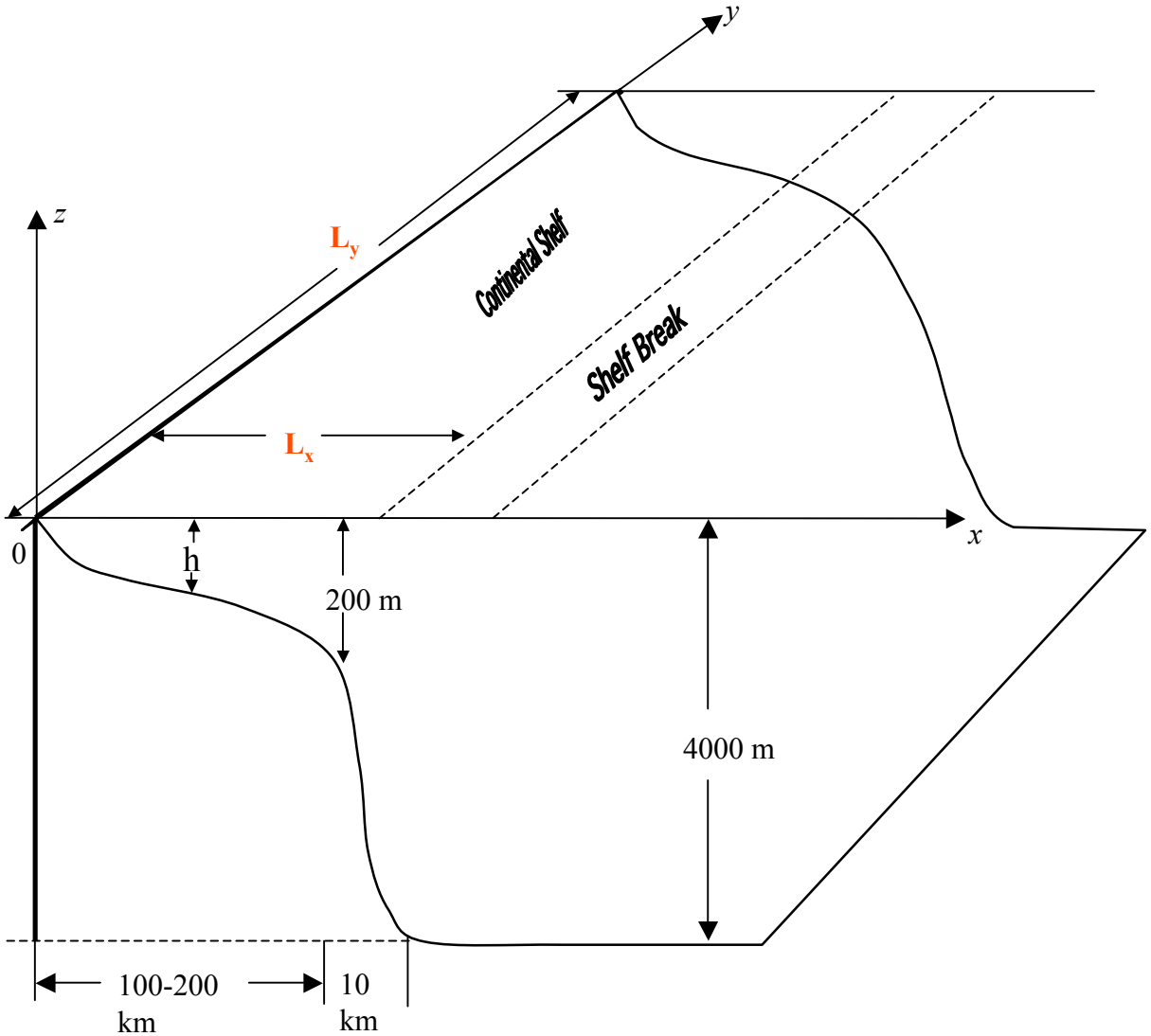
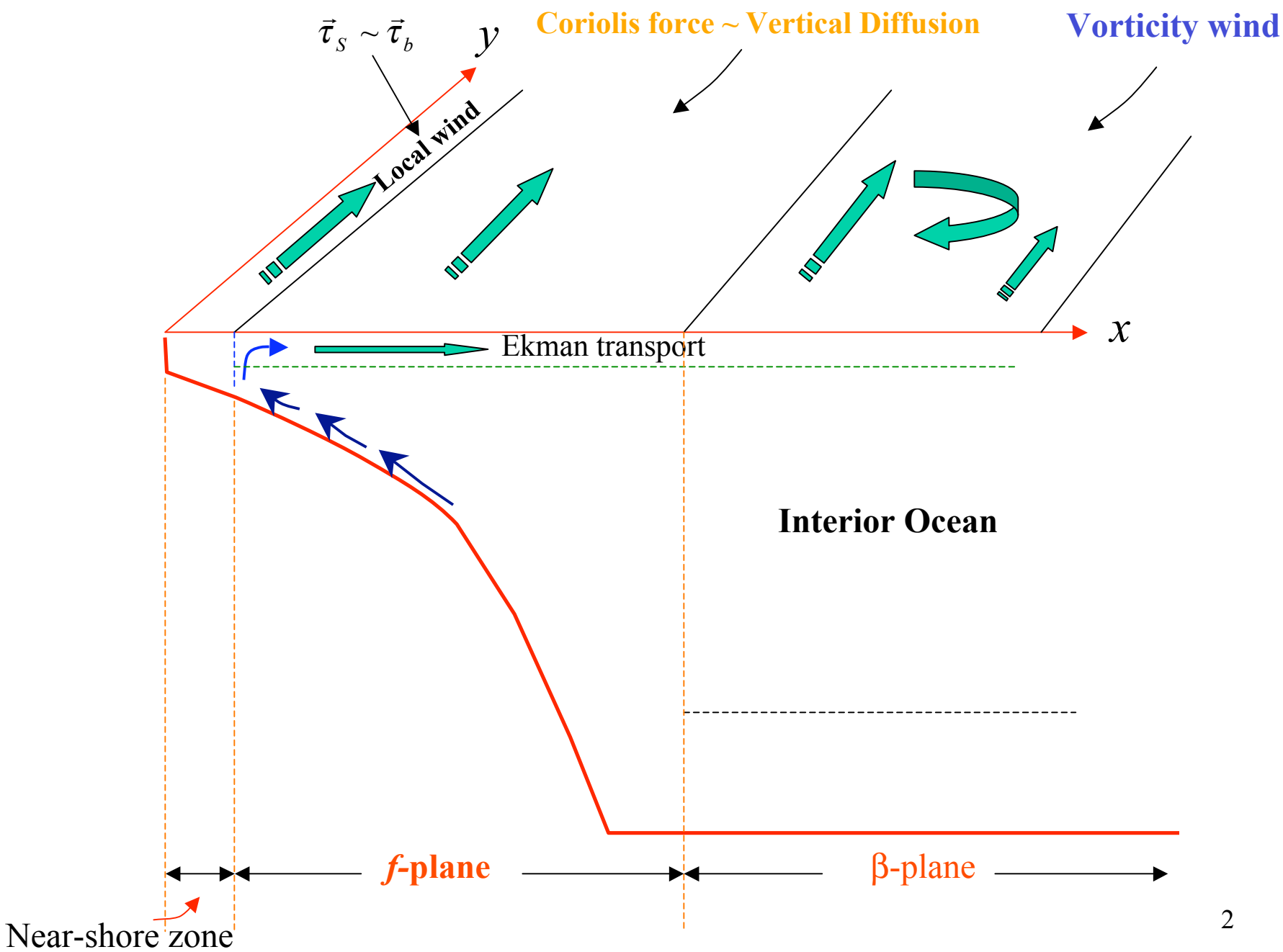
Lecture 24: Coastal Ocean Process-Oceanic Frontal System



- Coastal boundary
- $O(\Delta h) \sim O(h)$
- $L_x << L_y$
- Motion is constrained within the shelf;
- Significant time- and spatial variations.


$\vec{\tau}_S \sim \vec{\tau}_b$
y
Coriolis force ~ Vertical Diffusion
Vorticity wind
Local wind
x
Ekman transport
Interior Ocean
f-plane
β-plane
Near-shore zone

Over the continental shelf,

$$\boxed{L_x << L_y}$$

Looking at the horizontal continuous equation,

$$\frac{\partial U}{\partial x} + \frac{\partial V}{\partial y} = 0$$

$$O\left(\frac{U}{L_x}\right) \sim O\left(\frac{V}{L_y}\right) \longrightarrow U \sim V\left(\frac{L_x}{L_y}\right) << V$$

The cross-shelf velocity is one order of magnitude smaller than the along-shelf velocity.

Unlike the open ocean, the cross-shelf velocity over the continental shelf generally does not satisfy the geostrophic balance. The structure and distribution of the cross-shelf velocity is closed related to vertical mixing.

In the open ocean:

The motion is quasi-geostrophic with a slowly time variation scale

In the coastal ocean:

The motion is featured by strong nonlinear multiple-scale processes

Examples:

Small-scale high frequency surface waves → **Large-scale vertical resuspension of the sediments**

Small-scale turbulent mixing → **Formation of tidal mixing fronts**

Point freshwater discharge → **Large-scale buoyancy-driven flow**

Most interesting physical process:

1) Oceanic fronts, 2) Near-surface and bottom turbulent boundary layers; 3) Coastal trapped waves; 4) Steady and time-dependent wind- and density-driven flows; 5) Wind-mixing, tidal-mixing, tidal residual currents,

$-g\partial\zeta/\partial y$

Coastal Oceanic Fronts

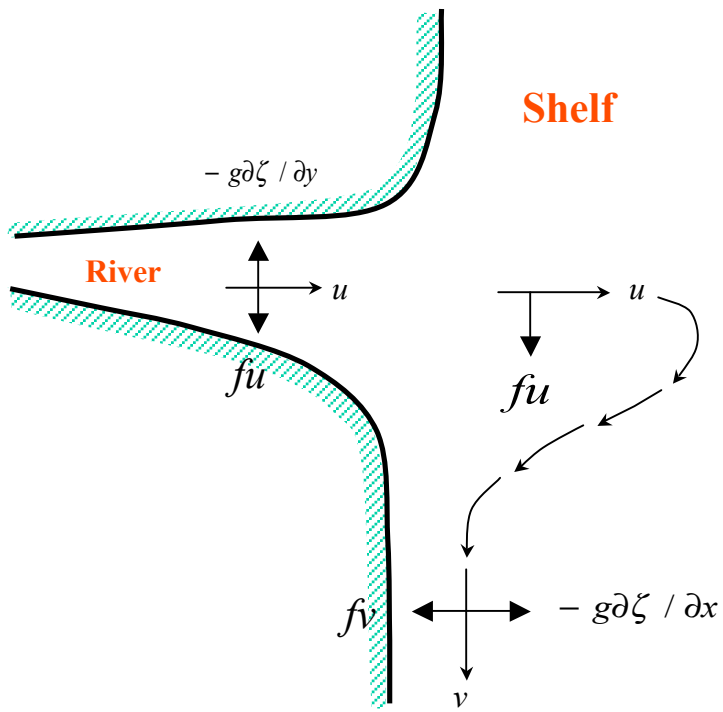
1) Low-salinity front; 2) Tidal mixing front; 3) Shelf break front; 4) Upwelling front

1) Low-salinity front

$$fu = -\frac{1}{\rho}\frac{\partial P}{\partial y}$$

$$P = P_o + \rho g(\zeta - z)$$

$$fu = -g\frac{\partial \zeta}{\partial y}$$

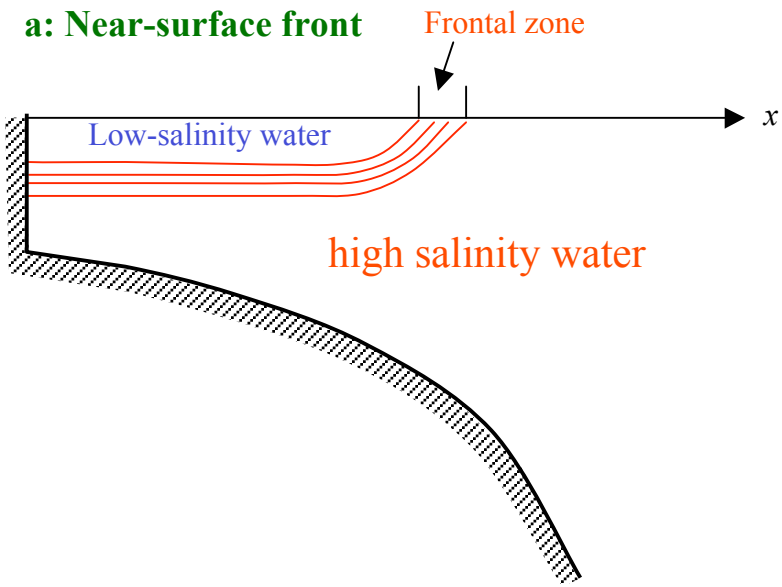


Low-salinity plume or estuarine plume

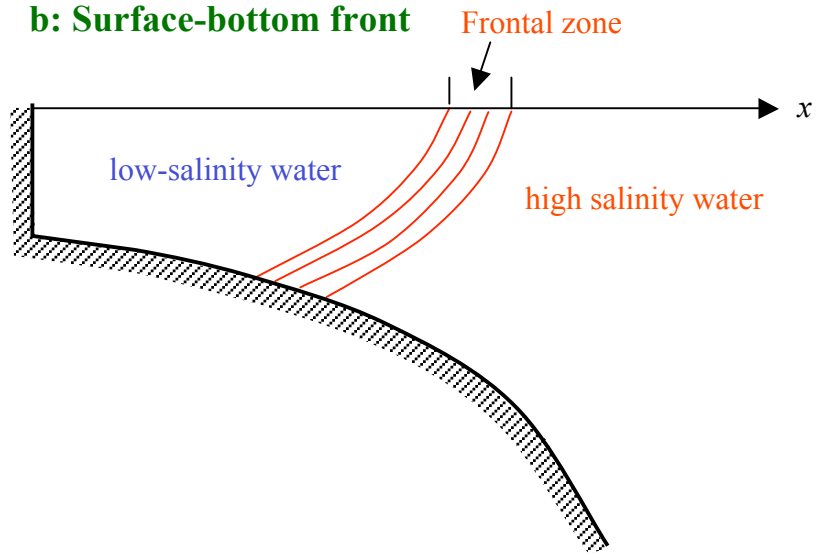
Decoupled from the bottom boundary layer

Coupled with the bottom boundary layer

a: Near-surface front

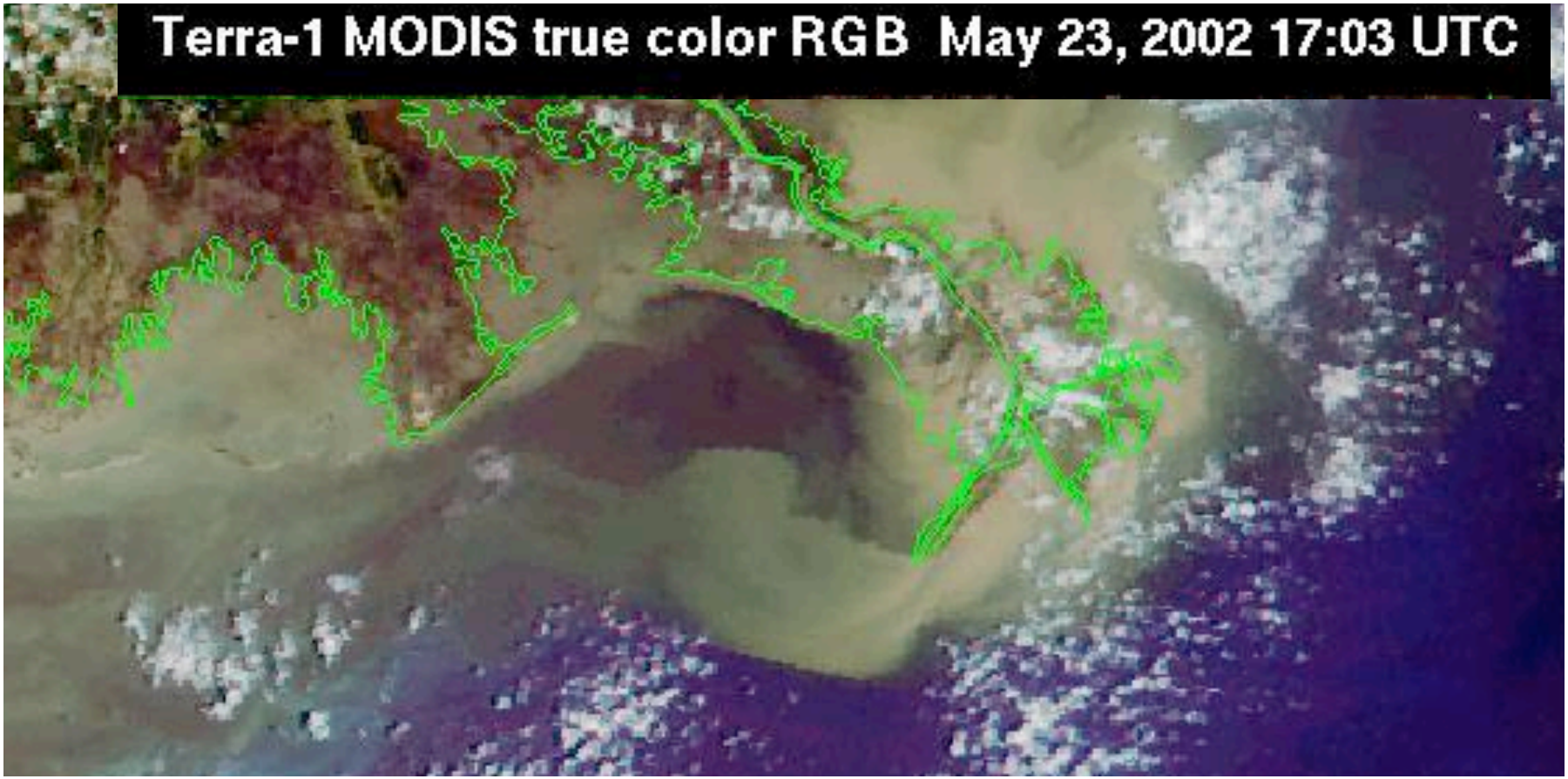


b: Surface-bottom front

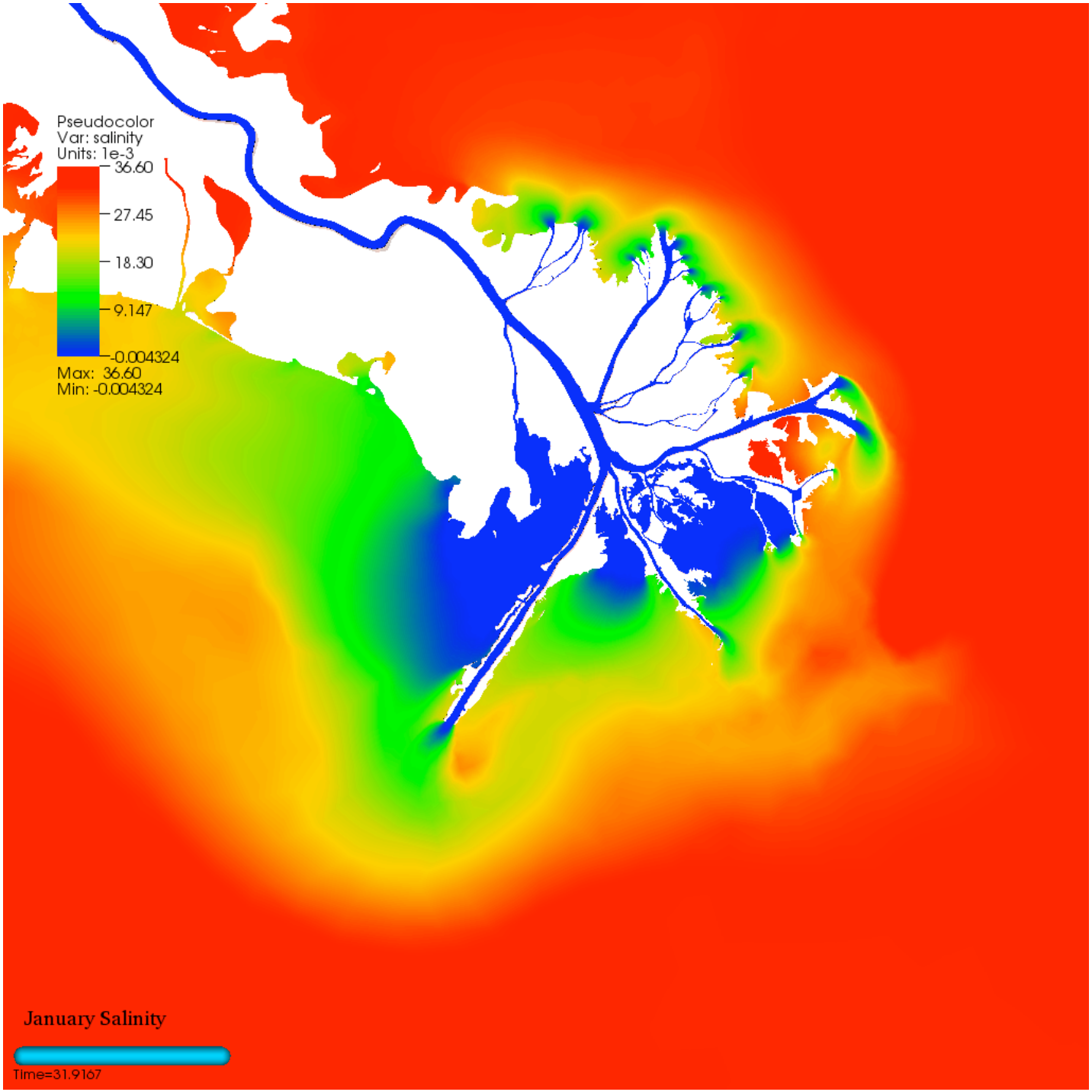


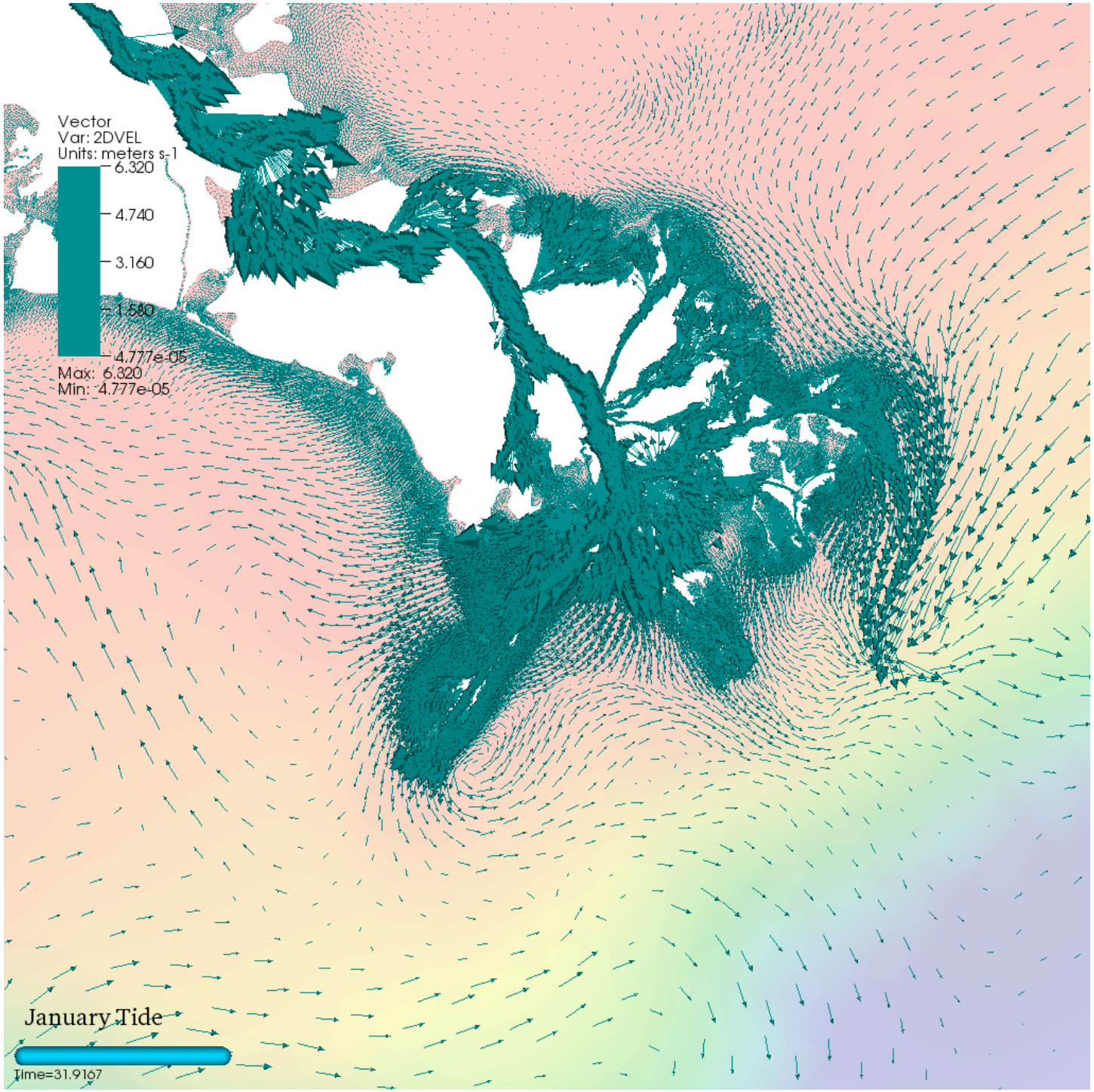
Mixing is caused by shear instability at the interface between low and high salinity waters

Mixing is controlled by the dynamics of the bottom boundary layer.

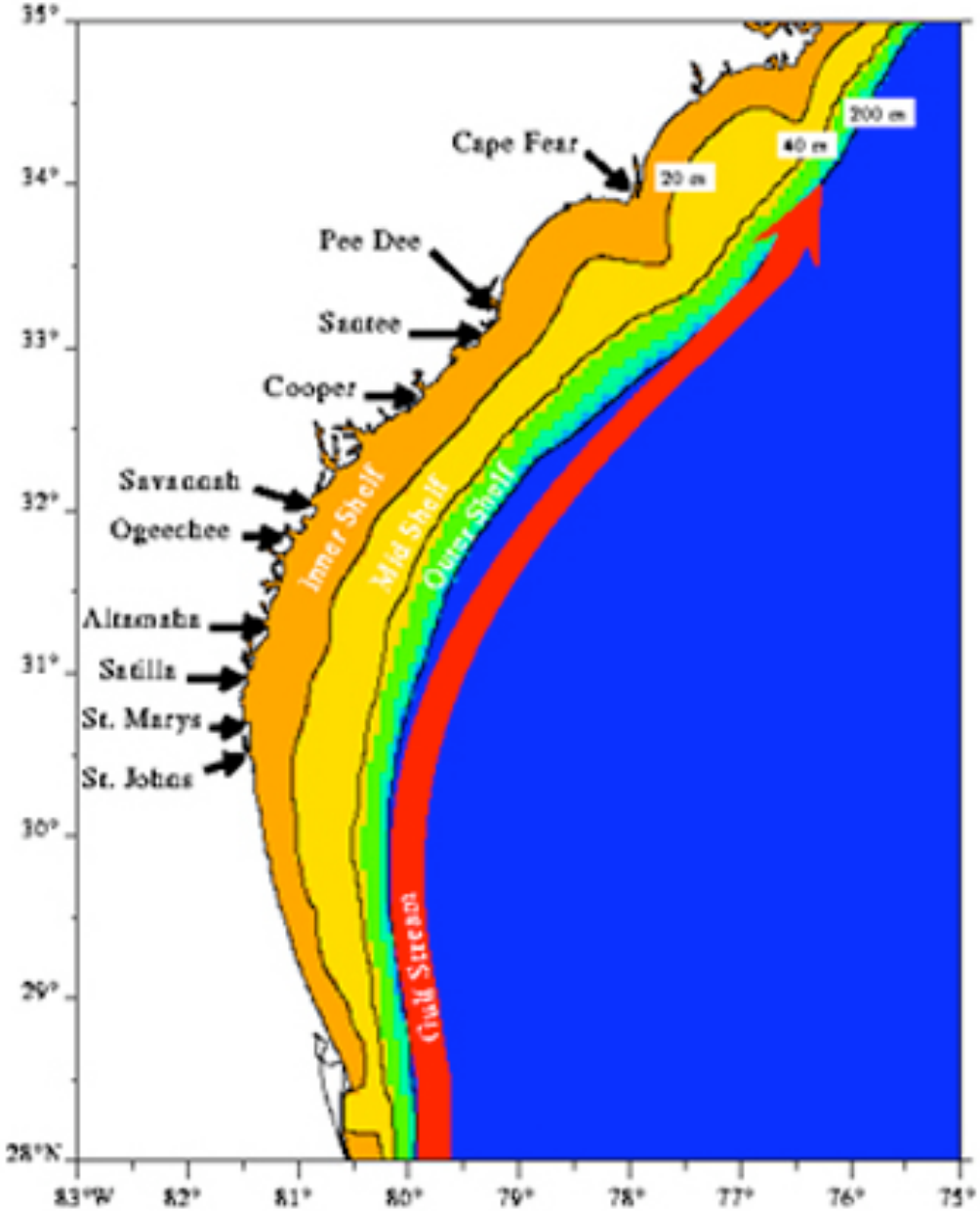


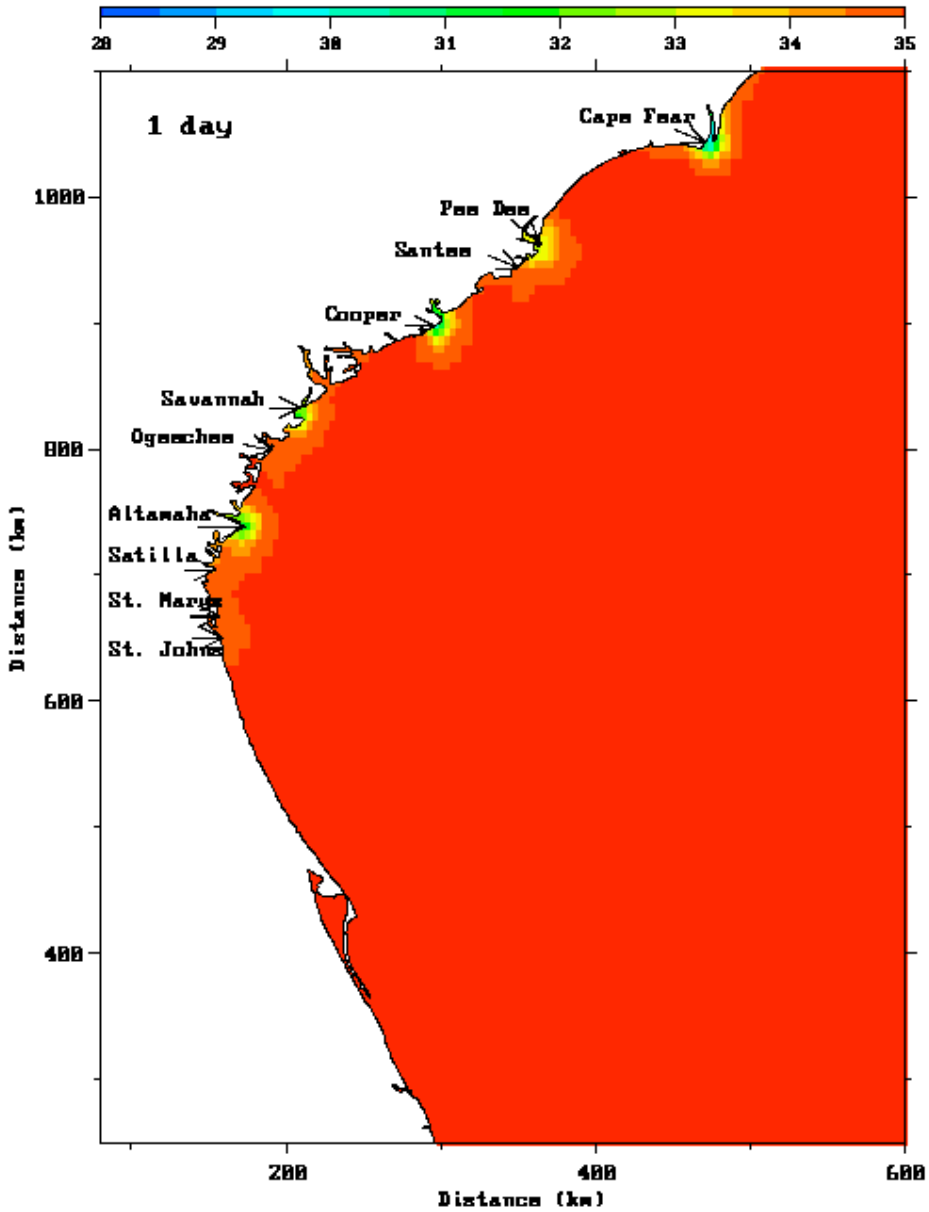
From Dr. Justic at LSU


Pseudocolor
Var: salinity
Units: 1e-3
36.60
27.45
18.30
9.147
-0.004324
Max: 36.60
Min: -0.004324
January Salinity
Time=31.9167


Vector
Var: 2DVEL
Units: meters s-1
6.320
4.740
3.160
1.580
4.777e-05
Max: 6.320
Min: 4.777e-05
January Tide
Time=31.9167

The South Atlantic Bight




28
29
30
31
32
33
34
35
1 day
Cape Fear
Pee Dee
Santee
Cooper
Savannah
Ogeechee
Altamaha
Satilla
St. Marys
St. Johns
1000
800
600
400
Distance (km)
200
400
600
Distance (km)

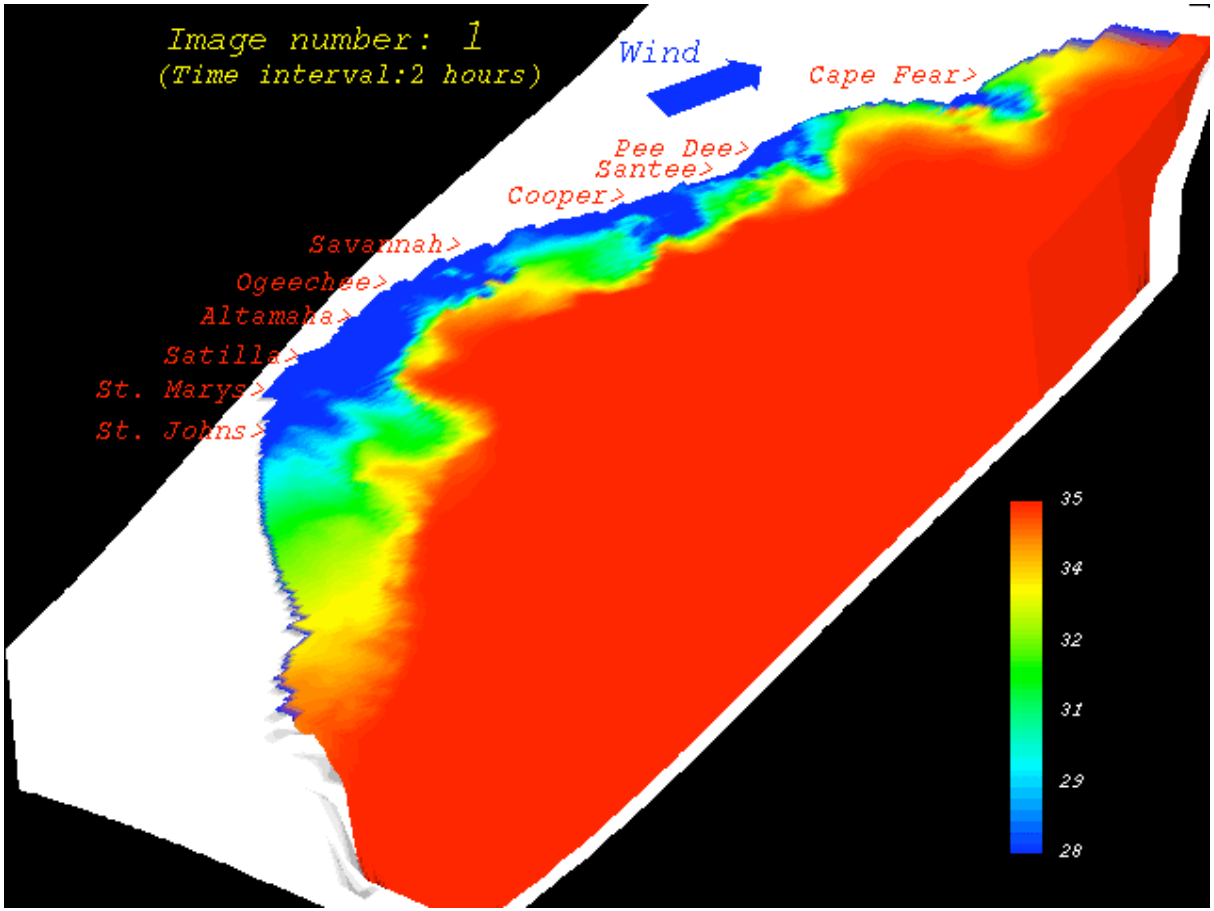
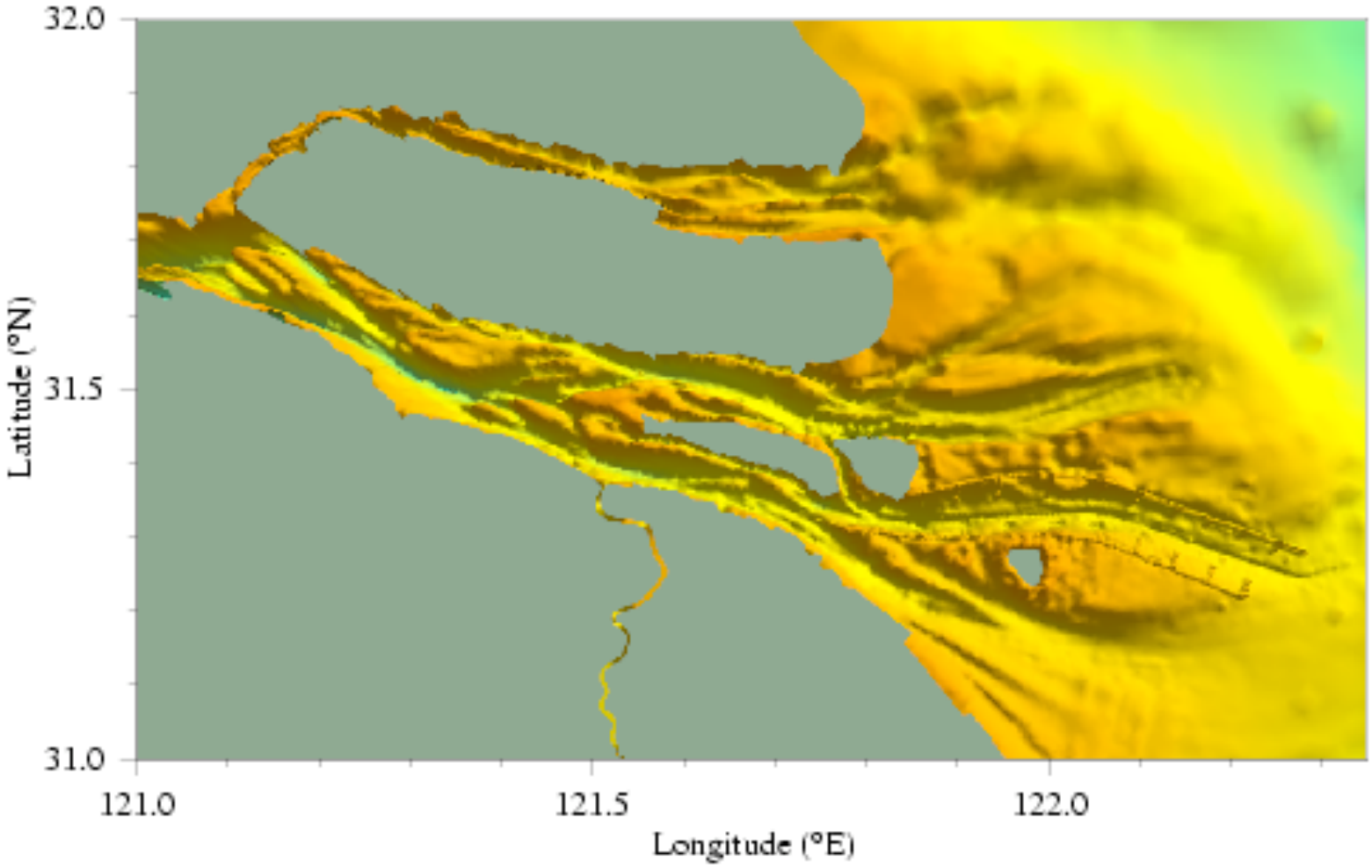
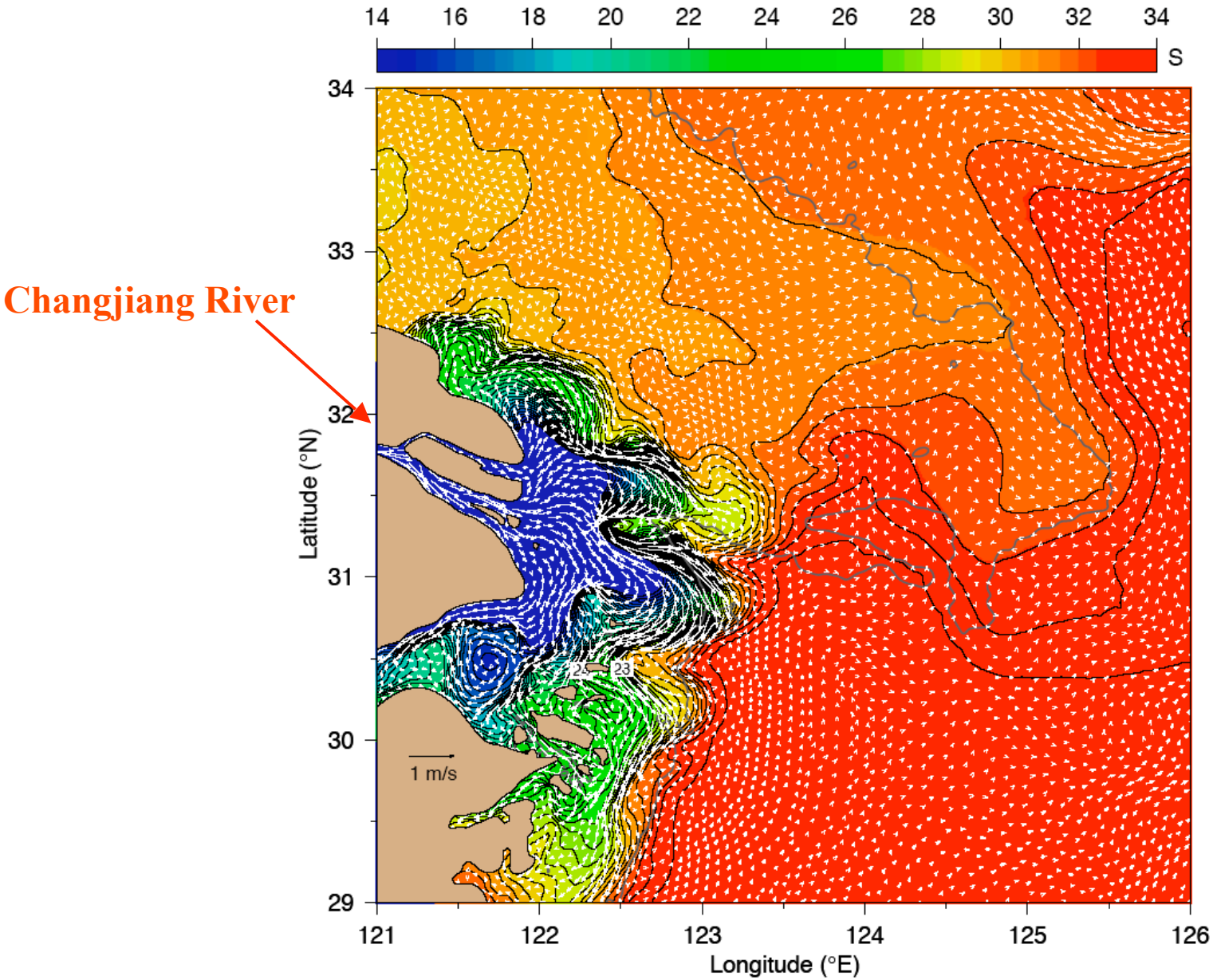


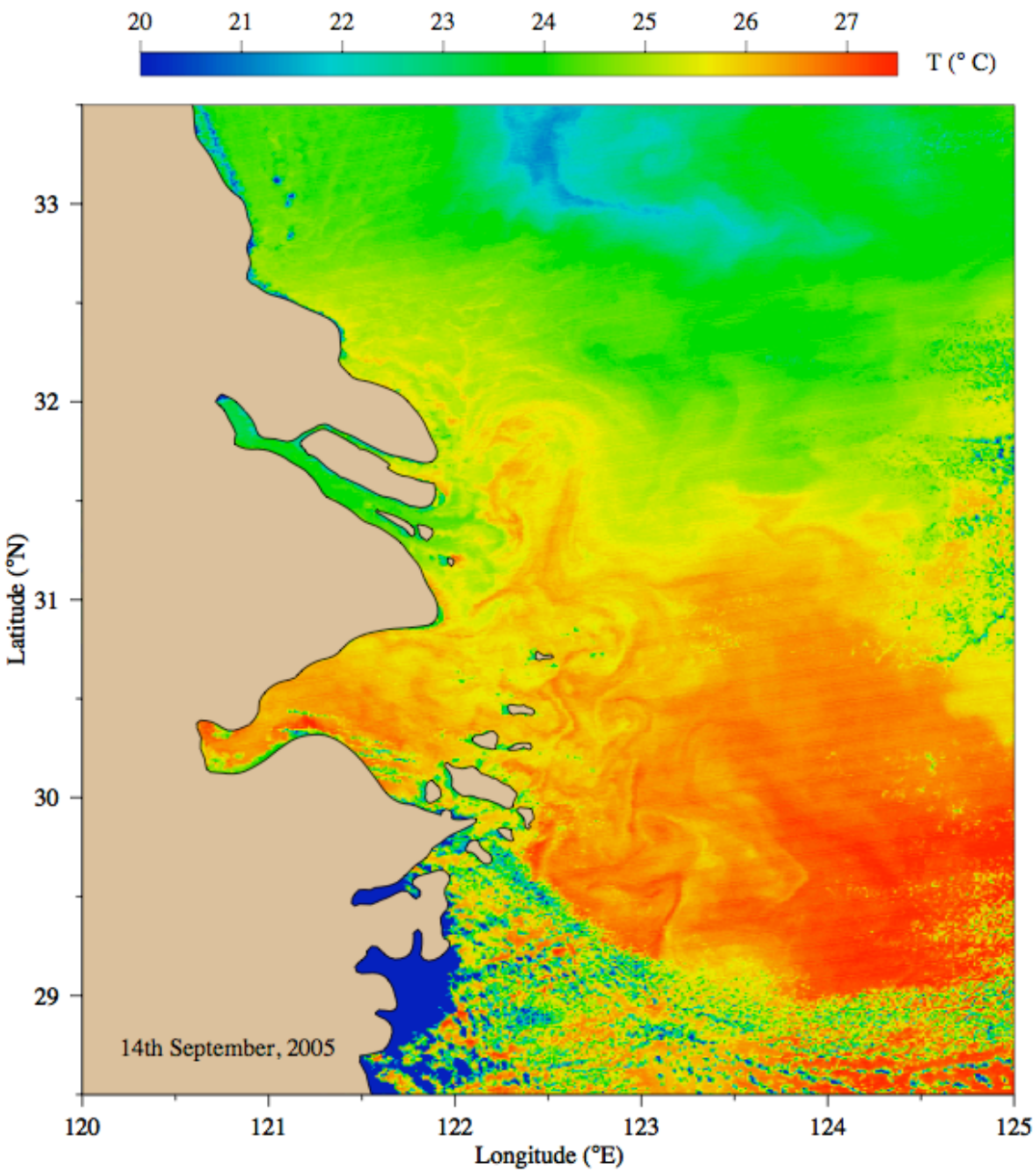
Image number: 1
(Time interval:2 hours)
Wind
Cape Fear>
Pee Dee>
Santee>
Cooper>
Savannah>
Ogeechee>
Altamaha>
Satilla>
St. Marys>
St. Johns>
35
34
32
31
29
28

Changjiang River, The East China Sea

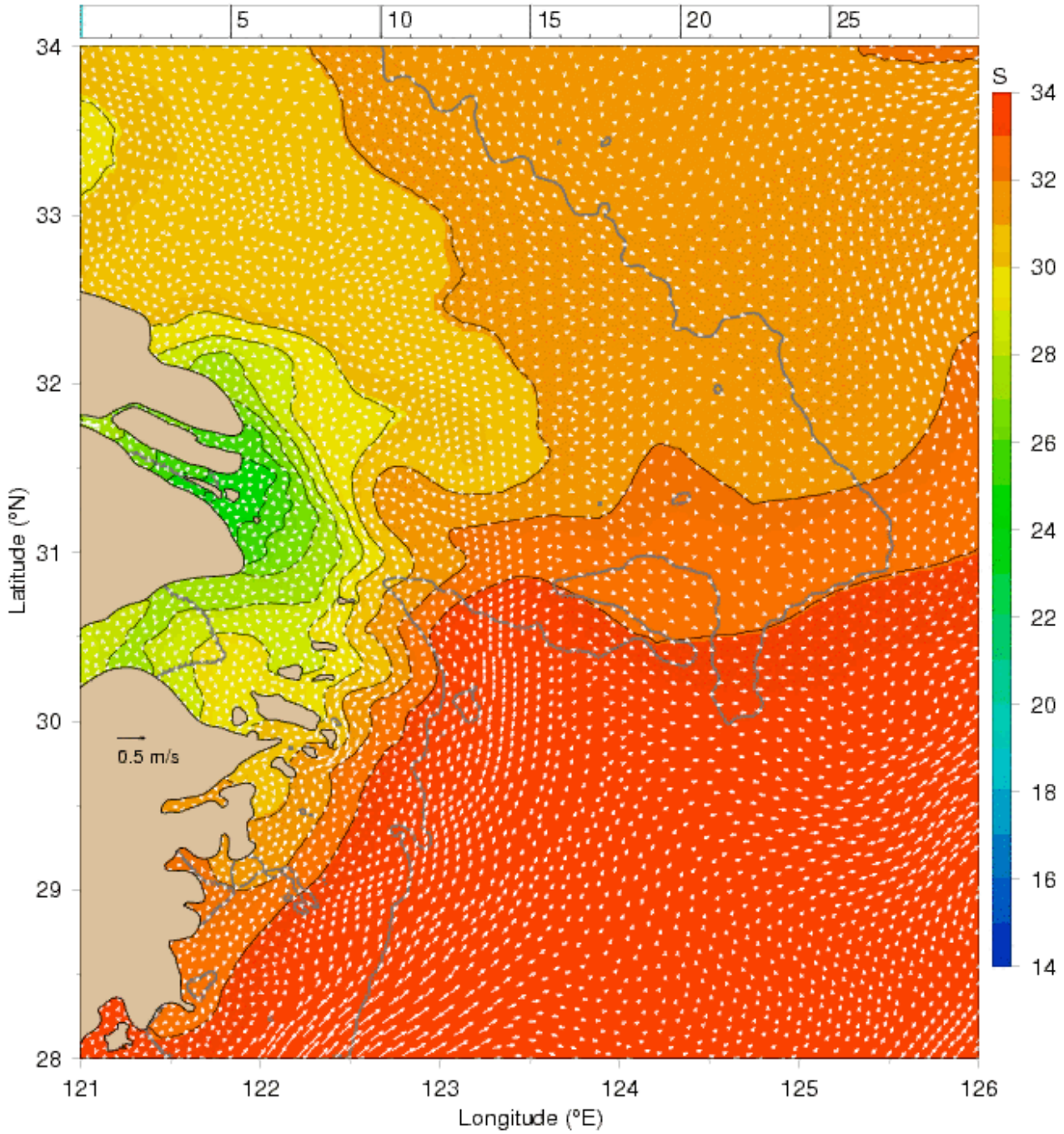


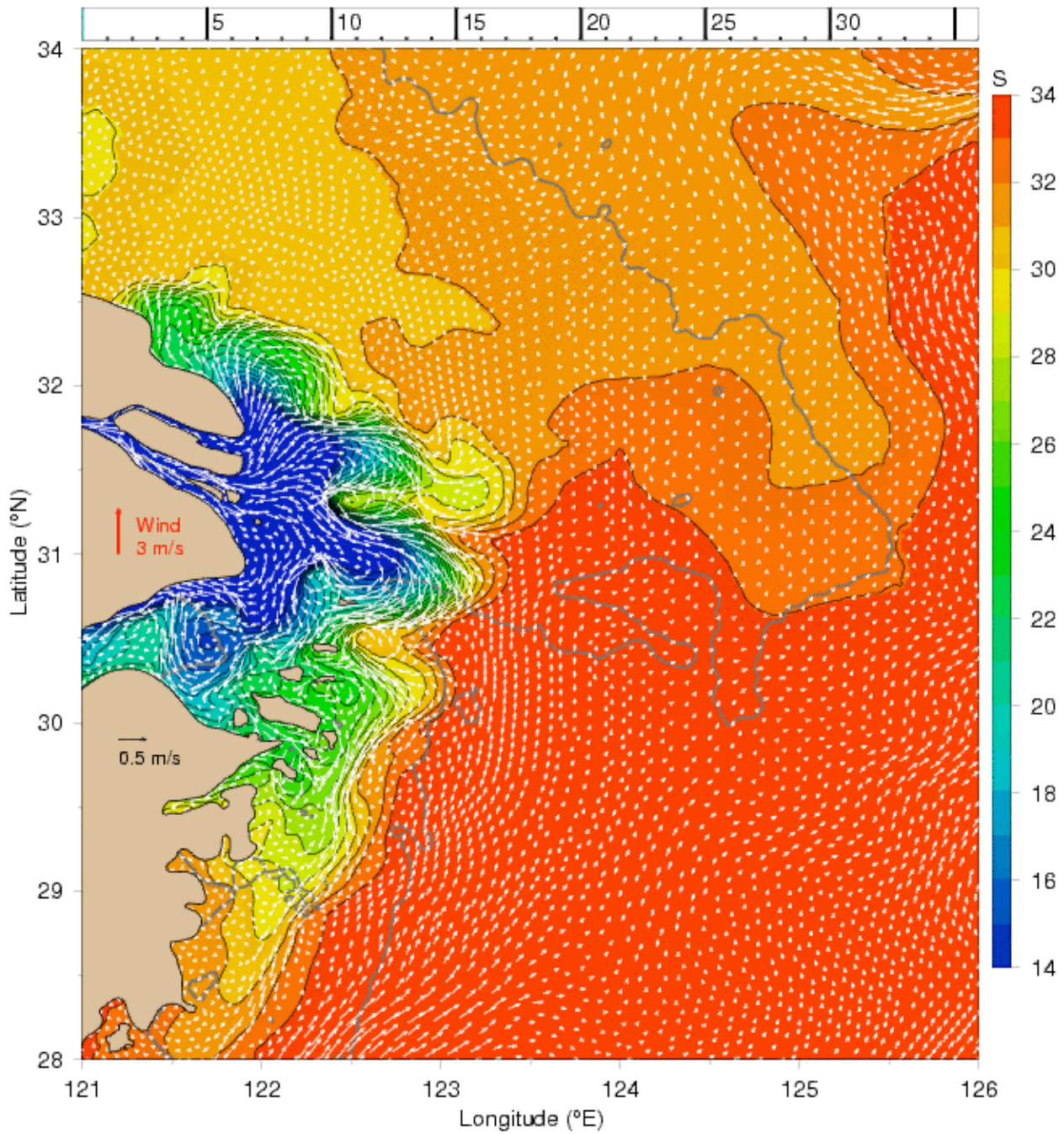
The East China Sea

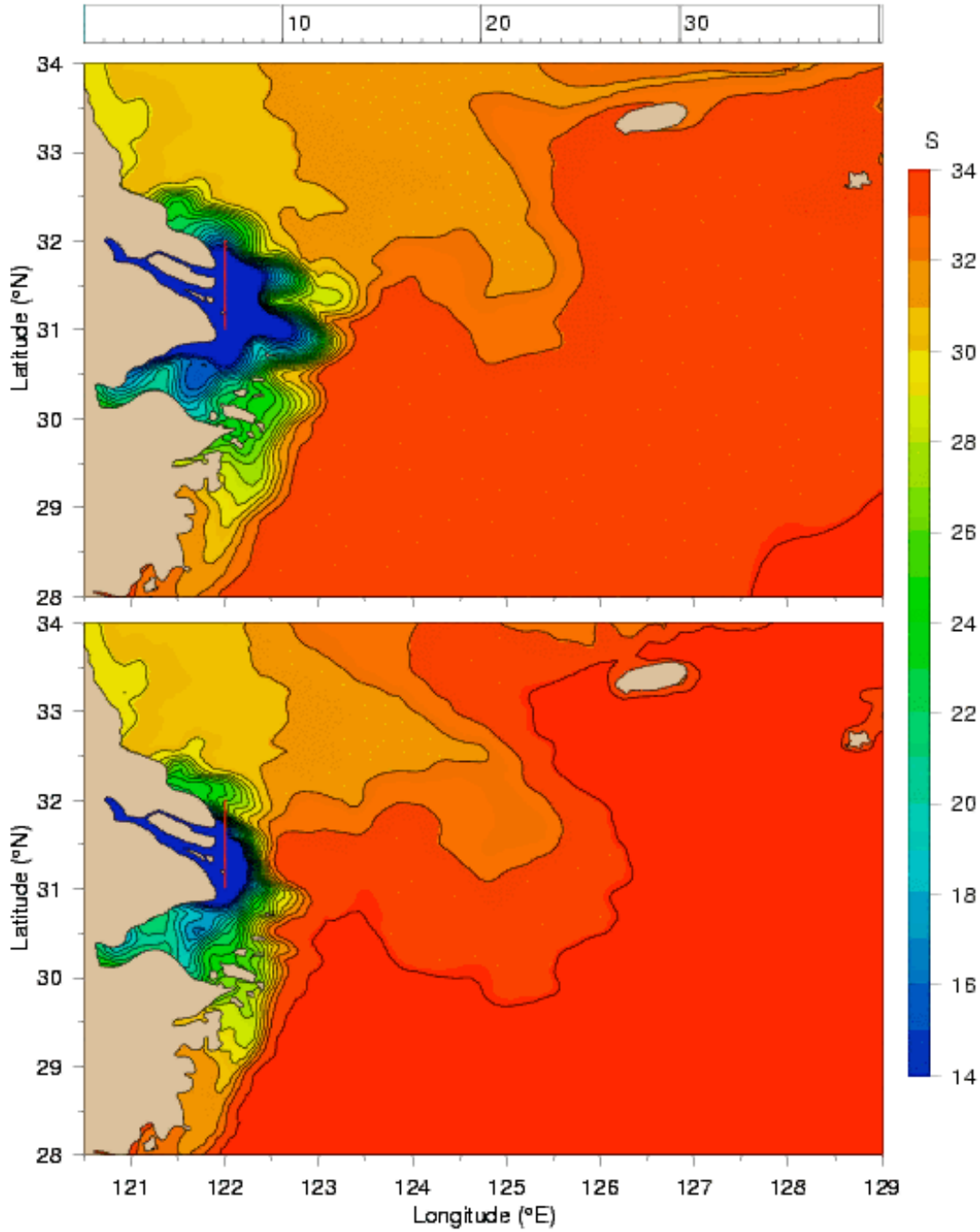


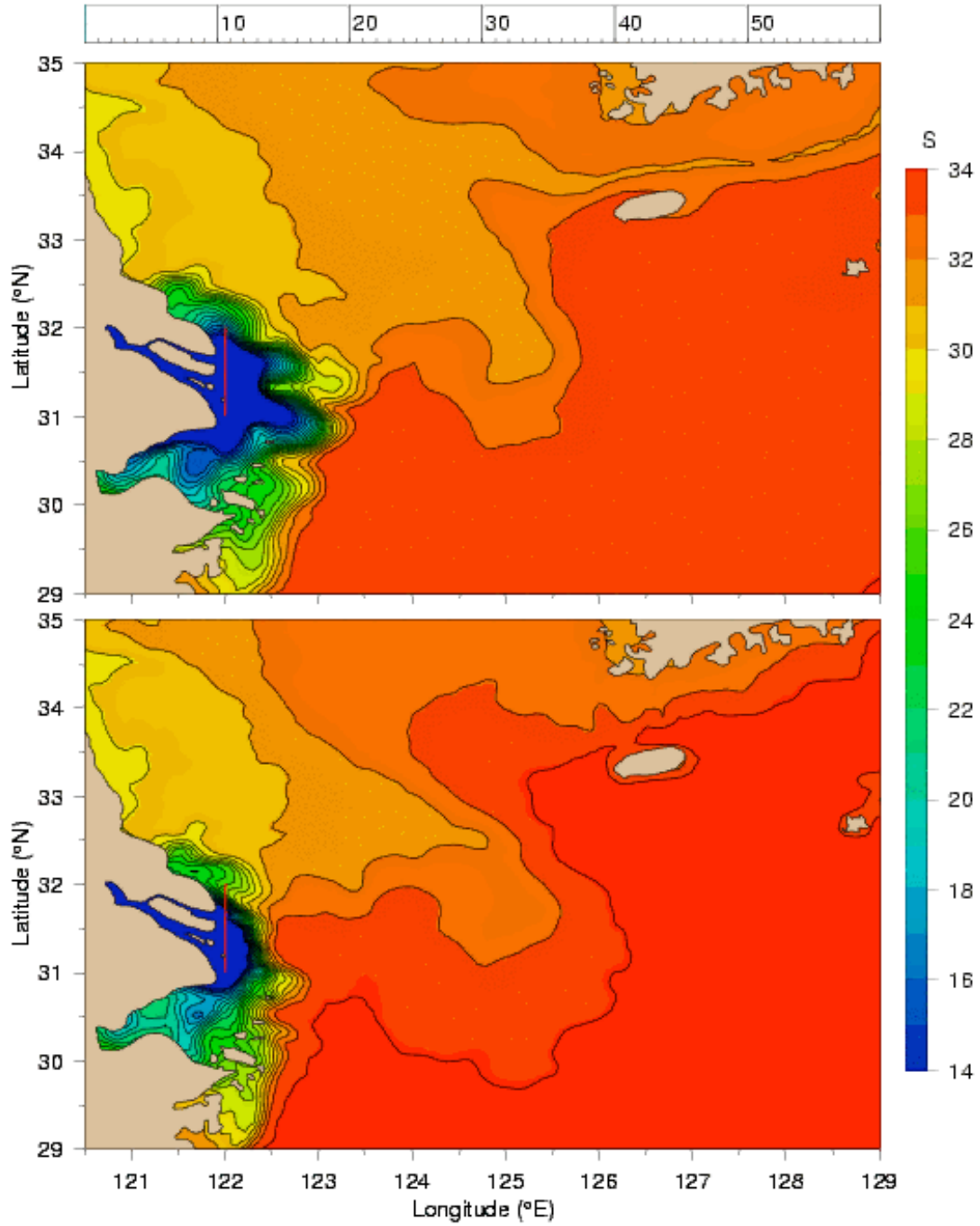

20
21
22
23
24
25
26
27
T (° C)
33
32
31
30
29
Latitude (°N)
14th September, 2005
120
121
122
123
124
125
Longitude (°E)

MODIS SST


5
10
15
20
25
34
33
32
31
30
29
28
Latitude (°N)
121
122
123
124
125
126
Longitude (°E)
0.5 m/s
S
34
32
30
28
26
24
22
20
18
16
14


5
10
15
20
25
30
34
33
32
31
30
29
28
Latitude (°N)
121
122
123
124
125
126
Longitude (°E)
Wind
3 m/s
0.5 m/s
S
34
32
30
28
26
24
22
20
18
16
14


10
20
30
34
33
32
31
30
29
28
Latitude (°N)
121
122
123
124
125
126
127
128
129
Longitude (°E)
S
34
32
30
28
26
24
22
20
18
16
14


10
20
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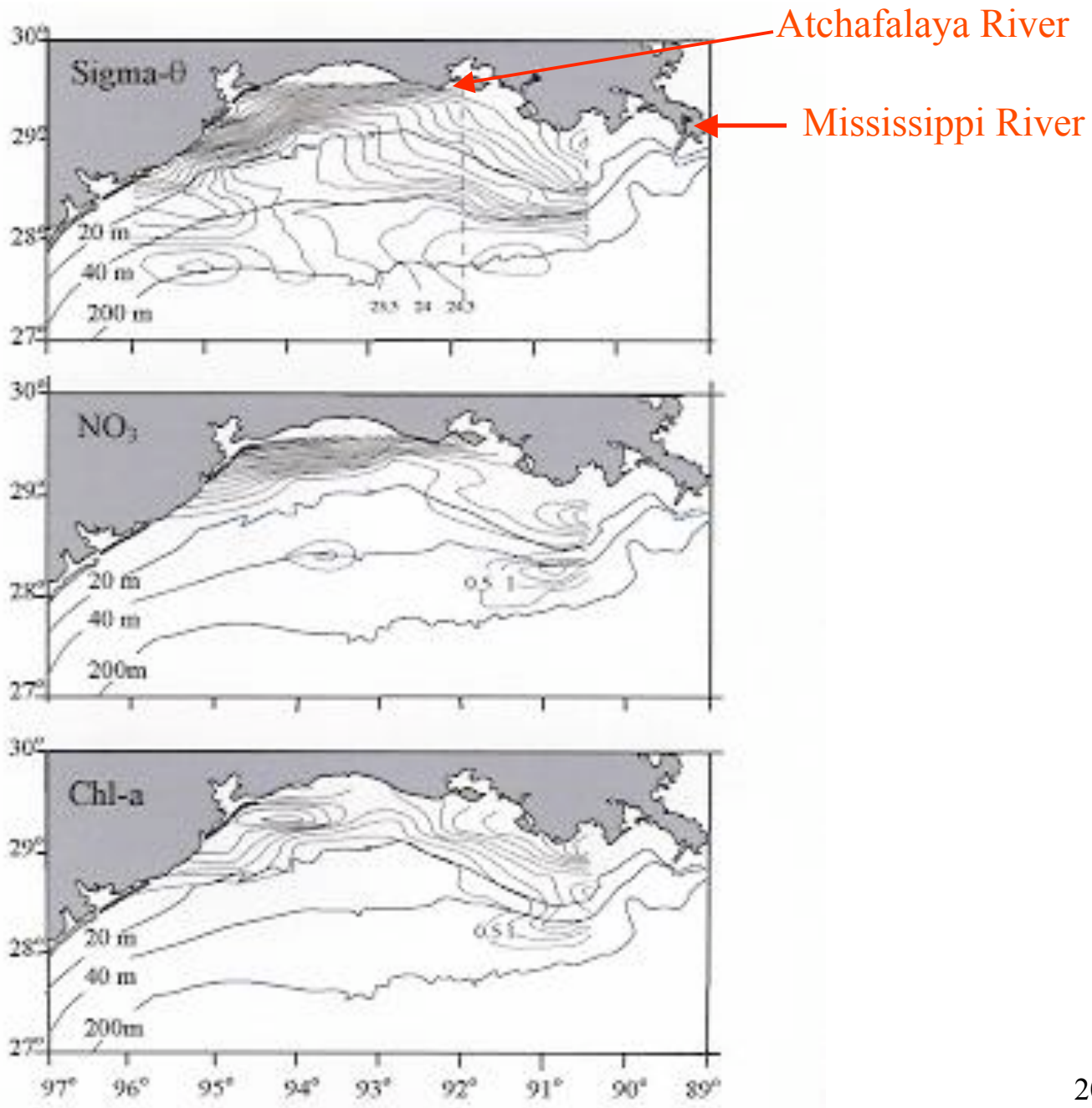
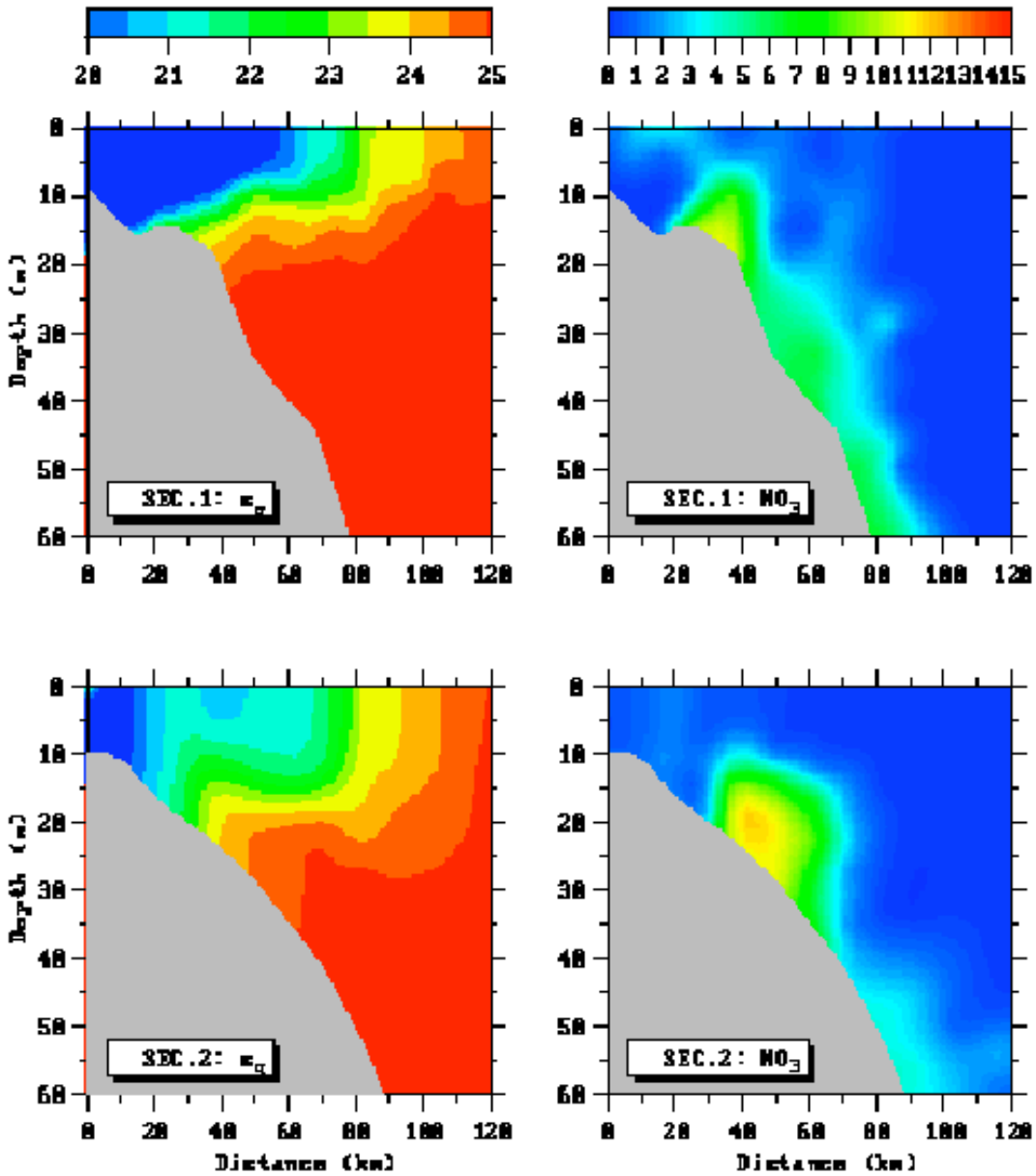
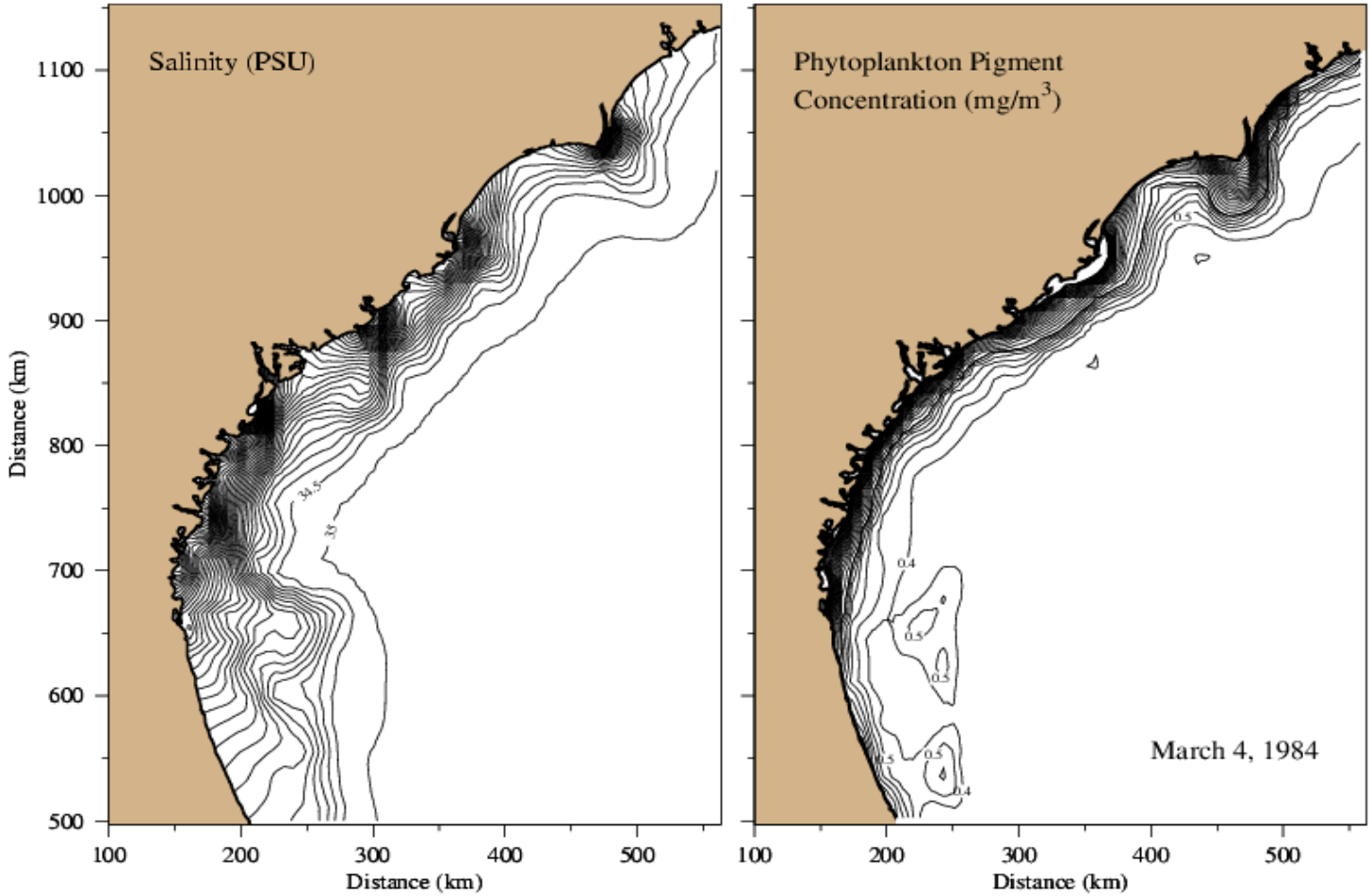
40
50
35
34
33
32
31
30
29
Latitude (°N)
S
34
32
30
28
26
24
22
20
18
16
14
121
122
123
124
125
126
127
128
129
Longitude (°E)

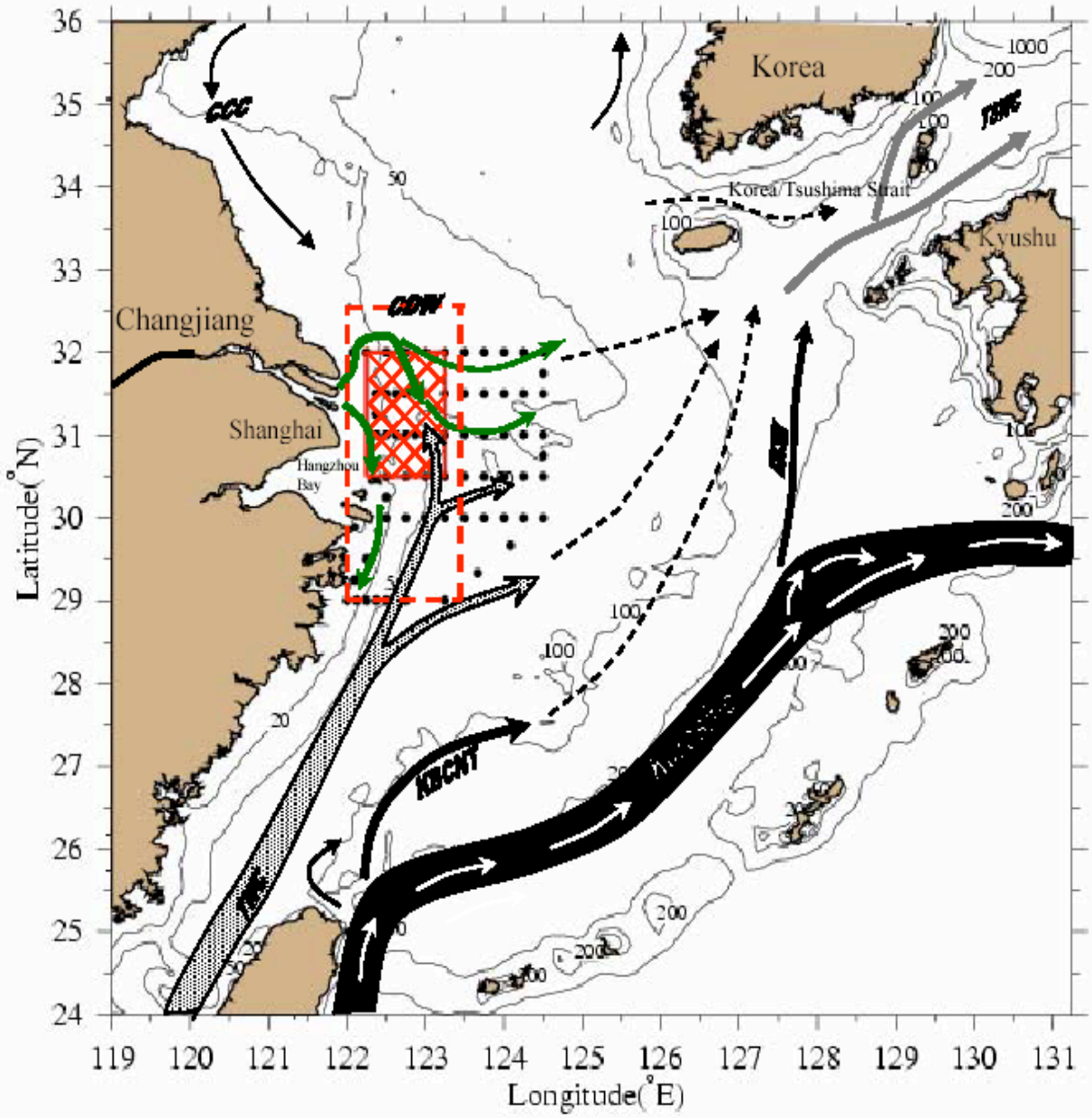
LATEX shelf


Atchafalaya River
Mississippi River
Sigma-θ
20 m
40 m
200 m
NO3
0.5 1
Chl-a
30°
29°
28°
27°
97°
96°
95°
94°
93°
92°
91°
90°
89°


20 21 22 23 24 25
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Depth (m)
SEC.1: σ_θ
SEC.1: NO_3
SEC.2: σ_θ
SEC.2: NO_3
Distance (km)

The South Atlantic Bight

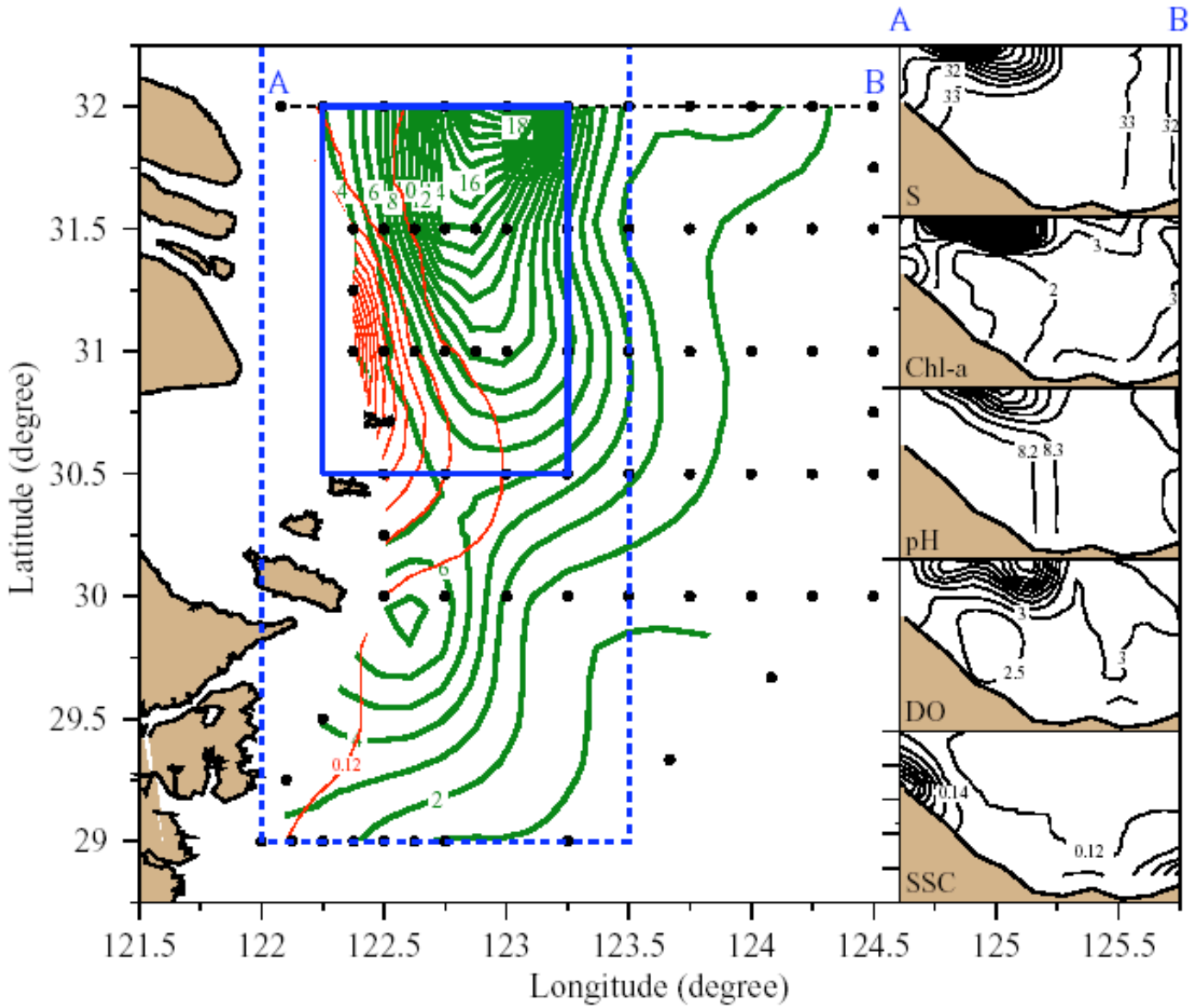


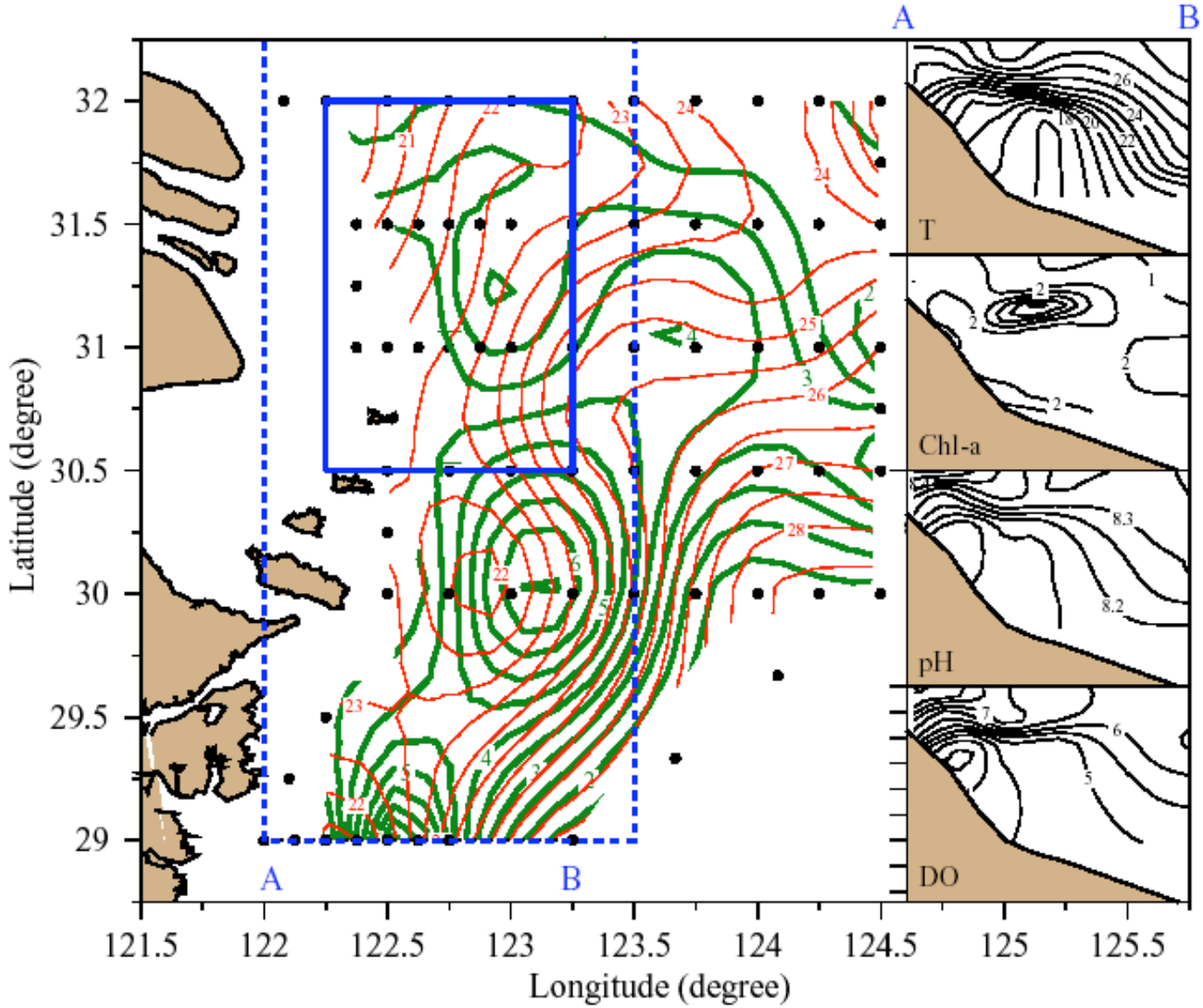

Korea
Korea/Tsushima Strait
Kyushu
Changjiang
Shanghai
Hangzhou Bay
CCC
CDW
TSW
KBCW
Latitude(°N)
Longitude(°E)

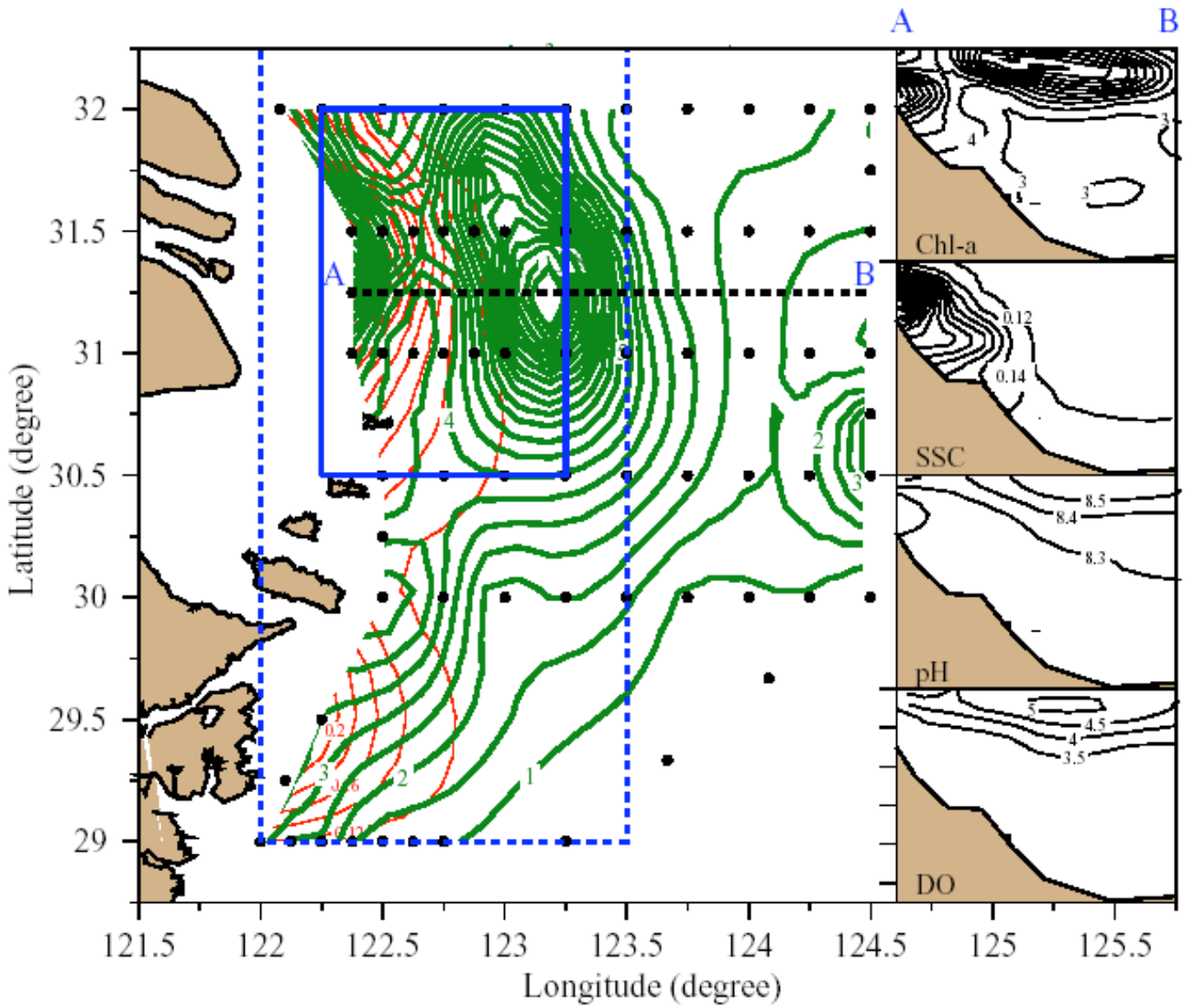
Nutrients due to the Changjiang River Discharge

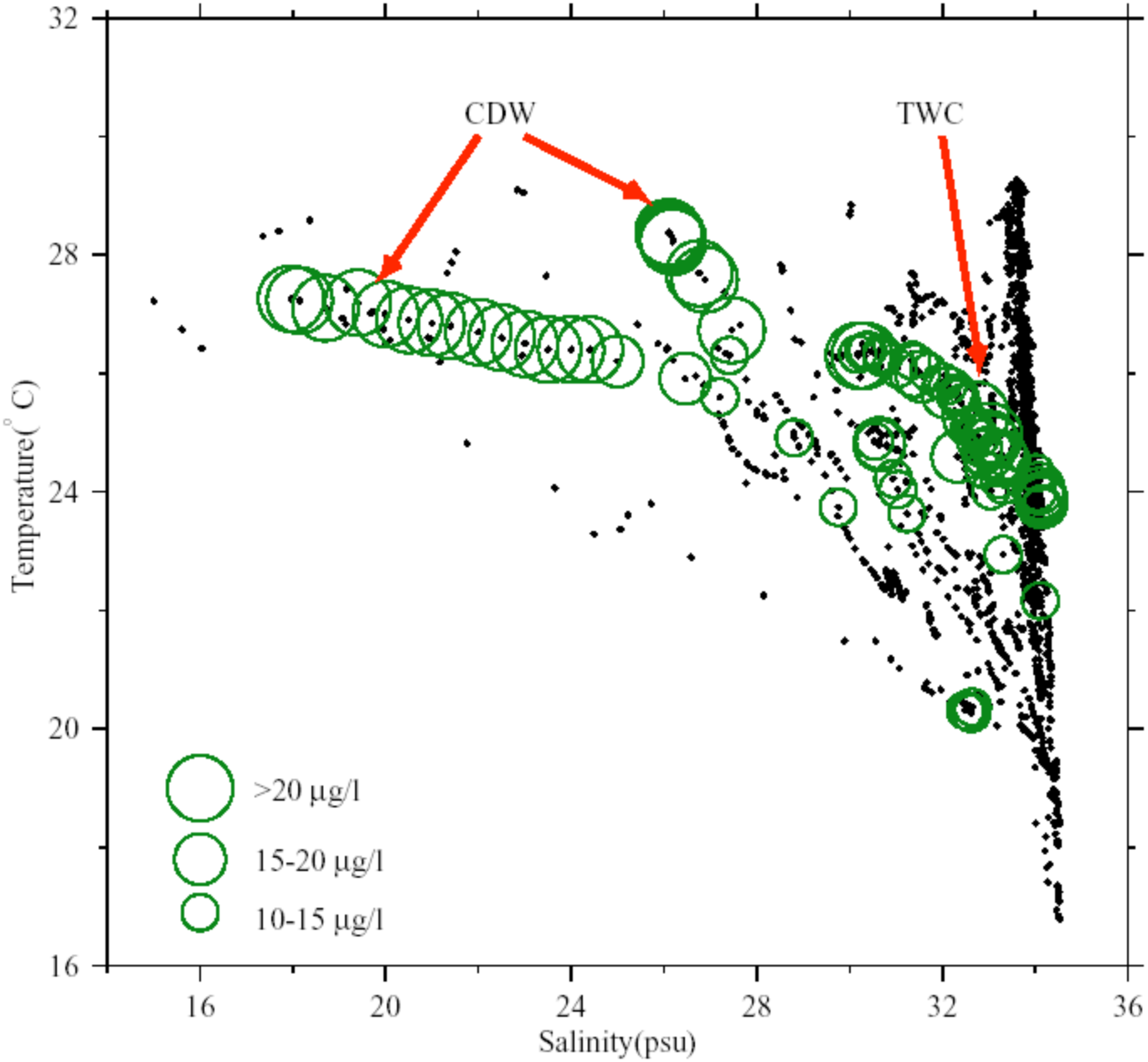
Year	DIN (μmol N/L)	DIP (μmol P/L)	DIN/DIP
1986	9	0.58	16
1992	56	0.68	82
1997	106	>0.91	117 (450)

DIN: Dissolved inogranic nitrogen
DIP: Dissovled inorganic phosphorus


A
B
Latitude (degree)
Longitude (degree)
32
31.5
31
30.5
30
29.5
29
121.5
122
122.5
123
123.5
124
124.5
125
125.5
S
Chl-a
pH
DO
SSC


A
B
Latitude (degree)
Longitude (degree)
32
31.5
31
30.5
30
29.5
29
121.5
122
122.5
123
123.5
124
124.5
125
125.5
T
Chl-a
pH
DO


A
B
Chl-a
SSC
pH
DO
Latitude (degree)
Longitude (degree)
32
31.5
31
30.5
30
29.5
29
121.5
122
122.5
123
123.5
124
124.5
125
125.5


CDW
TWC
>20 µg/l
15-20 µg/l
10-15 µg/l
Temperature(°C)
Salinity(psu)
32
28
24
20
16
16
20
24
28
32
36

Saltwater Intrusion into the Changjiang River