

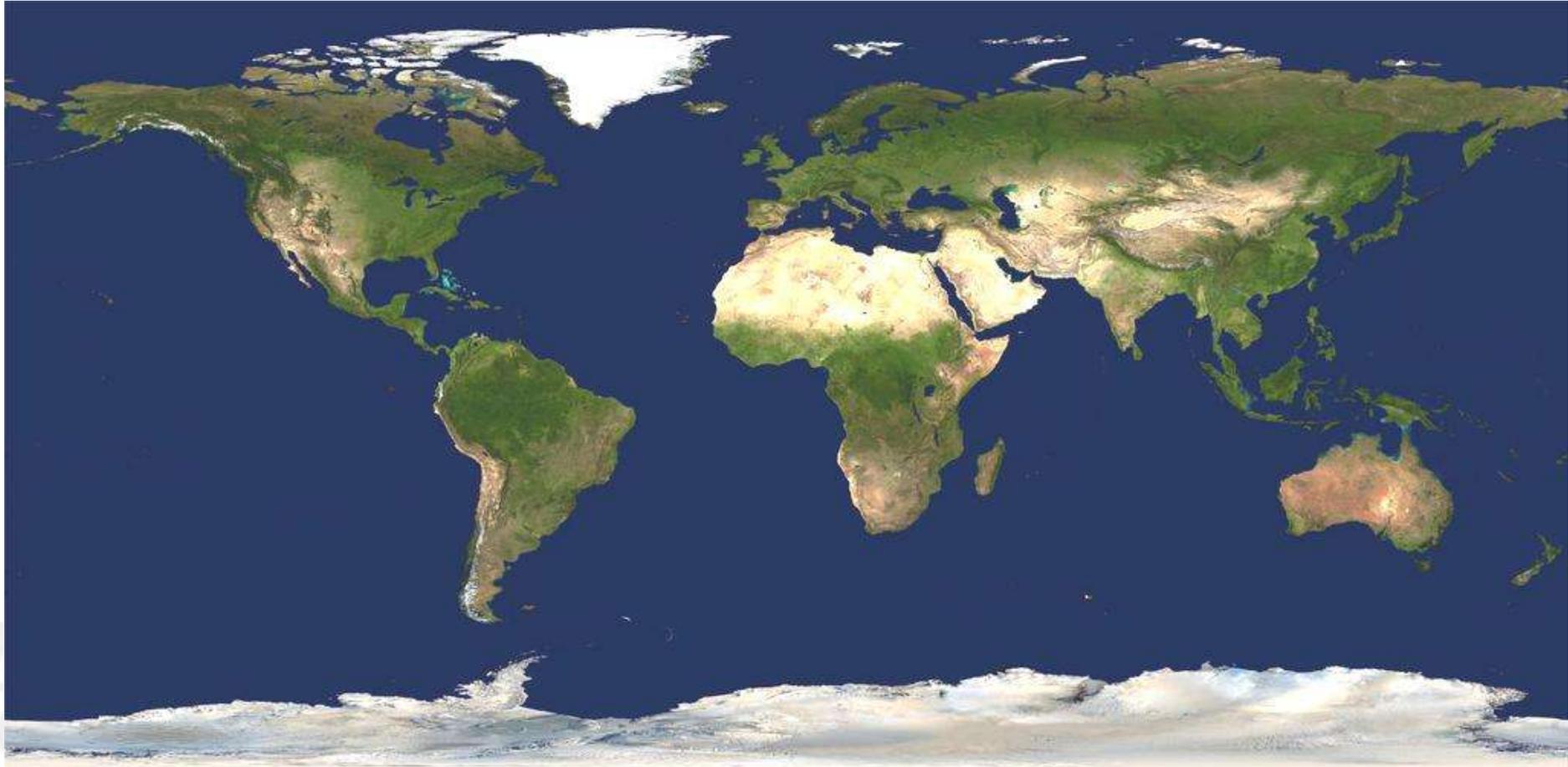
# A Robot's View of Our Ocean Planet

**Dr. Josh T. Kohut**  
**Rutgers University**

**MANY MANY MANY OTHERS**

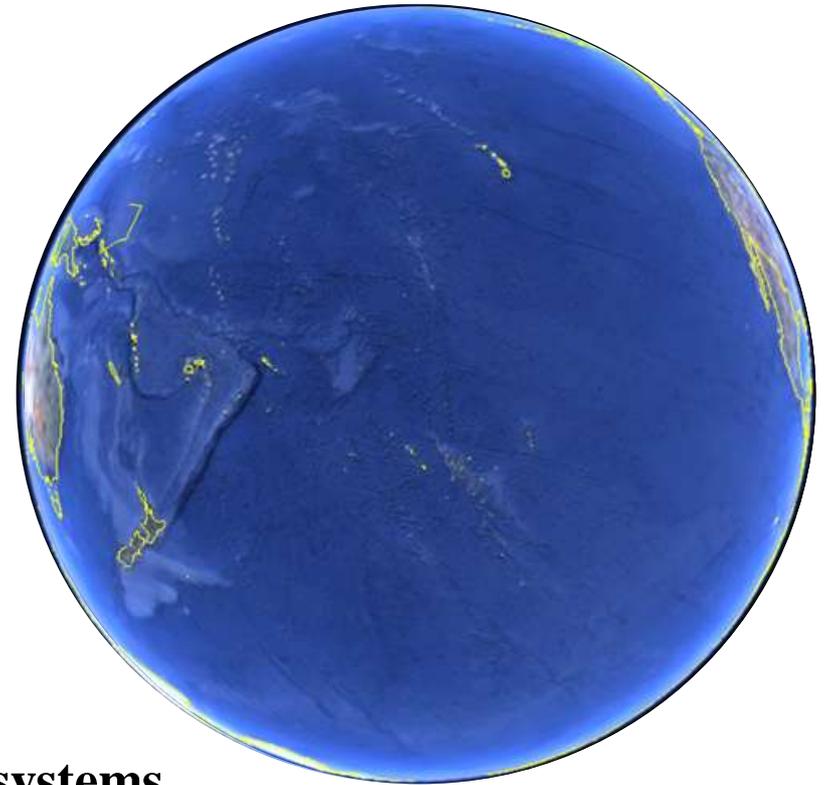


# How Many Oceans Are there?

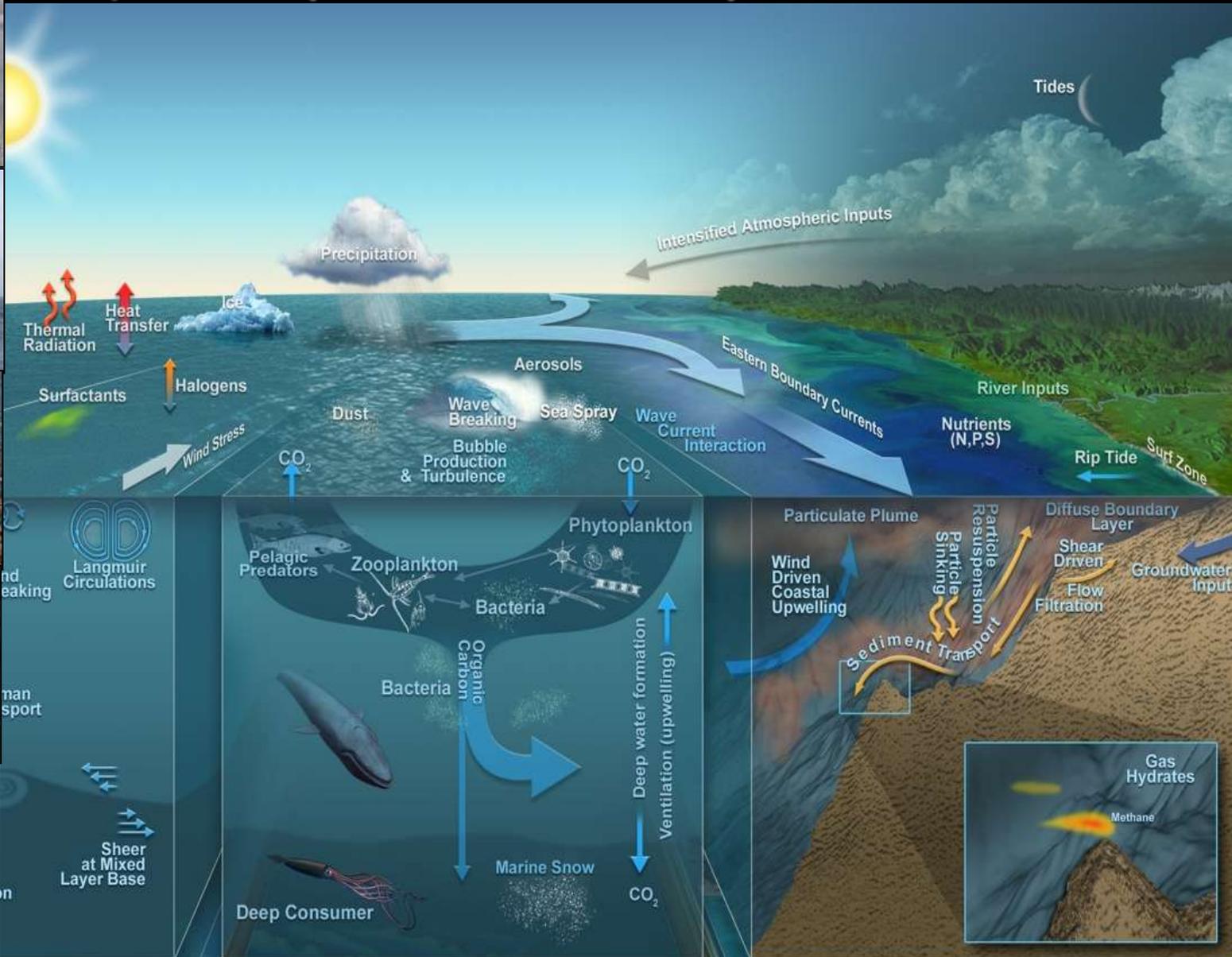


# Our Global Ocean...

- covers 71% of the Earth's surface.
- contains 97% of the Earth's water.
- has an average depth of 12,430 feet.
- supports a great diversity of life and ecosystems.
- is a major influence on weather and climate, making earth habitable.
- has had less than 10% explored by humans.

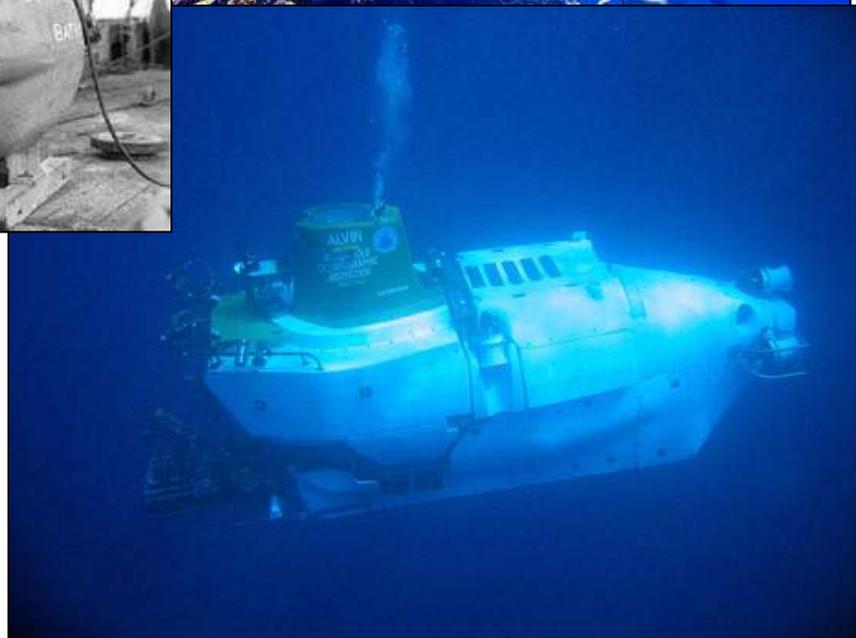
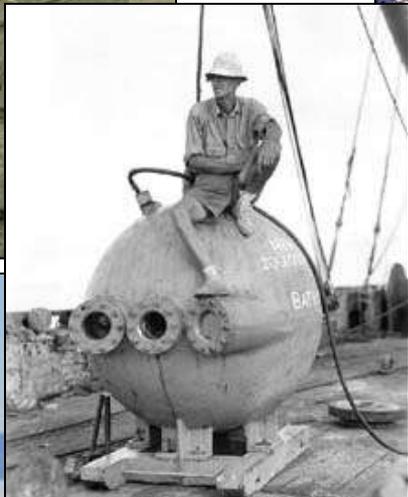


# Aquatic systems are complex



# Exploring our Global Ocean: The Early Days





# Discrete vs. Continuous













66



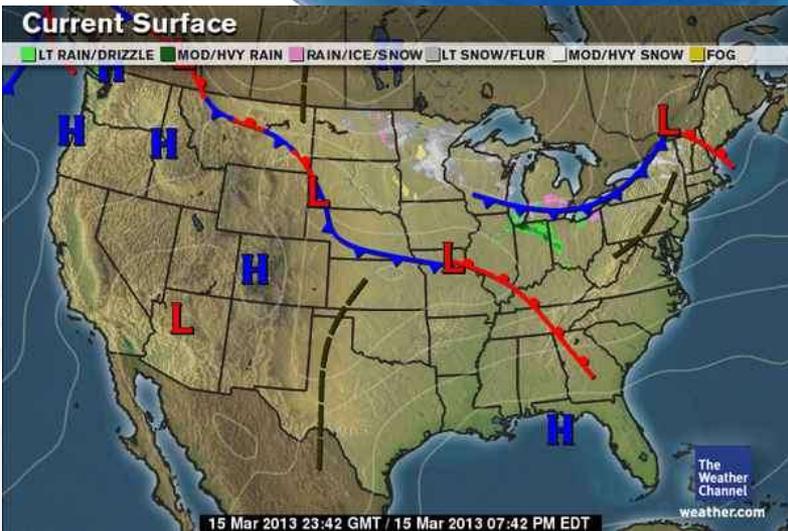
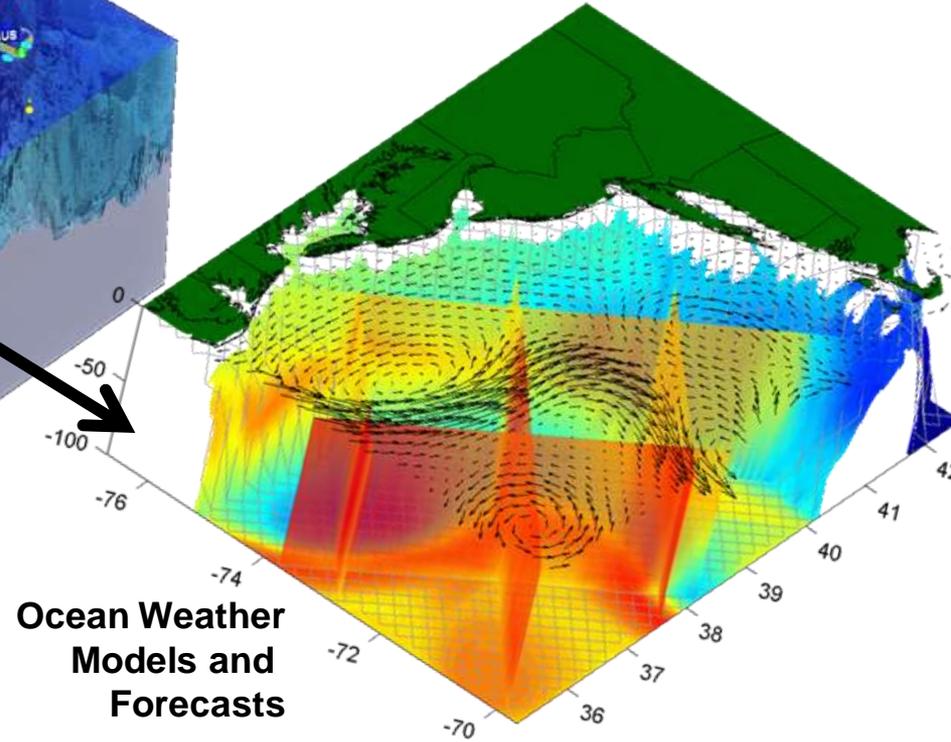
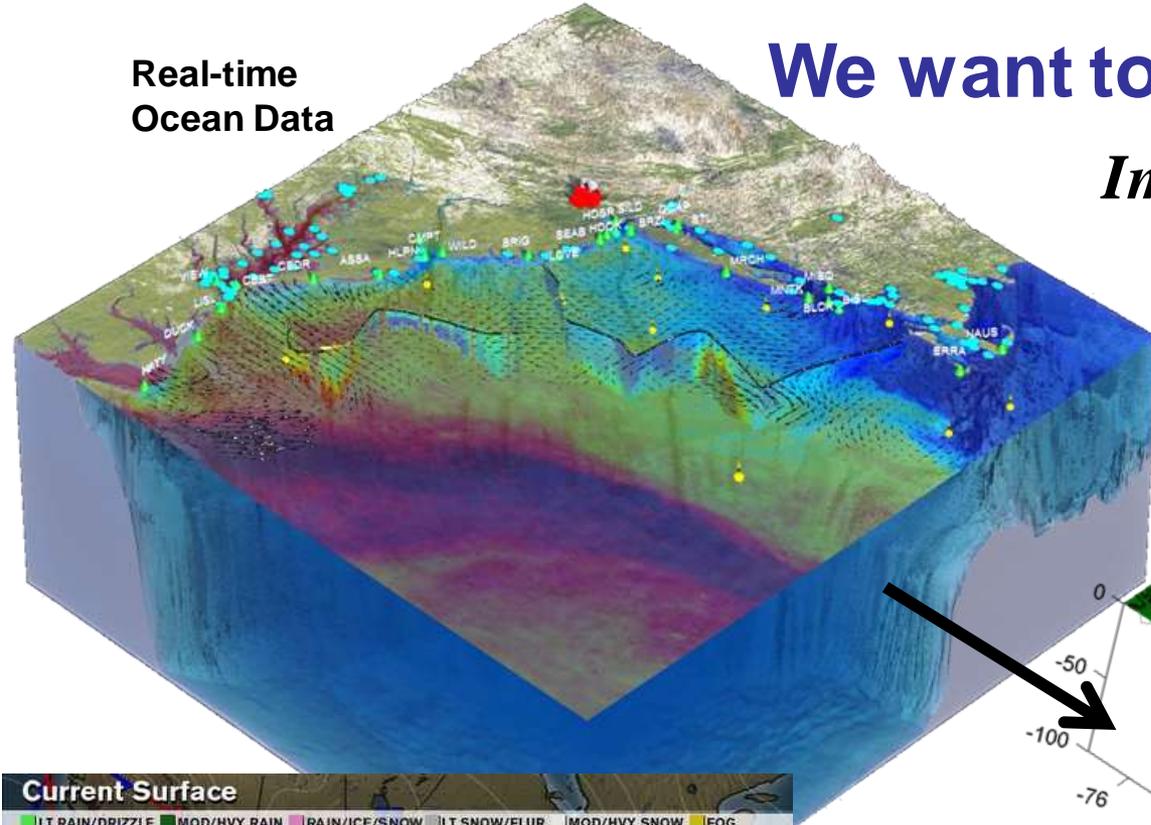
# Now for what really happened... (Continuous Data)



Real-time  
Ocean Data

# We want to see the Ocean in 4D

*Improved Ocean Applications  
and Ecosystem Research*



Ocean Weather  
Models and  
Forecasts

Oil Spill Response  
Coast Guard Search and Rescue  
Fisheries Science and Management  
Climate and Storm Research

# Rutgers University - Coastal Ocean Observation Lab



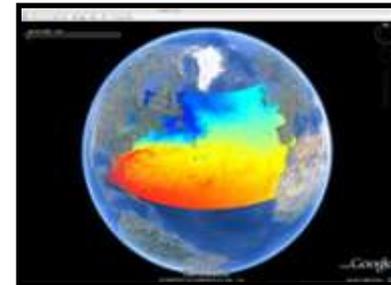
CODAR Network



L-Band & X-Band Satellite  
Receivers

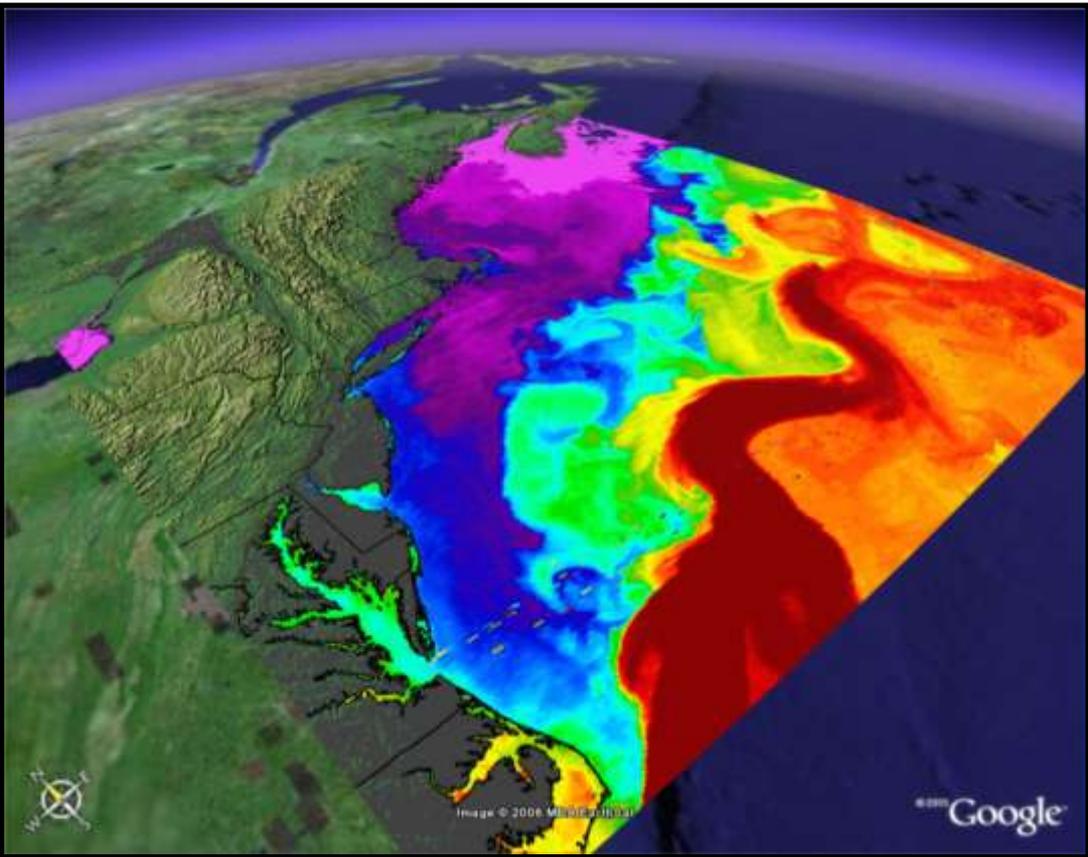


Glider Fleet

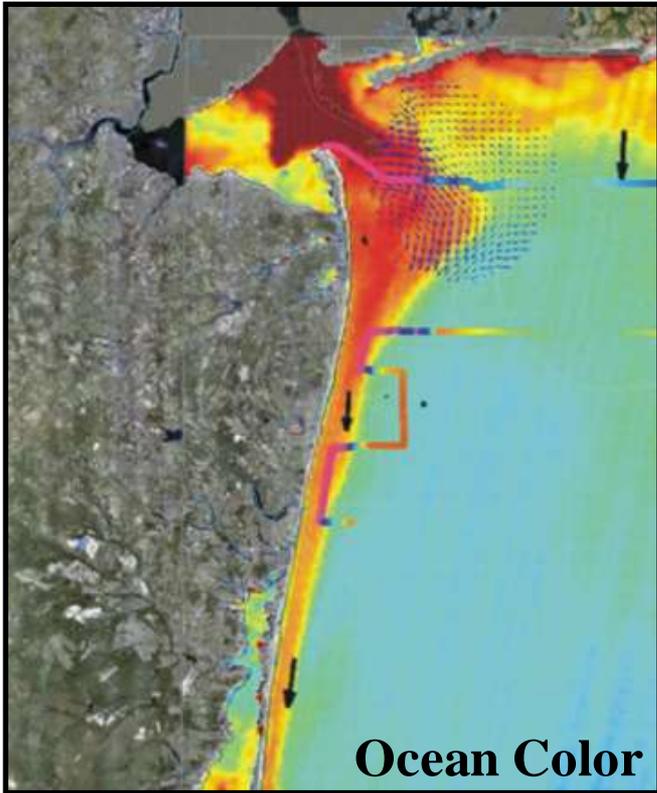


3-D Nowcasts  
& Forecasts

# Seeing the Ocean in Color - Satellites



**Sea Surface Temperature**



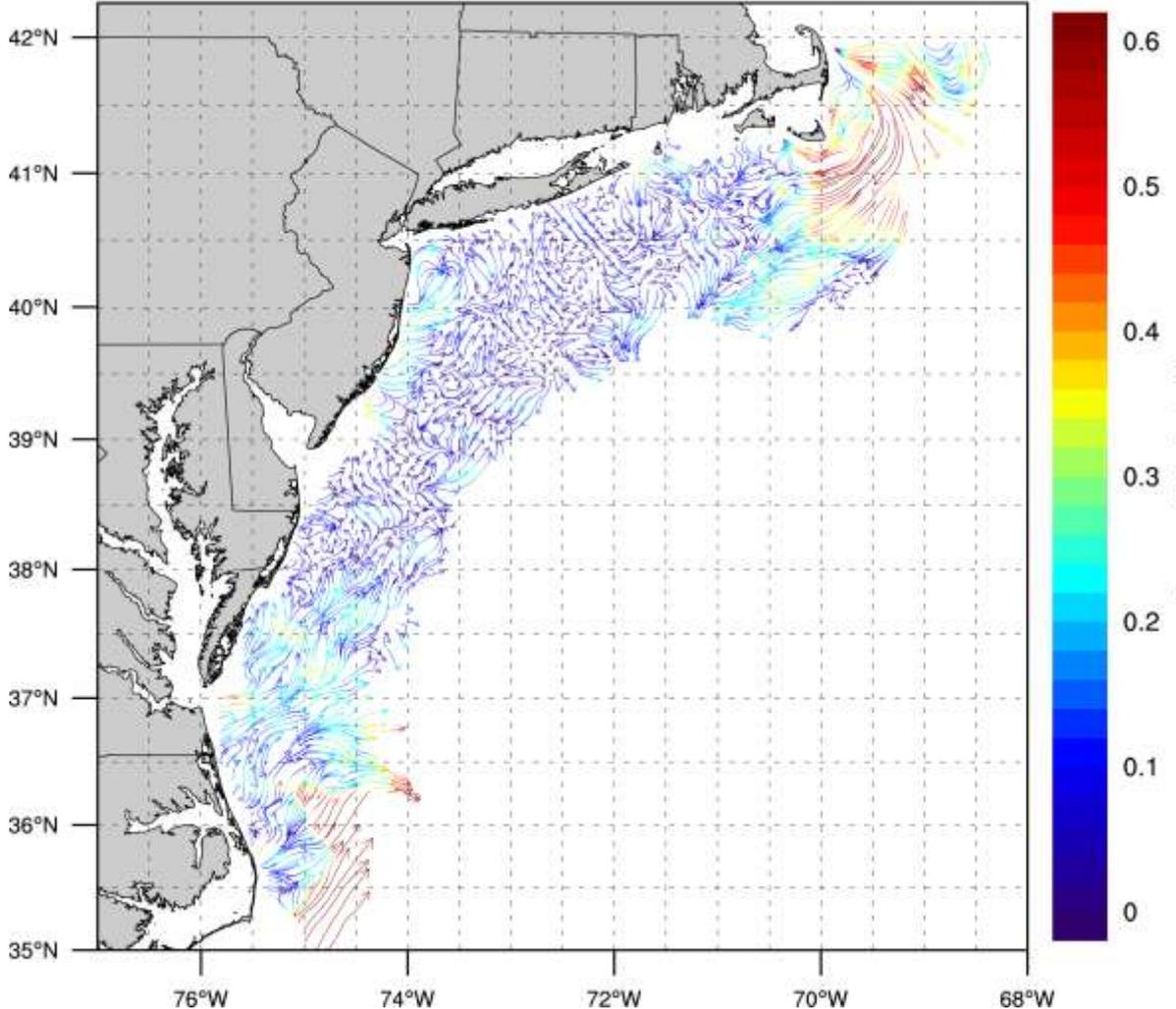
**Ocean Color**

# Ocean Movement - CODAR

## Surface Ocean Currents

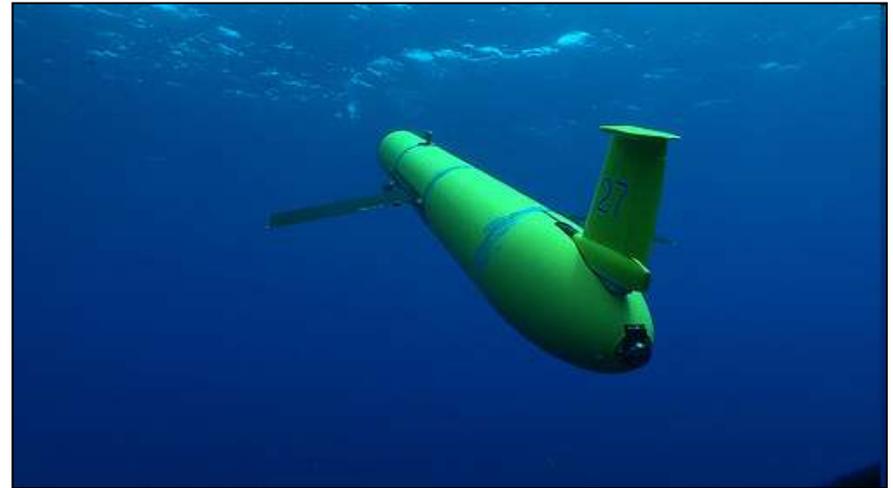


MARACOOS Hourly Surface Current Field: 2011-Sep-13 21:00 UTC



# What is a glider?

- **Autonomous Underwater Vehicle (AUV)**
- **Propels itself without a propeller**
- **Moves slowly through the water collecting data as it goes**

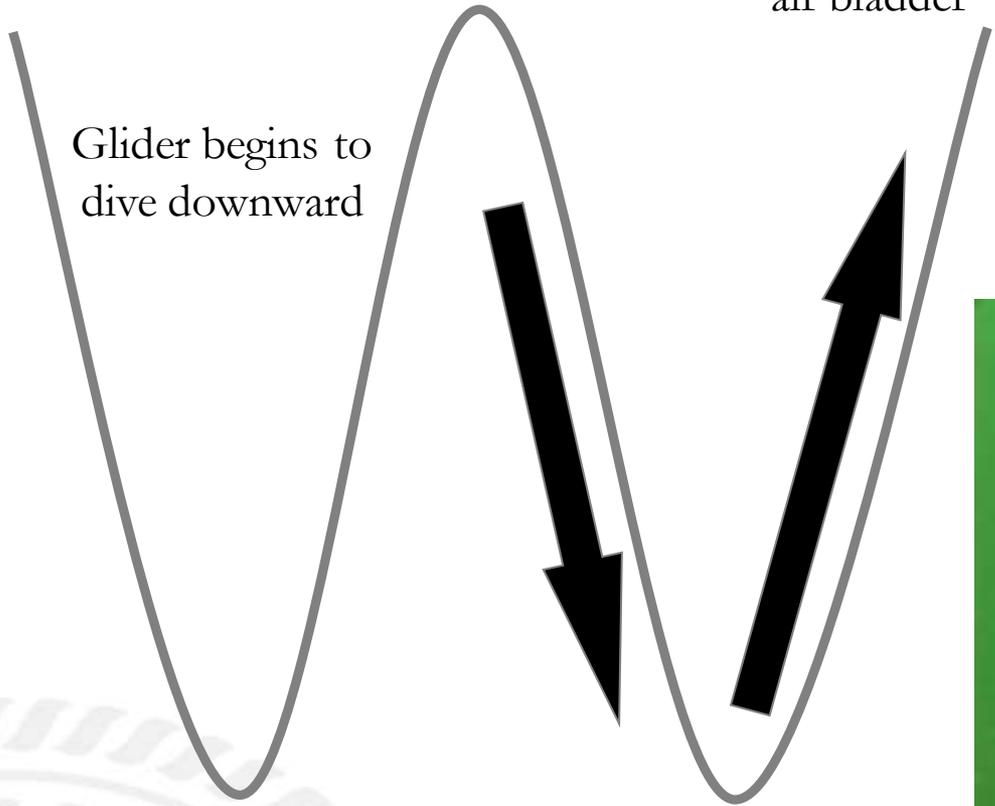


# How gliders “fly”

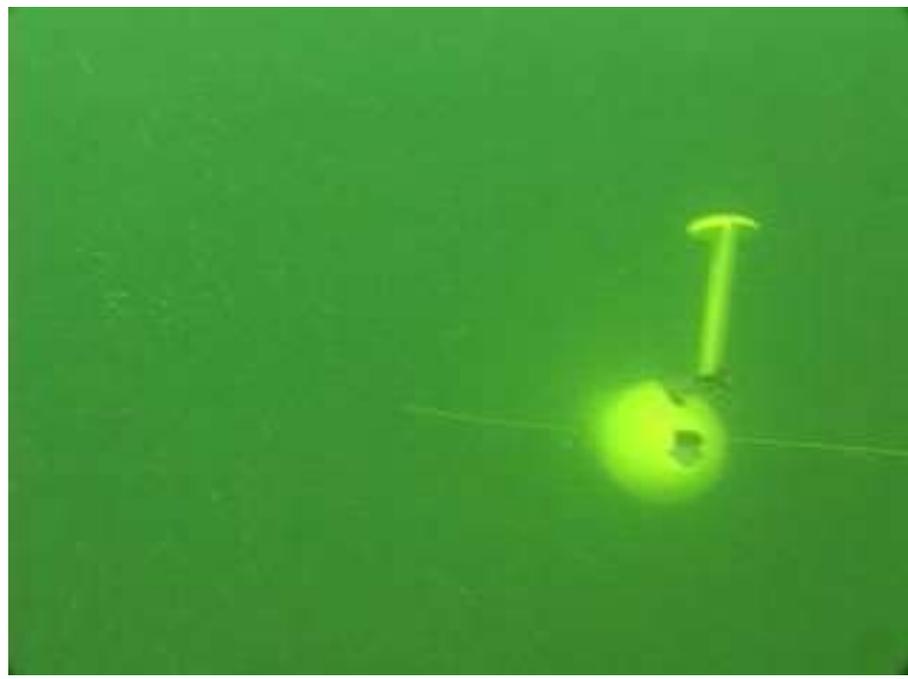
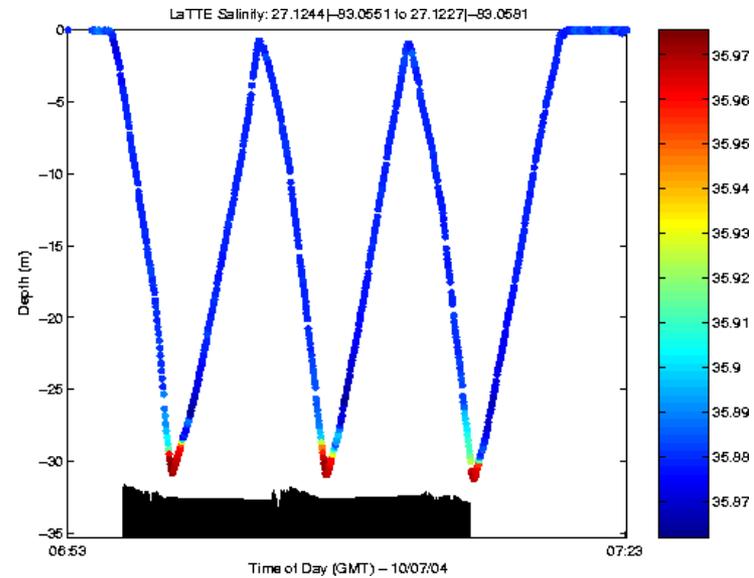
Buoyancy pump in ← the glider pulls in 0.5 L of water

When surfacing to connect glider inflates air bladder

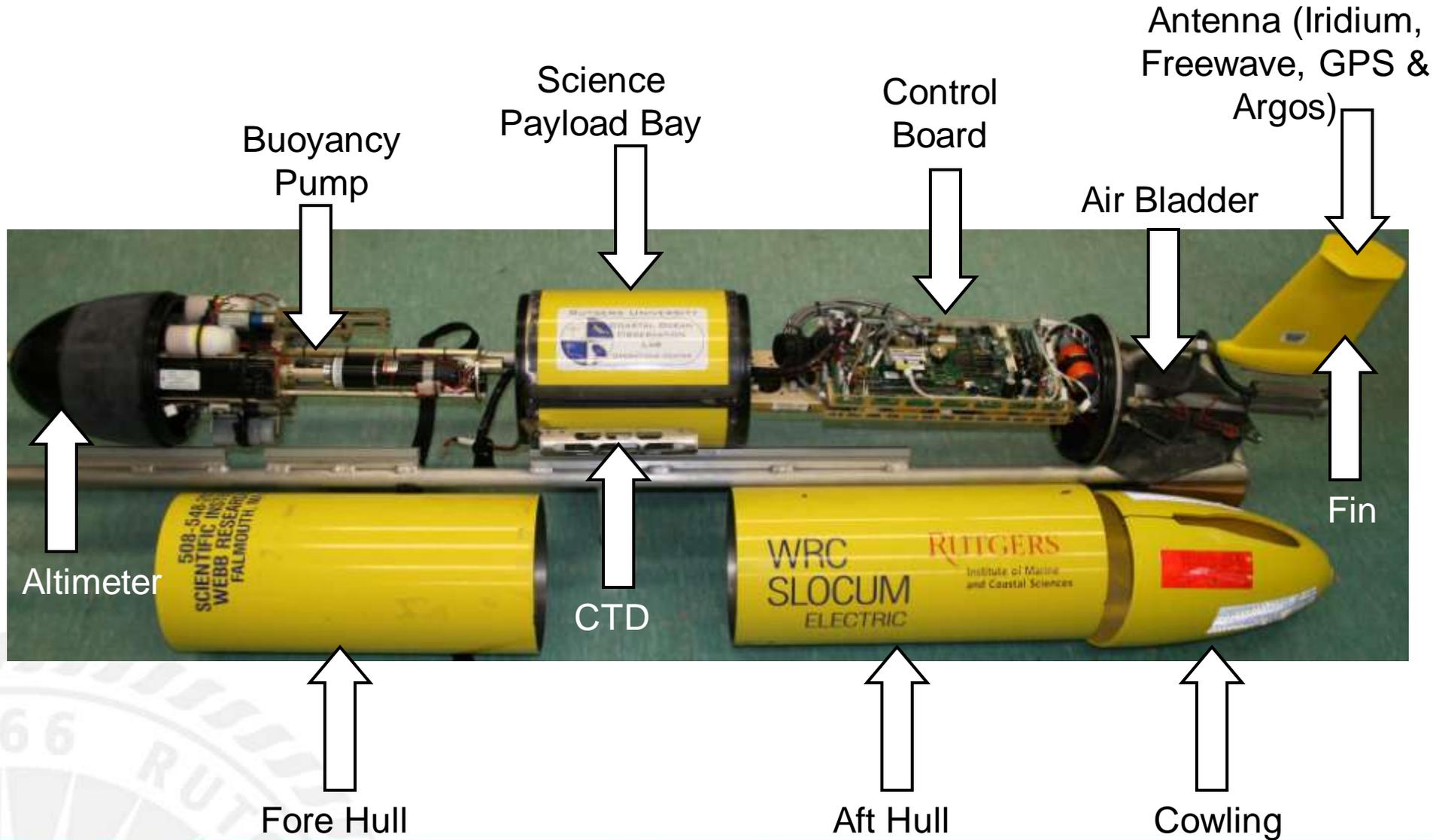
Glider begins to dive downward



Push pump out → glider inflects and begins to climb to the surface



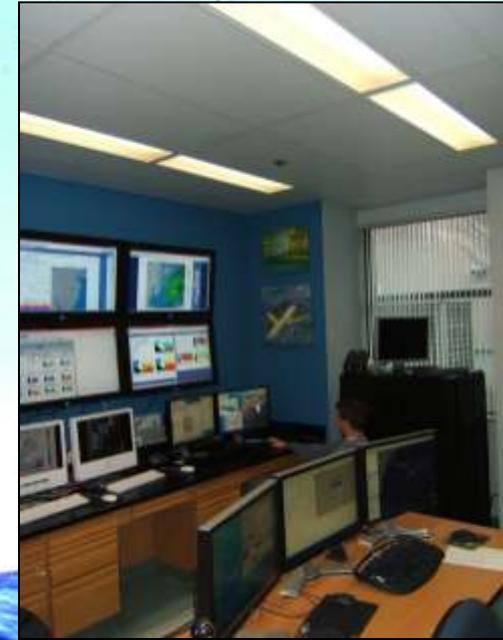
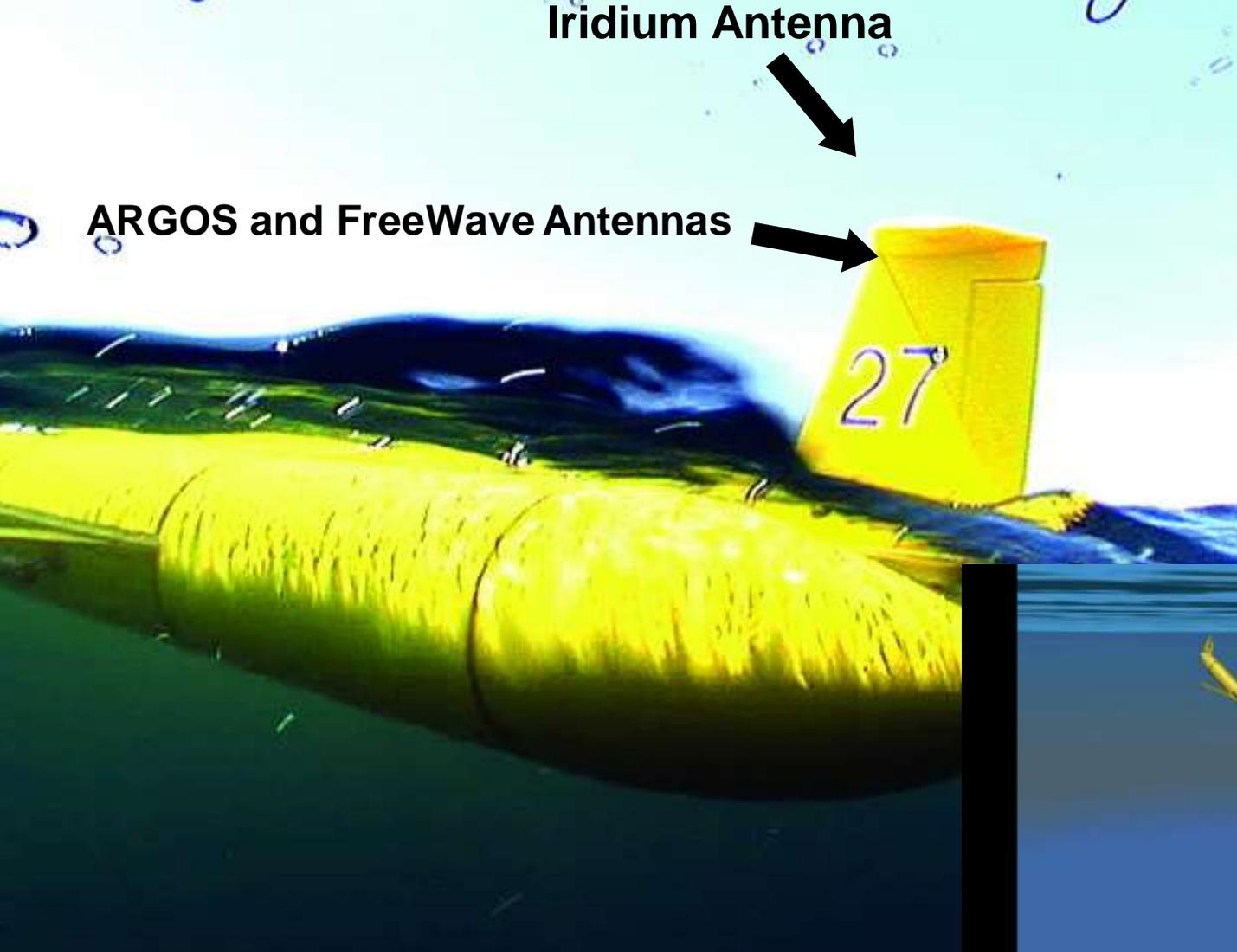
# Anatomy of a Glider



# Slocum Electric Glider Communication

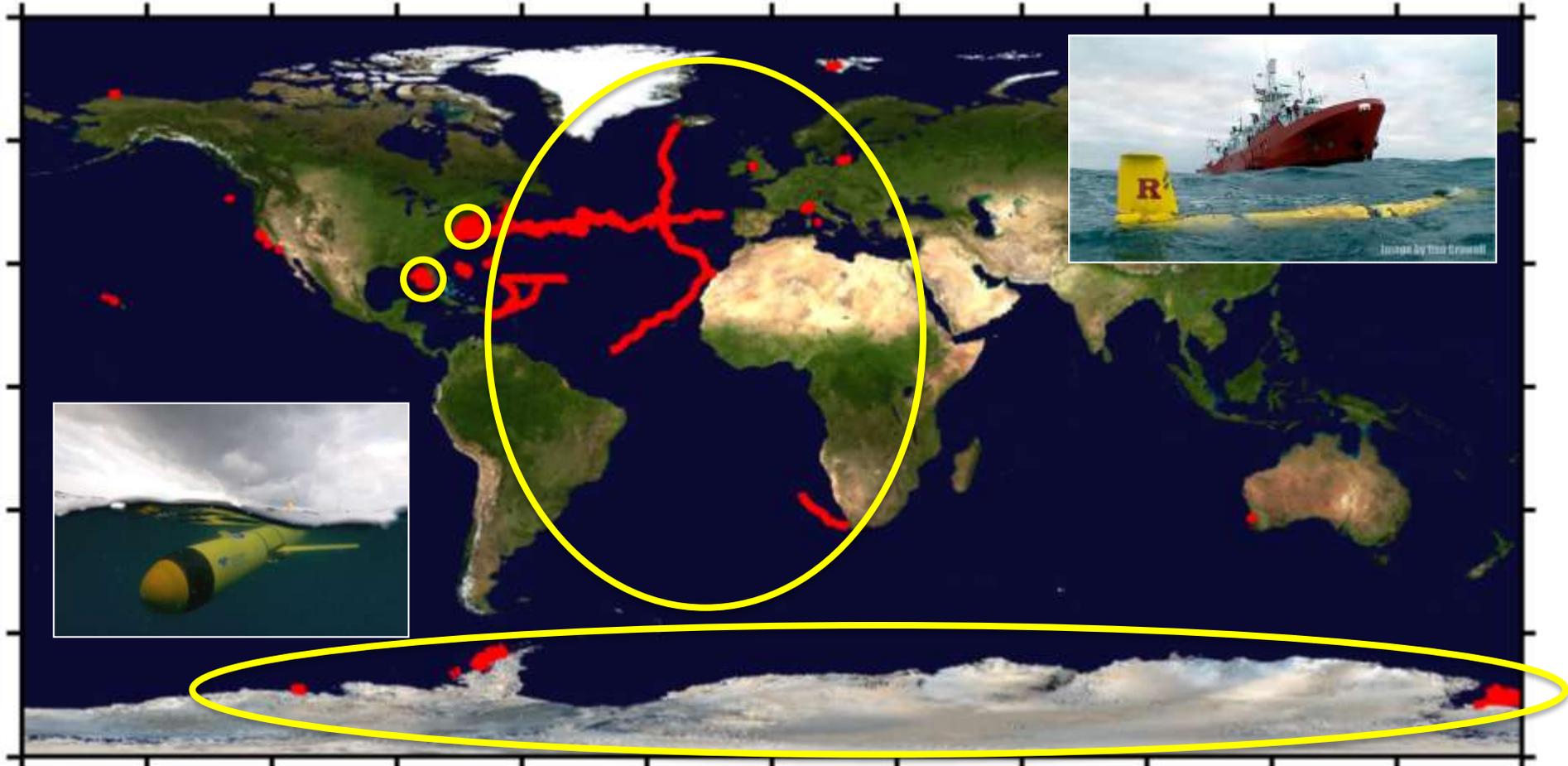
Iridium Antenna

ARGOS and FreeWave Antennas



# RU-COOL Global Slocum Glider Fleet Deployments

326 deployments - 132179.83km flown - 6059 days



**Gulf of Mexico – Deep Water Horizon**

**Extreme Environments – Antarctica**

**Hurricanes and Nor'easters**

**Long Duration Missions**

# Oil Spill Status : NOAA Guidance

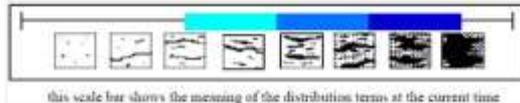
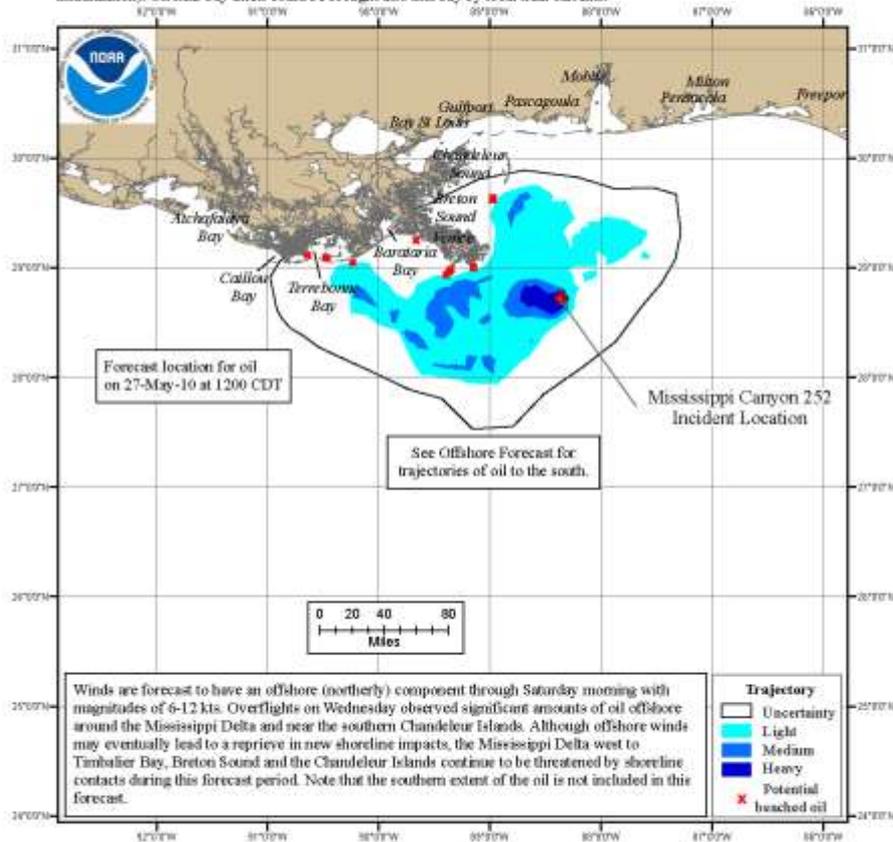
## Nearshore Surface Oil Forecast Deepwater Horizon MC252

NOAA/NOS/OR&R

Nearshore

Estimate for: 1200 CDT, Thursday, 5/27/10  
Date Prepared: 2100 CDT, Wednesday, 5/26/10

This forecast is based on the NWS spot forecast from Wednesday, May 26 PM. Currents were obtained from several models (NOAA Gulf of Mexico, West Florida Shelf/FUSE, TAMU/TGLO, NAVO/NRL) and HFR measurements. The model was initialized from Tuesday evening satellite imagery analysis (NOAA/NESDIS) and Wednesday overflight observations. The leading edge may contain tarballs that are not readily observable from the imagery (hence not included in the model initialization). Oil near bay inlets could be brought into that bay by local tidal currents.



Next Forecast:  
May 27th PM

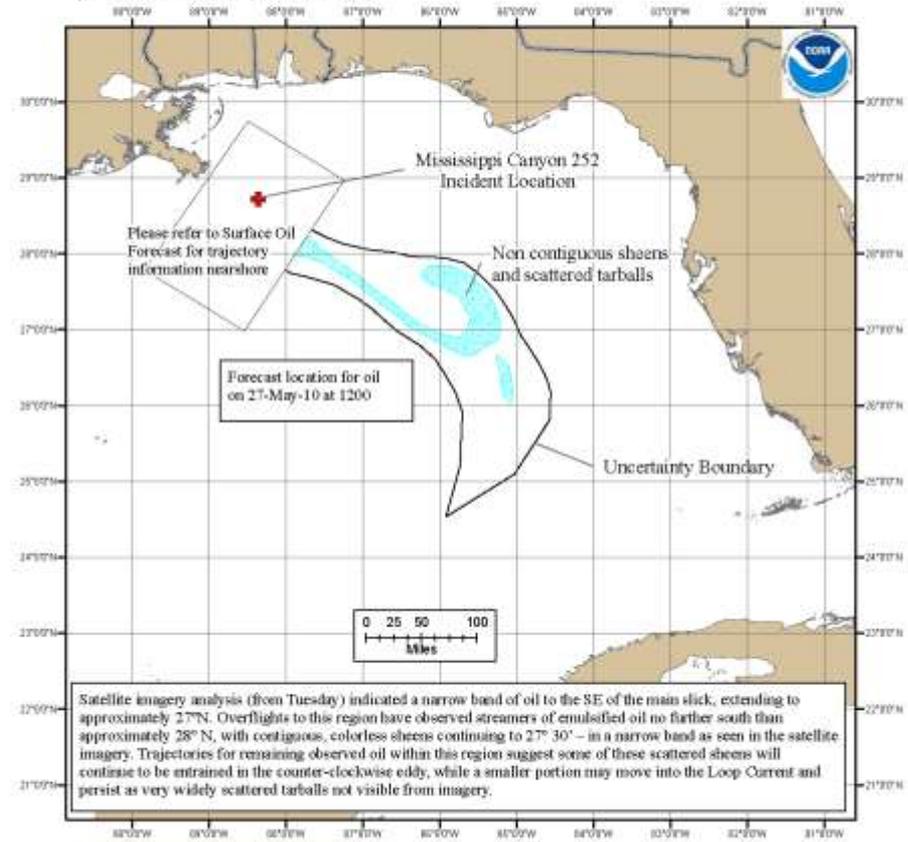
## Offshore Surface Oil Forecast Deepwater Horizon MC252

NOAA/NOS/OR&R

Offshore

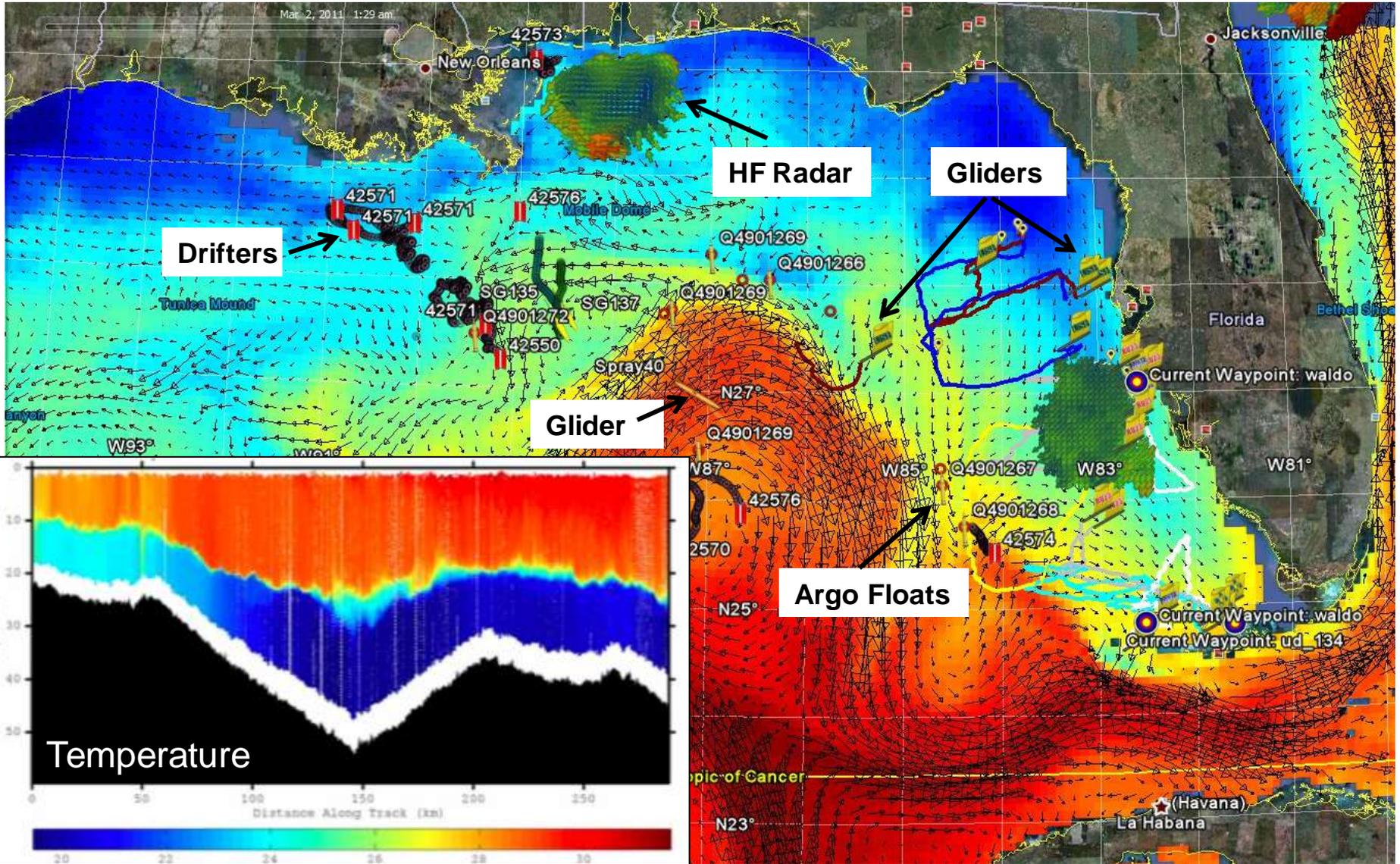
Estimate for: 1200 CDT, Thursday 5/27/10  
Date Prepared: 1800 CDT, Wednesday 5/26/10

Currents were obtained from four models: NOAA Gulf of Mexico, West Florida Shelf/FUSE, NRL IAS/NFS and NC State SABOOM. Each includes Loop Current dynamics. Gulf wide winds were obtained from the gridded NCEP product. The model was initialized from Tuesday morning satellite imagery analysis (NOAA/NESDIS) and observations from a Tuesday morning overflight. The leading edge may contain tarballs that are not readily observable from the imagery (hence not included in the model initialization).



Next Forecast:  
May 27th PM

# Deepwater Horizon: Ocean Forecasts



Bloomberg

The Miami Herald > We

# Hurricane

Sunday, 02.19.12 Wel

HOME NEWS SP

Miami-Dade | Brow

Posted on Friday, 09.02.11

HURRICANE SEASON

## Intensity

f Like 1

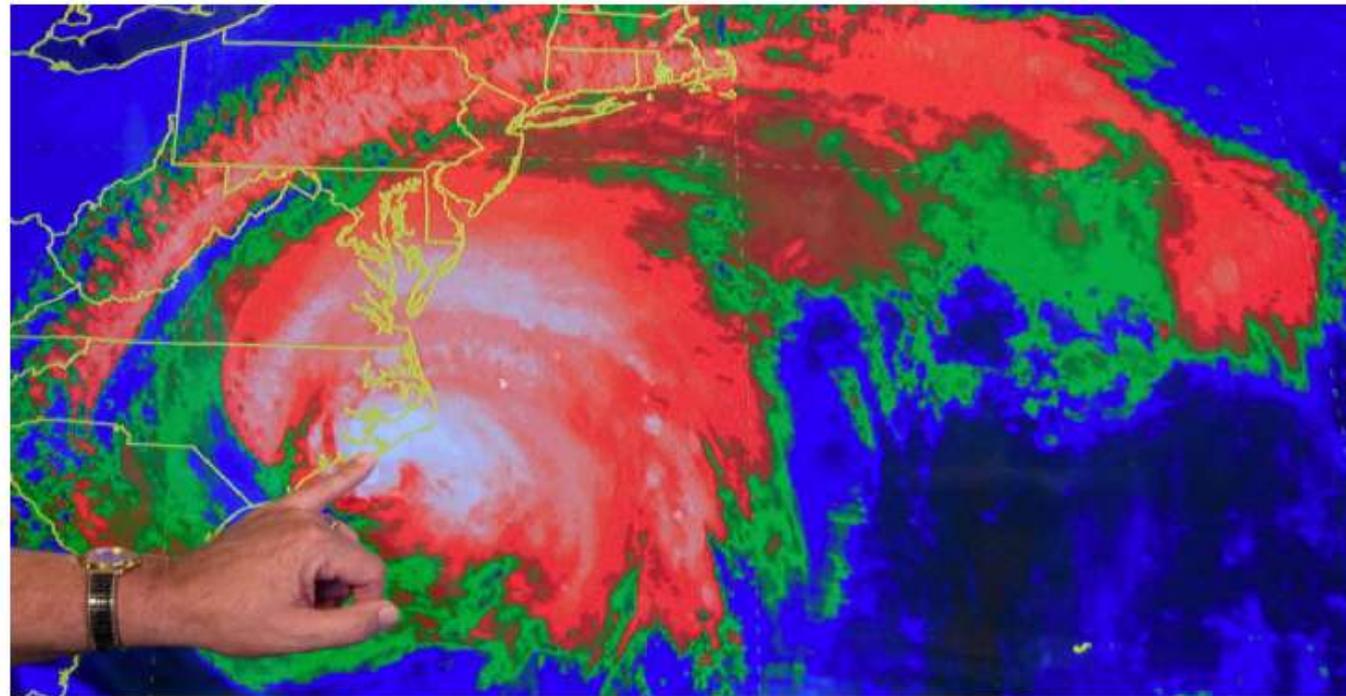
The National Hurricane Center says it wasn't the first time, but the increasing strength of hurricanes is a new phenomenon.

BY CURTIS MORGAN  
MORGAN@MIAMIHERALD.COM

THE GREAT COURSES

NOW ENJOY BRILLIANT COLLEGE COURSES IN YOUR HOME OR OFFICE

## Challenges in Predicting the Intensity of Storms



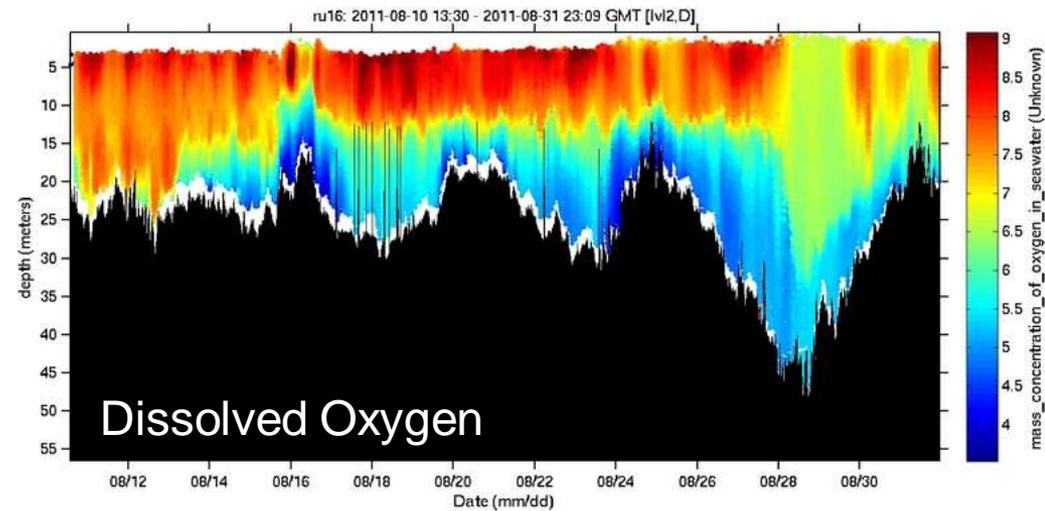
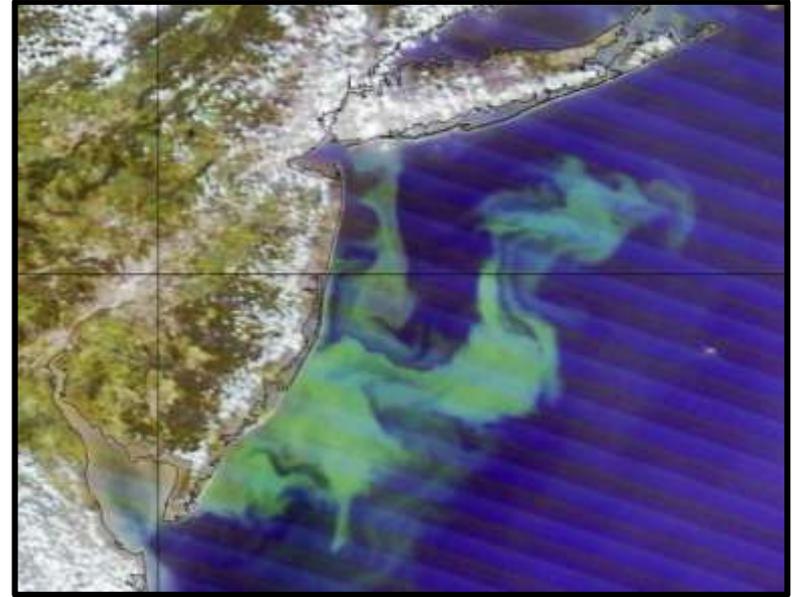
Andy Newman/Associated Press

Scientists say that it is much easier to accurately predict what path a hurricane will take.

By HENRY FOUNTAIN

Published: August 27, 2011

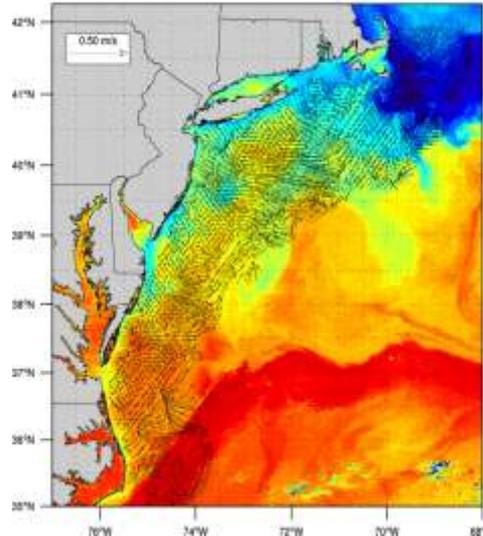
# Water Quality – Tracking Hurricane Irene



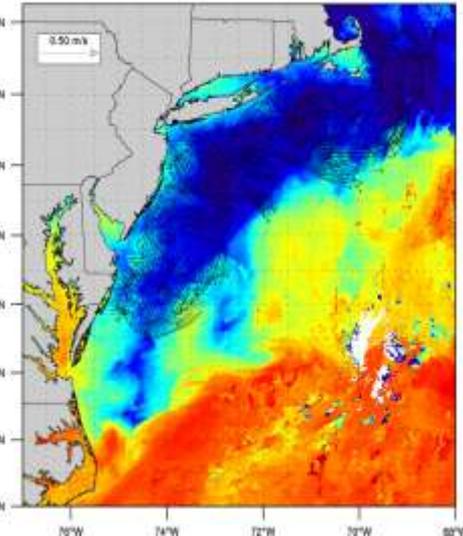
# Water Quality – Tracking Hurricane Irene



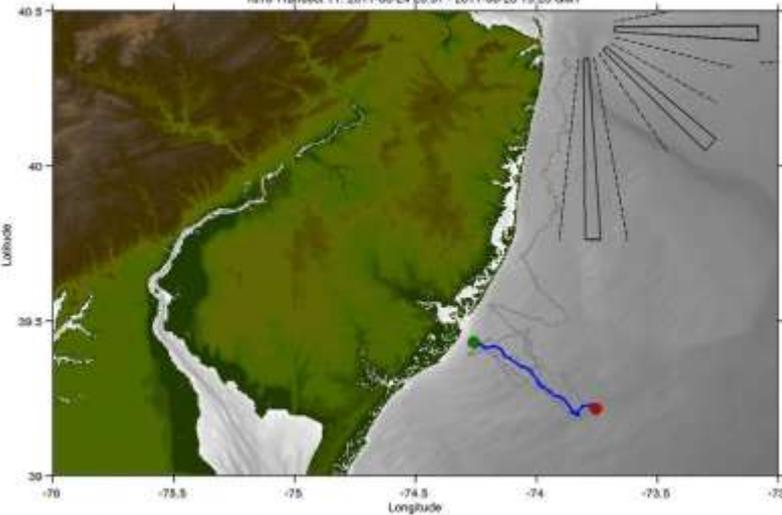
MARACOOS SST/Current Field Overlay: 2011-08-24 06:00:00 UTC (+/- 12 hours)



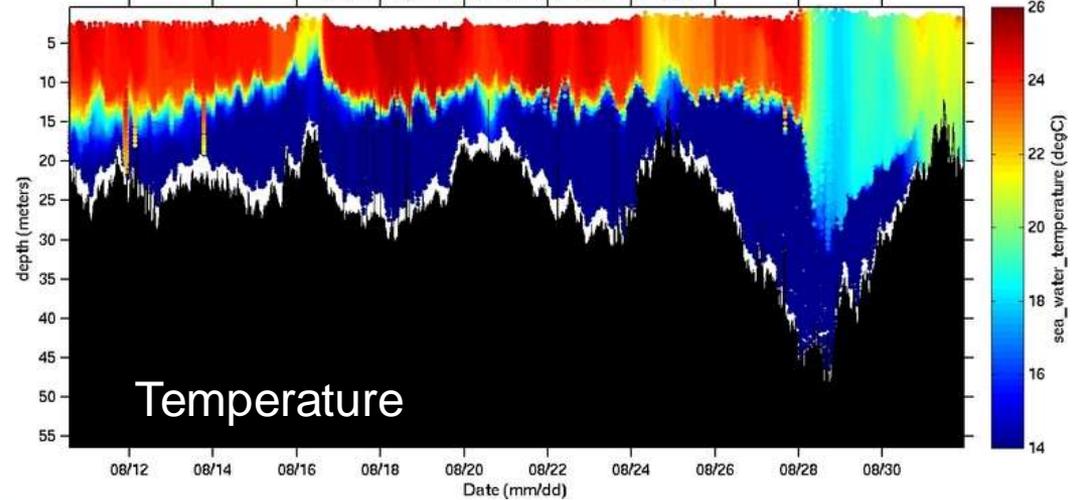
MARACOOS SST/Current Field Overlay: 2011-08-29 06:00:00 UTC (+/- 12 hours)



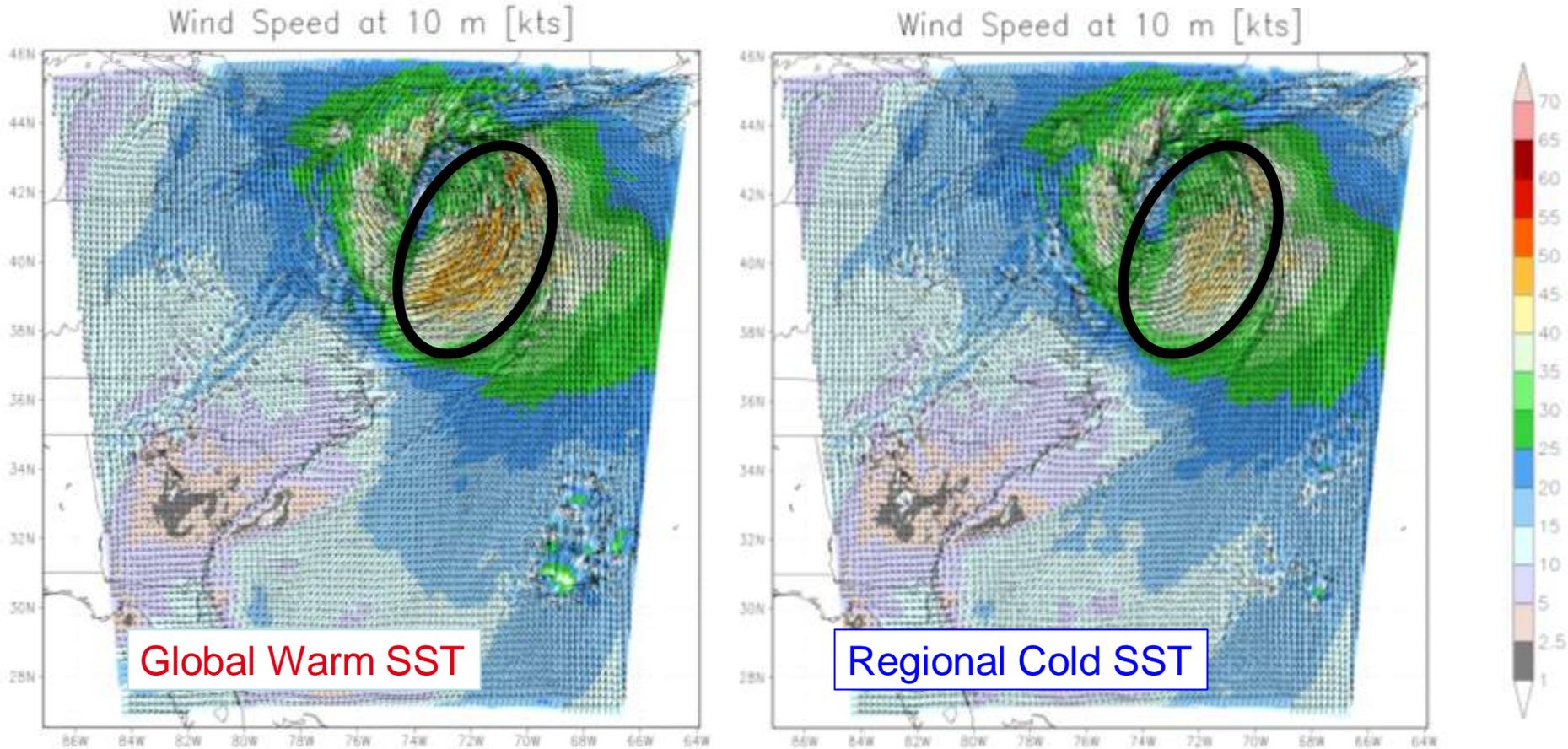
ru16 Traversed 11: 2011-08-24 20:57 - 2011-08-29 15:23 GMT



ru16: 2011-08-10 13:30 - 2011-08-31 23:09 GMT [lv12,D]



# Hurricane Irene SST Sensitivity Hindcast

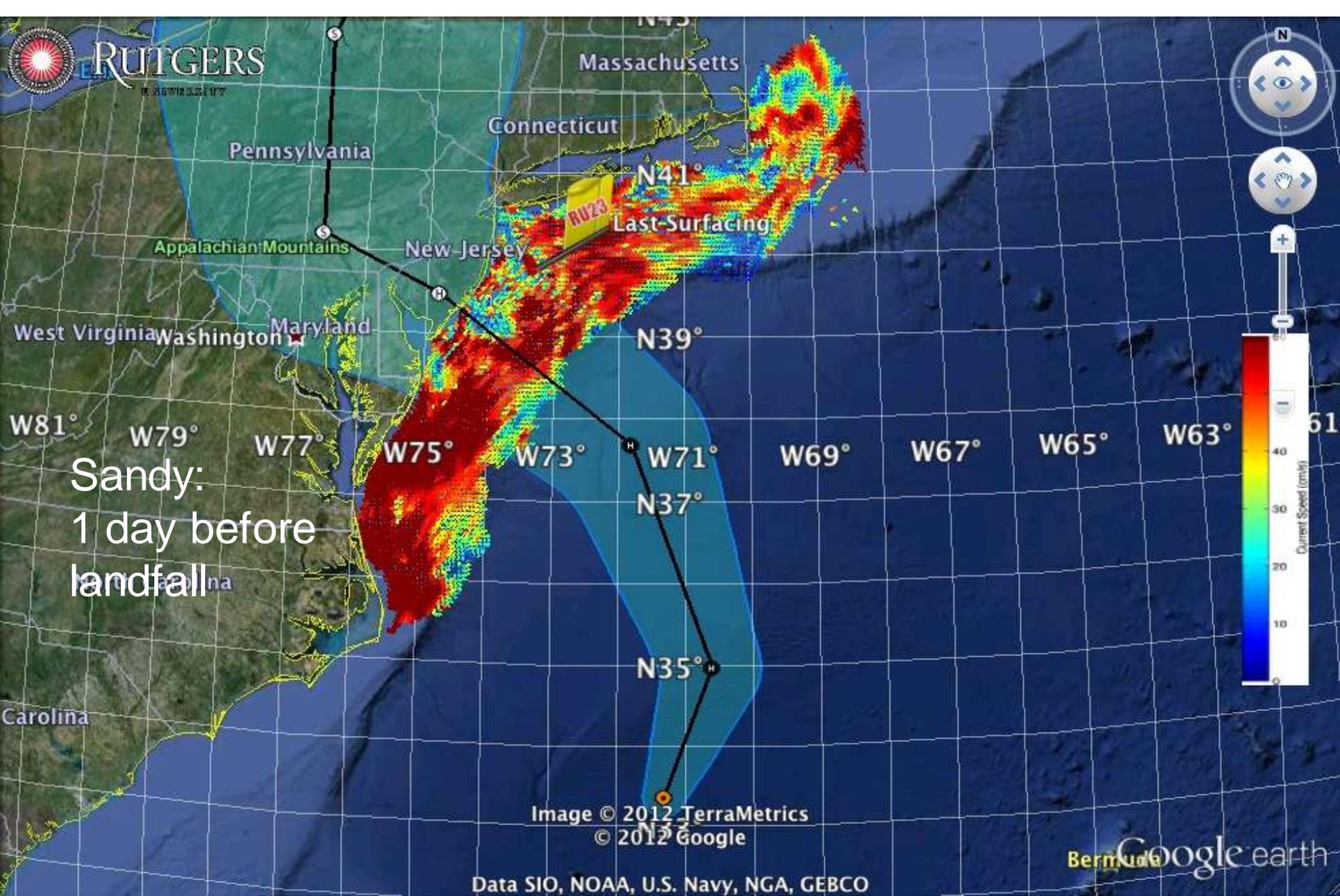


Maximum Wind Speed Skill Score	<i>Official Forecast</i>	<i>Warm SST Hindcast</i>	<i>Warm SST + OML Model Hindcast</i>	<i>Cold SST Hindcast</i>
<i>RMS Error (knots)</i>	9.43	7.13	7.09	3.61

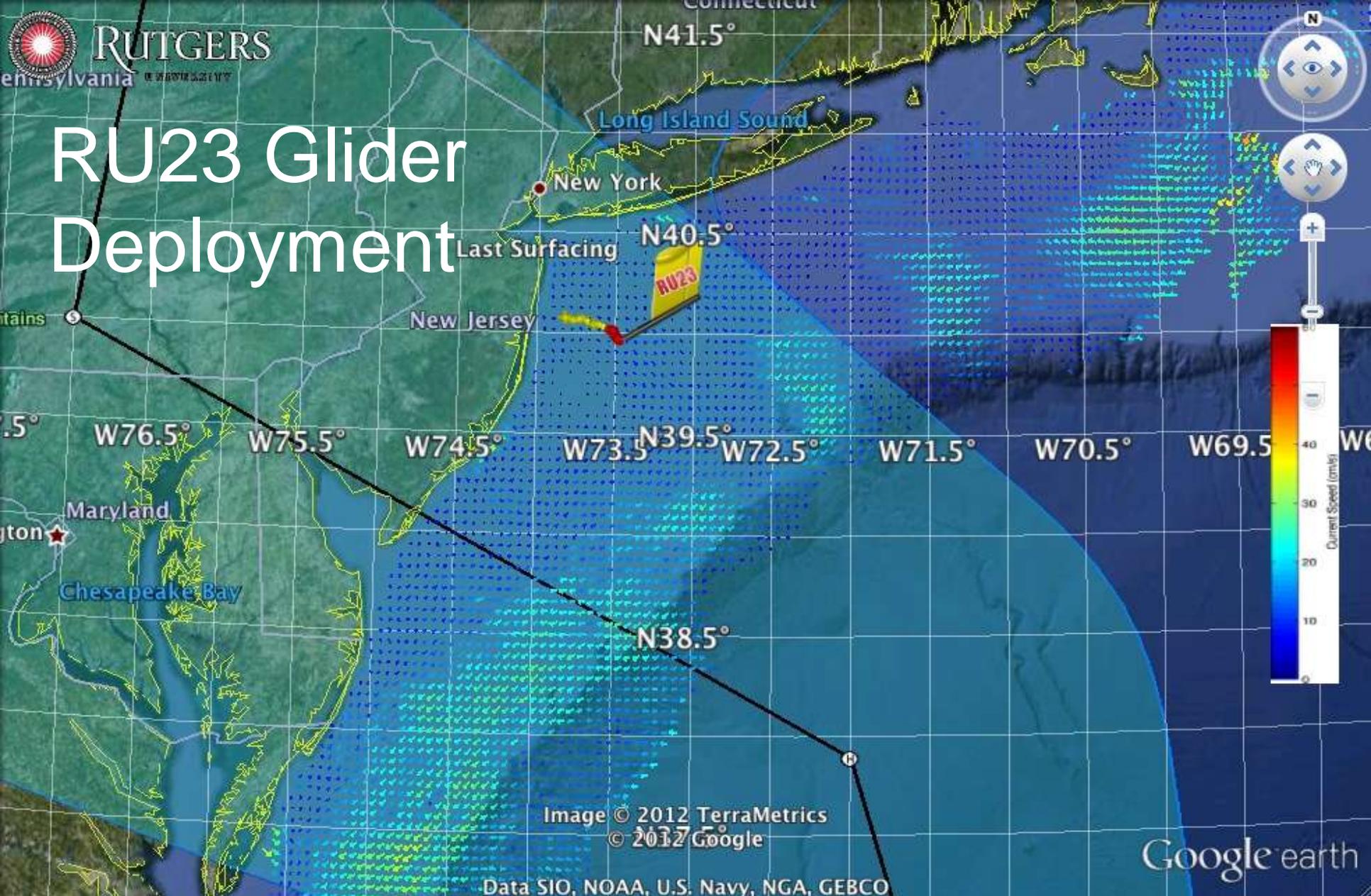


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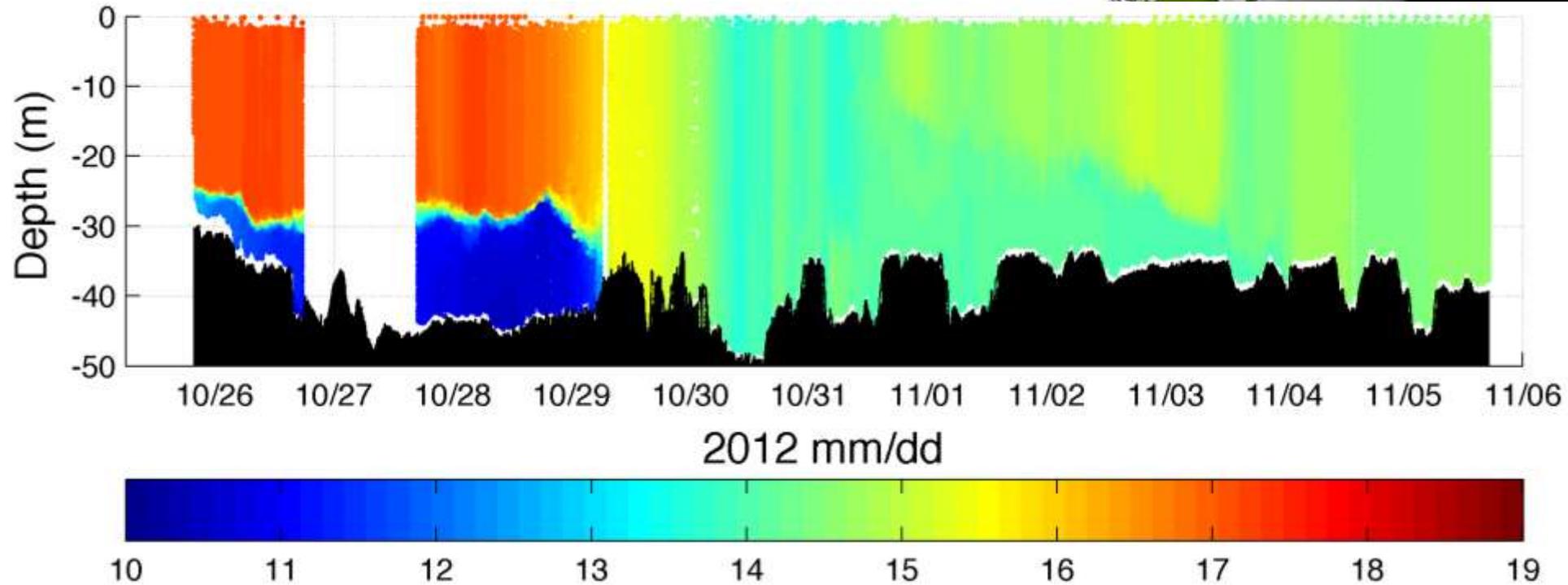
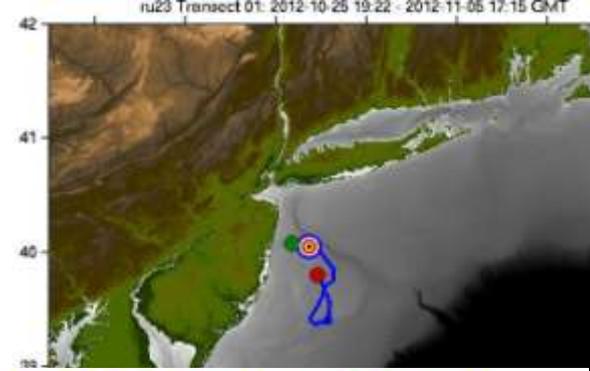




# RU23 Glider Deployment



# RU23 Glider



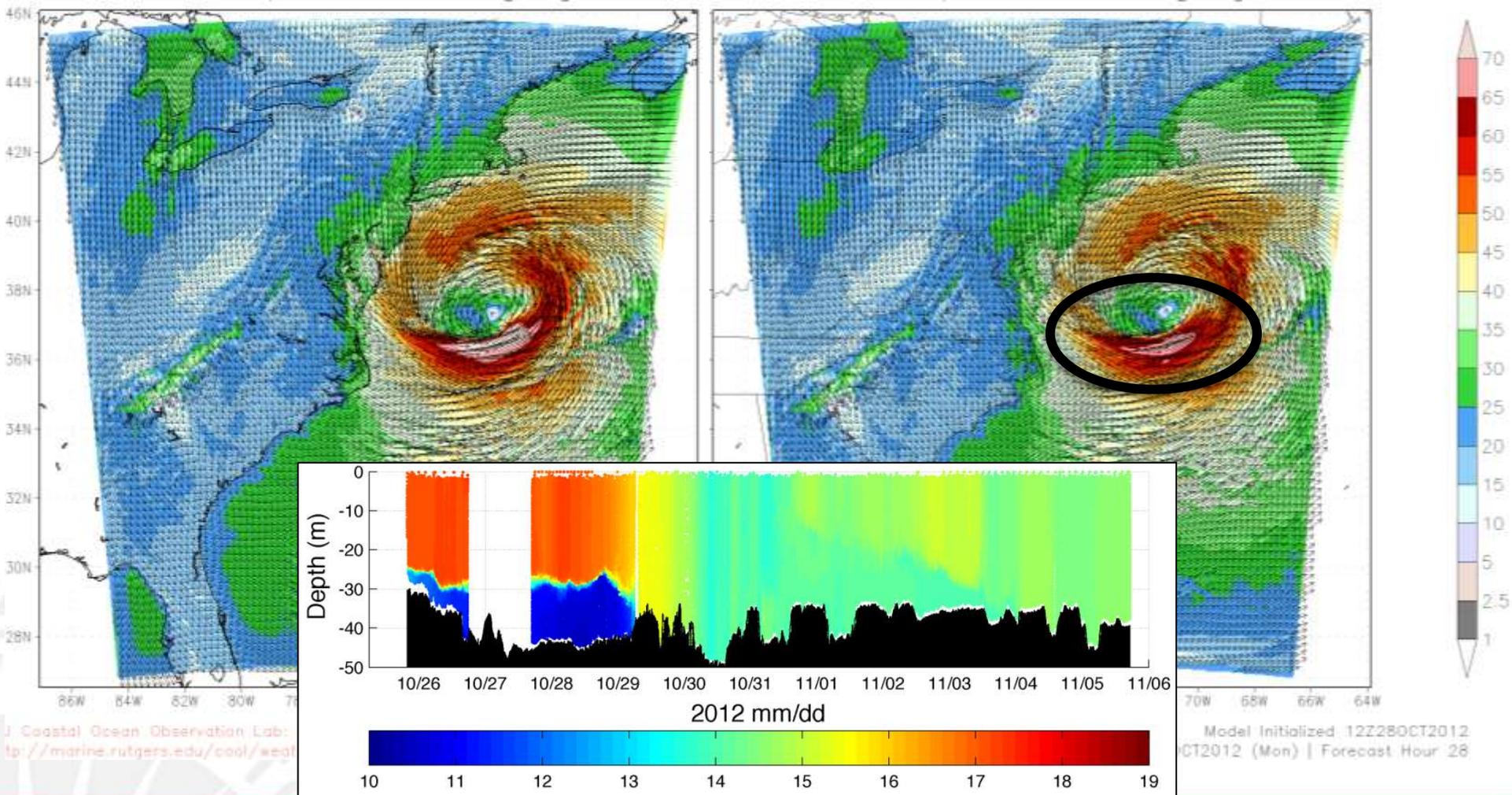
# Hurricane Sandy Hindcast: SST Sensitivity

Warm SST

Cold SST

Wind Speed at 10 m [kts]

Wind Speed at 10 m [kts]



Coastal Ocean Observation Lab:  
<http://marine.rutgers.edu/coo/woel>

Model Initialized 12Z28OCT2012  
OCT2012 (Mon) | Forecast Hour 28

# Last Week's Nor'easter

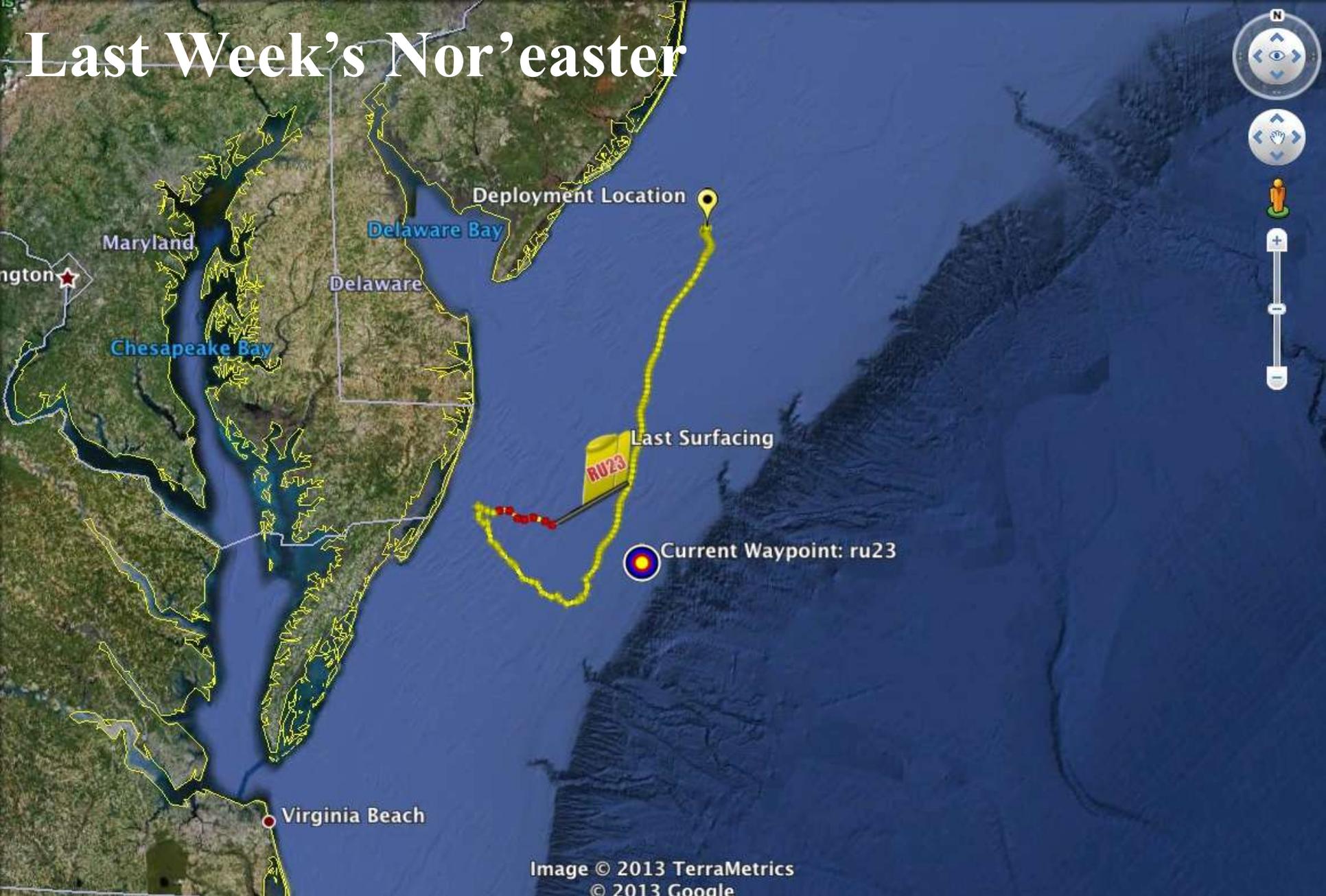
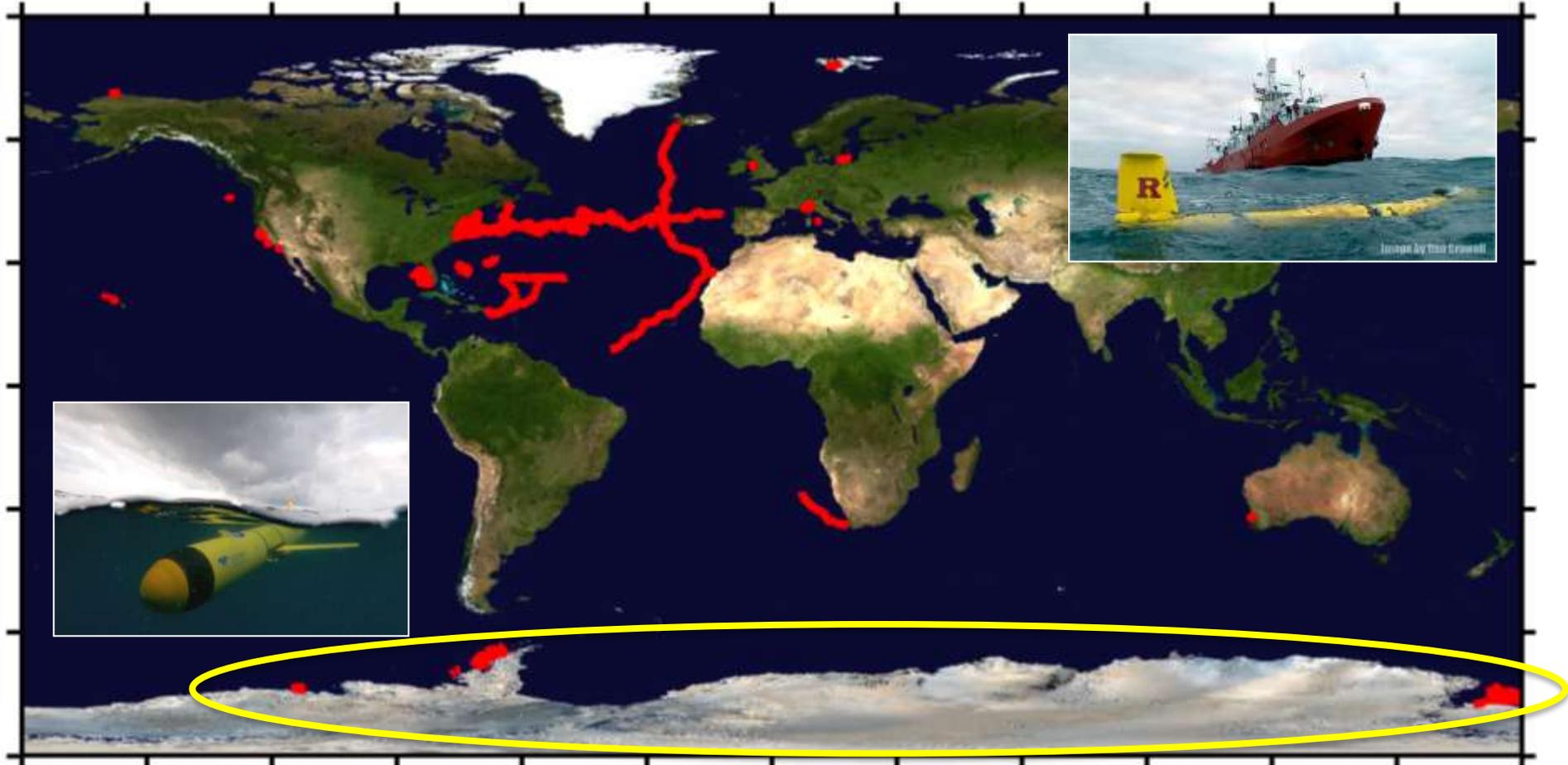


Image © 2013 TerraMetrics  
© 2013 Google

# RU-COOL Global Slocum Glider Fleet Deployments

326 deployments - 132179.83km flown - 6059 days



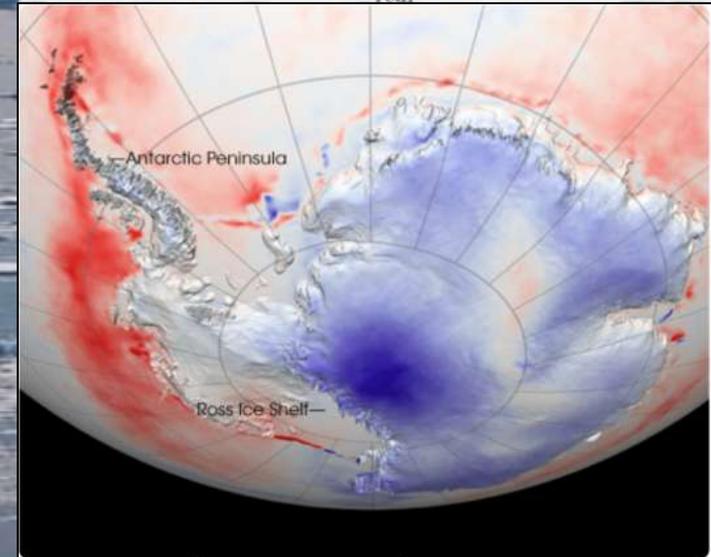
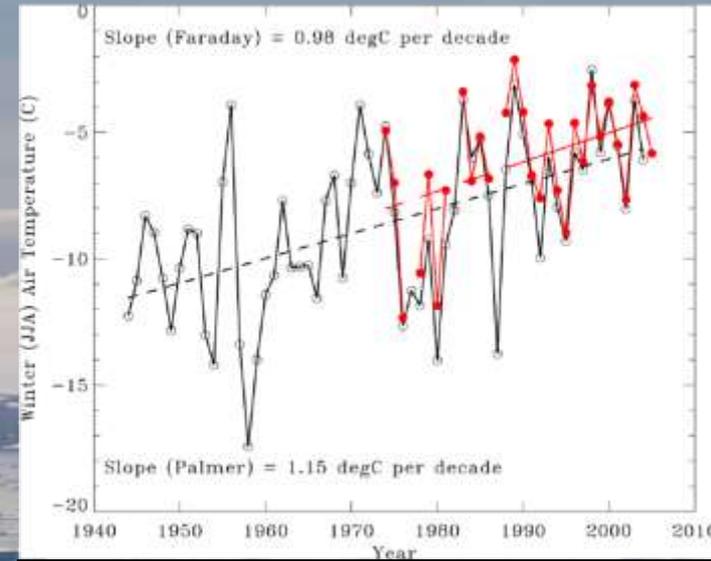
**Gulf of Mexico – Deep Water Horizon**  
**Extreme Environments – Antarctica**

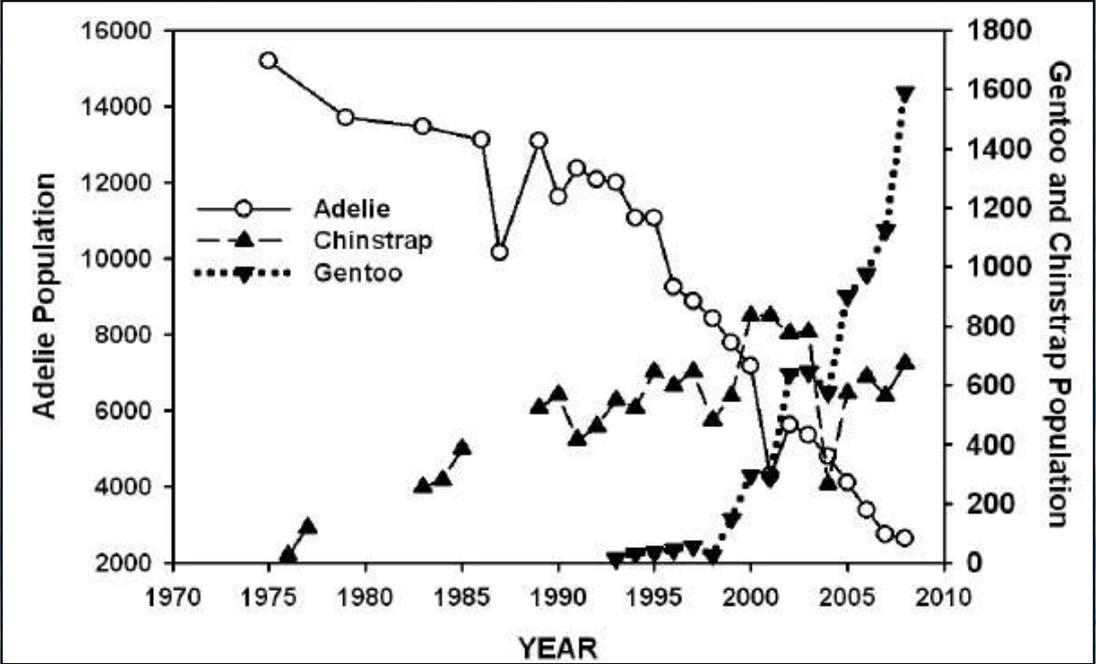
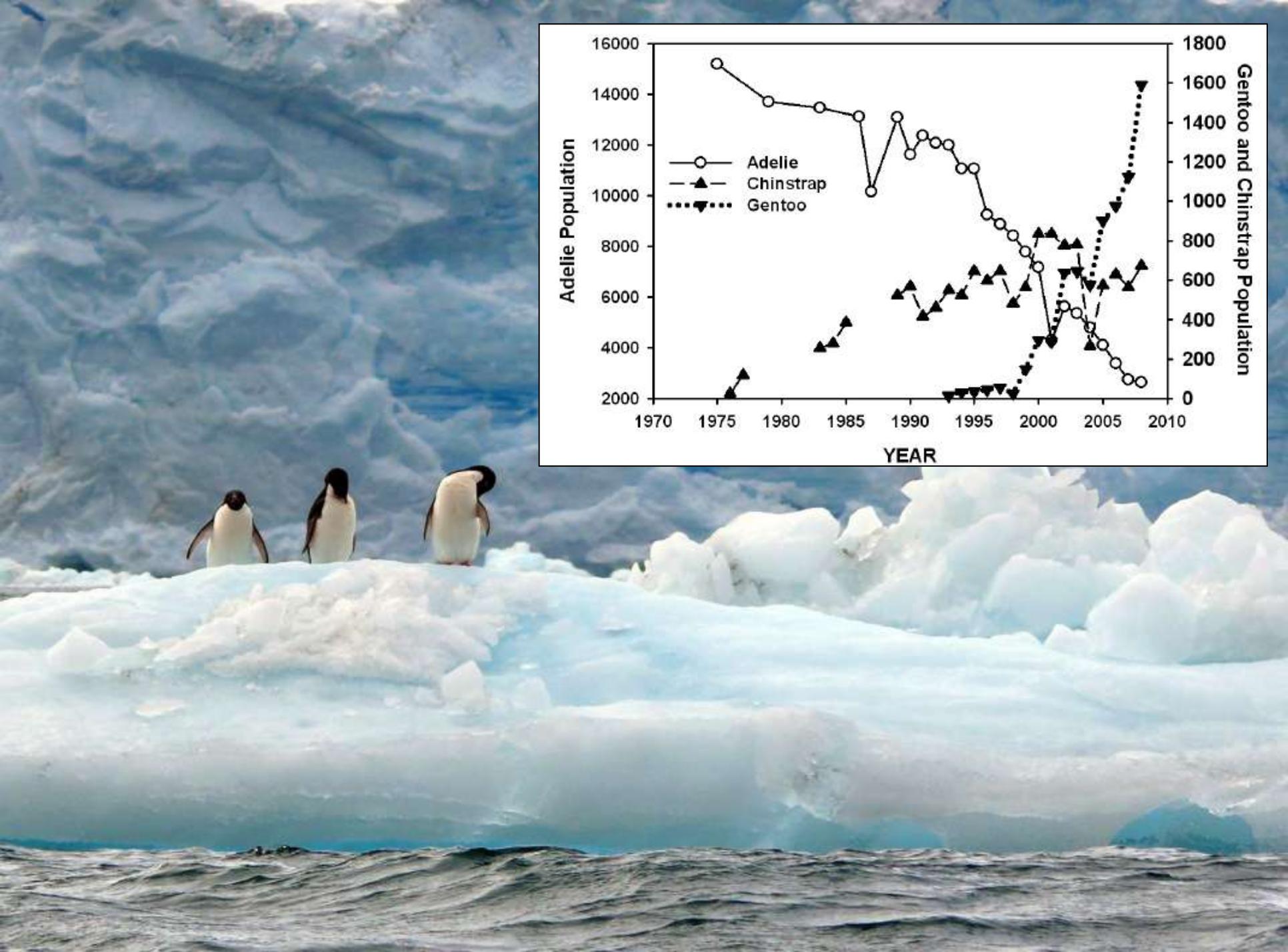
**Hurricanes and Nor'easters**  
**Long Duration Missions**

# Monitoring our Changing Planet



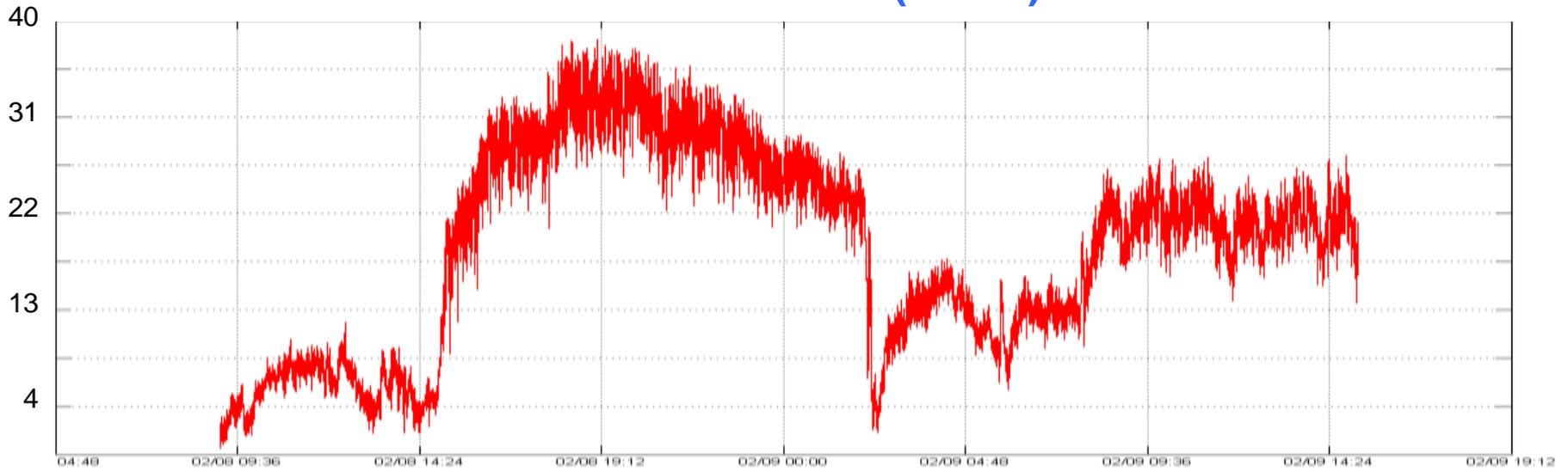
Mean Winter Temperatures







## 24 Hour Winds (knots)

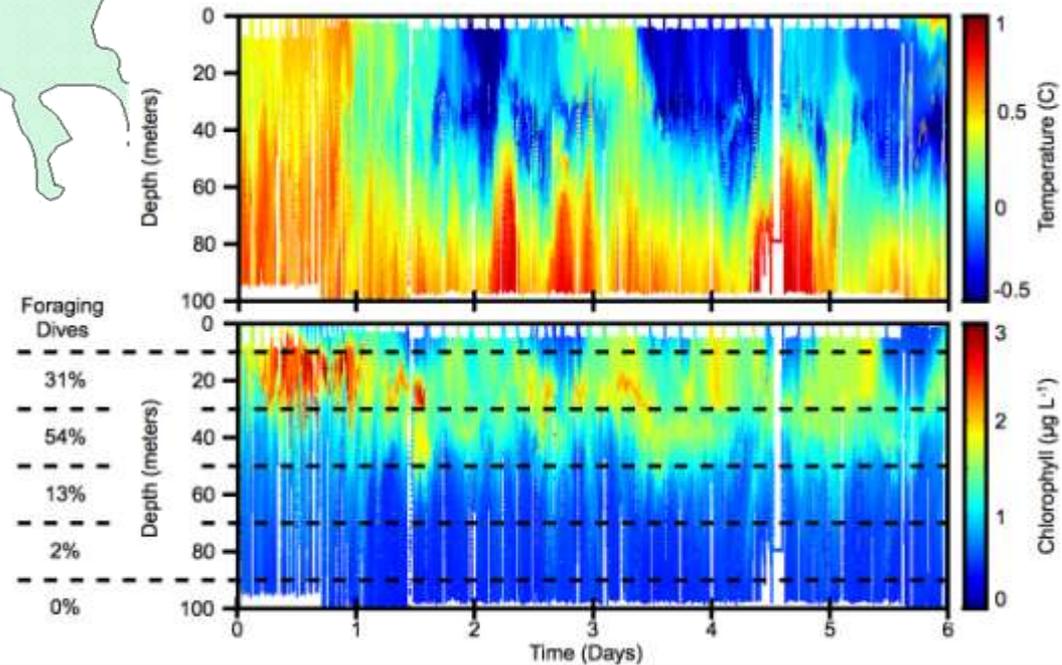
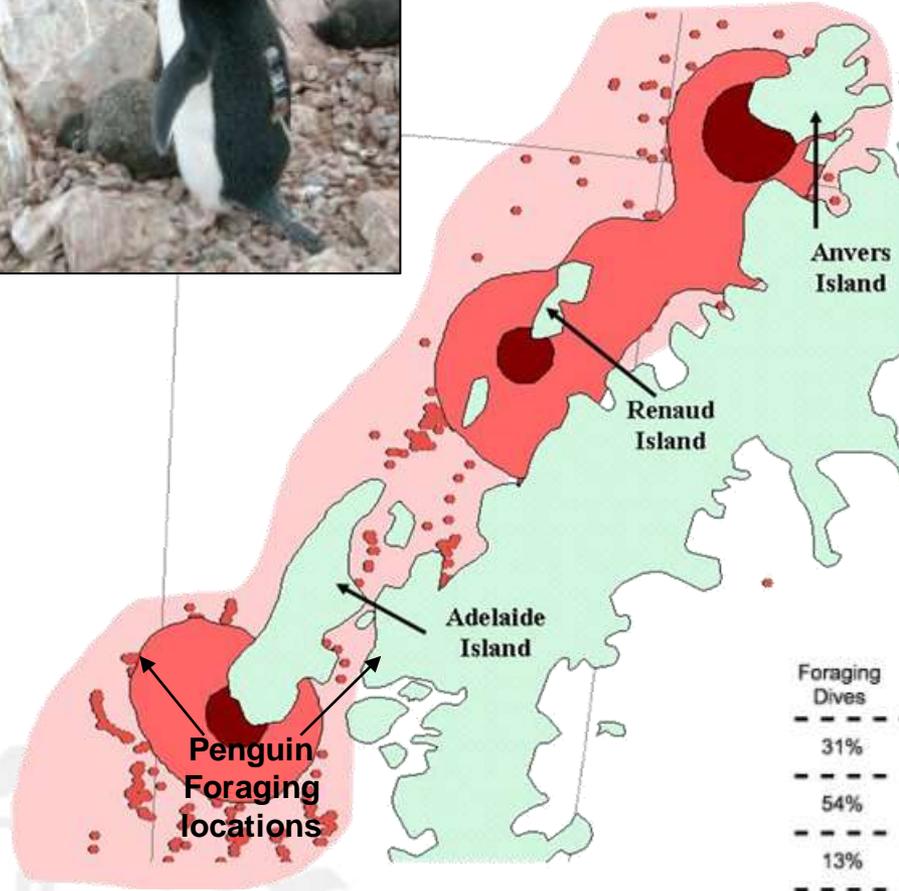


# Glider deployments in a unique ecosystem



© j.busecke

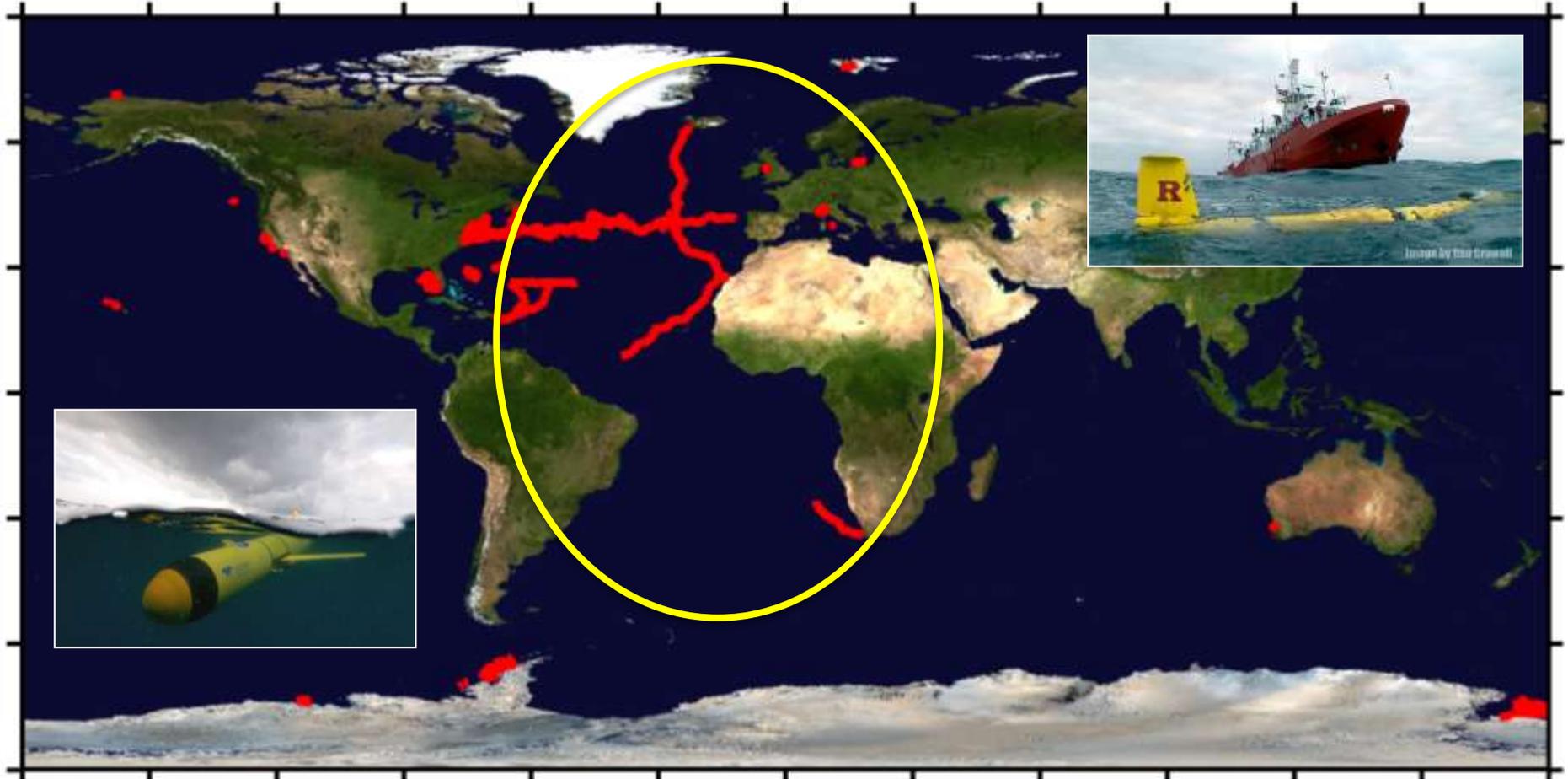
# Adaptive Sampling of Penguin Habitats



*Kahl et al., 2010*

# RU-COOL Global Slocum Glider Fleet Deployments

326 deployments - 132179.83km flown - 6059 days



**Gulf of Mexico – Deep Water Horizon**  
**Extreme Environments – Antarctica**

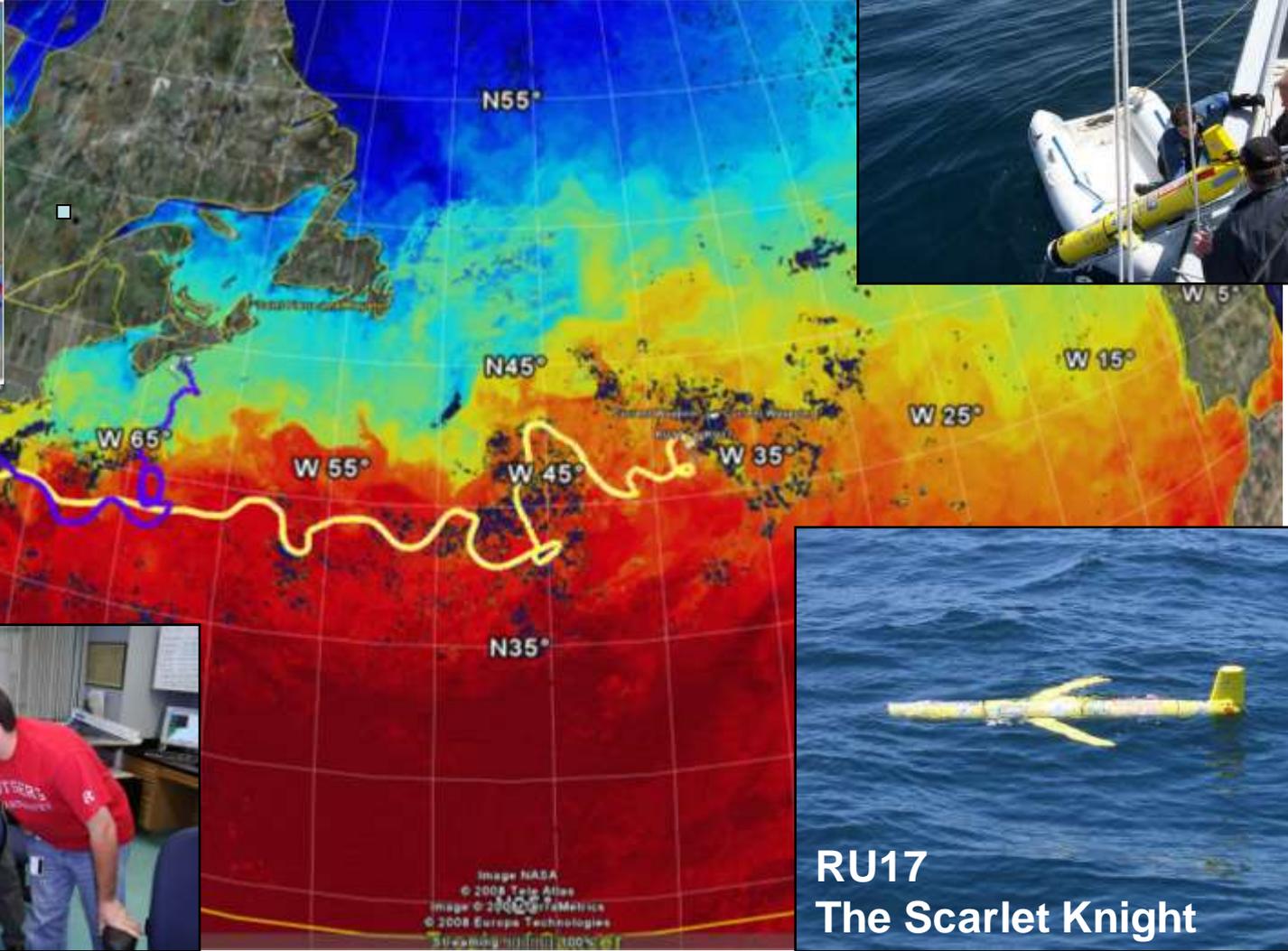
**Hurricanes and Nor'easters**  
**Long Duration Missions**

# Long-duration Glider Missions - Undergraduate Education

*RU15 - New Jersey to Halifax – 2008*

*RU17 - New Jersey to Azores (Almost) - 2008*

*RU27 - New Jersey to Europe - 2009*

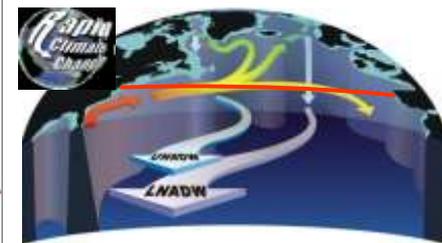
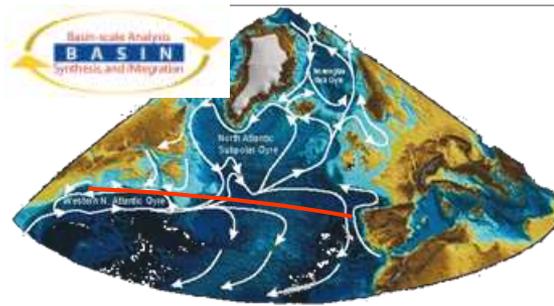


**RU17**  
**The Scarlet Knight**

# Glider Development: Enabling science over many scales (Beginning 2009)

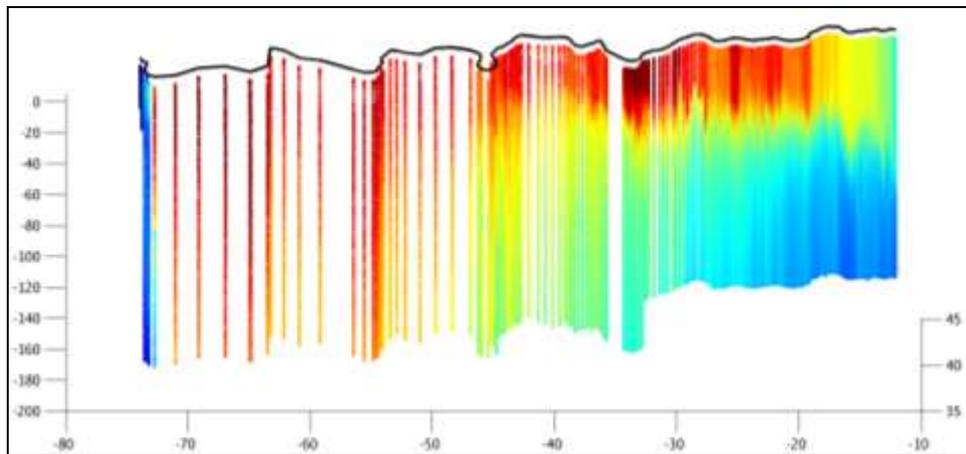
*North Atlantic Basin (5000 km)*

*300 day missions*



## *Scientific Impact:*

- Feedback loop between climate and ecosystems
- Impact of rapid climate variability on ocean circulation
- Tropical storm generation and intensification (ocean/atmosphere exchange)





# Mission Complete: Scarlet Knight is the first underwater robot to cross an ocean basin

221 Days  
7,409 km  
11,000 Dives  
11,000 Climbs



*Energy Equivalent of 8 minutes  
power for lights on the  
Rockefeller Center Tree.*



Tuckerton, New Jersey, USA



Baiona, Galicia, Spain

# Exciting the Next Generation in Science and Engineering



# Mission Complete: Scarlet Knight is the first underwater robot to cross an ocean basin

*A hero's Welcome, December 9, 2009*



*Baiona,  
Spain*

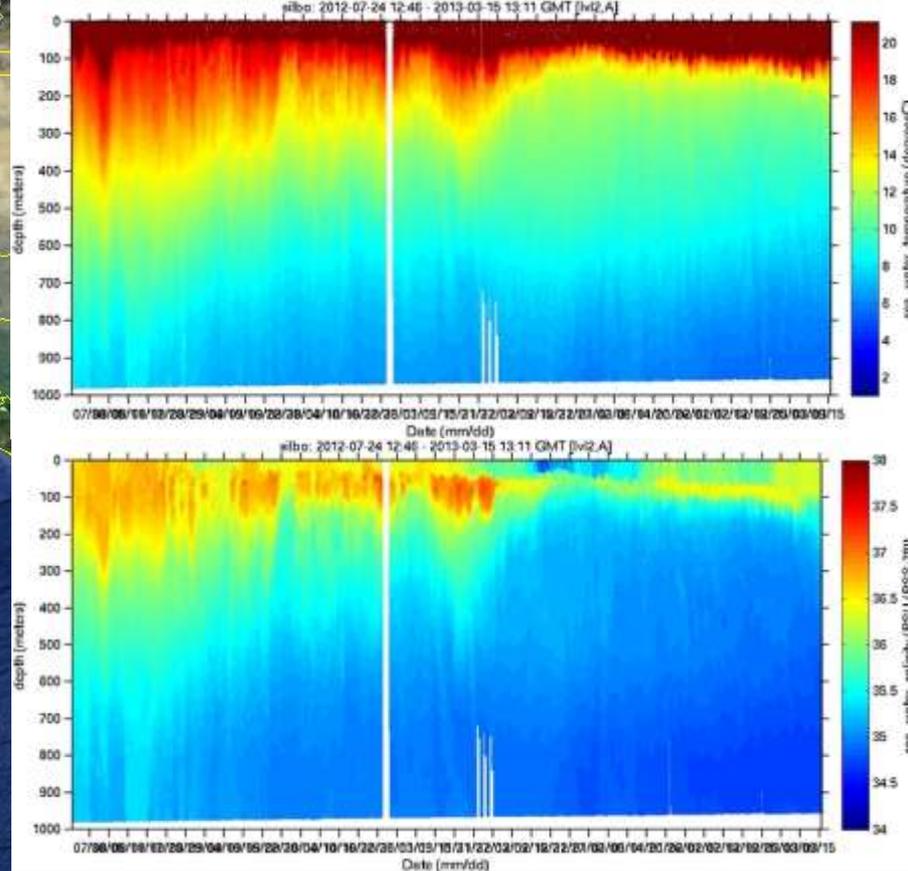
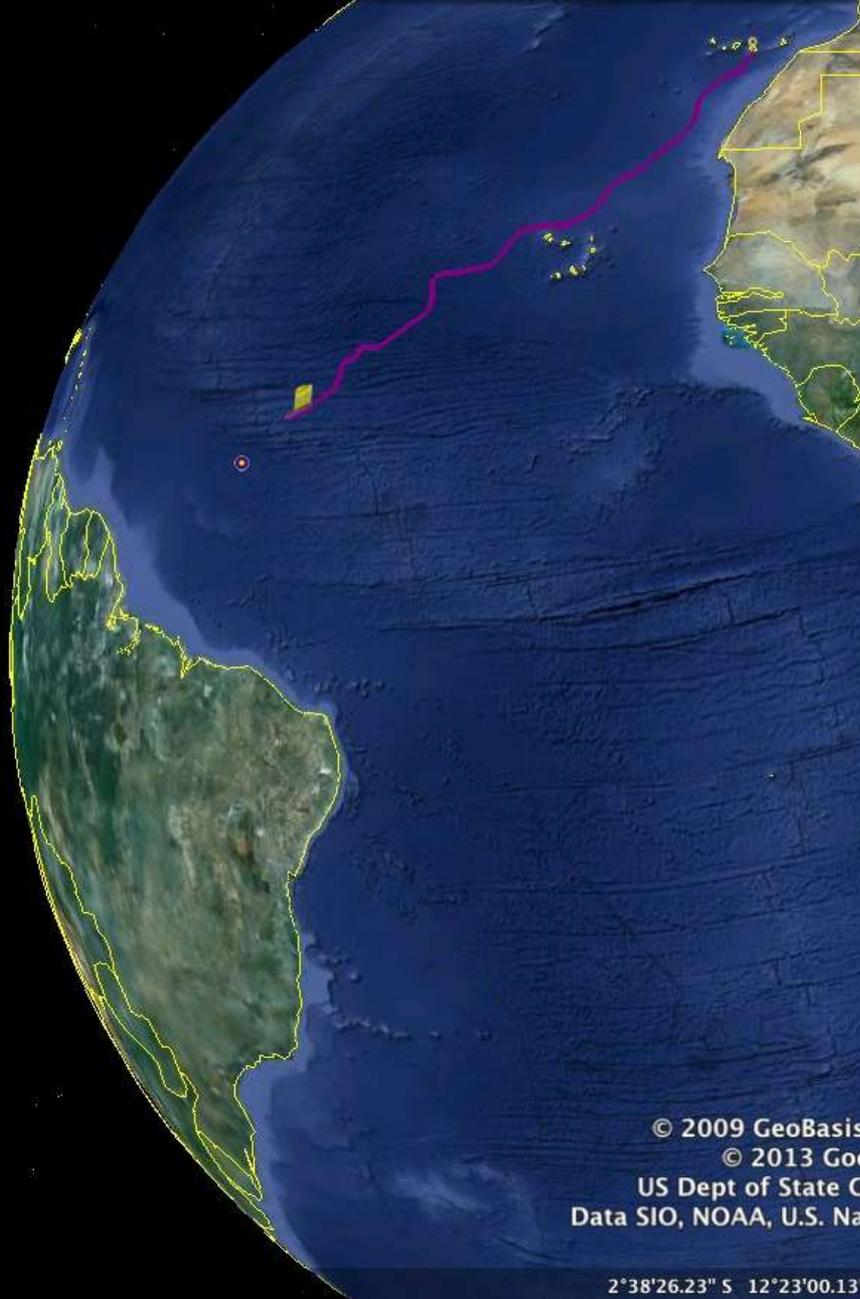


# Global Challenger Glider Mission



16 Legs with  
16 Global-Class  
Glider



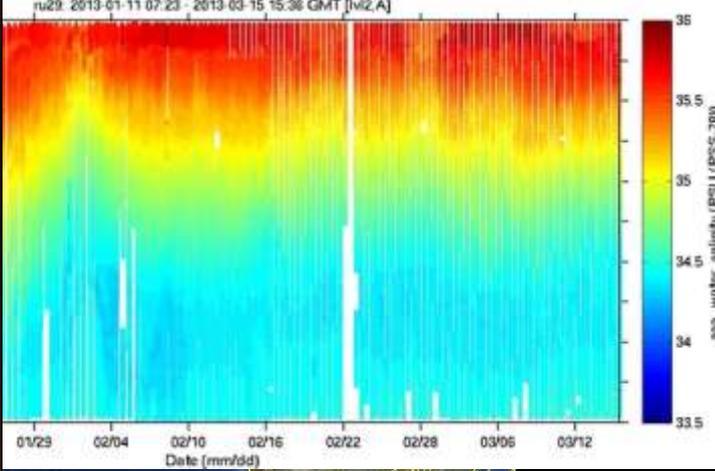
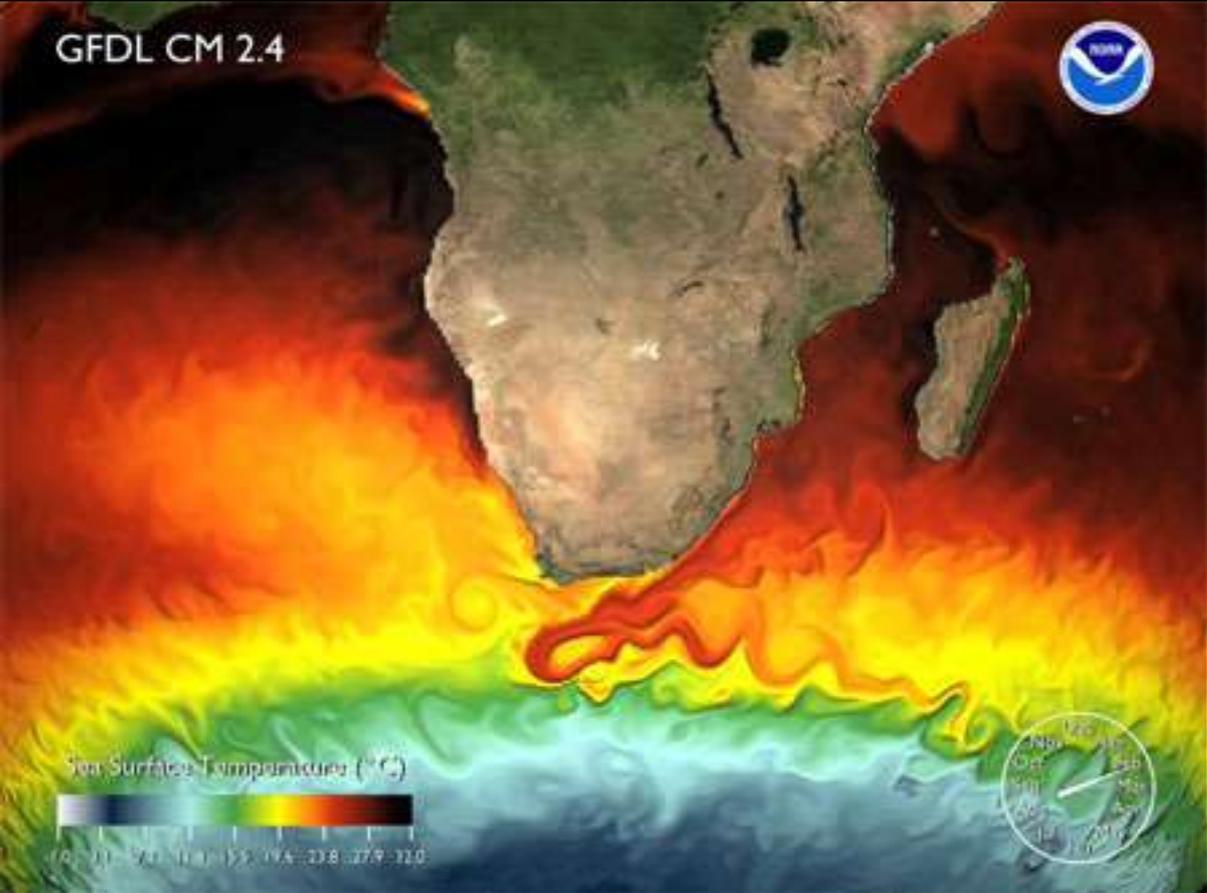
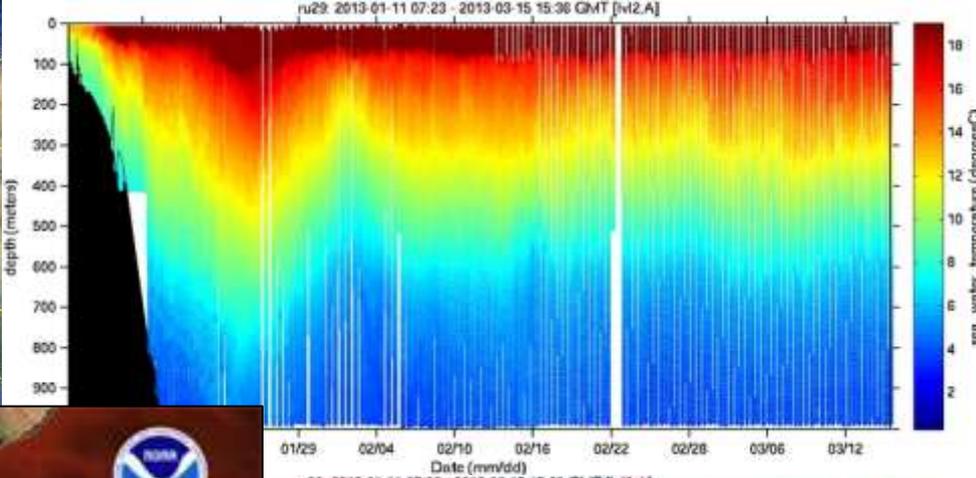


© 2009 GeoBasis-DE/BKG  
 © 2013 Google  
 US Dept of State Geographer  
 Data SIO, NOAA, U.S. Navy, NGA, GEBCO

Google earth

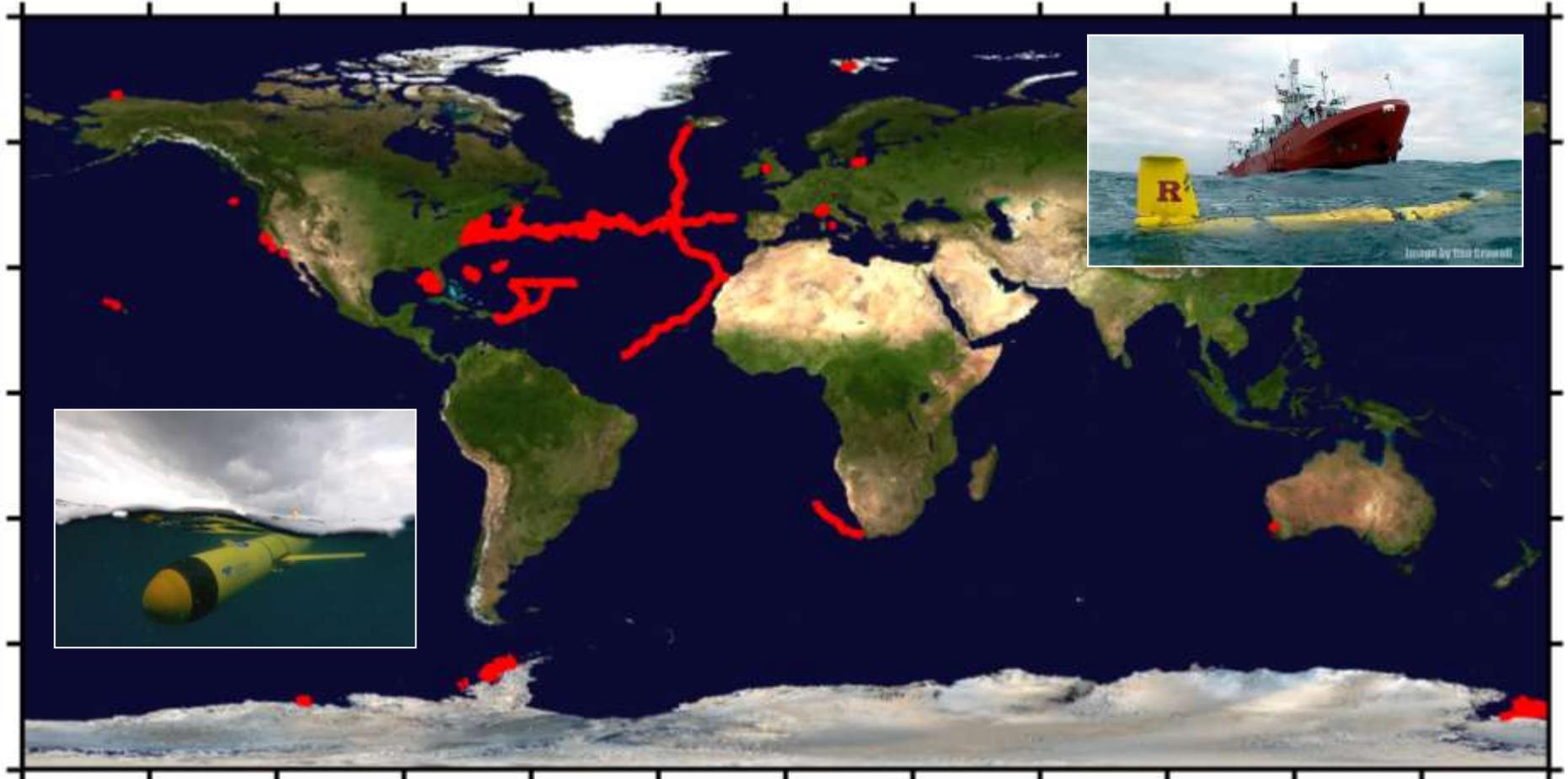
2°38'26.23" S 12°23'00.13" W elev -4042 m

Eye alt 7018.00 km



# RU-COOL Global Slocum Glider Fleet Deployments

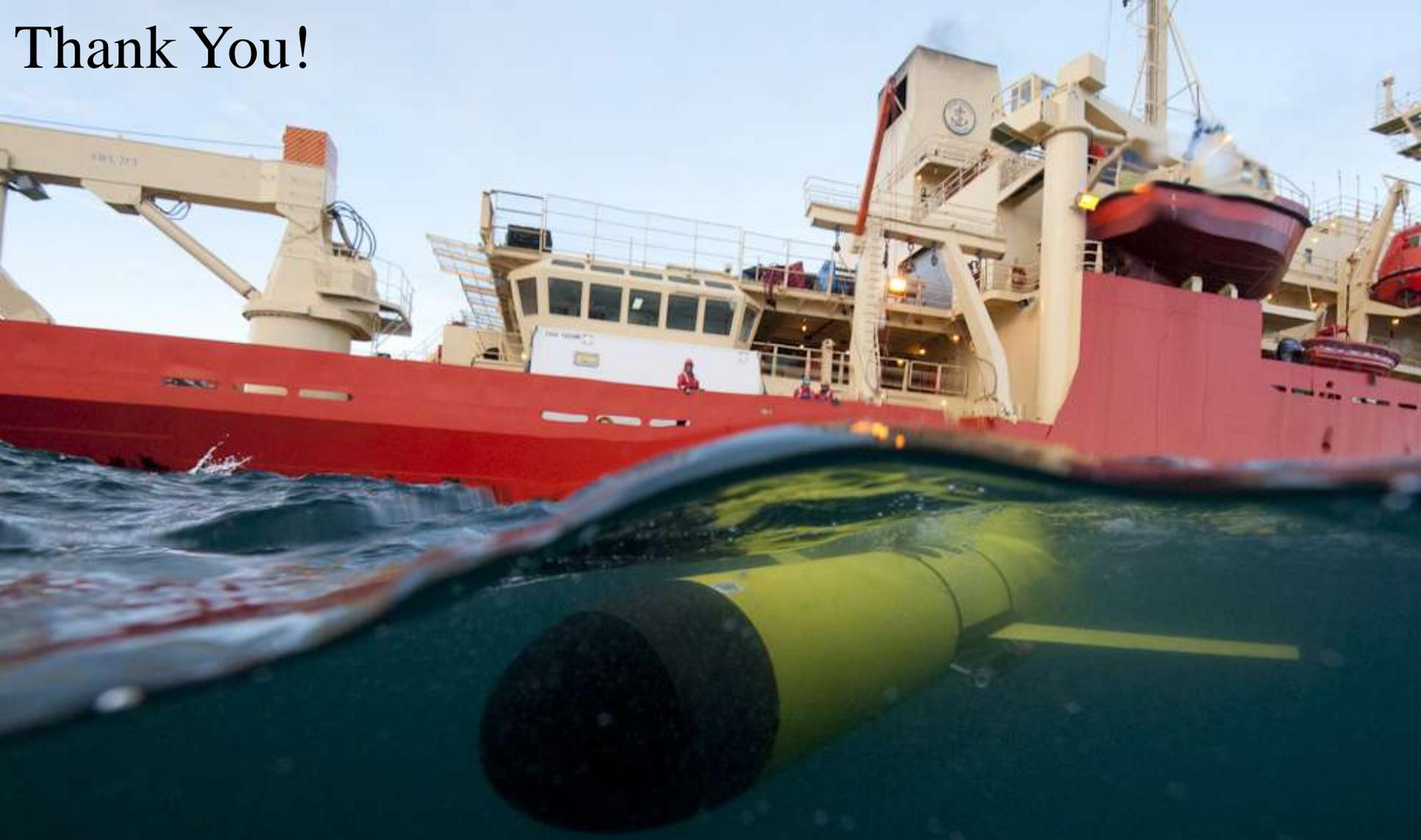
326 deployments - 132179.83km flown - 6059 days



**Gulf of Mexico – Deep Water Horizon**  
**Extreme Environments – Antarctica**

**Hurricanes and Nor'easters**  
**Long Duration Missions**

Thank You!



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<http://rucool.marine.rutgers.edu>

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JERSEY ROOTS, GLOBAL REACH

Coastal Ocean  
Observation Lab