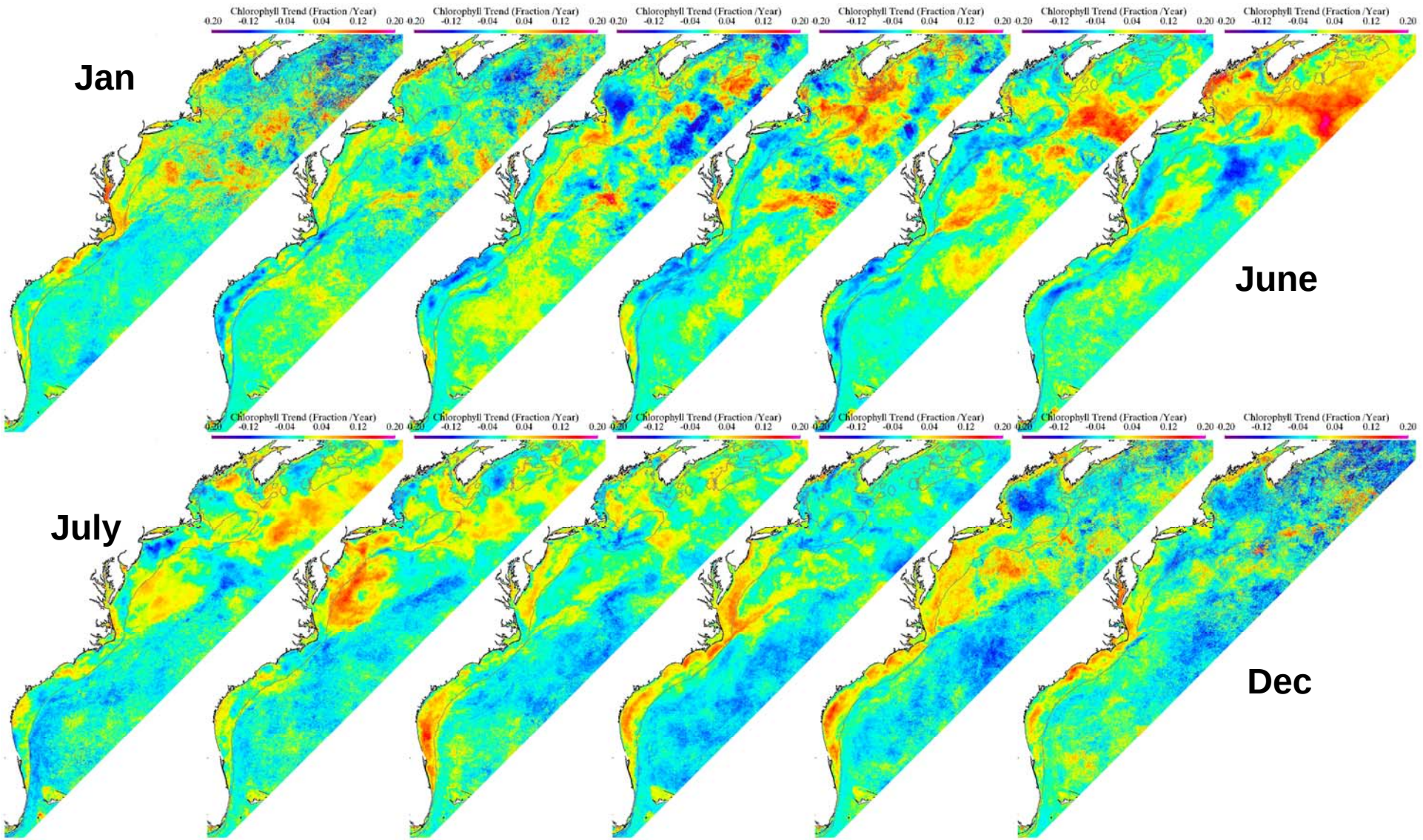
- Note southern MAB shelf
- Enhanced stratification in the Western Gulf of Maine ?
- Warming trend in Northern Slope Sea and 'upstream' Eastern Scotian Shelf
- (Two bands with a warming trend: one from Slope and one from the Gulf Stream

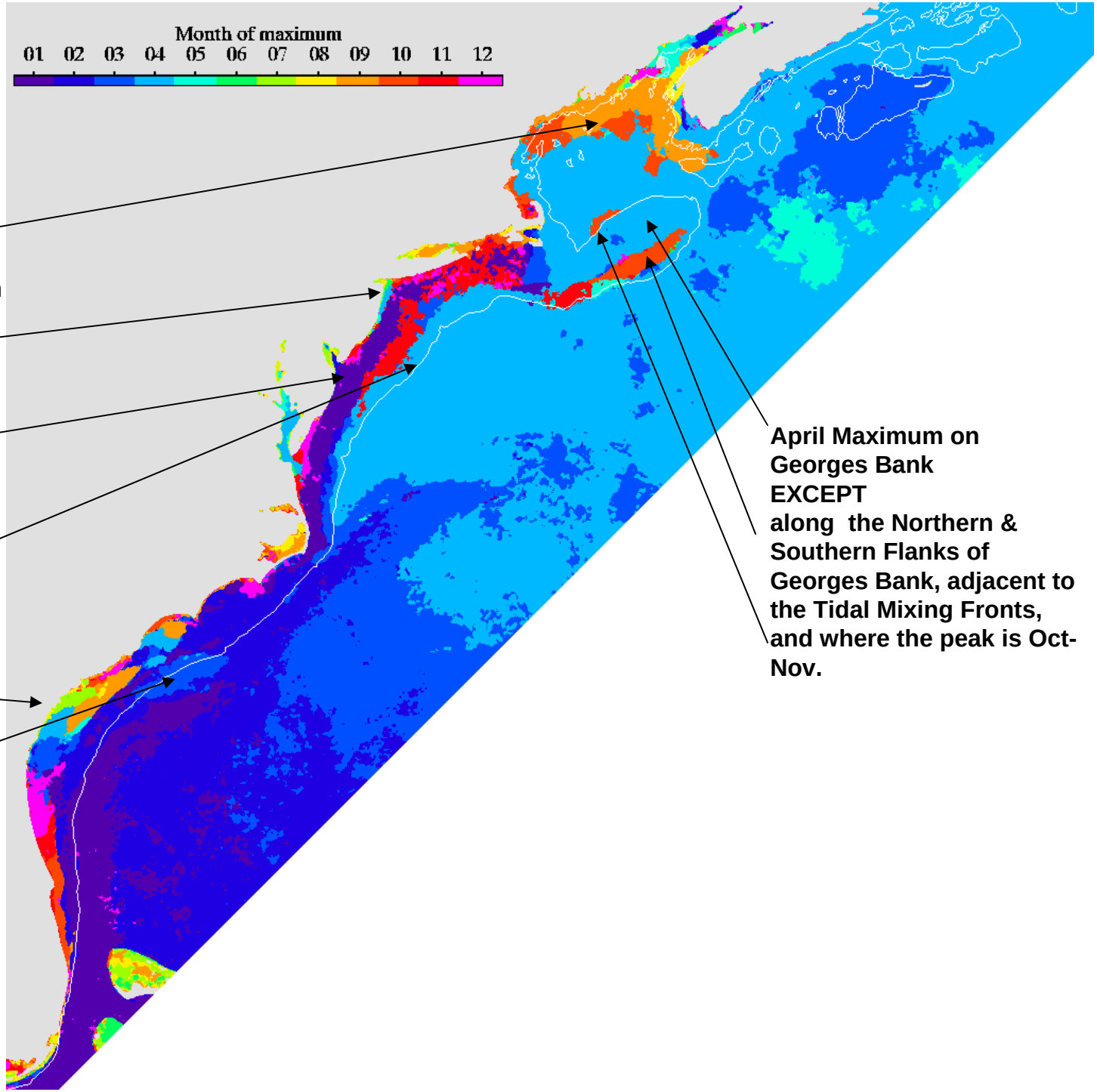


SST Trends for each Month, 1998-2006



SeaWiFS Chlorophyll Trends for each Month, 1998-2006





• Fall bloom (Sept. Oct) in Northern Gulf of Maine dominates over Spring Bloom

•May-June Hudson-Raritan Estuarine Plume (coincident with runnoff)

•Spring Bloom in January in the inner MAB shelf

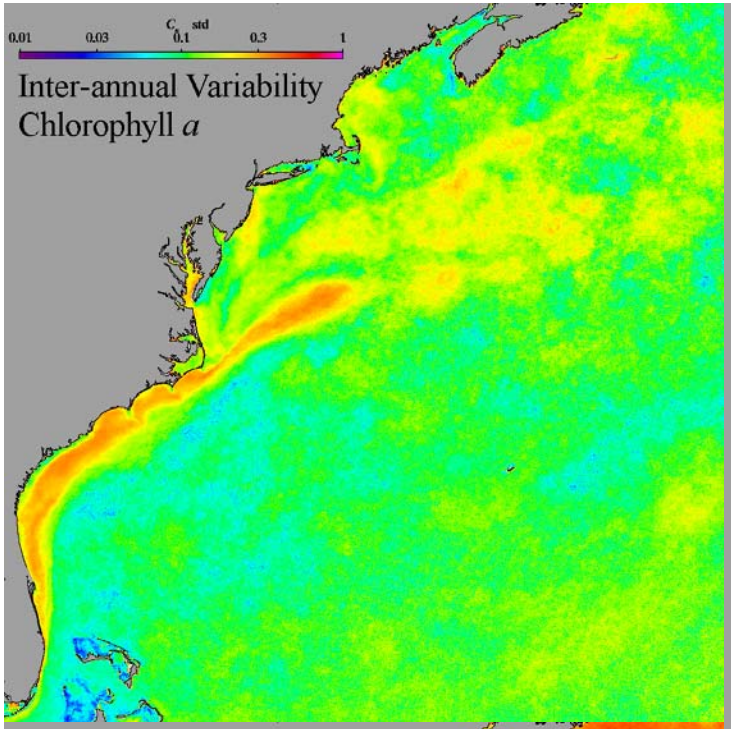
•Outer MAB SHELF & Slope Sea: April

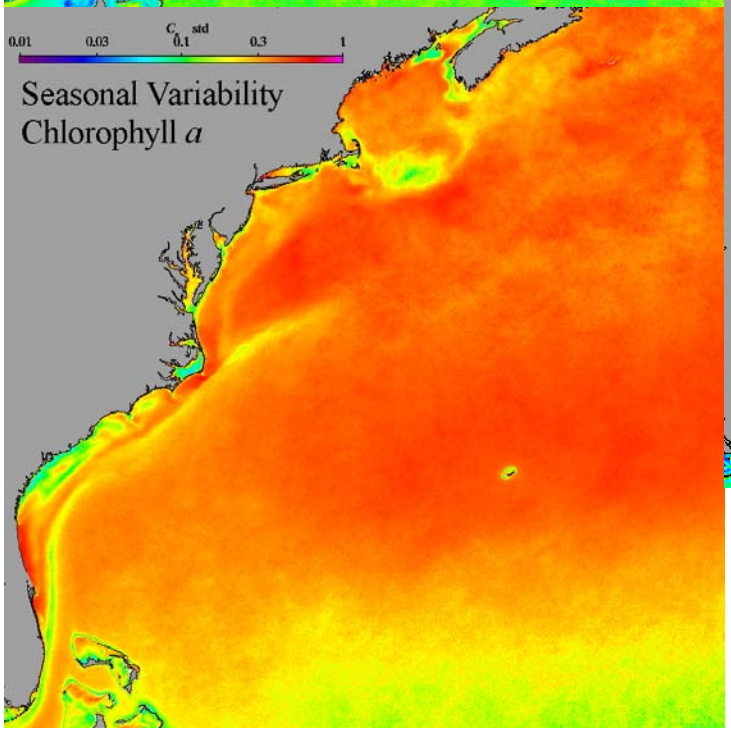
•Surprising degree of Spatial Heterogeneity in the timing of peak in the SAB

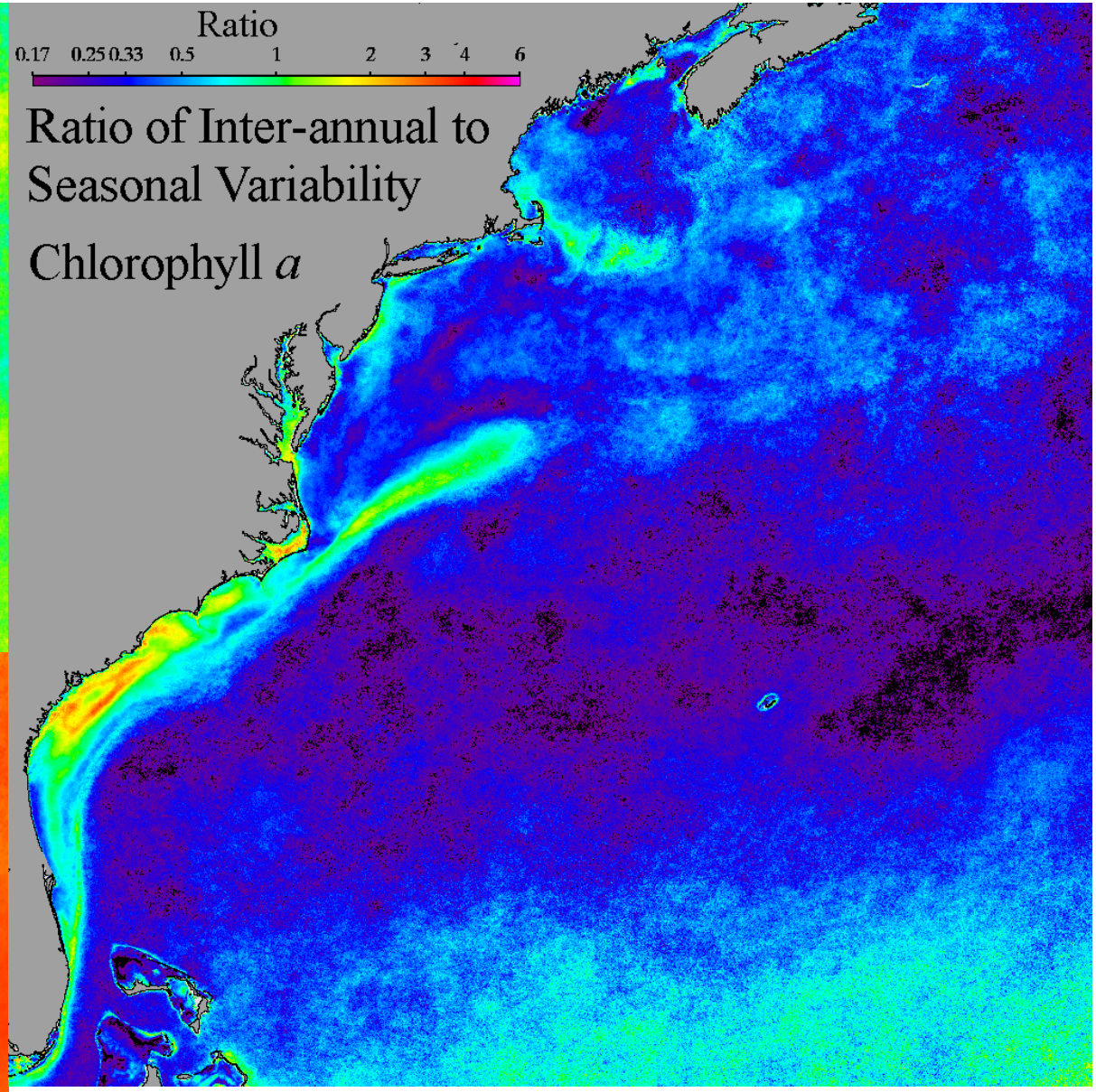
•Charleston Bump is Evident

•Meso-scale patchiness

April Maximum on Georges Bank EXCEPT along the Northern & Southern Flanks of Georges Bank, adjacent to the Tidal Mixing Fronts, and where the peak is Oct-Nov.







Inter-annual variability is significant:

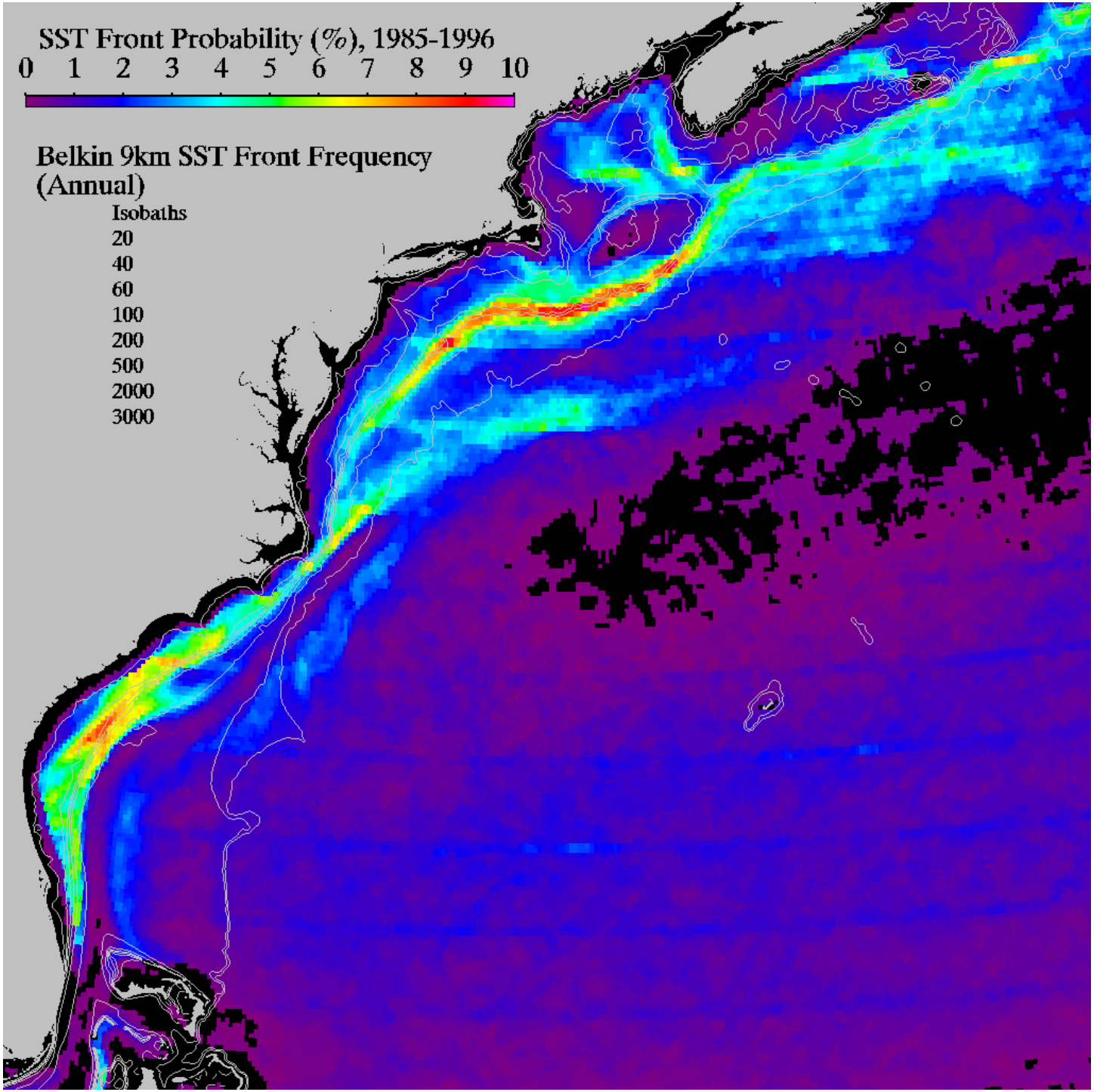
Northern SAB Midshelf; Gulf Stream; Hudson-Raritan, Delaware & Chesapeake Plumes; Coastal NJ Upwelling Region;

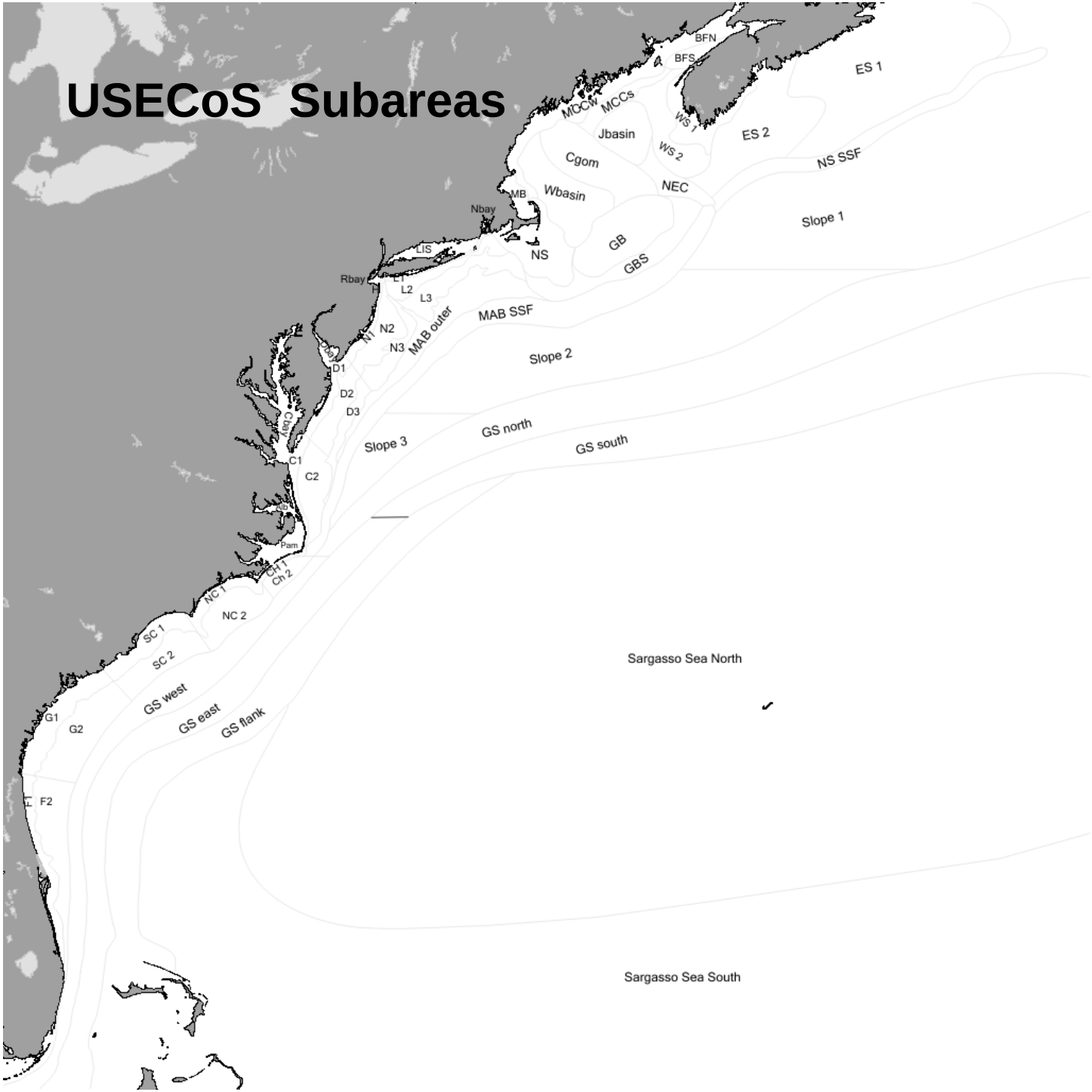
Mass Bay & Great South Channel region.

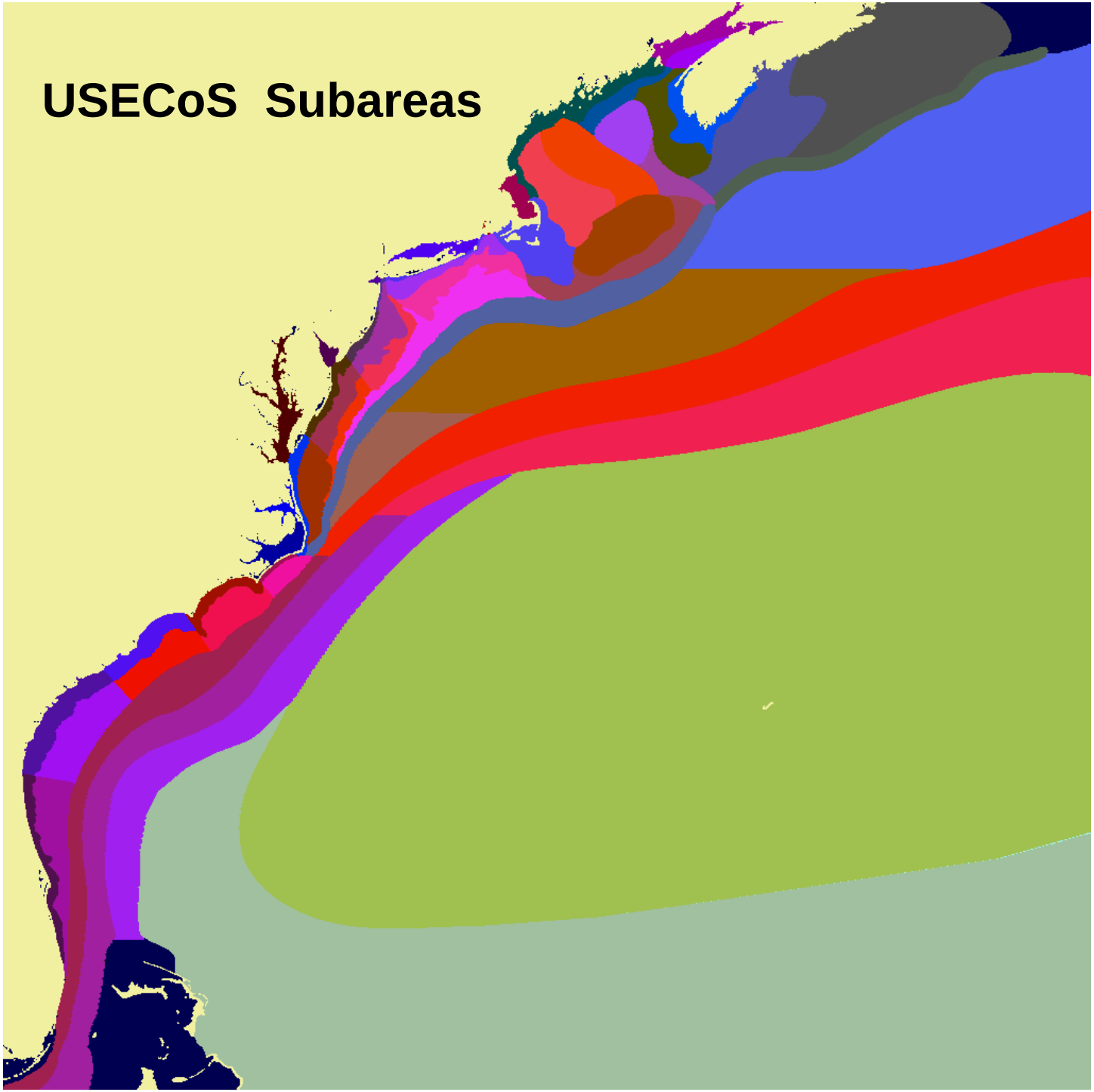
Spatial and Hydrographic Variability

- **Shelf slope front**
- **Tidal mixing fronts**
- **Gulf Stream front**
- **Seasonally stratified vs. tidally-mixed**

- **SAB: Gulf Stream-Shelf Front**
- **MAB: Shelf-Slope Front**
- **Spatial structure within the Slope Sea**




USECoS Subareas
BFN
BFS
ES 1
MCCs
MCCW
WS 1
ES 2
Jbasin
WS 2
NS SSF
Cgom
NEC
MB
Wbasin
Nbay
Slope 1
NS
GB
LIS
GBS
Rbay
L1
L2
L3
MAB SSF
MAB outer
N1
N2
N3
Slope 2
D1
D2
D3
GS north
Slope 3
GS south
C1
C2
Pam
Ch 1
Ch 2
NC 1
NC 2
SC 1
SC 2
Sargasso Sea North
GS west
GS east
GS flank
G1
G2
F2
Sargasso Sea South


USECoS Subareas

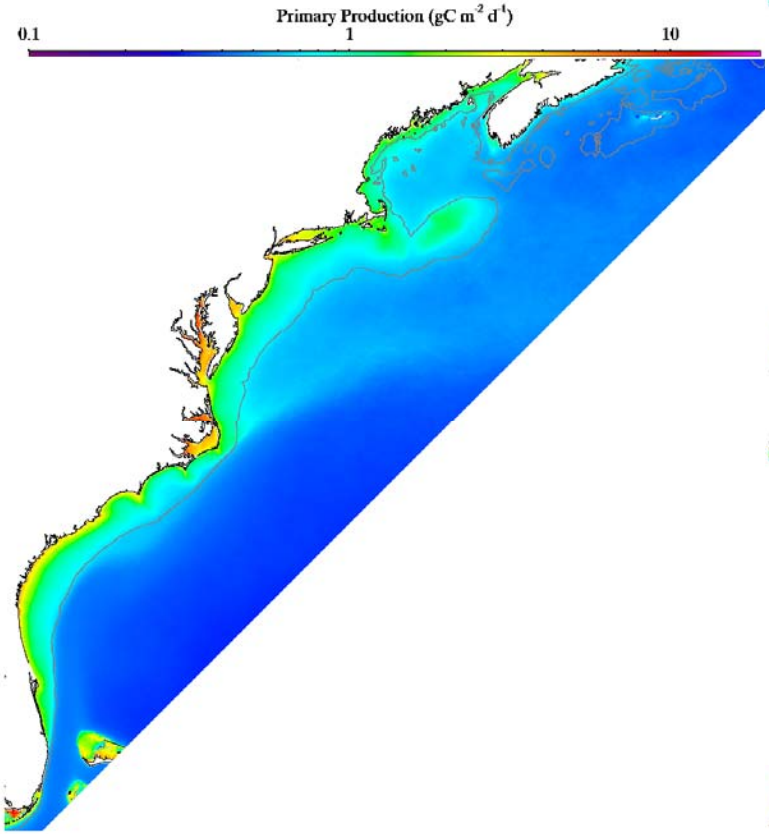
Mean Daily Primary Production

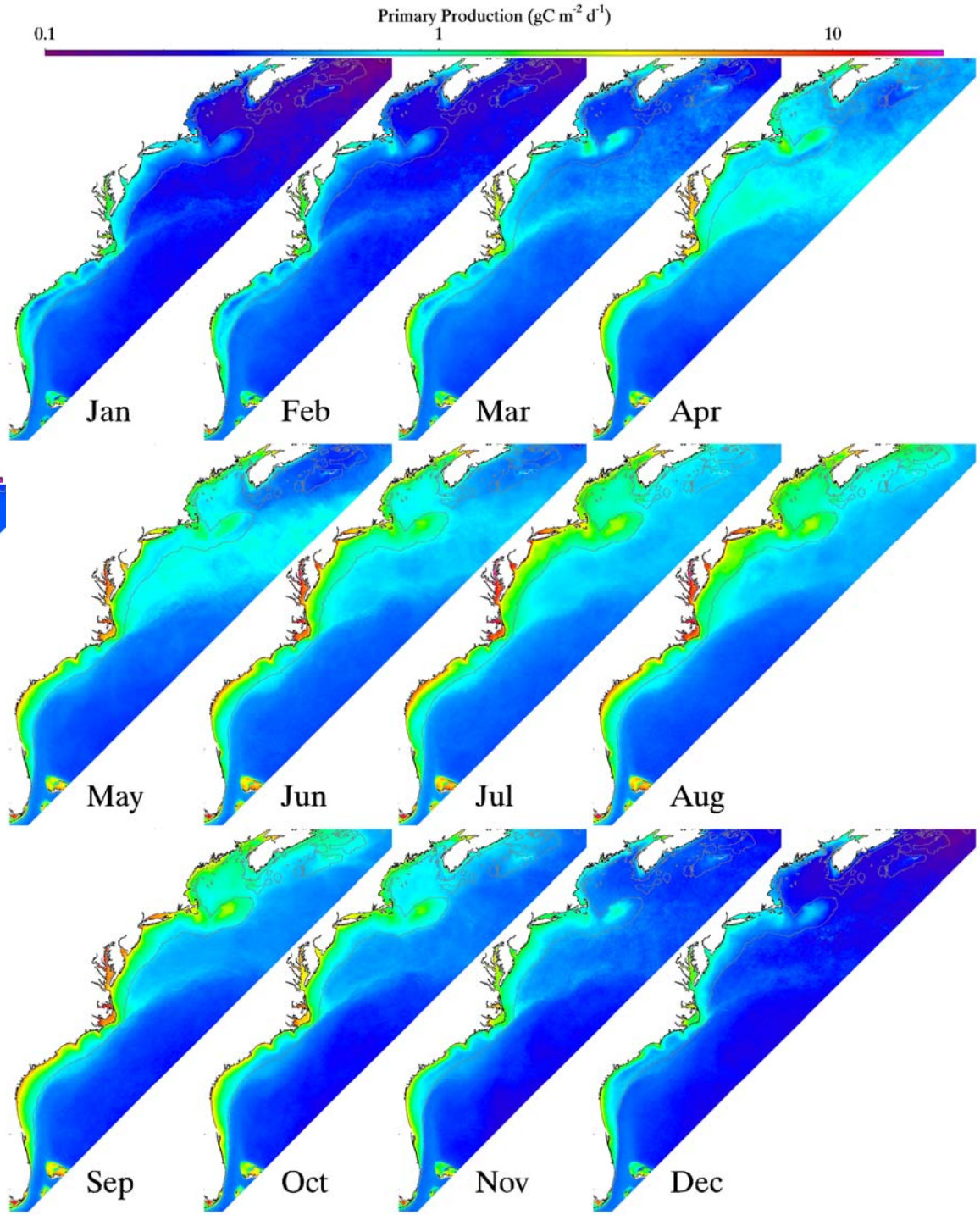
1997-2006

VGPM2a

SeaWiFS Chlorophyll & PAR

SST (AVHRR, MODIS Terra & Aqua)



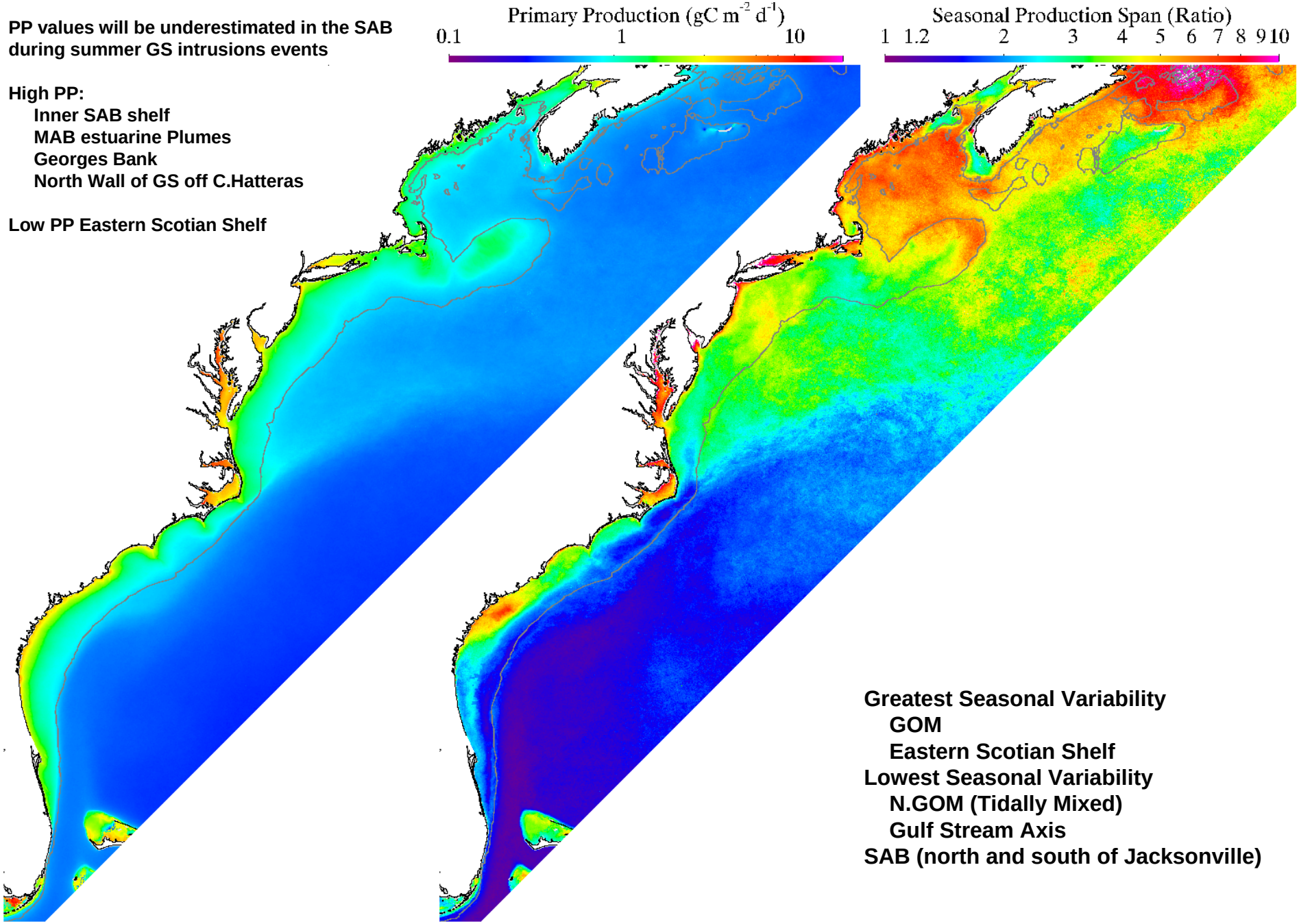


PP values will be underestimated in the SAB during summer GS intrusions events

High PP:

- **Inner SAB shelf**
- **MAB estuarine Plumes**
- **Georges Bank**
- **North Wall of GS off C.Hatteras**

Low PP Eastern Scotian Shelf



Greatest Seasonal Variability

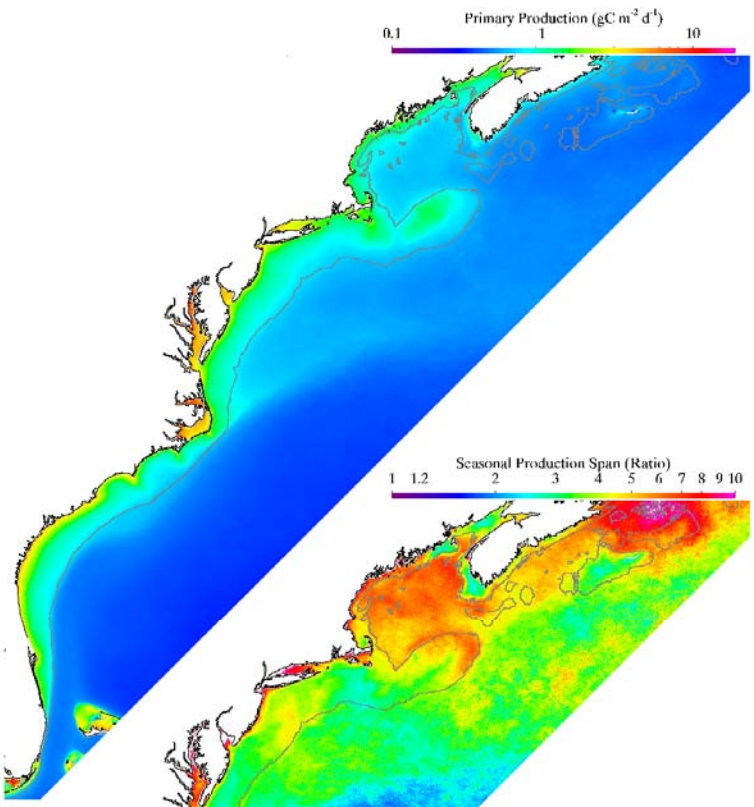
- **GOM**
- **Eastern Scotian Shelf**

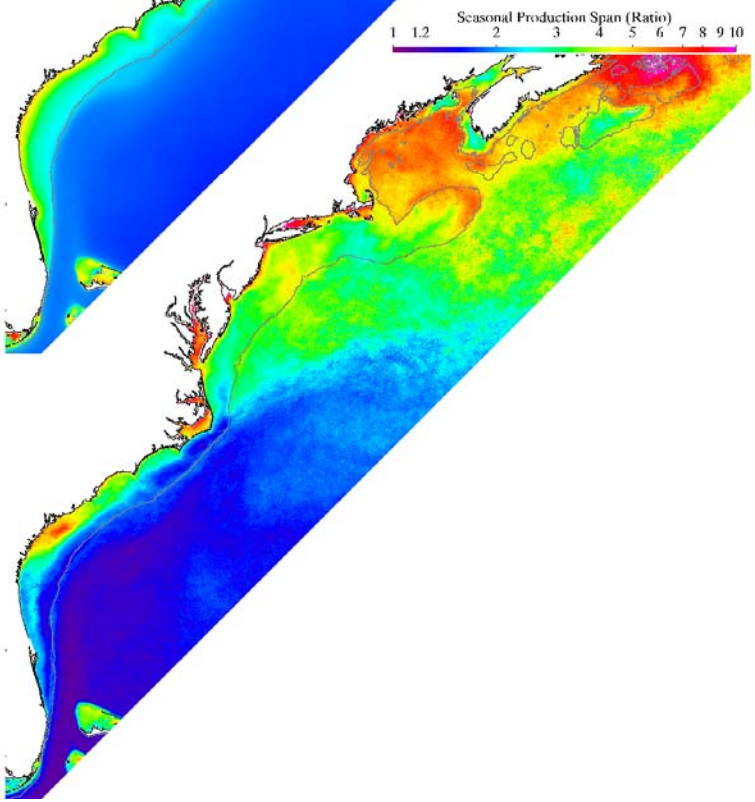
Lowest Seasonal Variability

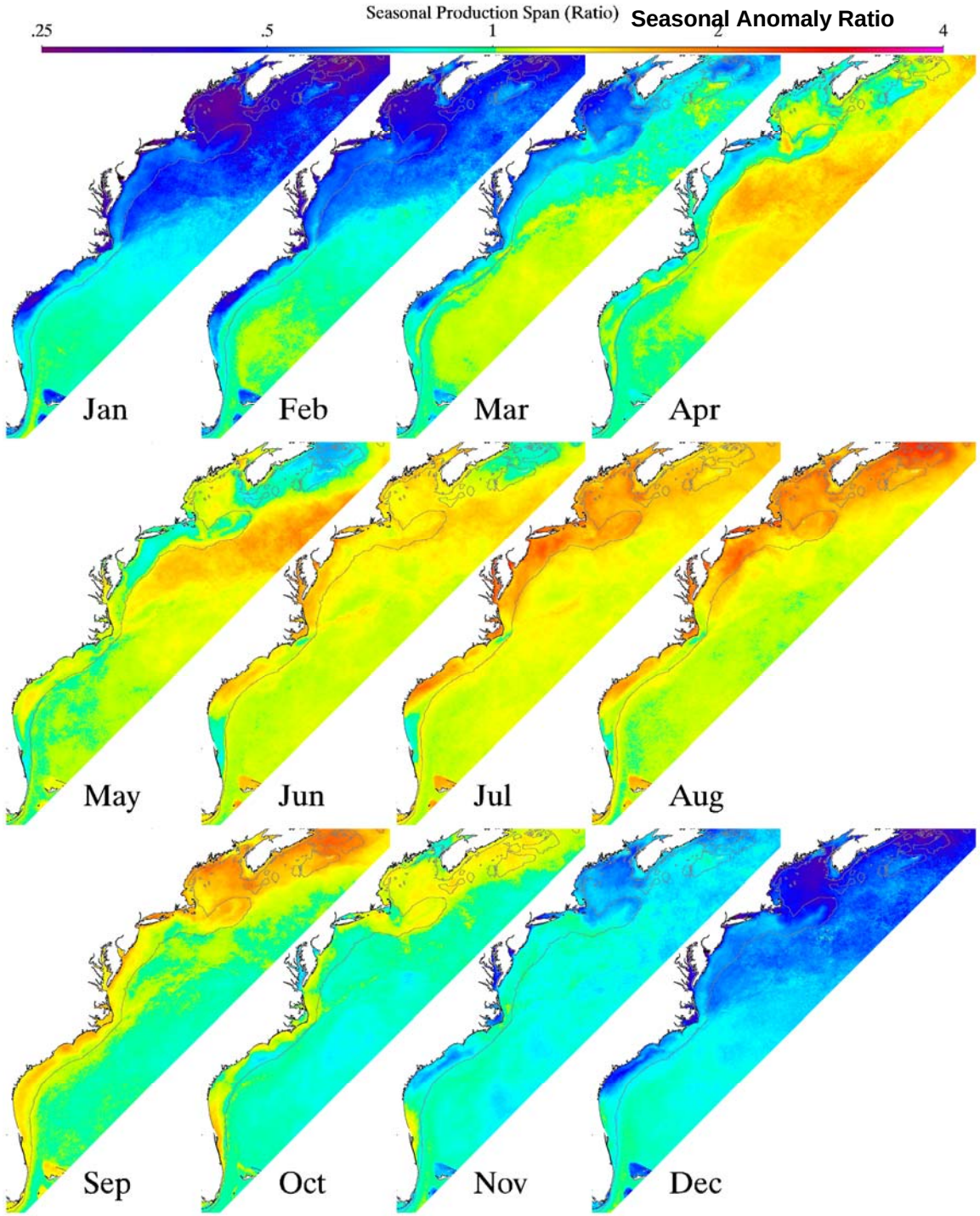
- **N.GOM (Tidally Mixed)**
- **Gulf Stream Axis**

SAB (north and south of Jacksonville)

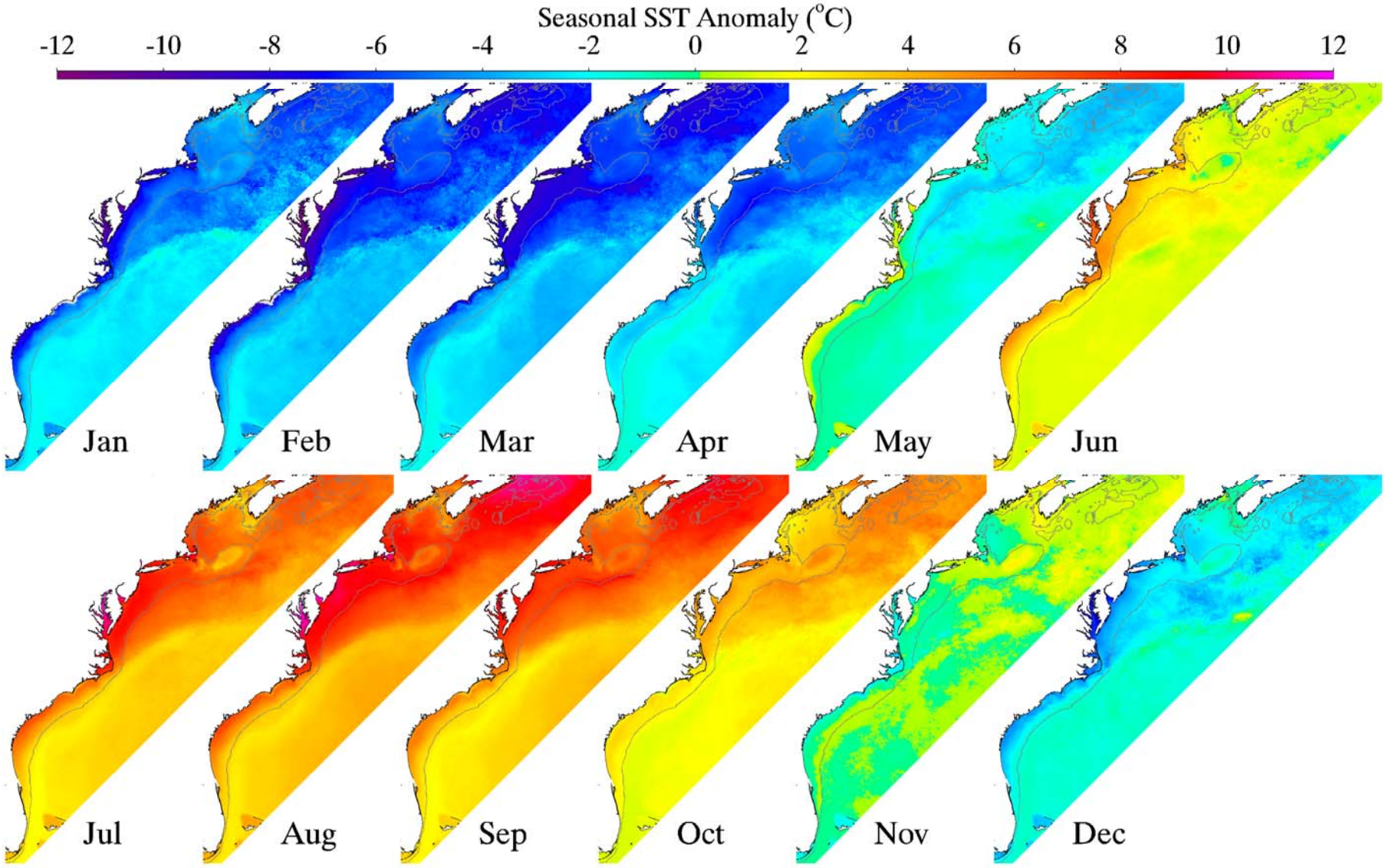
Primary Production





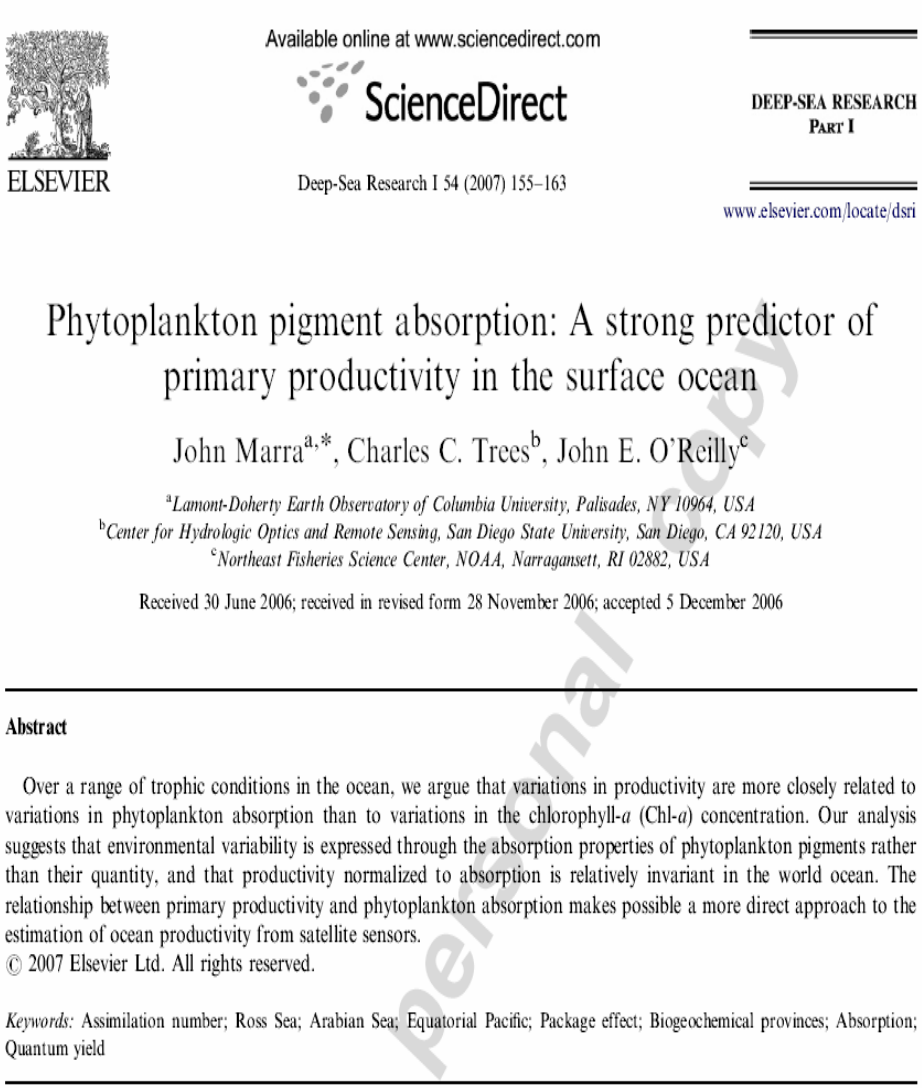


Seasonal Anomaly Ratio


Seasonal SST Anomaly (°C)
-12
-10
-8
-6
-4
-2
0
2
4
6
8
10
12
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

Satellite-Productivity Model Improvements
(With John Marra)

- **Vertically Resolved vs. Vertically Generalized Production Model (VGPM)**
- **More accurate chlorophyll profile shapes for shelf water**
- **K_Par improvements (Euphotic Depth)**
- **0.02 Quantum Efficiency (Marra,Trees,O'Reilly)**
- **Ocean Color Science Team Meeting: Inter-annual Variability in Primary Production in the Northeast U.S. Large Marine Ecosystem: Results from two models. O'Reilly, Marra**



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Phytoplankton pigment absorption: A strong predictor of primary productivity in the surface ocean

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Received 30 June 2006; received in revised form 28 November 2006; accepted 5 December 2006

Abstract

Over a range of trophic conditions in the ocean, we argue that variations in productivity are more closely related to variations in phytoplankton absorption than to variations in the chlorophyll-*a* (Chl-*a*) concentration. Our analysis suggests that environmental variability is expressed through the absorption properties of phytoplankton pigments rather than their quantity, and that productivity normalized to absorption is relatively invariant in the world ocean. The relationship between primary productivity and phytoplankton absorption makes possible a more direct approach to the estimation of ocean productivity from satellite sensors.
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Keywords: Assimilation number; Ross Sea; Arabian Sea; Equatorial Pacific; Package effect; Biogeochemical provinces; Absorption; Quantum yield

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