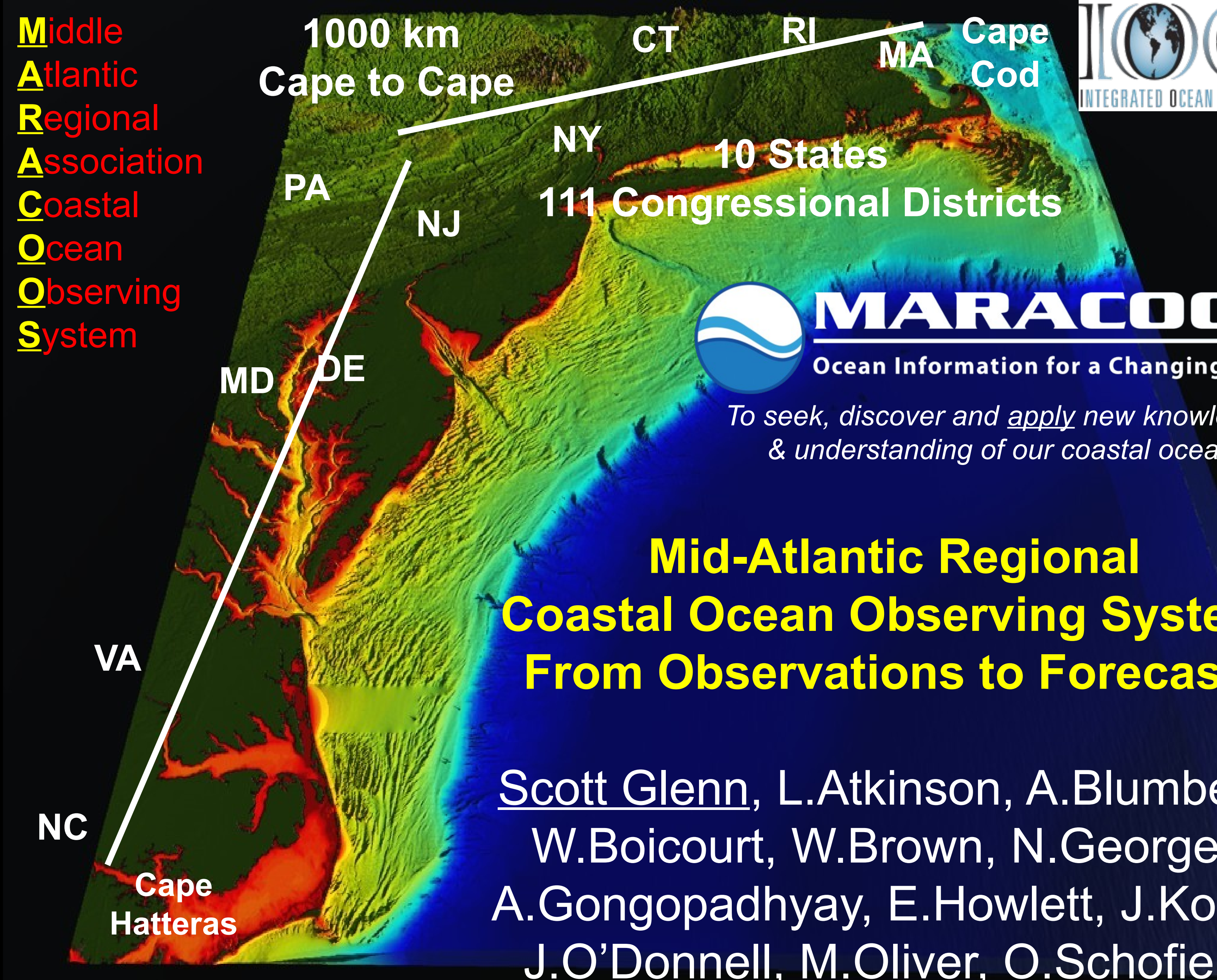


Middle
Atlantic
Regional
Association
Coastal
Ocean
Observing
System

IOOS
INTEGRATED OCEAN OBSERVING SYSTEM

MARACOOS
Ocean Information for a Changing World

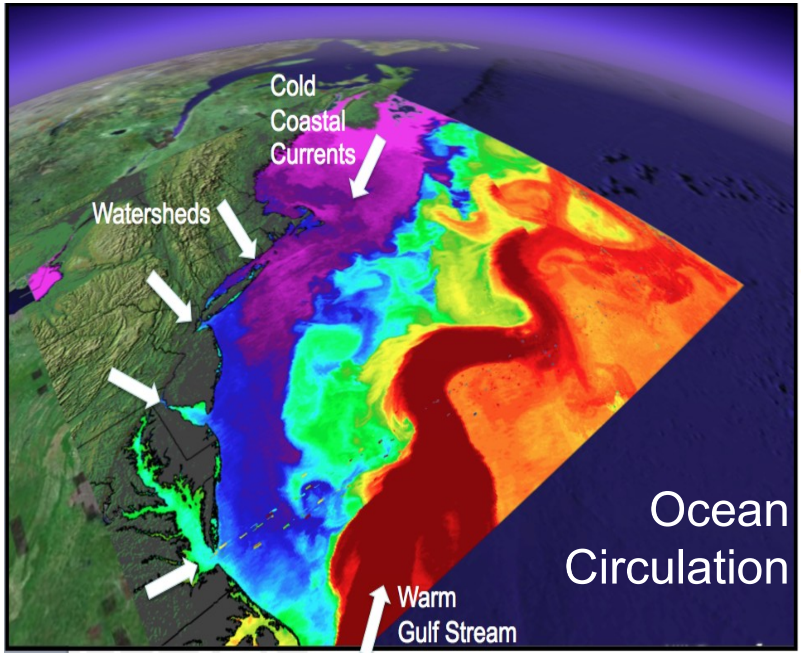
To seek, discover and apply new knowledge & understanding of our coastal ocean

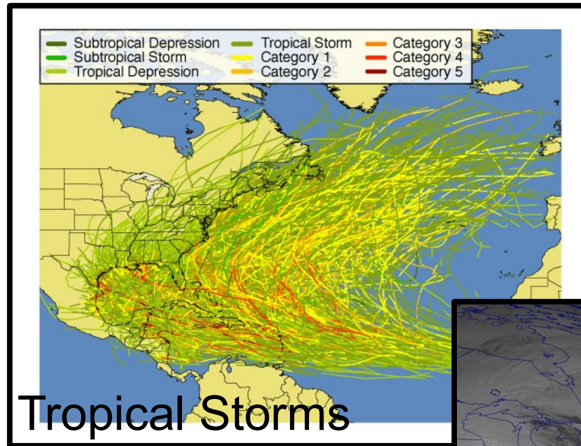
Mid-Atlantic Regional Coastal Ocean Observing System: From Observations to Forecasts

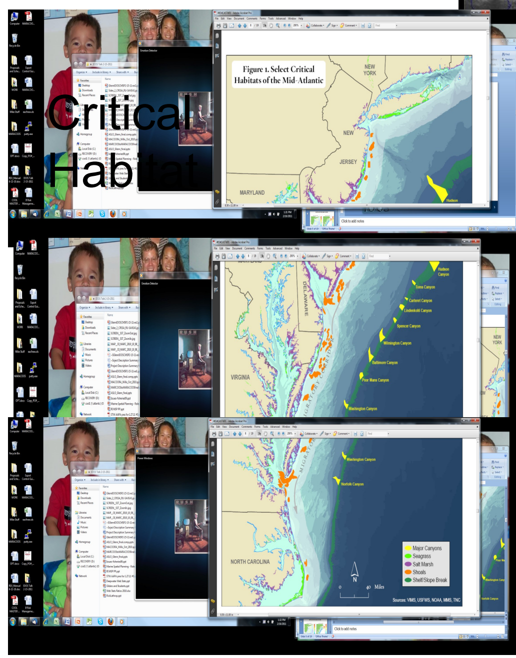
Scott Glenn, L.Atkinson, A.Blumberg, W.Boicourt, W.Brown, N.Georges, A.Gongopadhyay, E.Howlett, J.Kohut, J.O'Donnell, M.Oliver, O.Schofield, R.Signell, C.Thoroughgood, J.Wilkin,
Plus >30 Additional Co-PI's, from >20

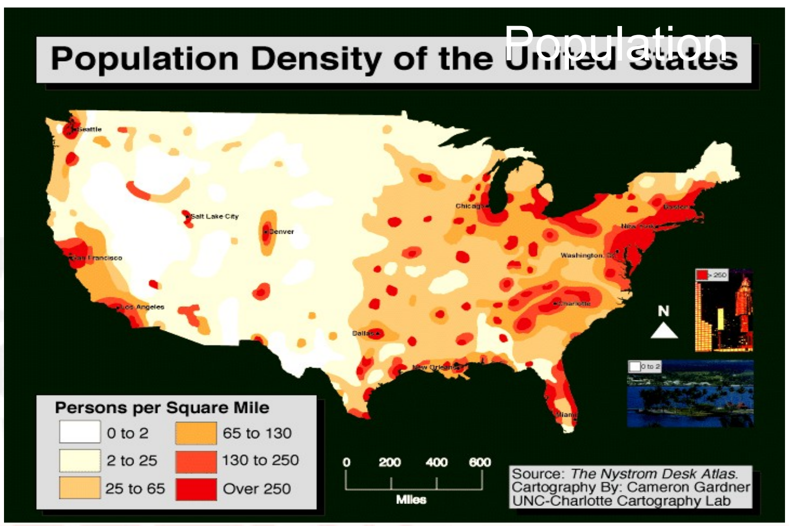
RUTGERS
JERSEY ROOTS, GLOBAL REACH
Coastal Ocean Observation Lab

Mid-Atlantic Regional Drivers

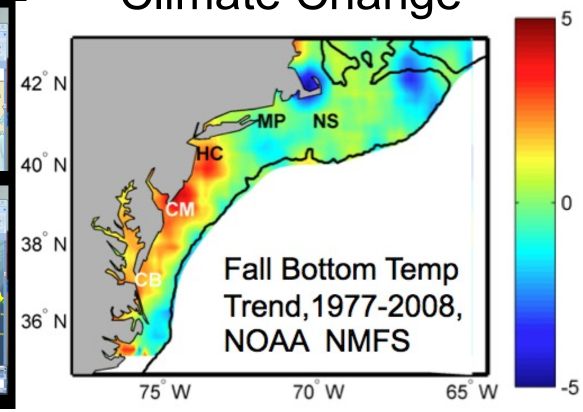








Climate Change



Evolution of Rutgers Major Coastal Ocean Observing Projects

1990's:
Technology Development for Science Experiments

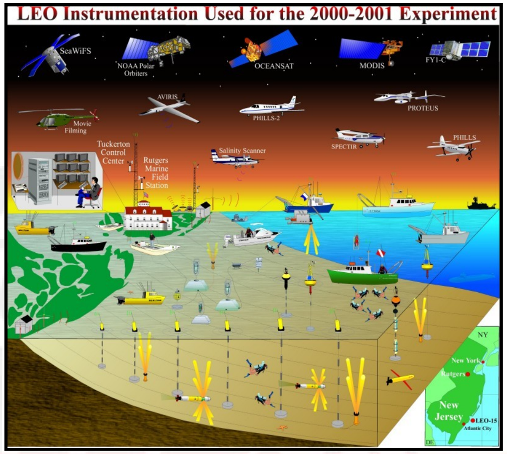
Projects:
- NOAA Undersea Research $2 M / 5 Yr
- NSF Upwelling Exp $1 M / 3 Yr

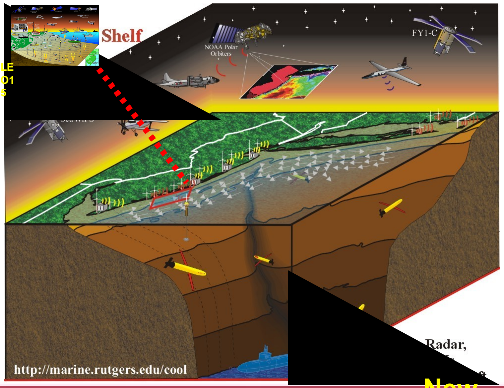
2000's:
Observation Network & Forecast Model Development for Science & Society

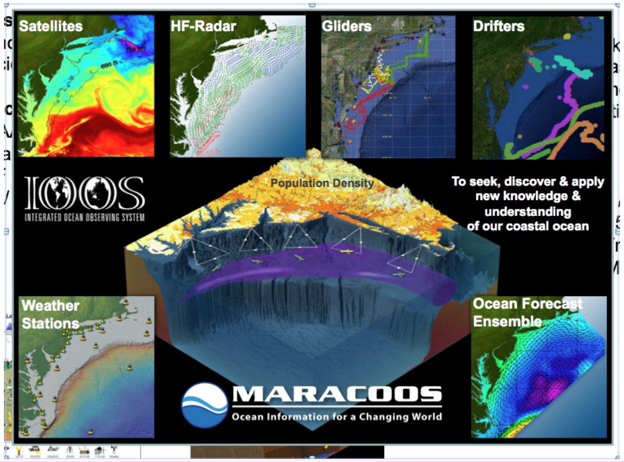
Projects:
- NOPP/ONR Coastal Predictive Skill Experiments $5 M / 4 Yr
- NSF Hudson River Plume Exp $5 M / 3 Yr
- NOAA IOOS MARCOOS $8 M / 4 Yr

2010's:
Observation Network Operations & Forecasting Ensemble Development for Society & Education

Projects:
- NOAA IOOS MARACOOS $20 M / 5 Yr
- DHS CSR $12 M / 5 Yr
- NJ BPU $2 M / 2 Yr
- NSF OOI Edu $5 M / 4 Yr

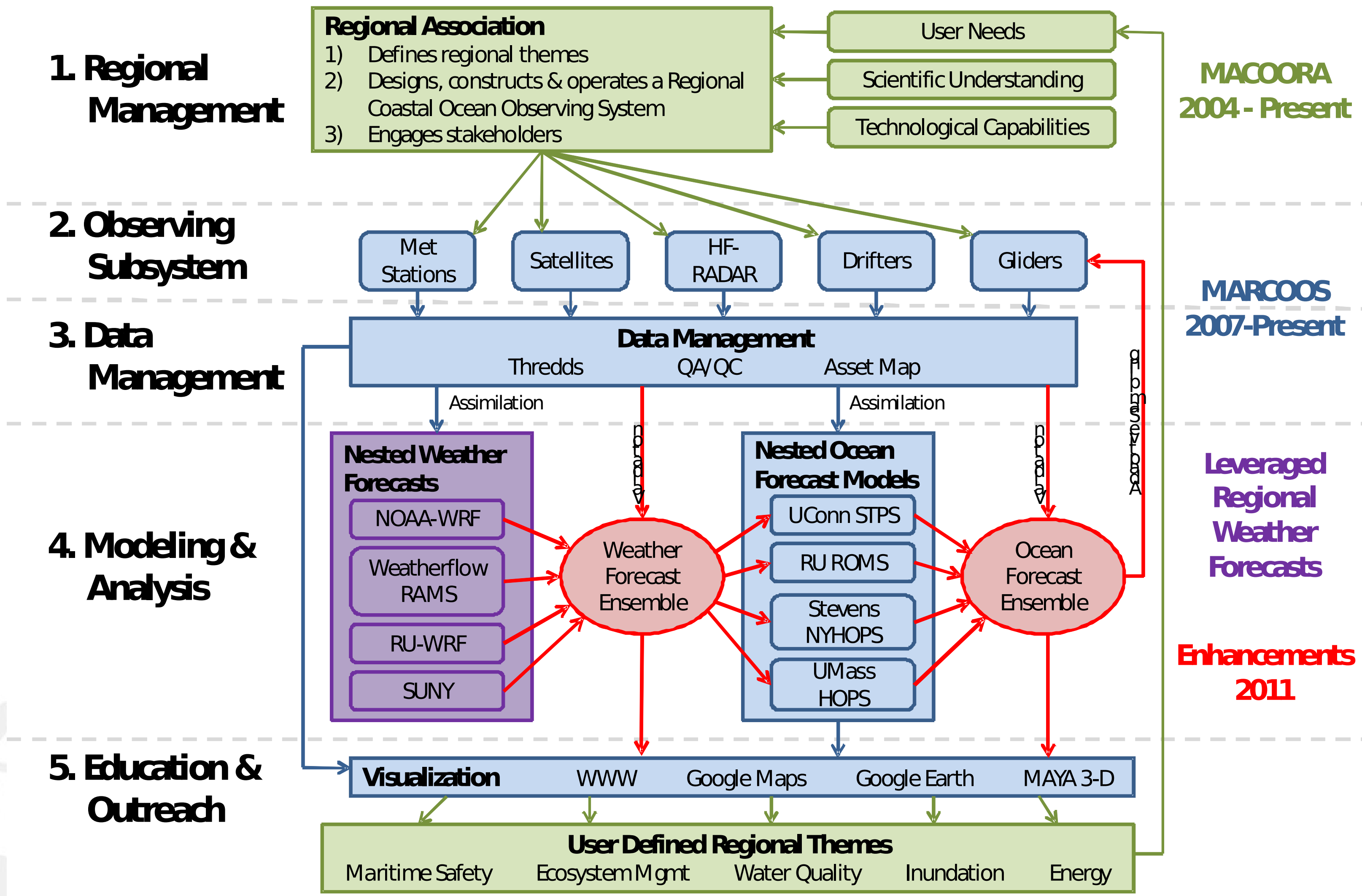






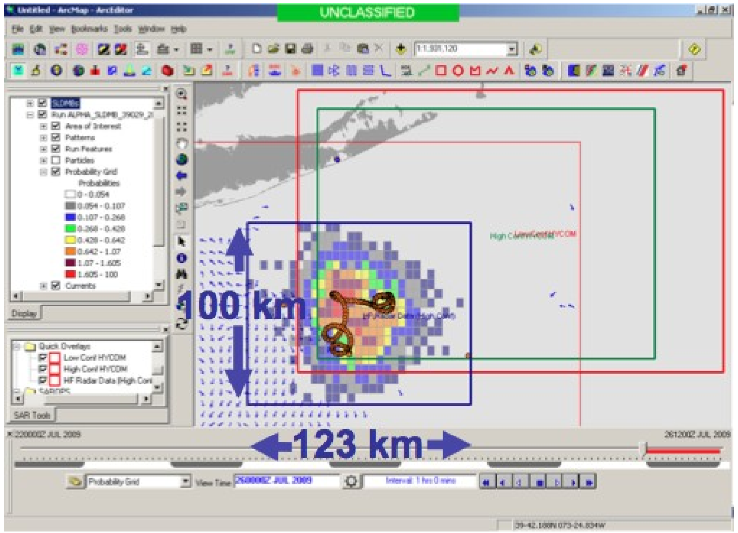
Evolution of the Mid Atlantic Observation & Modeling System

MARACOOS = MACOORA + MARCOOS + Enhancements

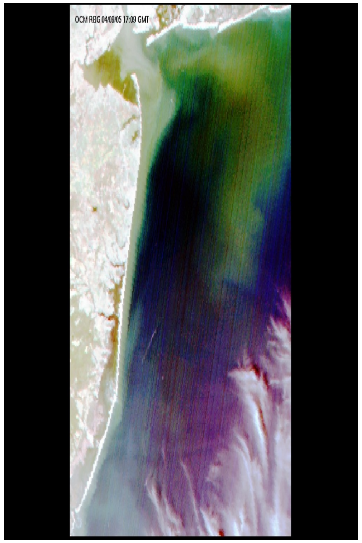


MARACOOS Regional Themes

1) Maritime Operations – Safety at Sea

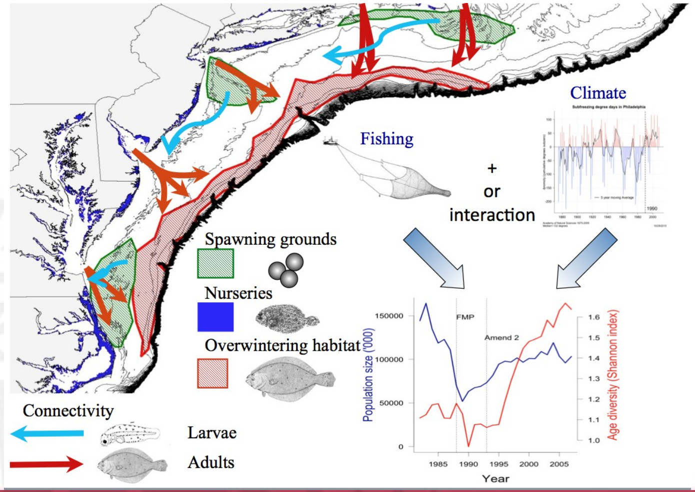


3) Water Quality – Floatables, Hypoxia, Nutrients

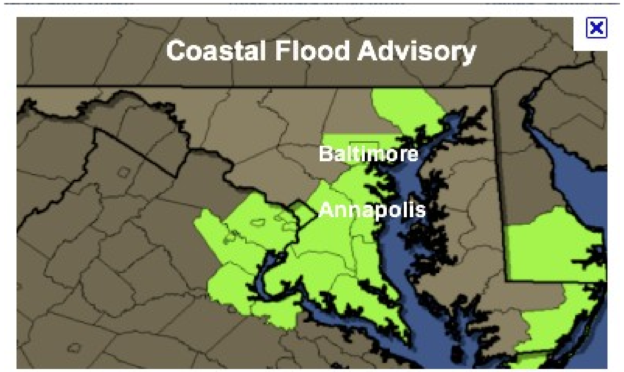


5) Energy – Offshore Wind

2) Ecosystem Decision Support - Fisheries

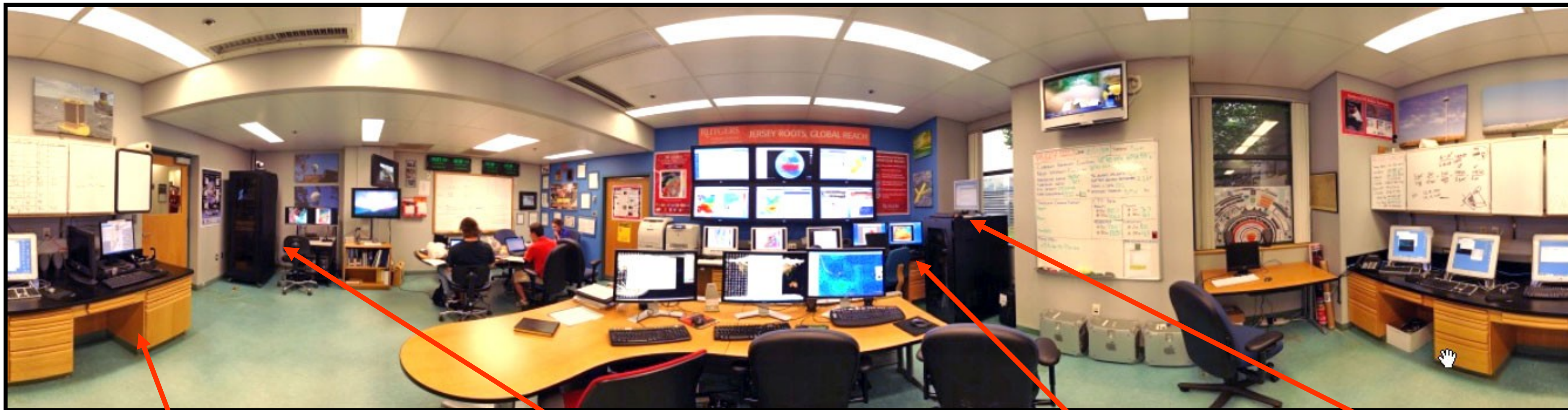


4) Coastal Inundation - Flooding



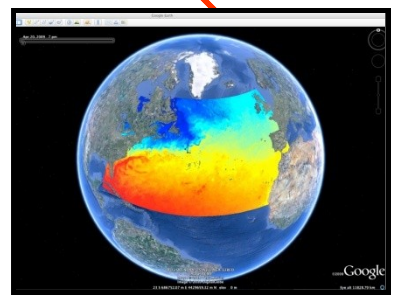
Rutgers University - Coastal Ocean Observation Lab

Observatory Operations & Education Center

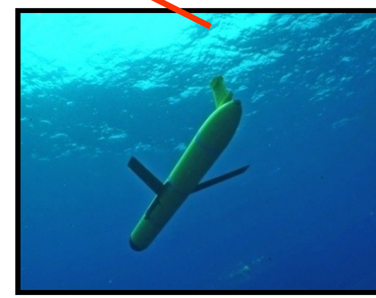


CODAR Network

L-Band & X-Band Satellite Receivers



3-D Nowcasts & Forecasts

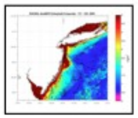


Glider Fleet

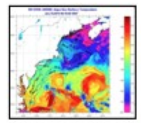
Direct Acquisition Satellite Data Evolution

L-band (1.2m antenna) Since 1992

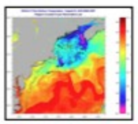
X-band (3.6m antenna) Since 2006



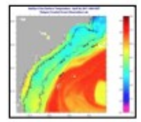
United States, NASA SeaWiFs
(9-year archive)
Product: 1km chlorophyll, reflectance, backscatter, absorption



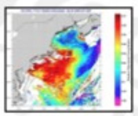
United States, NASA Aqua and Terra MODIS
(7-year product archive)
Product: 1km SST, chlorophyll, reflectance, absorption, backscatter



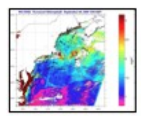
United States, NOAA POES AVHRR
(19-year archive)
Product: 1km sea surface temperatures (SST), de-clouded SST



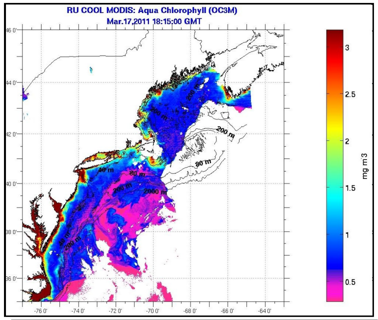
Europe, ESA Metop-A AVHRR
(2-year archive)
Products: 1km SST

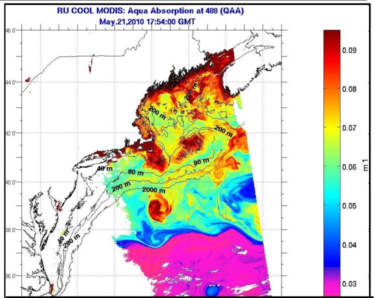


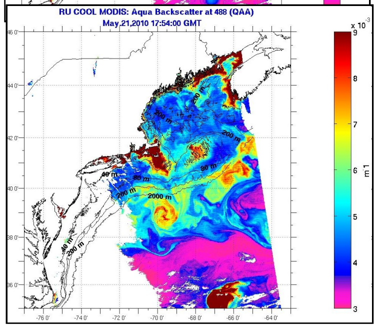
China, China FY1 MVISR
(10-year archive)
Product: 1km relative chlorophyll

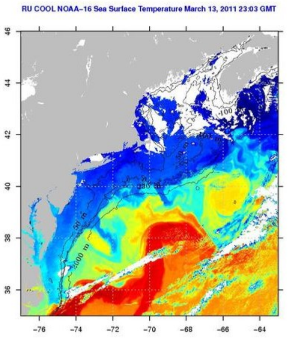


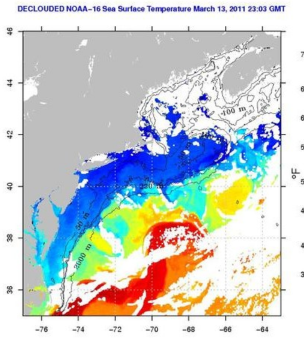
India, IRSO Ocean Color Monitor (past)
(7-year product archive)
Products: 360m chlorophyll

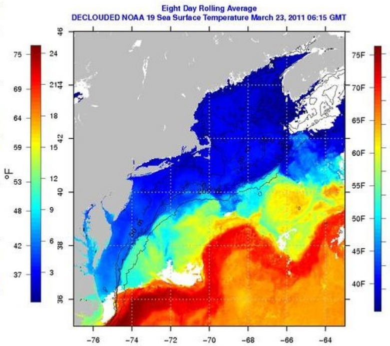


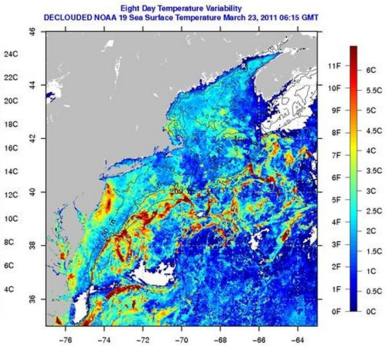


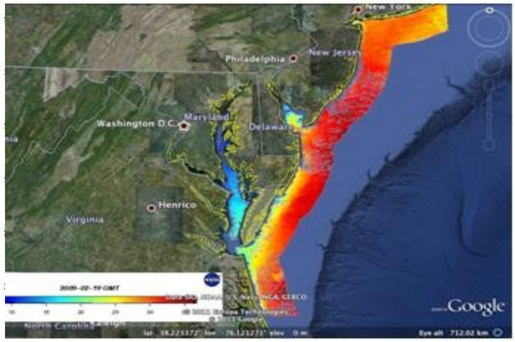




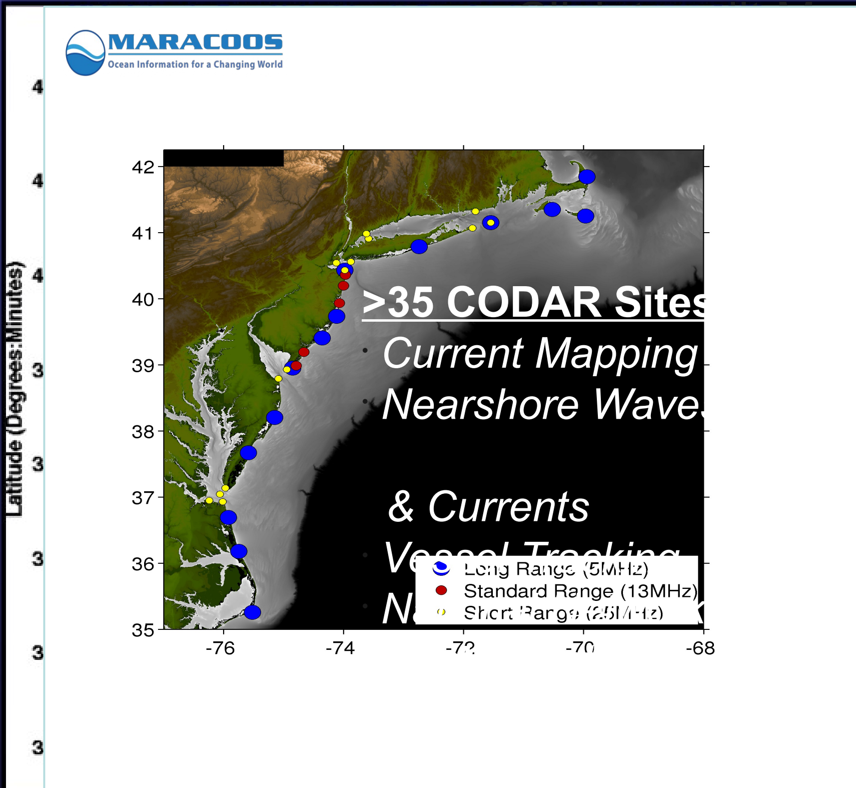


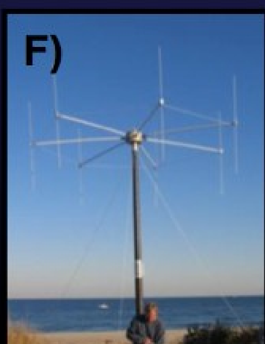


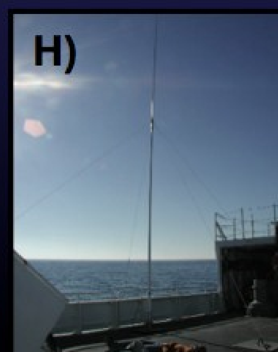




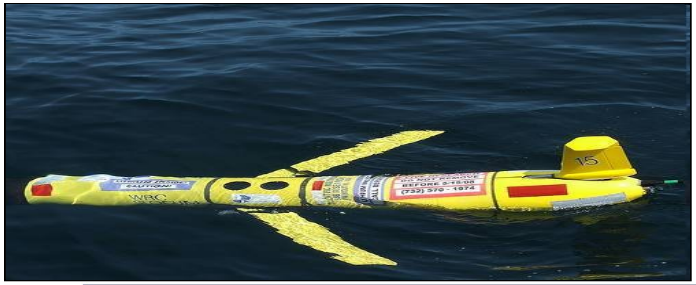
CODAR HF Radar Network Evolution in the Mid-Atlantic





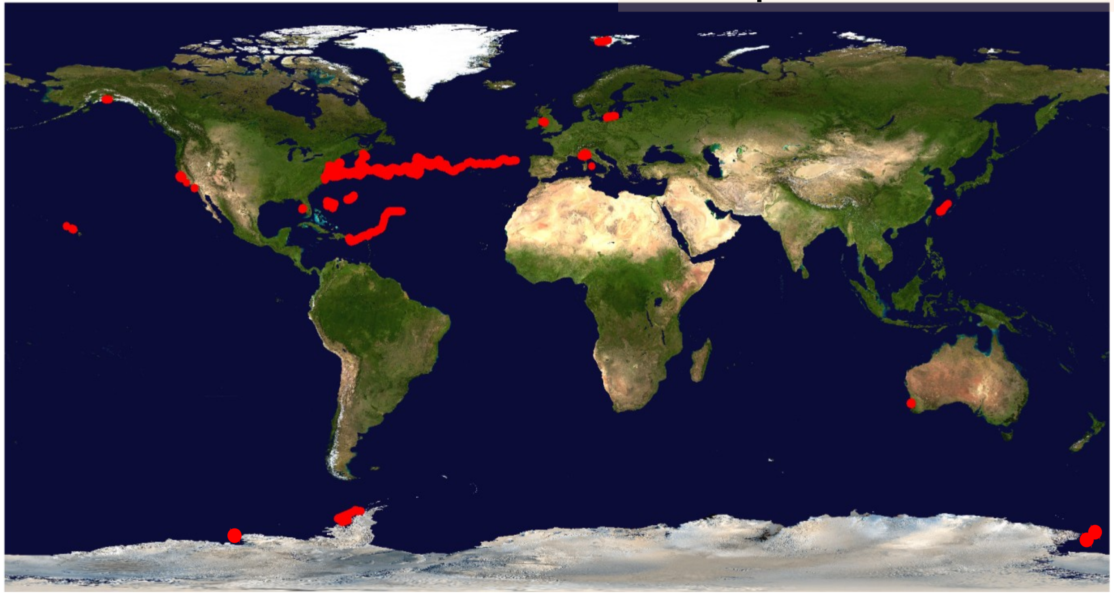


Rutgers Slocum Glider Fleet



Global Flight Statistics:
- 261 Deployments
- 4,037 In-water days
- 94,000 km flown

2.3 laps around the Earth



Glider Sensors

Figure 1: TRDI Explorer DVL

Ruggedized Tail Fin, Modular Payload Bays, Lithium Primary & Rechargeable Batteries

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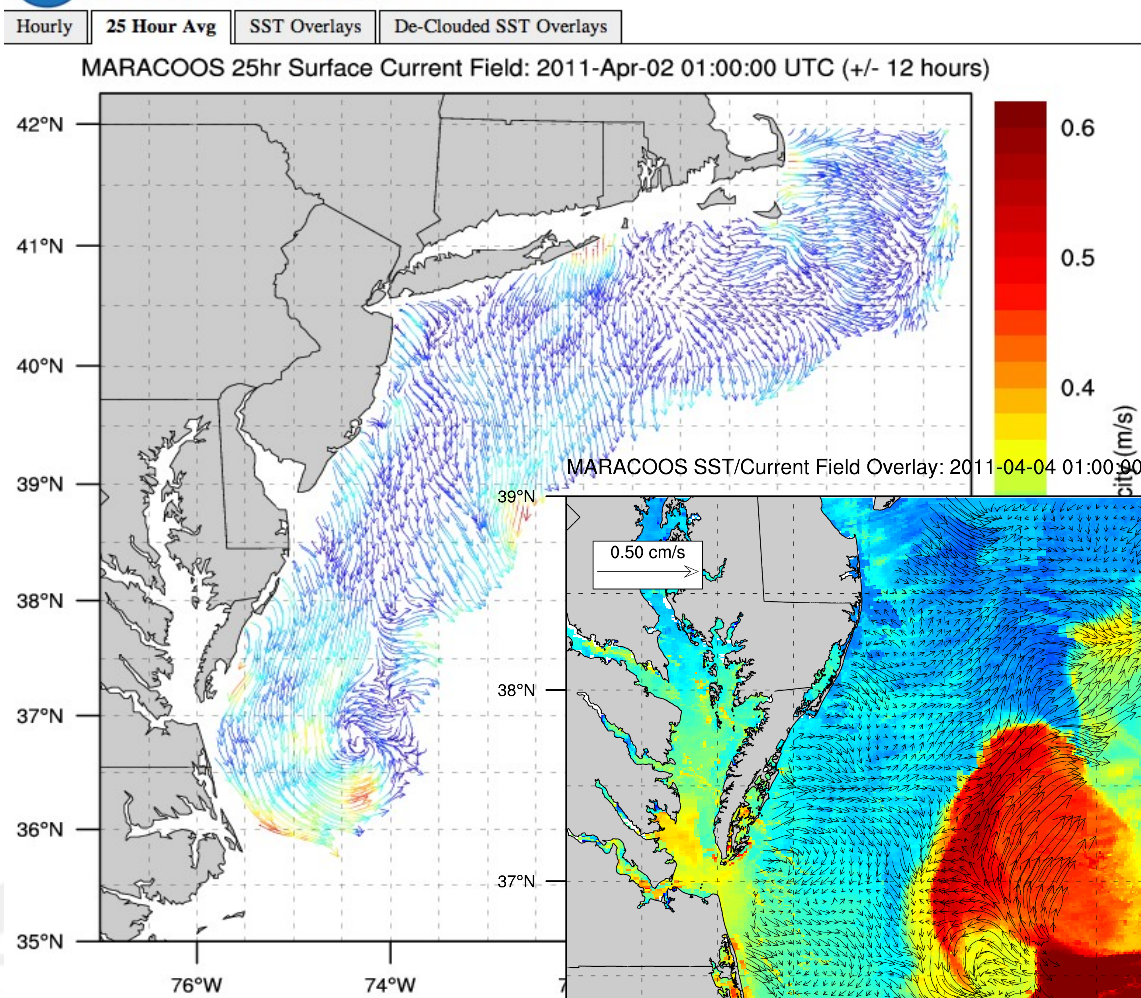
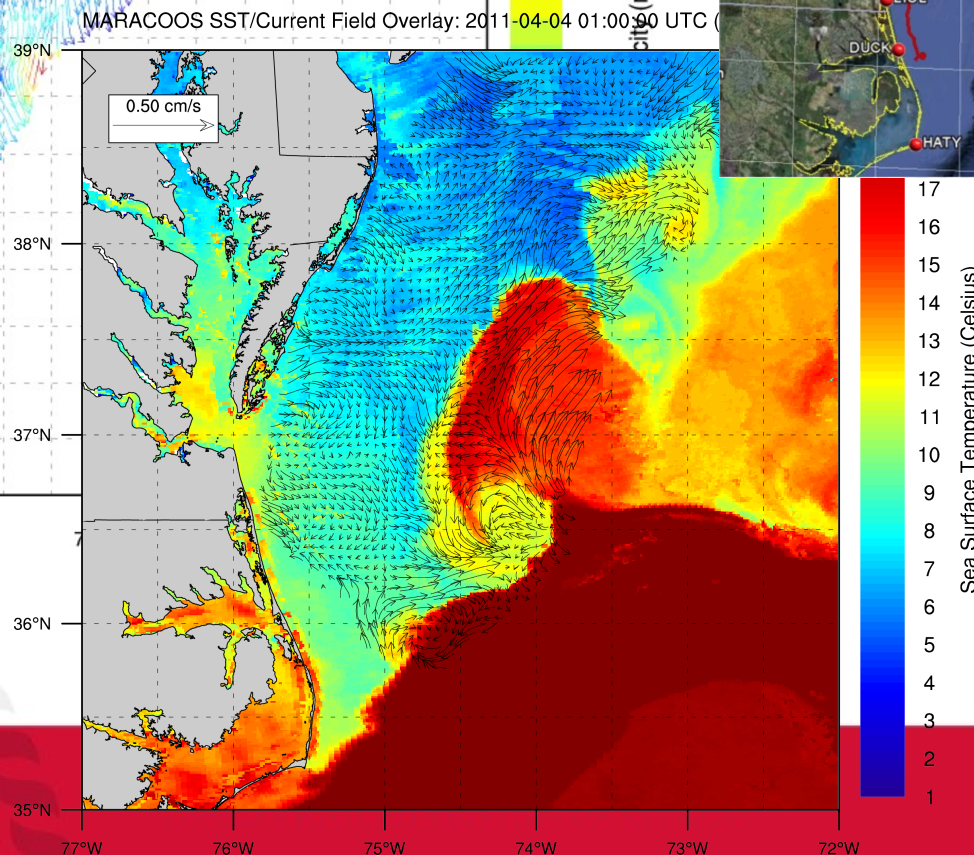
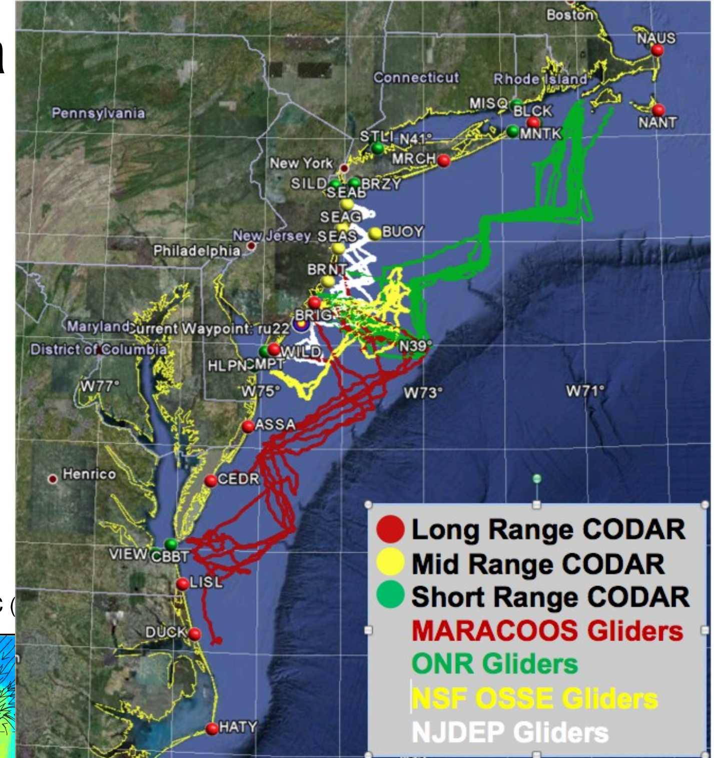
MARACOOS Regional Real-time Data

MARACOOS
Ocean Information for a Changing World



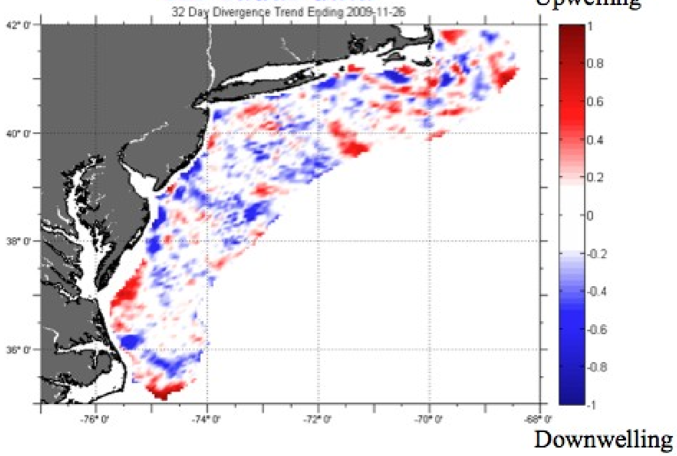




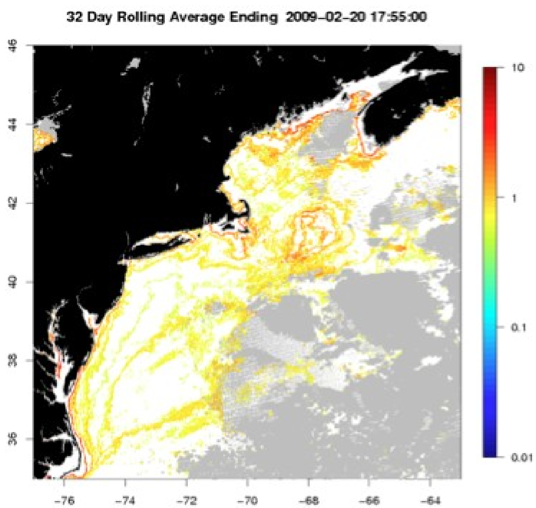
Combining MARACOOS Spatial Data with Fisheries Distribution Data

New Product: Butterfish Bycatch Reduction Model

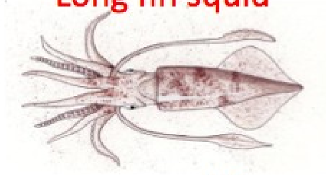
HF radar data



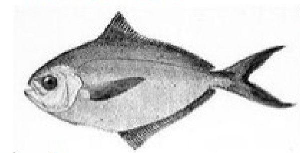
Satellite data



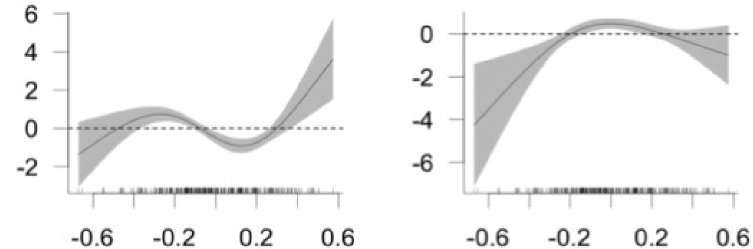
Long fin squid



Butterfish

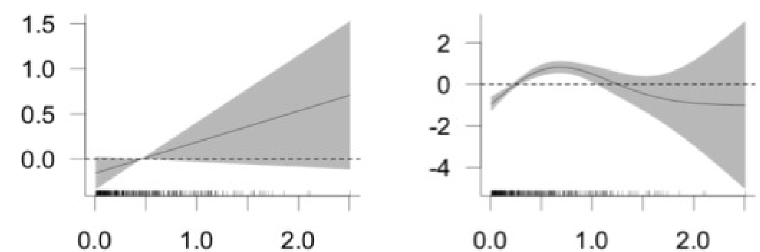


Divergence index



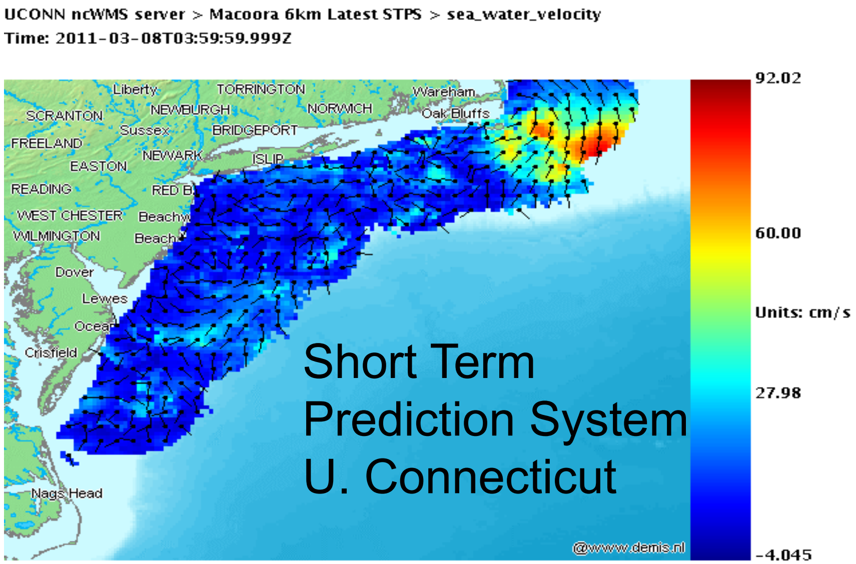
Downwelling Upwelling

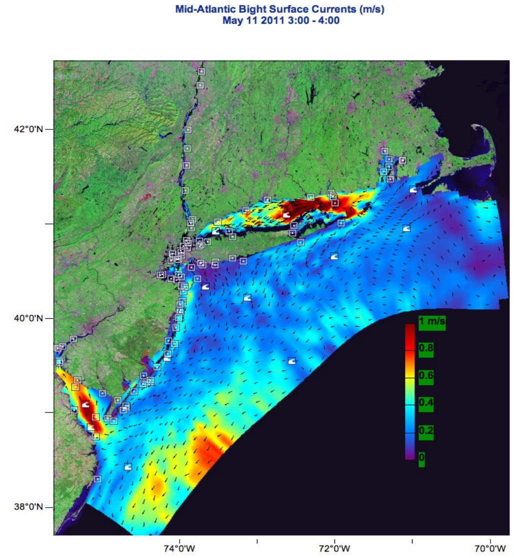
Frontal index



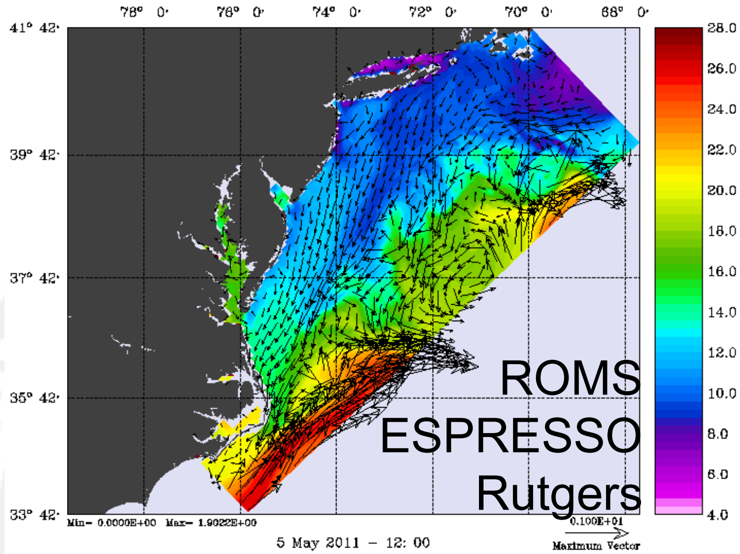
Distance: Far Close
Strength: Weak Strong

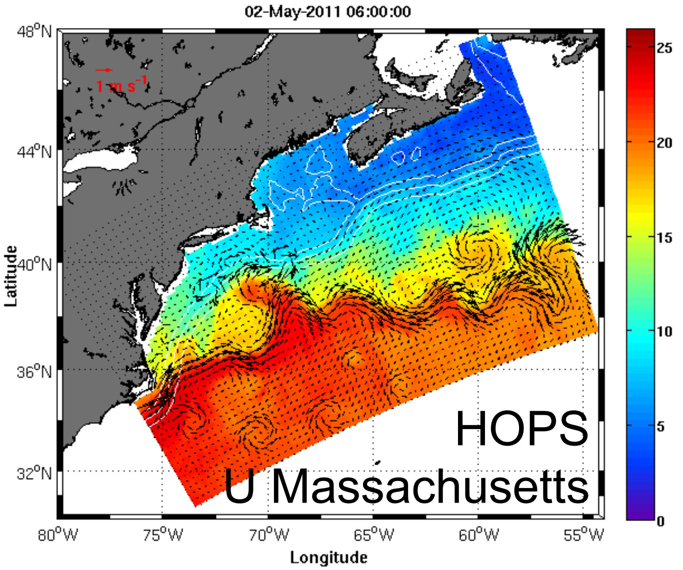
MARACOOS Ocean Forecast Models



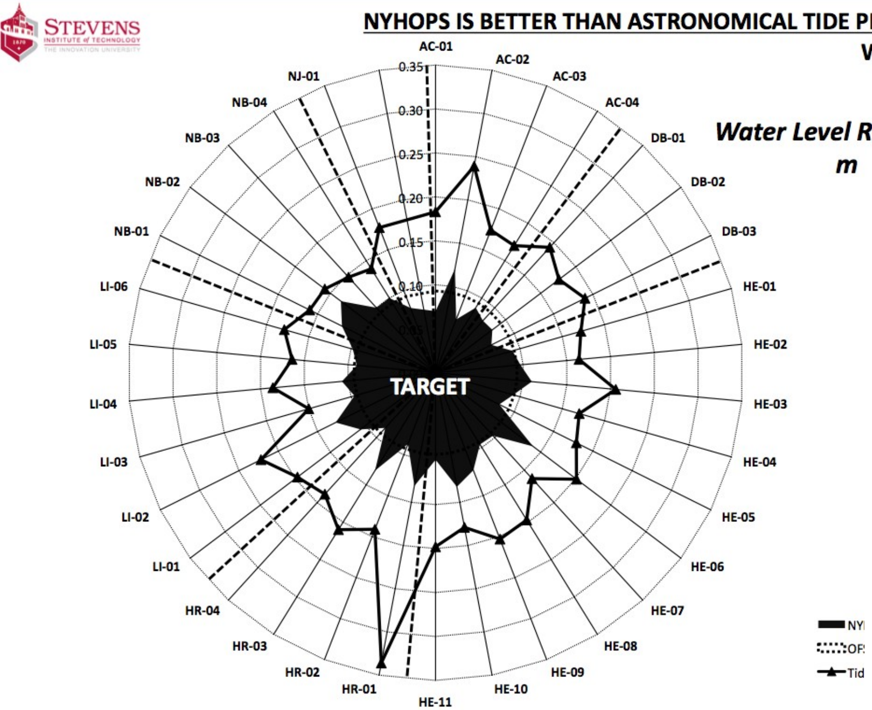


NY-HOPS
Stevens
Institute
Technology





Ocean Models Still Validated Against Standard Measures

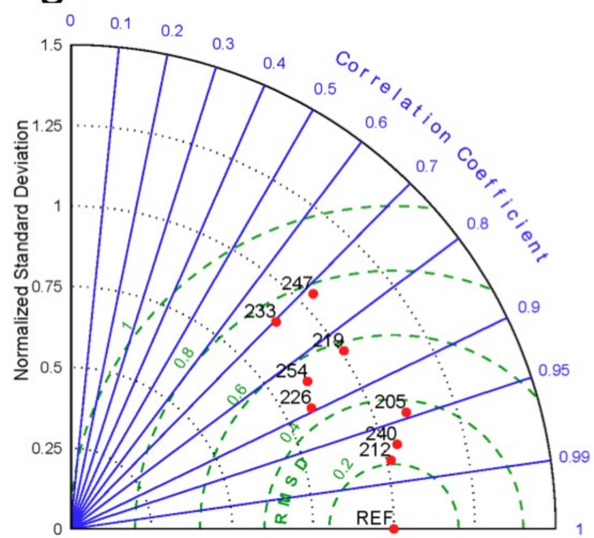


NY HOPS Compared to Sea Level Height Observations

UMass HOPS

Multiscale Forecast Validation

Large-scale Gulf Stream front weekly forecast

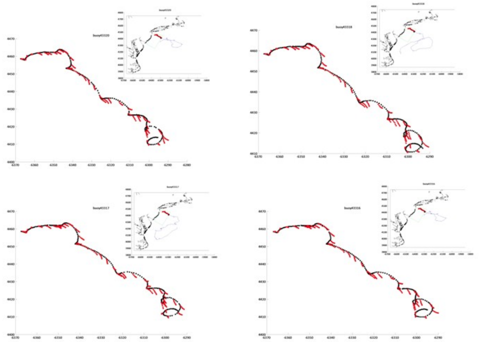


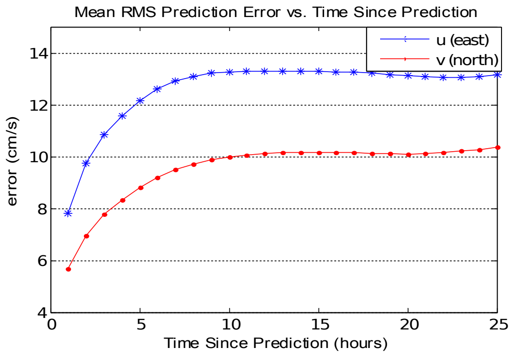
Taylor (2001) diagrams provide a statistical summary of how well model simulation and observation patterns match each other in terms of their correlation coefficient (R), their root-mean-square difference (E), and the ratio of their standard deviations (σ)

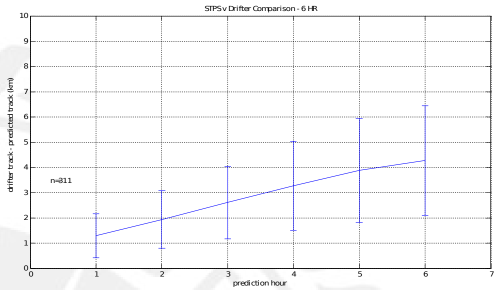
The normalized Taylor Diagram showing the model skill for seven-day forecasting of the Gulf Stream axis (the 15°C isotherm at 200 m) during the eight weekly runs denoted by their starting yeardays (212 through 254).

Forecast Model Comparisons to Drifters

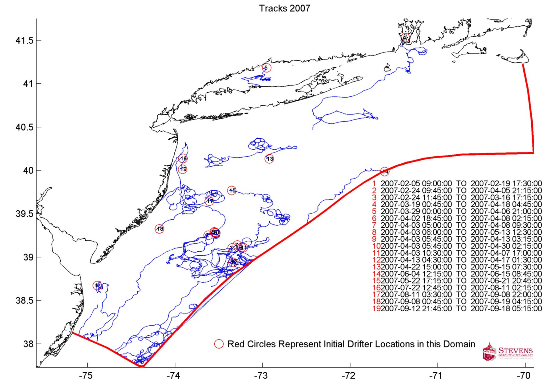
Uconn STPS

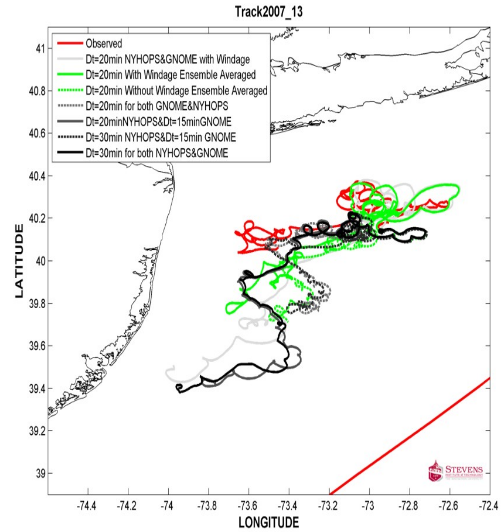






NY HOPS





UMass HOPS

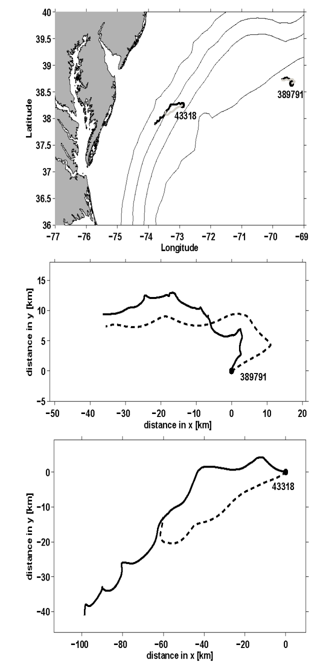


Figure 13: Drifter 43313 trajectories of model (gray) and data (black) for yearday 254. First-day simulation starting on 09/04/2006 at 0 hour. The black lines are the 200, 1000, 2000 and 3000 isobaths.

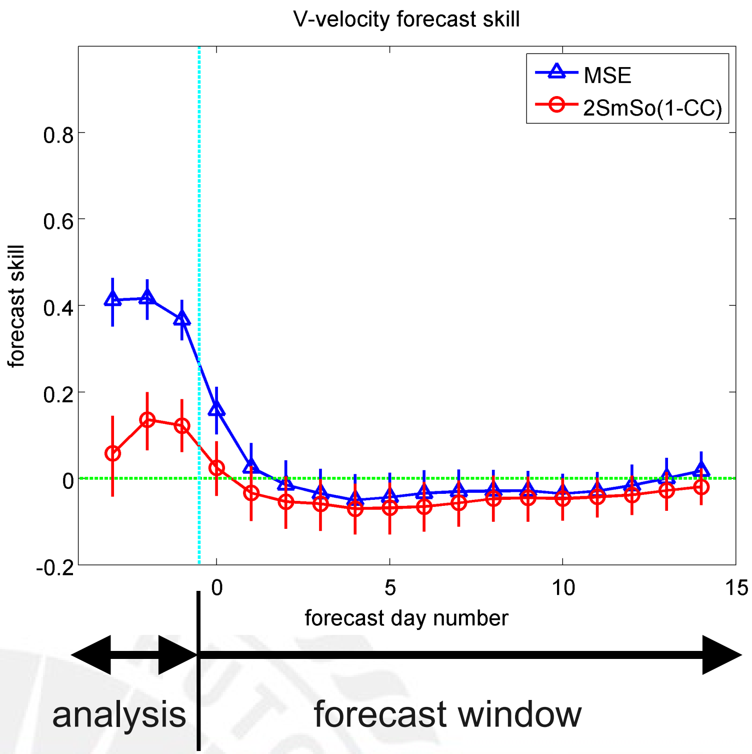
48

Surface velocity forecast skill improves with CODAR assimilation

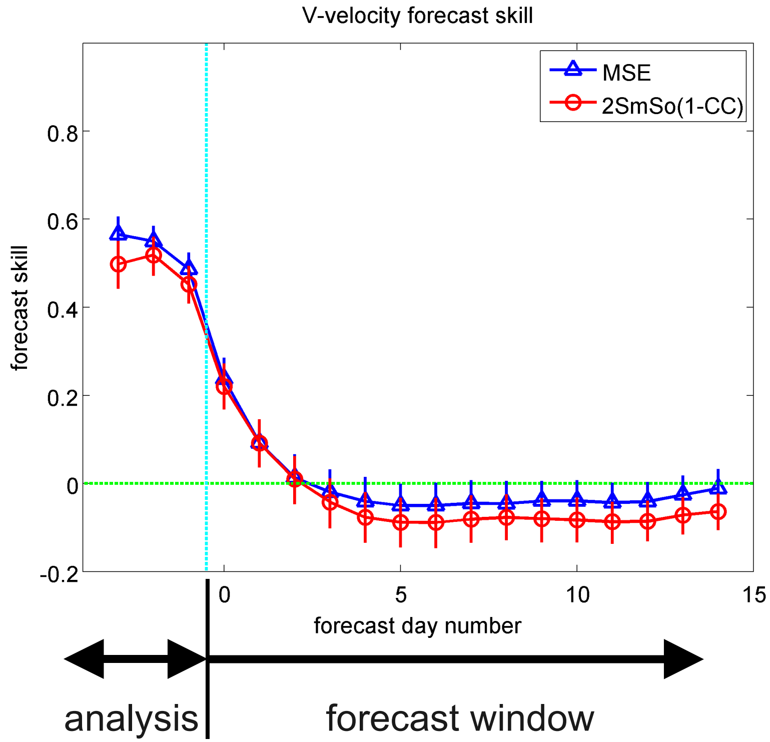
This analysis for ROMS LaTTE domain (NY Bight). 2-day forecast skill significantly improved for cross-correlation (submesoscale pattern variability)

MSE = mean squared error
CC = cross-correlation; Sm and So are std. dev. of model and obs

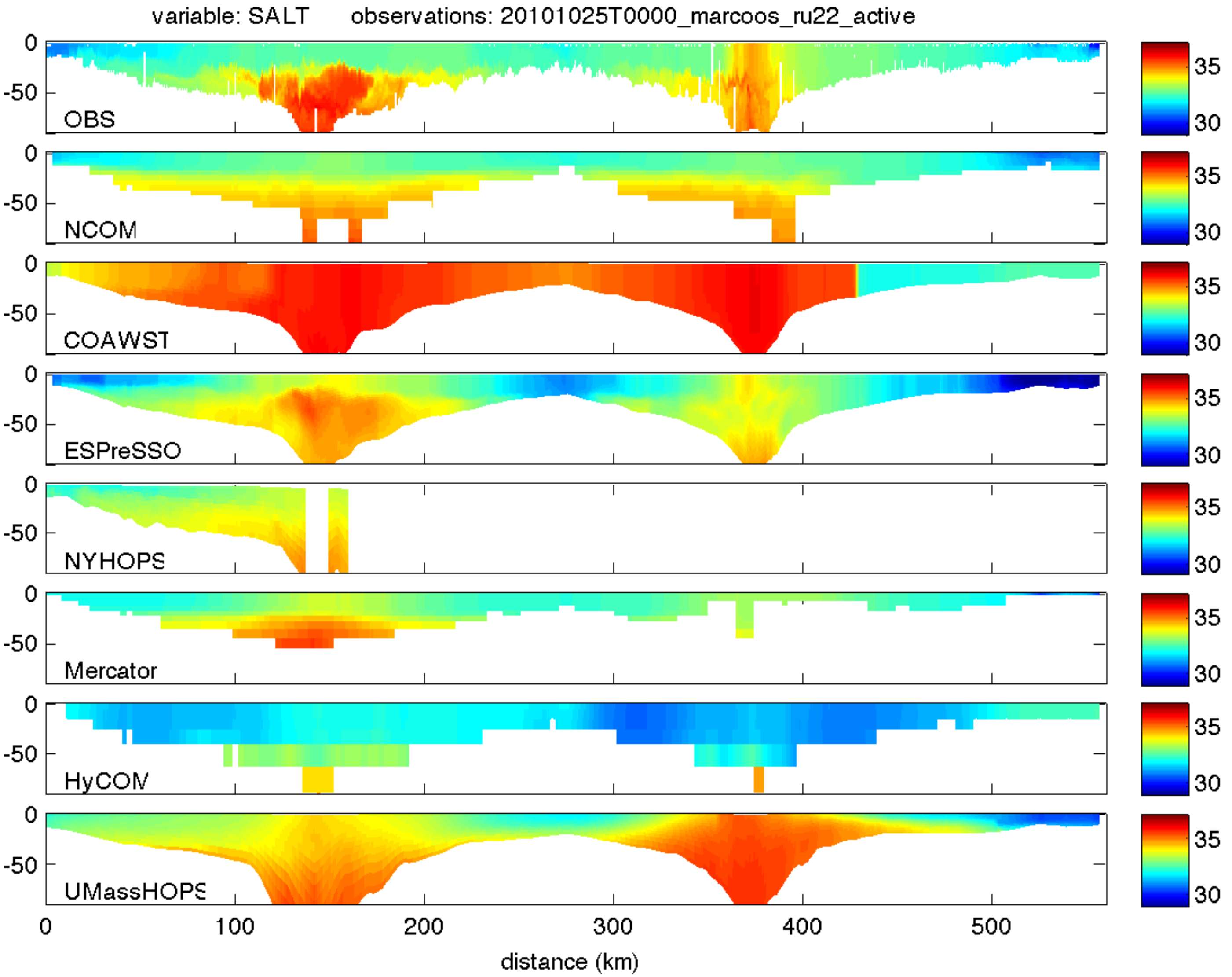
no assimilation of CODAR data

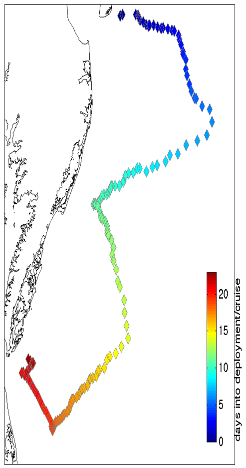


after assimilating CODAR data



Forecast Model Comparison with Subsurface Glider Data: Salinity





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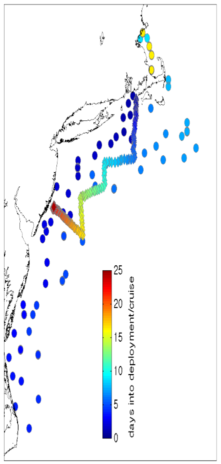
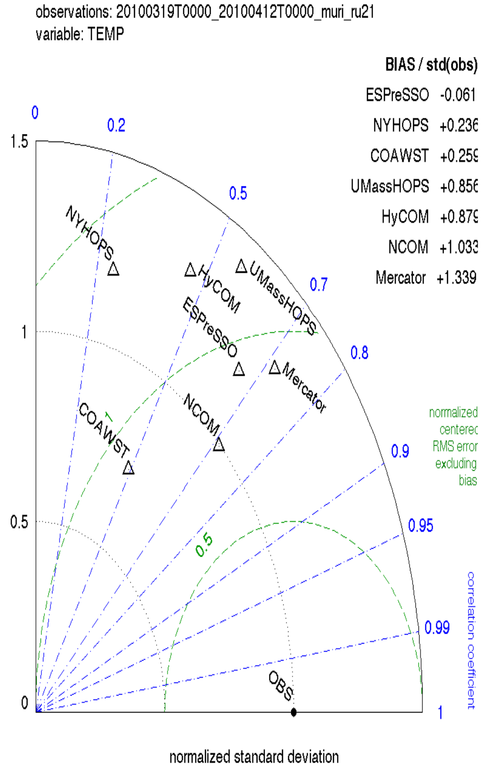
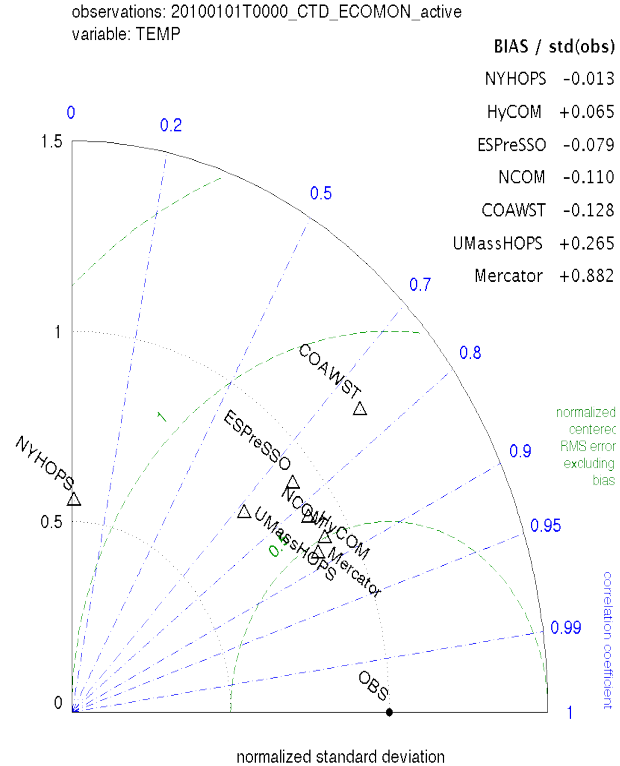
Two example validation data sets: Glider RU21 and NOAA ECOMON ship survey CTDs







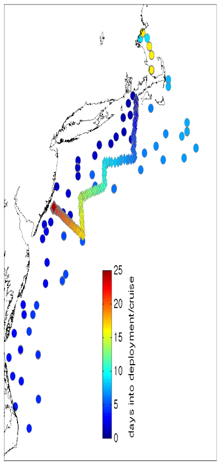
In Taylor diagrams, distance from OBS to MODEL (green dashed contours) depicts centered (bias removed) root mean squared error RMSE’ normalized by observation standard deviation.

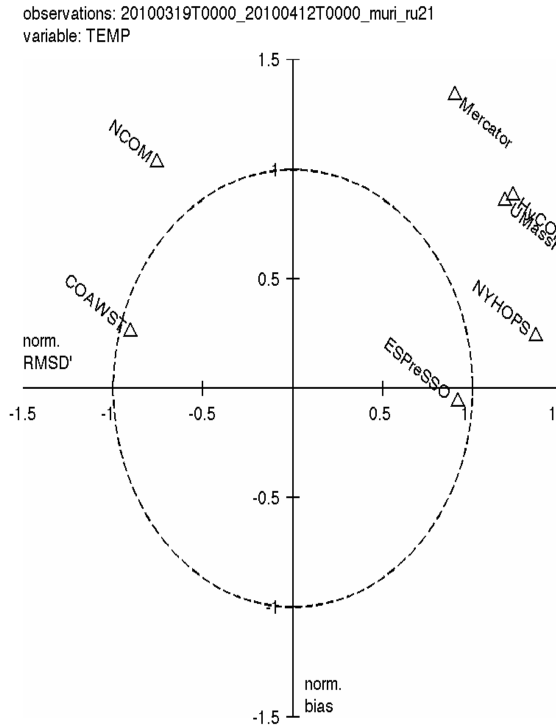
BIAS is tabulated separately in order of decreasing skill.

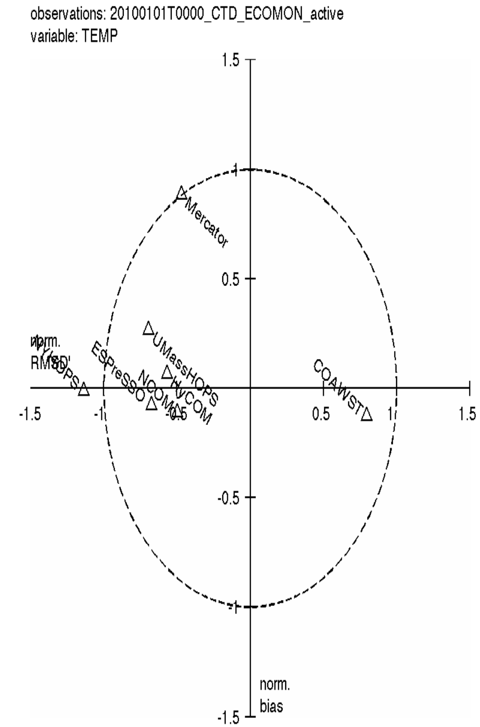
Comparison is for all operational models that include Mid-Atlantic Bight.

Global: HyCOM, NCOM, Mercator
Regional: NYHOPS, ESPreSSO, UMassHOPS. COAWST

Two example validation data sets: Glider RU21 and NOAA ECOMON ship survey CTDs





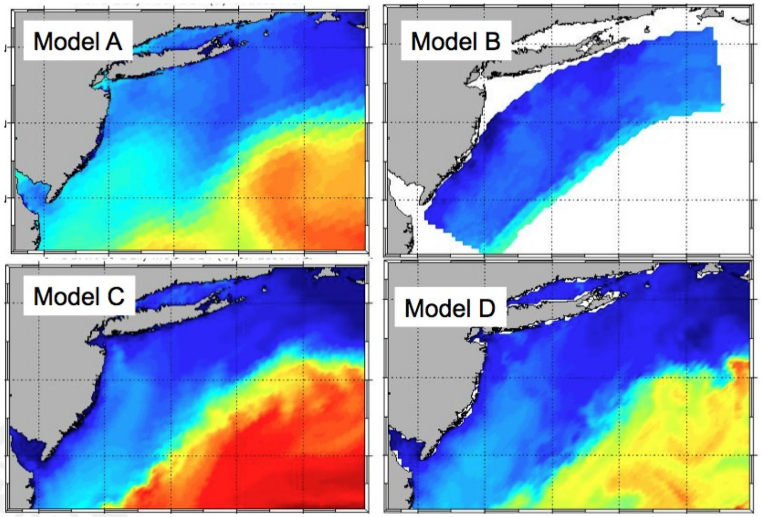


In Target diagrams, distance on y-axis is BIAS and distance on x-axis centered (bias removed) root mean squared error RMSE' normalized by observation standard deviation.

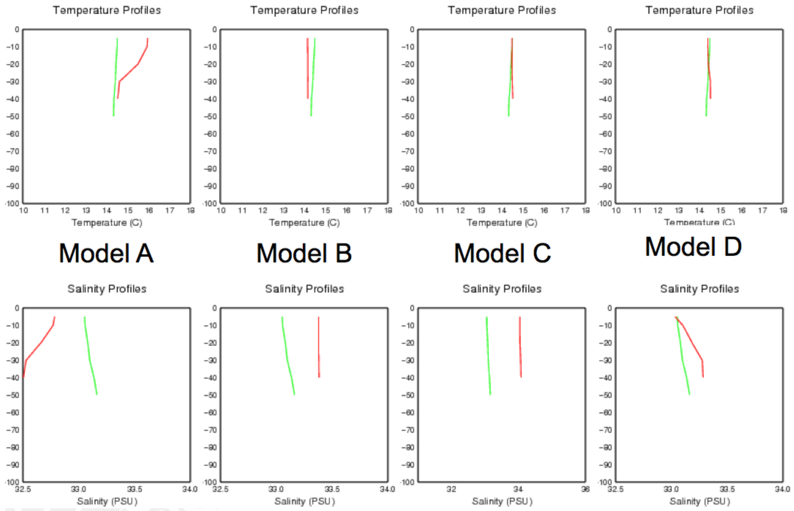
Comparison is for all operational models that include Mid-Atlantic Bight.

Global: HyCOM, NCOM, Mercator
Regional: NYHOPS, ESPreSSO, UMassHOPS. COAWST

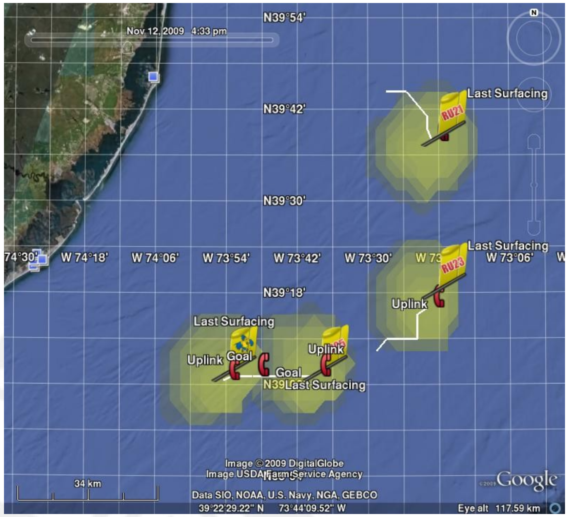
Glider Adaptive Sampling based on Ensemble of Ocean Forecasts



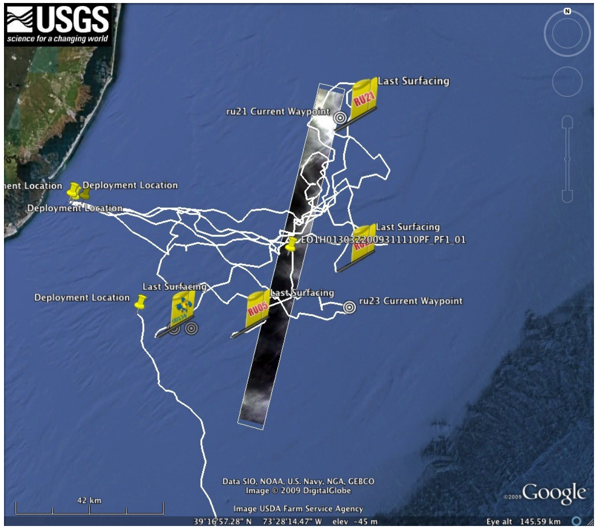
Ensemble of 4 Forecasts



Model-Data Profile Comparisons

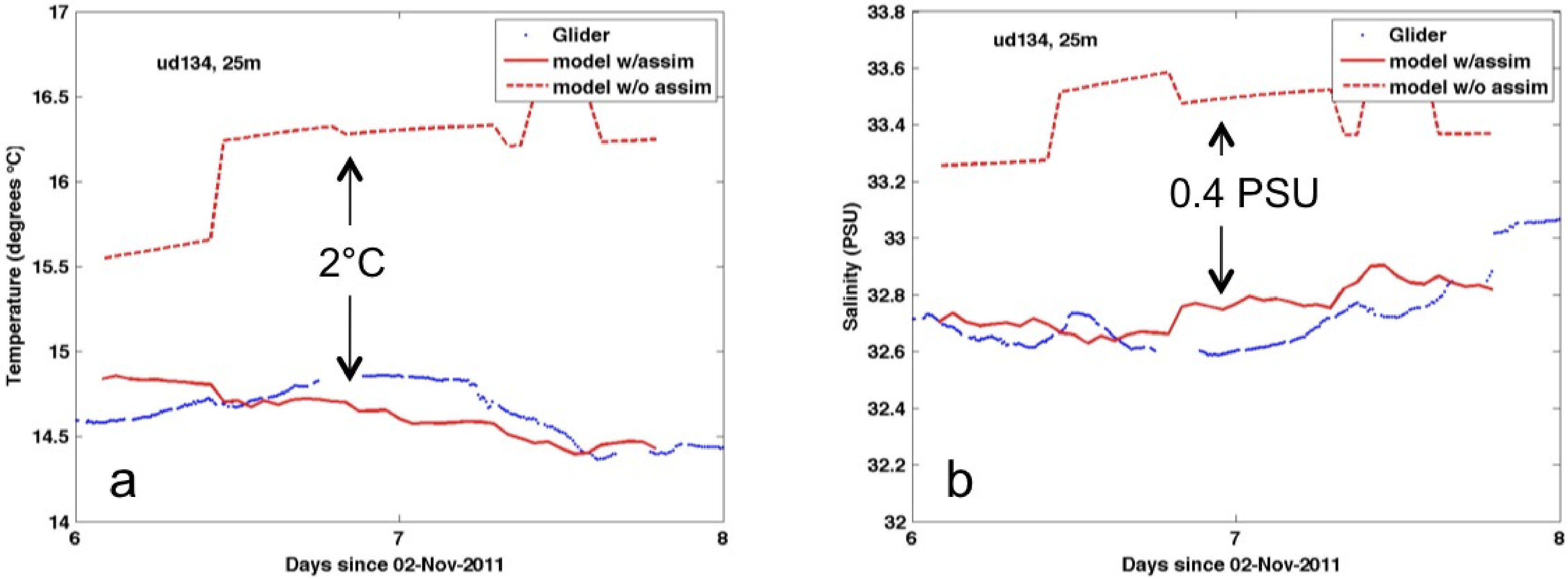


Forecast Currents determine Glider Range



Gliders Retasked based on Objectives

Multiscale Forecast Validation Glider data (t, s) assimilation



Independent Glider (UD134) data at 25-m for (a) temperature and (b) salinity, compared to the SMAST-HOPS 02 Nov 2009 runs. Only RU05, RU21 and RU23 data were assimilated (UD134 was not) during the first week. Glider data are shown with blue the model run with glider assimilation is shown with a red solid line, and the model run with no glider assimilation is shown with a dashed red line. Note the difference between assimilation and non-assimilation runs for temperature is about 2°C; while that for salinity is about 0.4 psu.

Conclusions:

- Sustained Regional Observing Networks are Proven
- Ensemble Ocean Forecast Models are a Useful Tool
- Emphasis is Shifting toward support for Societal Goals
- Workforce Development is Still Required