The Cape Hatteras Confluence
&
Implications for the Destinations of Oil Spills

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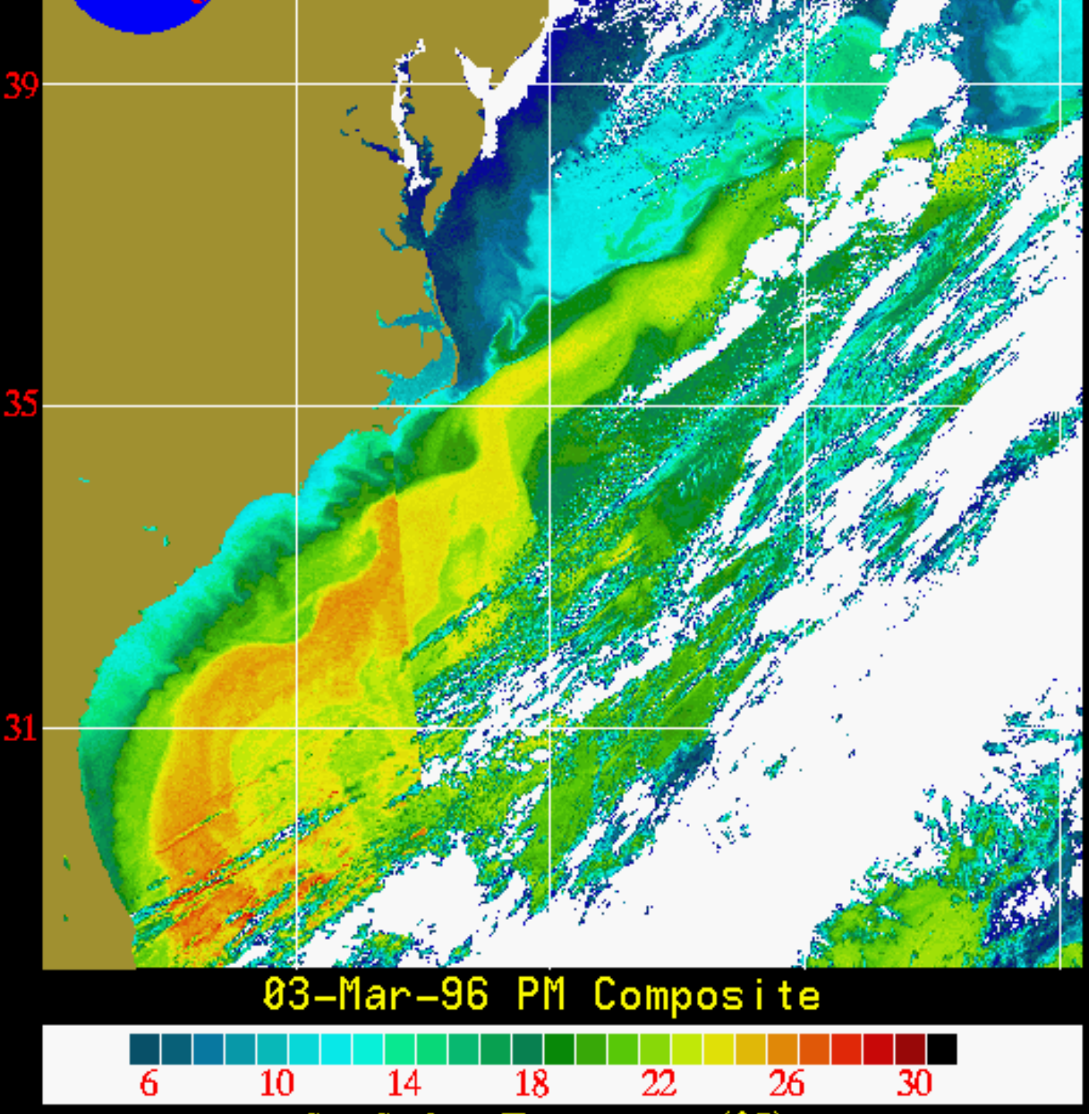
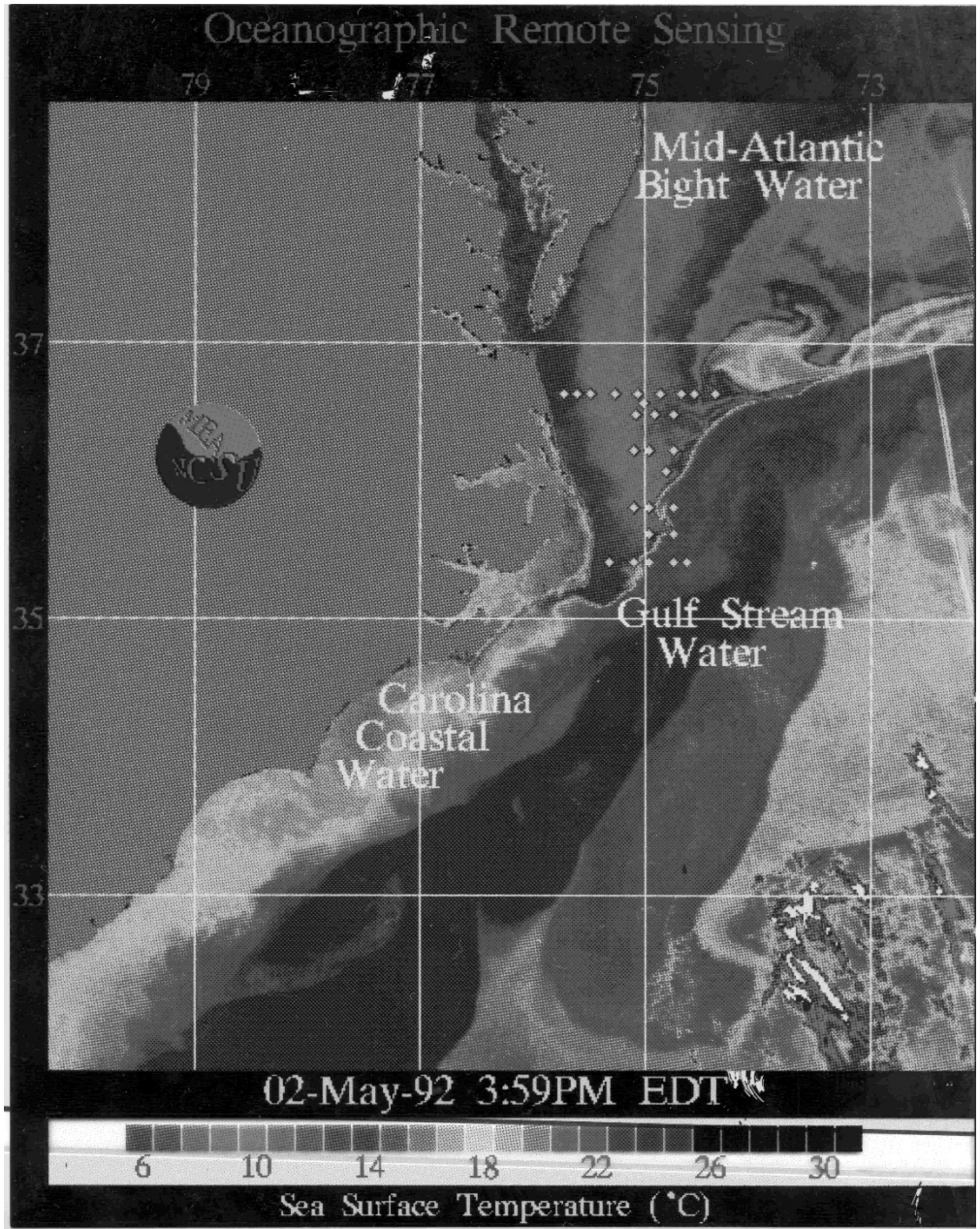
NC State University
Coastal Carolina University



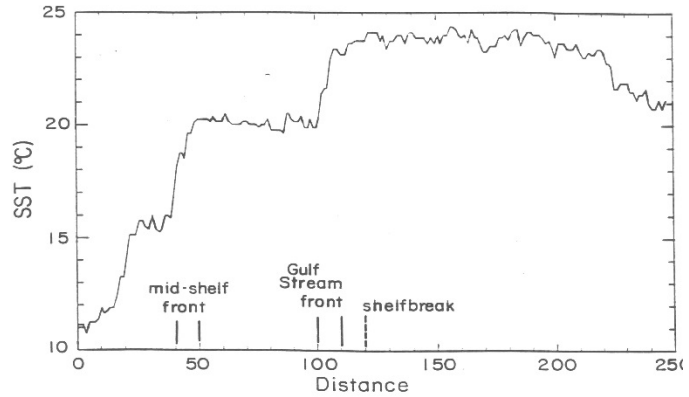
The “confluence”
Is clearly depicted
In this AVHRR SST
Where 6° C waters
Meet 12° to 20°
Waters

And Cold, Dry Air
Masses encounter
Warm, Moist
Gulf Stream
Conditioned
Air Masses

The Cape Hatteras Confluence has many special properties



Like multiple cross shelf fronts



And topographic influences, Which induces SB and Slope Upwelling ~ 10^{-1} cm/sec

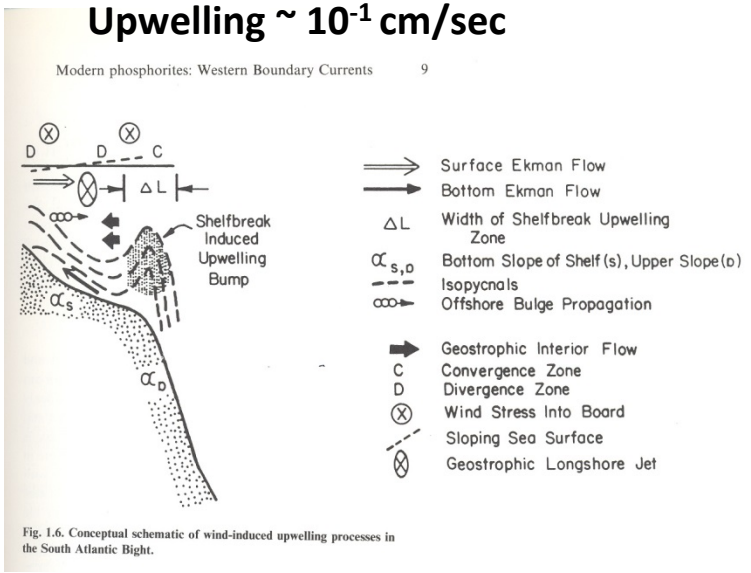


Fig. 1.6. Conceptual schematic of wind-induced upwelling processes in the South Atlantic Bight.

Thus creating a very complex Air-Sea interaction system

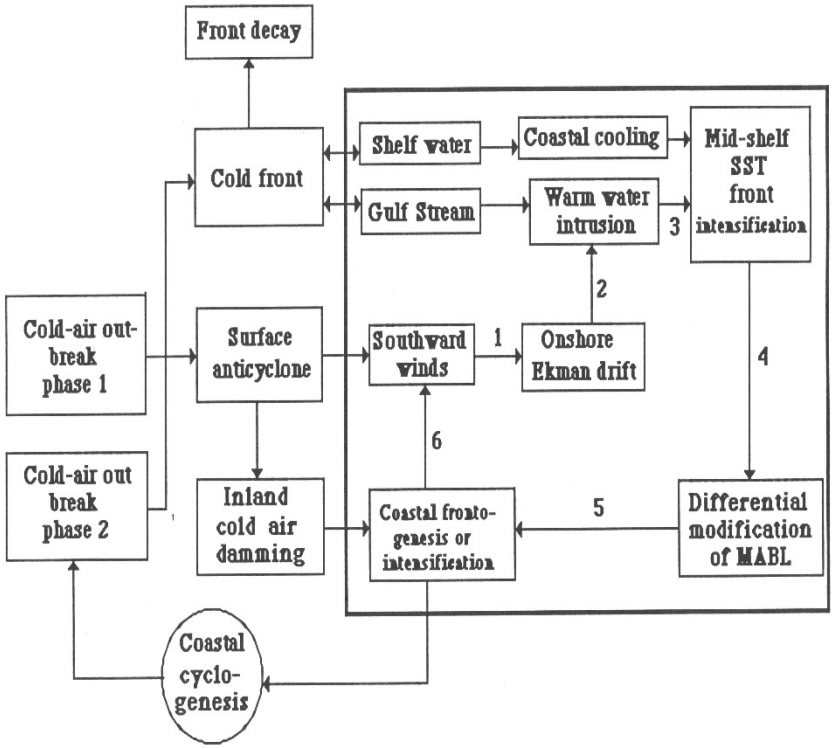


Fig. 2b A schematic representation of mid-shelf frontal air-sea interaction. The interaction loop consists 6 major processes labled as 1 to 6 (see text for details).

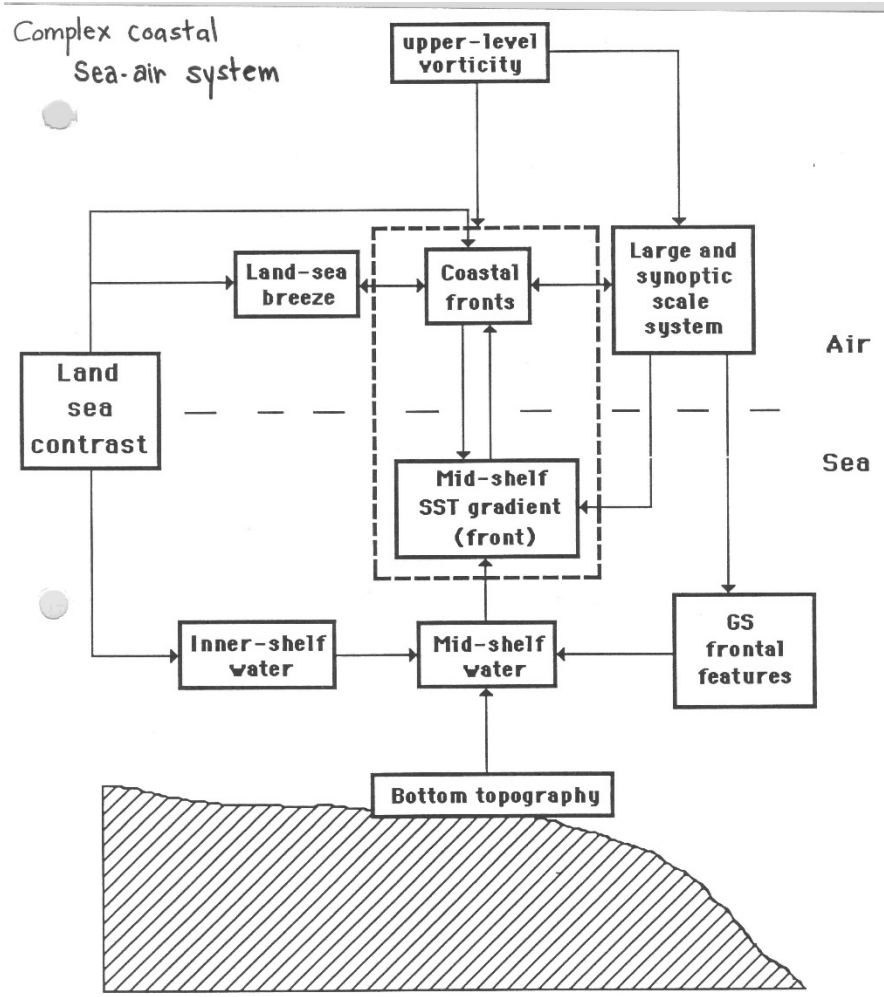
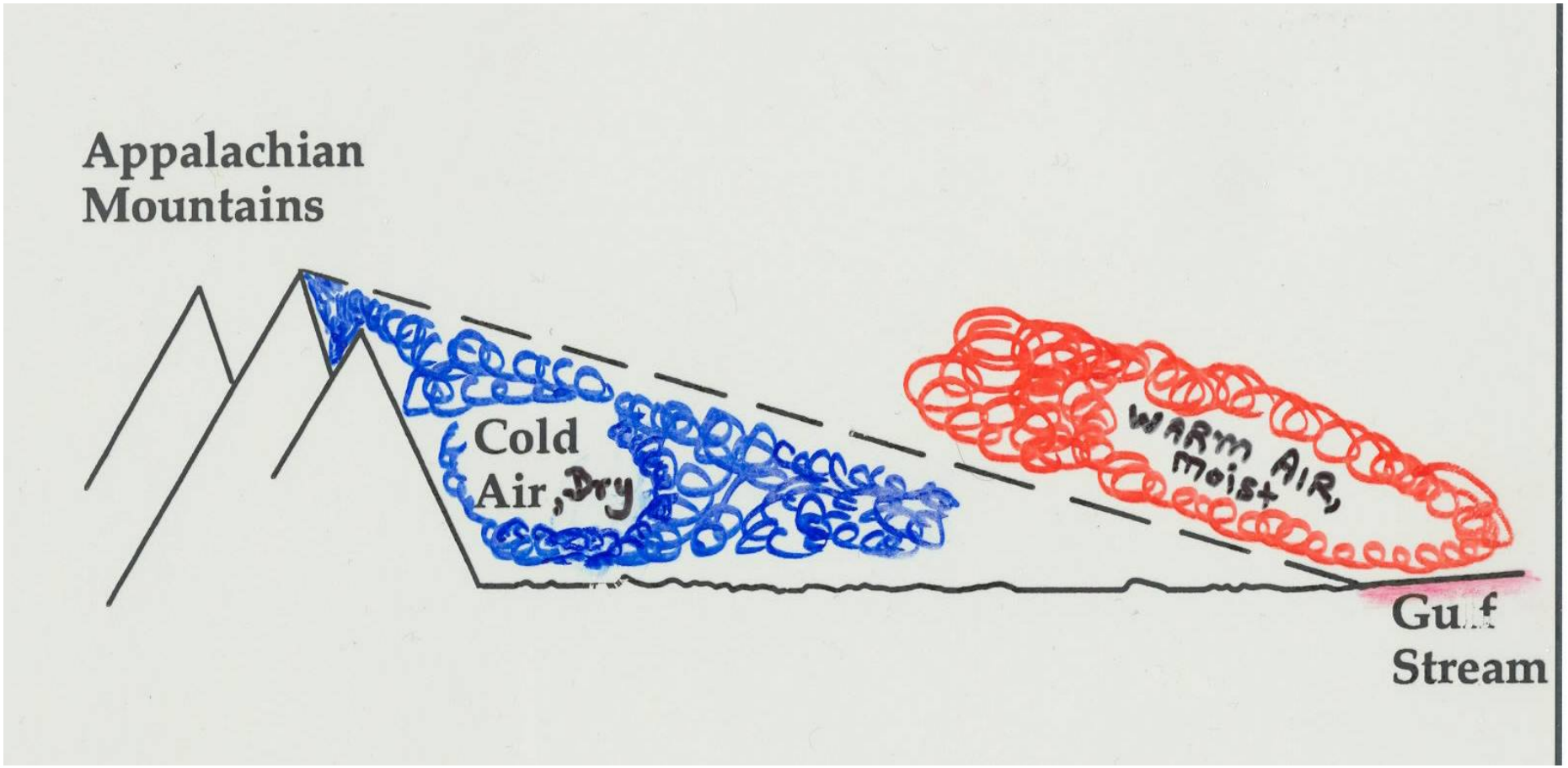
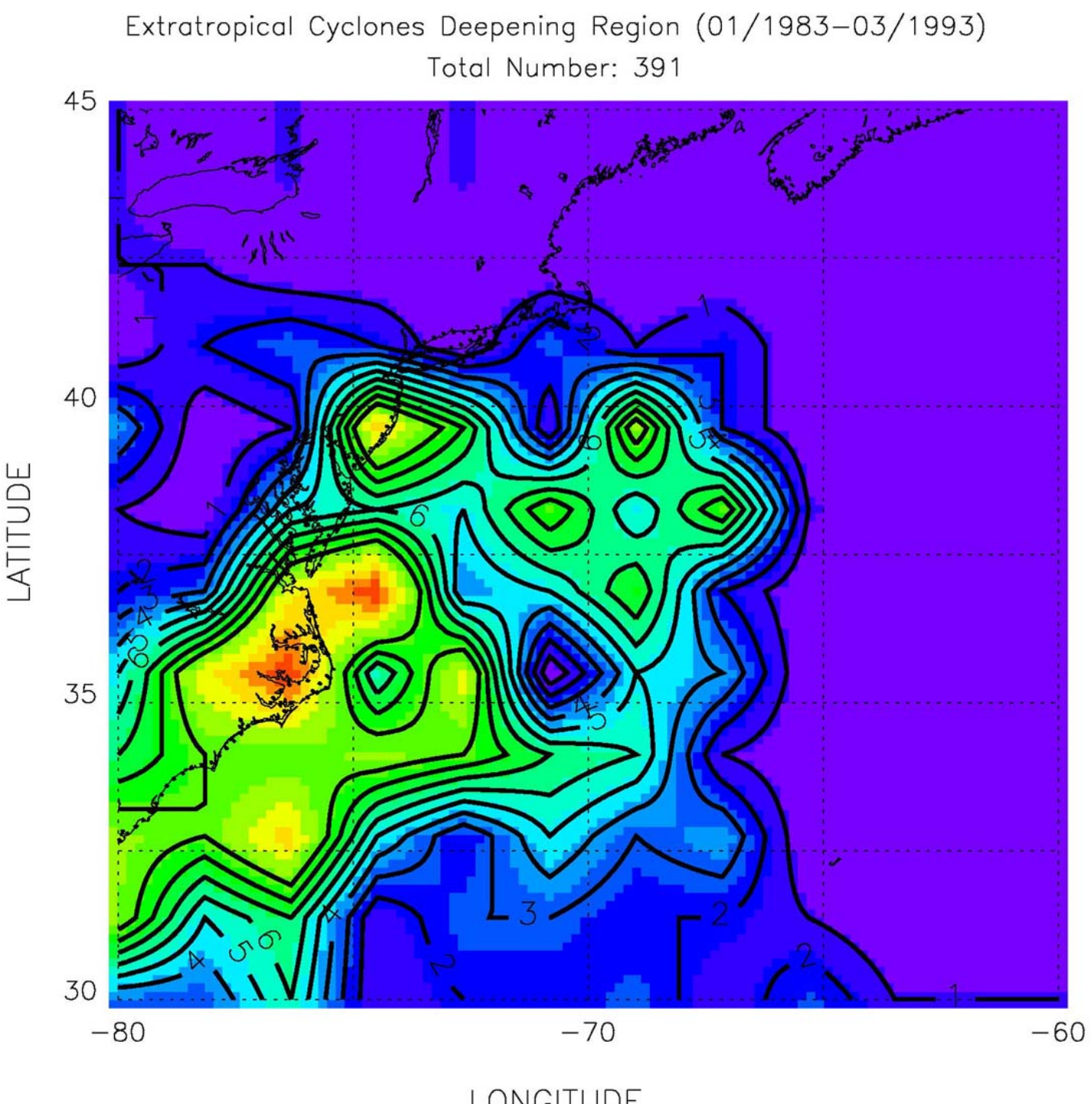


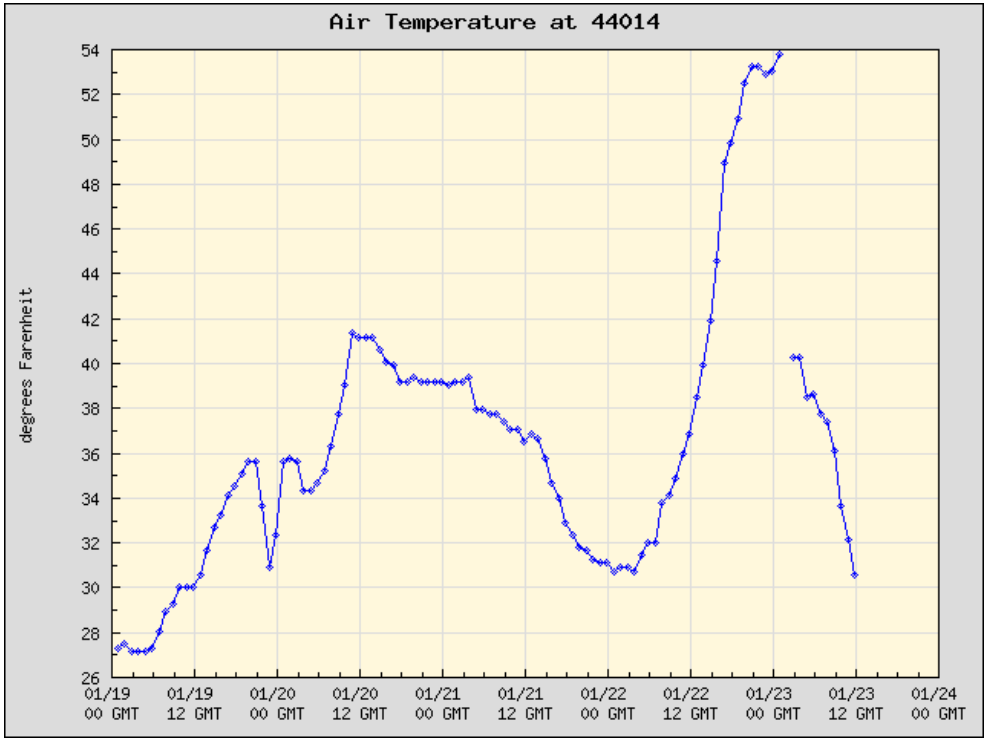
Figure 2a. Schematic representation of coupled coastal air-sea-land system. Dashed frame highlights the interaction between mid-shelf ocean front and coastal atmospheric front.

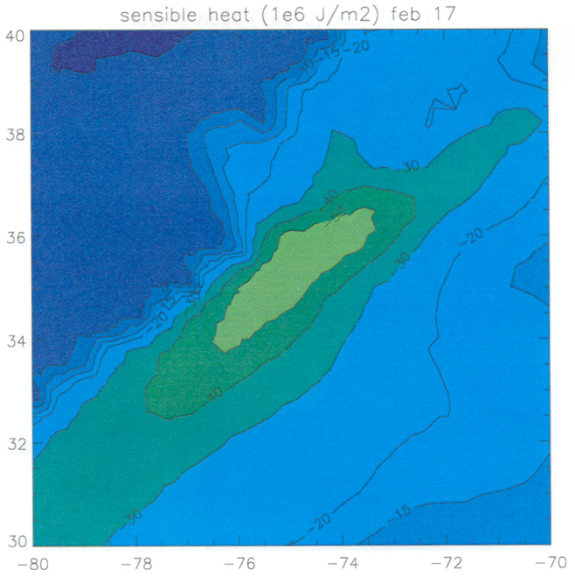
And conditions for “explosive cyclogenesis”
=> D(D(T))/DXDZ = maximum baroclinicity =>
an atmospheric “bomb”

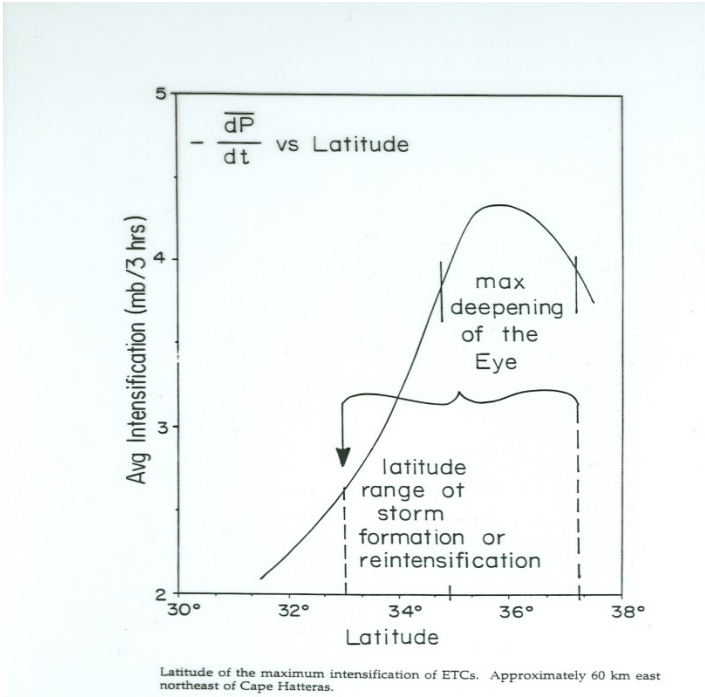



Extratropical Cyclones Deepening Region (01/1983–03/1993)
Total Number: 391
45
40
35
30
LATITUDE
−80
−70
−60
LONGITUDE

The spawning or further intensification of ETCs
left: The New England Blizzard of 2004







Latitude of the maximum intensification of ETCs. Approximately 60 km east northeast of Cape Hatteras.

a) Onset of an ETC

b) of ~ 100 cm/sec
and waves of height
(O) 5-10 meters;
effecting huge
Shear Stresses =>
bottom resuspension
and lateral erosion

c) Note MAB waters
breeching Diamond
Shoals down into
Raleigh Bay

d) The system relaxes
After 7- 8 days

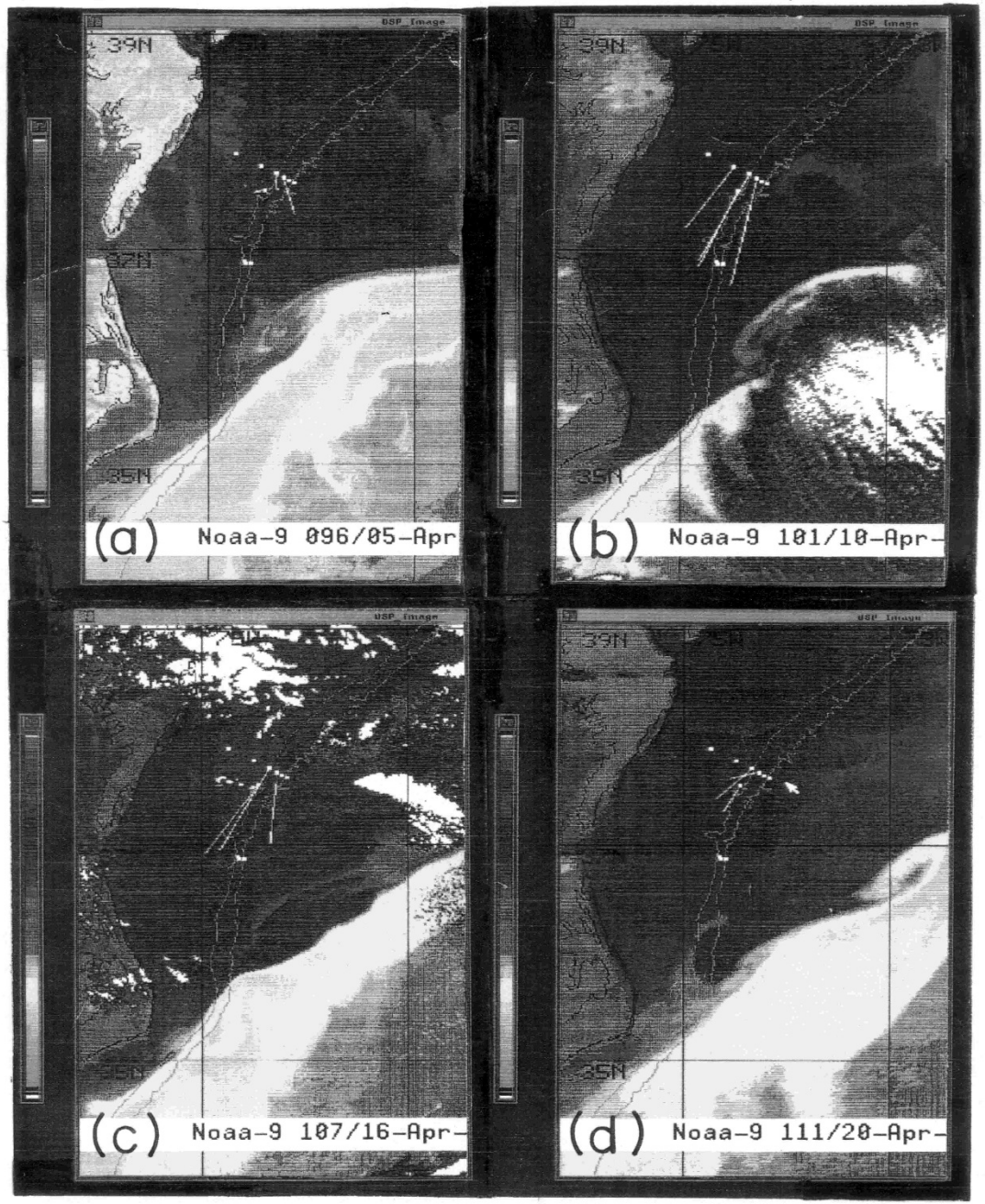
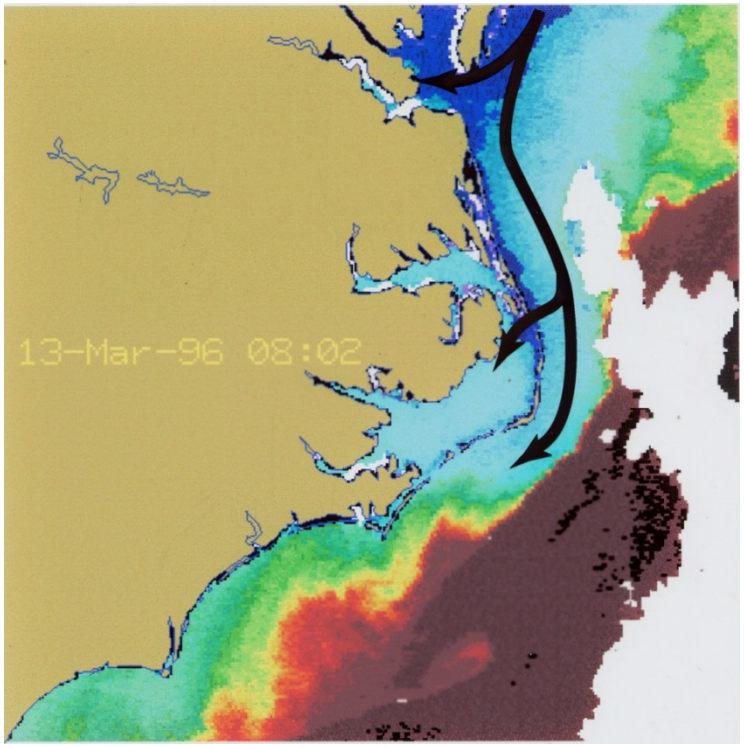


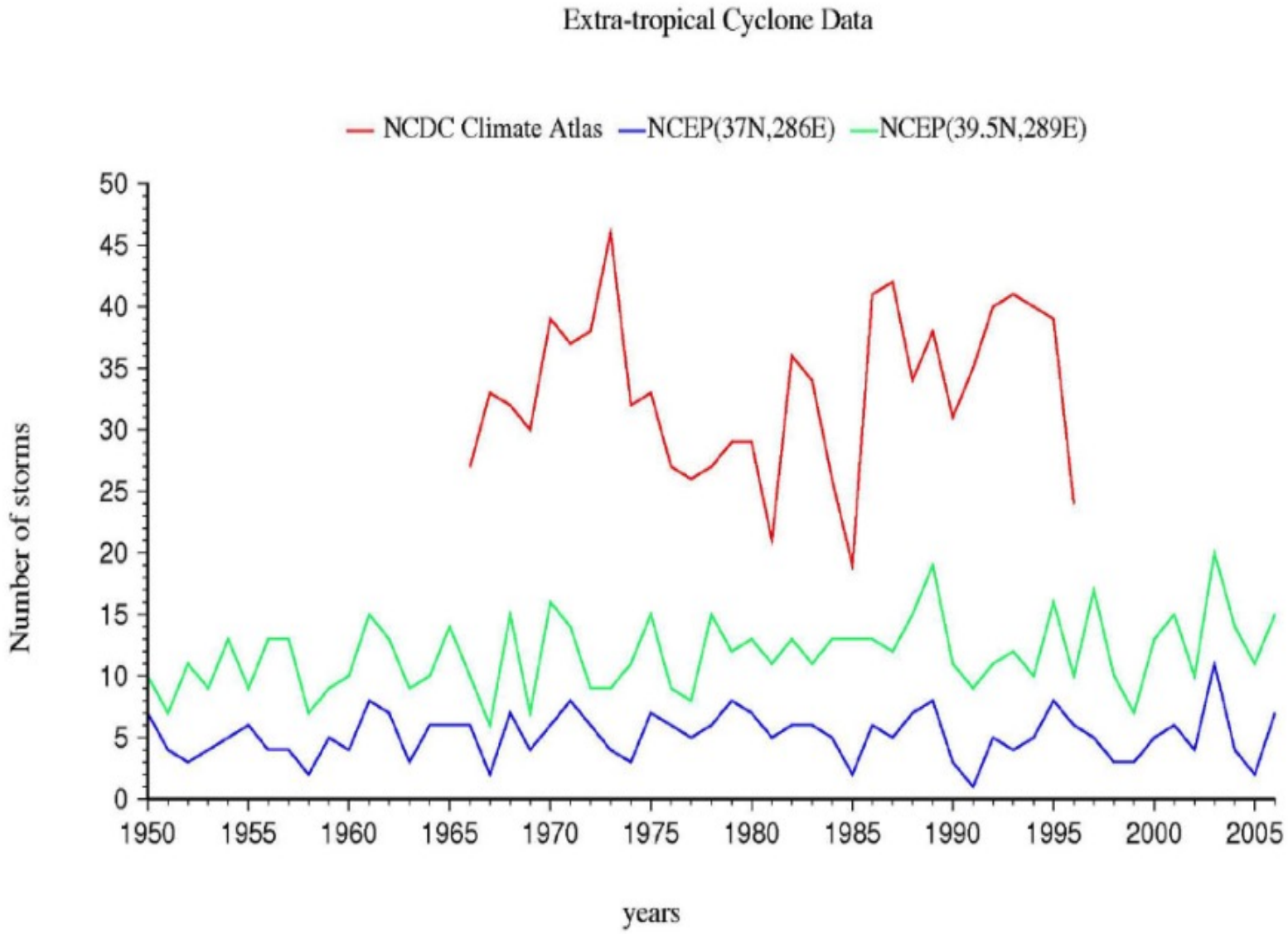
Figure 12. AVHRR satellite temperature fields for the month of April, 1988.

- So, ETCs carry heat northward… and
- drop heavy precipitation …and
- are characterized by southward to southwestward , i.e. northeasterly winds…hence the term “Nor’Easters”
- which move blue crab juveniles from Chesapeake Bay to the south and into the primary nurseries and settlement areas of Pamlico Sound via Oregon Inlet …and also…
- Bottom sediments are picked up by storm induced waves and currents and along with the Chesapeake Bay Plume also enter the Inlets



- The sediments follow a track similar to the crabs. The dirt ends up going through Oregon Inlet and being deposited on the backsides of the Outer Bank, barrier island chain.
- This process allows these ephemeral strips of sand to migrate west toward the mainland, thus ensuring their future during this period of sea level rise
- Estuarine dependent finfish also move across the shelf at the surface and the interior into the Pamlico Sound estuary

Numbers of ETCs
13 in 1998 and 24 in 2001



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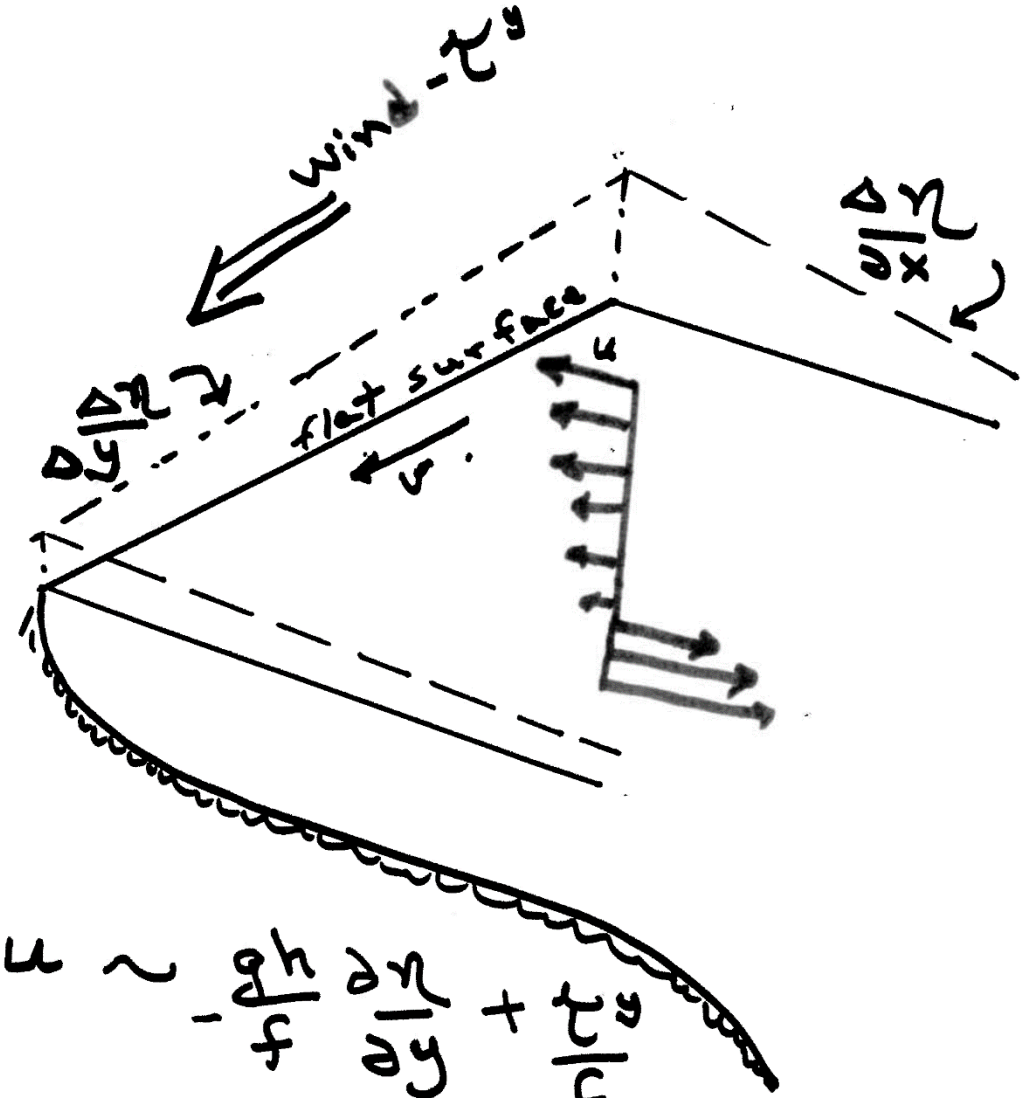
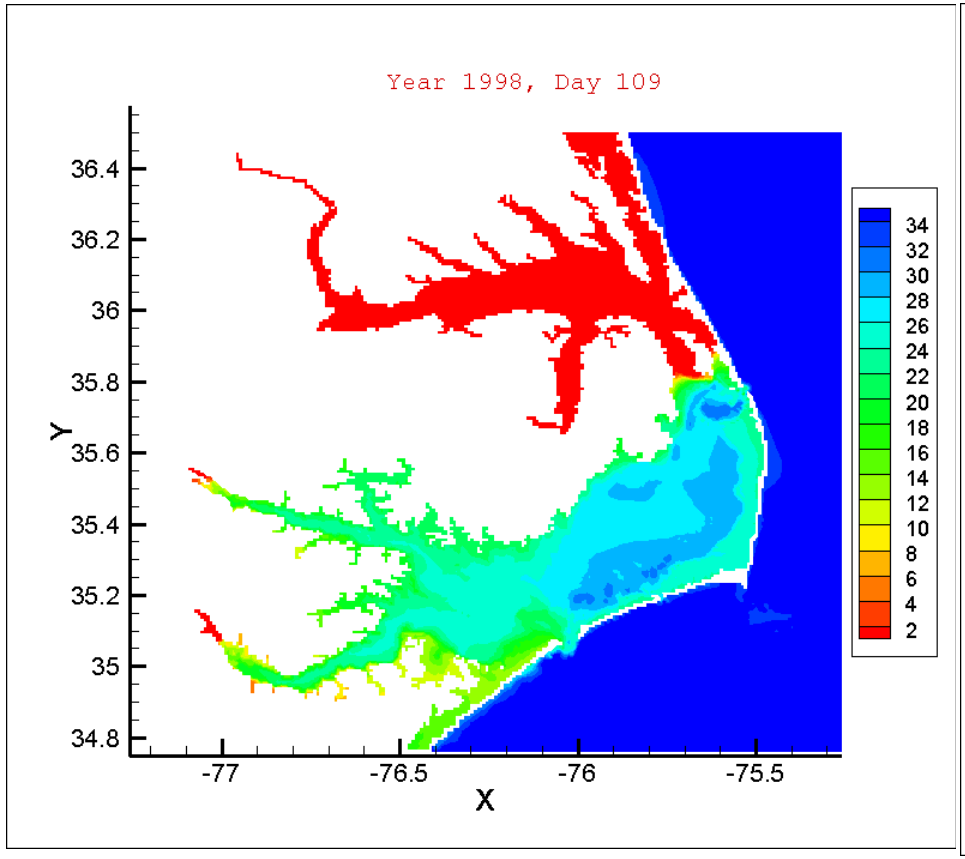


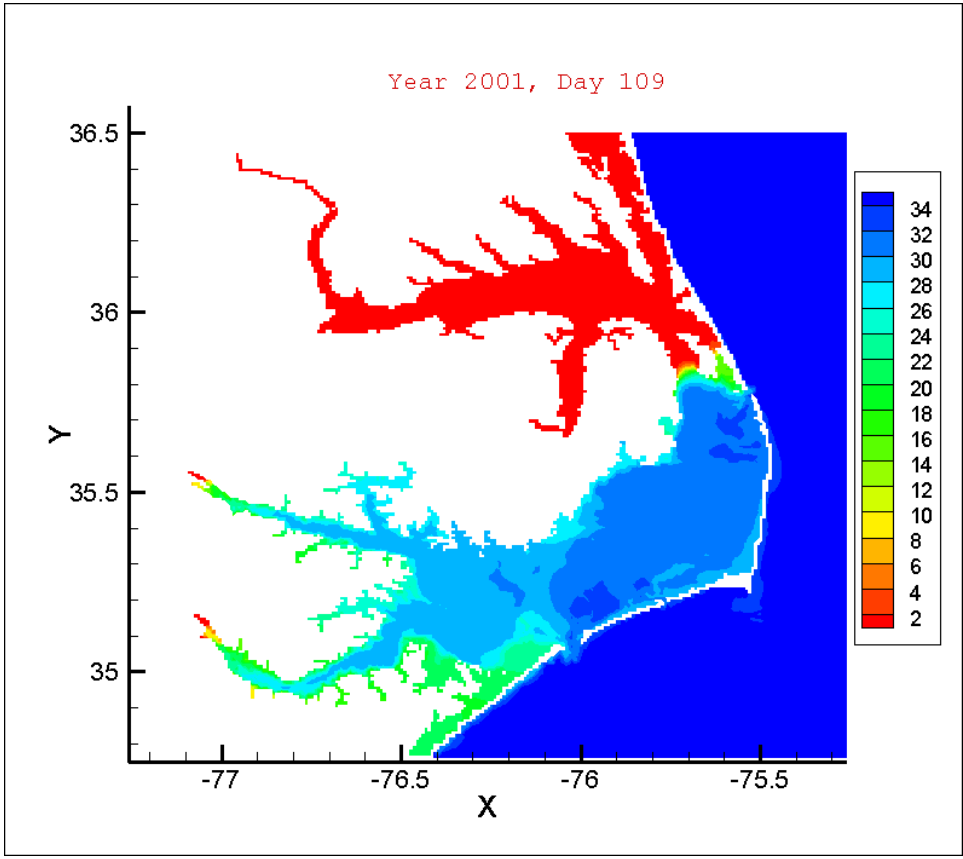
$$u \sim -\frac{gh}{f}\frac{\partial \eta}{\partial y} + \frac{\tau^y}{f}$$

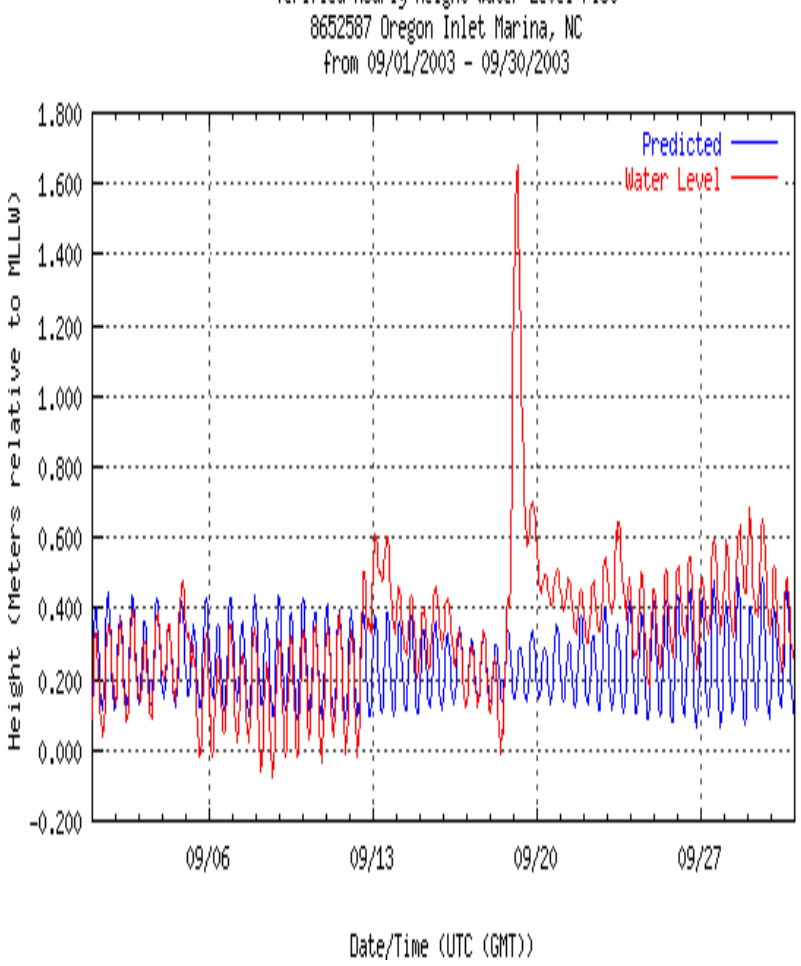
$$v \sim \frac{gh}{f}\frac{\partial \eta}{\partial x}$$

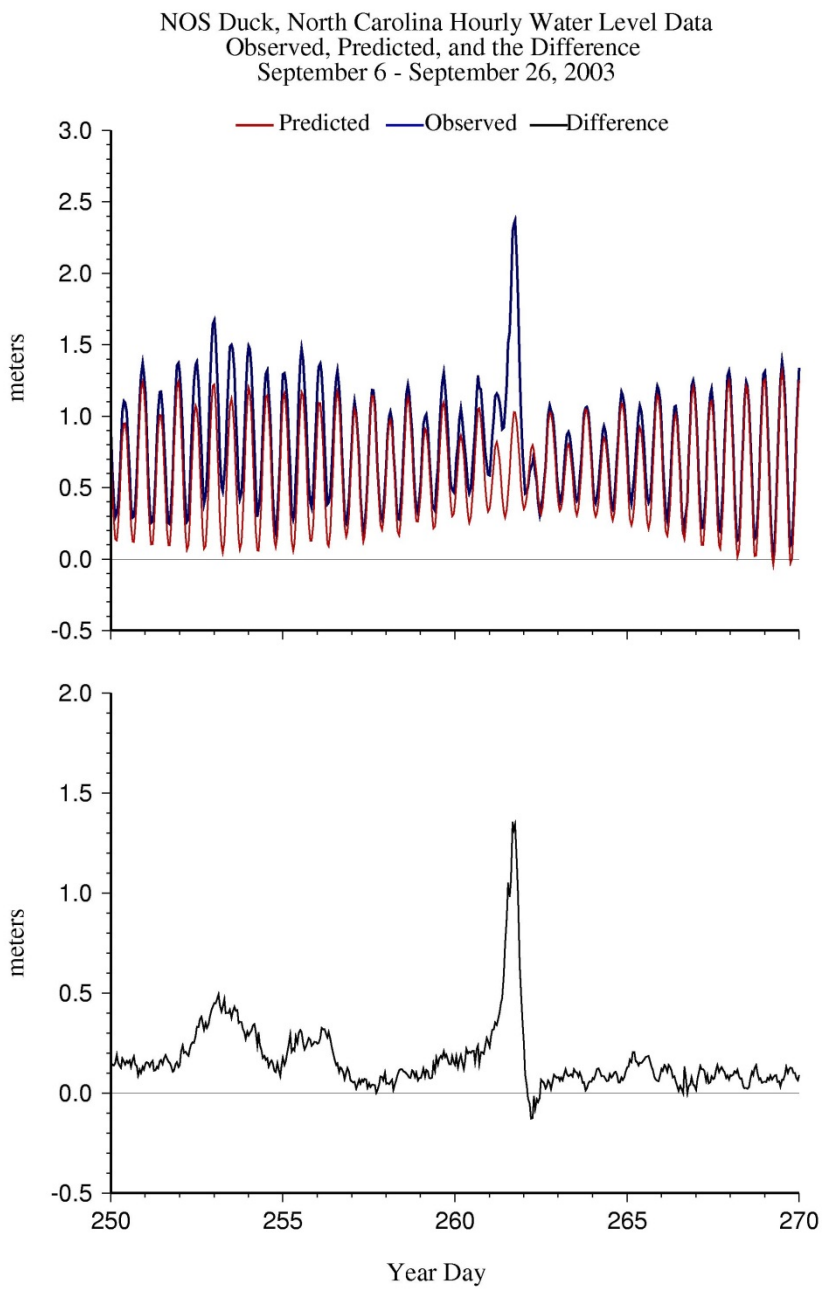
Fresh water flux (rainfall)

During a low ETC year there is less coastal water in the system than during a high ETC year



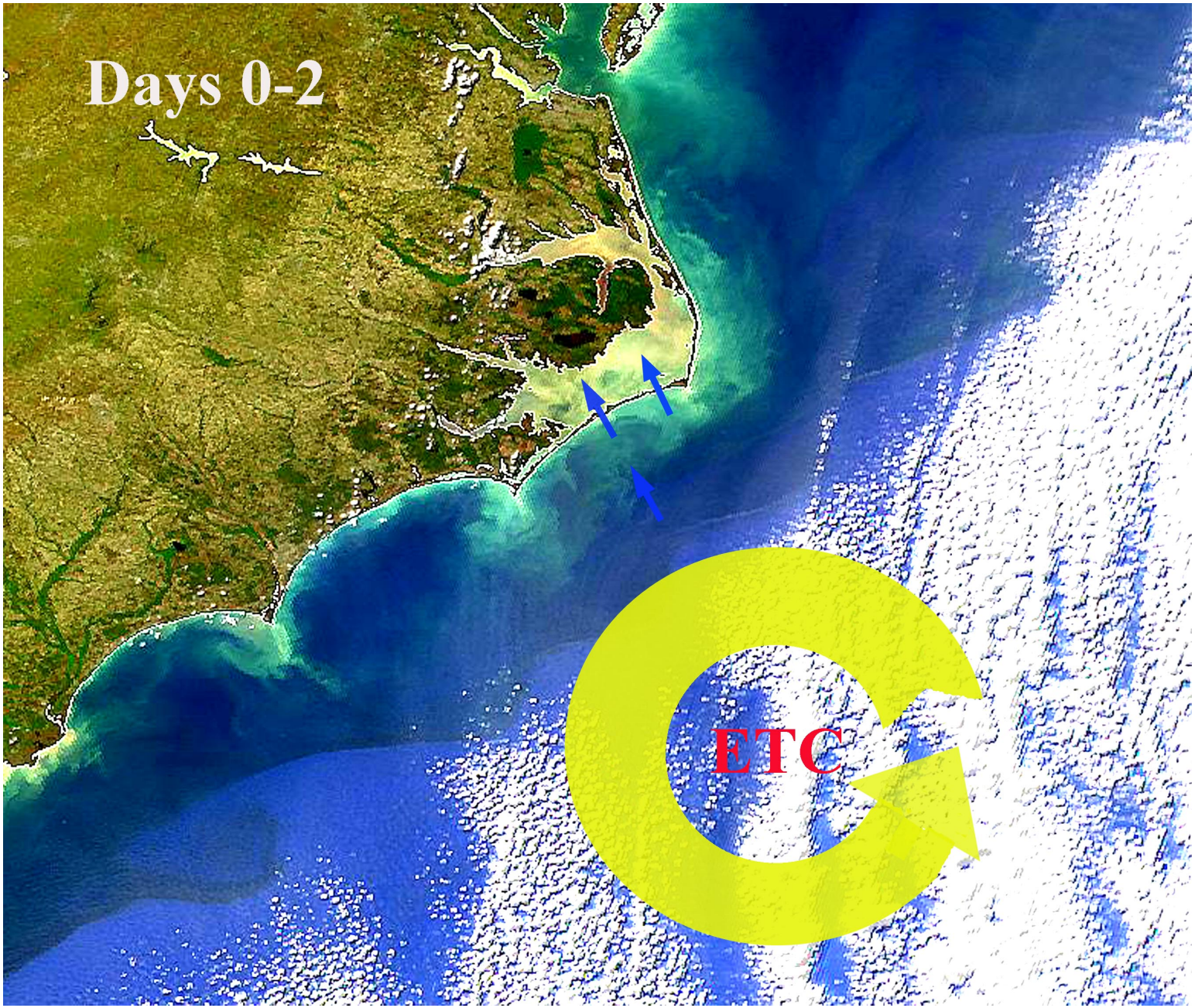






With NE' ly winds
Hydraulic Heads get created
Along the axes of the Inlets
And water pours into the system


Albemarle Sound
Oregon Inlet
Pamlico R.
Neuse R
Pamlico Sound
Hatteras Inlet
Ocracoke Inlet
New River
Beaufort Inlet
Cape Fear R.
Wilmington


Days 0-2
ETC

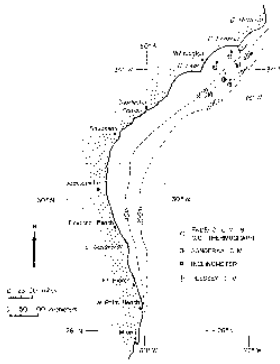


Figure 1 South Atlantic Bight

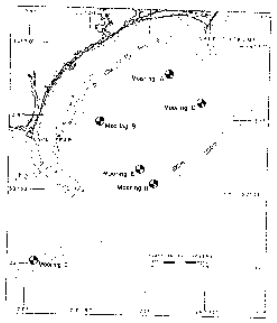


Figure 2 Onslow Bay, North Carolina-Study Area

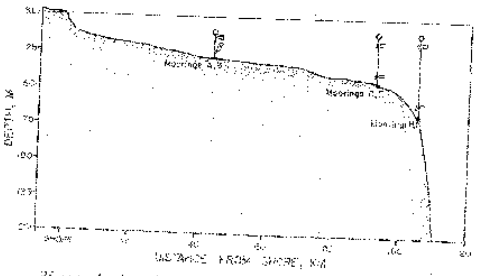


Figure 4 Vertical section of Instrument Moorings

14 Dec. 1976 –
21 Apr. 1977

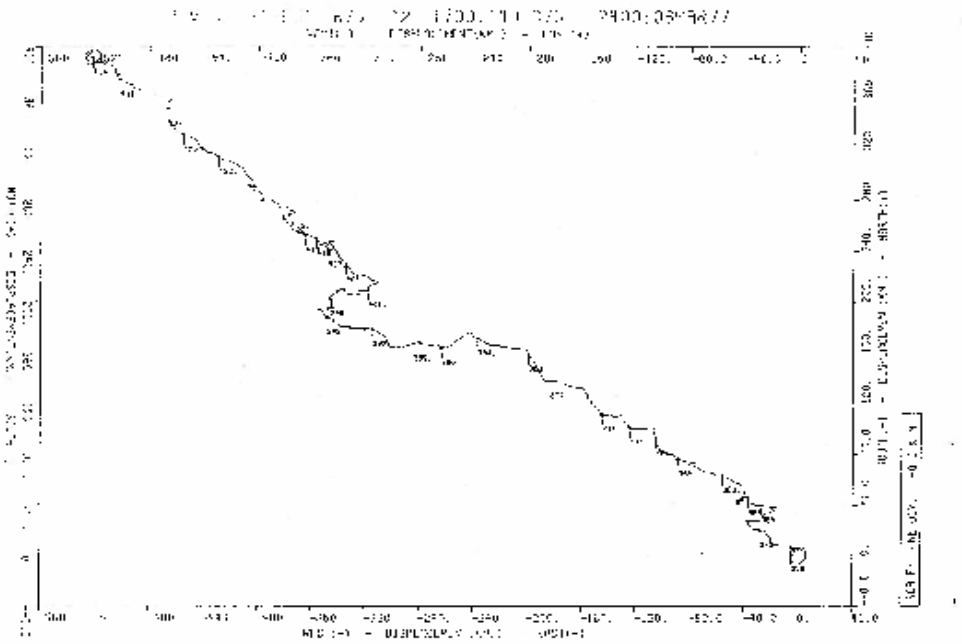


Figure 16 Progressive vector diagram of unfiltered current velocity from meter A_{top}, R ≠ 0

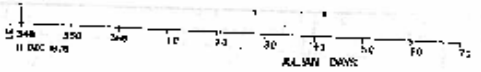


Figure 27 3HREP current velocity components from meter B_{top}, R = 0

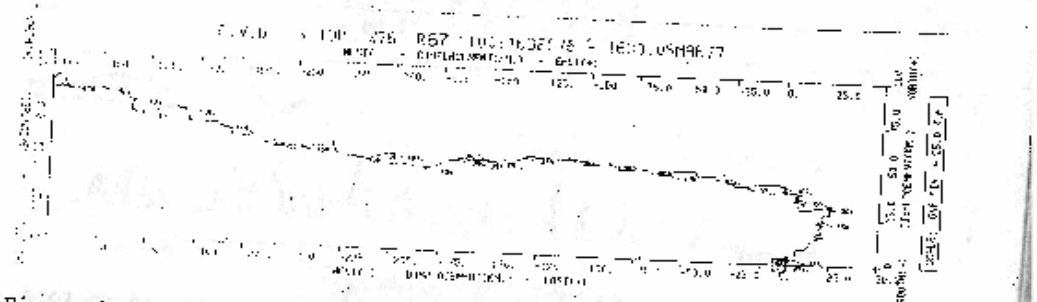
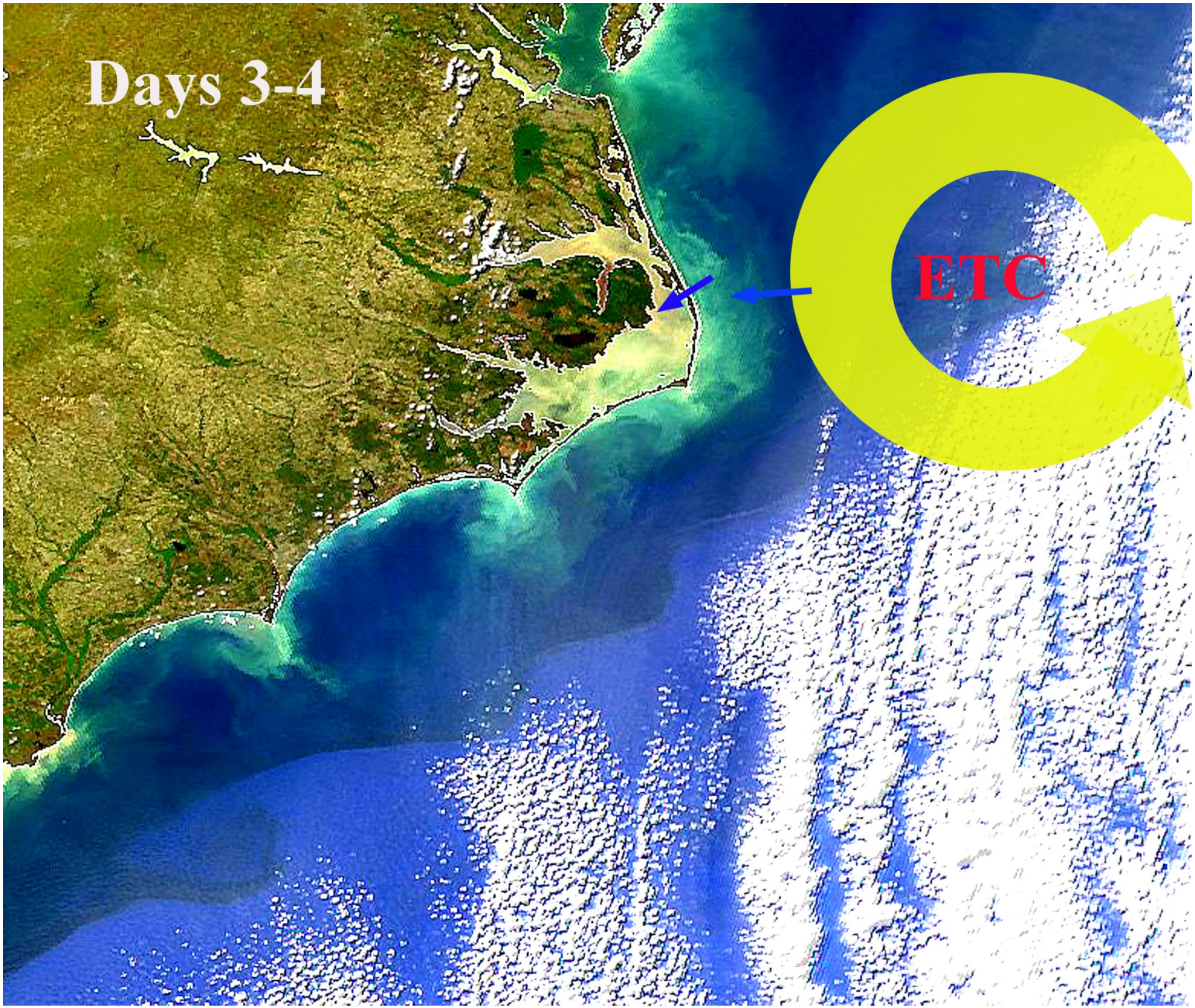
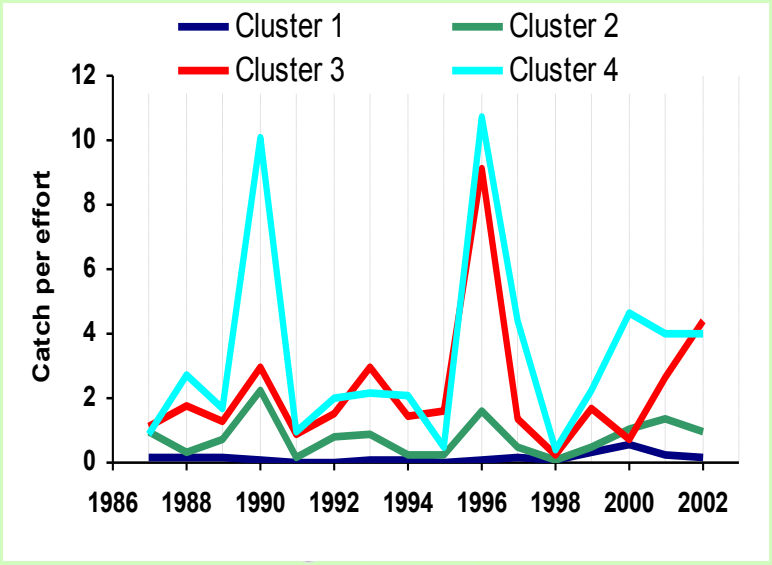


Figure 28 Progressive vector diagram of unfiltered current velocity from meter B_{top}, R ≠ 0


Days 3-4
ETC



Albemarle Sound

Pamlico R.

Pamlico Sound

Neuse R

New River

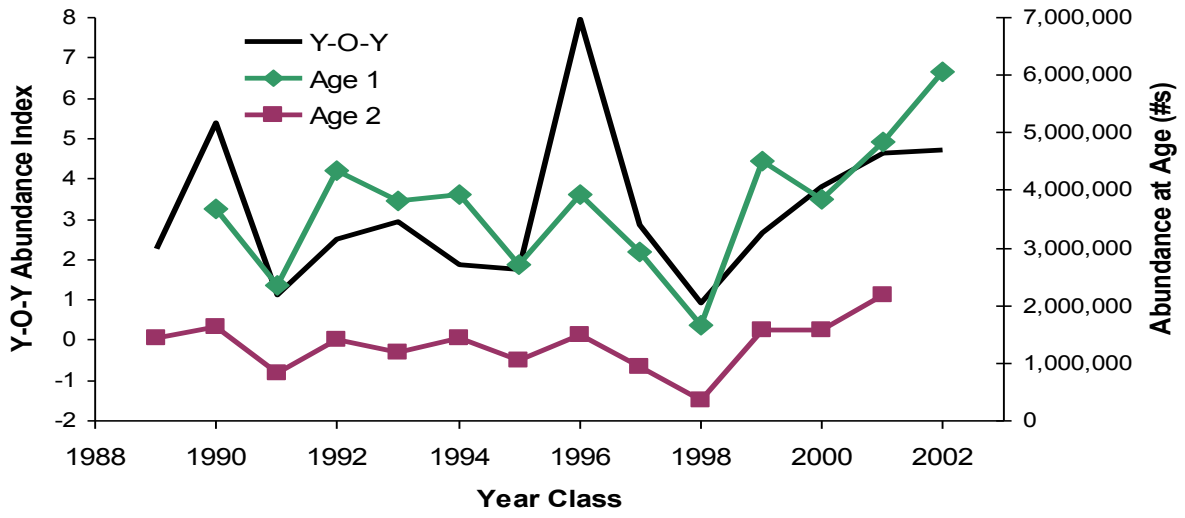
Morehead City/Beaufort

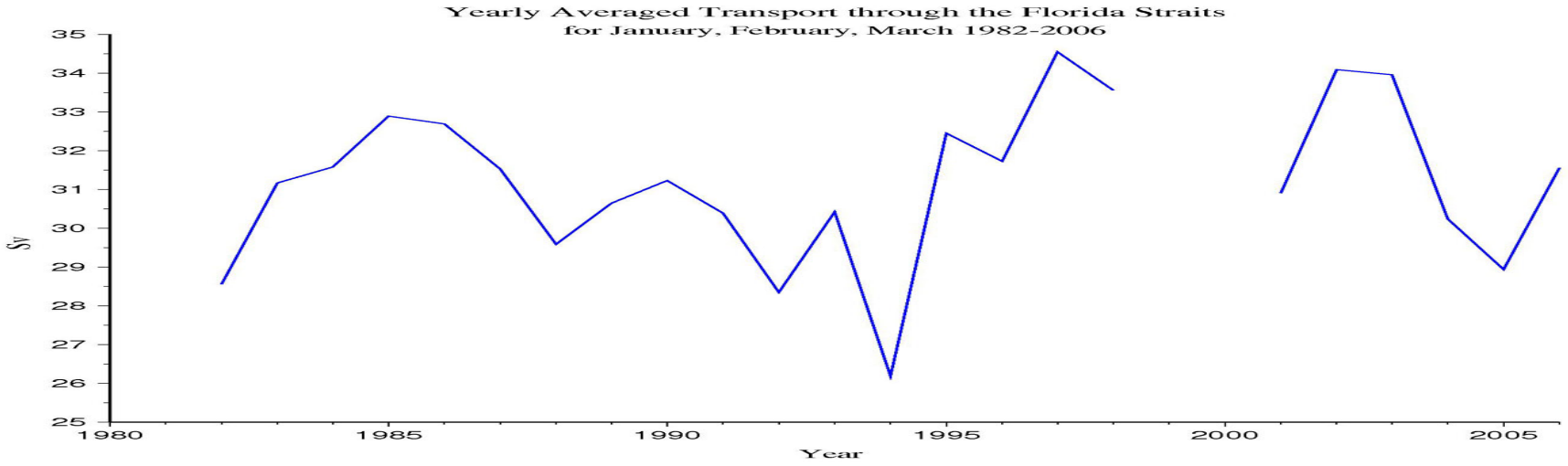
Atlantic Ocean

Cape Fear R.

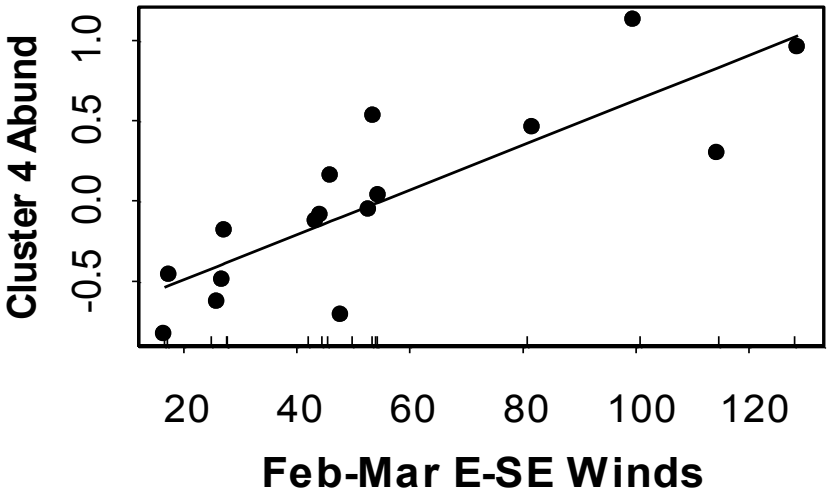
Wilmington

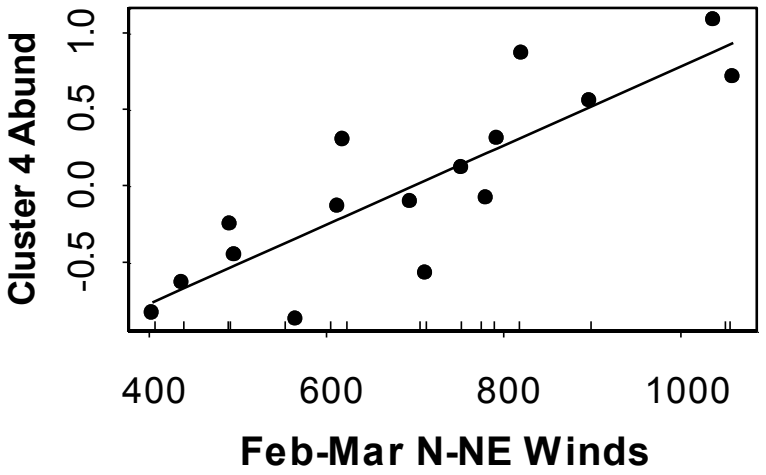
Variability within age classes. . .

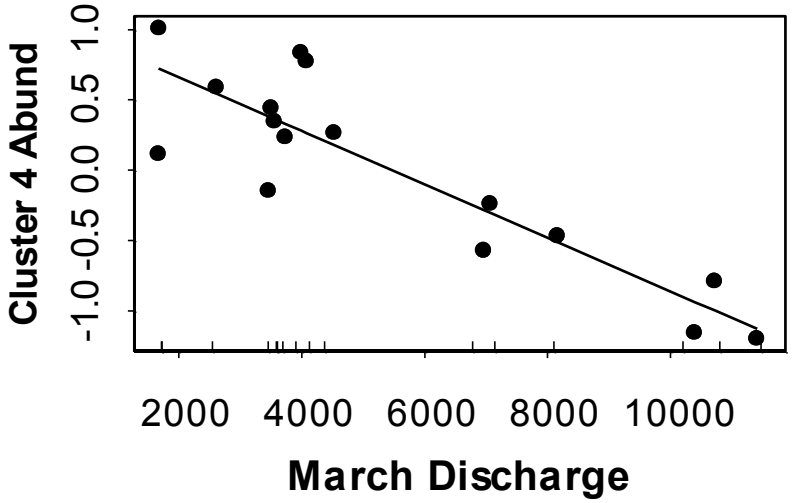


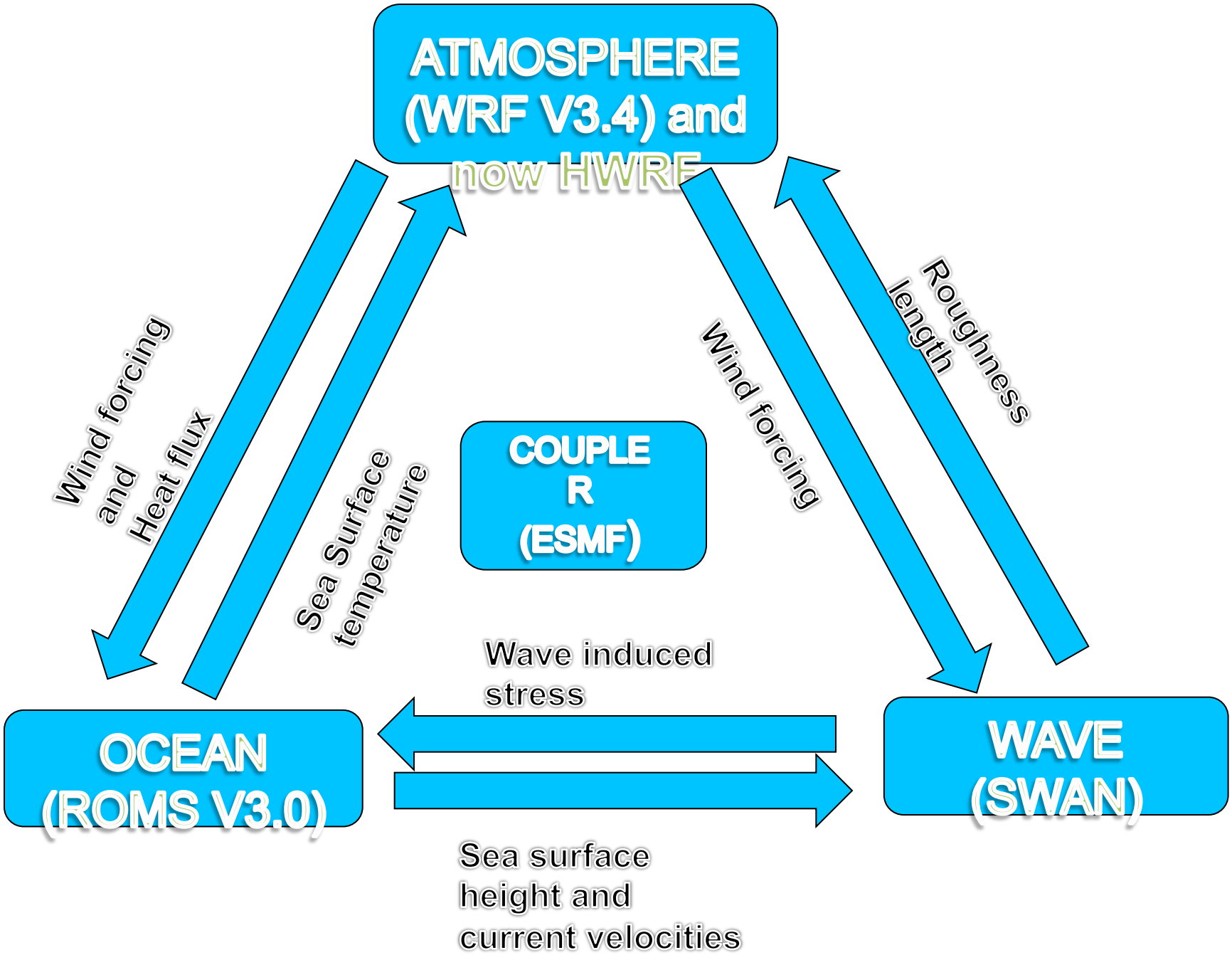


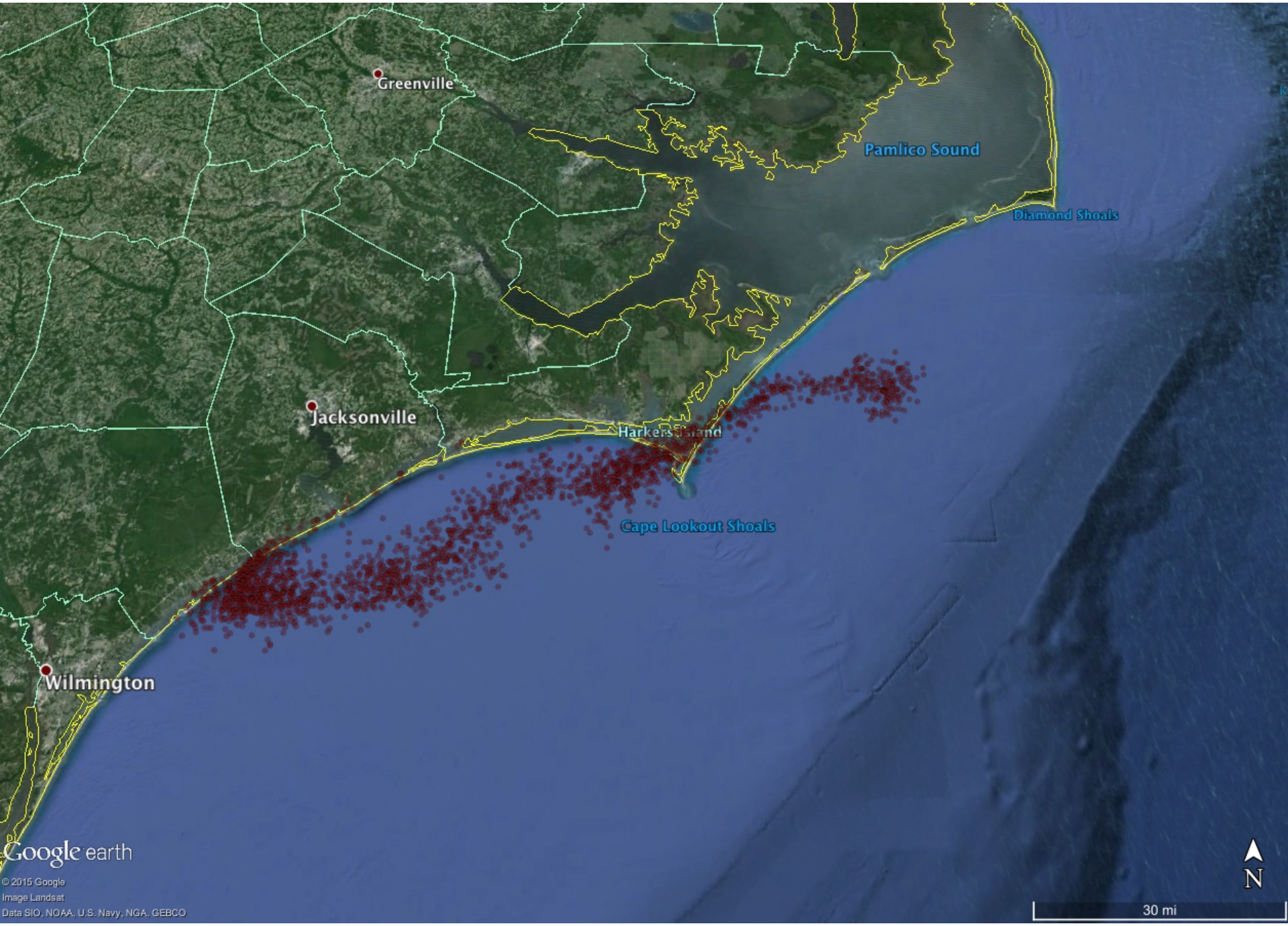
Cluster 4 vs. Environmental Factors



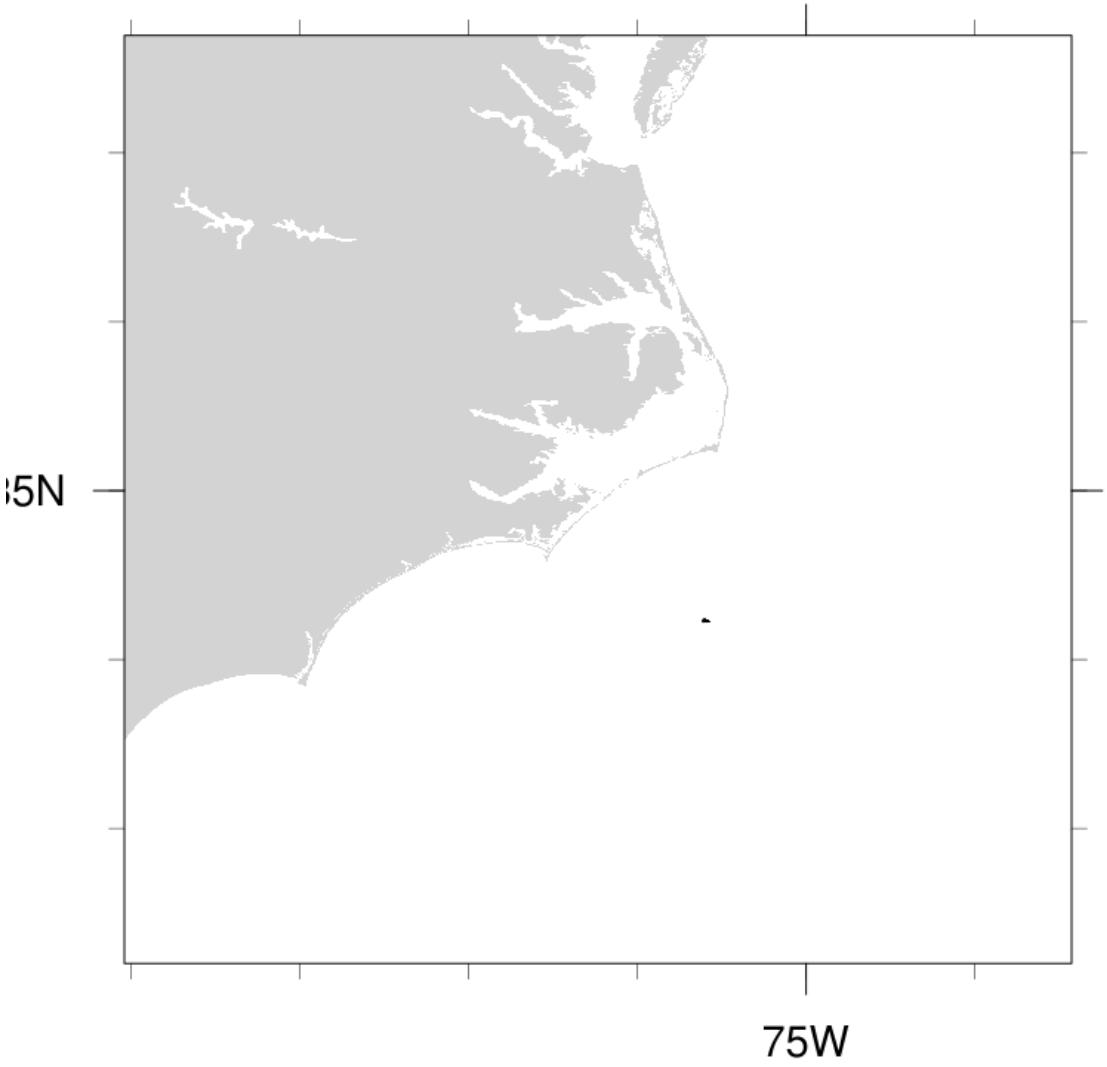





ATMOSPHERE
(WRF V3.4) and
now HWRF
Wind forcing
and
Heat flux
Sea Surface
temperature
COUPLE
R
(ESMF)
Wind forcing
Roughness
length
Wave induced
stress
OCEAN
(ROMS V3.0)
WAVE
(SWAN)
Sea surface
height and
current velocities

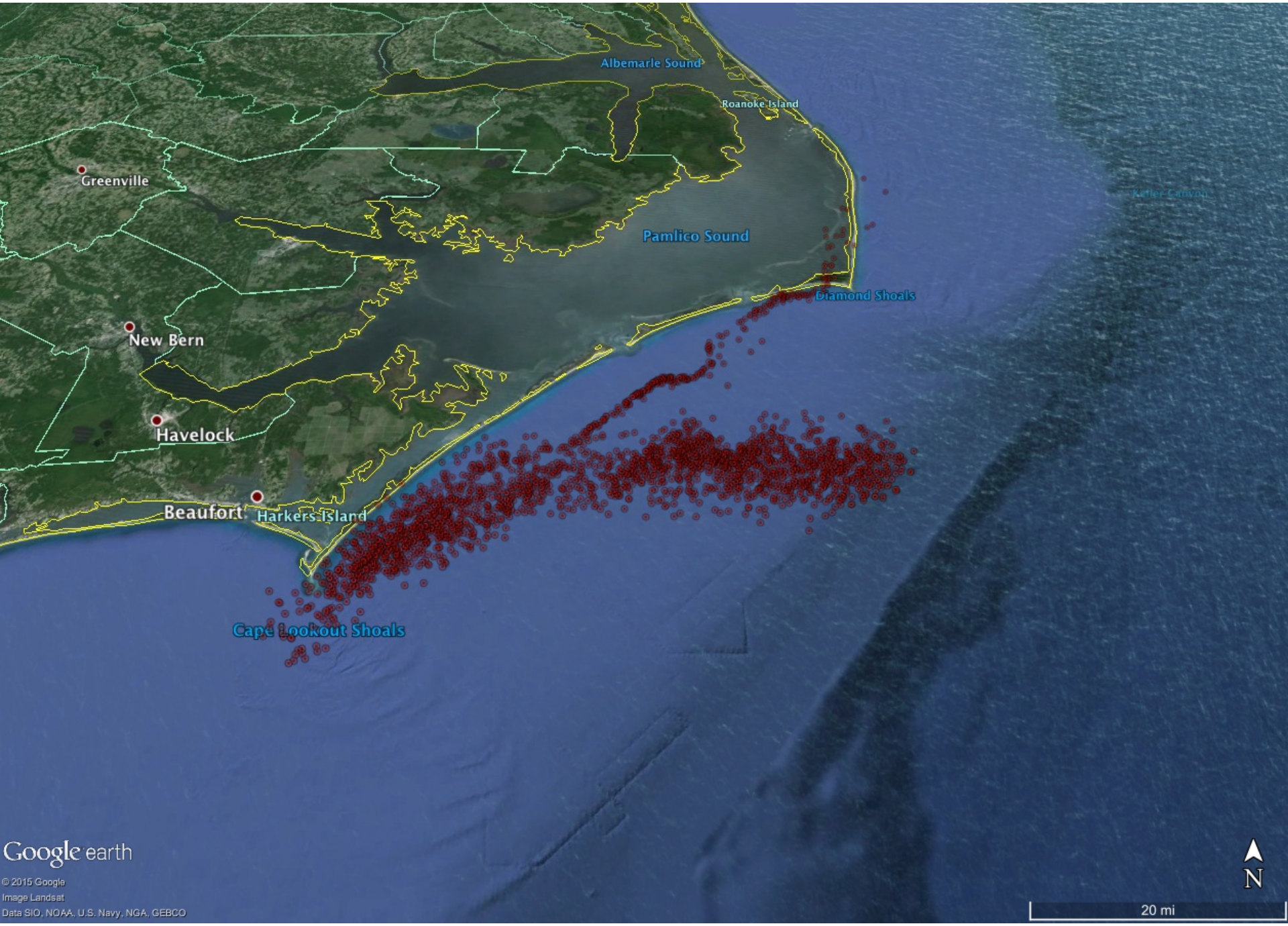

Greenville
Pamlico Sound
Diamond Shoals
Jacksonville
Harkers Island
Cape Lookout Shoals
Wilmington
Google earth
© 2015 Google
Image Landsat
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
N
30 mi

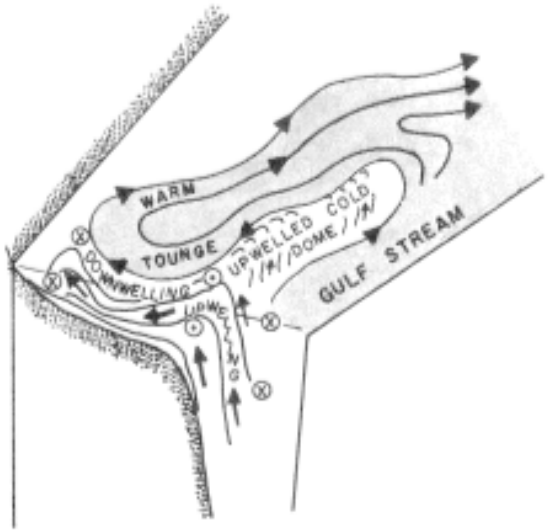
Site 3 spill from surface large (BP) spill rate

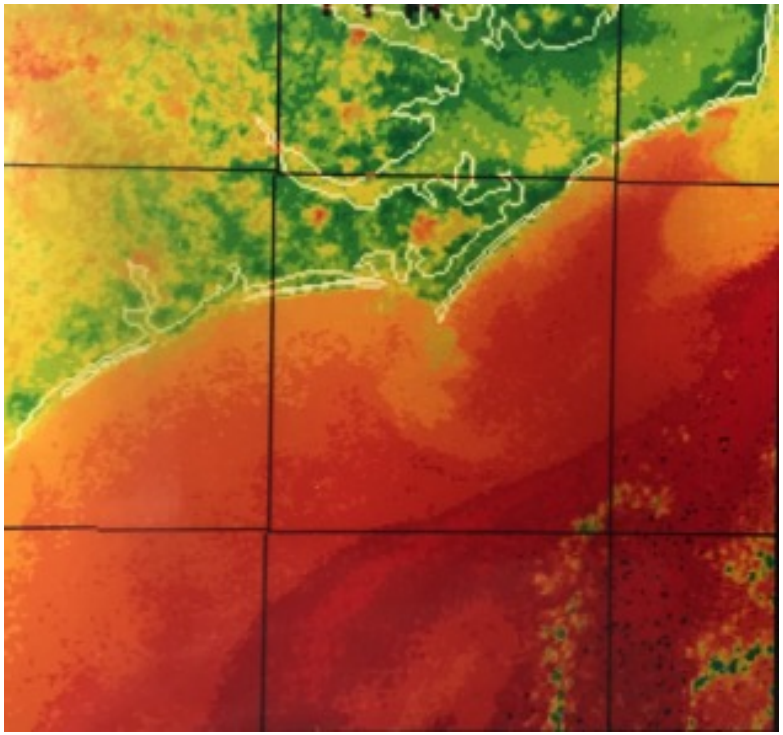


An Oil Spill in Raleigh Bay During an ETC:

- **High resolution near shore**
- **Wind direct drag on oil spill particles is considered**

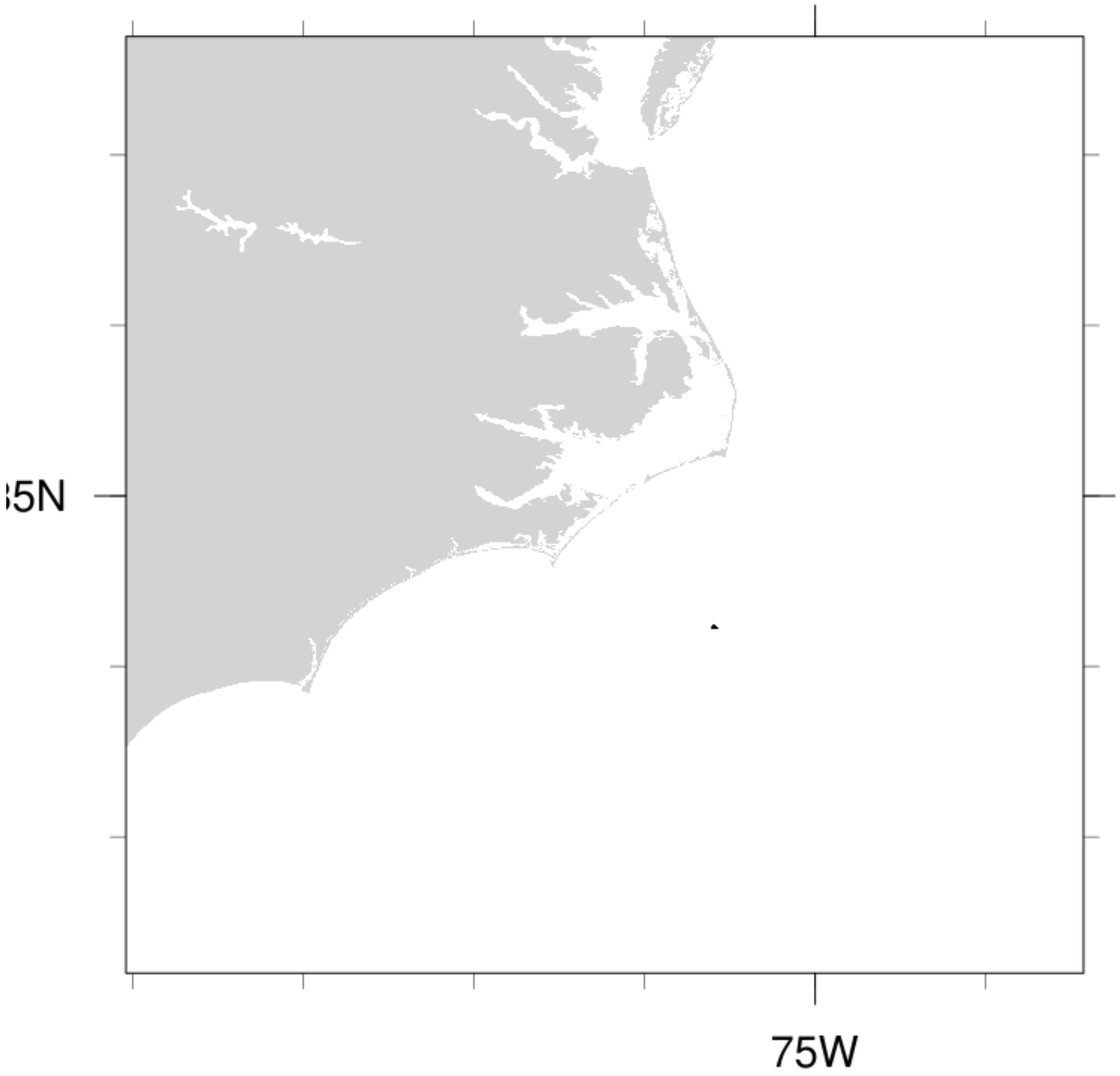

Albemarle Sound
Roanoke Island
Greenville
Pamlico Sound
Diamond Shoals
New Bern
Havelock
Beaufort
Harkers Island
Cape Lookout Shoals
Google earth
© 2015 Google
Image Landsat
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
N
20 mi

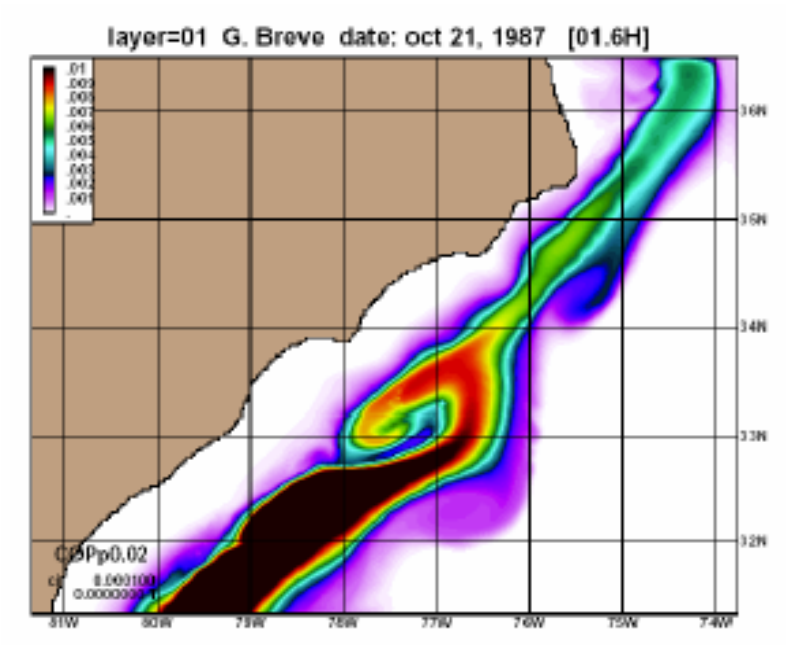


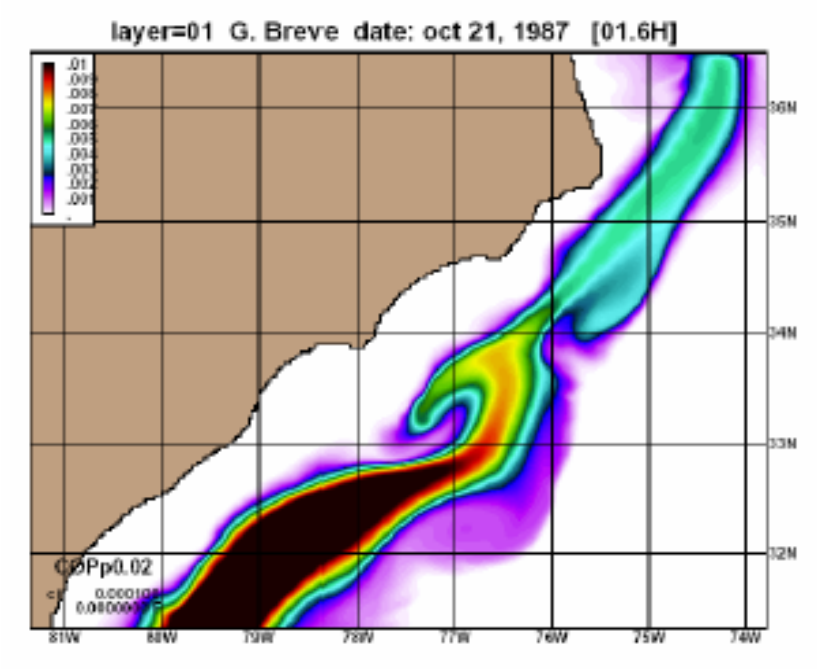


There is a Gulf Stream Frontal Filament Present And the Oil gets caught In it and Then gets blown Towards the coast by the NE'ly wind

Another ETC scenario







BTW, That is what happened in 1987 when the Red Tide invaded NC coastal waters, And were subsequently Advected by the NE'ly winds Towards and onto the NC Beaches and all the way to SC Coastal waters as well

Lessons learned:

In waters 30 meters deep or shallower, Oil in the upper 15 meters will ~ always be driven towards the coast and

Enter the Inshore Estuarine Systems

through the Inlets along the entire

NC Coast during the passage of an ETC

&

If a Frontal Filament is present, then

During the passage of an ETC,

Oil in the upper 15 meters, even well offshore (~ 75m deep) can/will be Advected towards

the NC Coast

Thanks!