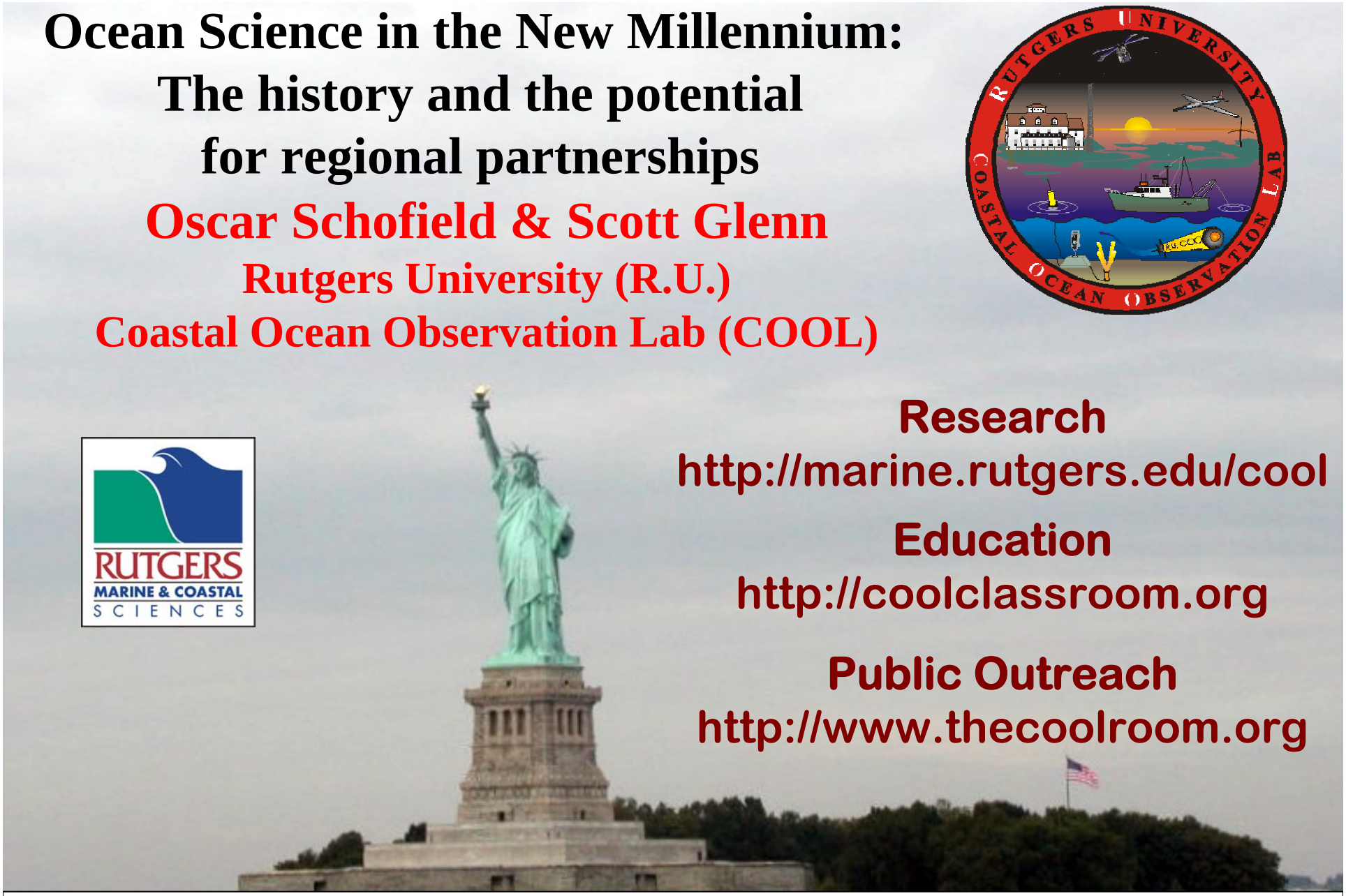
Ocean Science in the New Millennium: The history and the potential for regional partnerships

Oscar Schofield & Scott Glenn

Rutgers University (R.U.)

Coastal Ocean Observation Lab (COOL)



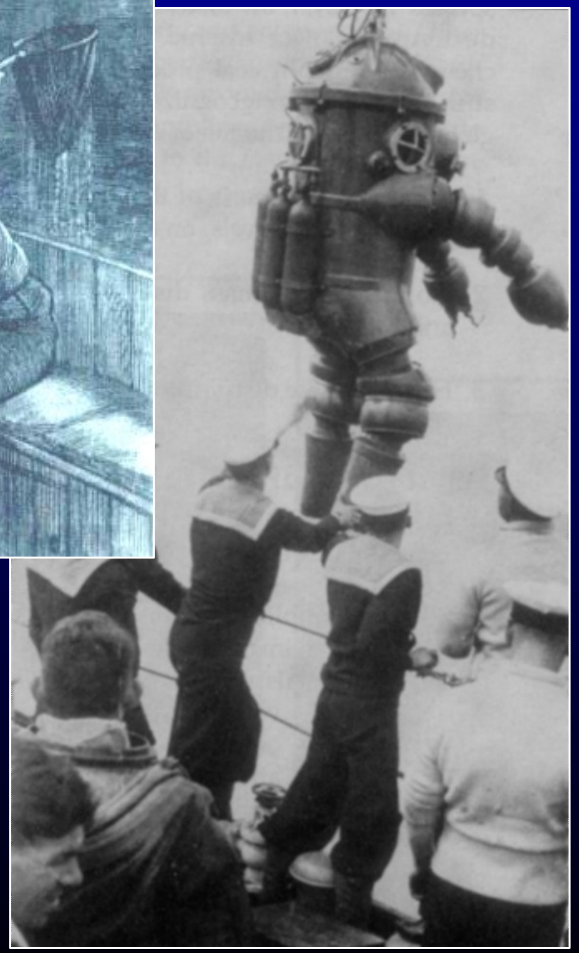
Research
http://marine.rutgers.edu/cool

Education
http://coolclassroom.org

Public Outreach
http://www.thecoolroom.org

A Look Back

By Tommy Dickey
UCSB

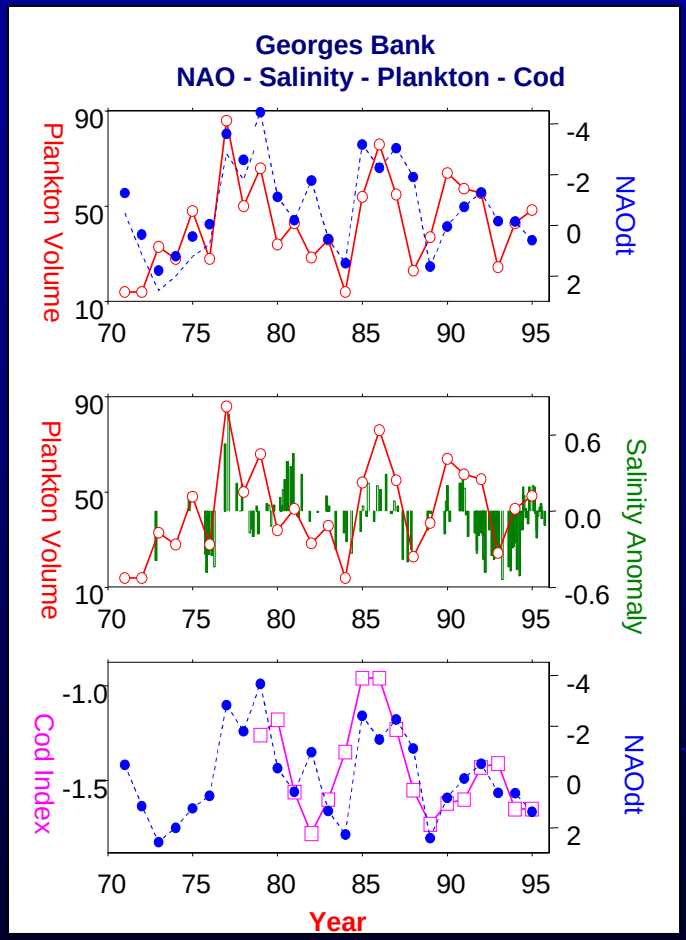


"If I were to choose a single phrase to characterize the first century of modern oceanography, it would be a century of under-sampling."

Walter Munk 2000

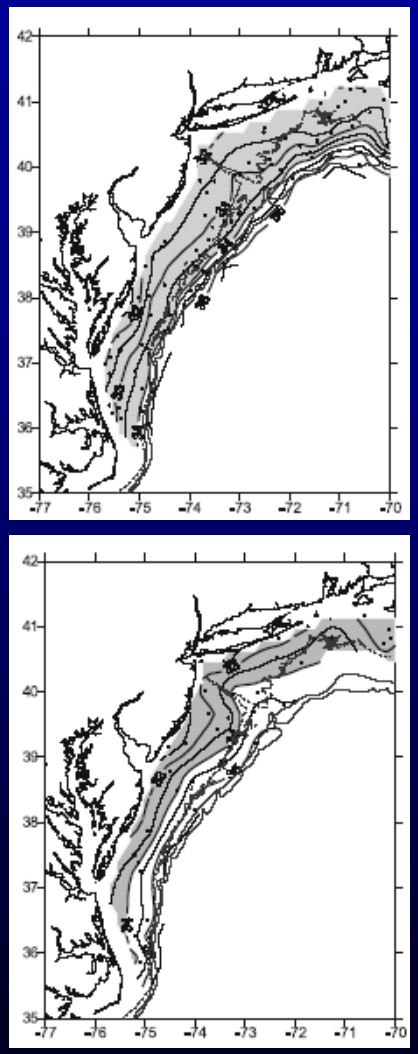
The Oceans are dynamic and they are changing

NorthEast United States



Plankton Volume and Cod Survival Linked to NAO (Fogarty [WHOI] and Haidvogel [Rutgers])

Mid-Atlantic Bight



-MAB waters warmer and less saline in the 1990's then in the 70's & 80's

Mountain JGR 1998

Nor. E. Fish. Sci. Ctr.

Human Impacts on our Planet

How can you tell the difference between..
Natural variability in the ocean and changes caused by human impacts?

Things to watch:

- The carbon cycle
- Coastal food webs and sustainable fisheries
- Harmful algal blooms
- Coastal erosion, flooding, and
- Sea level rise

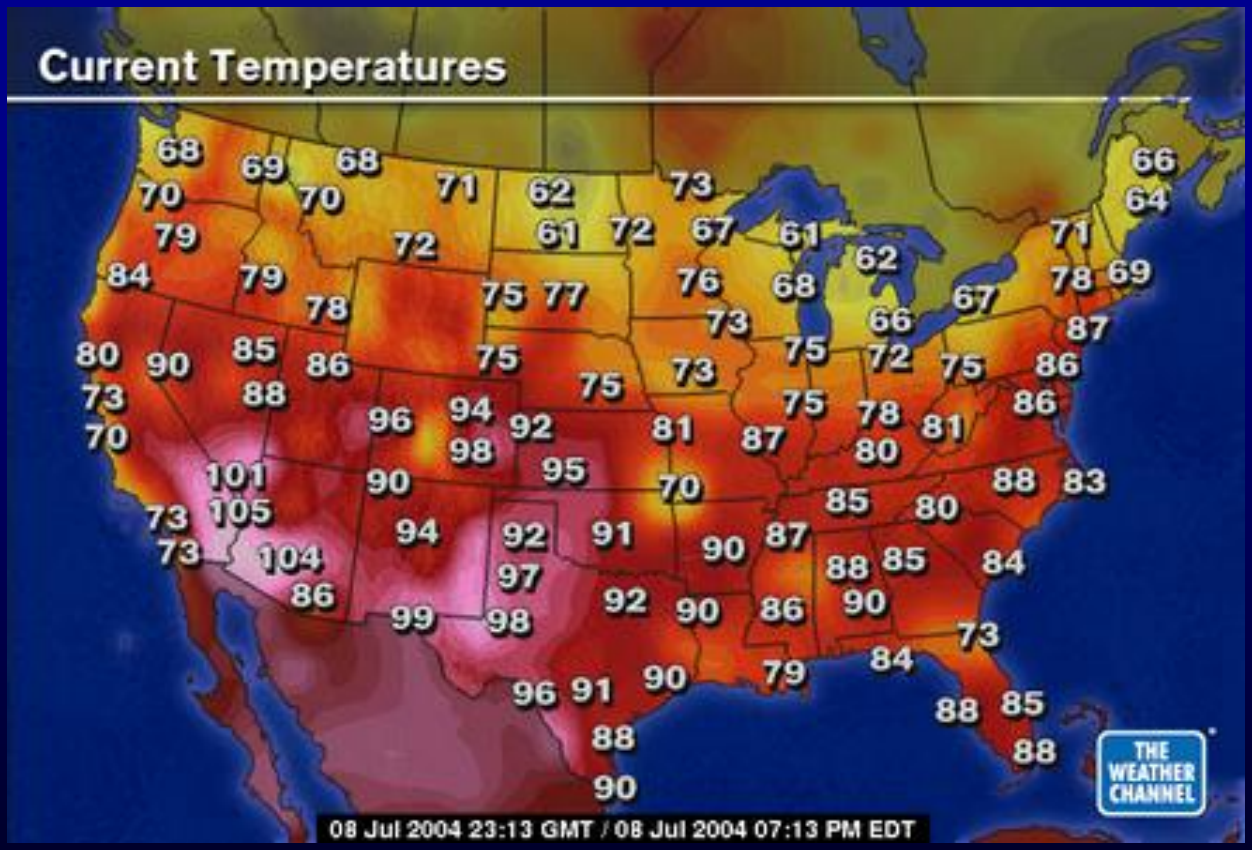
Assessment is crucial

Studying the Ocean

How do we as a community build a system capable of catching an "EVENT". The traditional approach expeditionary mode often requires the luck of being at the right place and at the right time.

How can we better understand our changing planet?

What lessons can we learn from our atmospheric colleagues?



How does the weather channel make this map for today, and a similar map for tomorrow?

Why do we need an Ocean Observatory?

Nowcasting and Forecasting

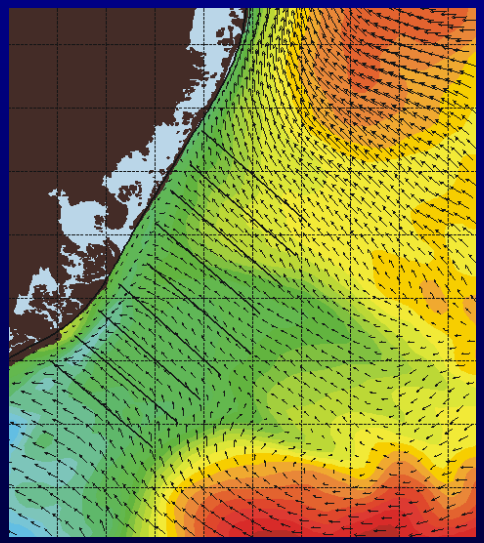
FOR A SINGLE PARTICLE

$$x = x_0 + v_0 t + \frac{1}{2} a t^2$$

Observations

Models

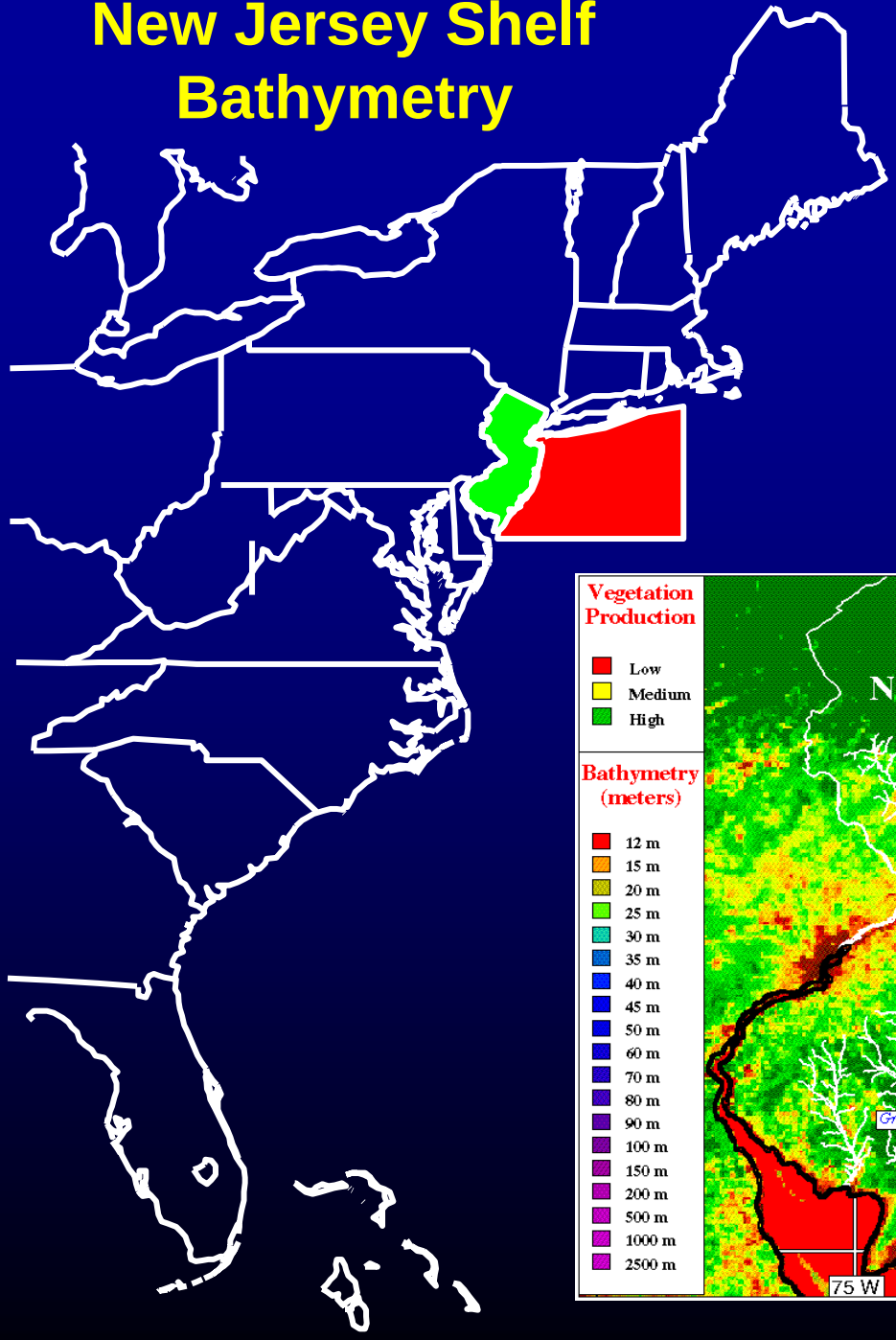
FOR AN OCEAN OF PARTICLES

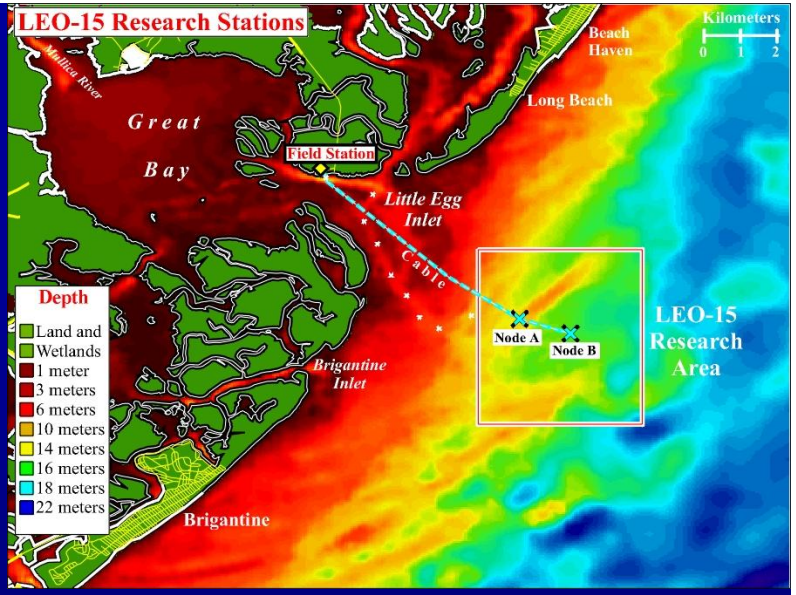


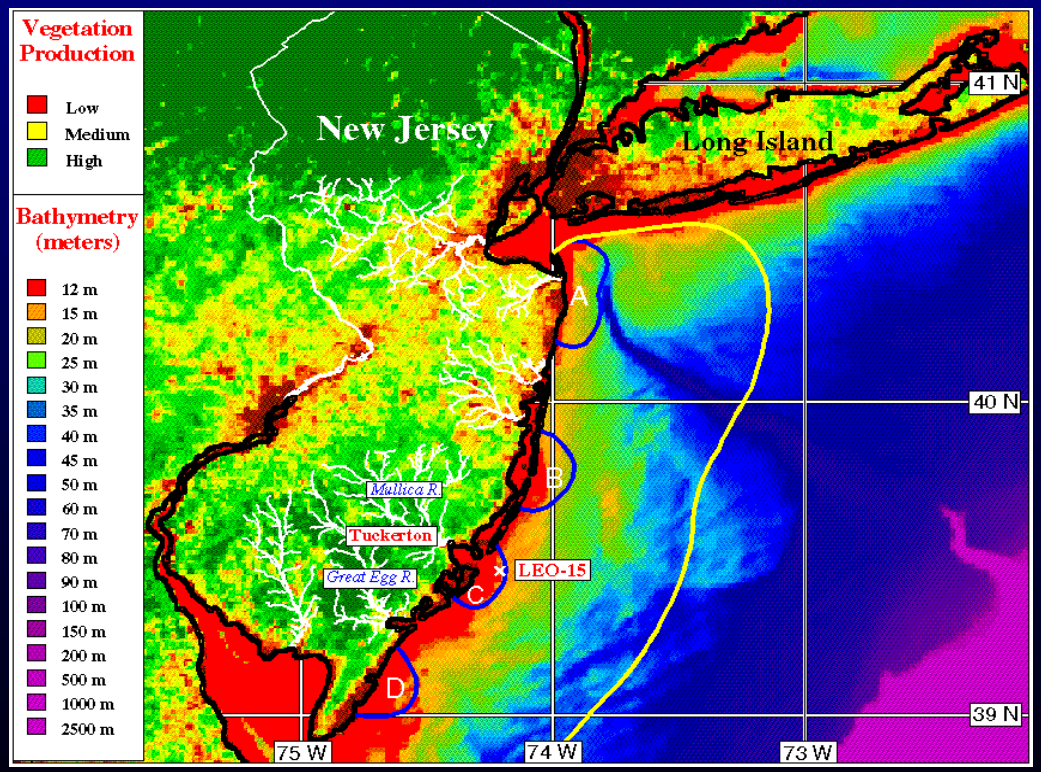
To get these initial conditions:

- **Modelers like to assimilate maps of coherent array data**
- **Modelers do not like to assimilate single point time series data**

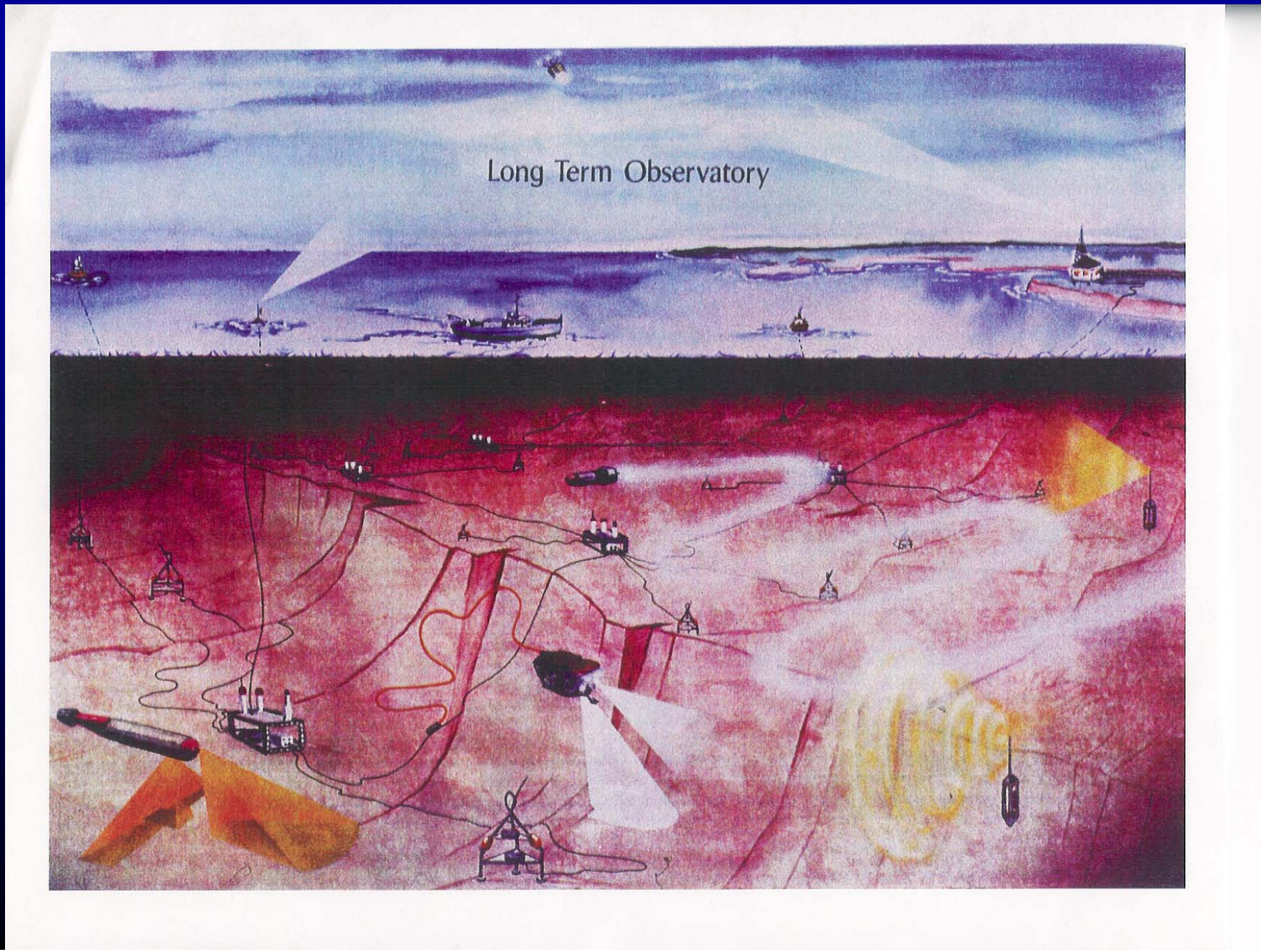
New Jersey Shelf Bathymetry

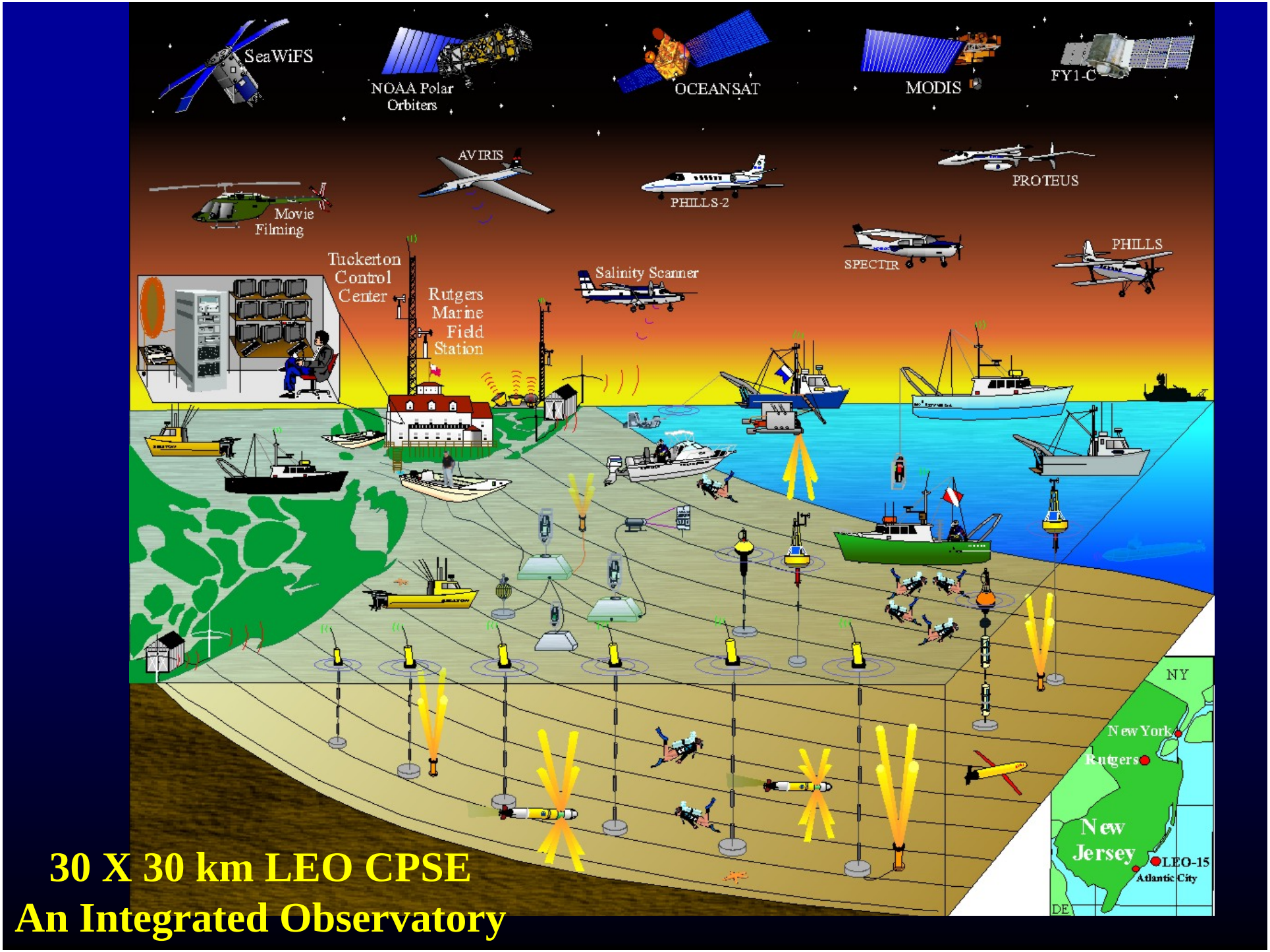




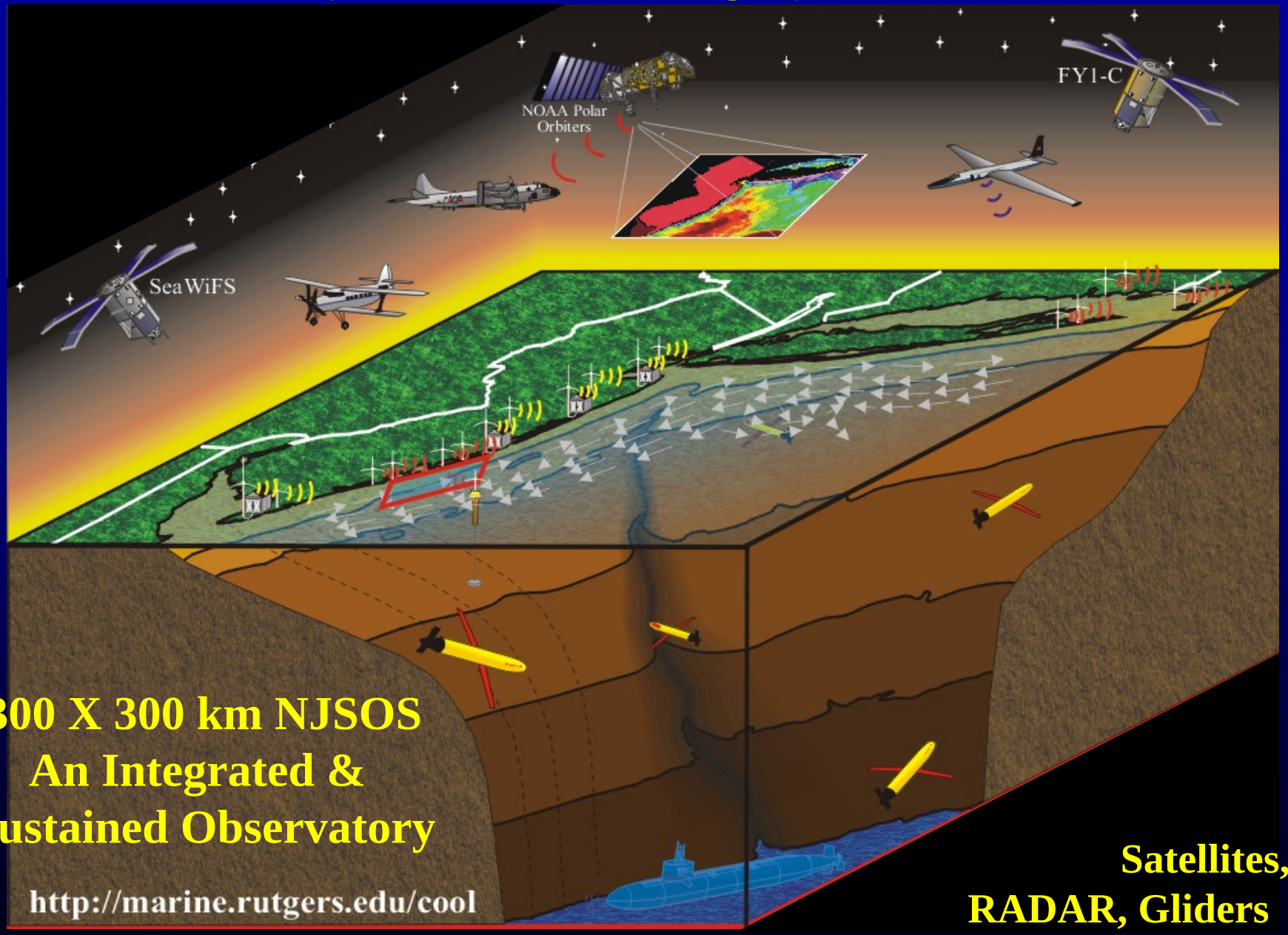


The Long-term Ecosystem Observatory (LEO) – 1993 Artist's View




SeaWiFS
NOAA Polar Orbiters
OCEANSAT
MODIS
FY1-C
AVIRIS
PROTEUS
PHILLS-2
Movie Filming
Tuckerton Control Center
Rutgers Marine Field Station
Salinity Scanner
SPECTIR
PHILLS
NY
New York
Rutgers
New Jersey
LEO-15
Atlantic City
DE
30 X 30 km LEO CPSE
An Integrated Observatory

New Jersey Shelf Observing System (NJ-SOS)



Coastal Ocean Observation Lab

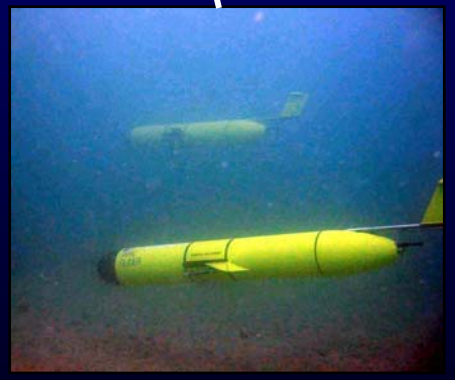
Observatory Control Room

The COOLroom

CODAR Network

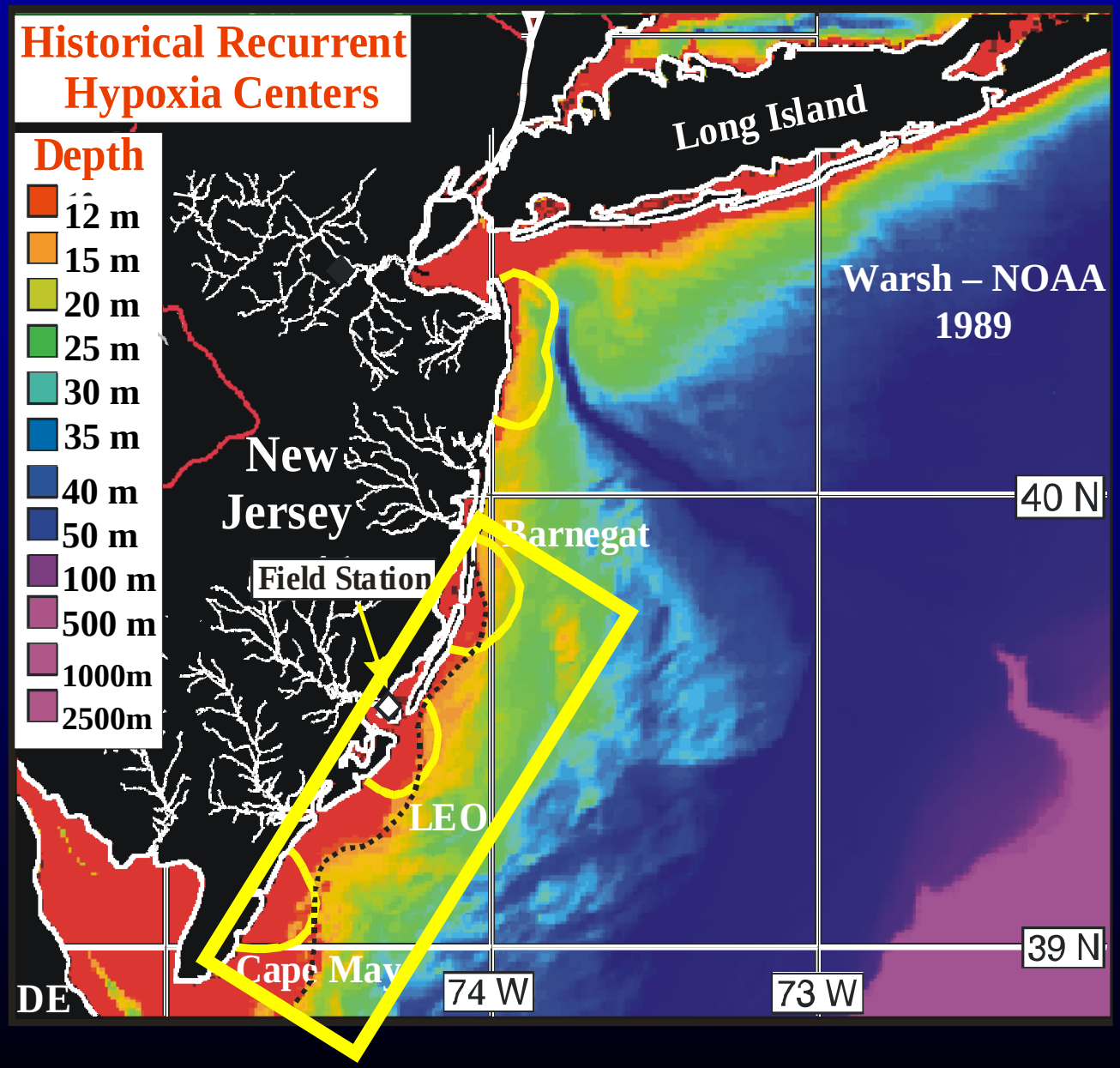
L-Band

X-Band

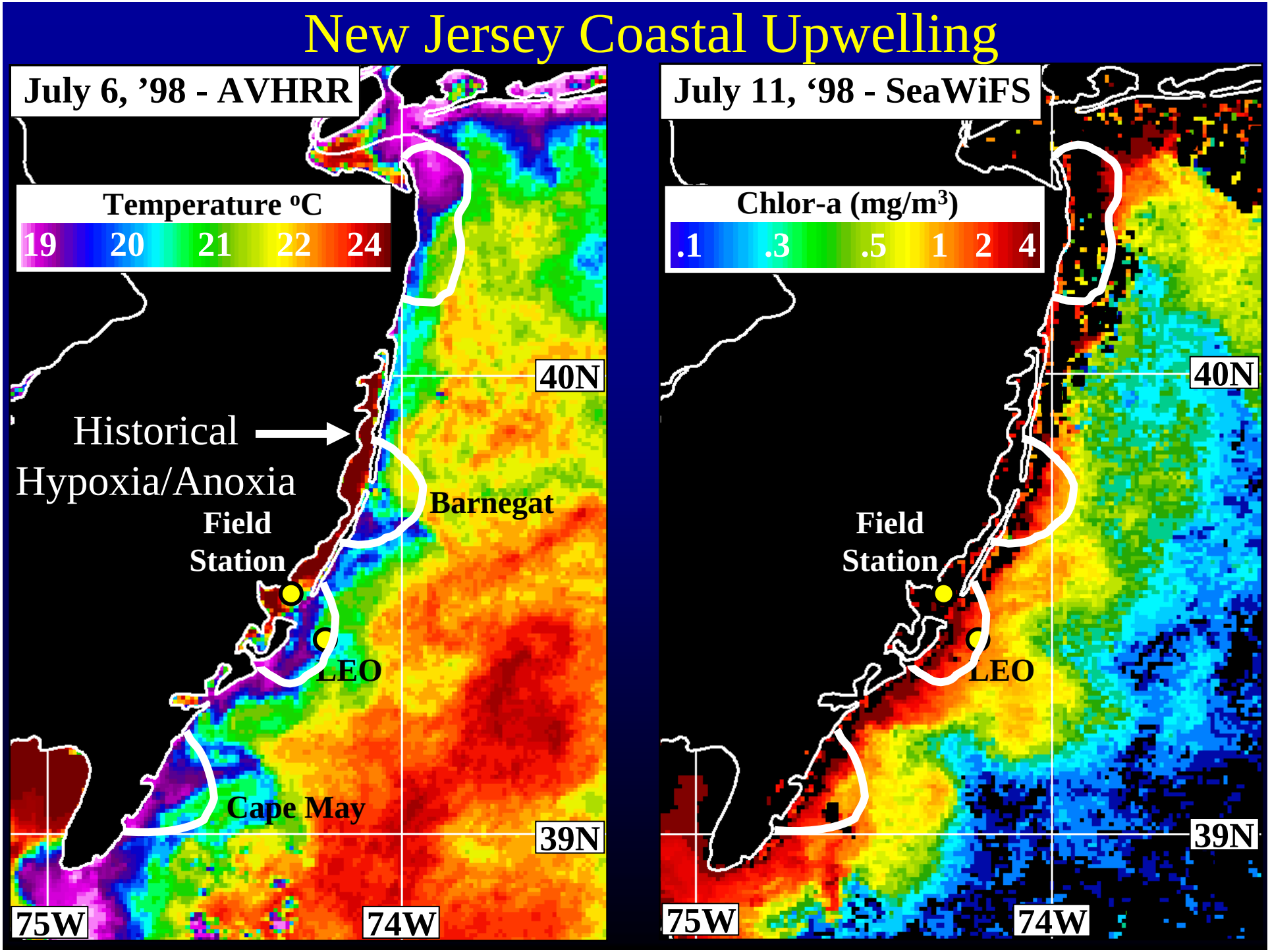


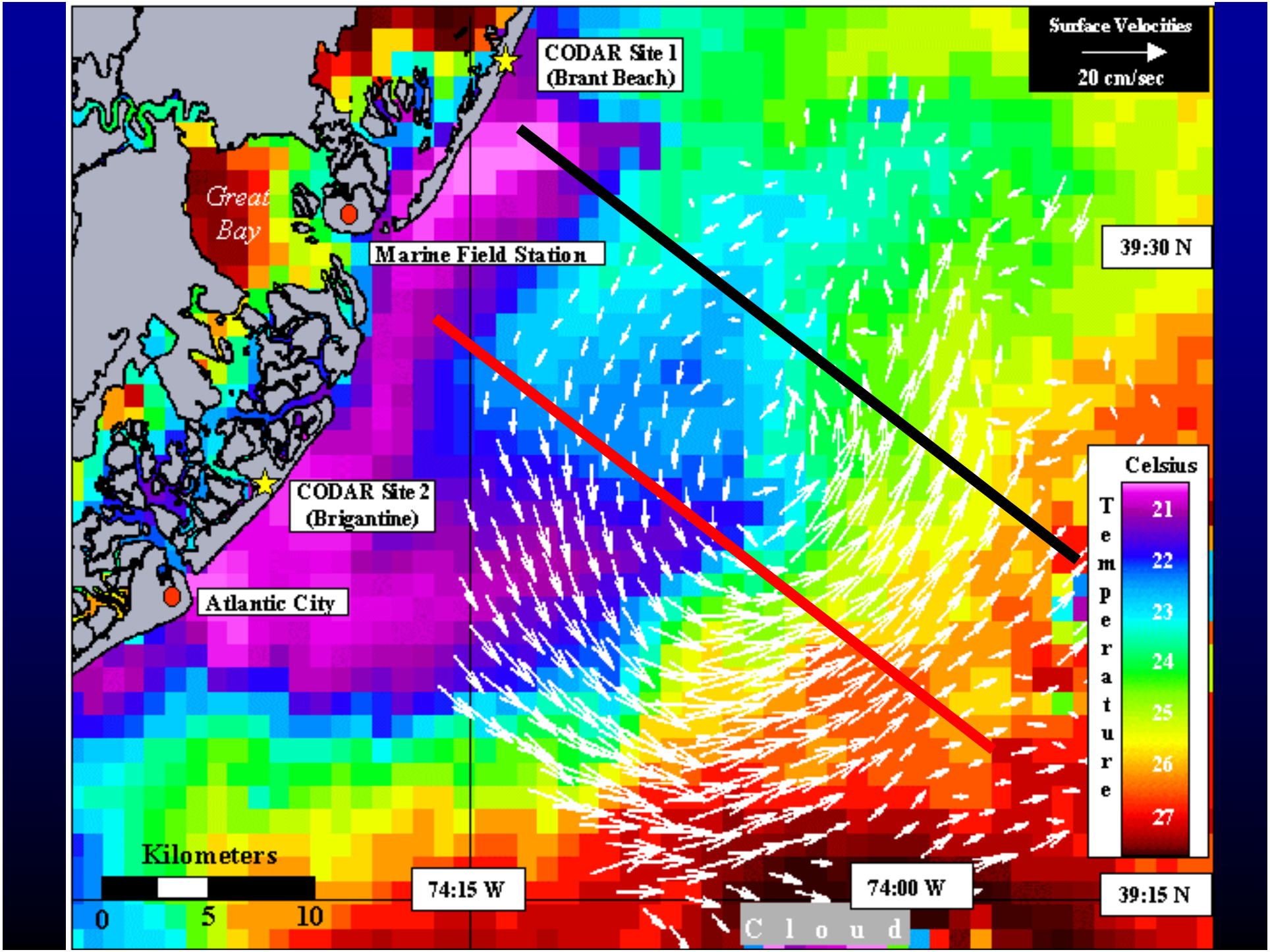
Glider Fleet

Hypoxia/Anoxia & Bottom Bathymetry

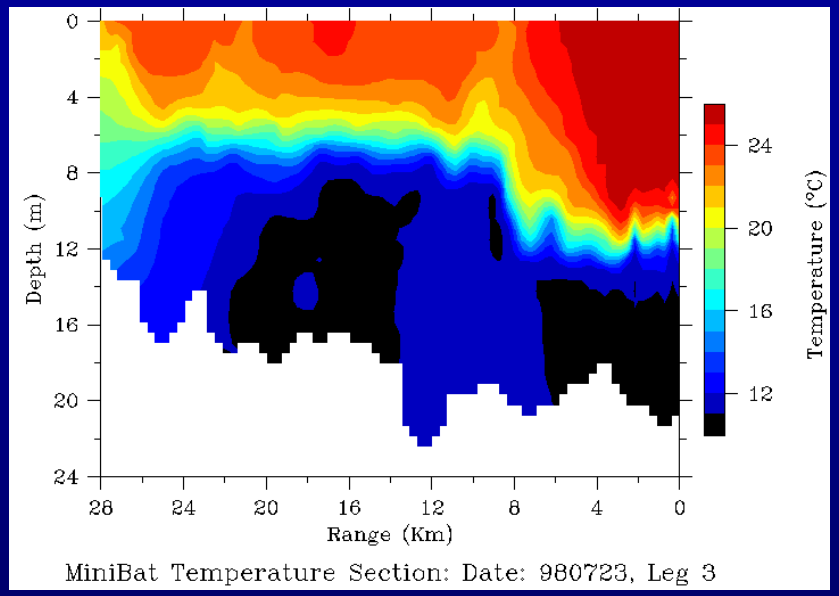


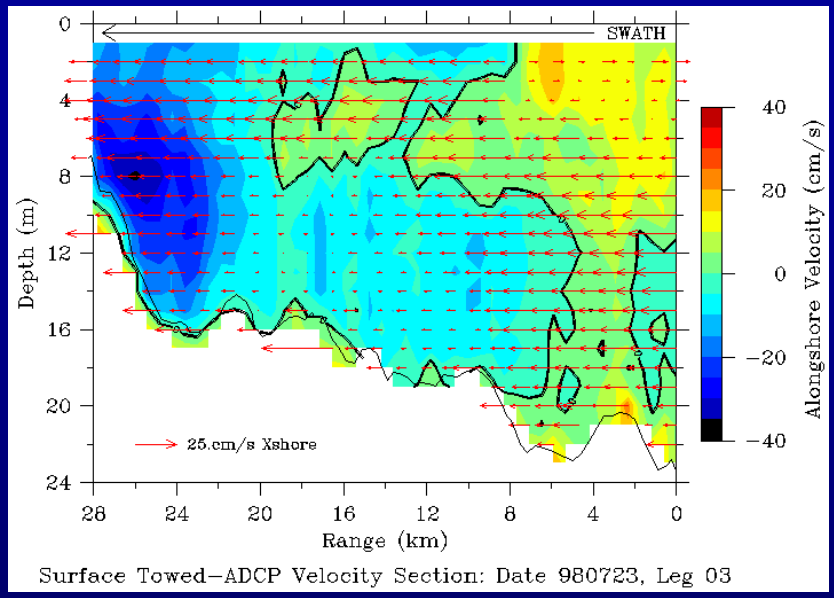
New Jersey Coastal Upwelling

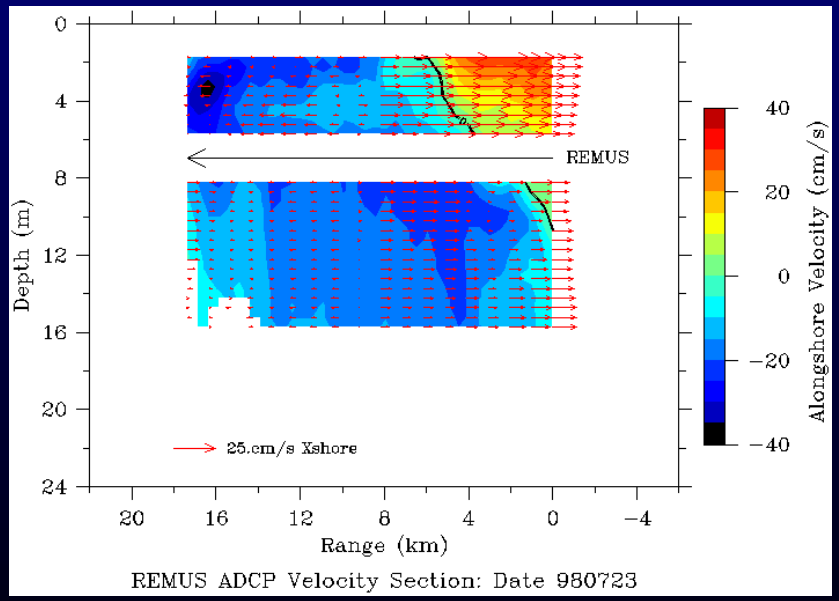


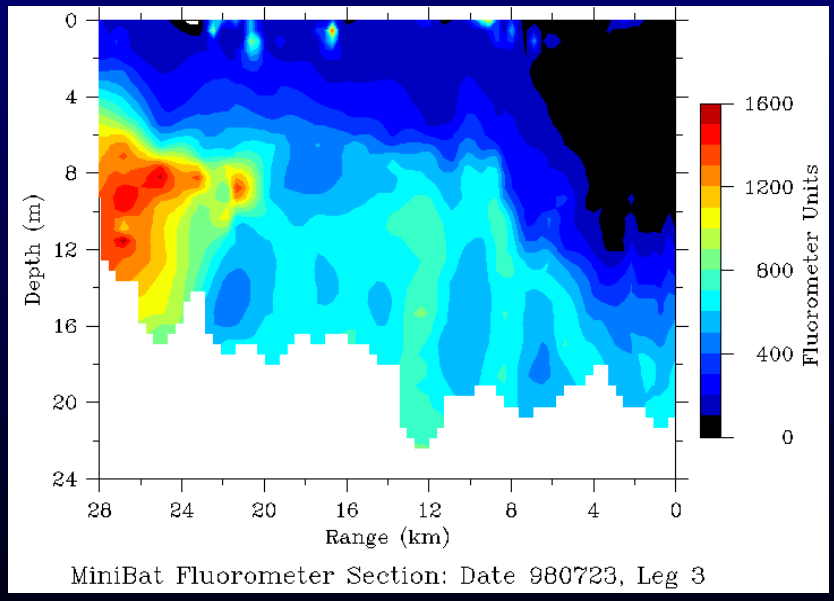

Surface Velocities
20 cm/sec
CODAR Site 1
(Brant Beach)
Great
Bay
Marine Field Station
39:30 N
CODAR Site 2
(Brigantine)
Atlantic City
Celsius
Temperature
21
22
23
24
25
26
27
Kilometers
0
5
10
74:15 W
74:00 W
39:15 N
Cloud

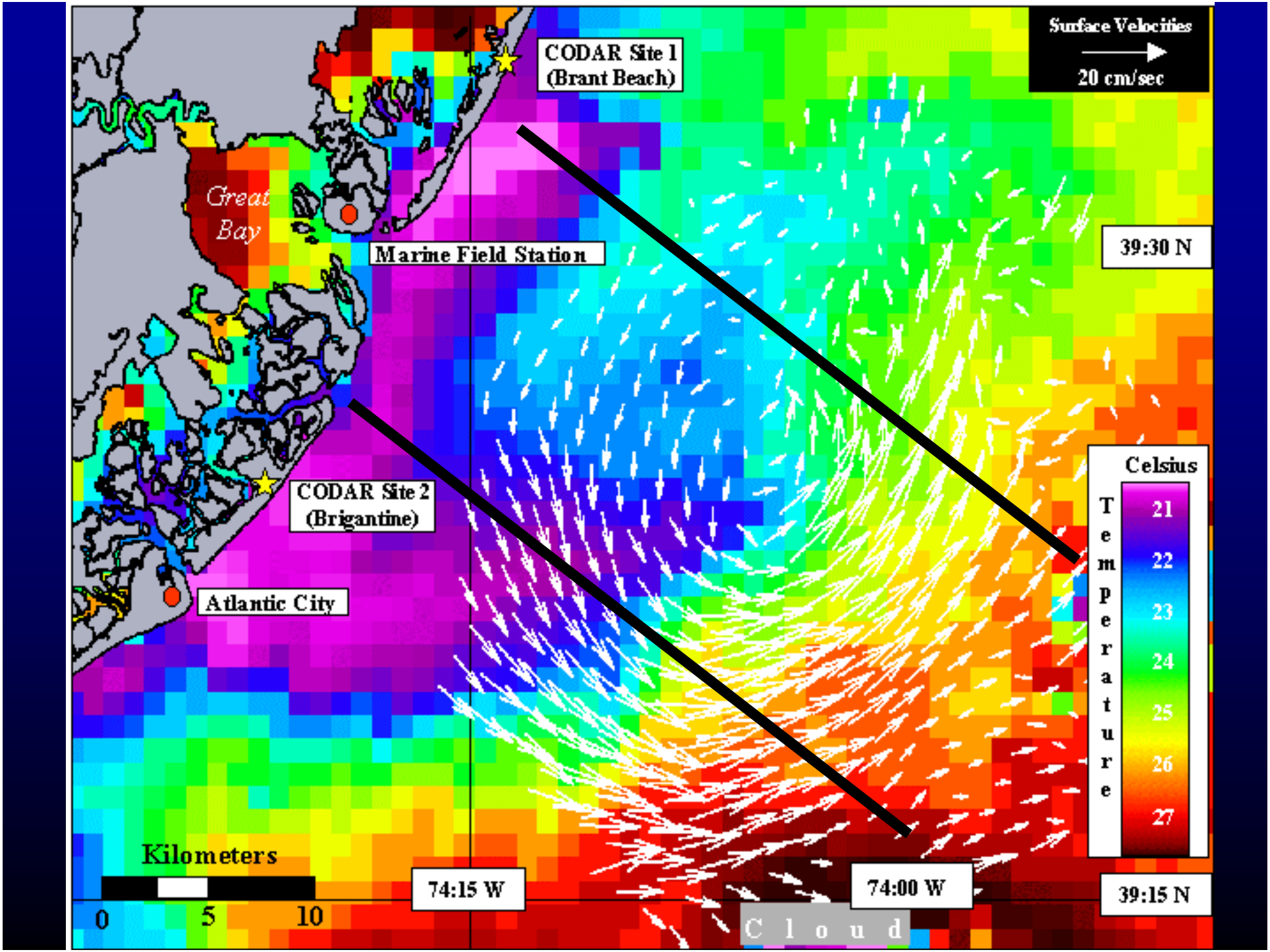
Shipboard surveys



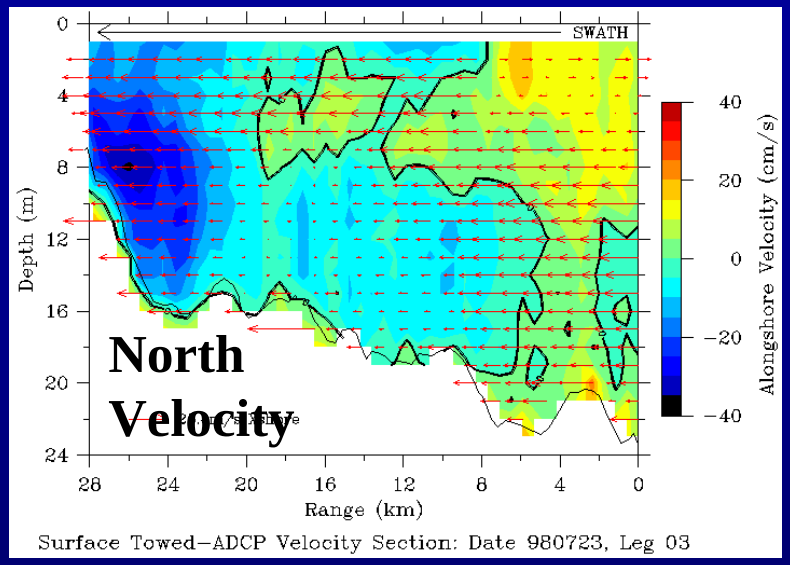


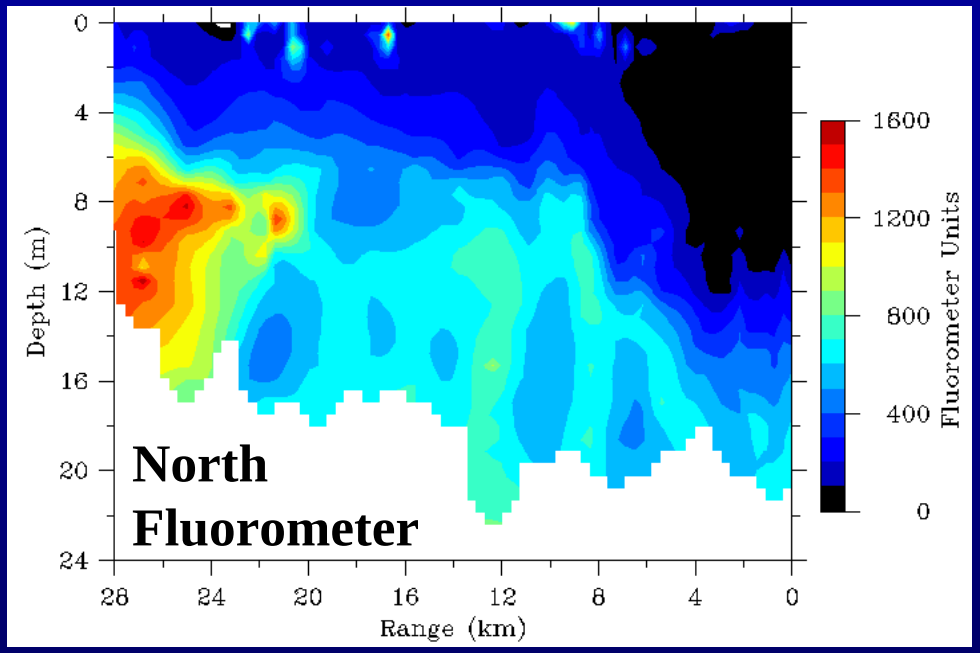


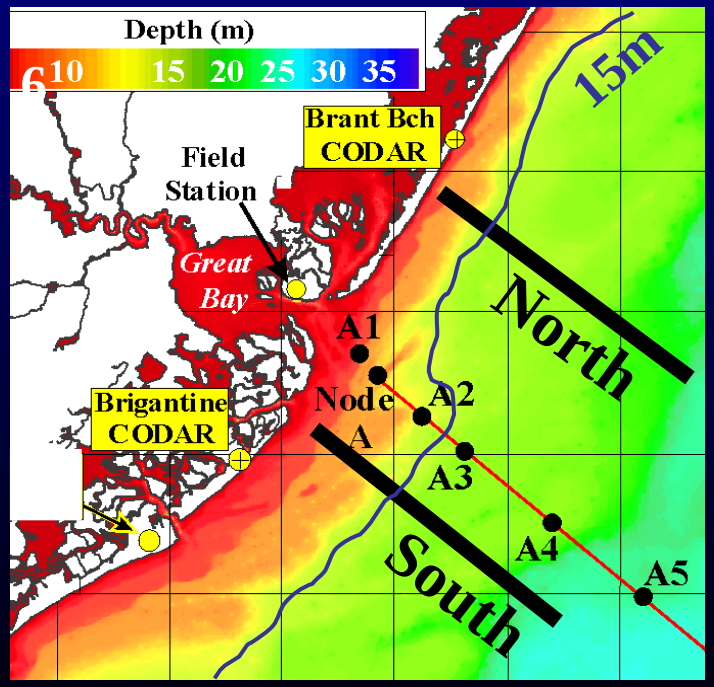


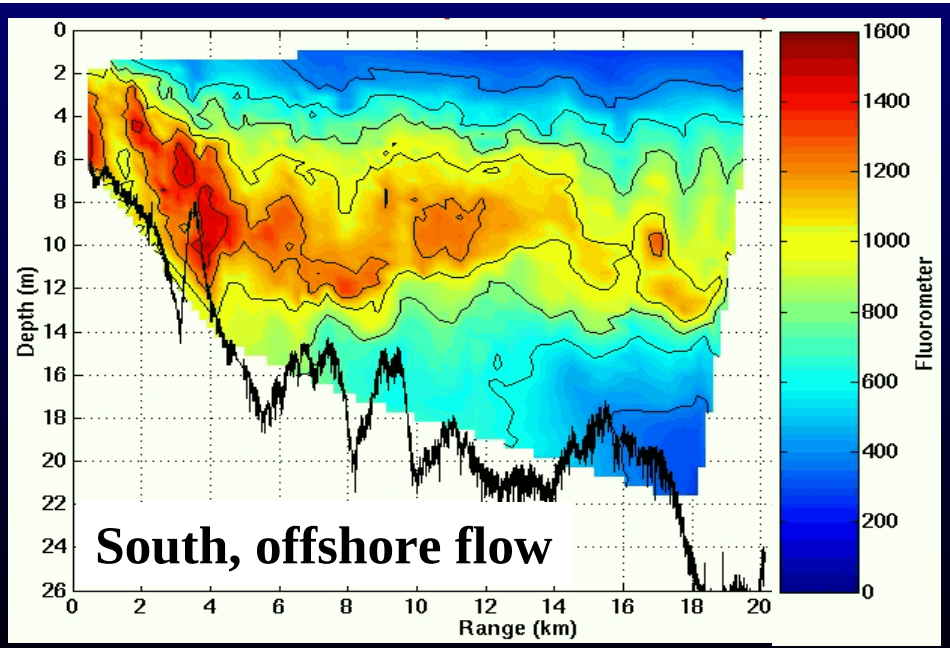

Surface Velocities
20 cm/sec
CODAR Site 1
(Brant Beach)
Great
Bay
Marine Field Station
39:30 N
CODAR Site 2
(Brigantine)
Atlantic City
Celsius
Temperature
21
22
23
24
25
26
27
Kilometers
0
5
10
74:15 W
74:00 W
39:15 N
Cloud

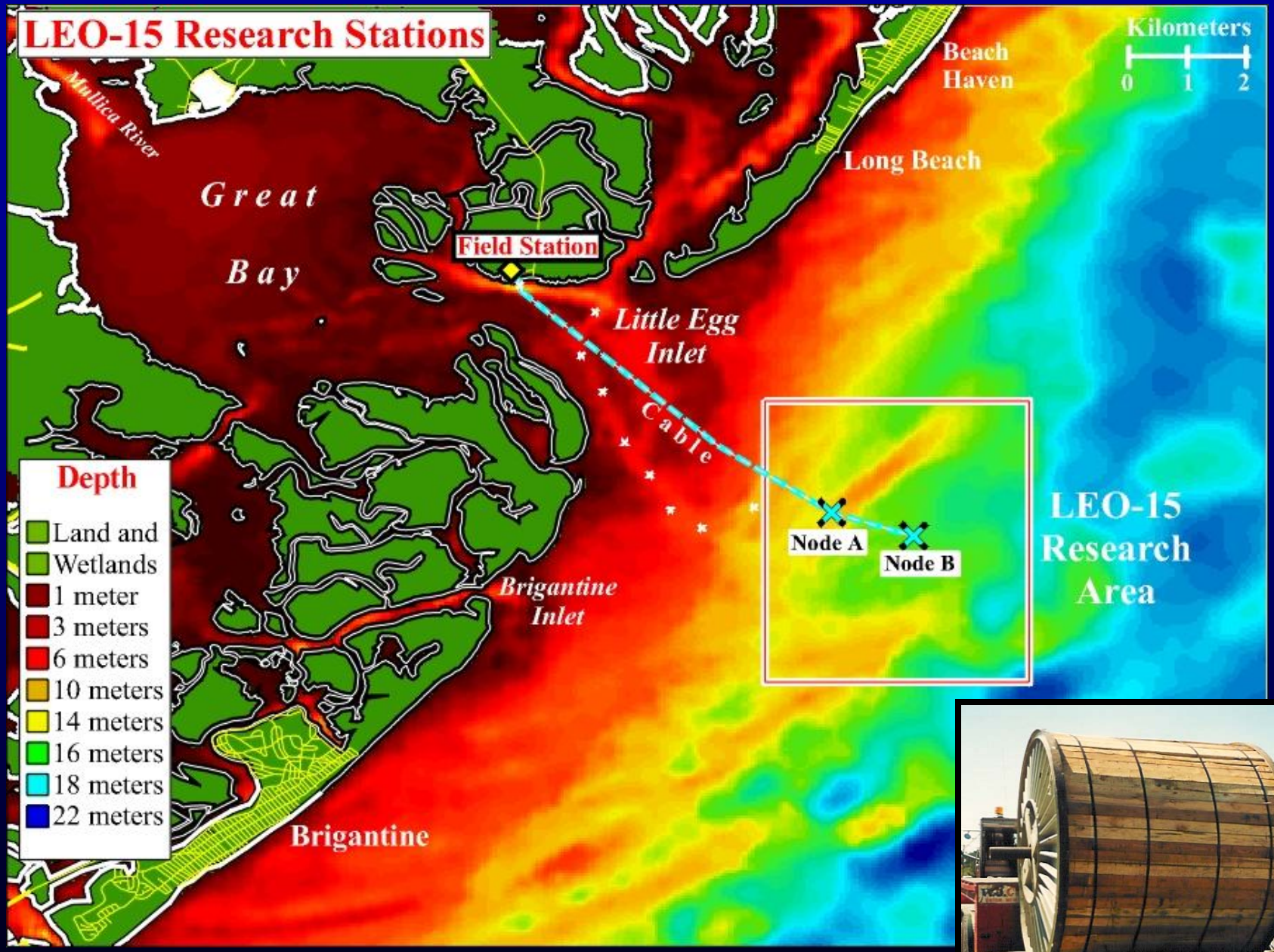
Adaptive Sampling of Resolved Scales- Shipboard & AUV surveys



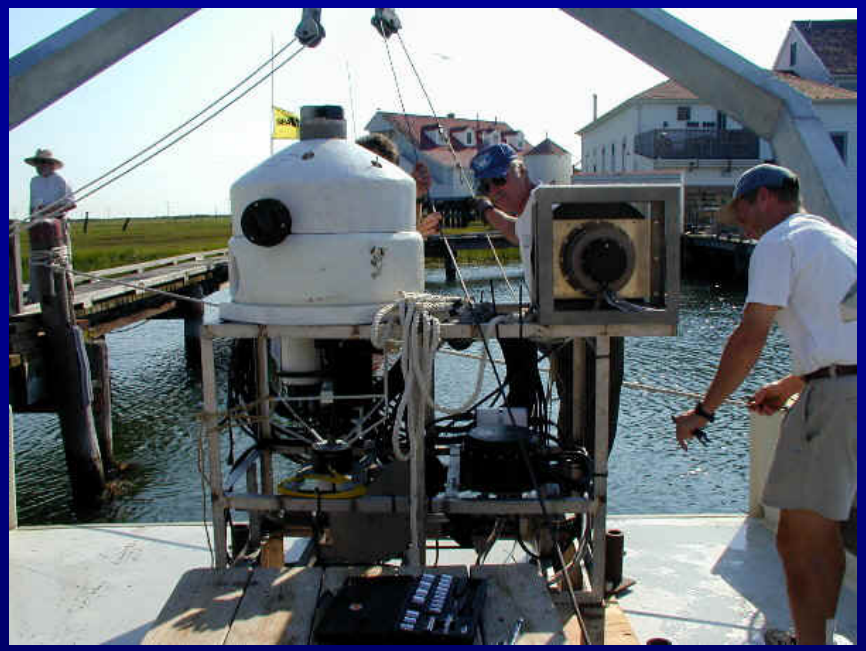




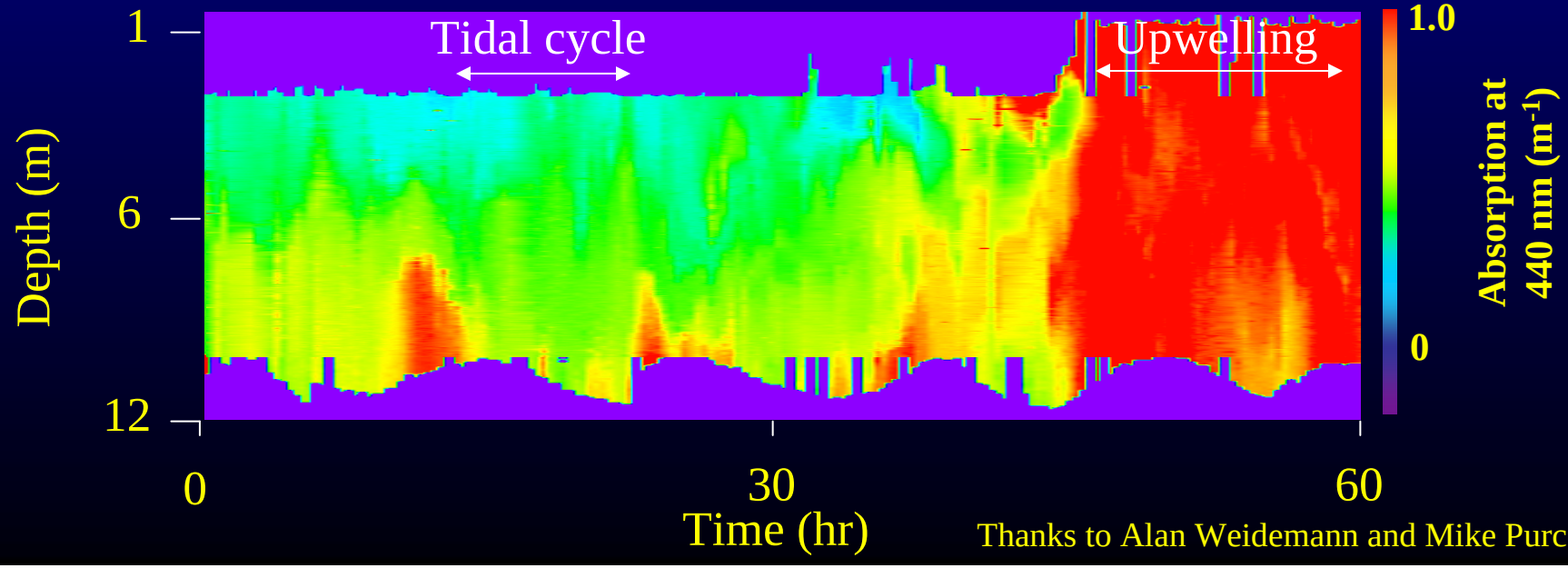



LEO-15 Research Stations
Mullica River
Great Bay
Field Station
Little Egg Inlet
Cable
Beach Haven
Long Beach
Kilometers
0 1 2
Depth
Land and Wetlands
1 meter
3 meters
6 meters
10 meters
14 meters
16 meters
18 meters
22 meters
Brigantine Inlet
Brigantine
Node A
Node B
LEO-15 Research Area

Optical profiler deployed on LEO-15 guest port



Instrument Package for 2000: ac-9, HiSTAR, FRR, LISST, HS-2, Biolum, VSM



Thanks to Alan Weidemann and Mike Purcell

Sediment Transport Studies at LEO Site –early 1990's

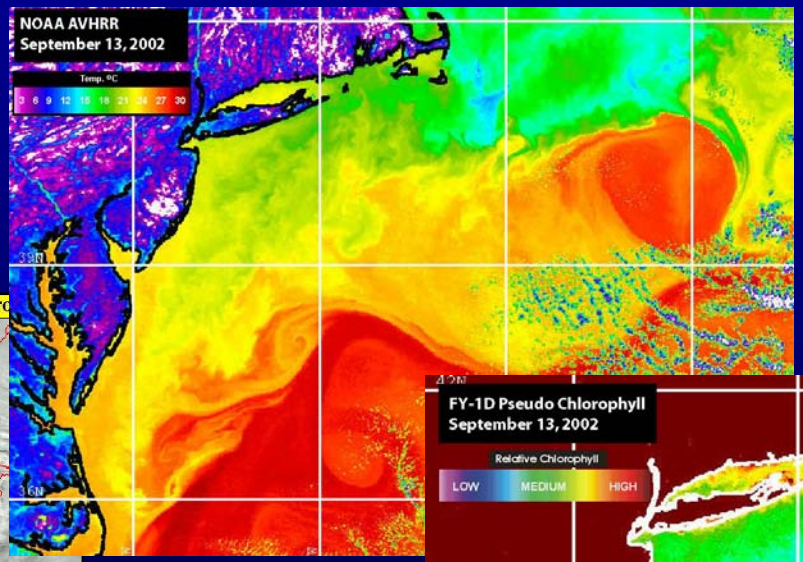
Benthic Acoustic Stress Sensor (BASS) Tripod
Before and After Summer Deployment at LEO

BASS Tripod
For LEO-15

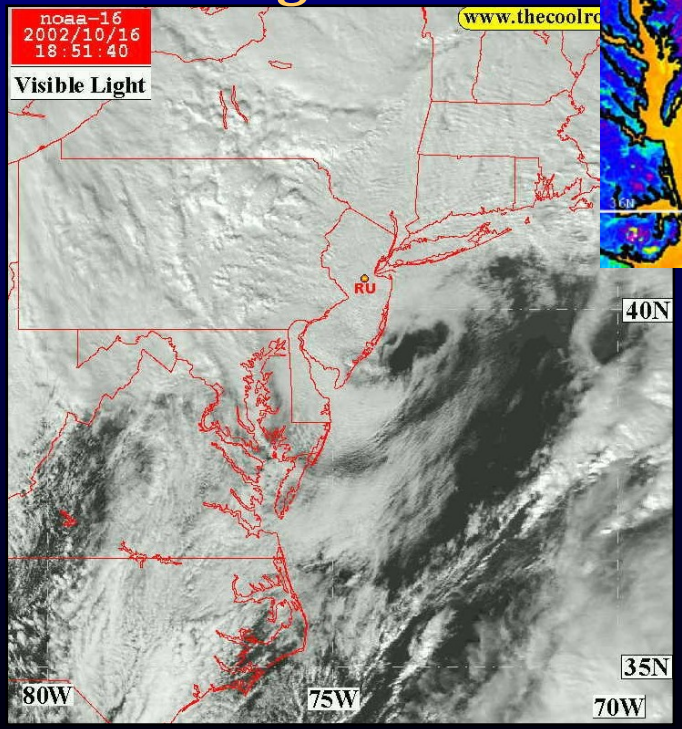
Late 1990's

A decade of SST on the Web, and tapping the international constellation of ocean color satellites since 1998

Sea Surface Temperature



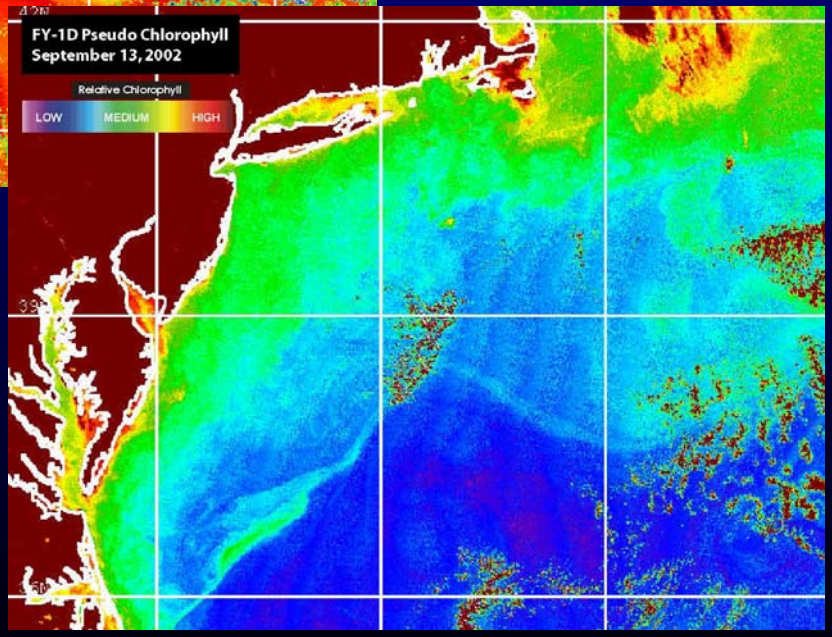
Visible Light

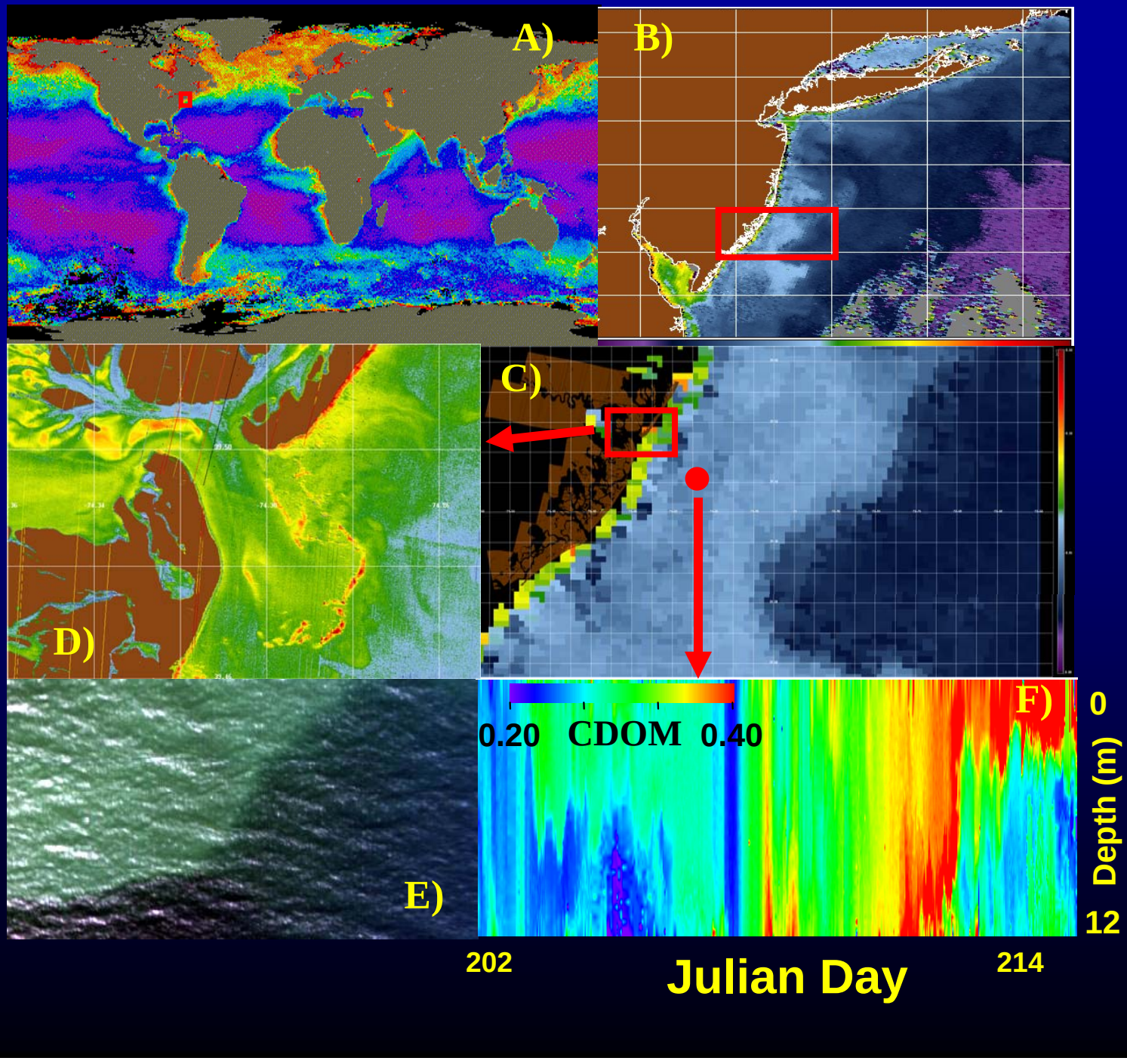


NOAA AVHRR

FY1-D (China)

Ocean Color




A)
B)
C)
D)
E)
F)
0.20 CDOM 0.40
0
Depth (m)
12
202
Julian Day
214

MODIS
Sept. 20
2004

MODIS
Sept. 23
2004

CODAR System Antennas

5 MHz

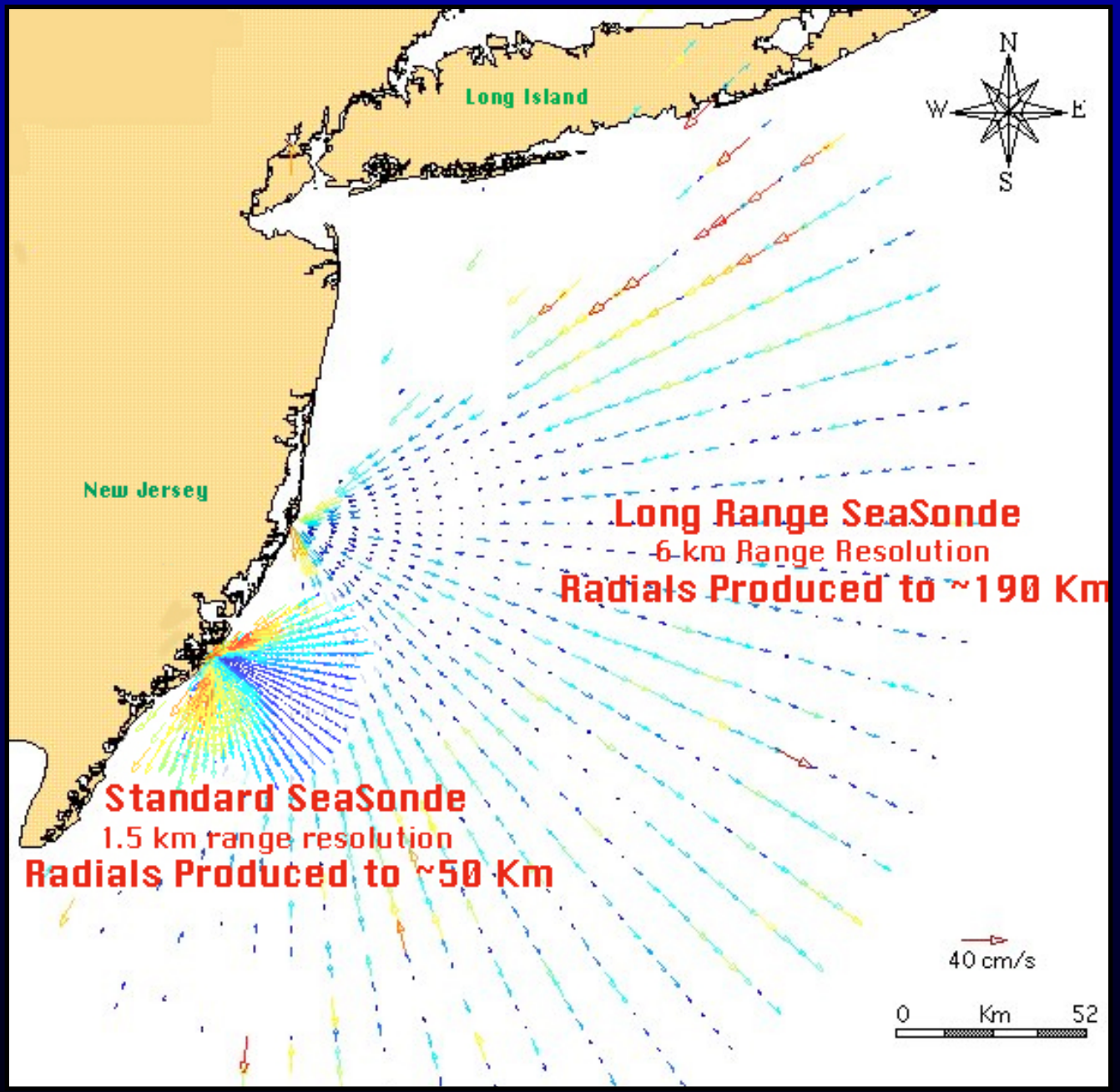
Transmit Antenna

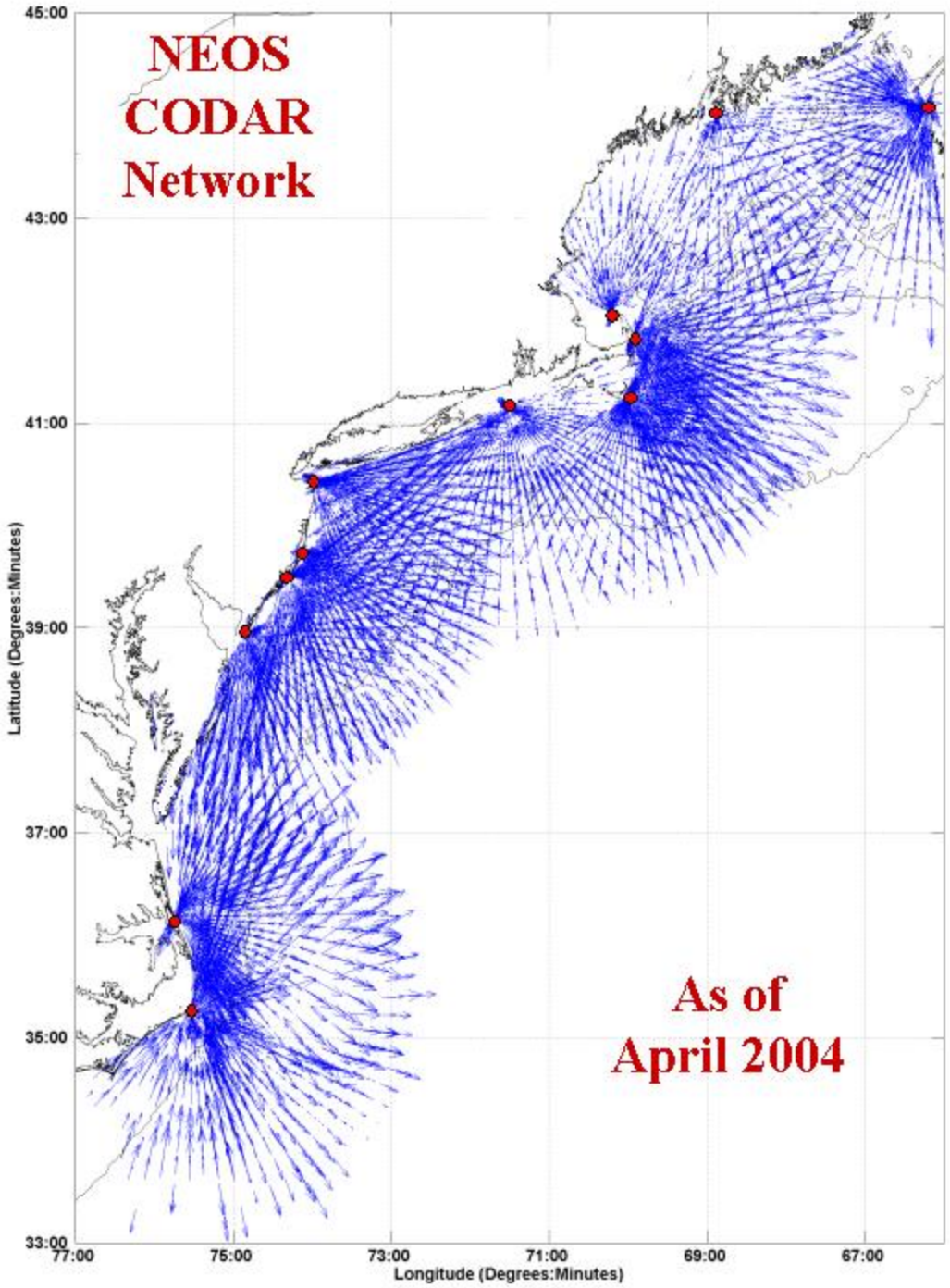
Receive Antenna

25 MHz and 13 MHz

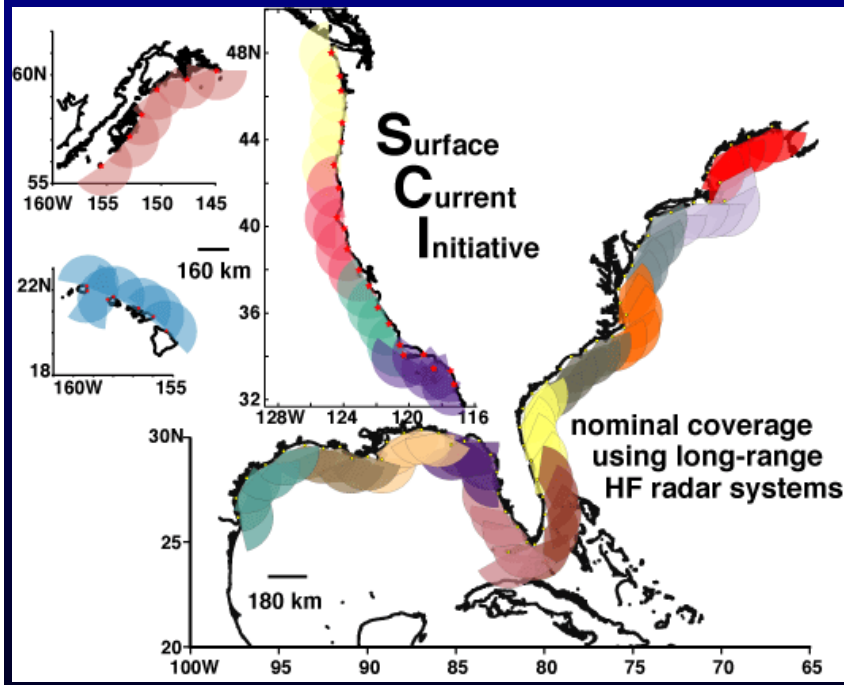
Main Product

Radial Current Maps

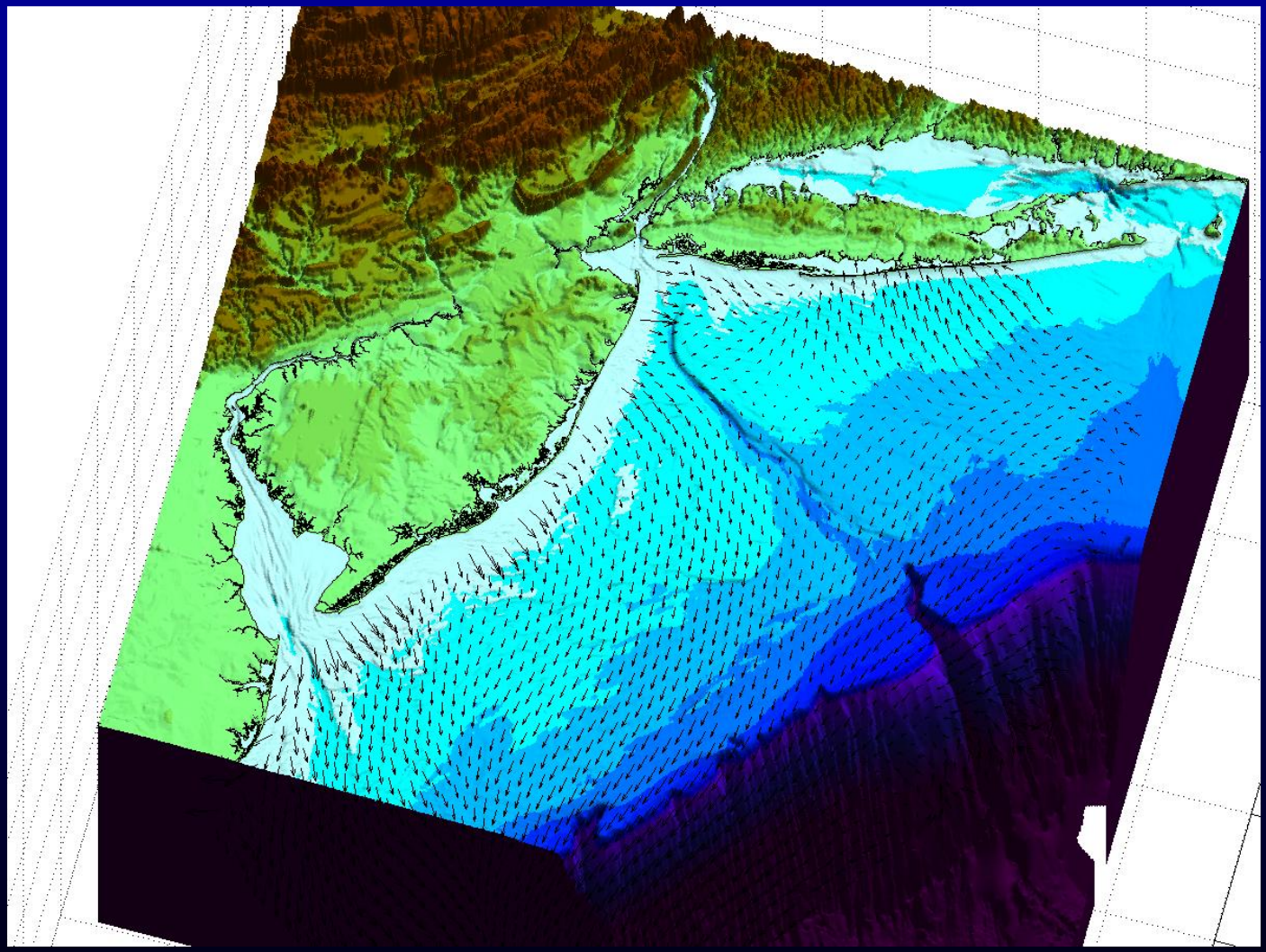




Ocean.US Surface Current Mapping Initiative 2003

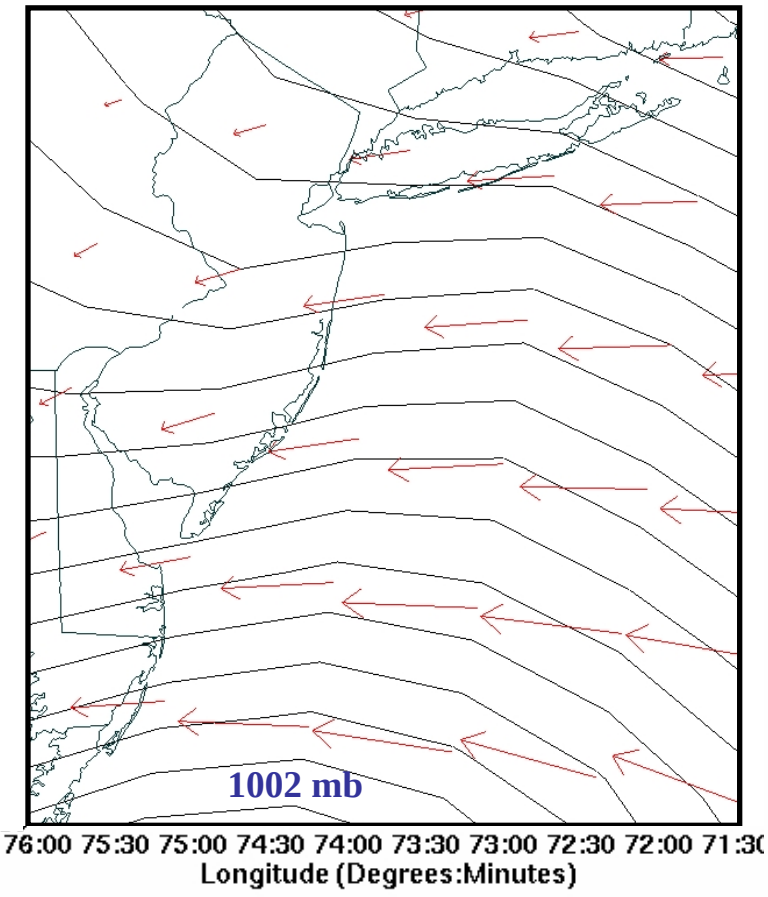


CODAR surface currents for the full continental shelf



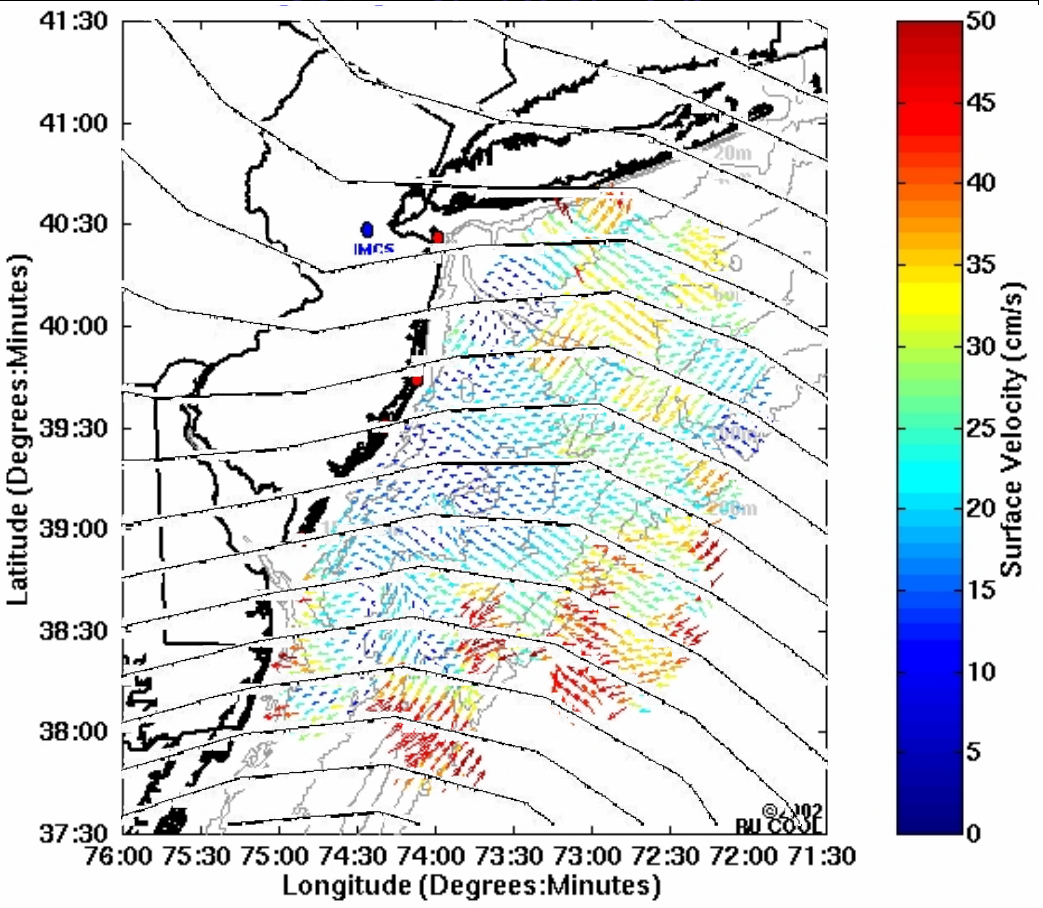
Spatial Maps
10/16/2002 0700 GMT

RUC Wind and Pressure Analysis



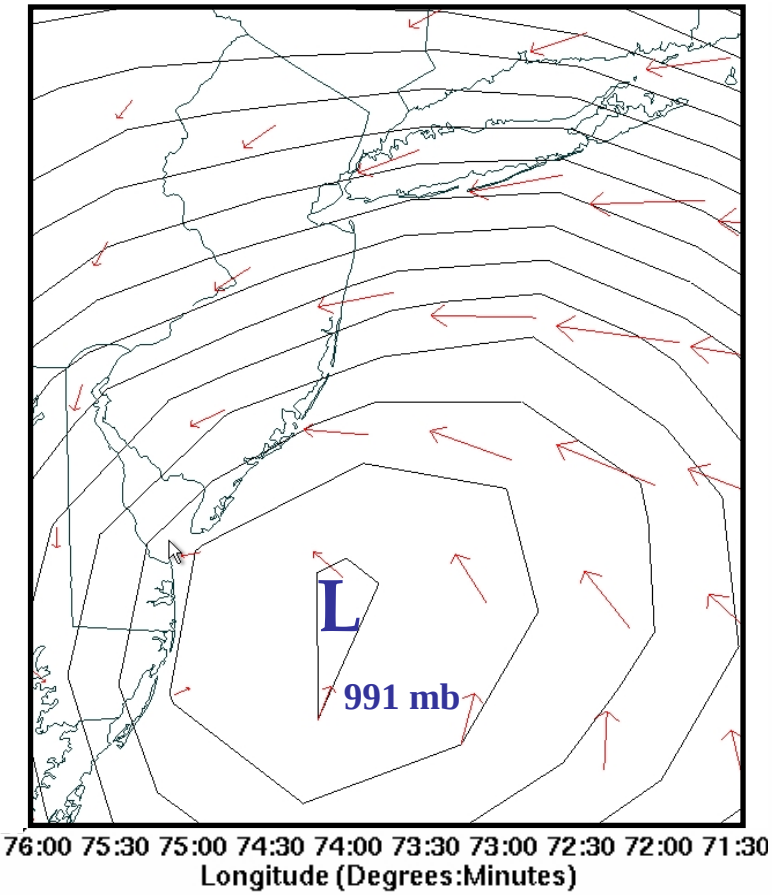
Contour resolution – 1 mb

CODAR Surface Currents



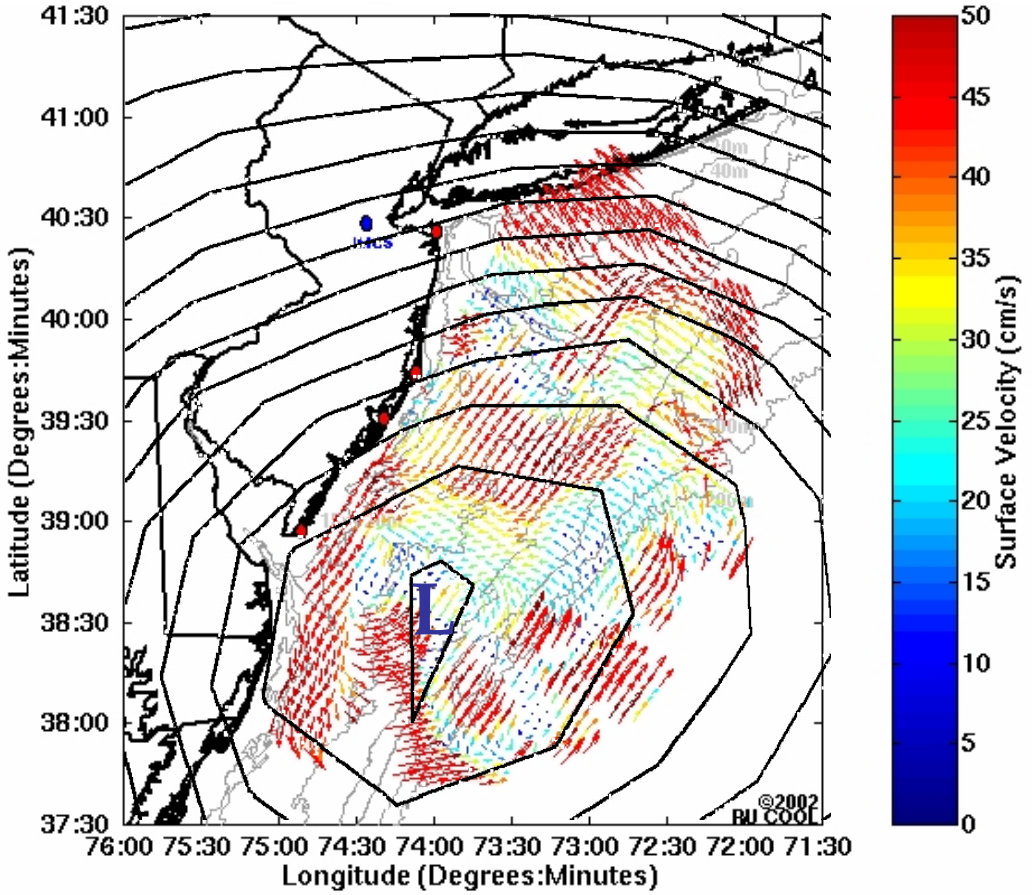
10/16/2002 1500 GMT

RUC Wind and Pressure Analysis



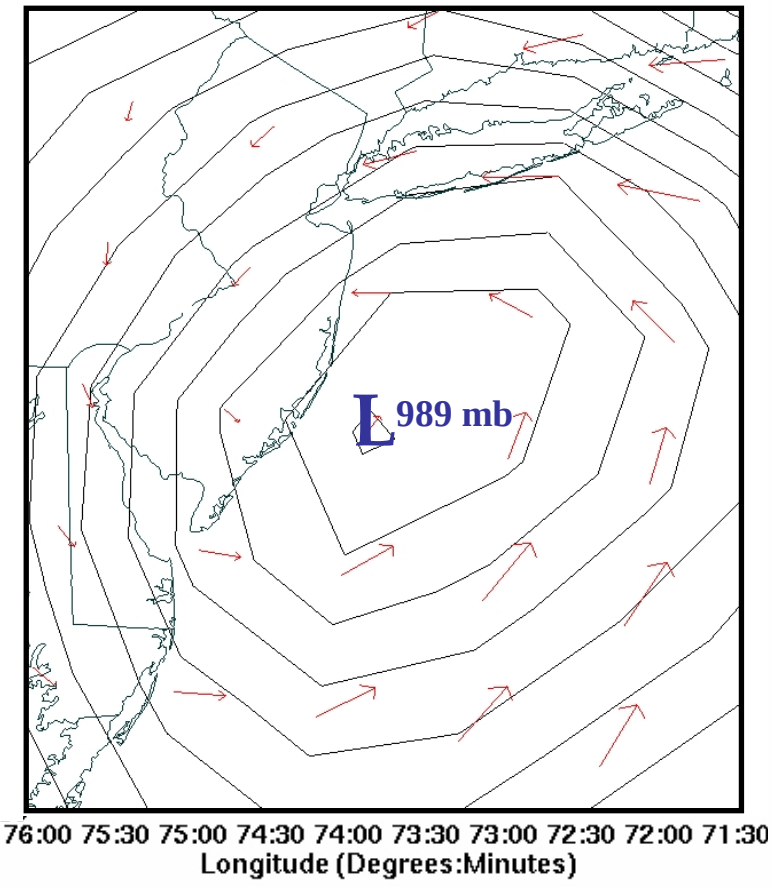
Contour resolution – 1 mb

CODAR Surface Currents



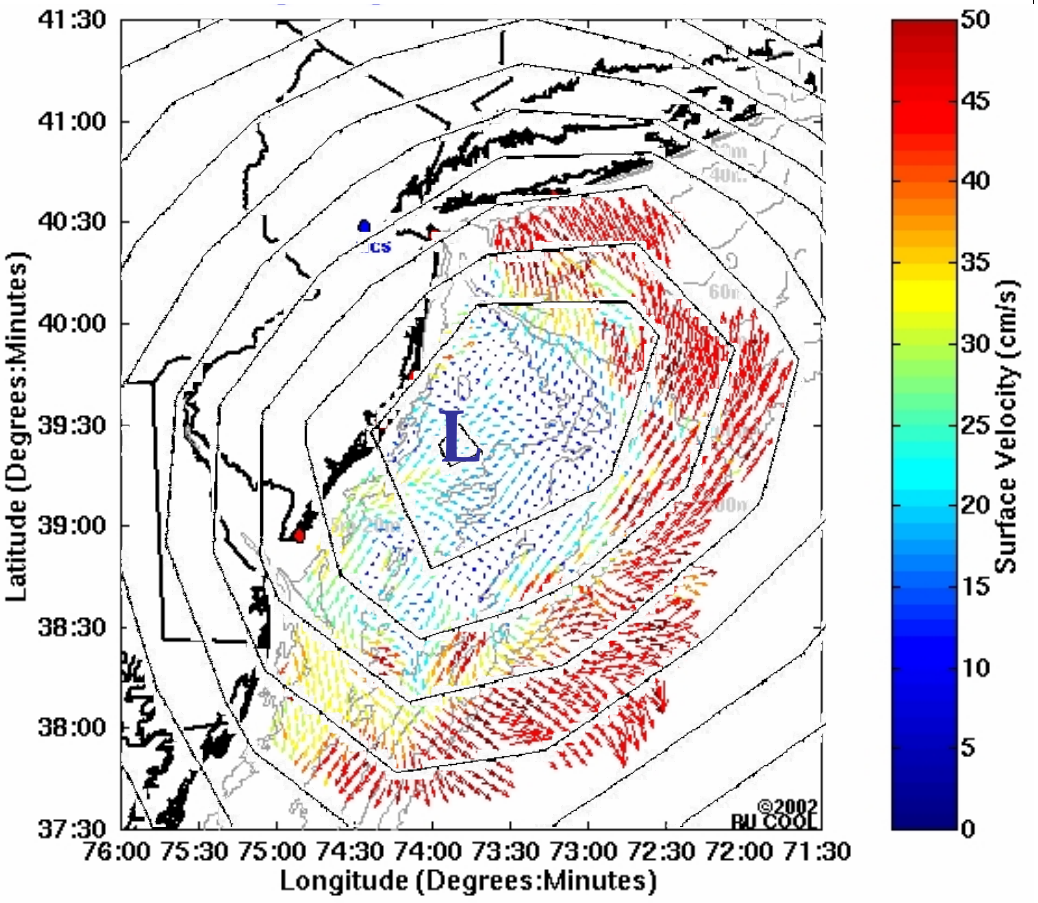
10/16/2002 1800 GMT

RUC Wind and Pressure Analysis



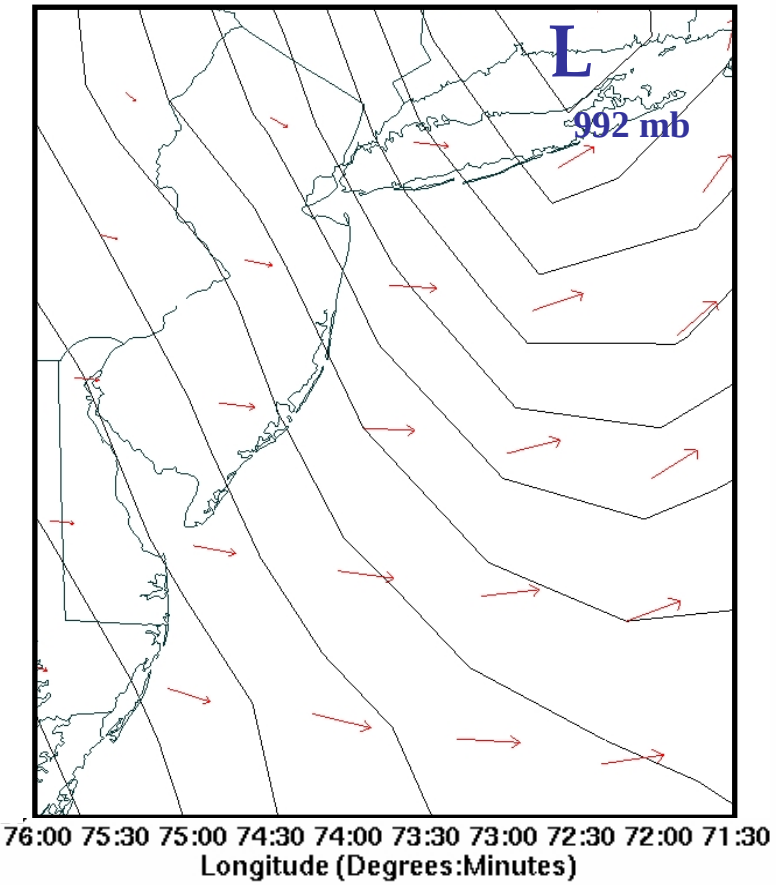
Contour resolution – 1 mb

CODAR Surface Currents



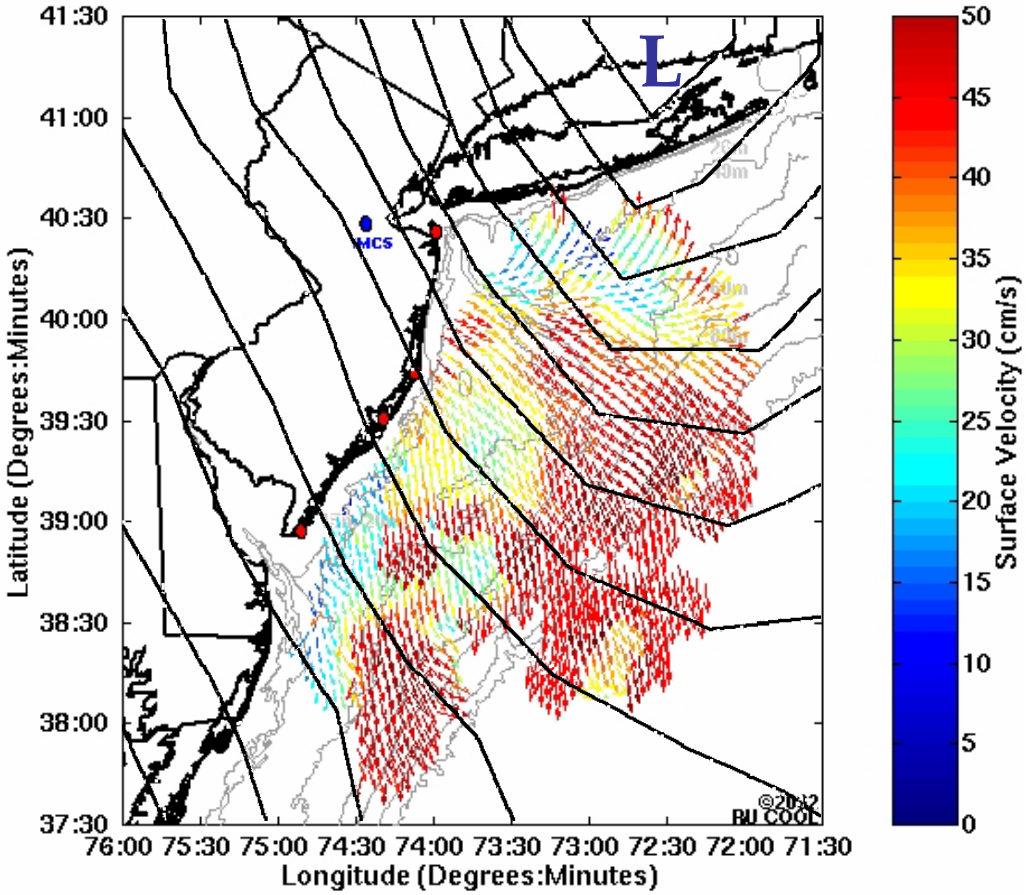
10/17/2002 0000 GMT

RUC Wind and Pressure Analysis

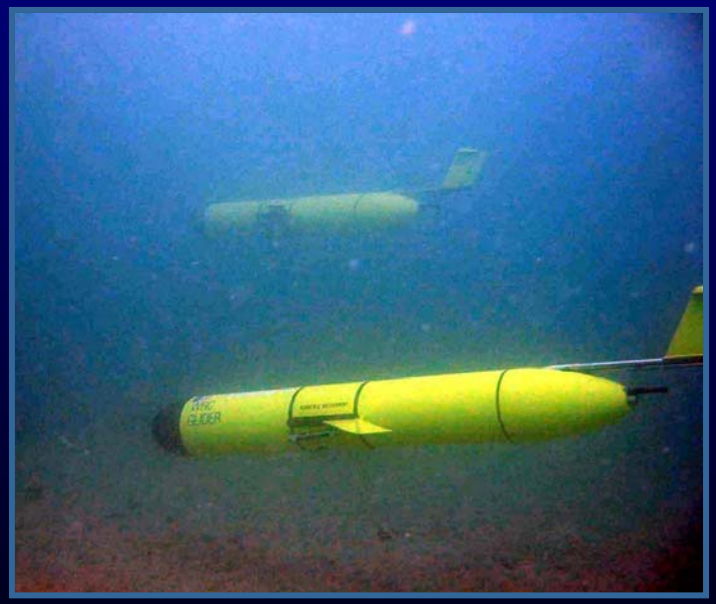


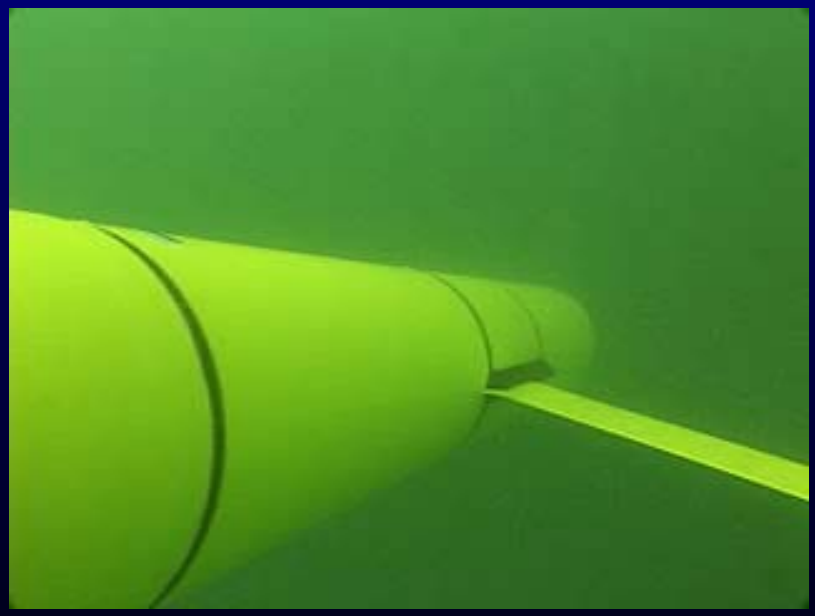
Contour resolution – 1 mb

CODAR Surface Currents



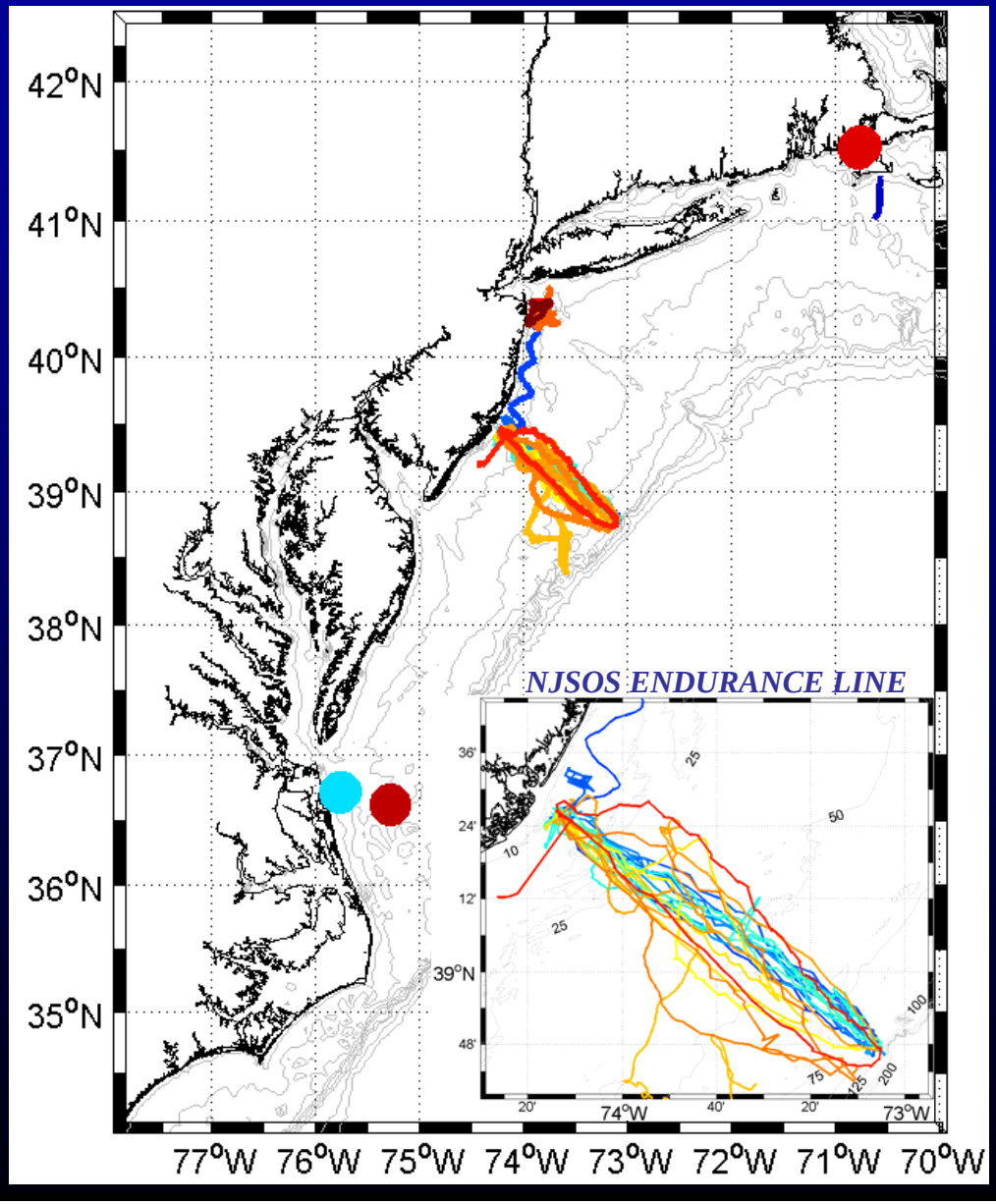
Slocum Autonomous Glider
-Long-duration AUV
-Webb Research

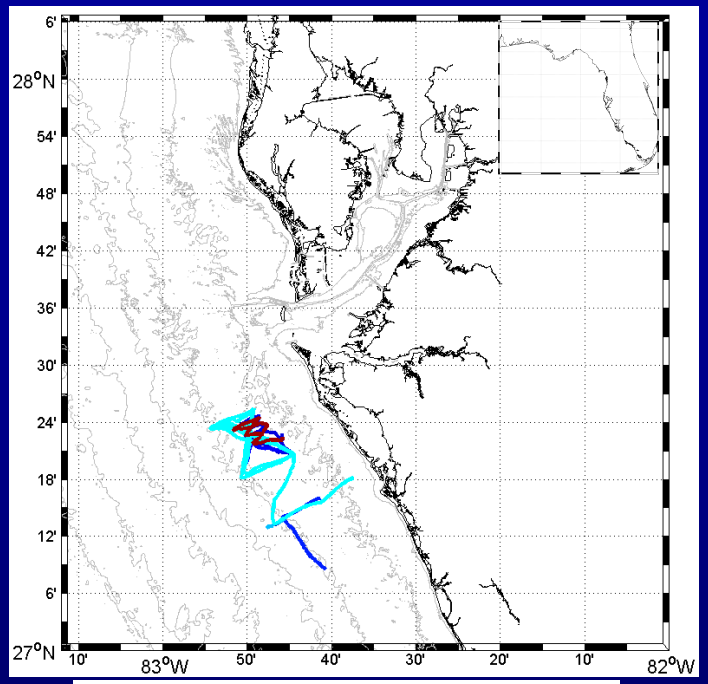


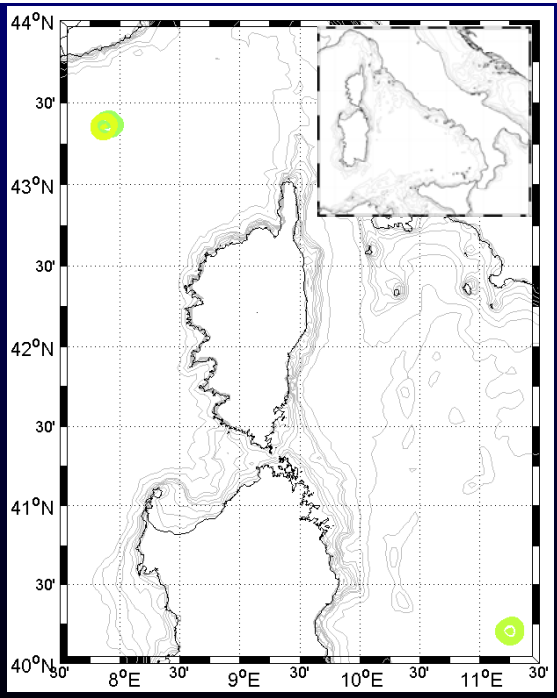


RU-COOL Glider Deployments as of September 23, 2004

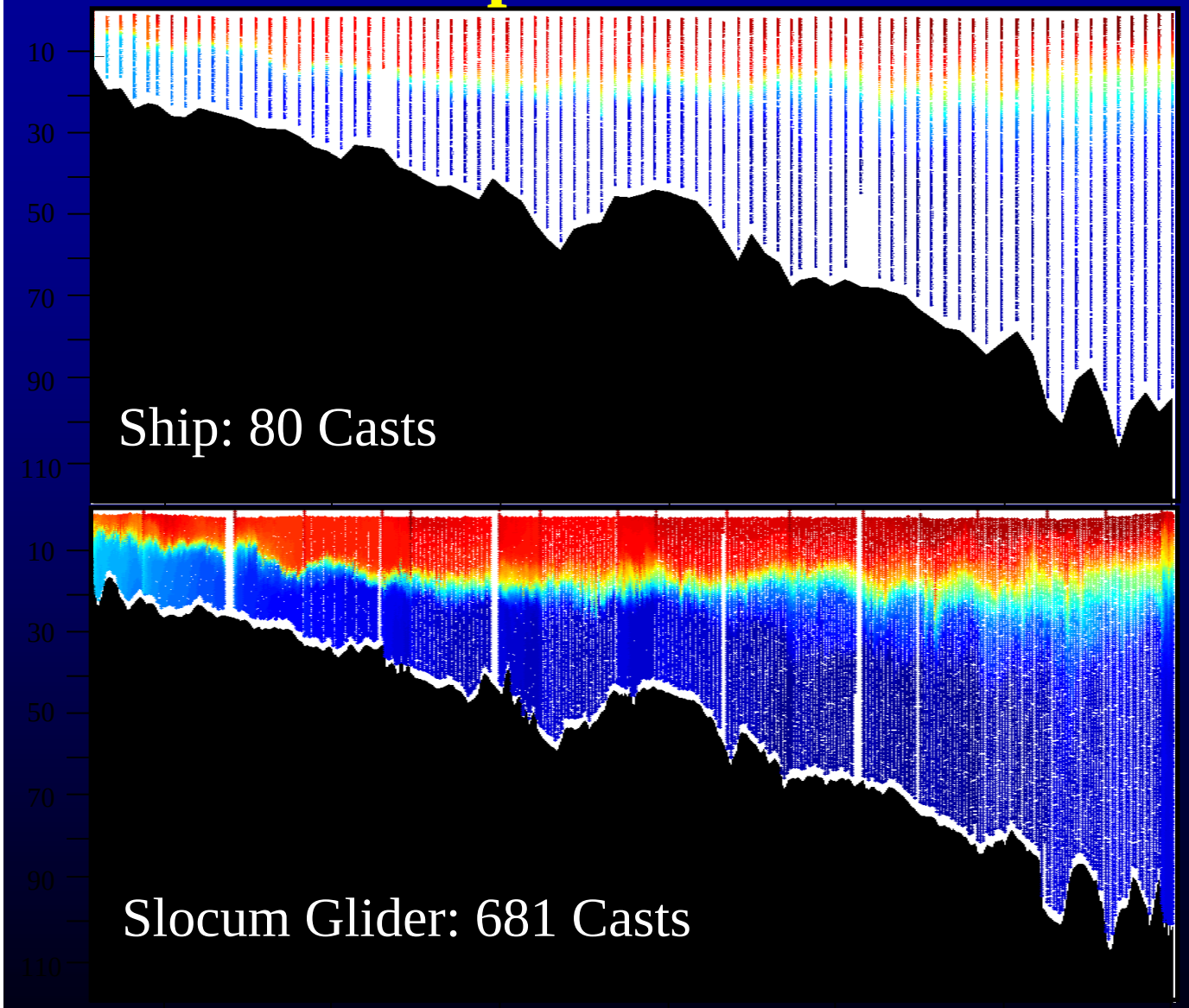
From 10/28/03 – 9/23/2004:
Elapsed calendar days: 331 days
Number of calendar days in the water: 231 days
Number of Days with at least 1 glider in the water: 290 days
Total Distance Flown: 5753.341 km

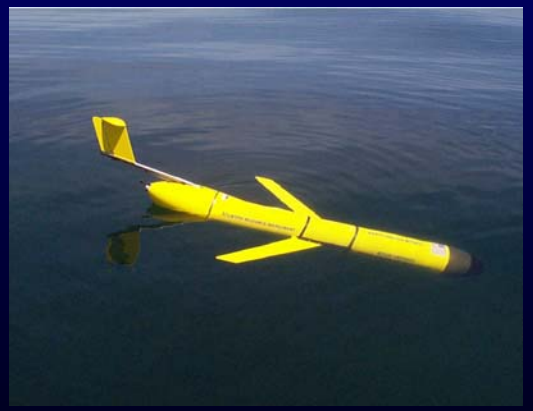




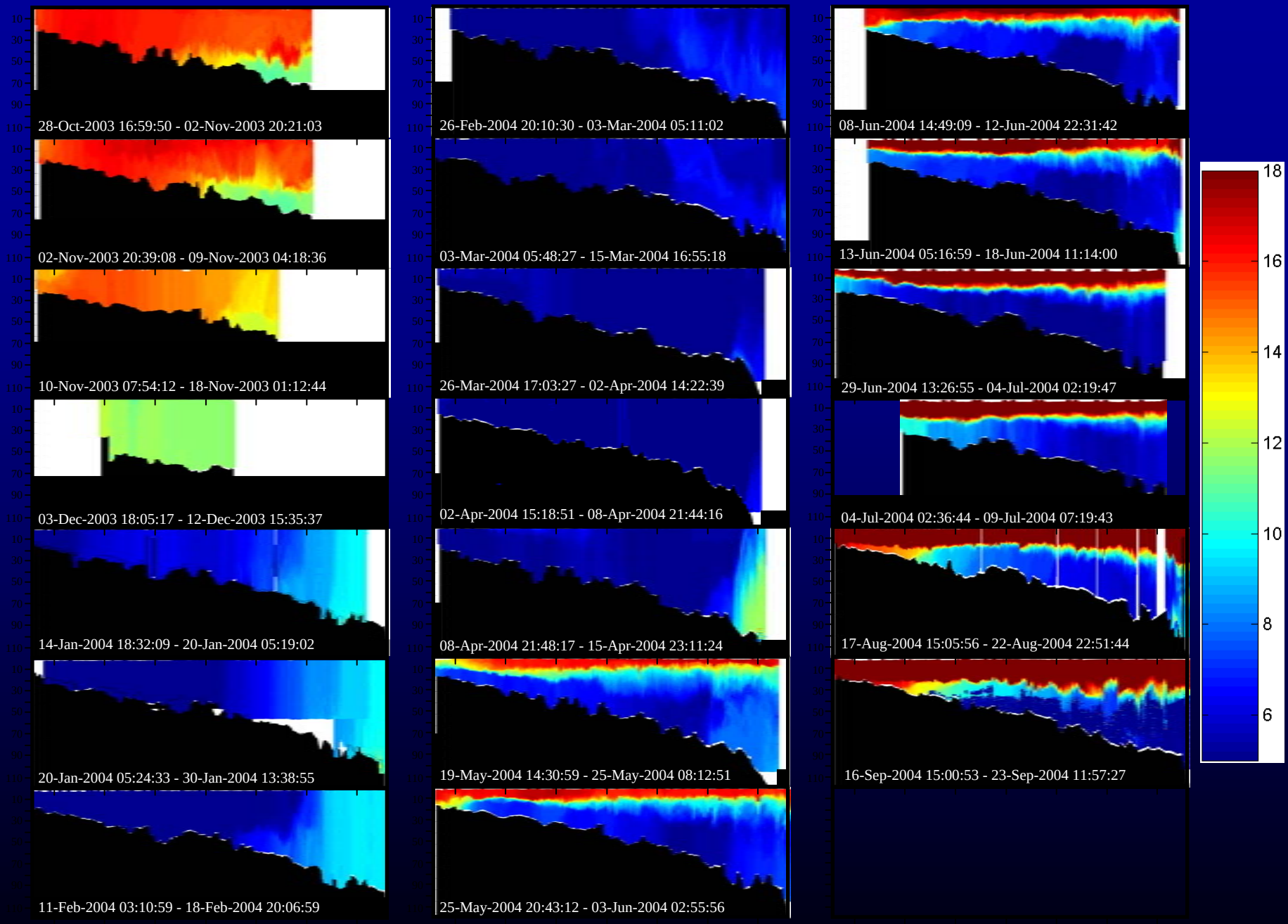


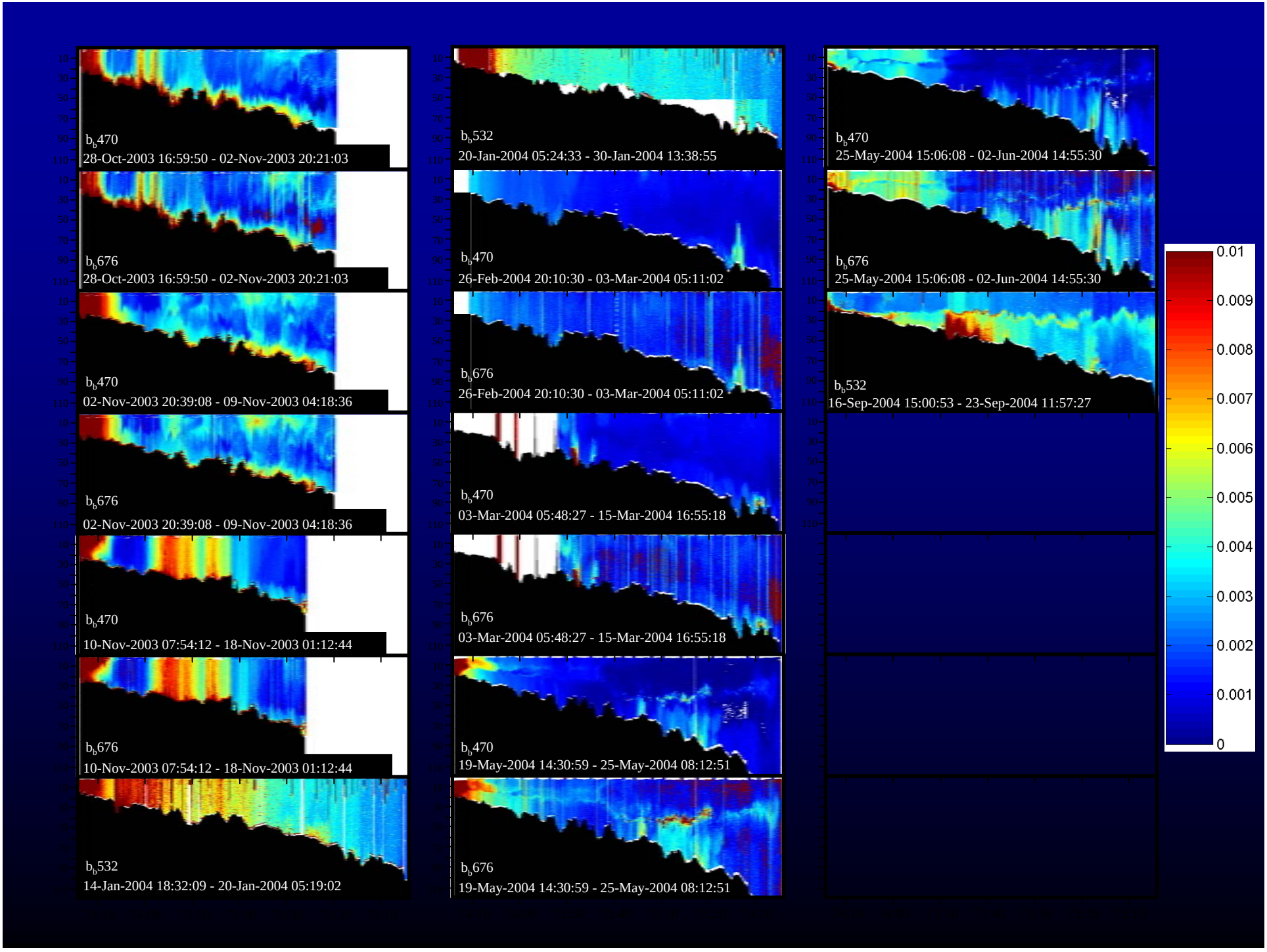
Cross-shelf Temperature Section: Shipboard vs. Glider AUV



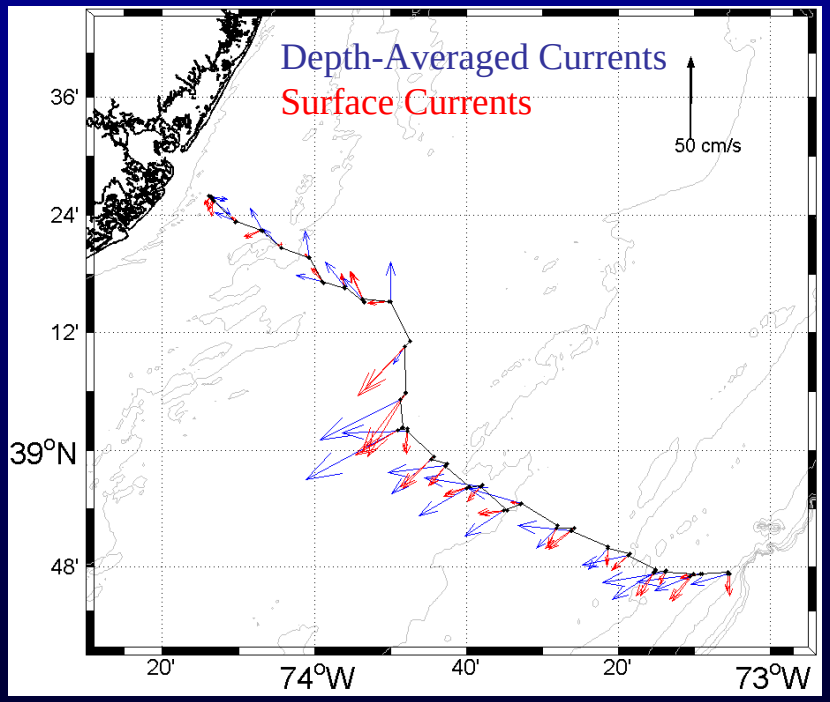


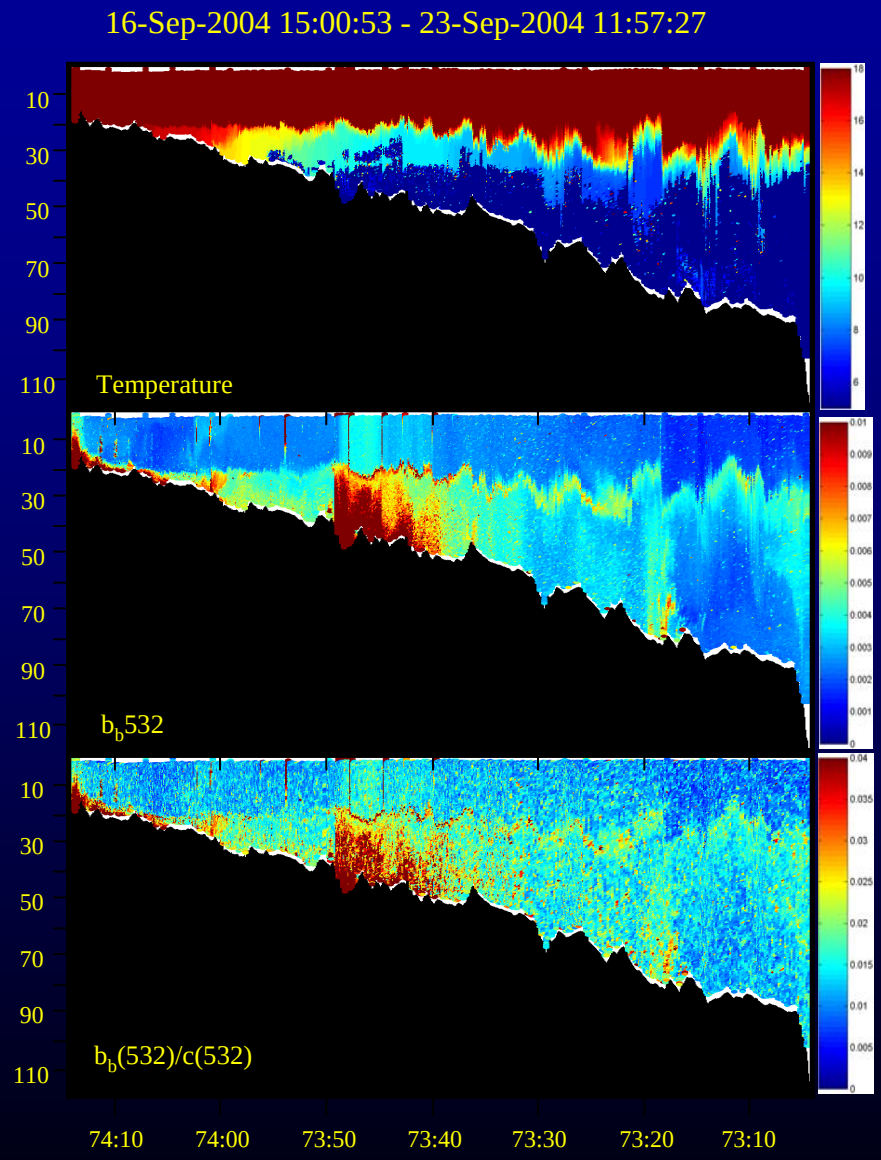
NJSOS Endurance Line: Seasonal Cross-Shelf Temperature Transects




b_b470
28-Oct-2003 16:59:50 - 02-Nov-2003 20:21:03
b_b676
28-Oct-2003 16:59:50 - 02-Nov-2003 20:21:03
b_b470
02-Nov-2003 20:39:08 - 09-Nov-2003 04:18:36
b_b676
02-Nov-2003 20:39:08 - 09-Nov-2003 04:18:36
b_b470
10-Nov-2003 07:54:12 - 18-Nov-2003 01:12:44
b_b676
10-Nov-2003 07:54:12 - 18-Nov-2003 01:12:44
b_b532
14-Jan-2004 18:32:09 - 20-Jan-2004 05:19:02
b_b532
20-Jan-2004 05:24:33 - 30-Jan-2004 13:38:55
b_b470
26-Feb-2004 20:10:30 - 03-Mar-2004 05:11:02
b_b676
26-Feb-2004 20:10:30 - 03-Mar-2004 05:11:02
b_b470
03-Mar-2004 05:48:27 - 15-Mar-2004 16:55:18
b_b676
03-Mar-2004 05:48:27 - 15-Mar-2004 16:55:18
b_b470
19-May-2004 14:30:59 - 25-May-2004 08:12:51
b_b676
19-May-2004 14:30:59 - 25-May-2004 08:12:51
b_b470
25-May-2004 15:06:08 - 02-Jun-2004 14:55:30
b_b676
25-May-2004 15:06:08 - 02-Jun-2004 14:55:30
b_b532
16-Sep-2004 15:00:53 - 23-Sep-2004 11:57:27
0.01
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0

RIDER IN THE STORM



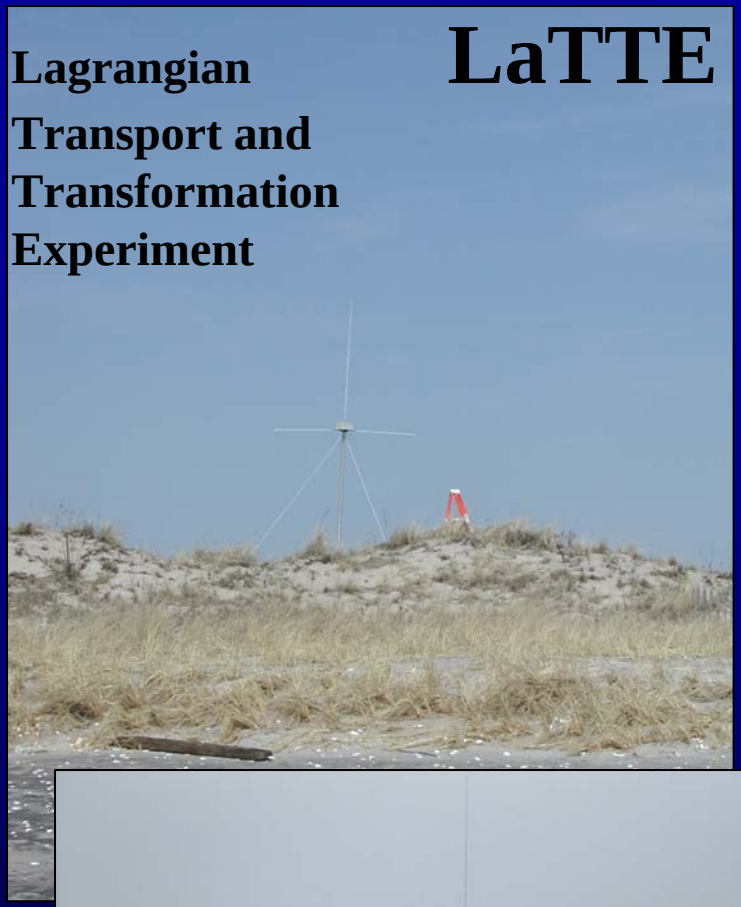


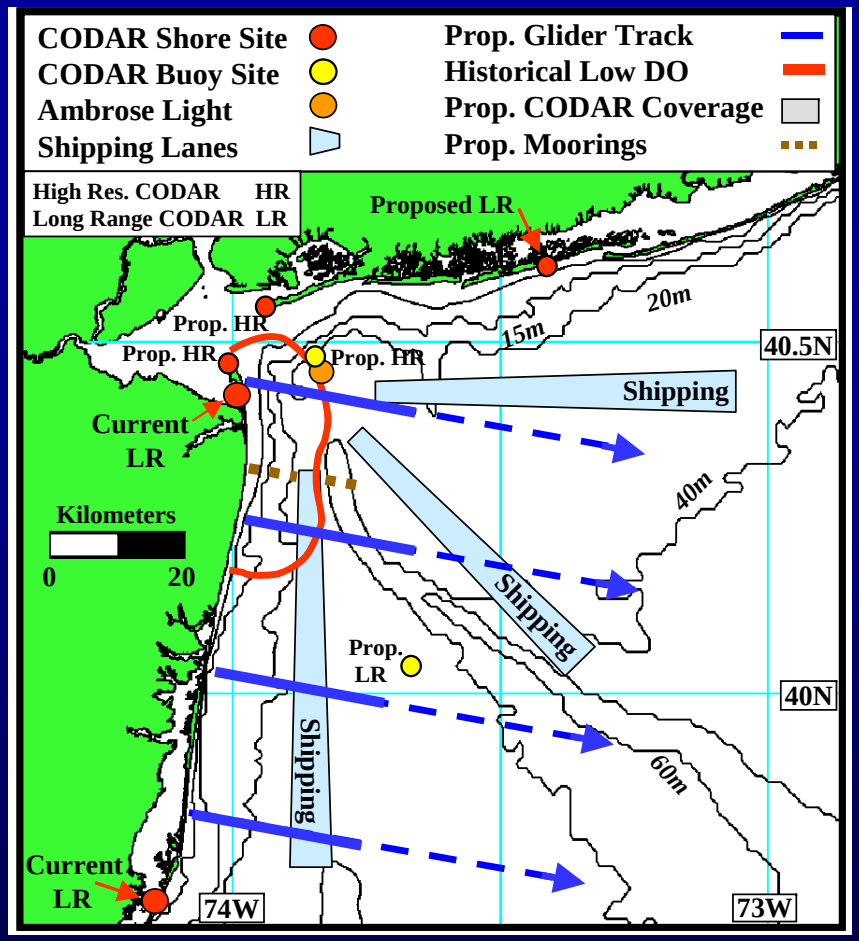
PLUME TRACKING

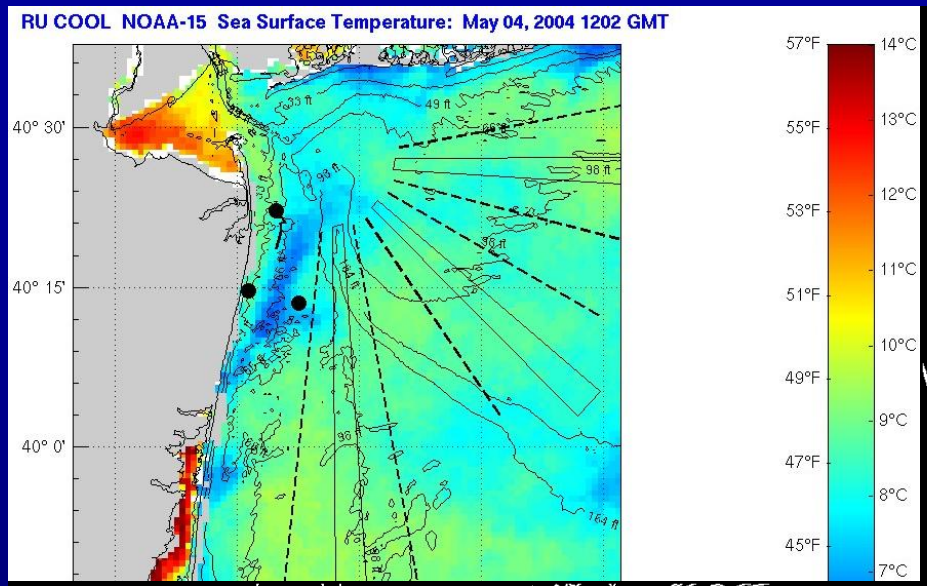
Plumes include freshwater rivers
& pollution slicks
& humans

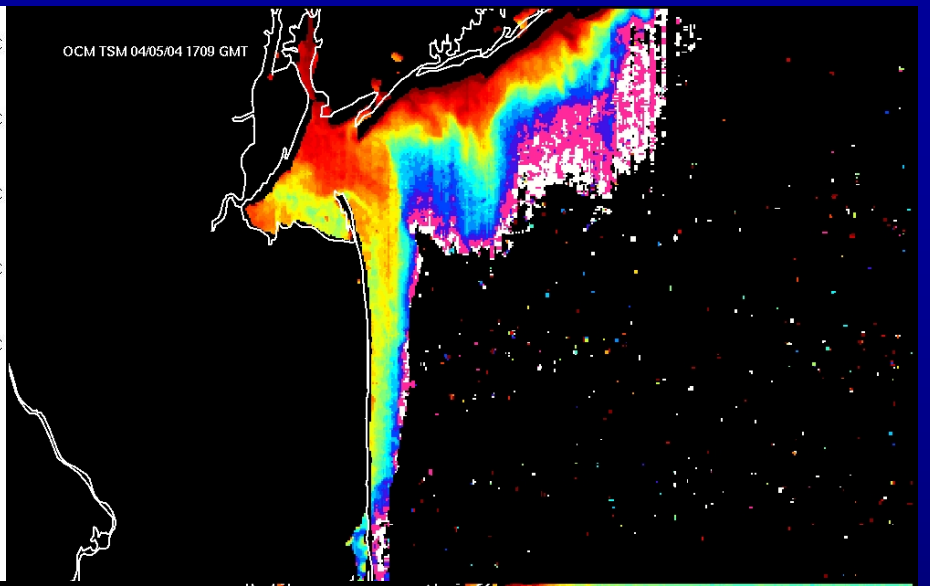
LaTTE

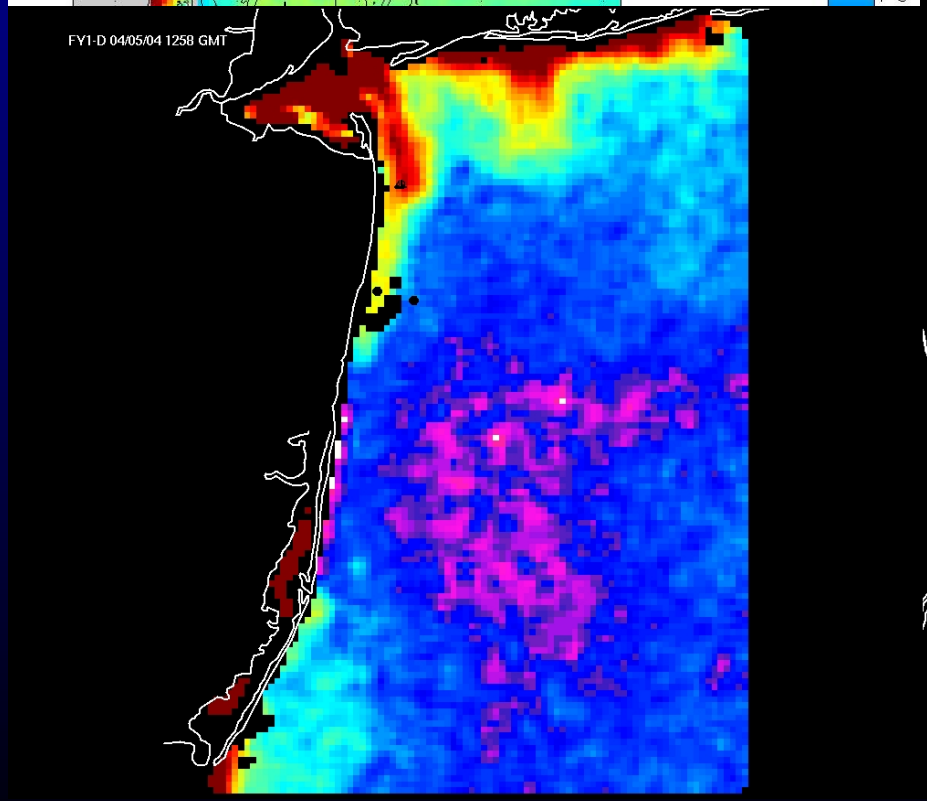
Lagrangian Transport and Transformation Experiment

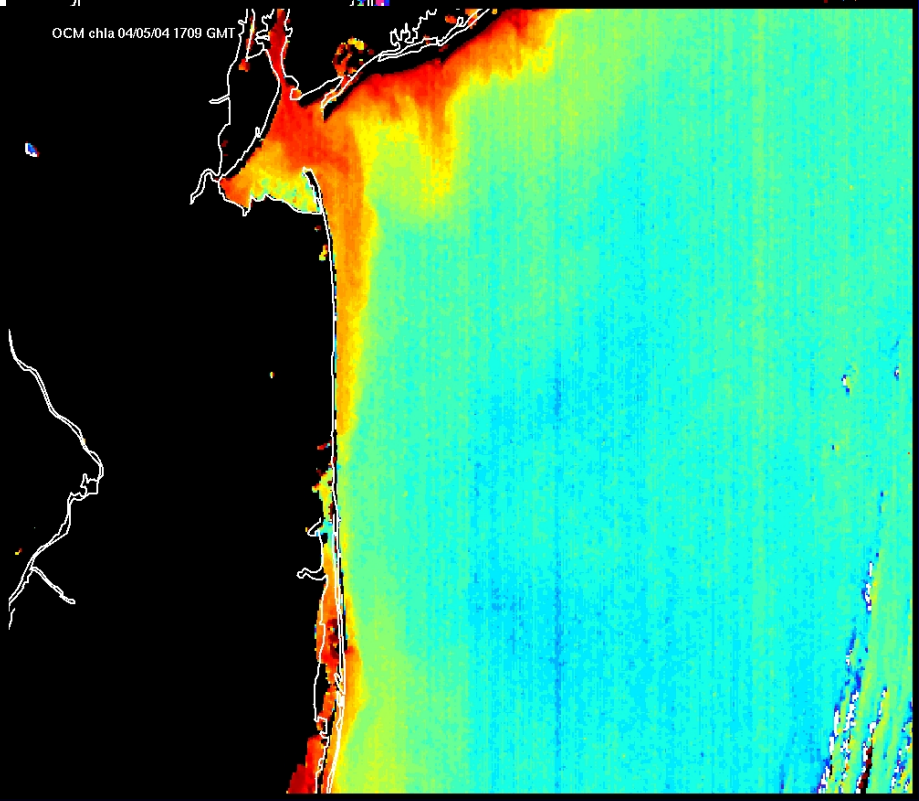


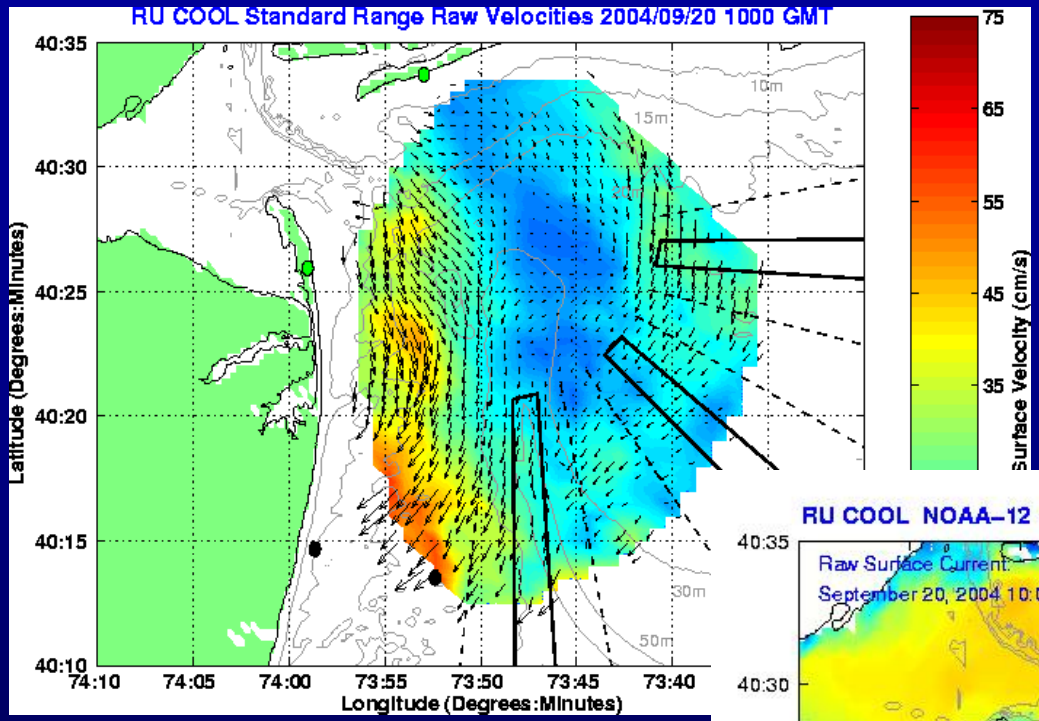


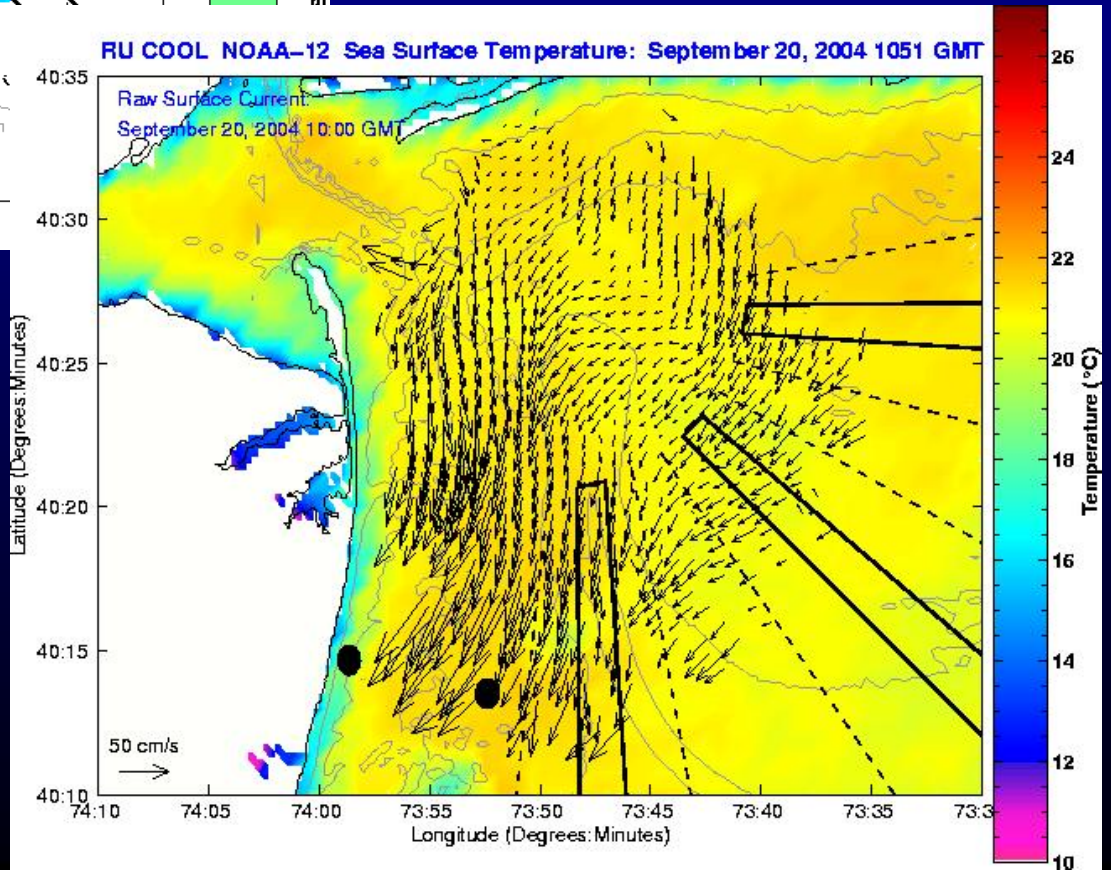

RU COOL NOAA-15 Sea Surface Temperature: May 04, 2004 1202 GMT
40° 30'
40° 15'
40° 0'
57°F
55°F
53°F
51°F
49°F
47°F
45°F
14°C
13°C
12°C
11°C
10°C
9°C
8°C
7°C


OCM TSM 04/05/04 1709 GMT


FY1-D 04/05/04 1258 GMT


OCM chla 04/05/04 1709 GMT

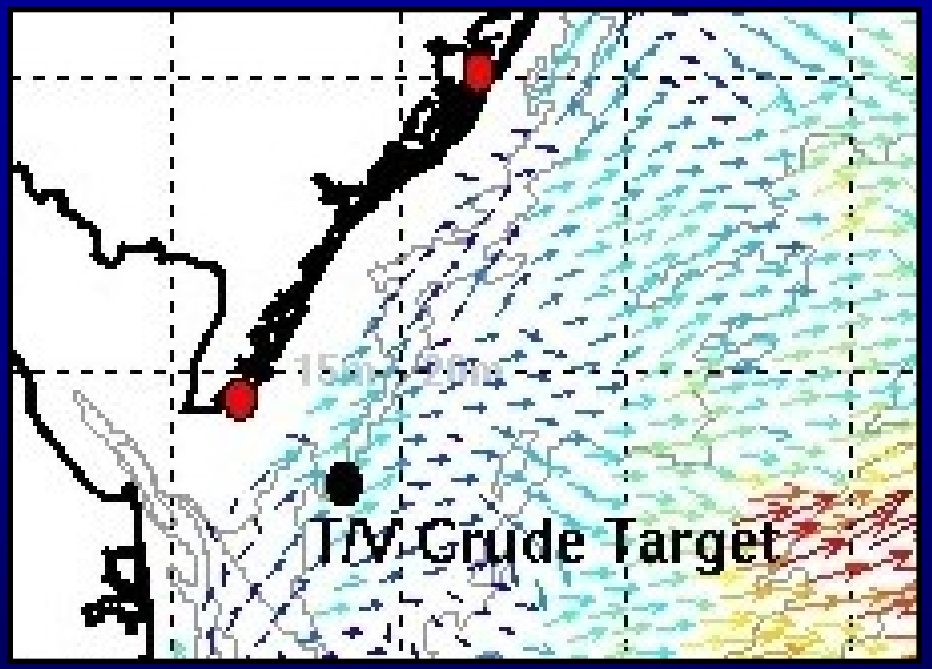

RU COOL Standard Range Raw Velocities 2004/09/20 1000 GMT
Latitude (Degrees:Minutes)
Longitude (Degrees:Minutes)
Surface Velocity (cm/s)
10m
15m
30m
50m
40:35
40:30
40:25
40:20
40:15
40:10
74:10
74:05
74:00
73:55
73:50
73:45
73:40
75
65
55
45
35


RU COOL NOAA–12 Sea Surface Temperature: September 20, 2004 1051 GMT
Raw Surface Current:
September 20, 2004 10:00 GMT
50 cm/s
Latitude (Degrees:Minutes)
Longitude (Degrees:Minutes)
Temperature (°C)
40:35
40:30
40:25
40:20
40:15
40:10
74:10
74:05
74:00
73:55
73:50
73:45
73:40
73:35
26
24
22
20
18
16
14
12
10

Tanker runs aground off Cape May, NJ

At approximately 0715 EDT the T/V CRUDE TARGET grounded while enroute into Delaware Bay. The position of the ship is 38:48.5 N / 074:37.3 W or approximately 13 miles ESE of Cape May, NJ. The ship is carrying **42 million gallons** of West African Crude

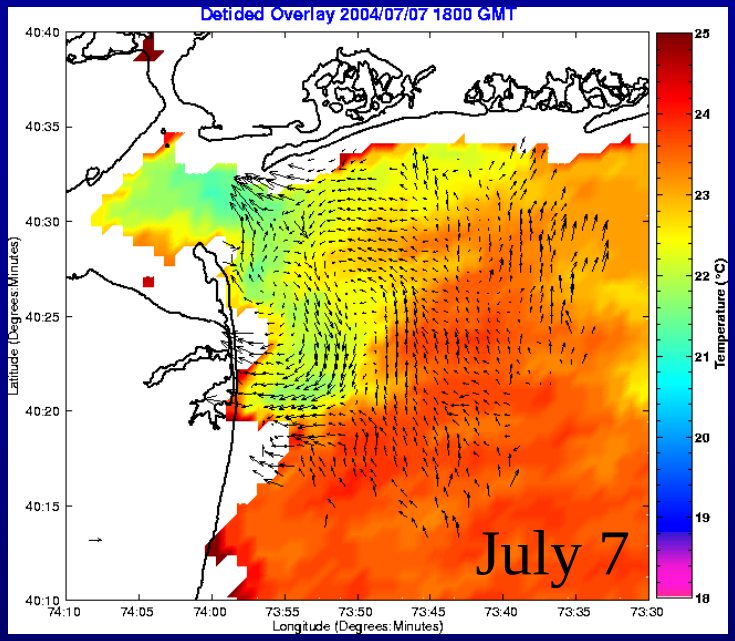
For comparison, the Exxon Valdez spilled about **11 million gallons** of the 53 million gallons of crude oil it was carrying

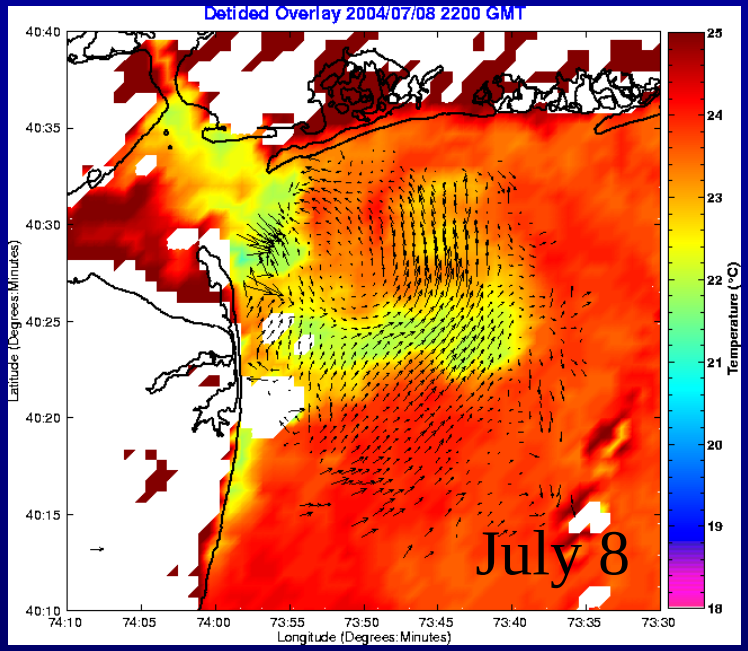


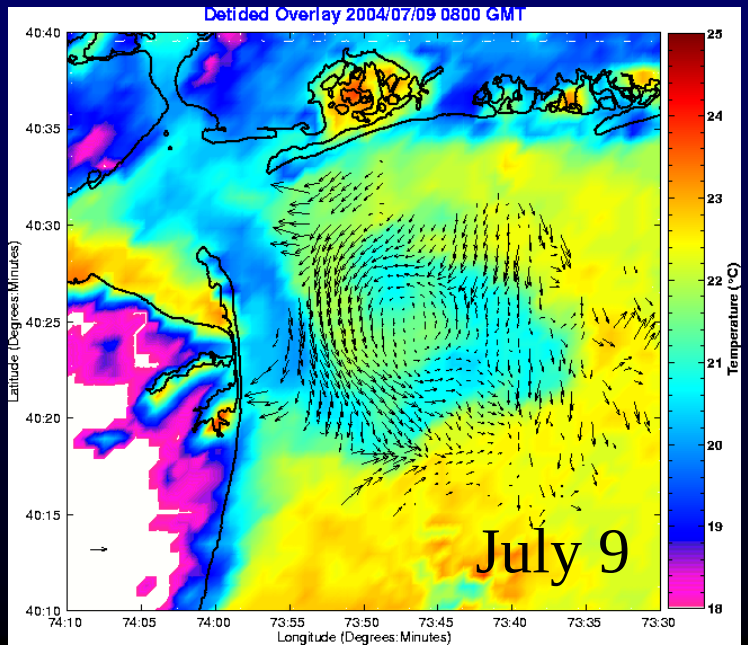
"For this particular incident, we went to the Rutgers CODAR site, to help with the calibration. The web site provided not only data but valuable analysis on the data. Through a phone number provided on the web site I also contacted Josh Kohut who was very helpful in providing additional information concerning the real-time data as well as personal observations of how the coastal currents typically behave off the New Jersey coastline."

- Glen Watabayashi
Oceanographer (NOAA/OP&R/HAZMAT)

Tracking the July 2004 Trash Spill

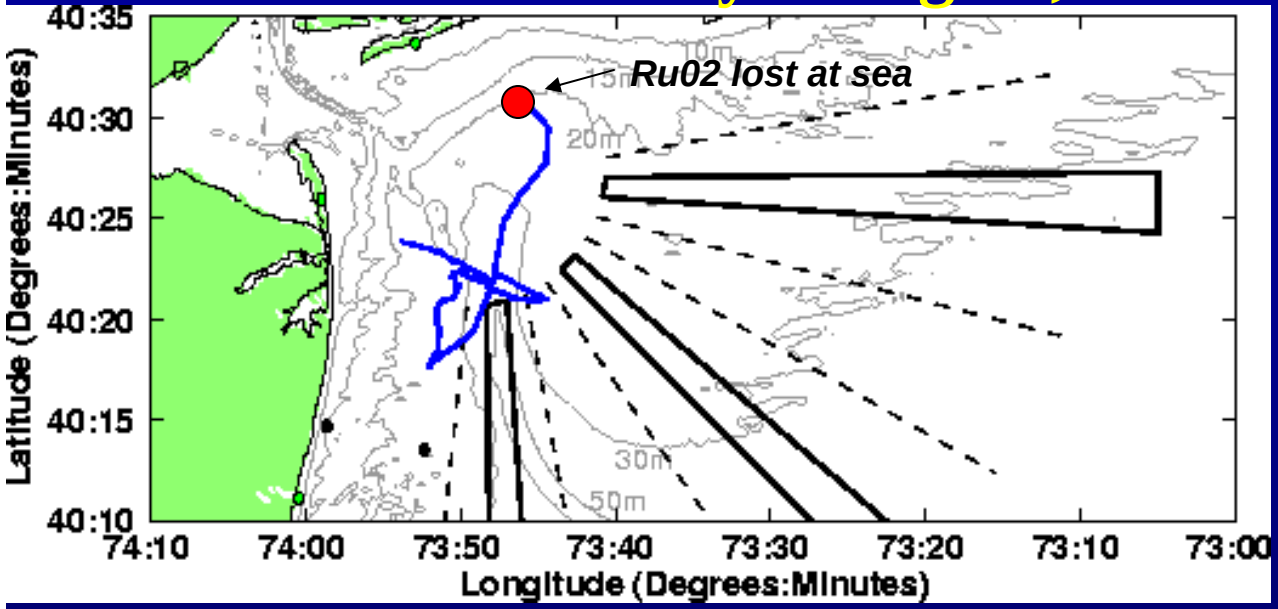


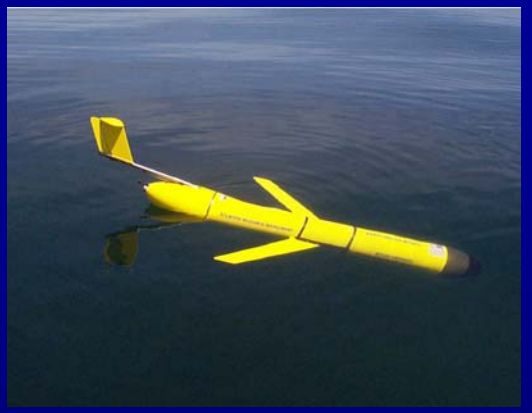




A line of floating trash was observed on a straight line Extending due east from the beach at the base of Sandy Hook for 10's of kilometers offshore

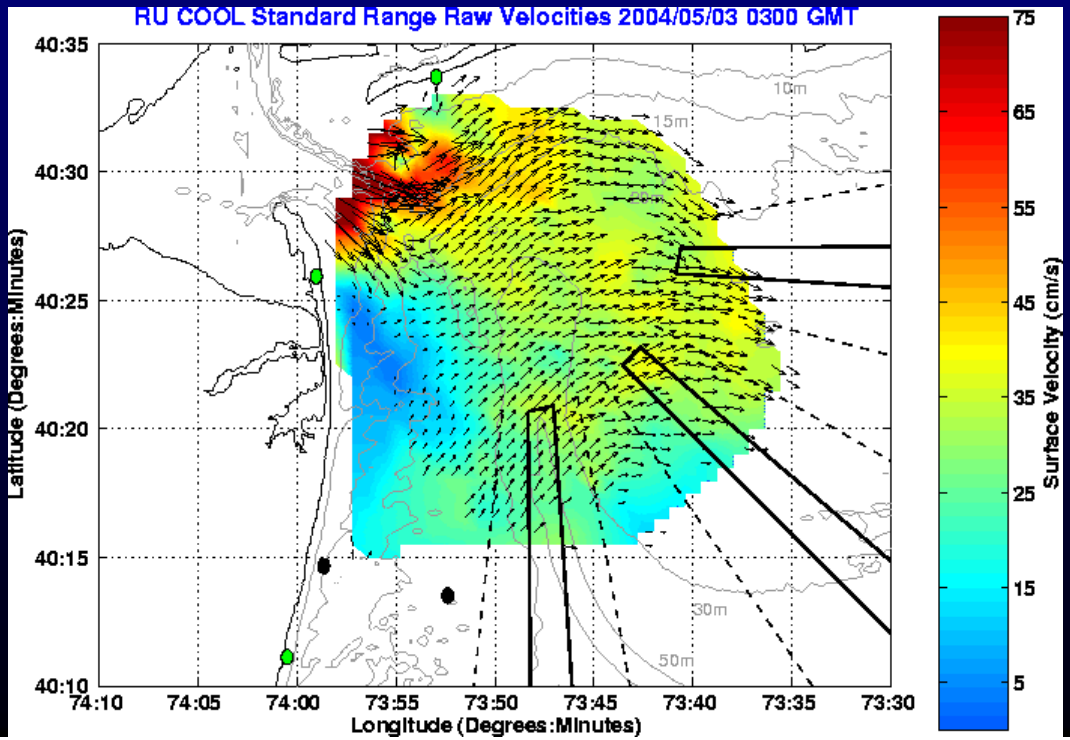
Lost Glider Recovery: Rutgers, USCG, Civil Air Patrol



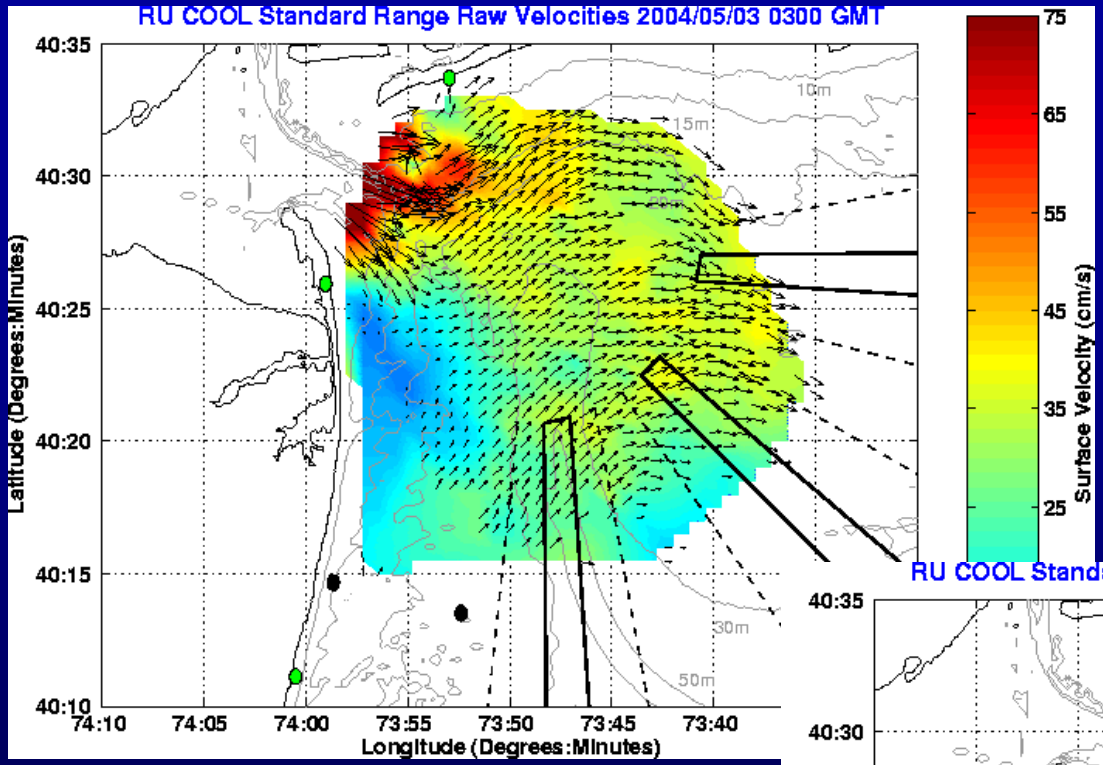


The wind switches to a more upwelling favorable direction and glider ru02 is retasked to head up toward the freshwater outflow.

During the mission, the glider looses communication with mission control and begins to drift.



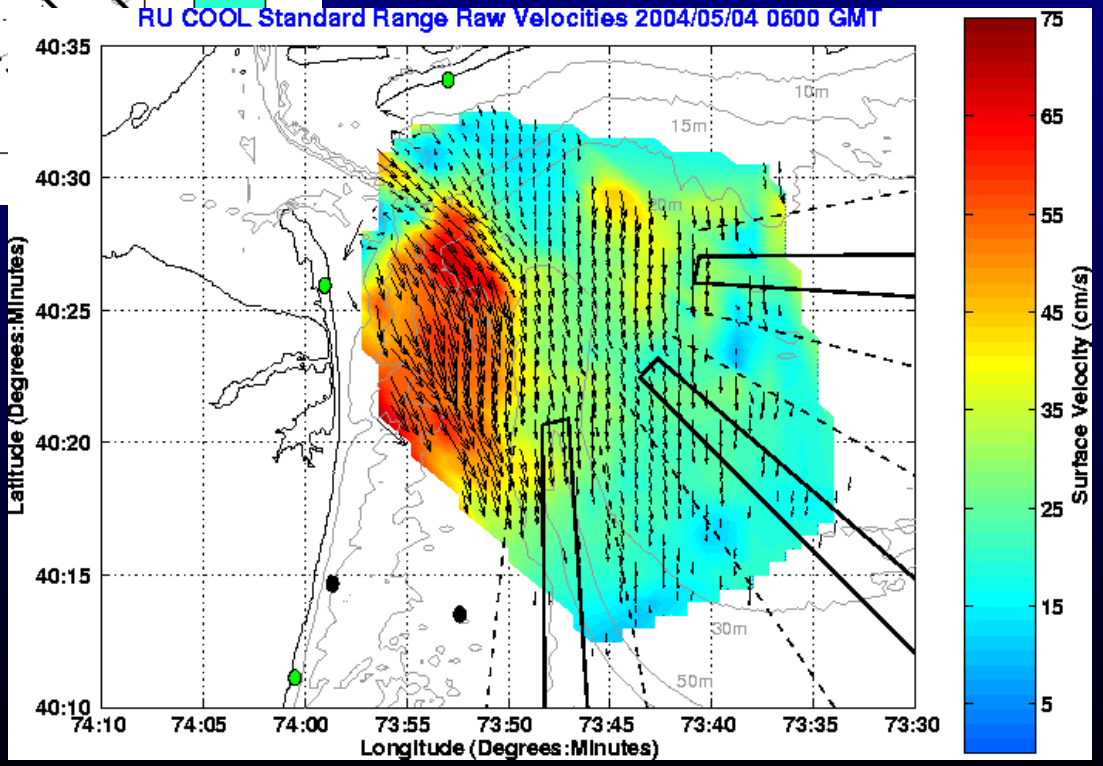
Lost Glider Recovery: Rutgers, USCG, Civil Air Patrol



Upwelling favorable

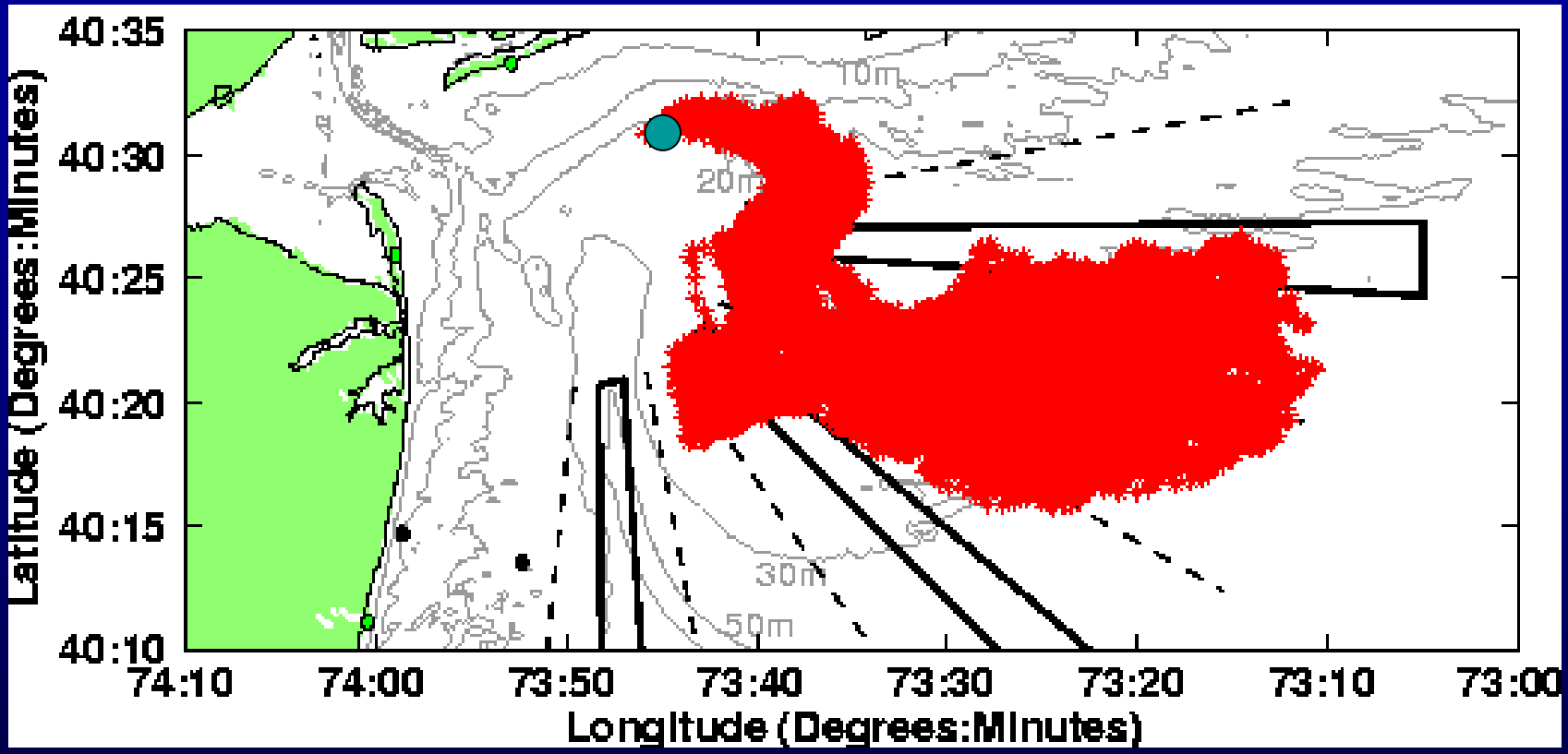
The days following the last glider communication, the wind and currents oscillated between upwelling and downwelling conditions

Downwelling favorable



Lost Glider Recovery: Rutgers, USCG, Civil Air Patrol

20 virtual drifters released to simulate the potential location of ru02



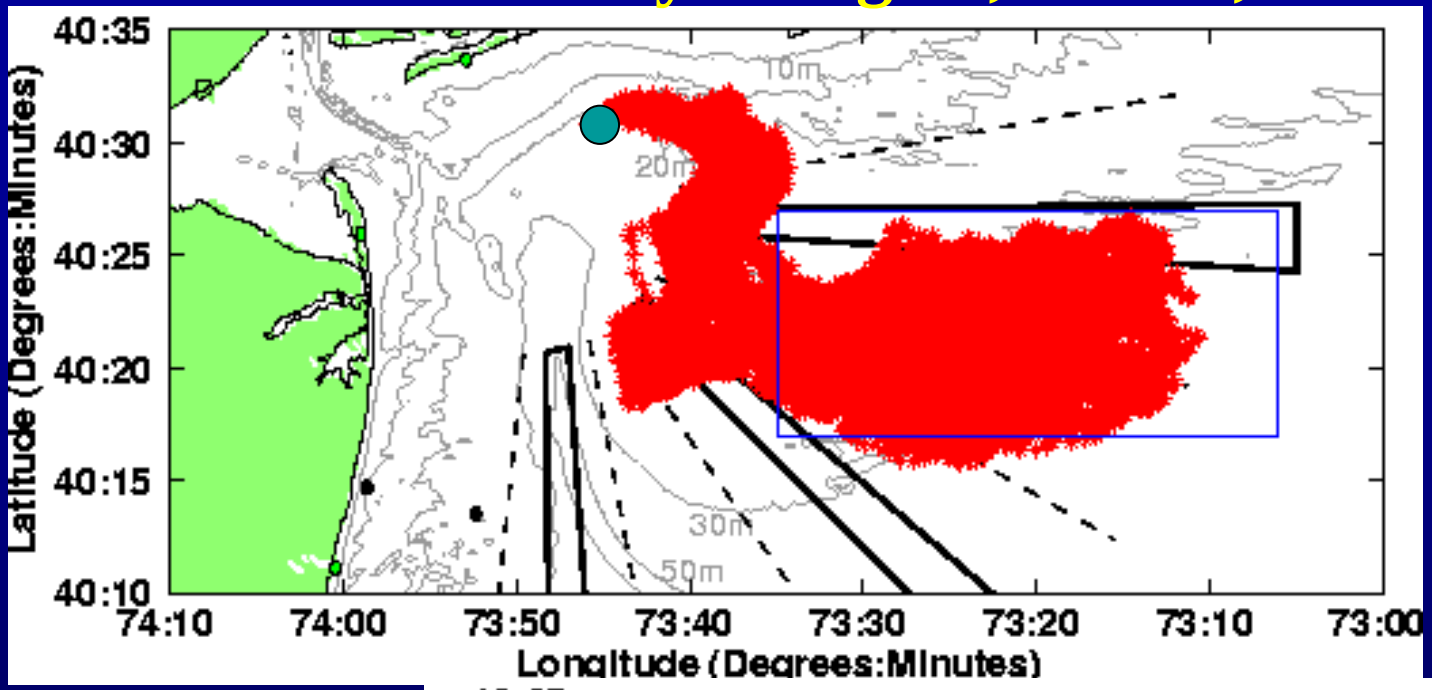
$$d = v\,t$$

d = distance traveled during each time step

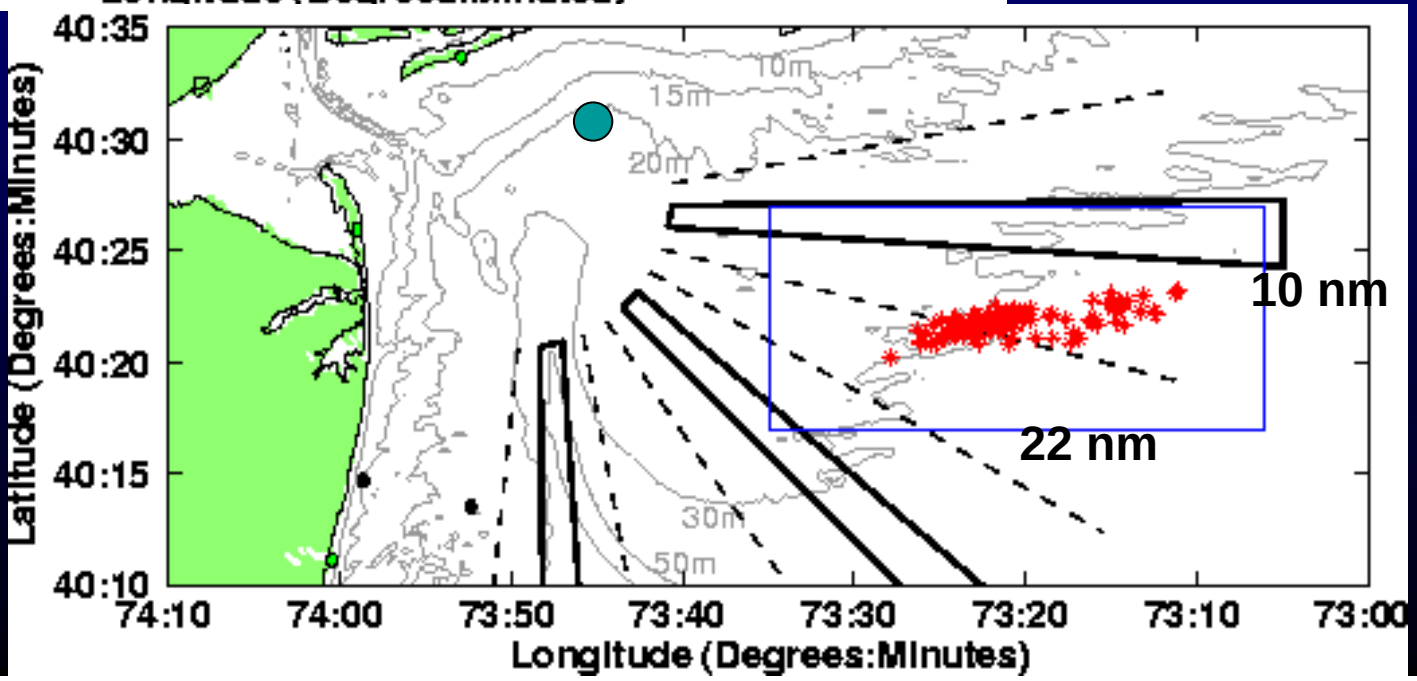
v = surface velocity of closest CODAR grid point (+/- 5 cm/s)

t = 1 hour (time sampling of the CODAR system)

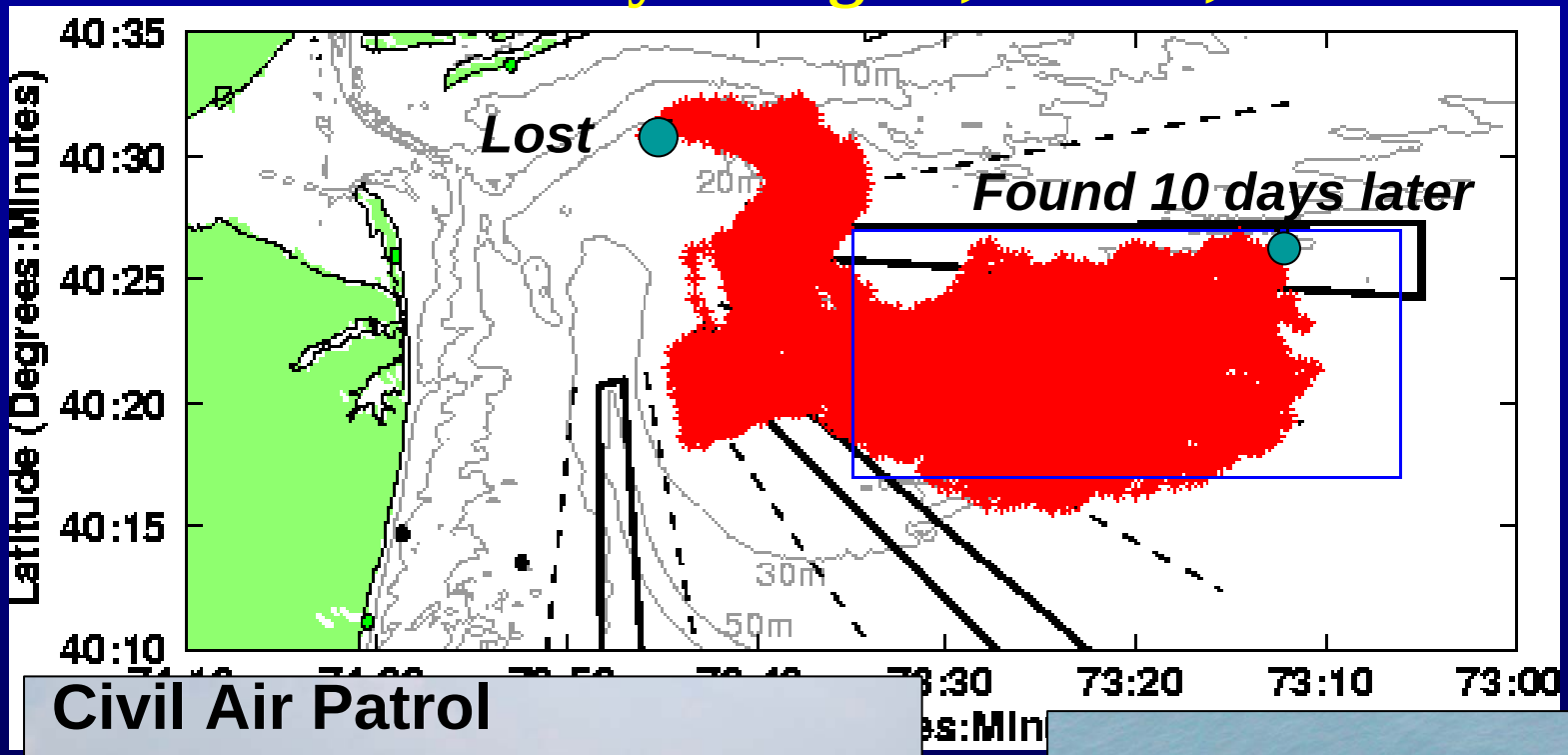
Lost Glider Recovery: Rutgers, USCG, Civil Air Patrol

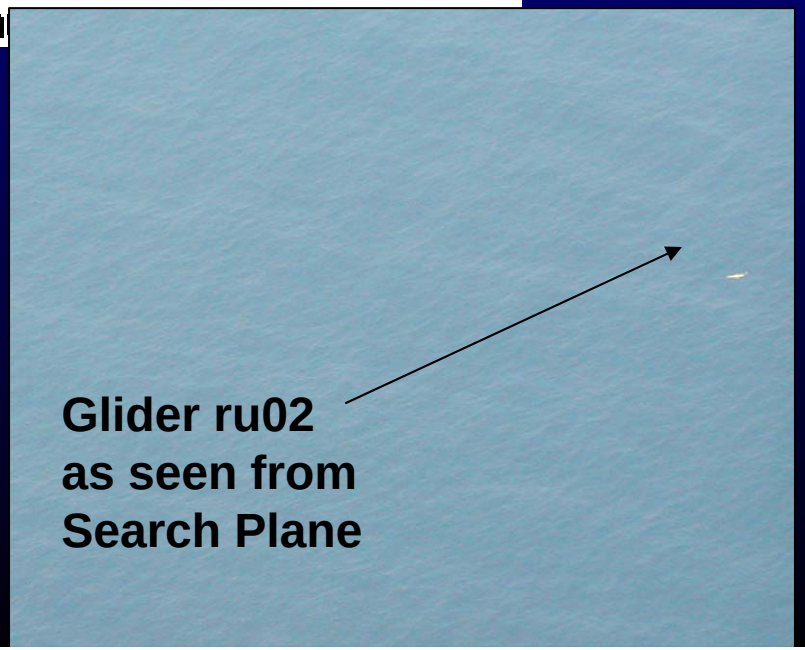


A search area is defined for the glider's probable location 10 days after communication is lost

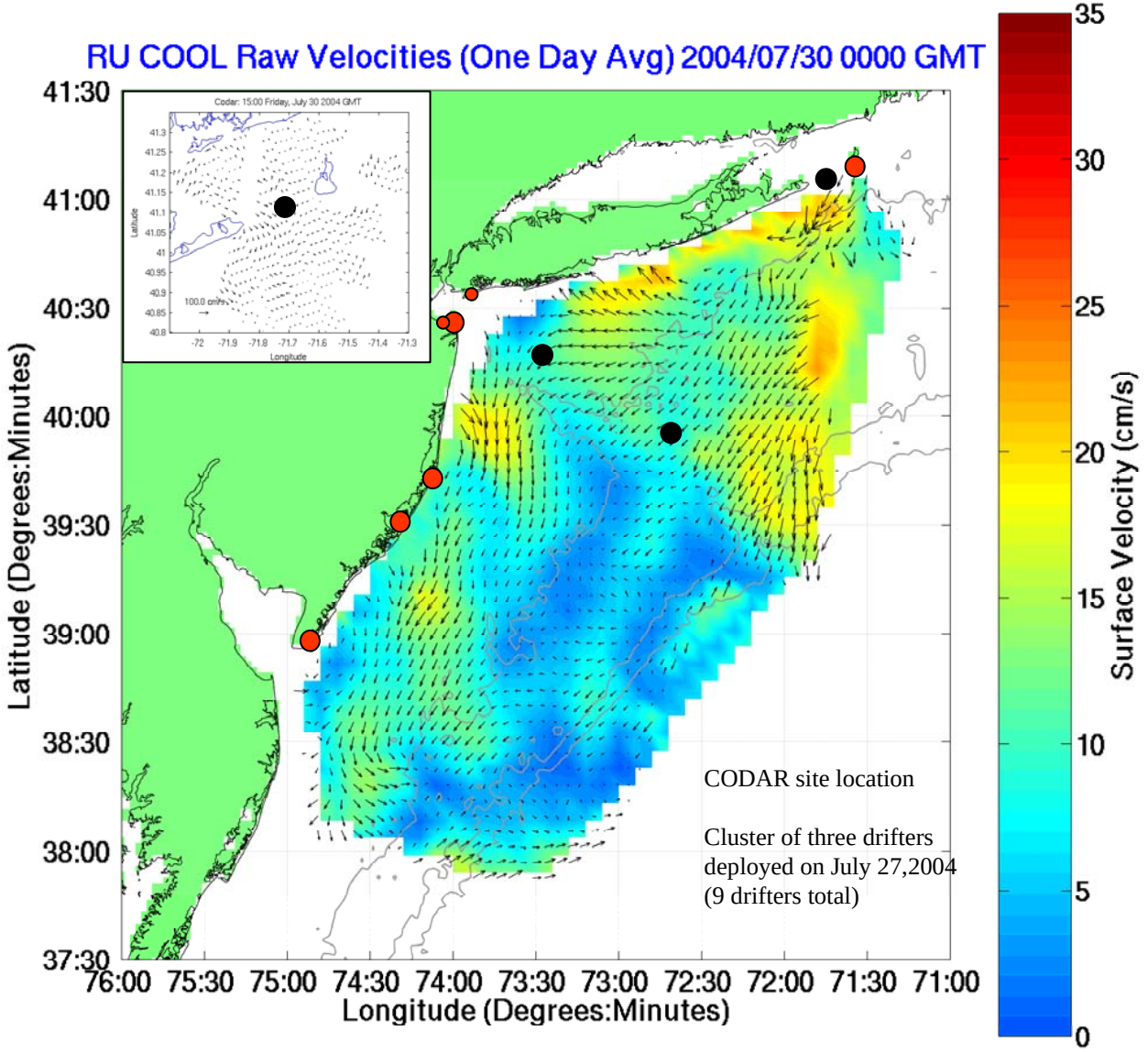


Lost Glider Recovery: Rutgers, USCG, Civil Air Patrol





Integration of Coastal Ocean Dynamic Application Radar (CODAR) surface current data and Short term Predictive System (STPS) into the Search and Rescue Optimal Planning System (SAROPS)



RESEARCH & DEVELOPMENT CENTER
UNITED STATES COAST GUARD

University of Connecticut
Marine Sciences

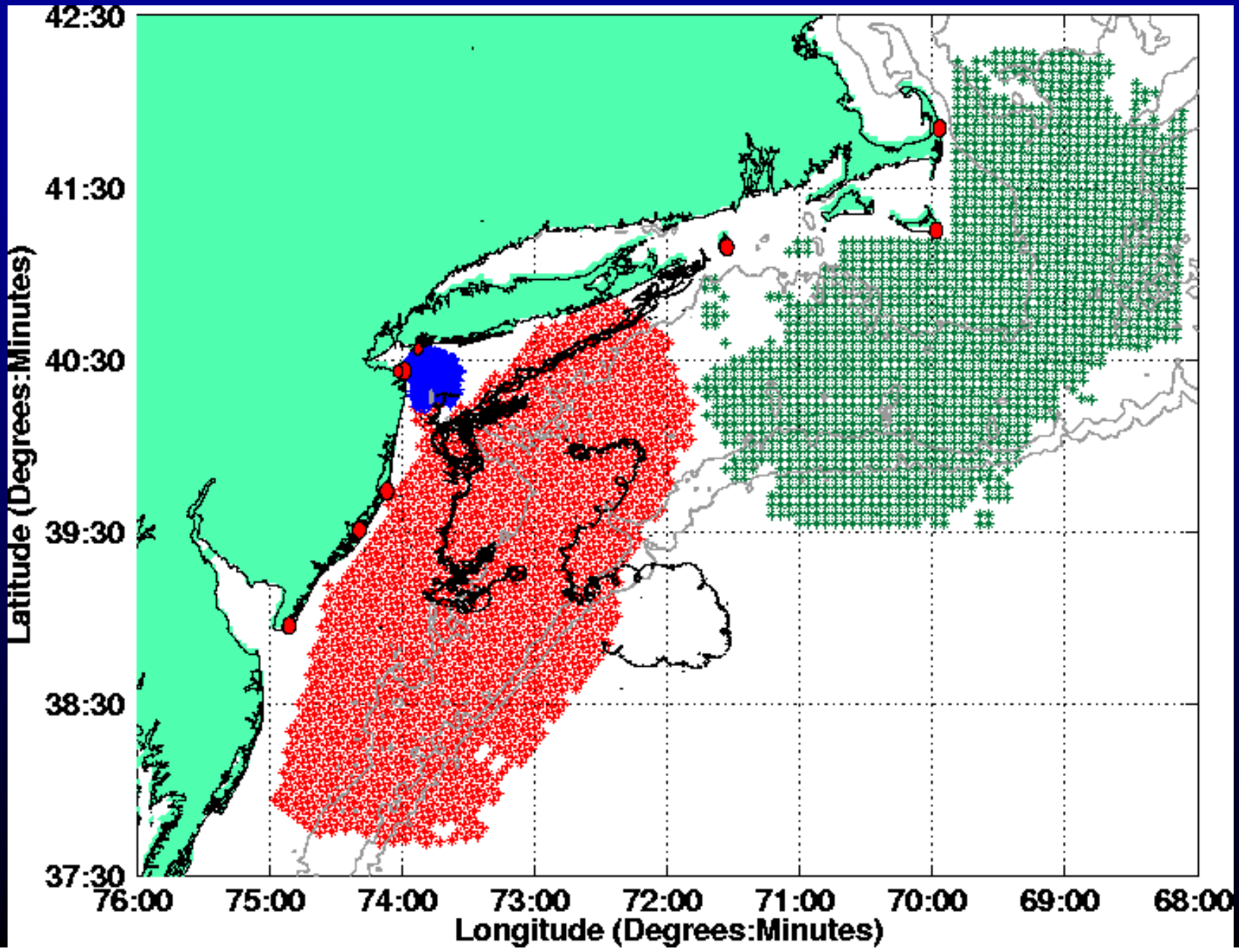
Graduate School of Oceanography
UNIVERSITY OF RHODE ISLAND

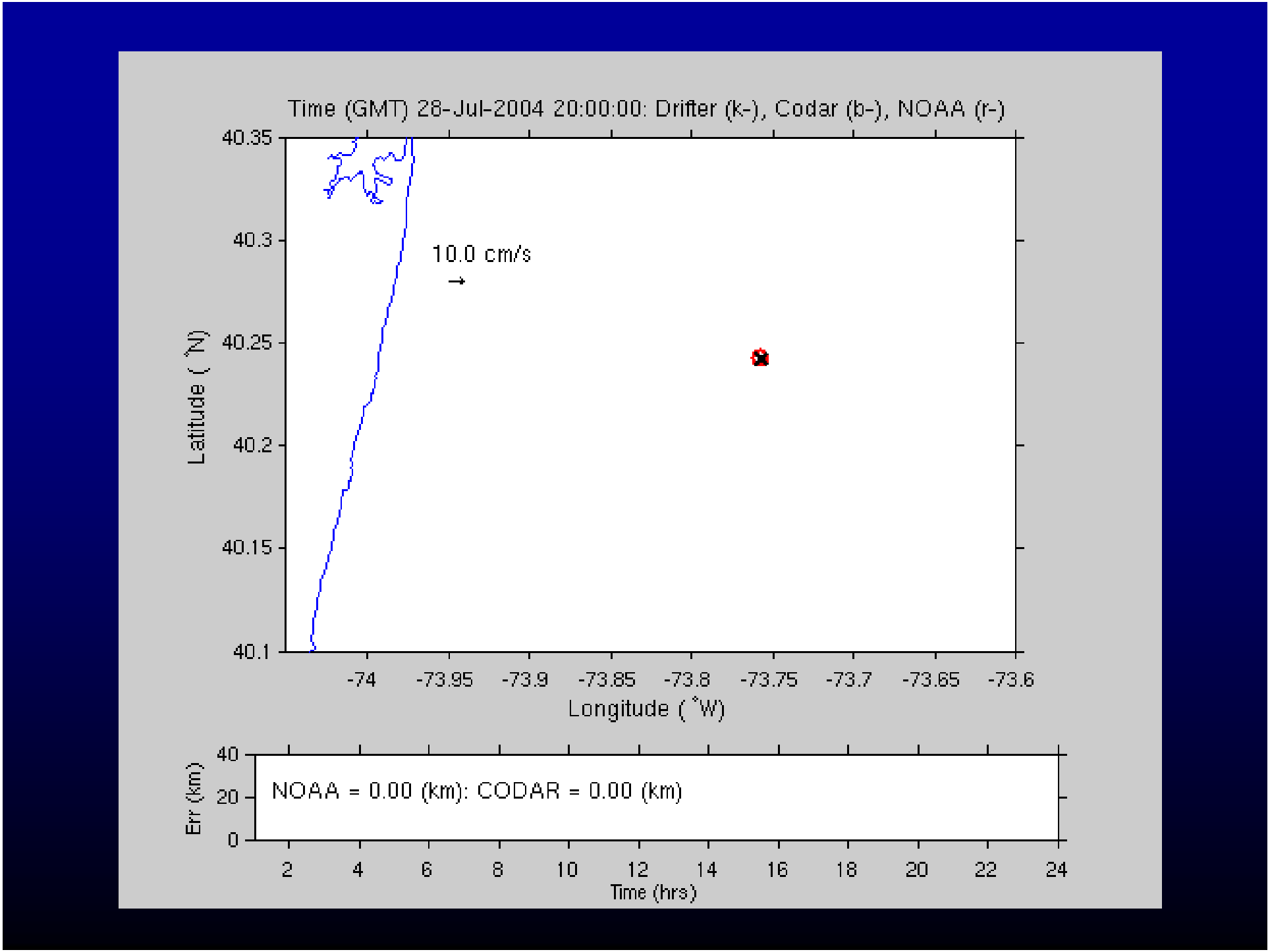
APPLIED SCIENCE ASSOCIATES, INC.

RUTGERS
MARINE & COASTAL SCIENCES

Anteon

Coast Guard Drifter Trajectories (July 27, 2004 - August 23, 2004)




Time (GMT) 28-Jul-2004 20:00:00: Drifter (k-), Codar (b-), NOAA (r-)
10.0 cm/s
Latitude (°N)
40.35
40.3
40.25
40.2
40.15
40.1
-74
-73.95
-73.9
-73.85
-73.8
-73.75
-73.7
-73.65
-73.6
Longitude (°W)
Err (km)
40
20
0
NOAA = 0.00 (km): CODAR = 0.00 (km)
2
4
6
8
10
12
14
16
18
20
22
24
Time (hrs)

Energy, Pollution, & Prediction
Oceans & Sea breeze
(the coupling of models and observations)

Why do we care?

Energy policy:

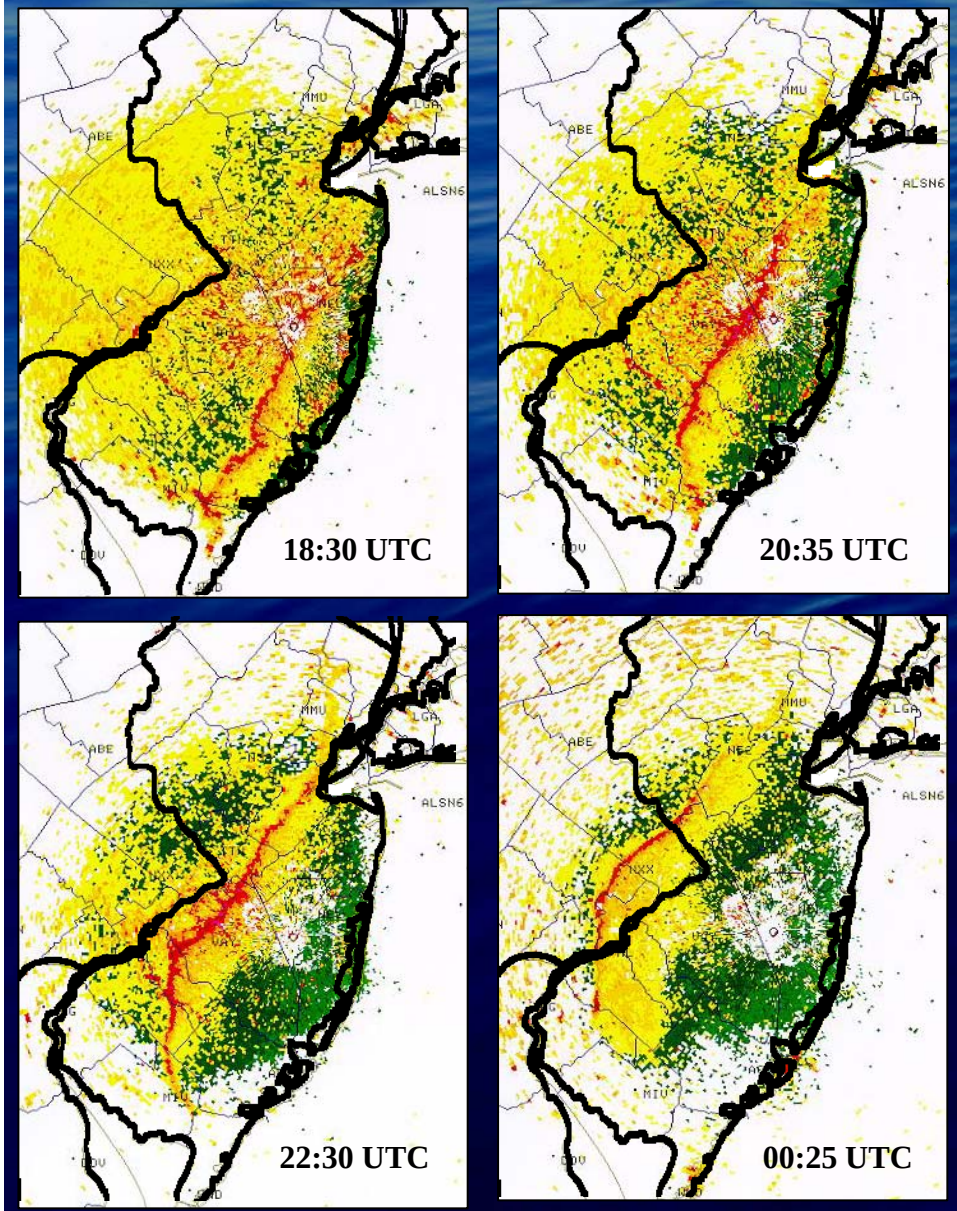
- Energy is bought by the power utilities in advance. You use the weather forecast to buy the energy you need tomorrow at cheap price (~$30/MWhr to ~$80/MWhr). If you need more on the day costs go up ($525/MWhr).

-If you buy too much power, you can't keep it, and you are hit with a pollution problem.

-So what regulates demand? The number of people and the presence of cool air. Where is this a big issue? NJ shore

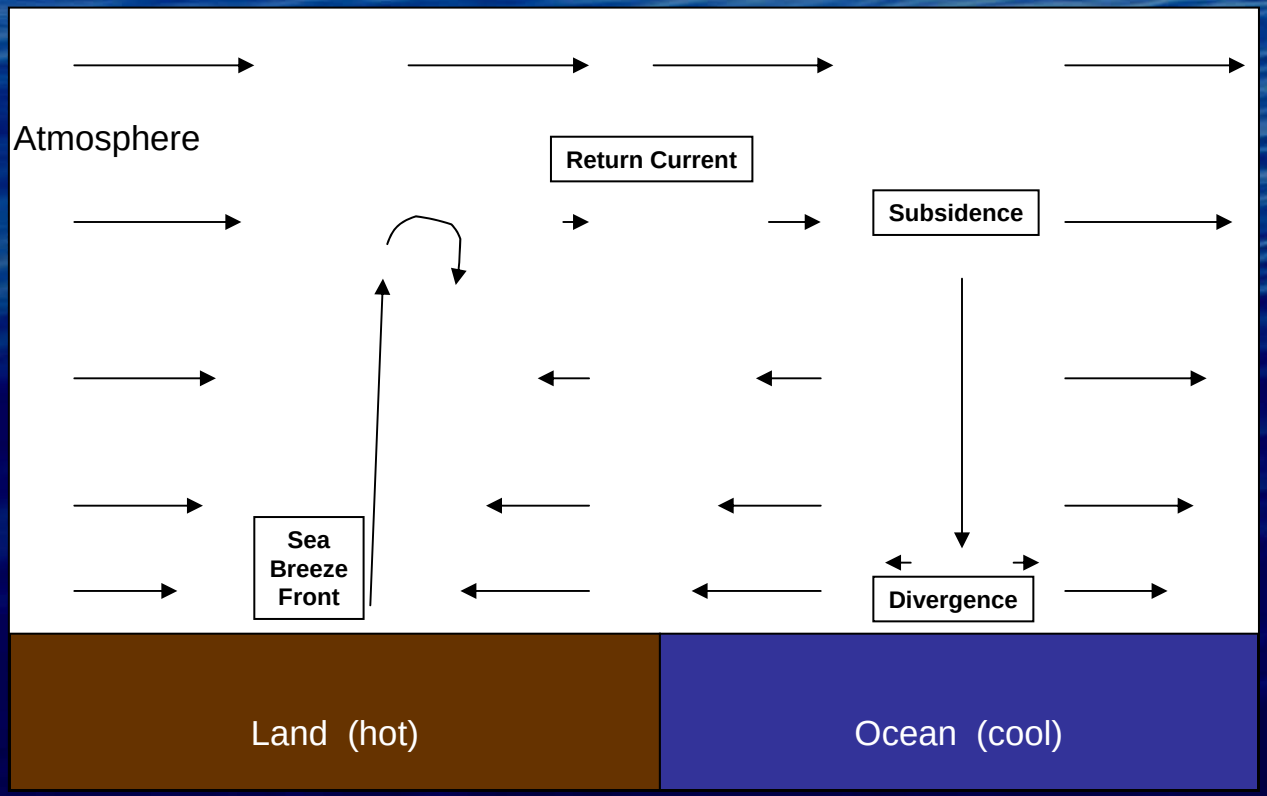
Who does the sea breeze affect?

Radar Reflectivity from Doppler radar



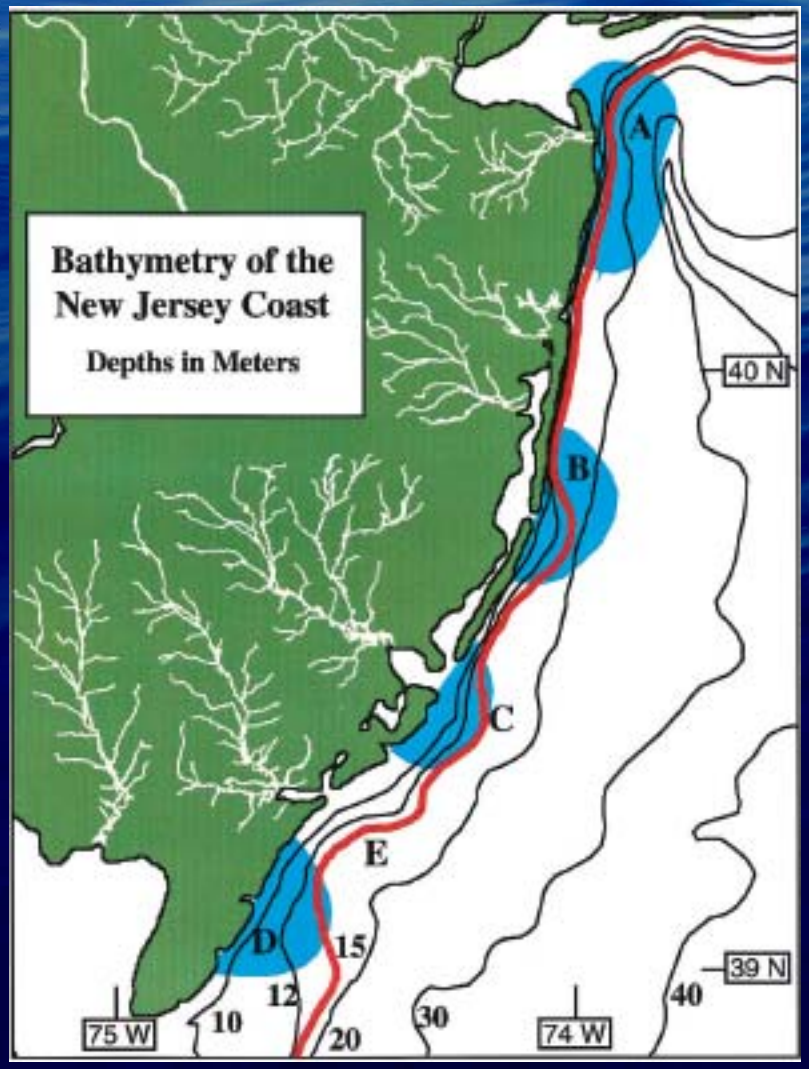
- Develops as a result of the land/sea temperature gradient
- Can occur during almost any month of the year
- Can affect almost all of New Jersey and into SE Pennsylvania

What is a sea breeze?



- Develops as a result of the land/sea temperature gradient

What is coastal upwelling?



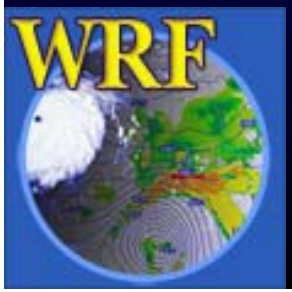
- Upwelling frequently occurs at four distinct upwelling centers along the NJ coast
- Upwelling centers occur near topographic highs in the bathymetry (Glenn et. al., 1996; Song et. al., 2001)
- Coastal ocean research, including the coastal upwelling phenomenon have taken place at LEO-15 offshore Tuckerton, NJ

Weather Research Forecast Model Coupled to the Ocean

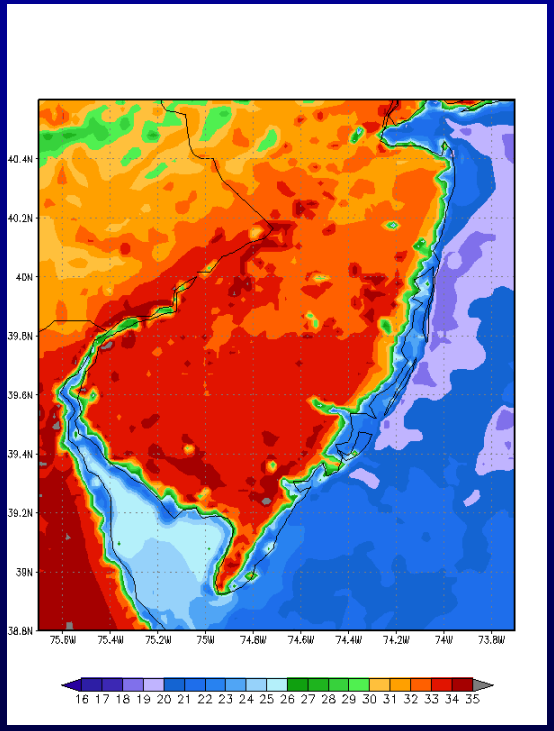
- Developed by NCAR/MMM and NOAA/FSL
- Released as community research model (2000)
- Developed for research and operational purposes
- Operational-test phase NWS model late 2004
- Intended full operational use by 2007

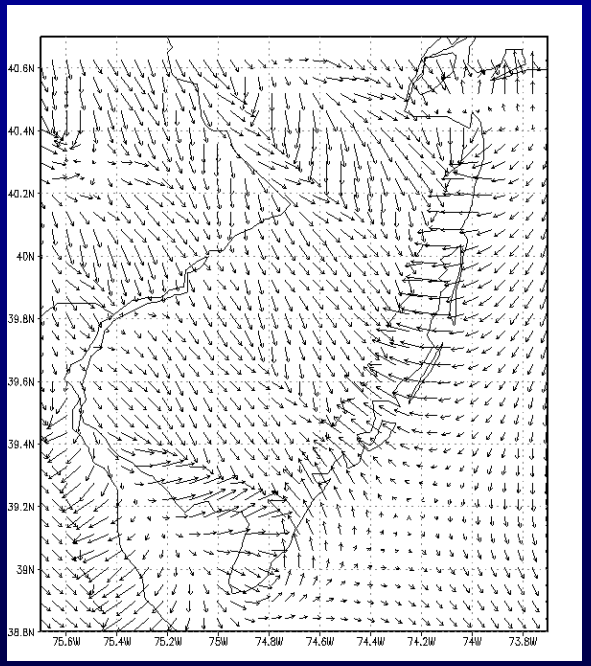
- Arakawa C-grid
- 3rd order Runge-Kutta Technique
- Mass-based terrain following coordinate

- Output as netcdf
- Model graphics displayed using the Grid Analysis and Display System (GrADS)



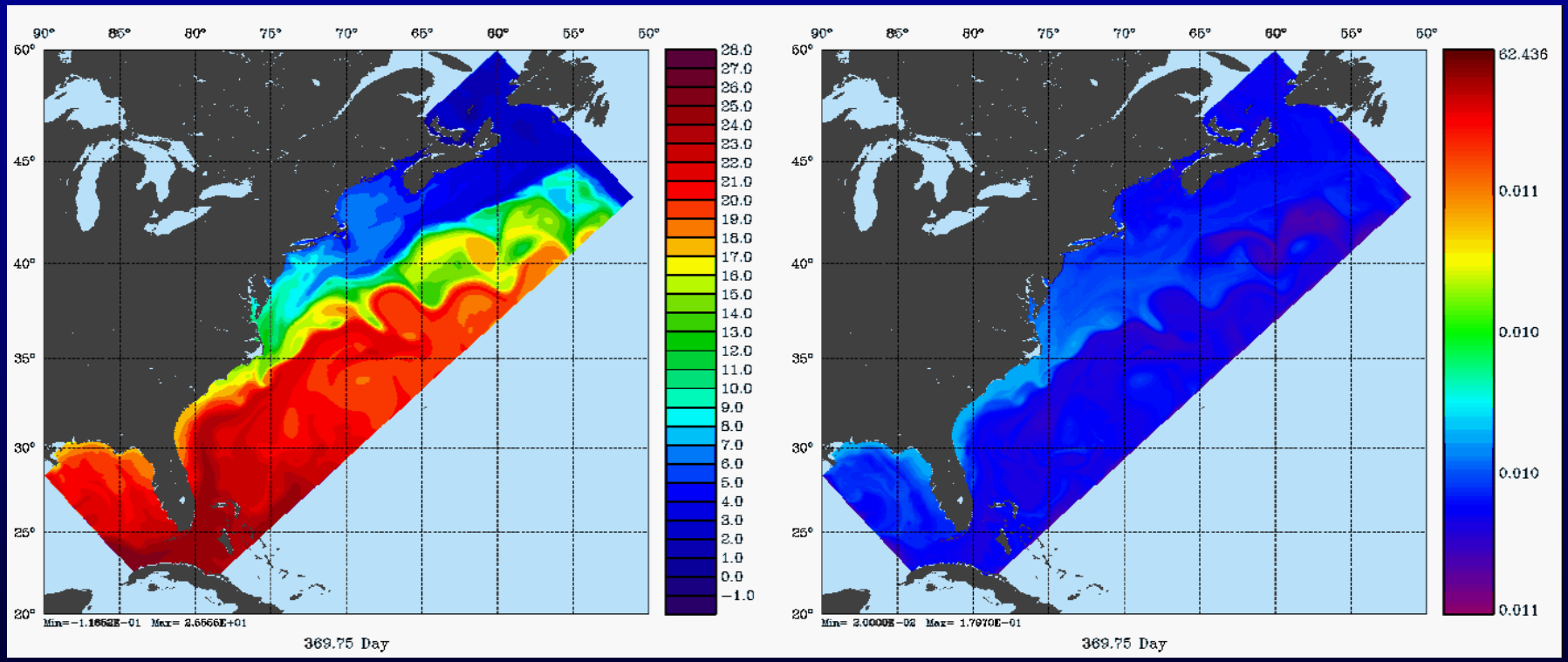
July 5 2004 SST



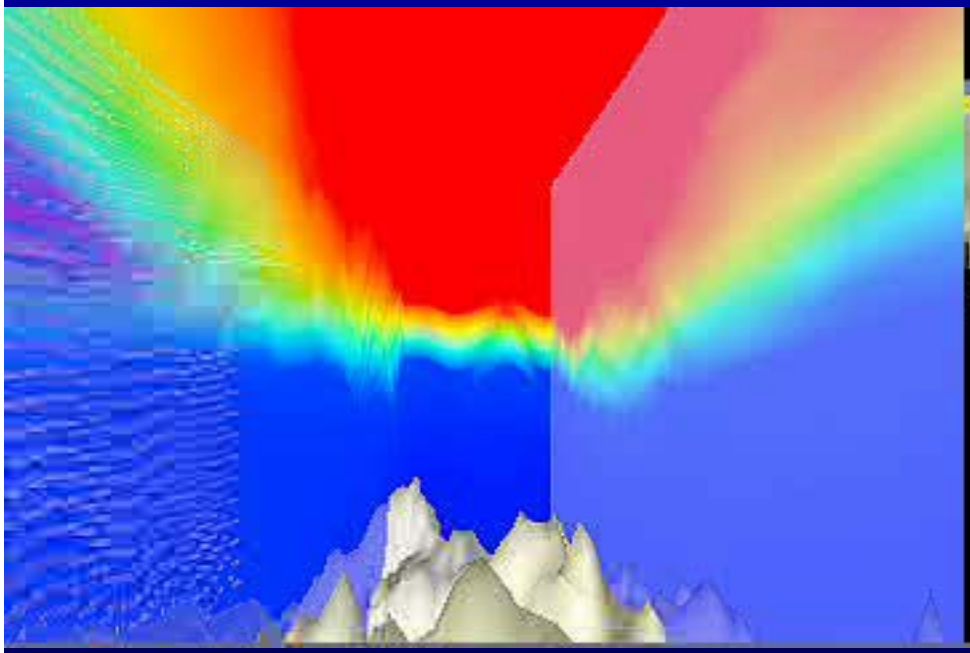
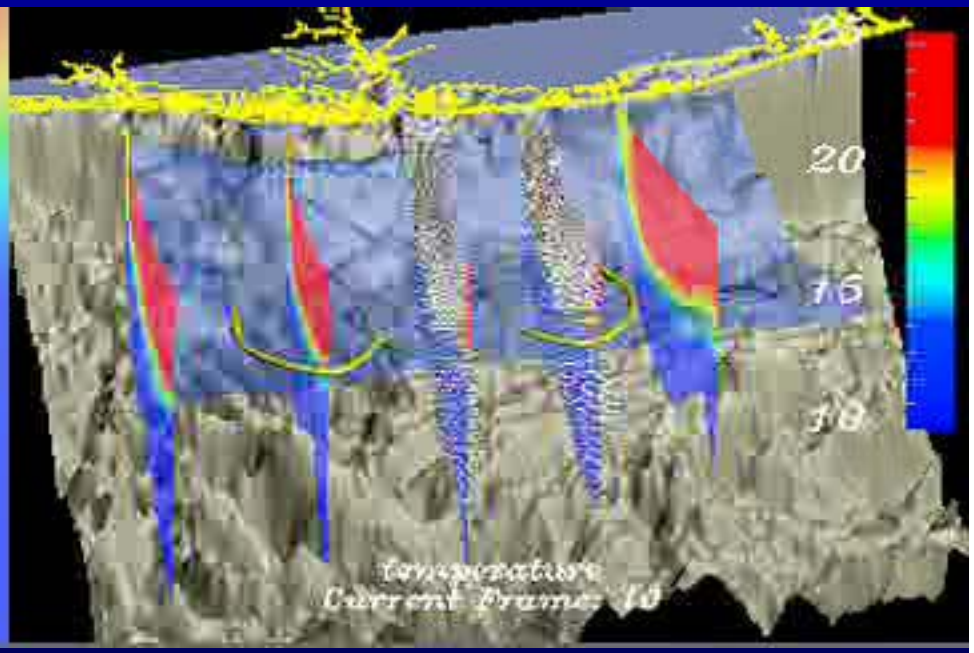


Northeast North Atlantic (NENA) embedded within NATL

3-day average open boundary values from NATL
7-component NPZD ecosystem



Temperature **Chlorophyll**

John Wilkin & Katja Fennel (Rutgers)

Visualization