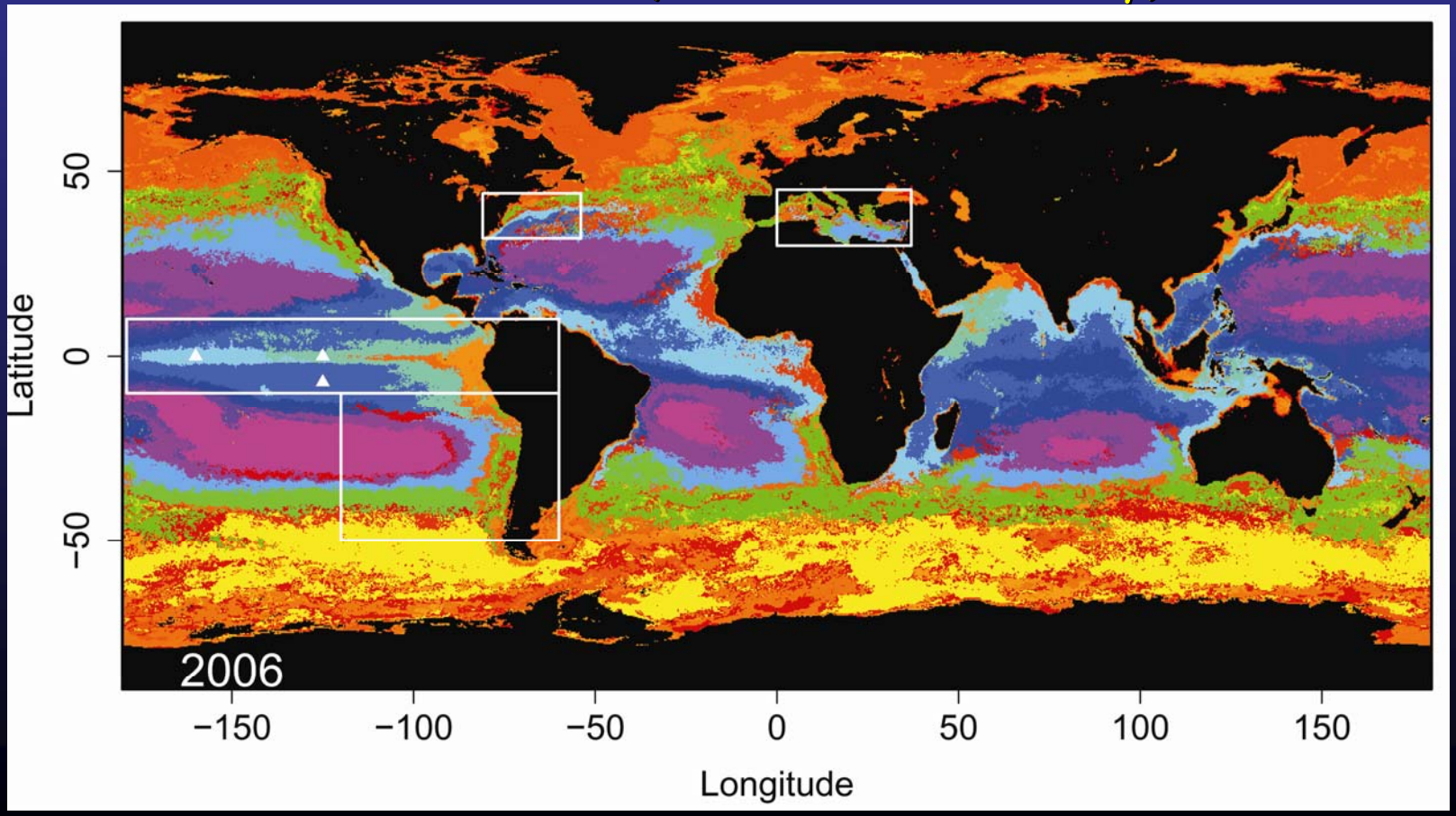
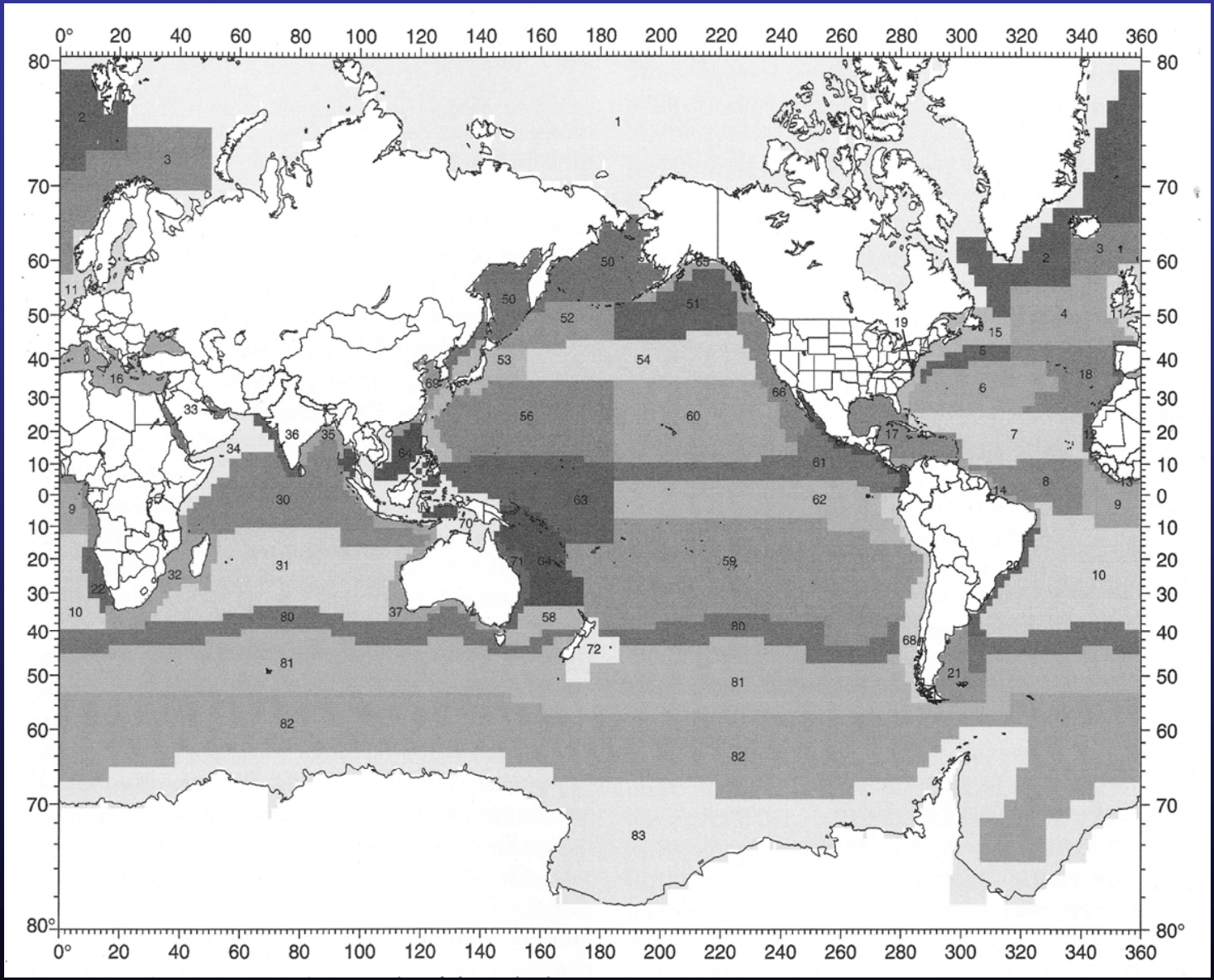
Satellite Bioinformatics as a tool to actively track and monitor the ocean

Matthew Oliver (U. Del.), Oscar Schofield (Rutgers),
Andrew Irwin (Mt. Allison University)

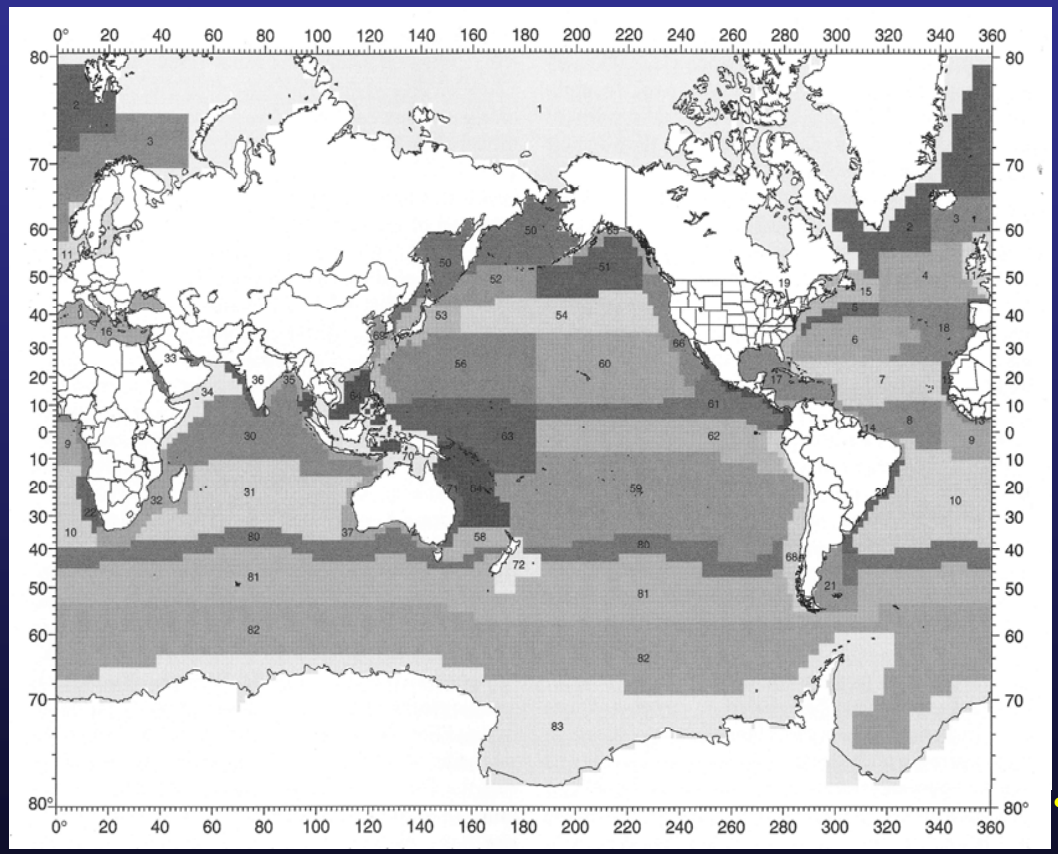


Static, manual water-masses



Longhurst (1995, 1998, 2006)

Can we dynamically map water masses in space-time? Can it be automated? Can it be done objectively?



What would be the applications?

- Water Mass boundaries are predictive of hydrography

Changes in Water Mass size and distributions are bellwethers for cyclical and secular earth cycles

- Allows for a true comparative analysis by controlling for advection (ie making provinces a quantitative measurement)

- Local changes in water masses impact fisheries and water quality (ie river plumes and upwelling)

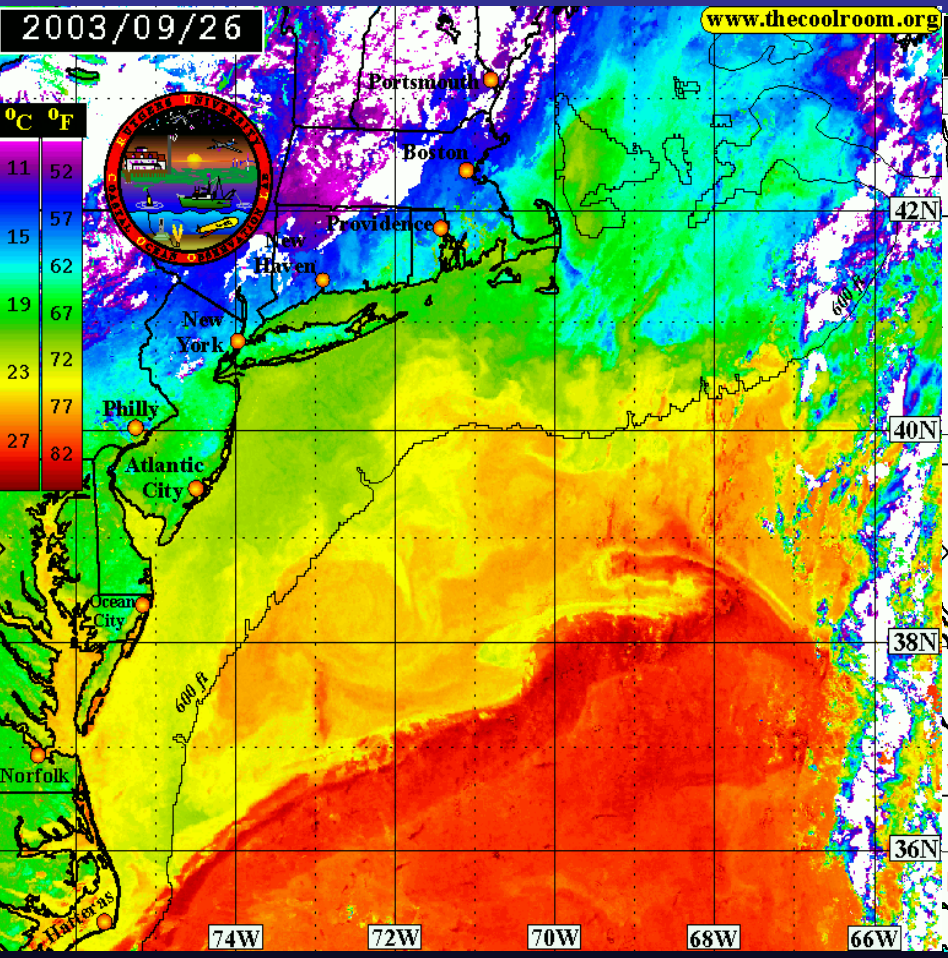
The Problem

Where do you put the boundaries?

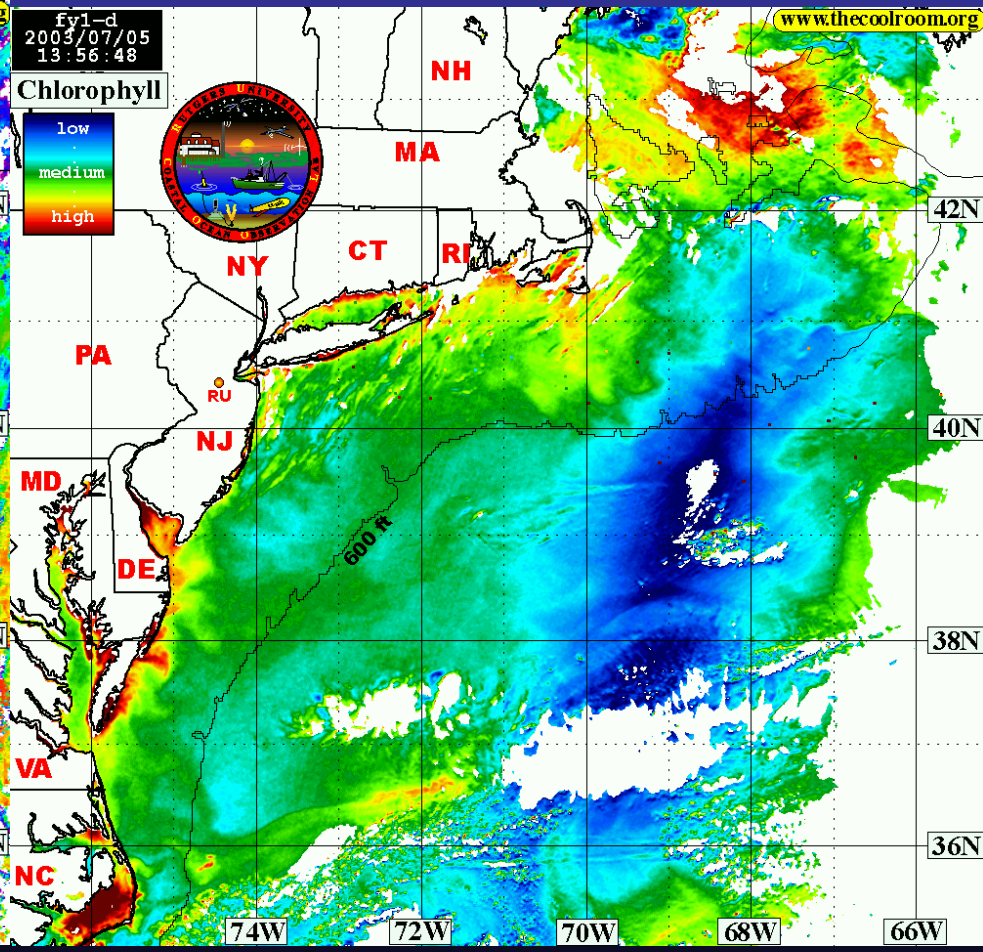
Extremes are obvious, middle ground isn't so clear

The Data Sources

Temperature



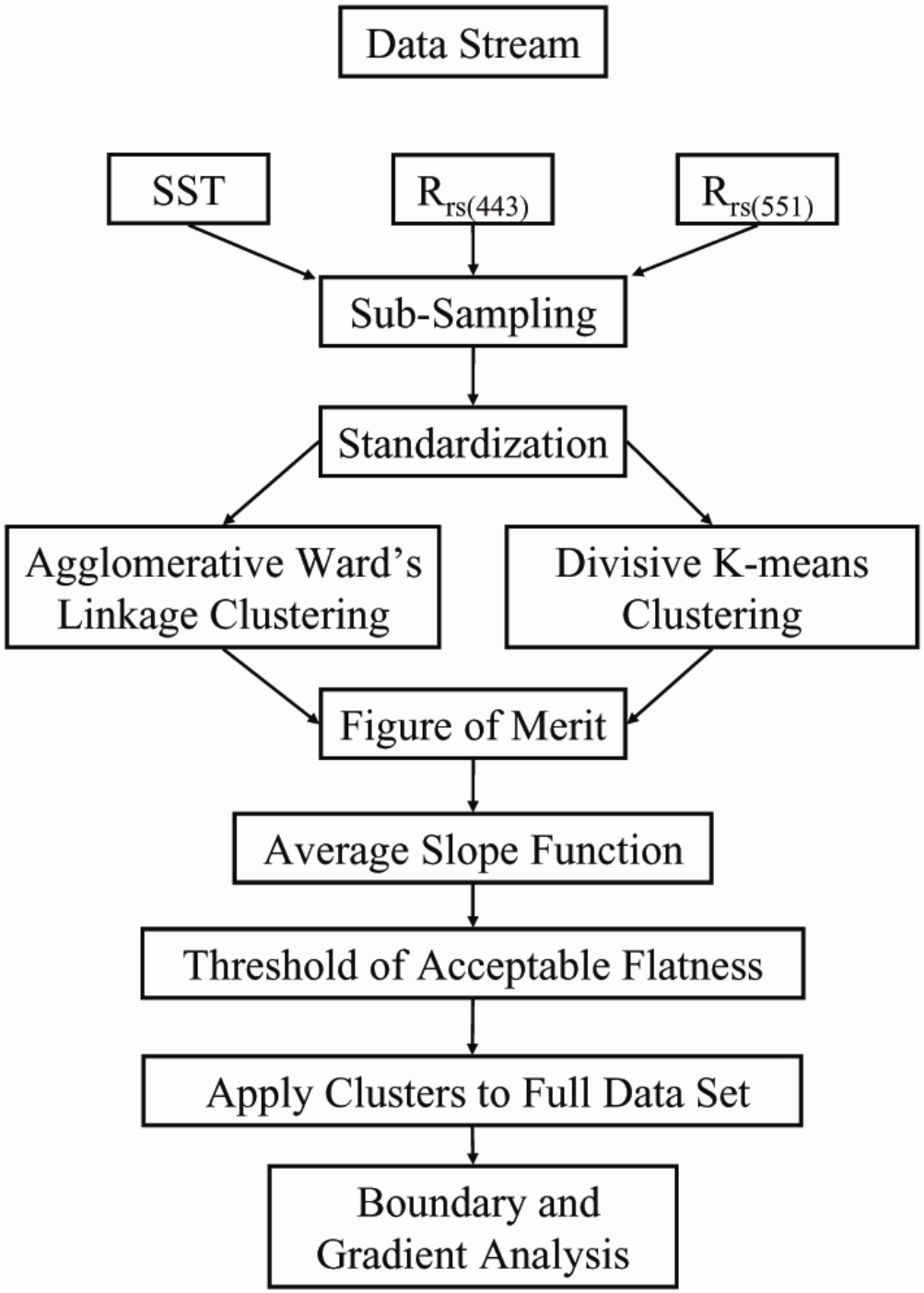
Ocean Color

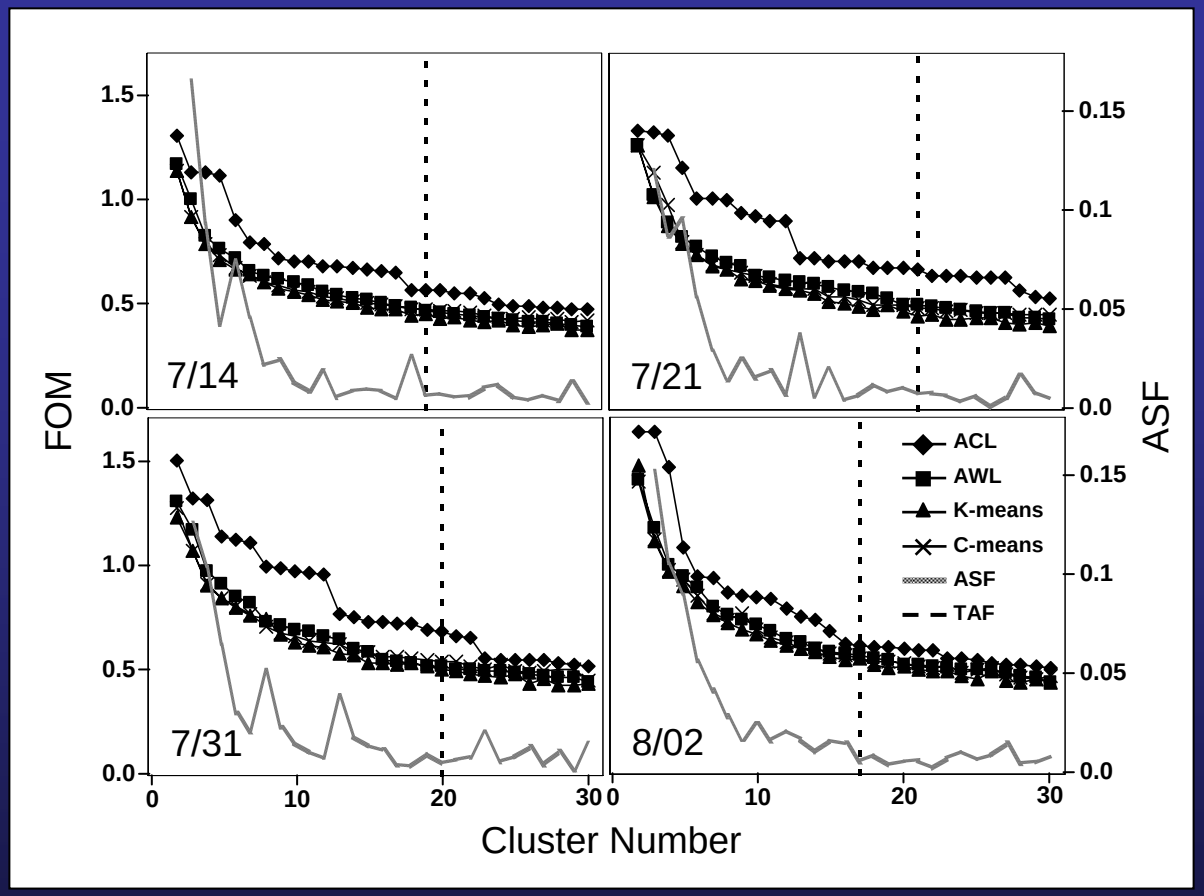


Automatic unsupervised classification

SeaWiFS
MODIS/Aqua
AVHRR SST

Oliver et al (2004) JGR Oceans

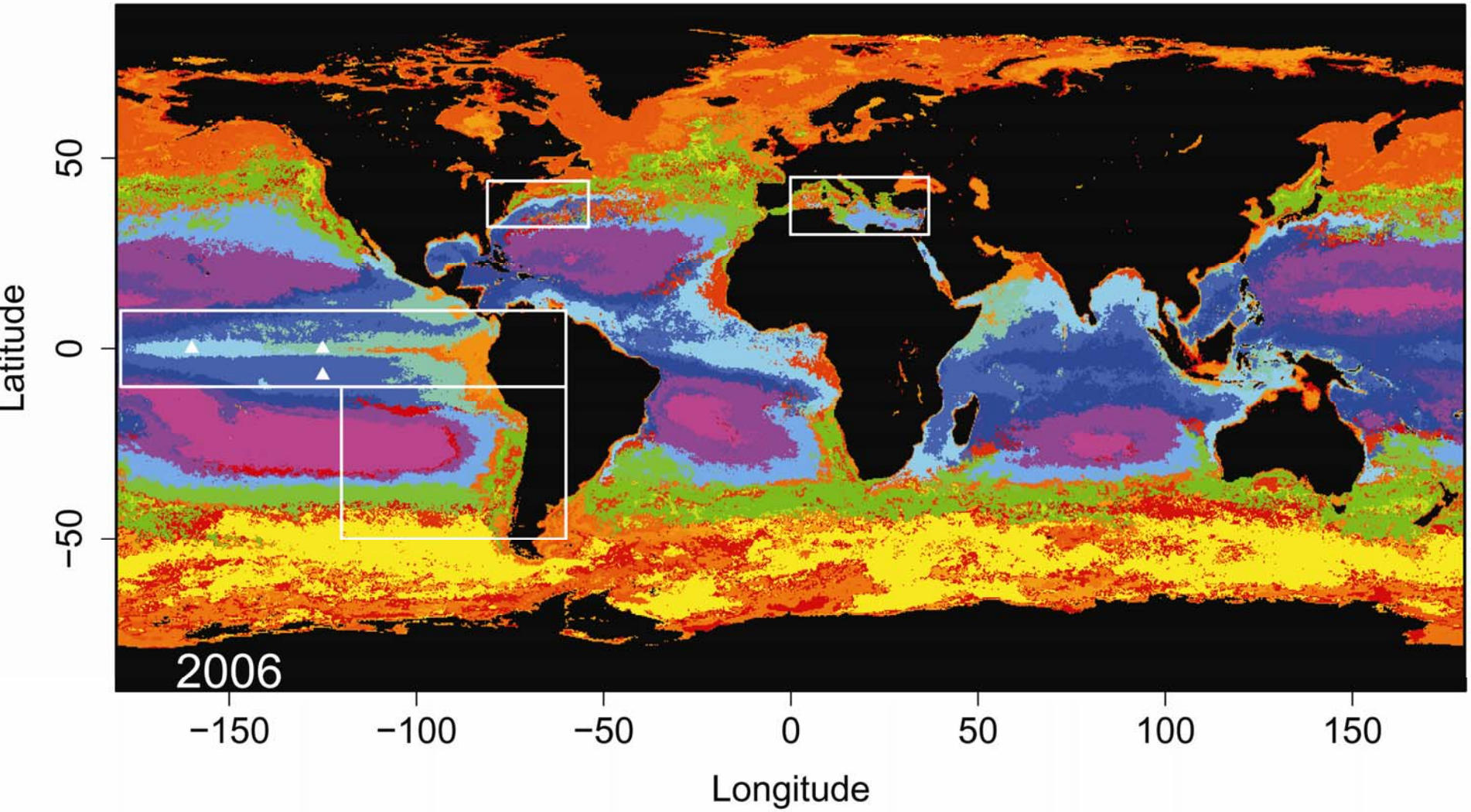


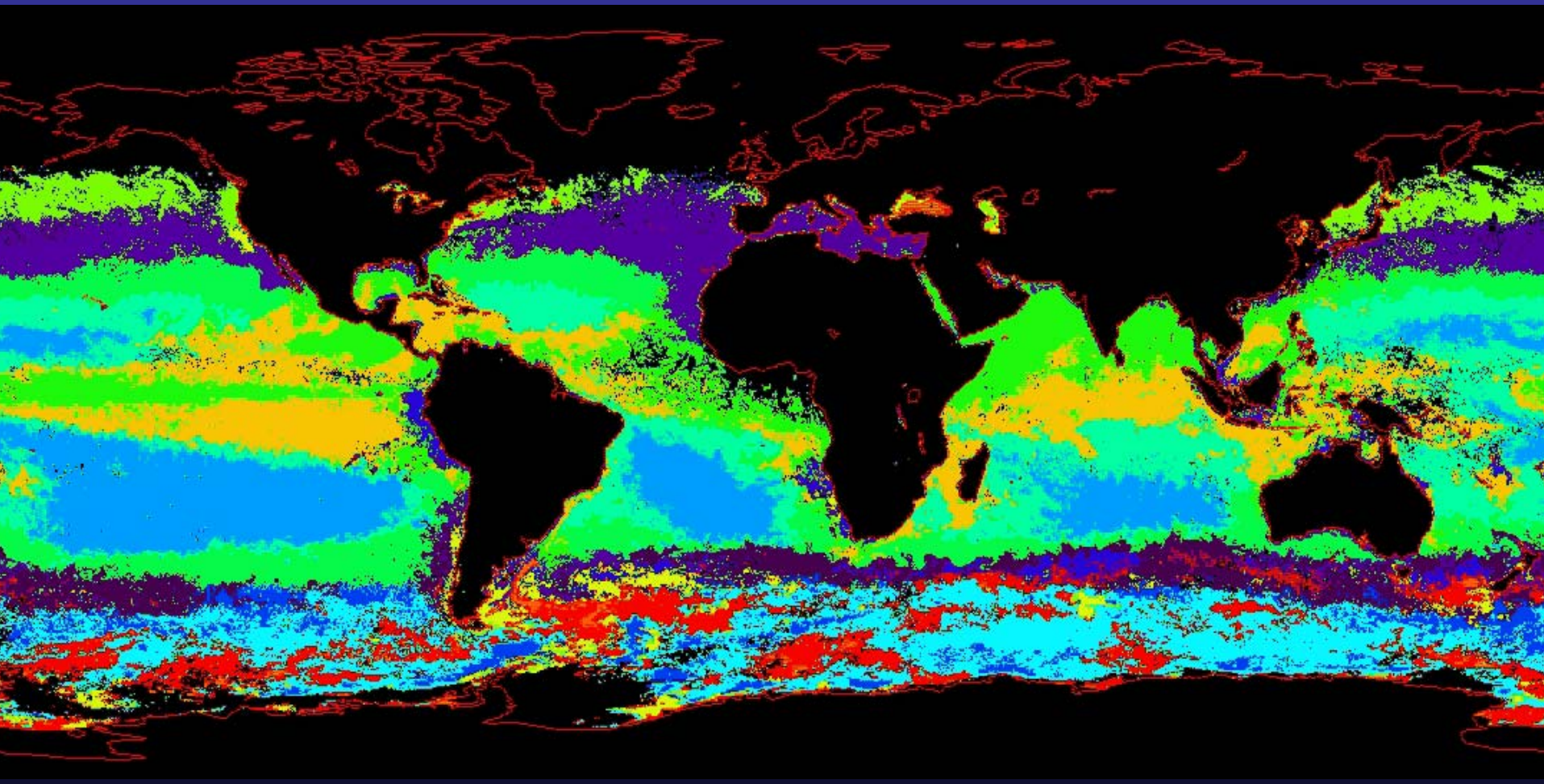


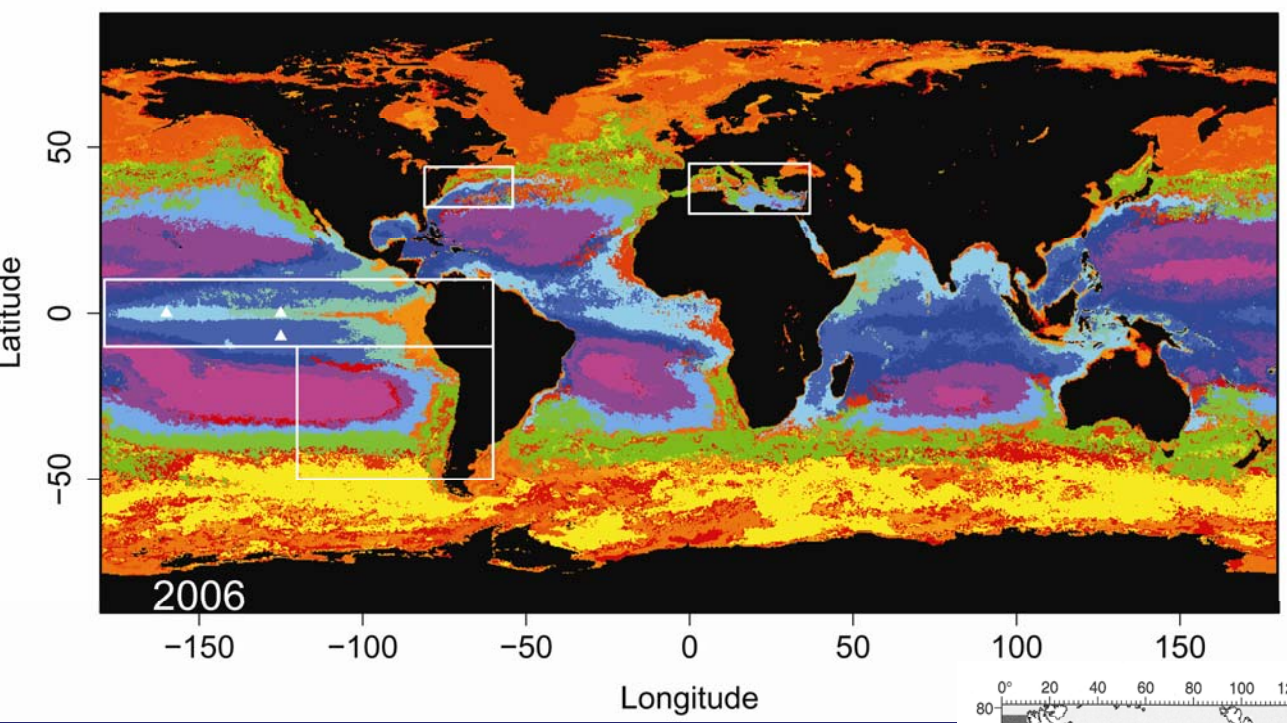
$$ASF(k) = \frac{1}{4}\sum_{c=1}^{4} \frac{FOM(c,k+1) - FOM(c,k)}{FOM_{\max}(c)}$$

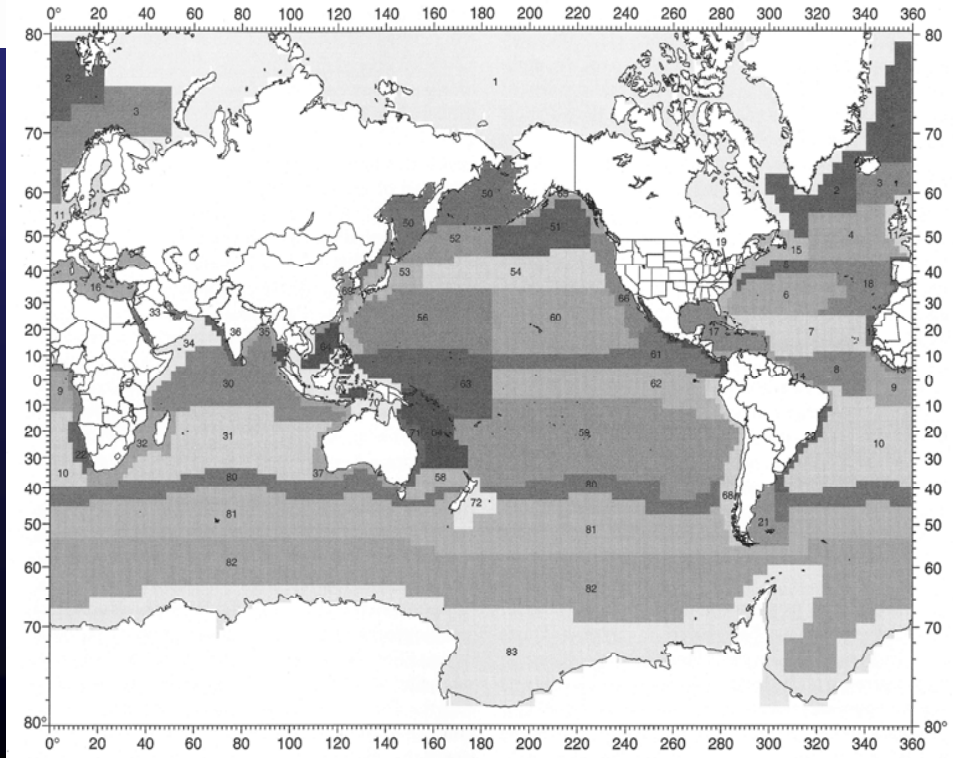
A <u>Threshold of Acceptable Flatness</u> *:* smallest cluster *k* where ASF < 0.01 for three or more consecutive clusters

2006 Annual mean





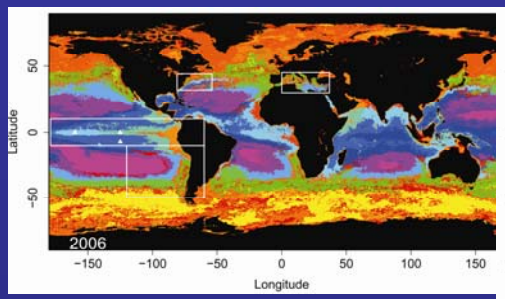


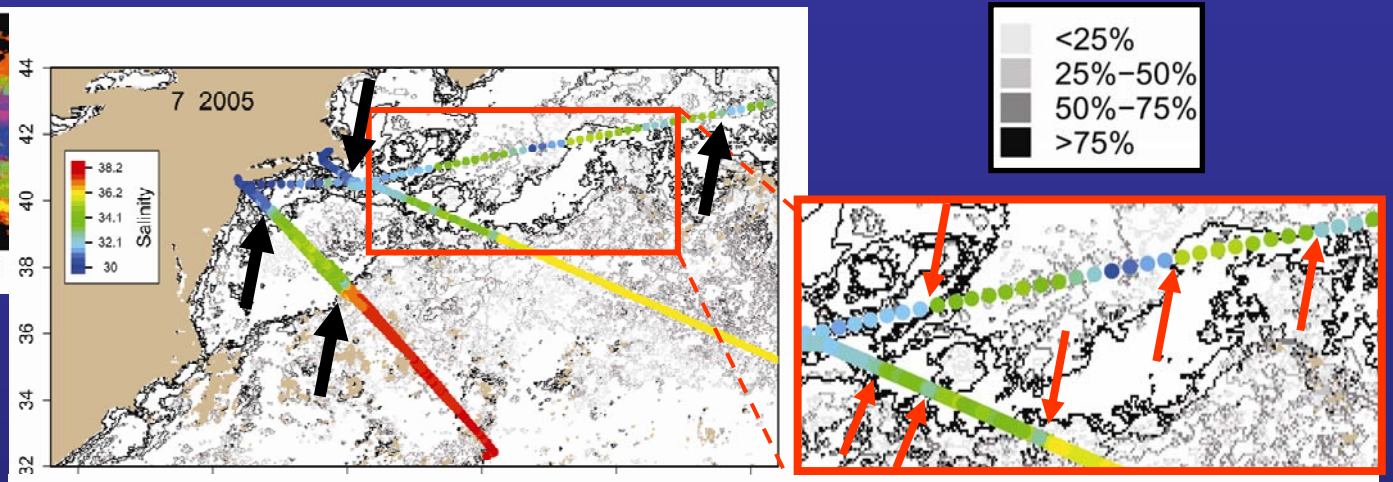


Maps are quite similar

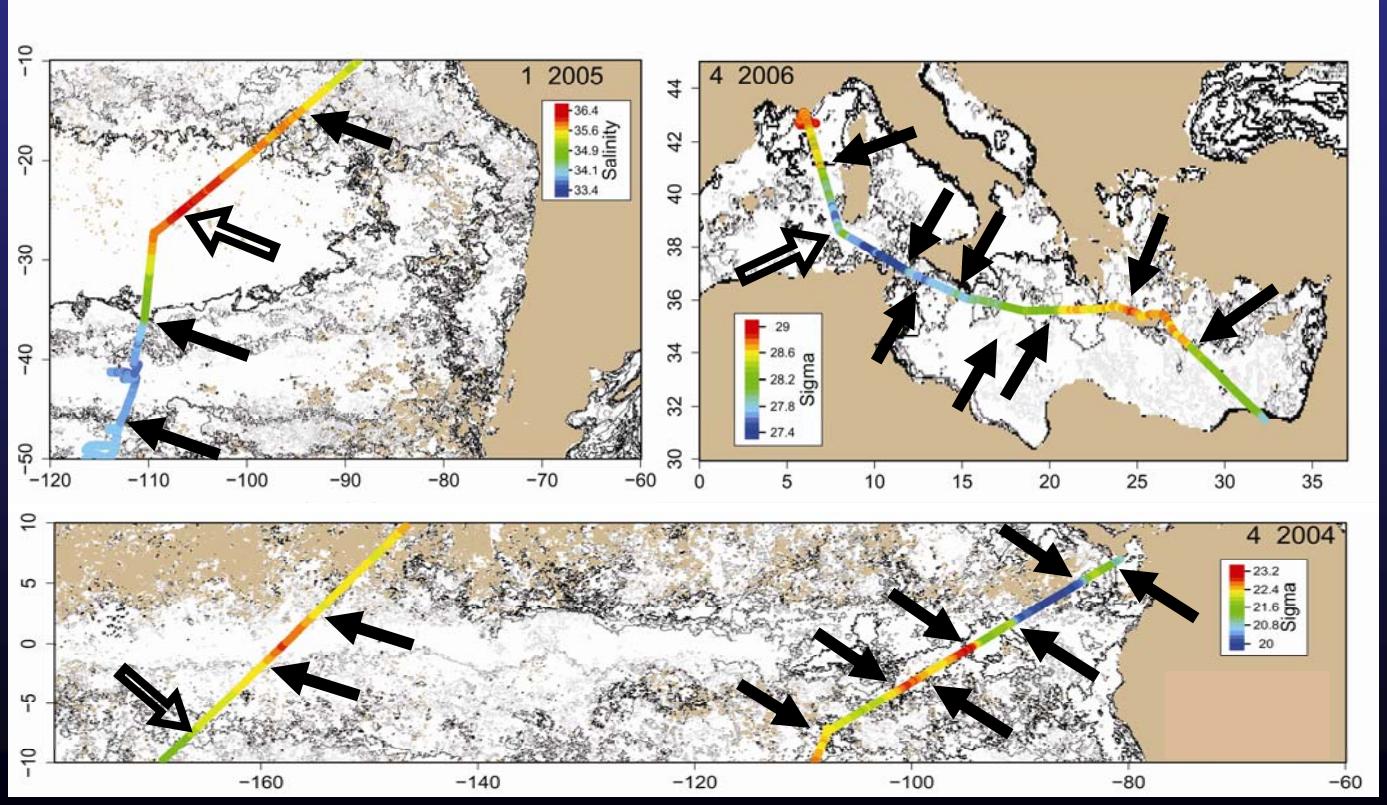
Are they real?

DOES IT WORK?

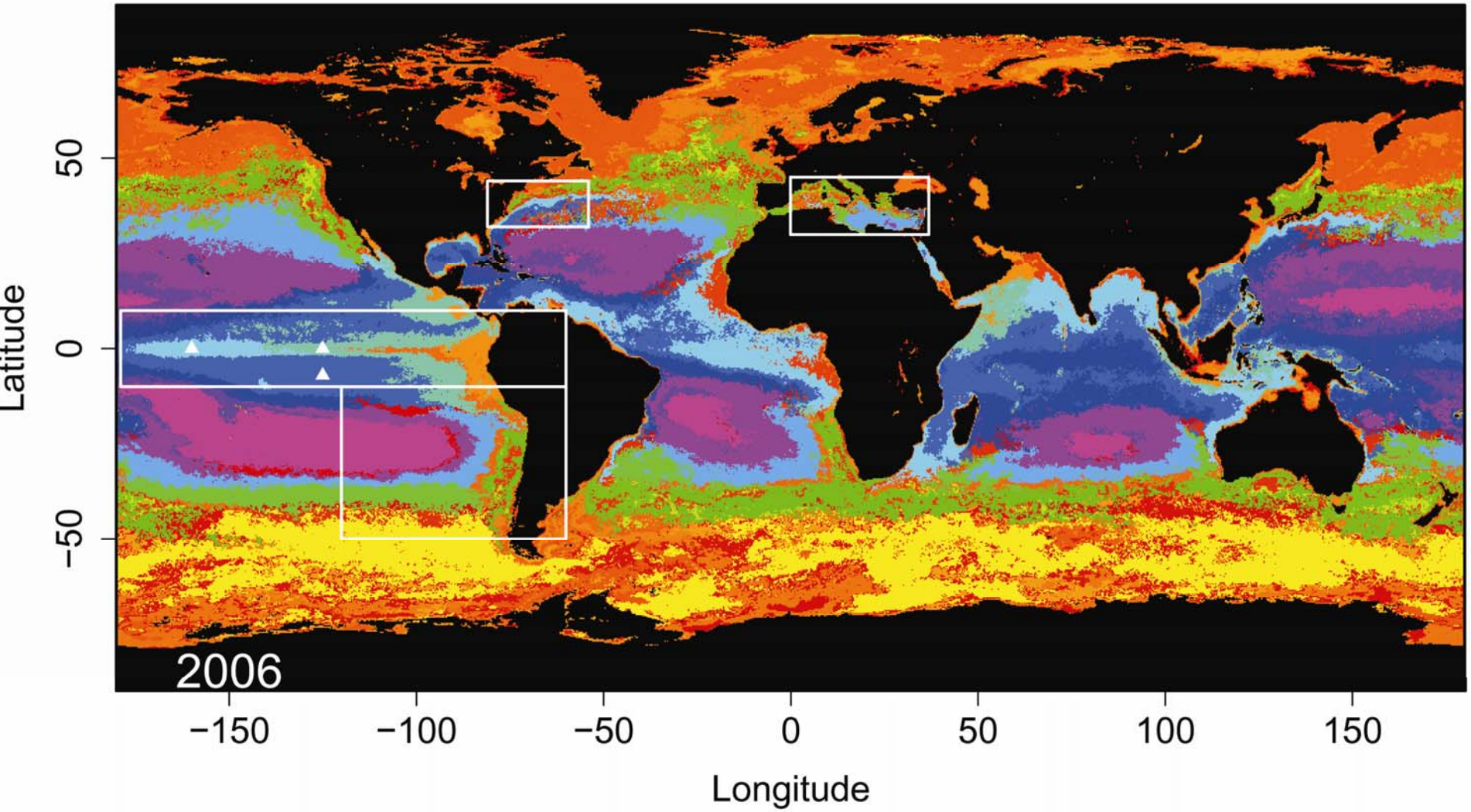


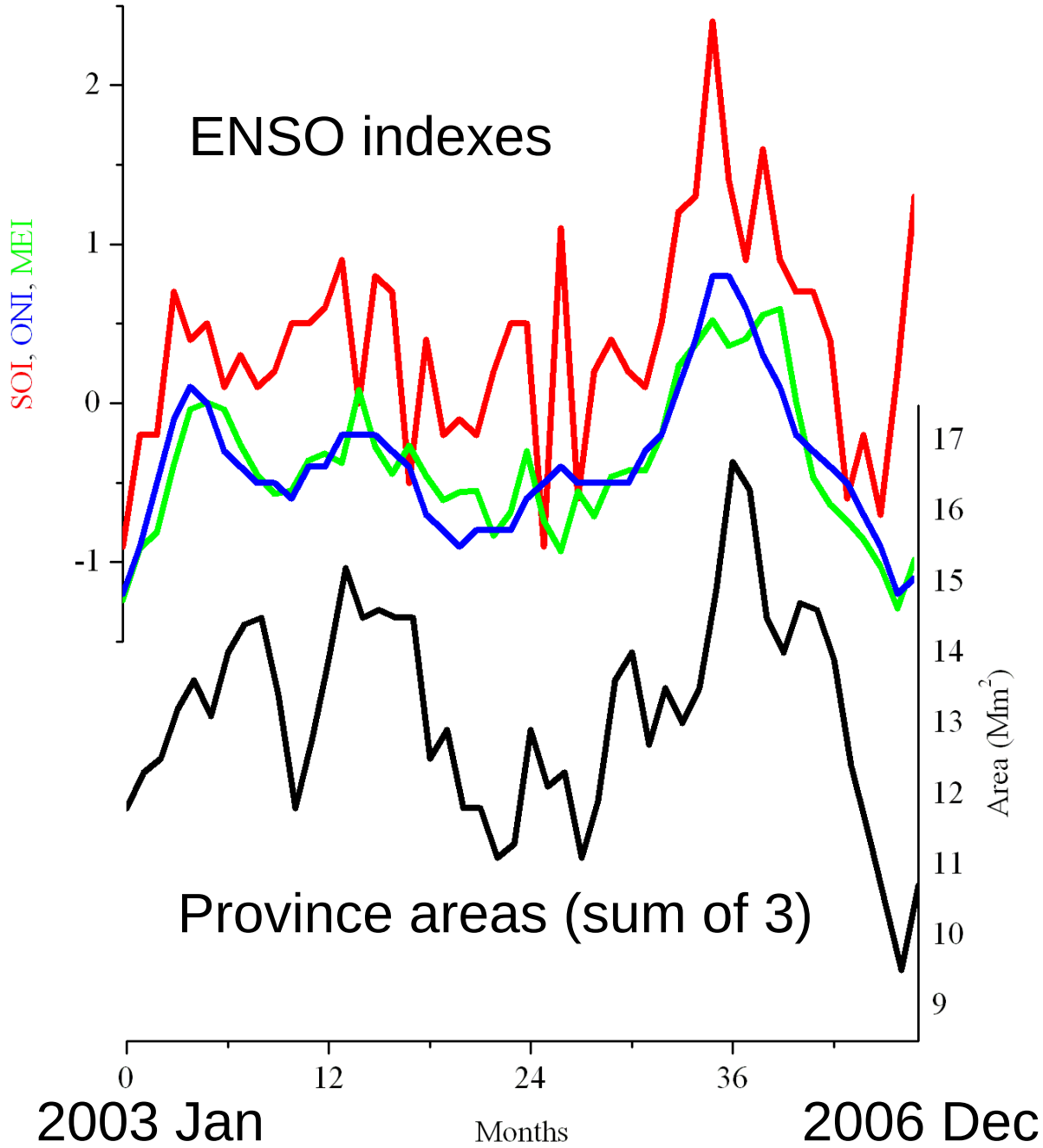


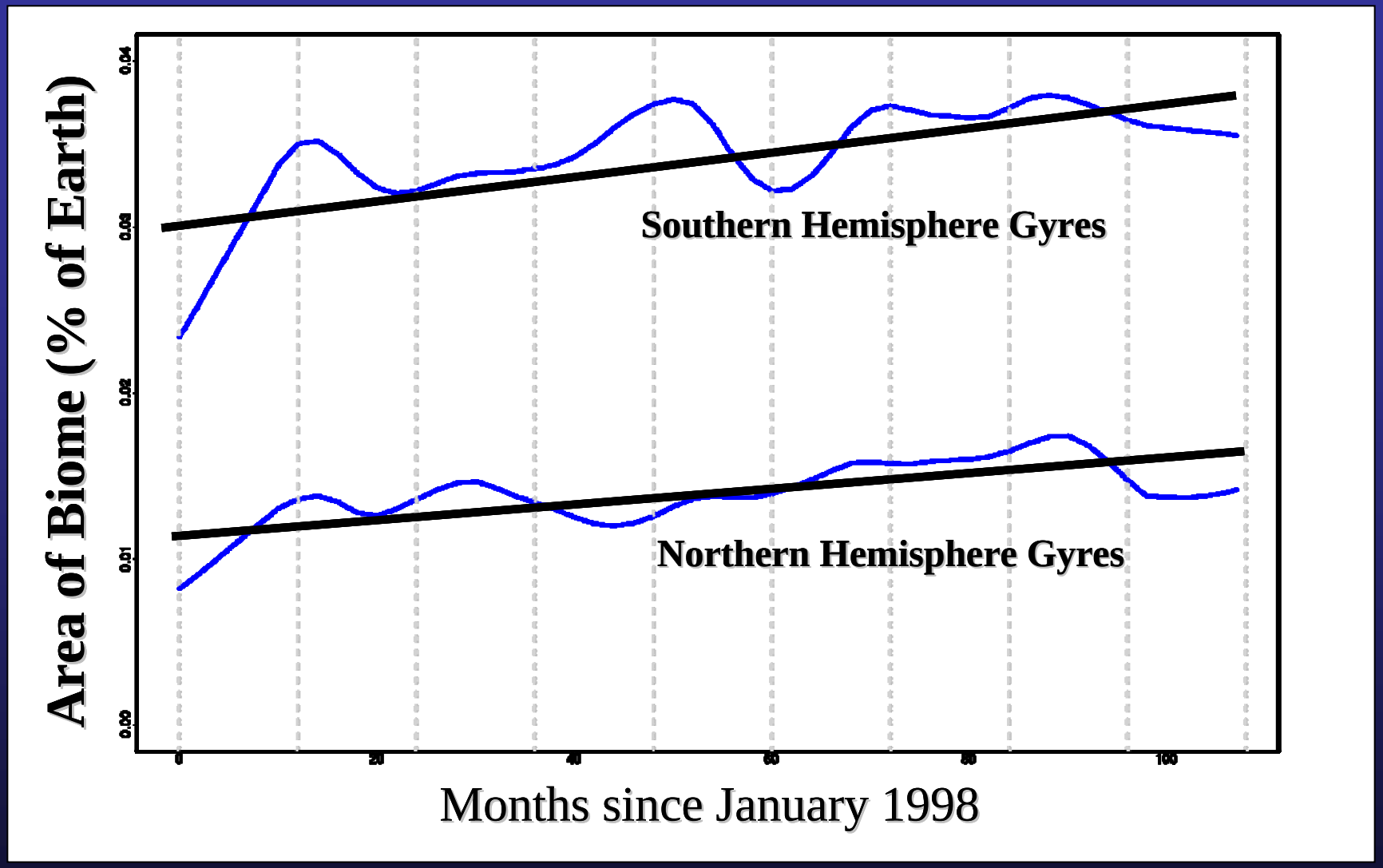
In-situ verification on global and regional scales



Global Applications (Climate)



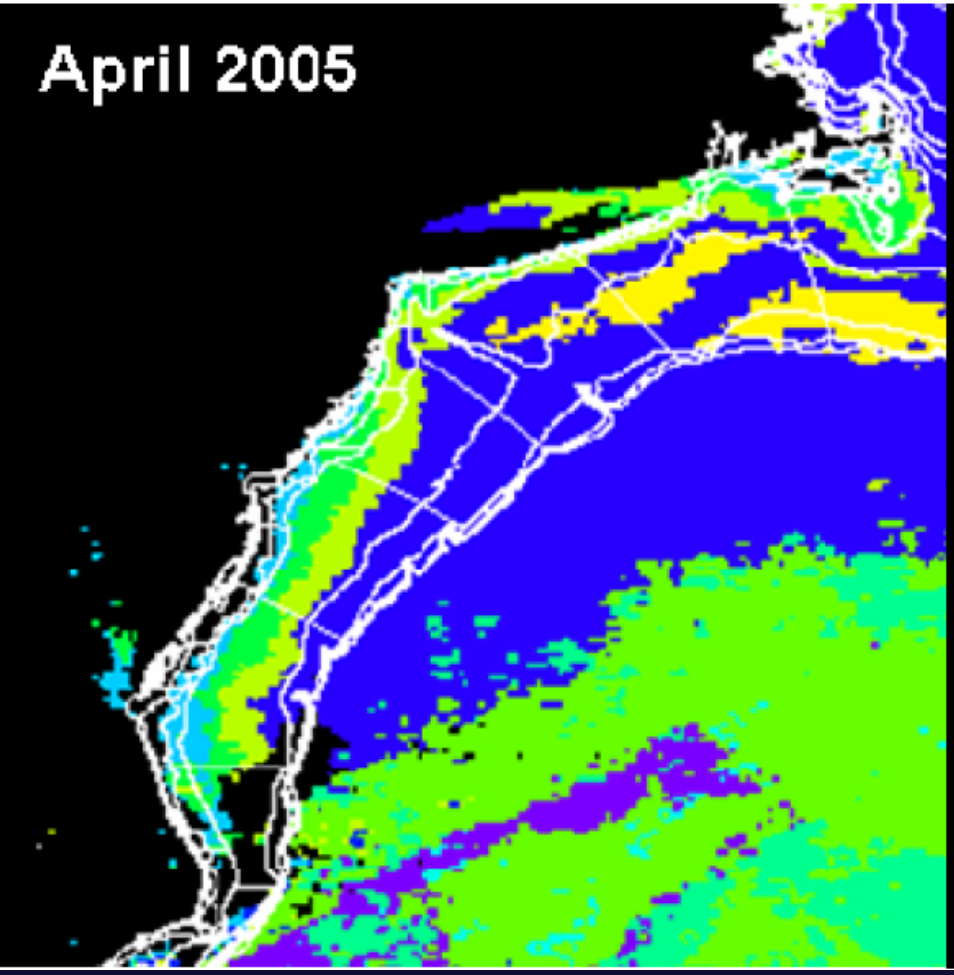

ENSO indexes
SOI, ONI, MEI
2
1
0
-1
Province areas (sum of 3)
17
16
15
14
13
12
11
10
9
Area (Mm^2)
0
12
24
36
Months
2003 Jan
2006 Dec

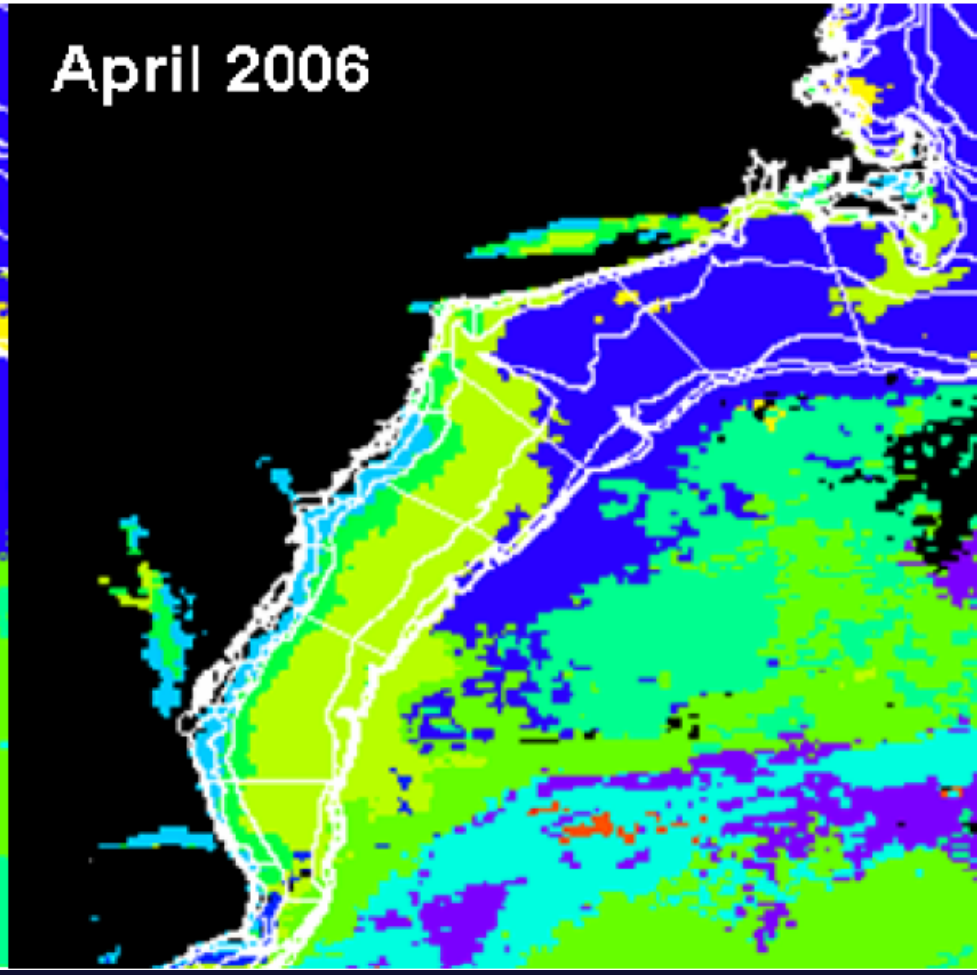


Gyre area Jan 1998 To Dec 2006

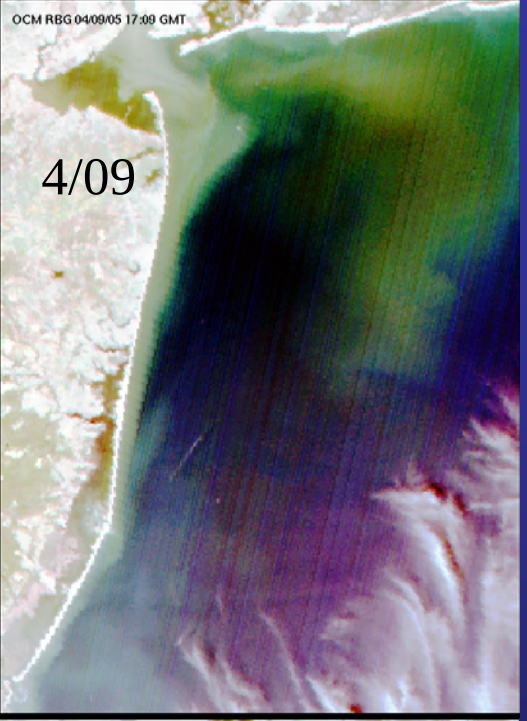
Regional Applications (Ecological Indicators)

Using water mass identity as NMFS Fish Stock Indicators





Local Applications
(Tracking River Plumes)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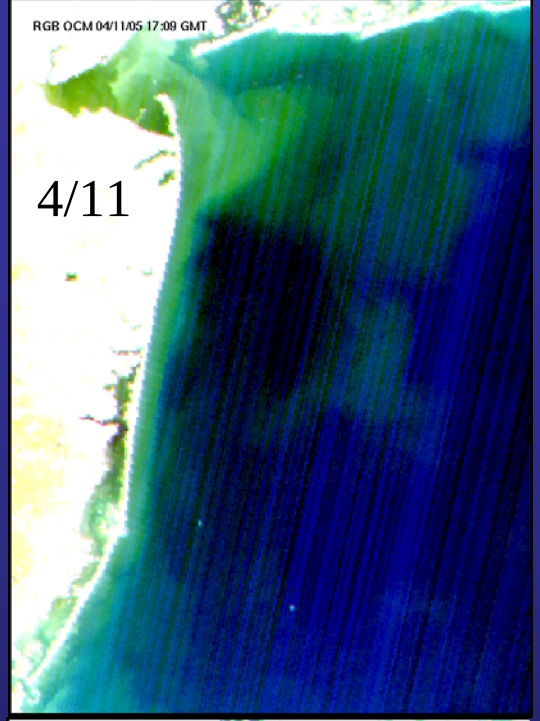
4/09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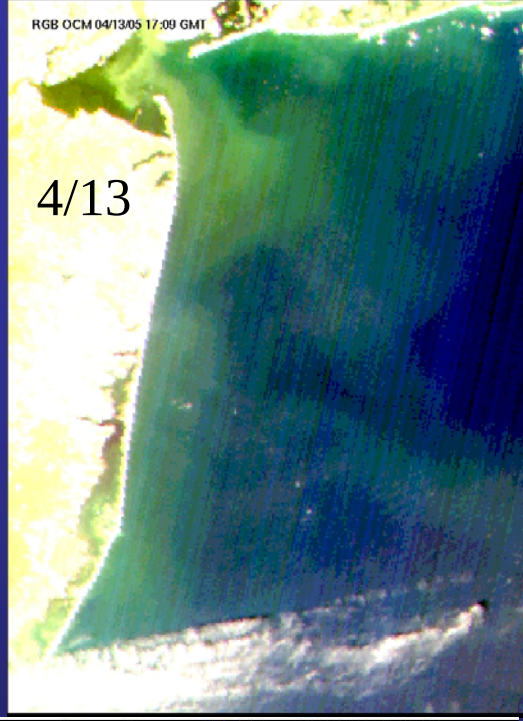
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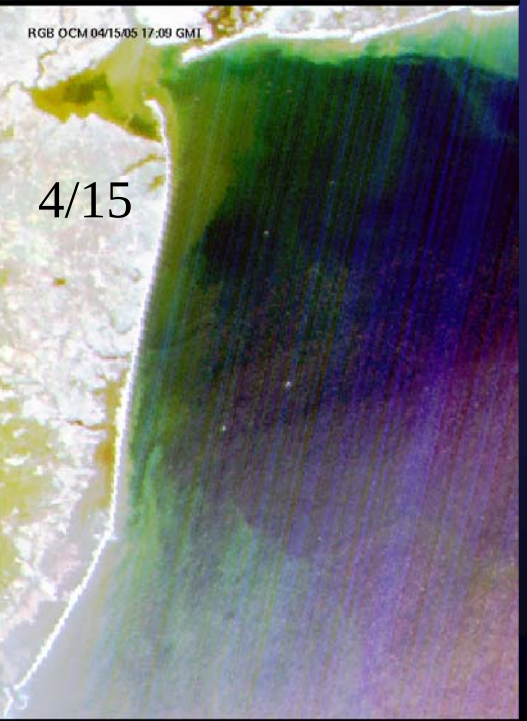
4/13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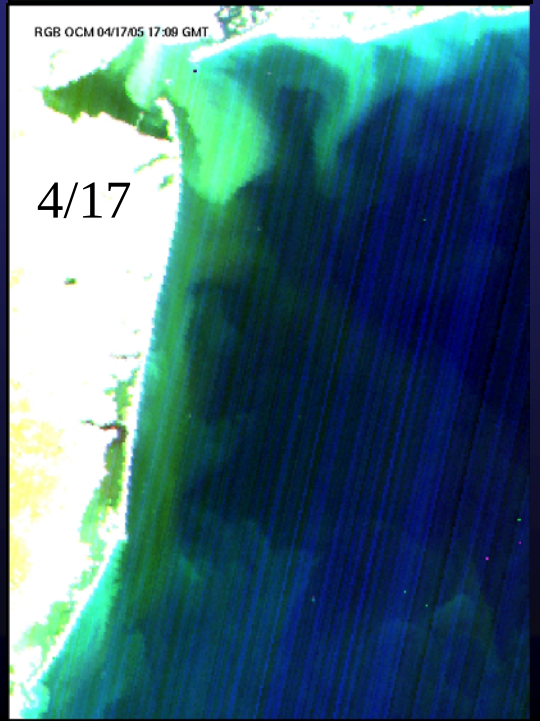
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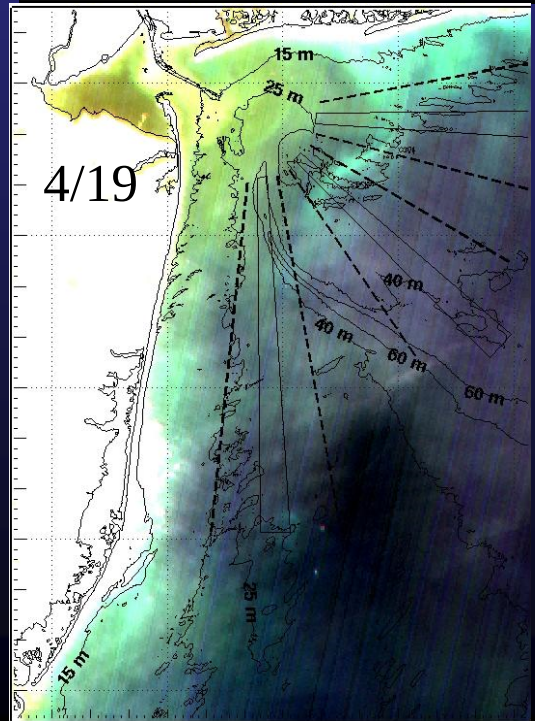
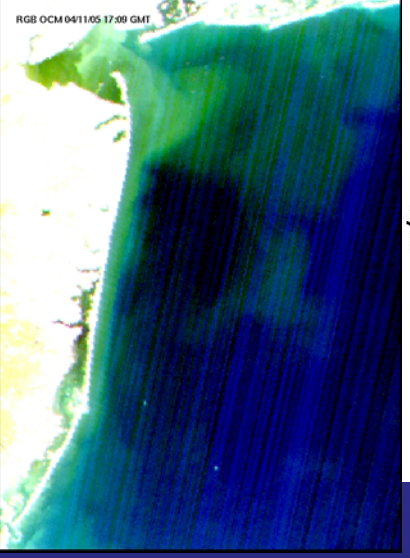

4/19
15 m
25 m
40 m
40 m
60 m
60 m
25 m
15 m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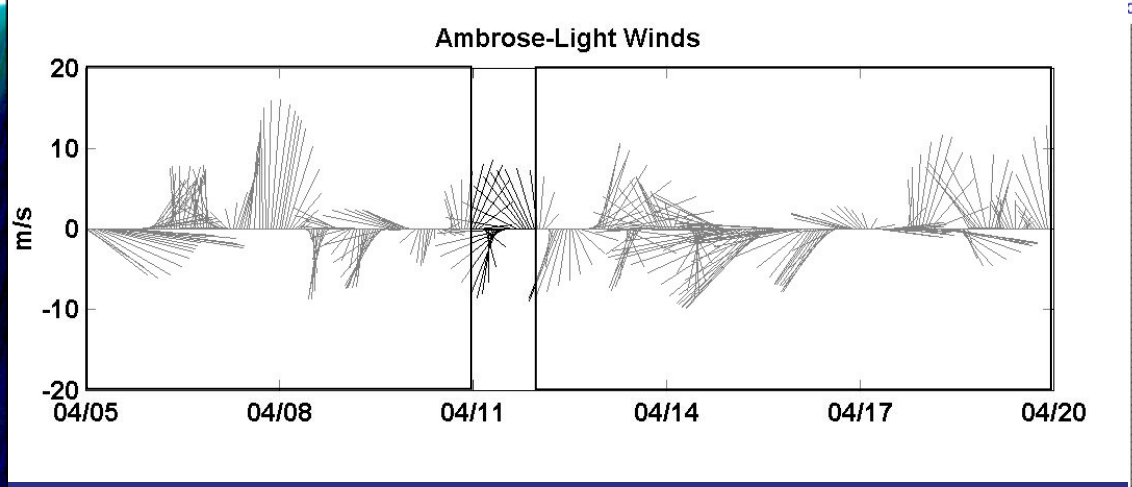
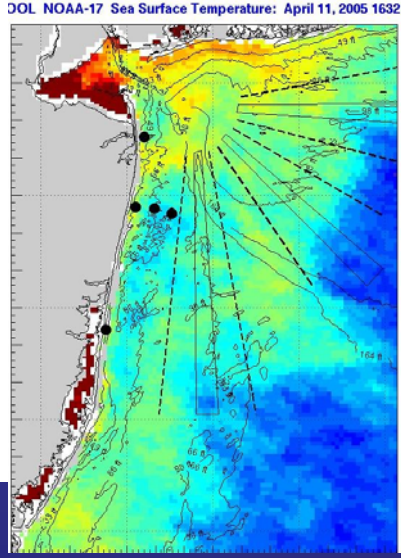
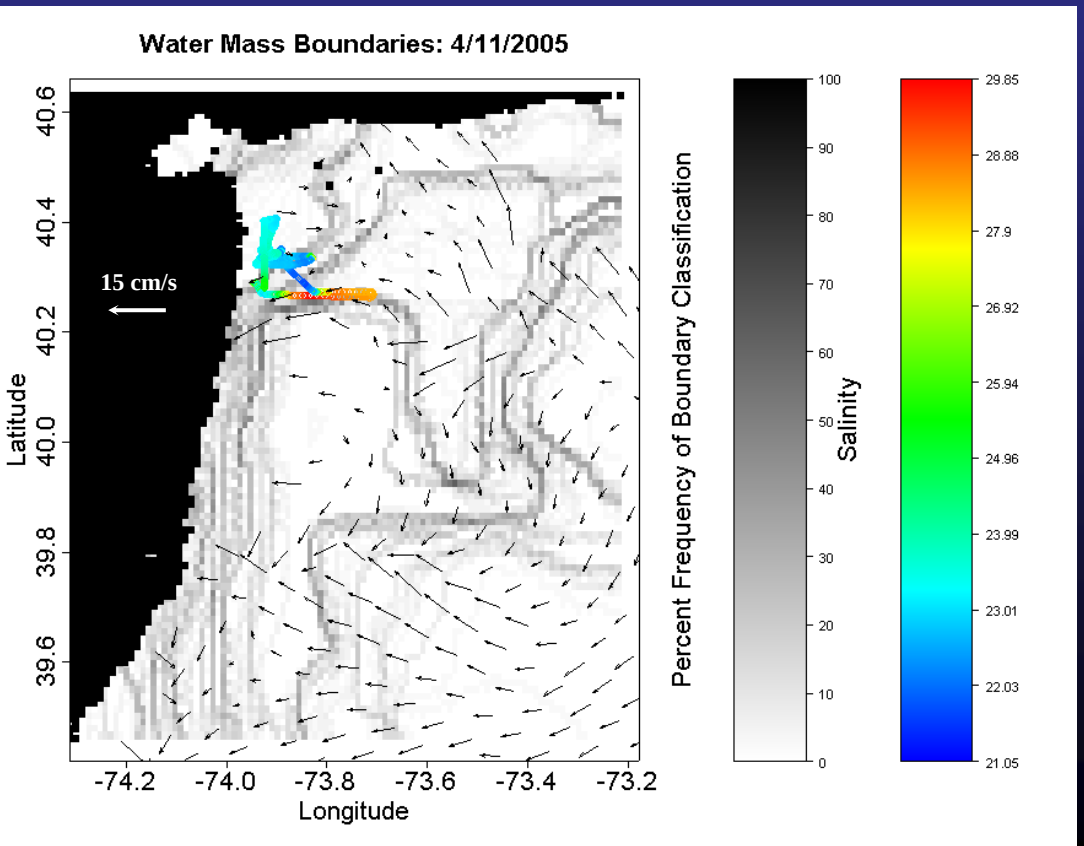
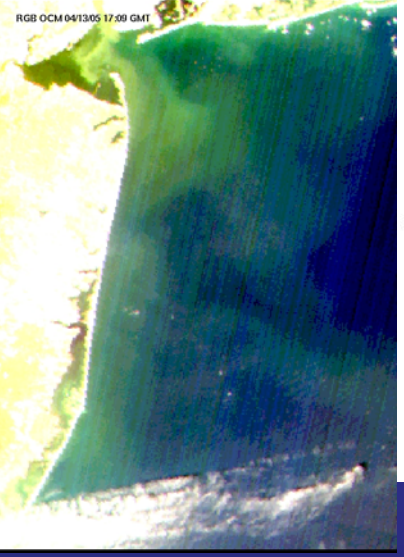
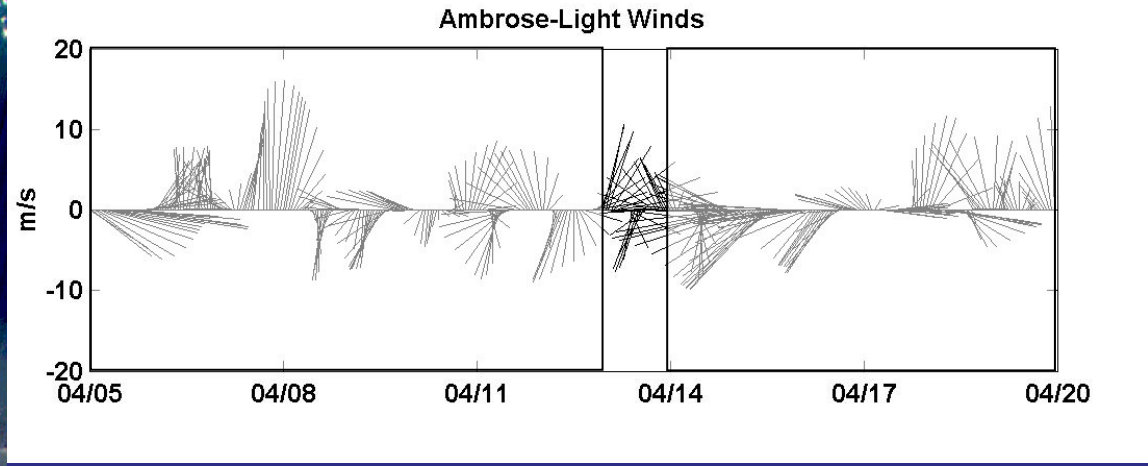

Ambrose-Light Winds
m/s
20
10
0
-10
-20
04/05
04/08
04/11
04/14
04/17
04/20

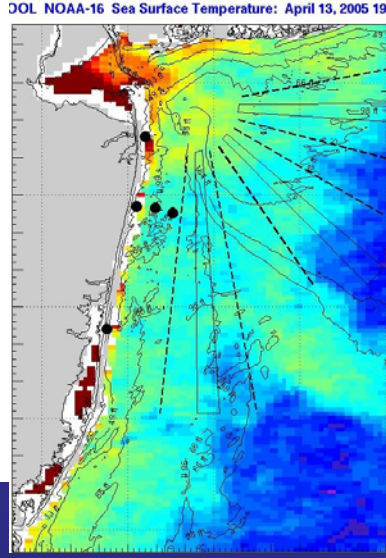

DOL NOAA-17 Sea Surface Temperature: April 11, 2005 1632

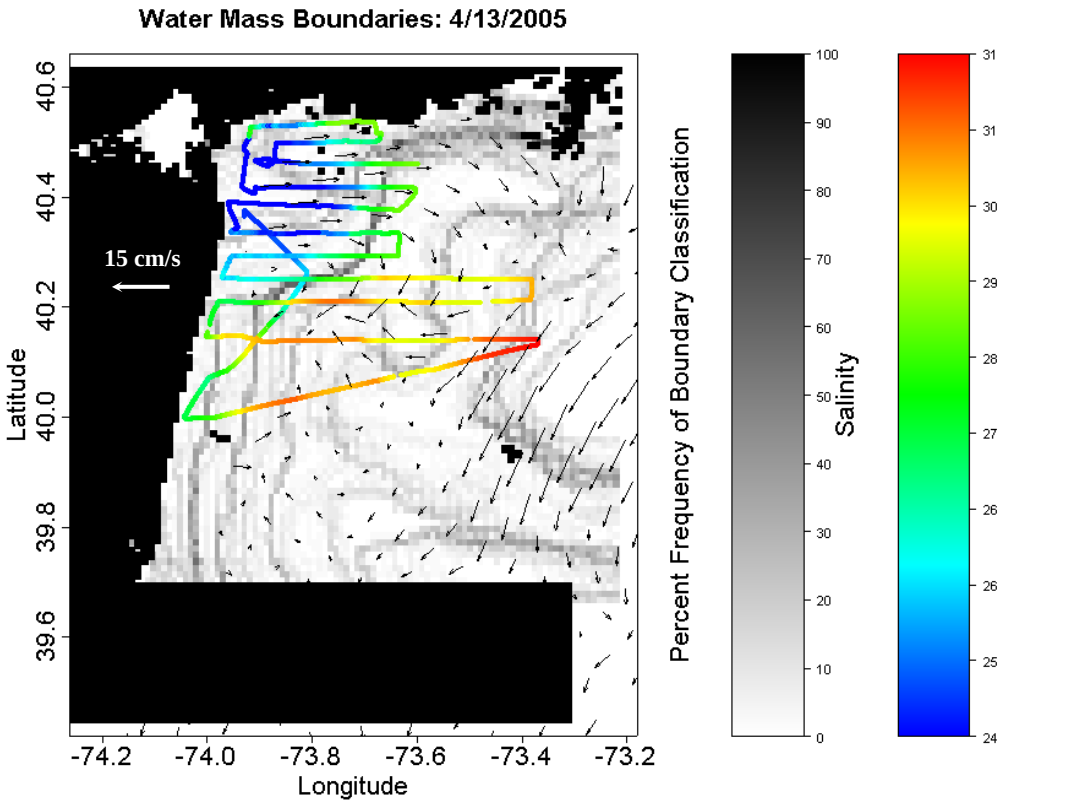

Water Mass Boundaries: 4/11/2005
15 cm/s
Latitude
40.6
40.4
40.2
40.0
39.8
39.6
-74.2
-74.0
-73.8
-73.6
-73.4
-73.2
Longitude
Percent Frequency of Boundary Classification
100
90
80
70
60
50
40
30
20
10
0
Salinity
29.85
28.88
27.9
26.92
25.94
24.96
23.99
23.01
22.03
21.05

15 cm/s

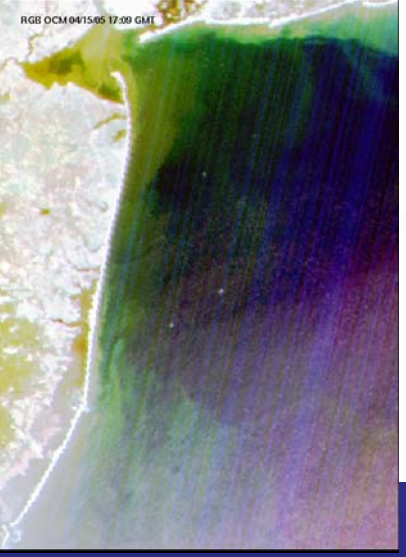

RGB OCM 04/13/05 17:09 GMT

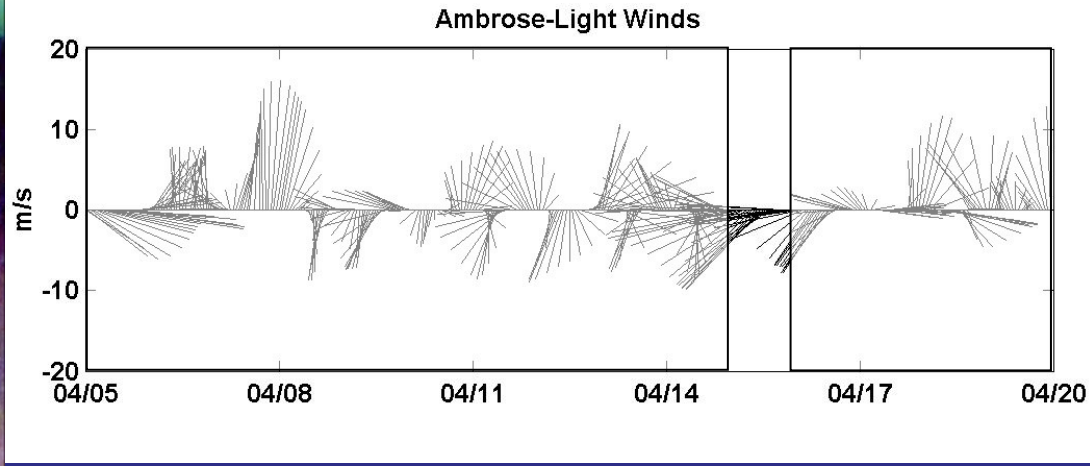

Ambrose-Light Winds
m/s
20
10
0
-10
-20
04/05
04/08
04/11
04/14
04/17
04/20

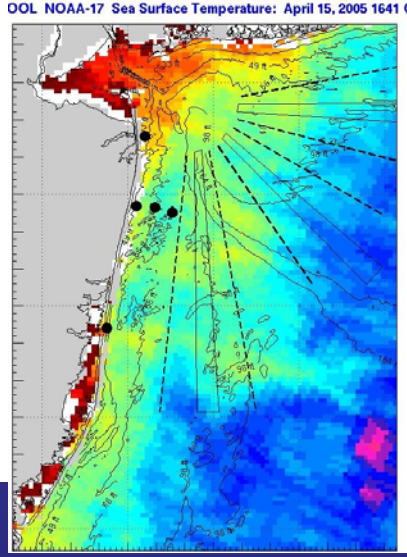

OOL NOAA-16 Sea Surface Temperature: April 13, 2005 19

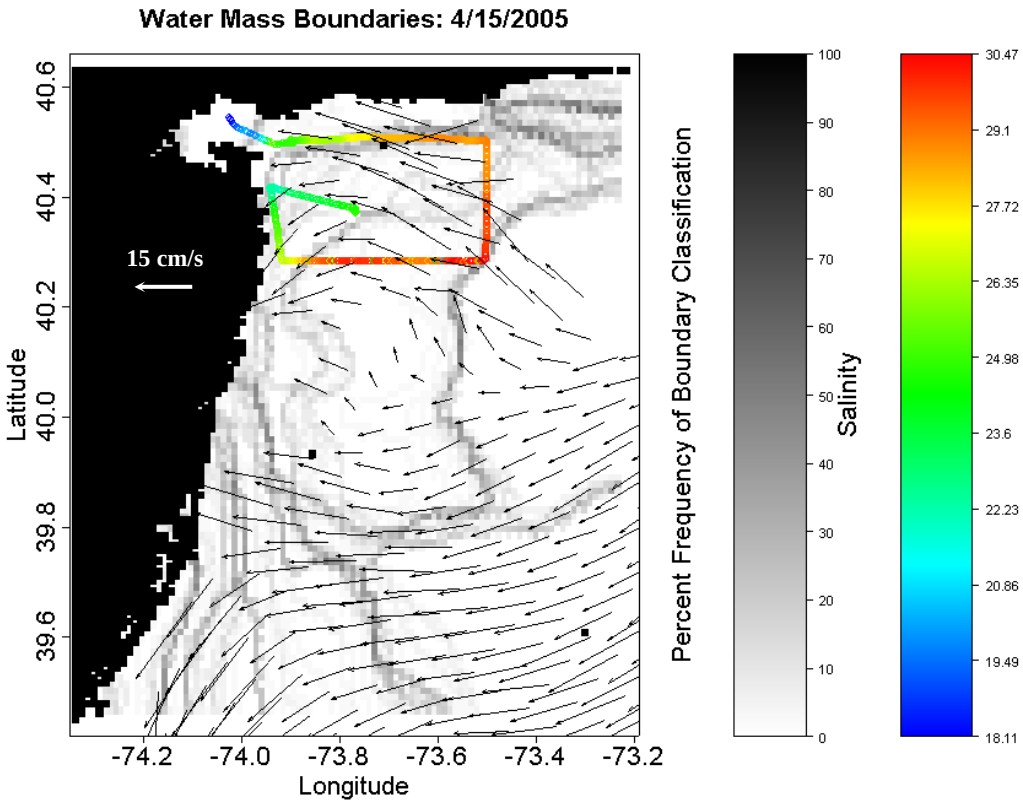

Water Mass Boundaries: 4/13/2005
15 cm/s
Latitude
40.6
40.4
40.2
40.0
39.8
39.6
-74.2
-74.0
-73.8
-73.6
-73.4
-73.2
Longitude
Percent Frequency of Boundary Classification
100
90
80
70
60
50
40
30
20
10
0
Salinity
31
31
30
29
28
27
26
26
25
24

15 cm/s

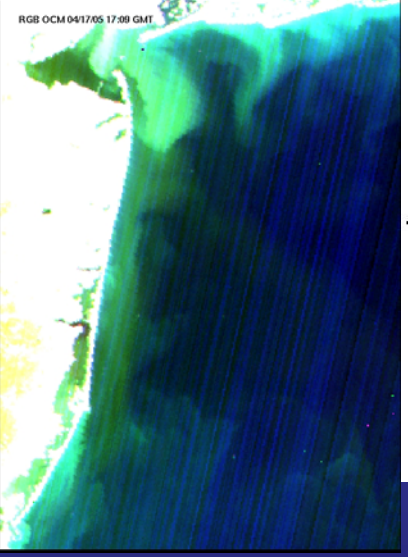

RGB OCM 04/15/05 17:09 GMT


Ambrose-Light Winds
m/s
20
10
0
-10
-20
04/05
04/08
04/11
04/14
04/17
04/20


OOL NOAA-17 Sea Surface Temperature: April 15, 2005 1641 G


Water Mass Boundaries: 4/15/2005
15 cm/s
Latitude
40.6
40.4
40.2
40.0
39.8
39.6
-74.2
-74.0
-73.8
-73.6
-73.4
-73.2
Longitude
Percent Frequency of Boundary Classification
100
90
80
70
60
50
40
30
20
10
0
Salinity
30.47
29.1
27.72
26.35
24.98
23.6
22.23
20.86
19.49
18.11

15 cm/s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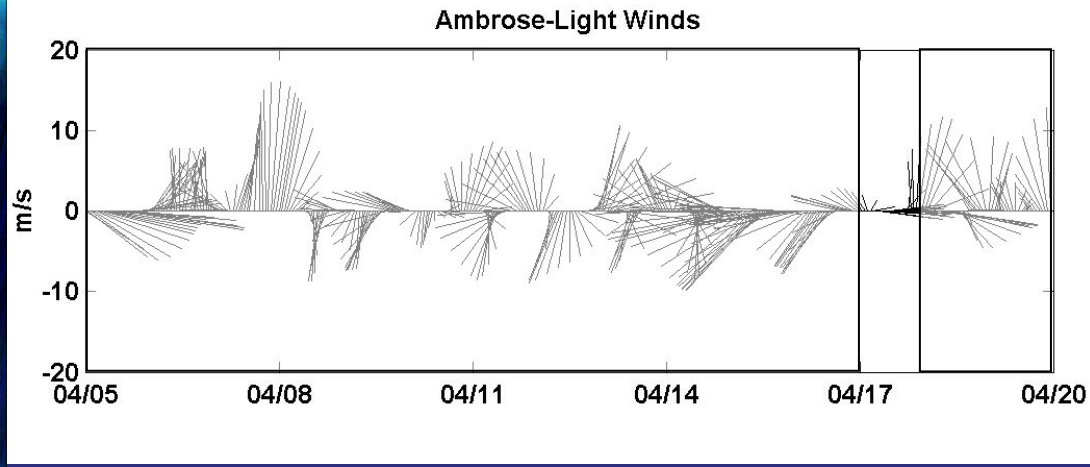
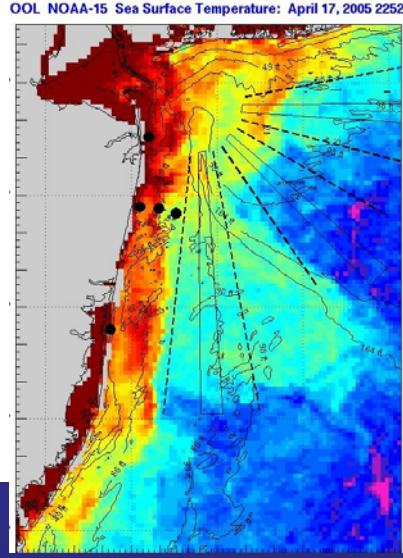
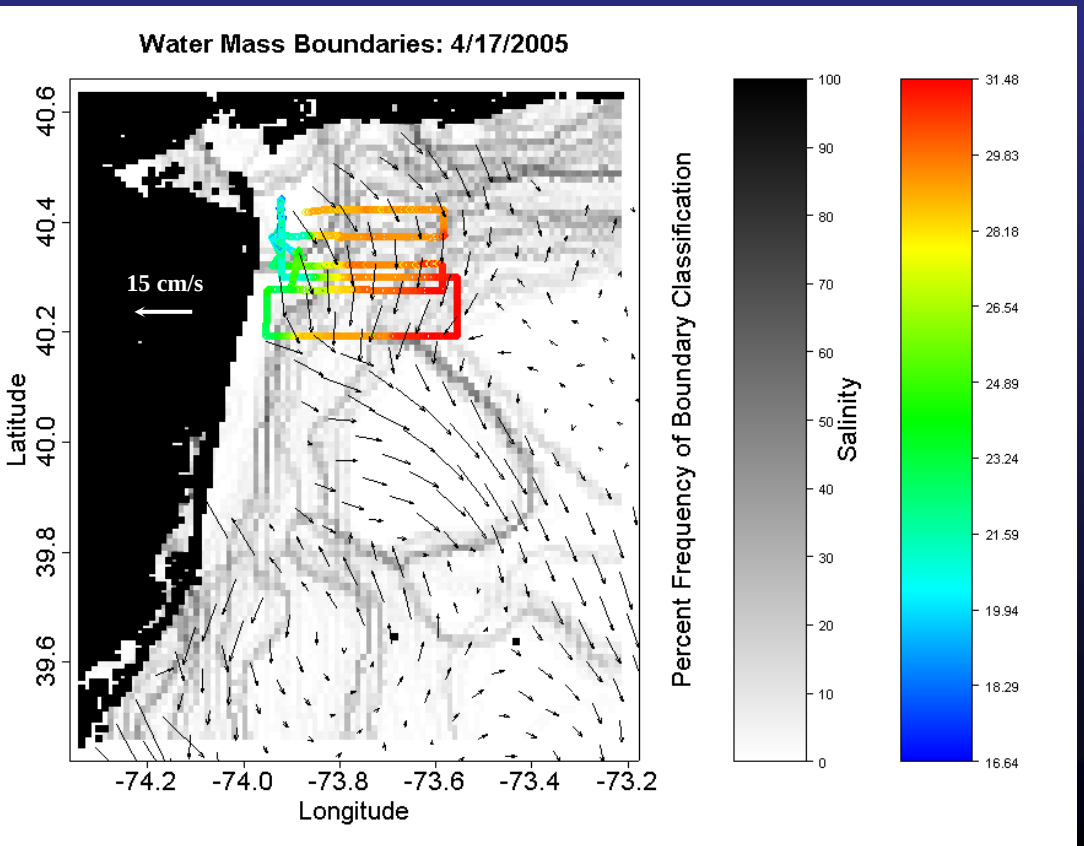
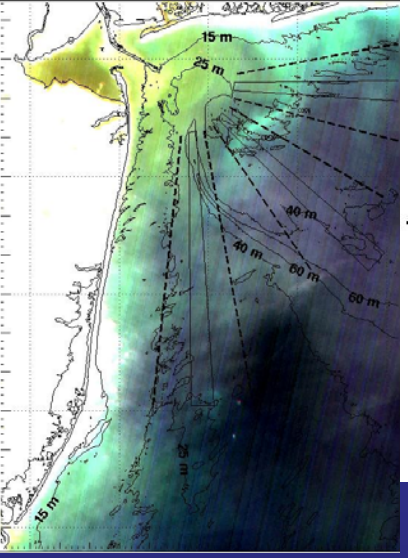
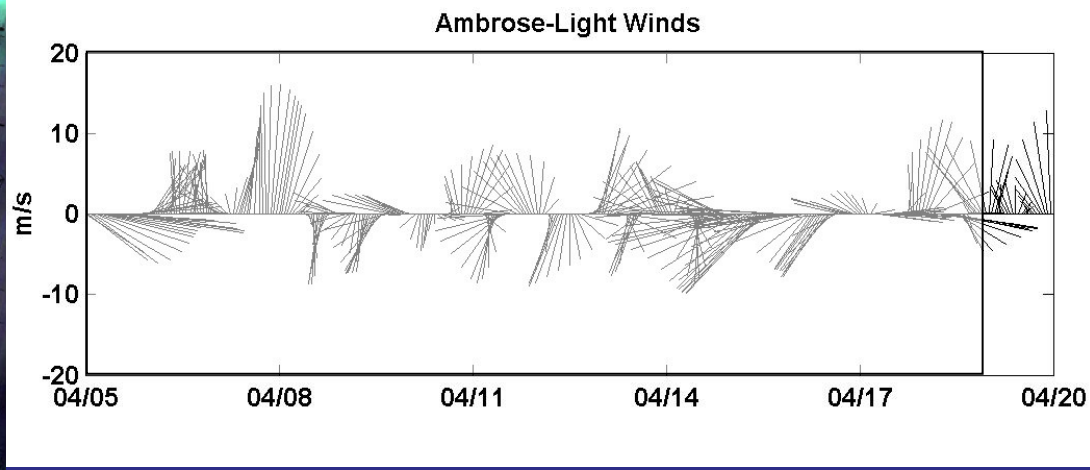

Ambrose-Light Winds
m/s
20
10
0
-10
-20
04/05
04/08
04/11
04/14
04/17
04/20

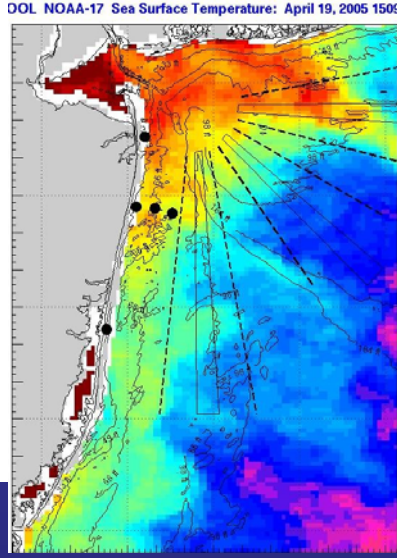

OOL NOAA-15 Sea Surface Temperature: April 17, 2005 2252

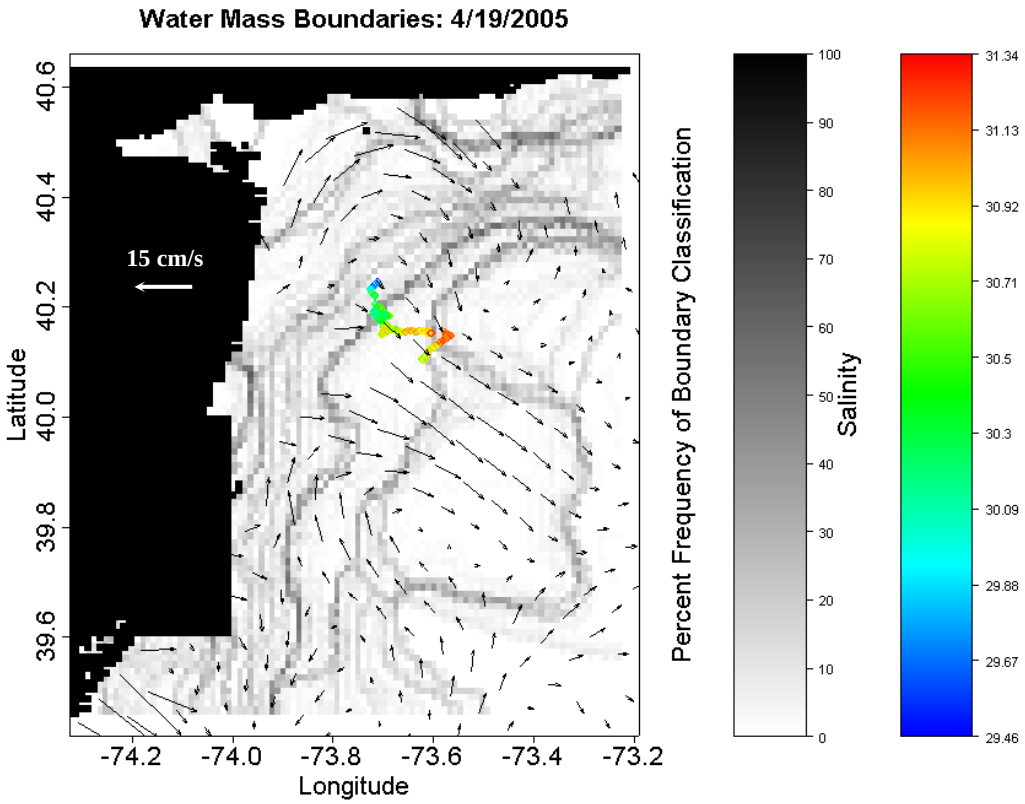

Water Mass Boundaries: 4/17/2005
15 cm/s
Latitude
40.6
40.4
40.2
40.0
39.8
39.6
-74.2
-74.0
-73.8
-73.6
-73.4
-73.2
Longitude
Percent Frequency of Boundary Classification
100
90
80
70
60
50
40
30
20
10
0
Salinity
31.48
29.83
28.18
26.54
24.89
23.24
21.59
19.94
18.29
16.64

15 cm/s


15 m
25 m
40 m
40 m
60 m
60 m
15 m


Ambrose-Light Winds
m/s
20
10
0
-10
-20
04/05
04/08
04/11
04/14
04/17
04/20


DOL NOAA-17 Sea Surface Temperature: April 19, 2005 1509


Water Mass Boundaries: 4/19/2005
15 cm/s
Latitude
40.6
40.4
40.2
40.0
39.8
39.6
-74.2
-74.0
-73.8
-73.6
-73.4
-73.2
Longitude
Percent Frequency of Boundary Classification
100
90
80
70
60
50
40
30
20
10
0
Salinity
31.34
31.13
30.92
30.71
30.5
30.3
30.09
29.88
29.67
29.46

15 cm/s

Conclusions

- We can Dynamically Map Global Surface Water Masses
- Global applications to Climate Change detection
- Regional applications as ecological indicators of fish catch.
- Local indicators of coastal water quality.