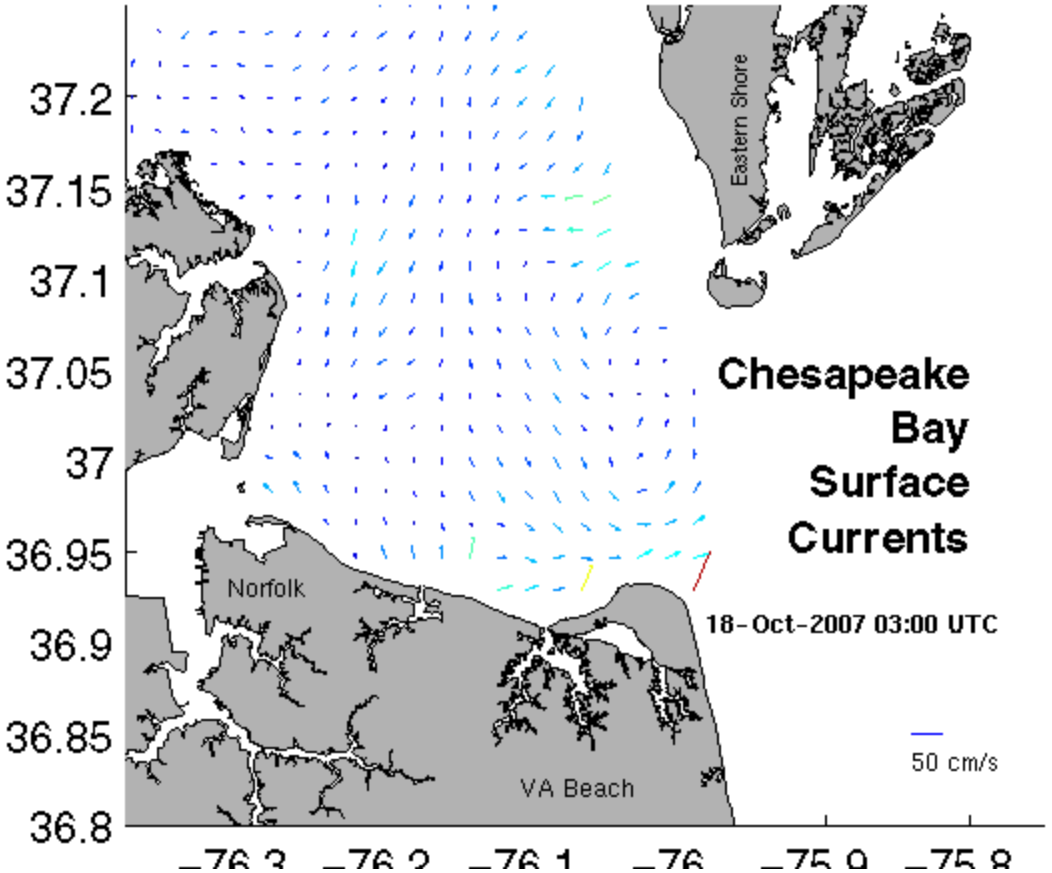
# Surface Current Mapping with High Frequency RADAR

CODAR OCEAN SENSORS




CENTER FOR COASTAL PHYSICAL OCEANOGRAPHY
OLD DOMINION UNIVERSITY

MACOORA
Mid-Atlantic Coastal Ocean Observing Regional Association

NOAA

CIT
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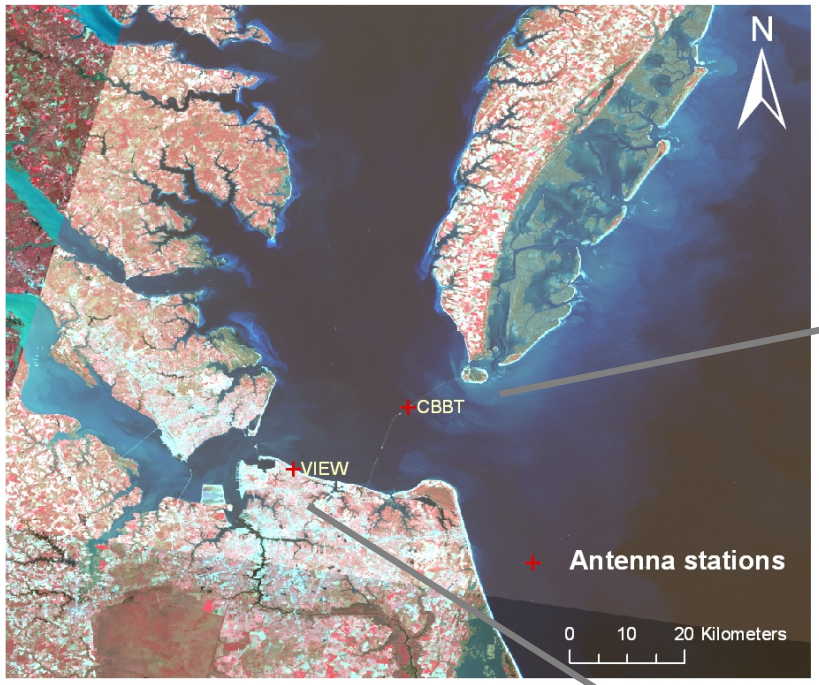
# Applications

- Search and rescue
- Navigation
- Pollution Tracking (Oil spills, red tides, …)
- Recreational boating
- Fishing
- Assimilation into numerical circulation models to improve nowcast/forecast capabilities

# Study Area & Antenna Sites




Source: U.S. Geological Survey
(www.seamless.usgs.gov/viewer)

Source: http://www.cbbt.com/

# AT OUR FIELD SITES

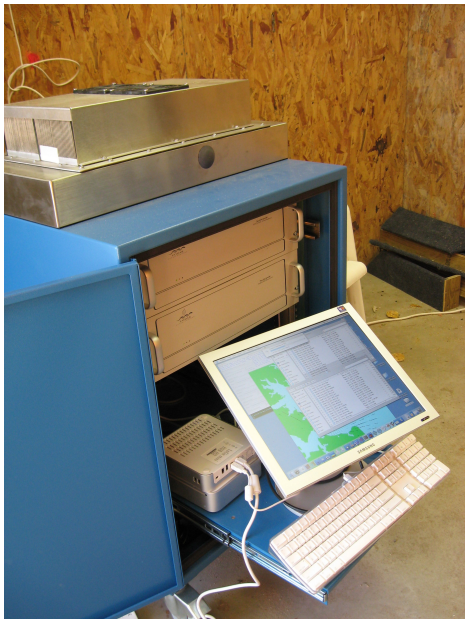
25.4 MHz CODAR Standard Range

Antennas with co-located Tx/Rx

MiniMac Field Computers

Cell phone/Cable modem connections





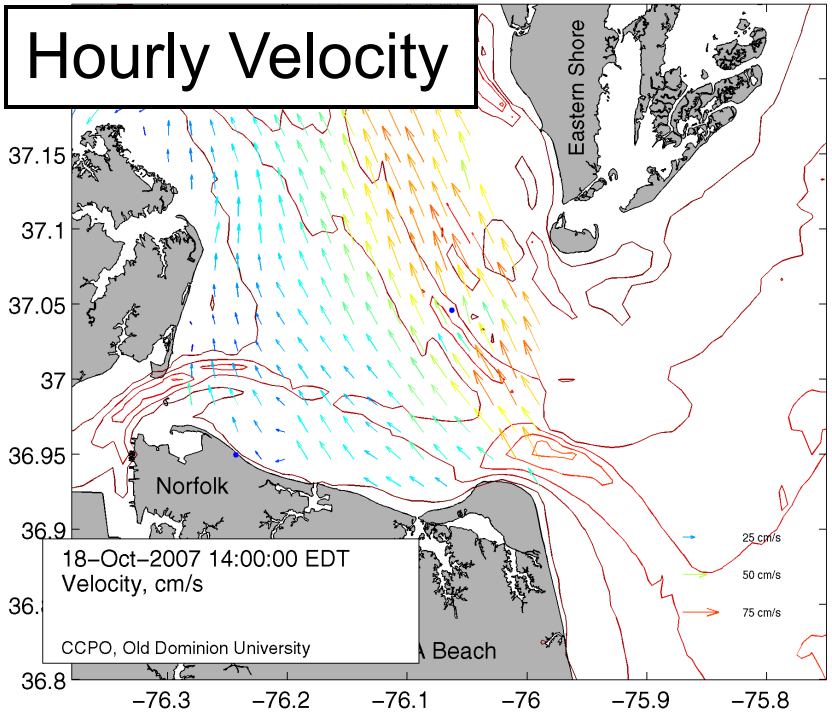
# Operating Costs

- Equipment (antenna, computer, electronics enclosure, software) roughly 150K / site
- Power / network connections / access to the site
  - CBBT $220/ month
  - VIEW $100/ month
- Technician
- Additional costs: Pattern measurements

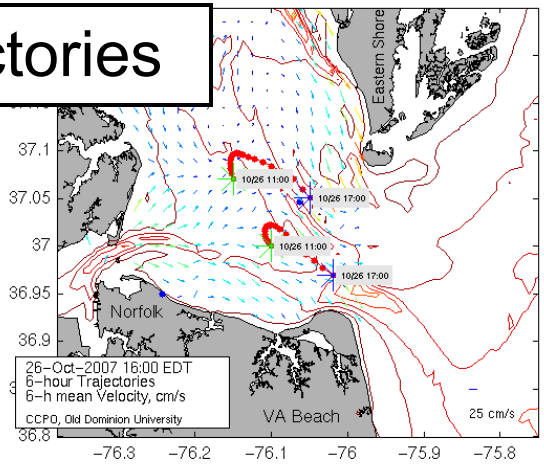
# Data Products Updated Hourly

(http://www.lions.odu.edu/org/cbc)

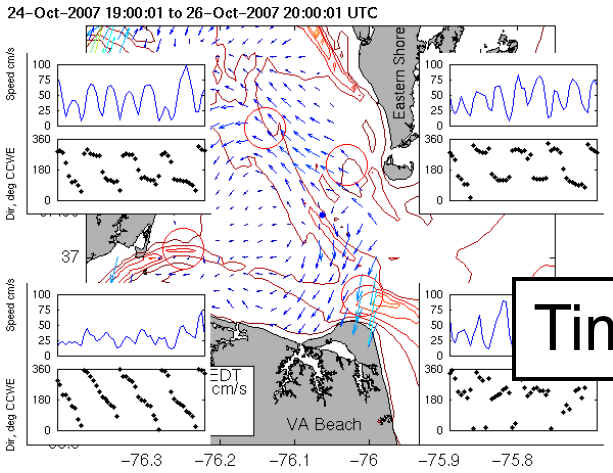
## Hourly Velocity



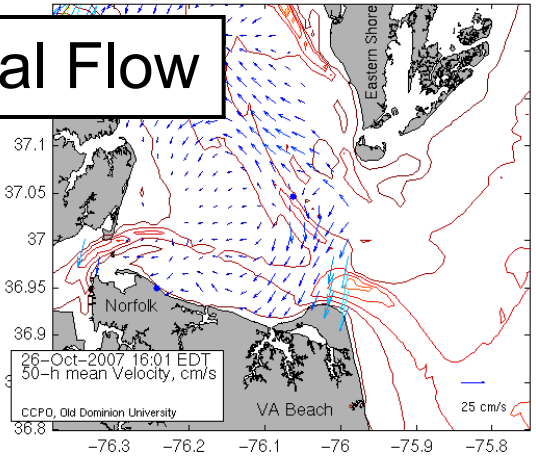

## Trajectories



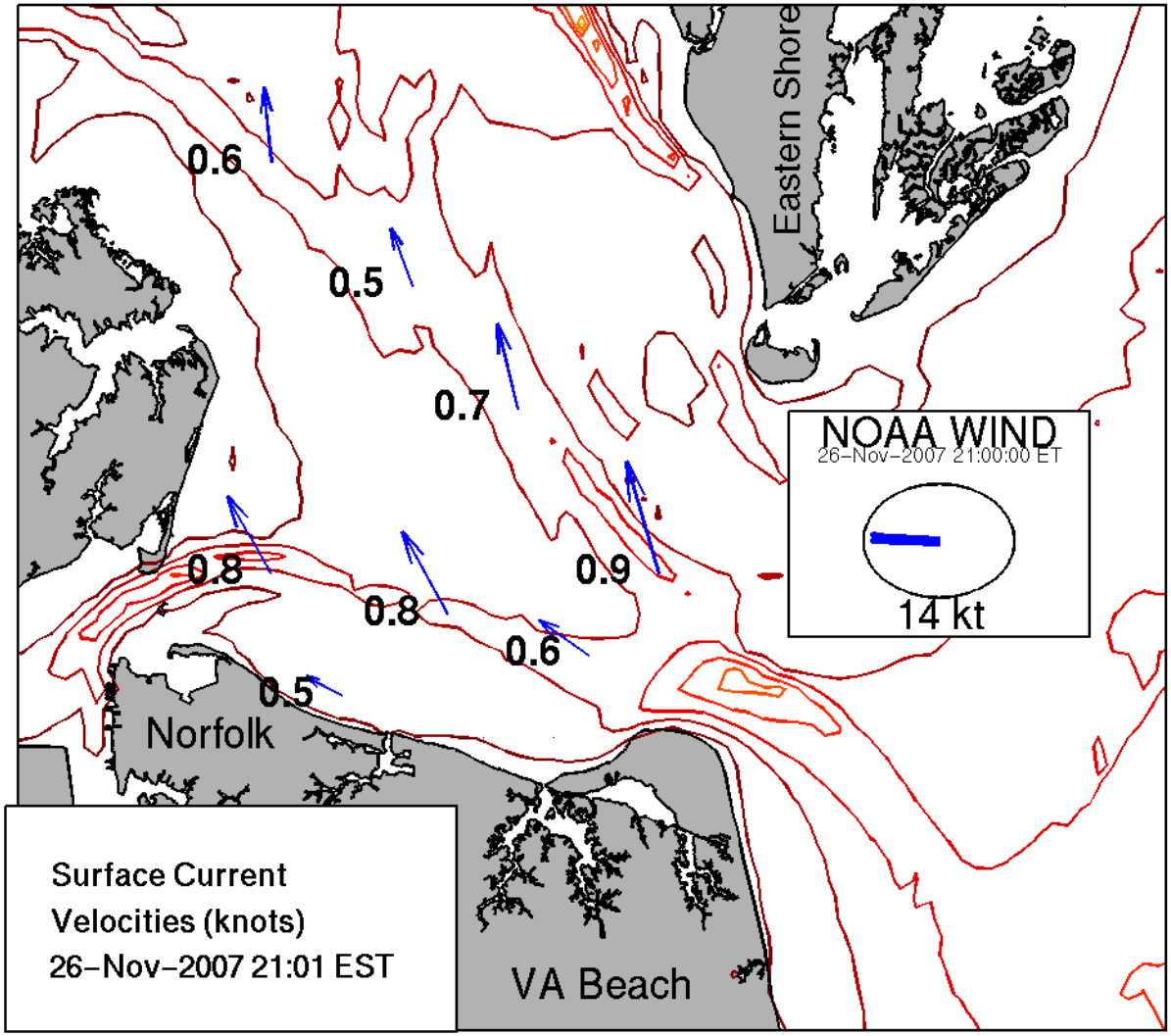

## Time Series



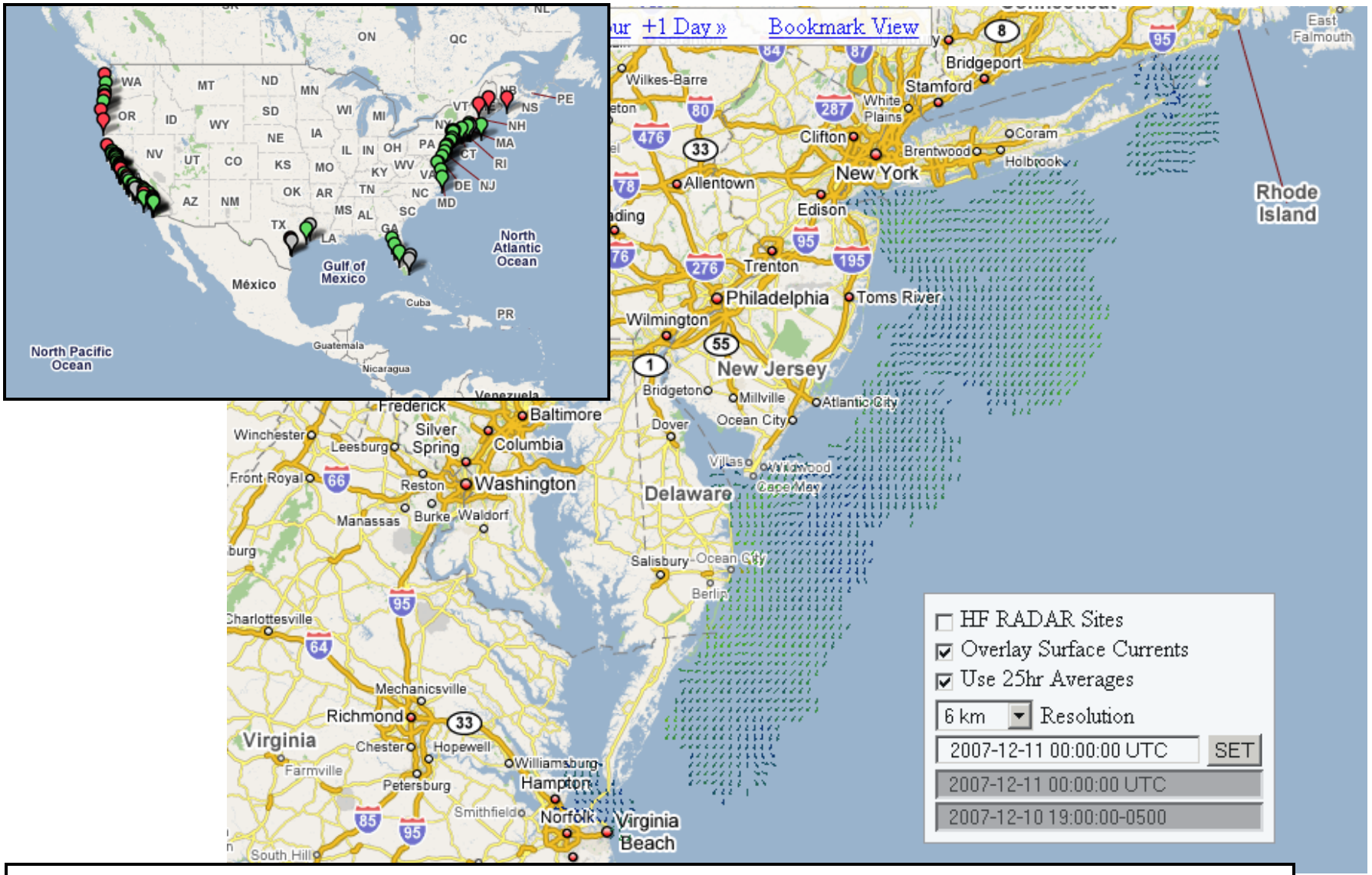

## Sub-tidal Flow



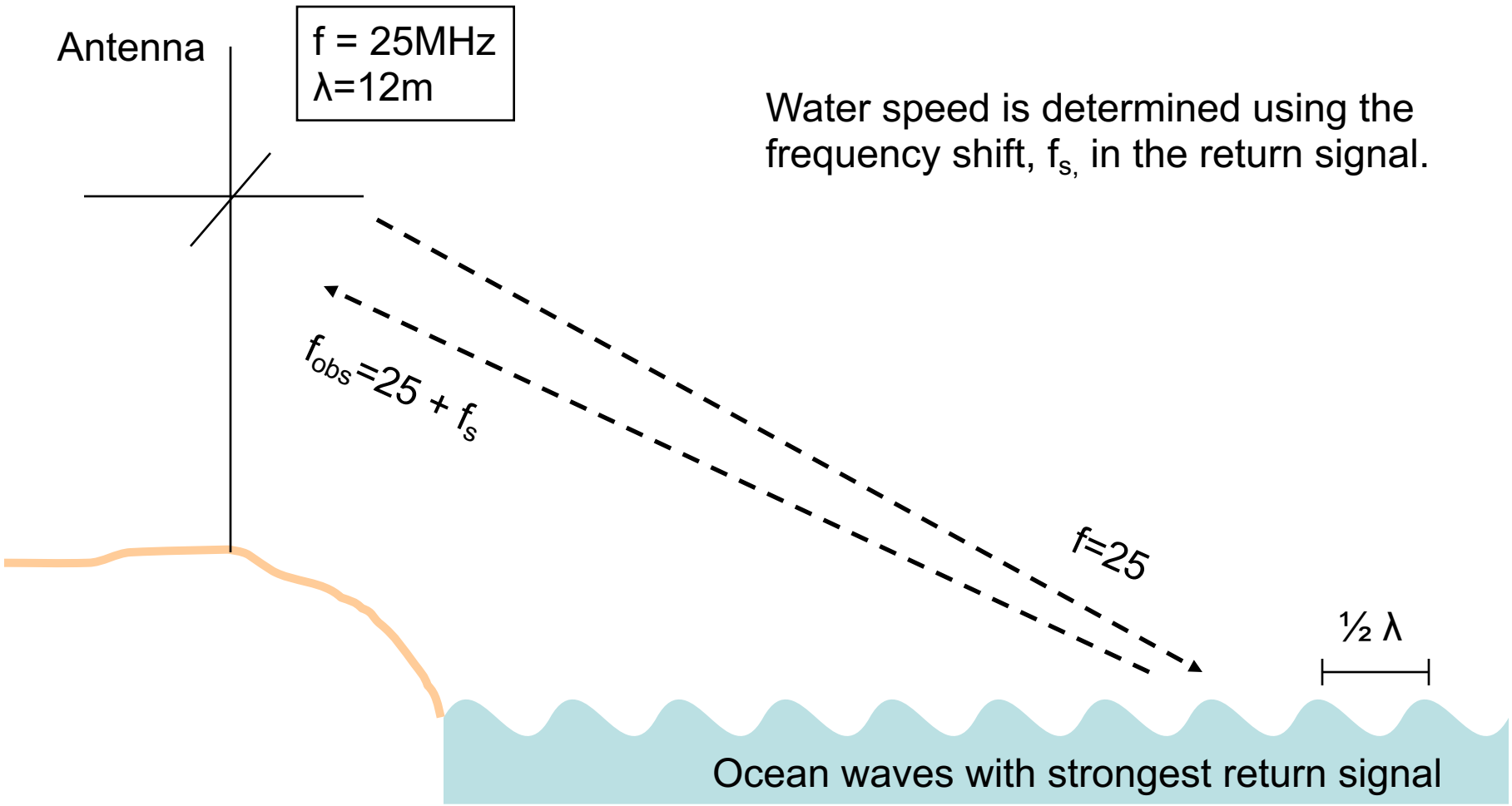
# Shipping Channels



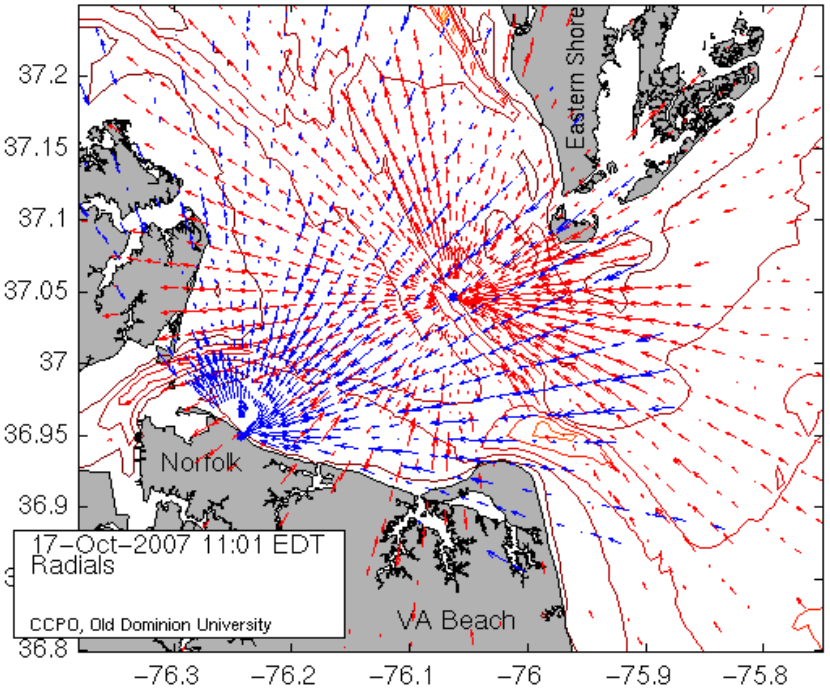
# HF RADAR National Network




UCSD, Scripps Institute http://cordc.ucsd.edu/projects/mapping/maps


Antenna
f = 25MHz
λ=12m
Water speed is determined using the frequency shift, $f_s$, in the return signal.
$f_{obs}=25+f_s$
f=25
½ λ
Ocean waves with strongest return signal

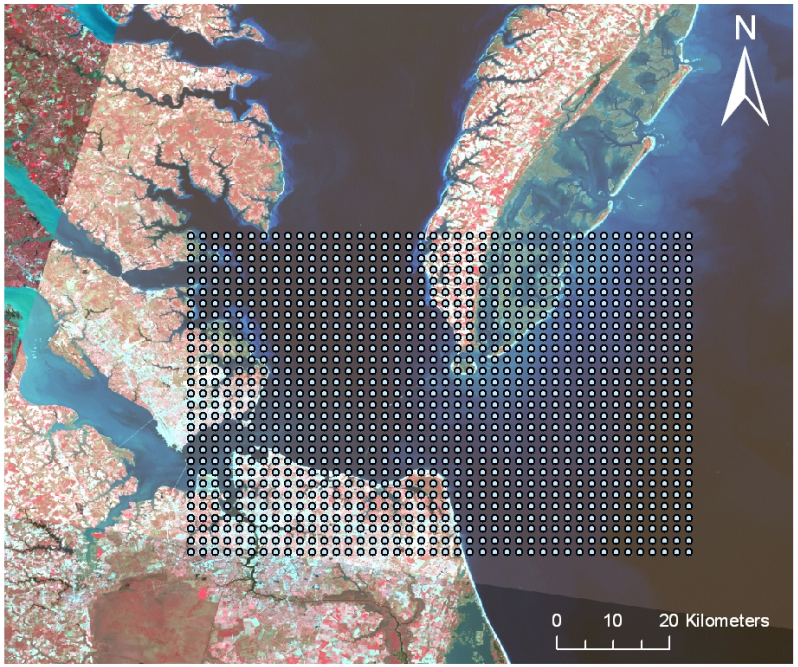
## Radial Current Velocities…




A single antenna measures only one component of the water velocity, the speed of the water moving directly towards or away from it.

Radial vectors are output in range bins of 1.5 km and directional bins of 5 degrees.

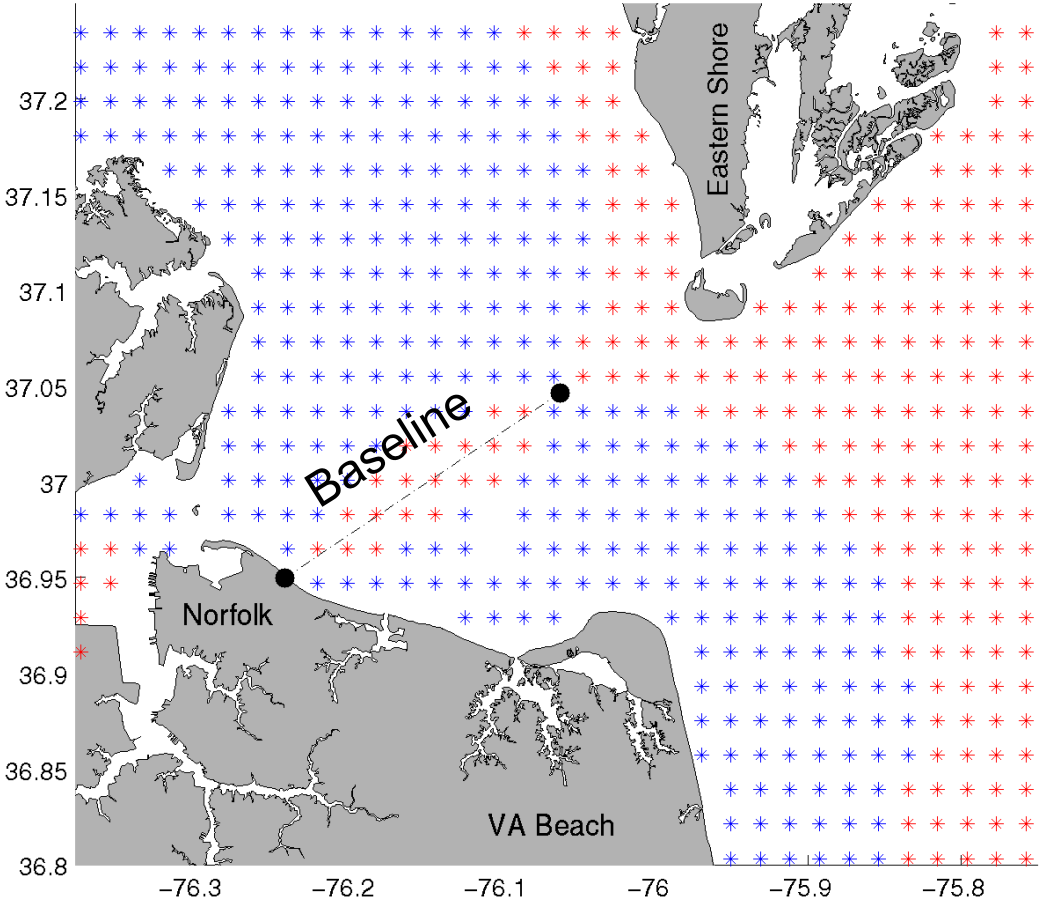
## are combined on a grid




The grid is designed by the operator.

**Mapping requires at least two antennas!**

# Grid for Total Current Vectors

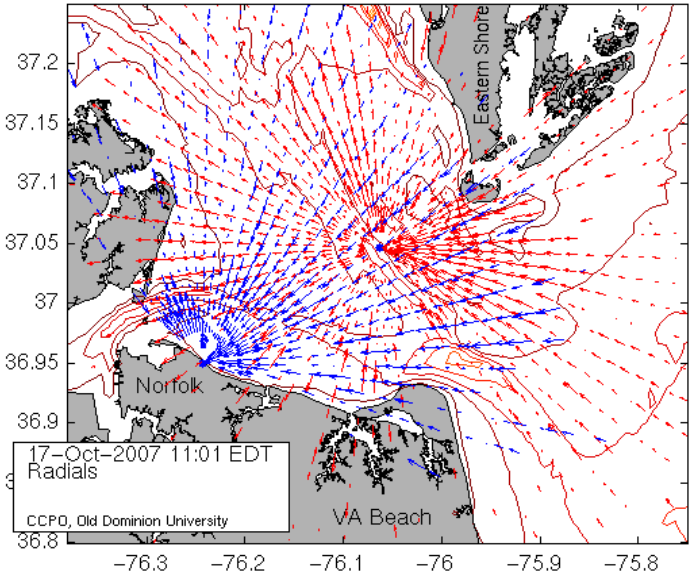



2 km Grid courtesy of CORDC National Network

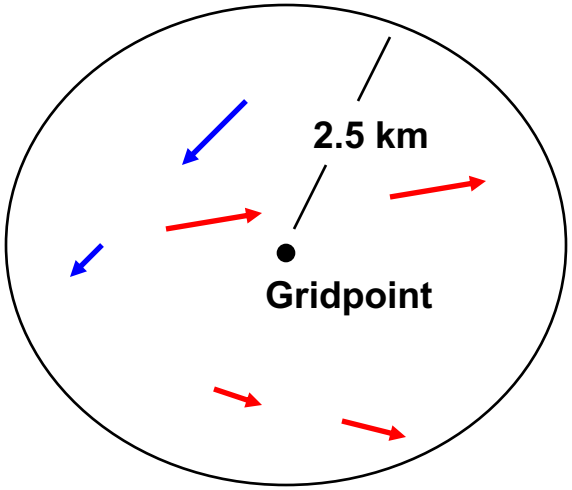
Preserves orthogonality

Red points fail stability angle requirements

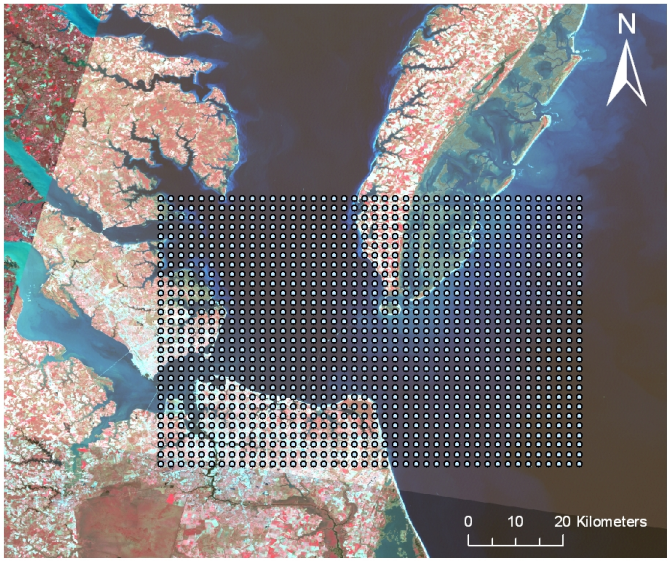
# Radial Current Velocities



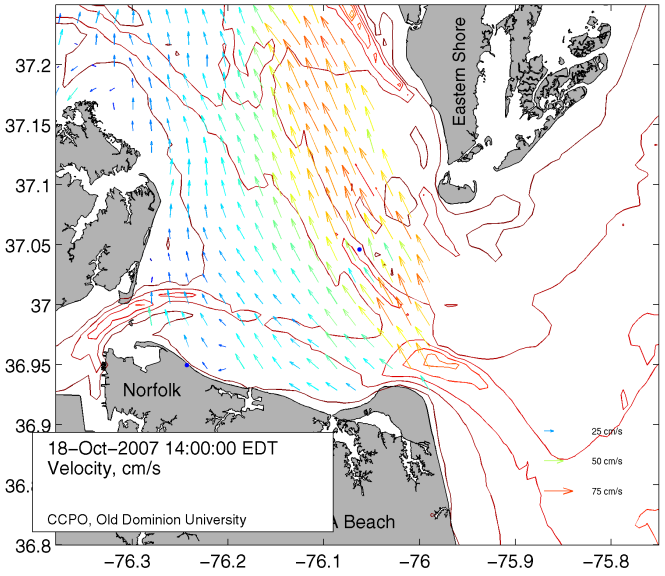

Around each grid point…
Combine Radial Vectors (Least Squares Average)




# + Grid




# Total Current Velocities

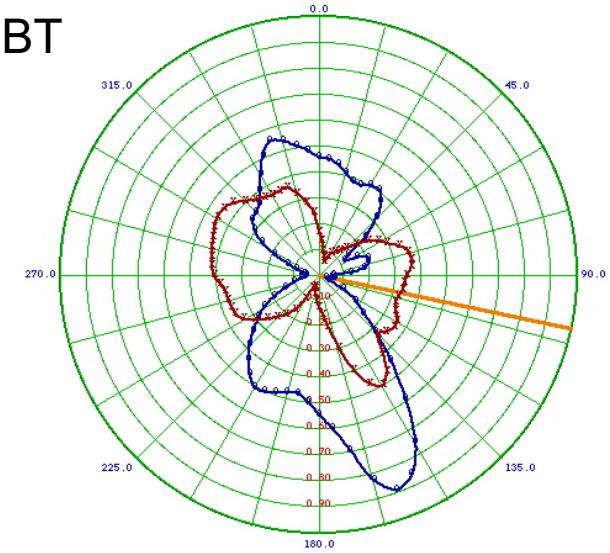


# Data Quality

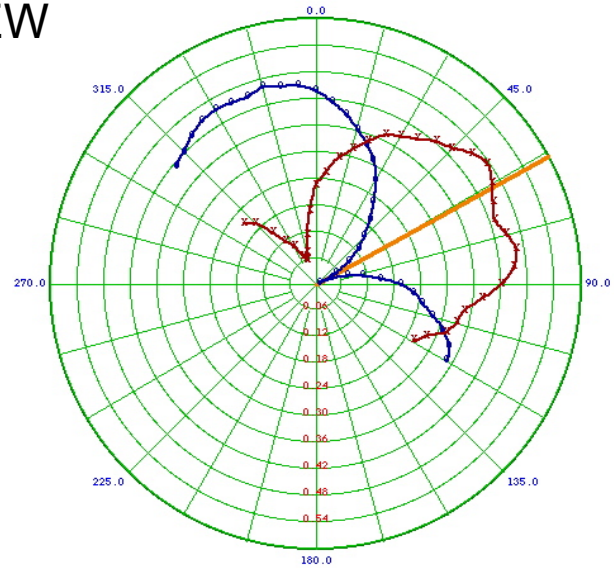
## Calibration and Radial Coverage

# Antenna Patterns

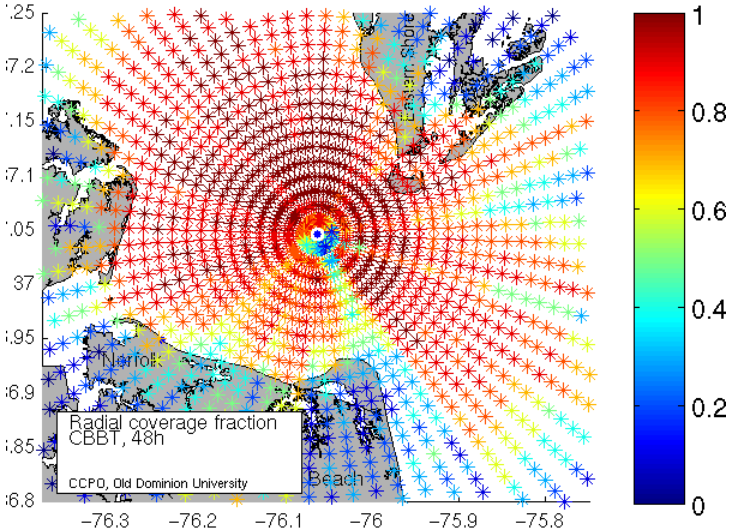
CBBT

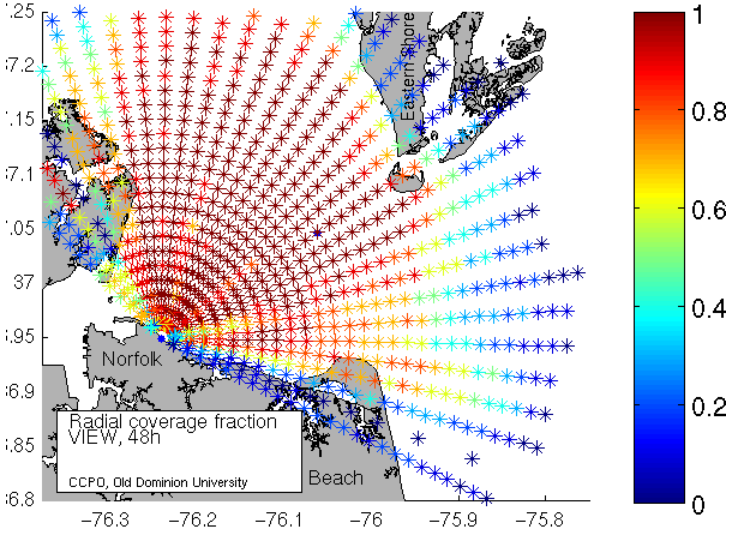



VIEW



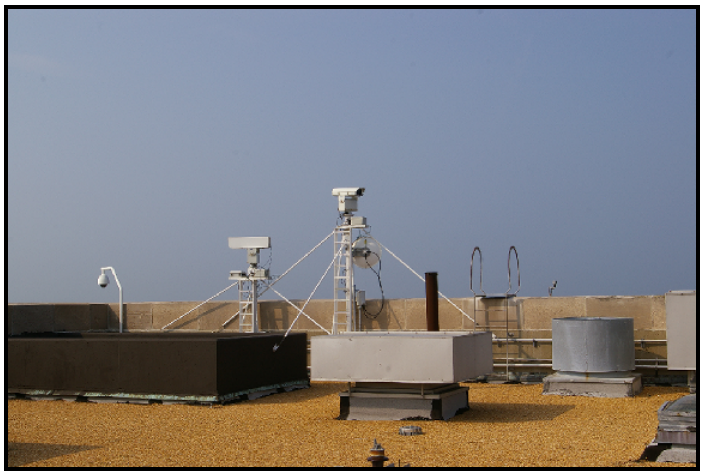

# Radial Coverage



# Challenges

- At a 360° site, antenna pattern measurement is essential
- Antenna isolation
- Summertime heat
- Interference (Natural & Man-made)

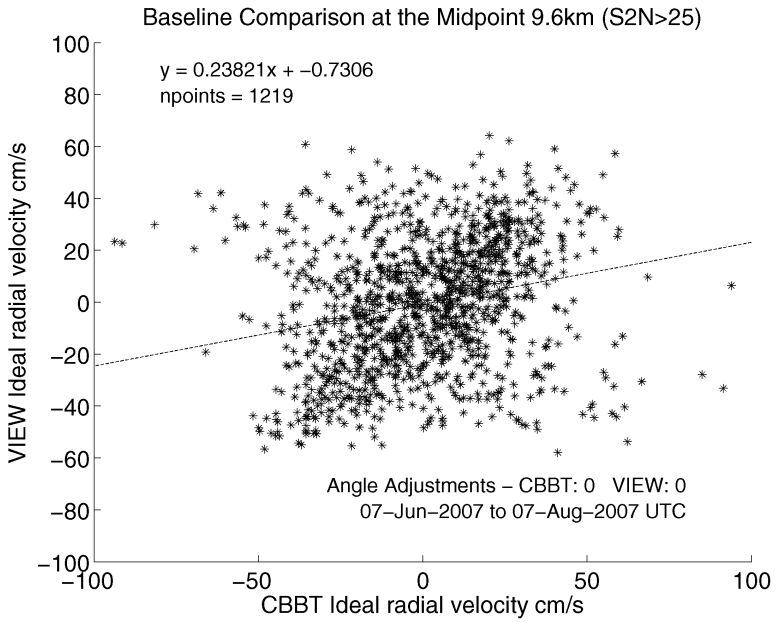


# Data Validation by Comparison

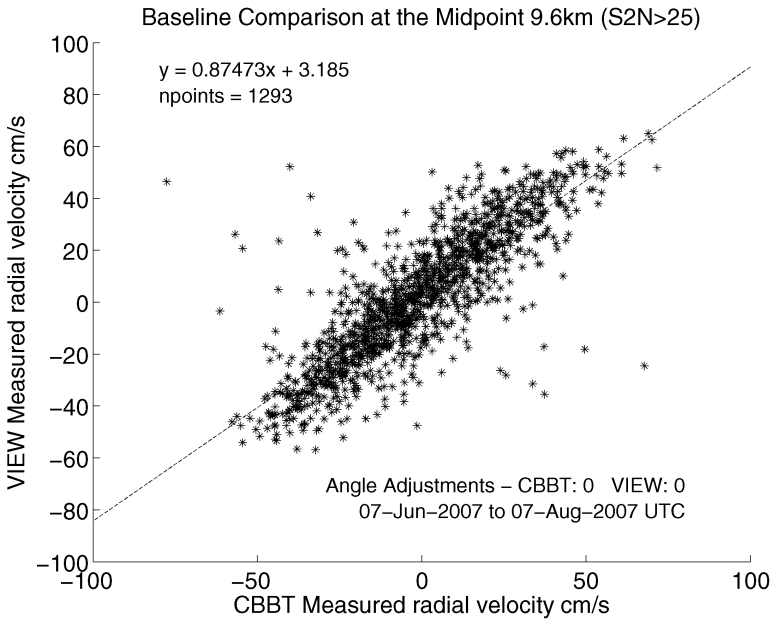
- Baseline (consistency)
- Tide
- Moored ADCP
- Towed ADCP


Photo Source: NOAA OSTEP report

# Baseline Comparisons

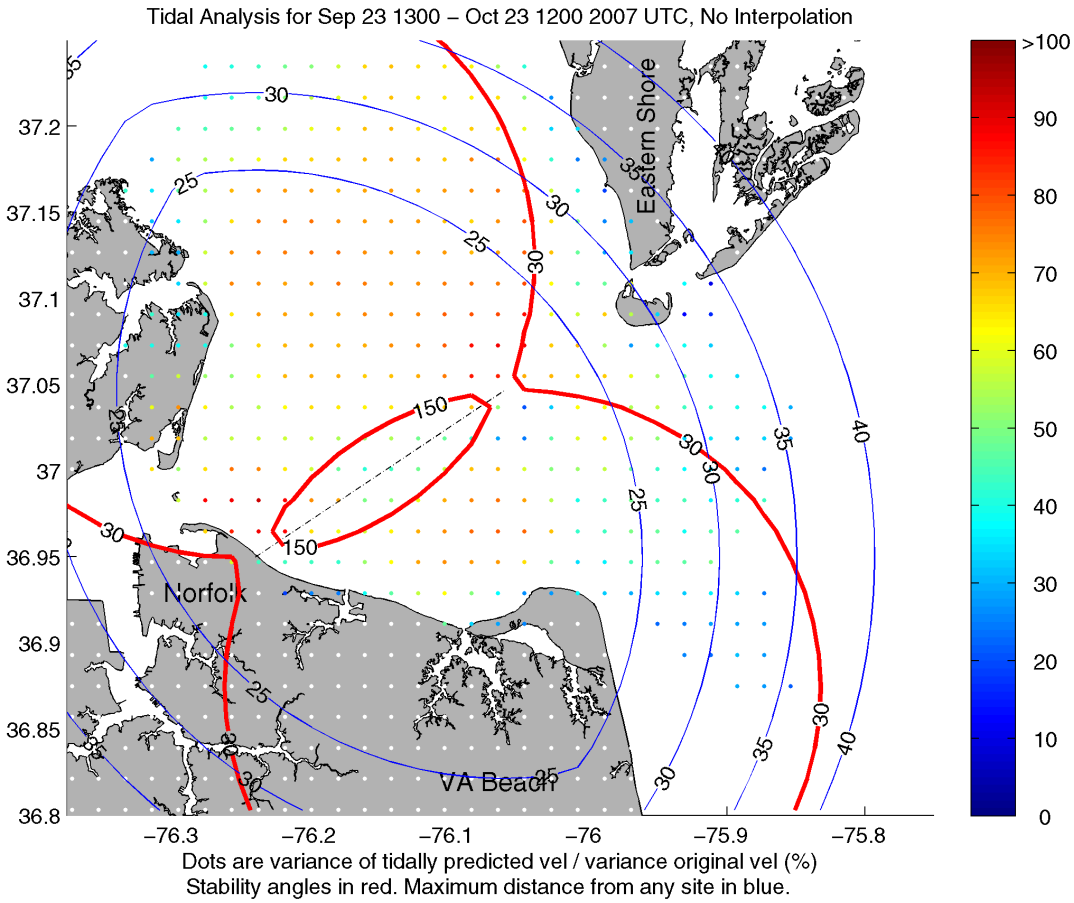



Ideal antenna patterns

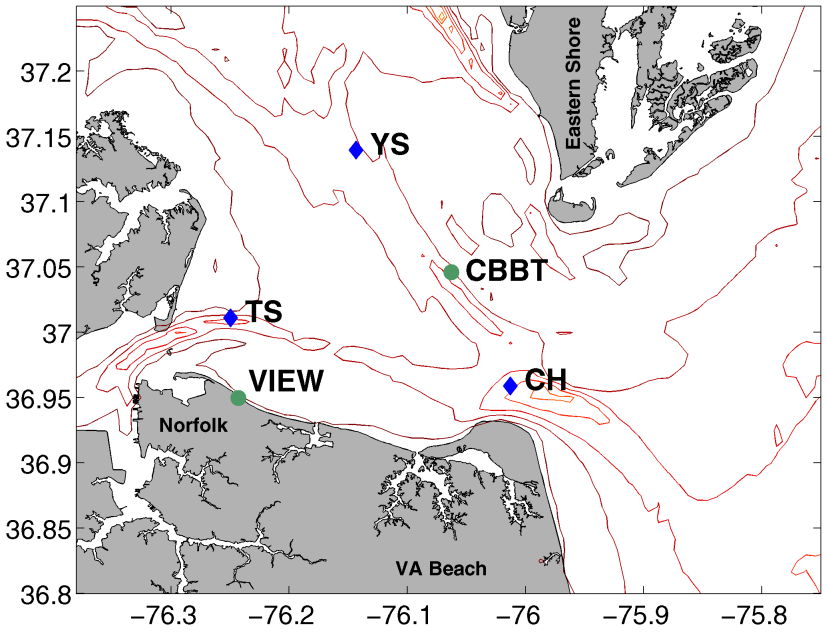


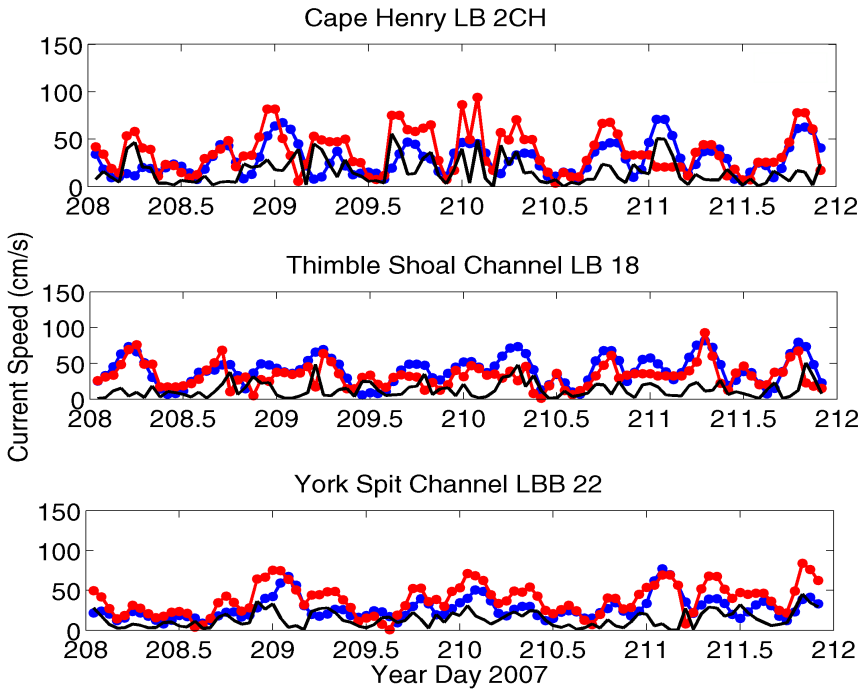

Measured antenna patterns

# Tidal Analysis



# Moored ADCP Comparison




Difference Statistics

| Site | Mean | S.Dev |
|---|---|---|
| Cape Henry | 16.2 | 14.0 |
| Thimble Shoals | 13.2 | 11.2 |
| York Spit | 13.9 | 10.0 |

Red line = CODAR
Blue line = NOAA ADCP
Black = |NOAA-CODAR|

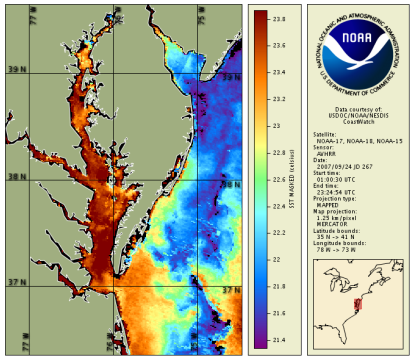
# CODAR Current Research & Development

- Bistatic system: enhance coverage by using precise timing so that Rx can receive sea scatter from another transmitter (e.g. on a buoy)
- RiverSonde
- Ship detection
- Shallow water waves

Source: CODAR Research & Development poster

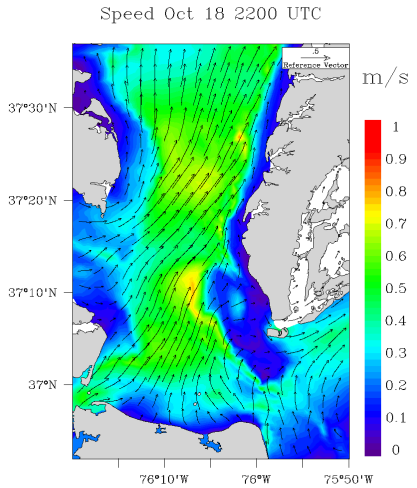
# Our Future Plans

- Incorporate data into GIS; map with other regional spatial data
- Continue to work with trajectories/ plume tracking
- Model comparisons
- Outreach (VA Aquarium, education)
- Web page & product development
  - Shipping channels
  - Ocean View beaches



AVHRR SST Daily Composite, September 24, 2007

from NOAA Coastwatch




ChesROMS model output

# Acknowledgements


- Larry Atkinson and Jose Blanco
- CIT, MACOORA, NOAA
- CODAR support
- Advice and assistance from numerous other HF RADAR operators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