



Bermuda 1-2 2017

Gulf Stream: Structure and Strategy

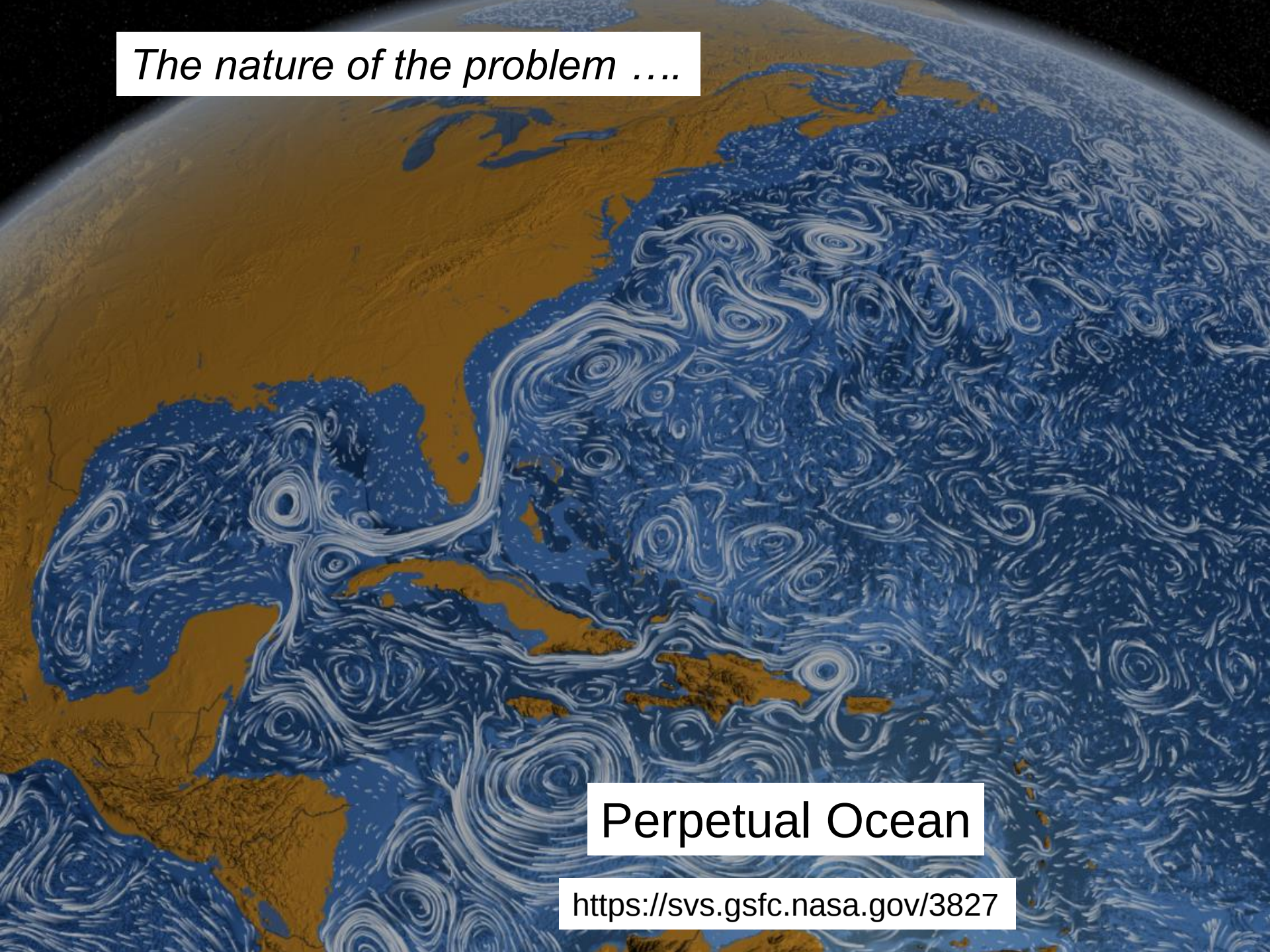
W. Frank Bohlen
Bohlen@uconn.edu

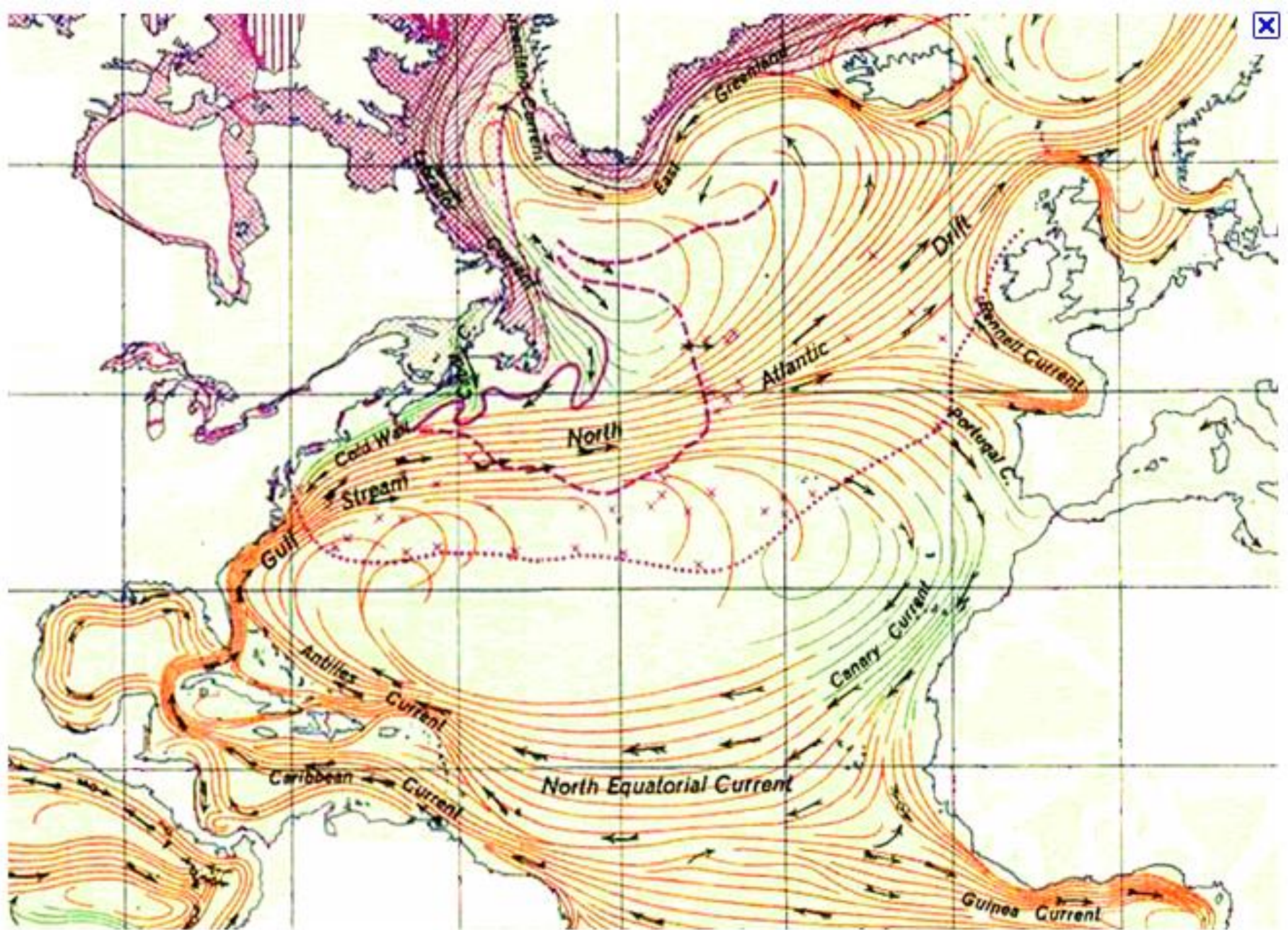
*“Races are lost on the water”
Anon..*

The nature of the problem

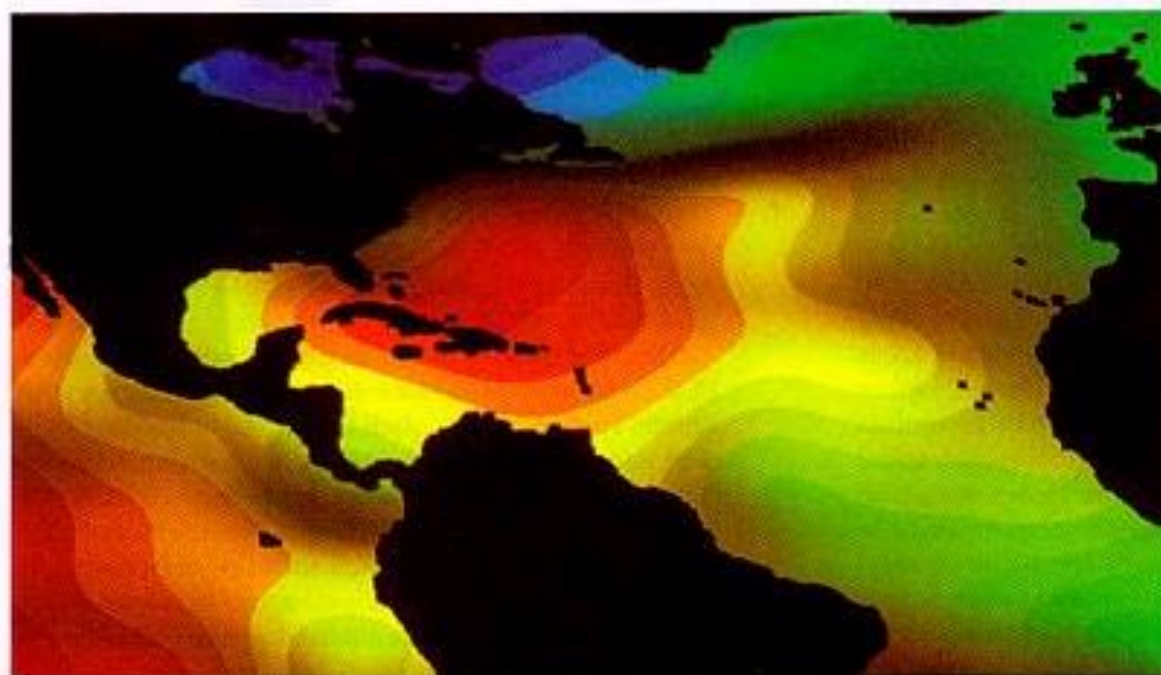
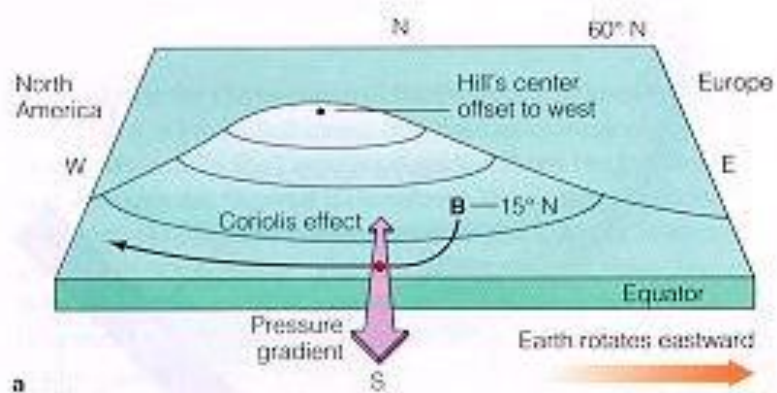
Perpetual Ocean

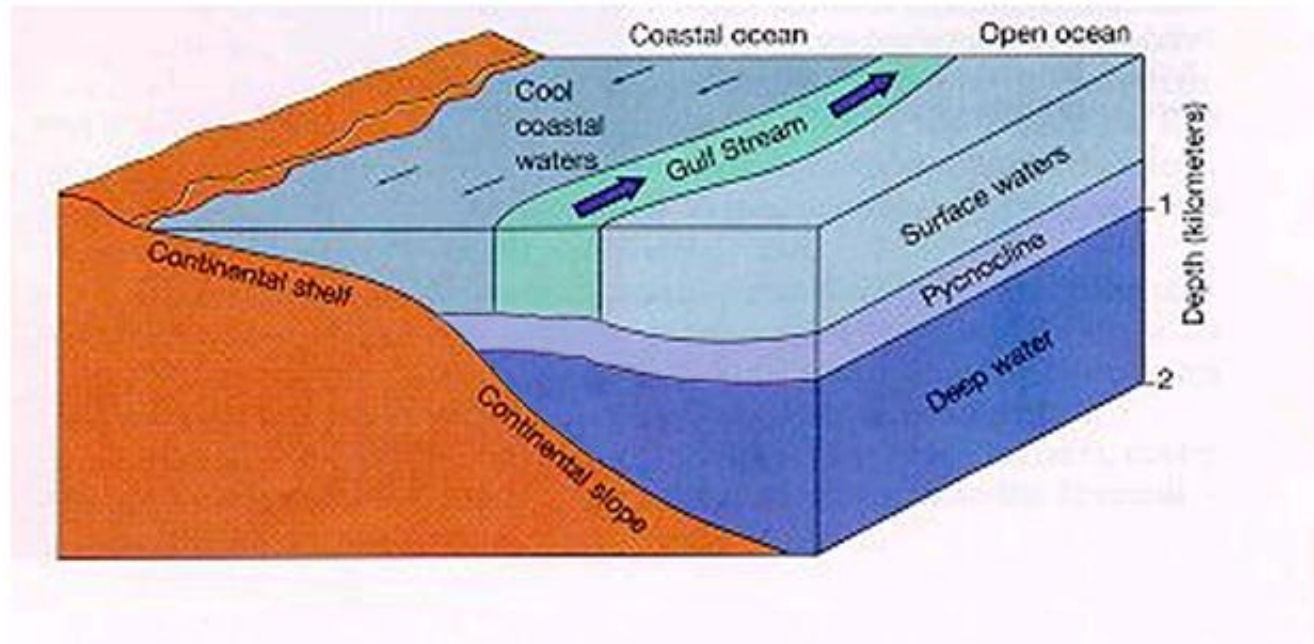
<https://svs.gsfc.nasa.gov/3827>





North Atlantic Gyre

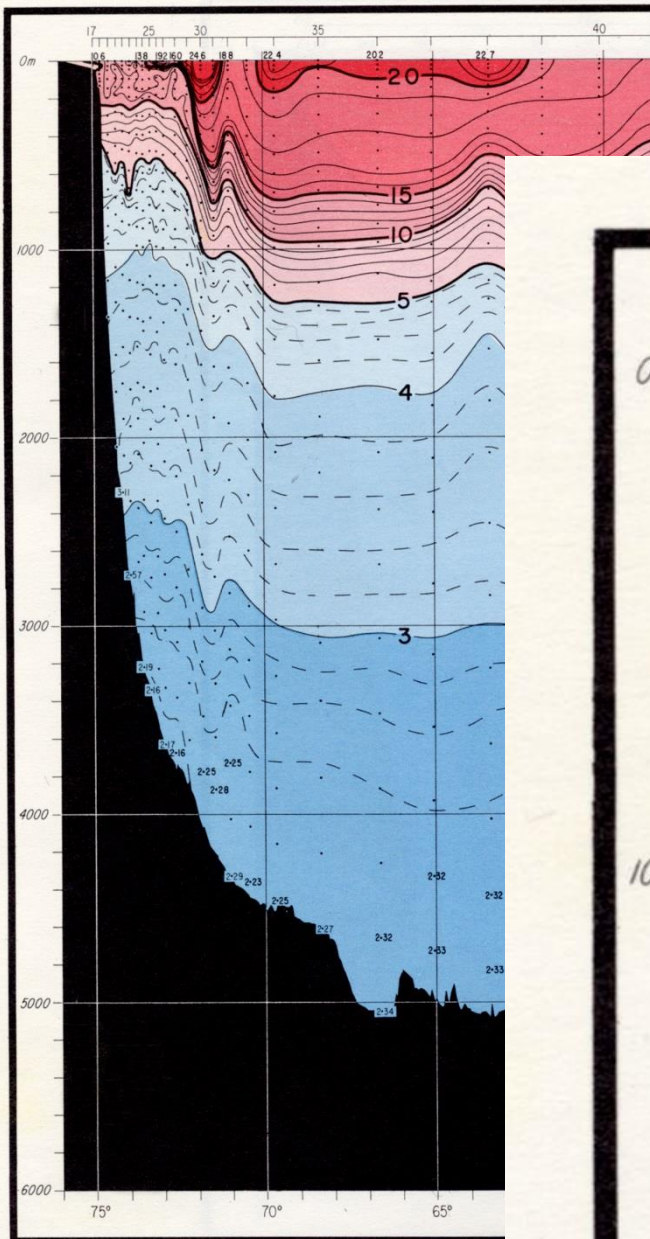




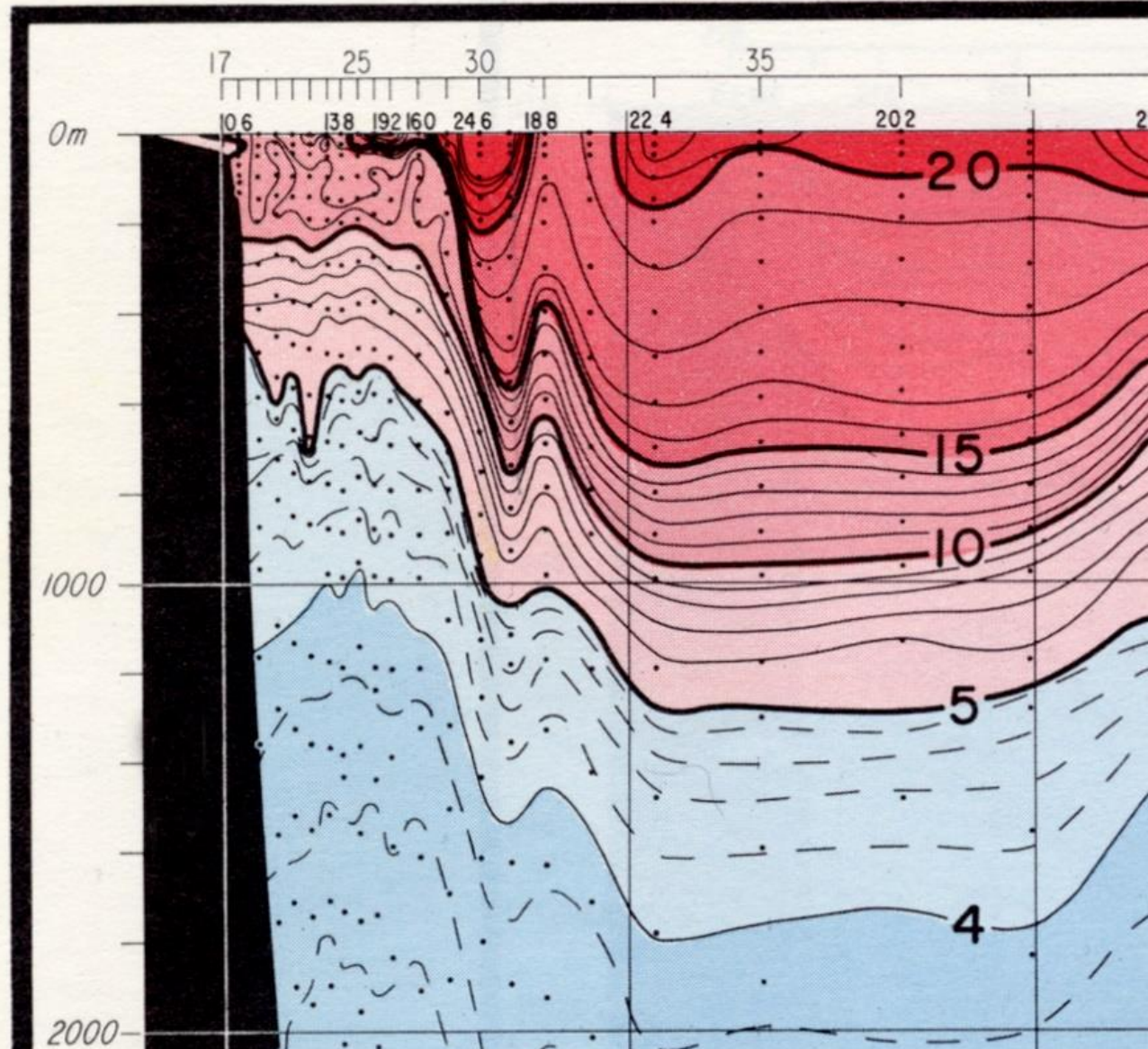
The Gulf Stream is an example of a Western Boundary Current

A boundary between cold shelf water and warm Sargasso Sea water

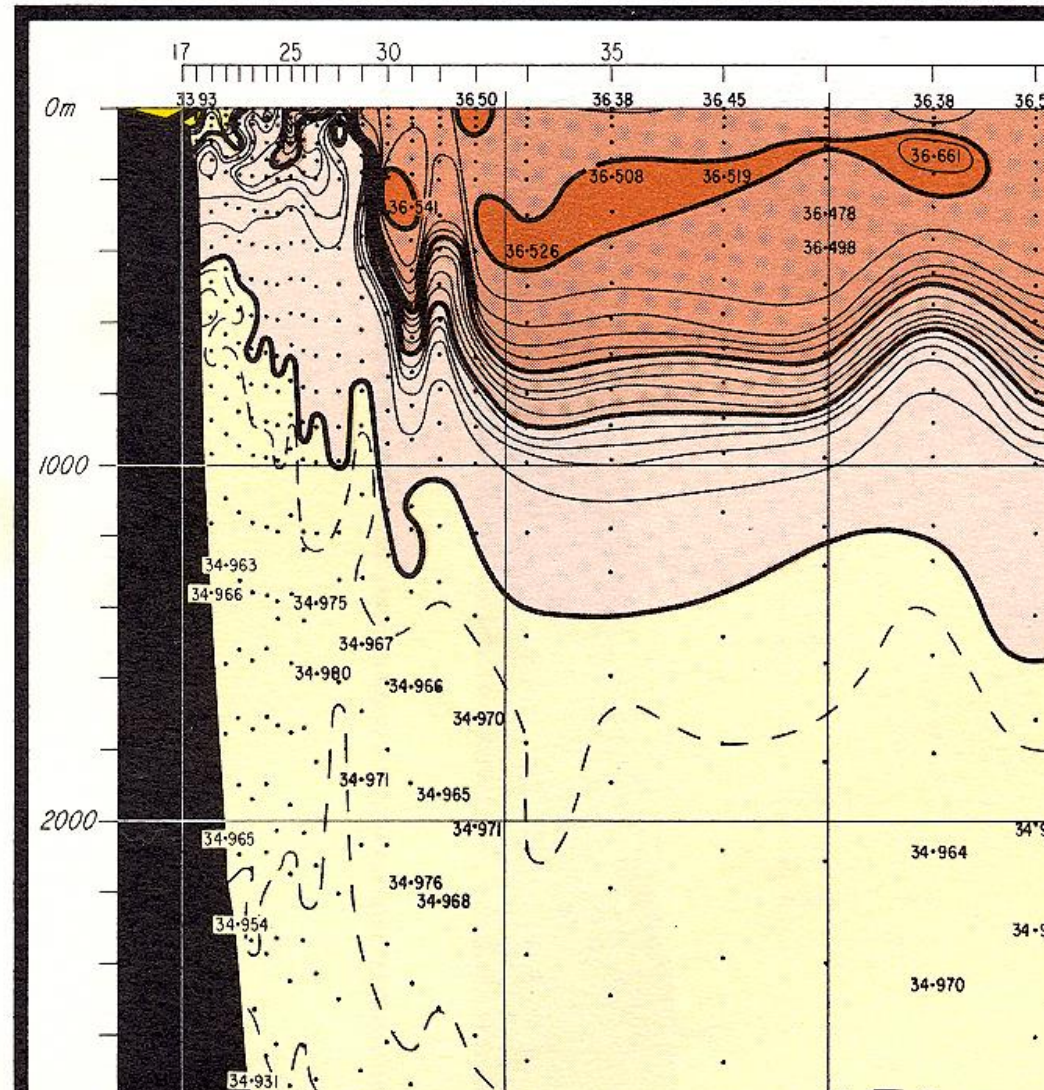
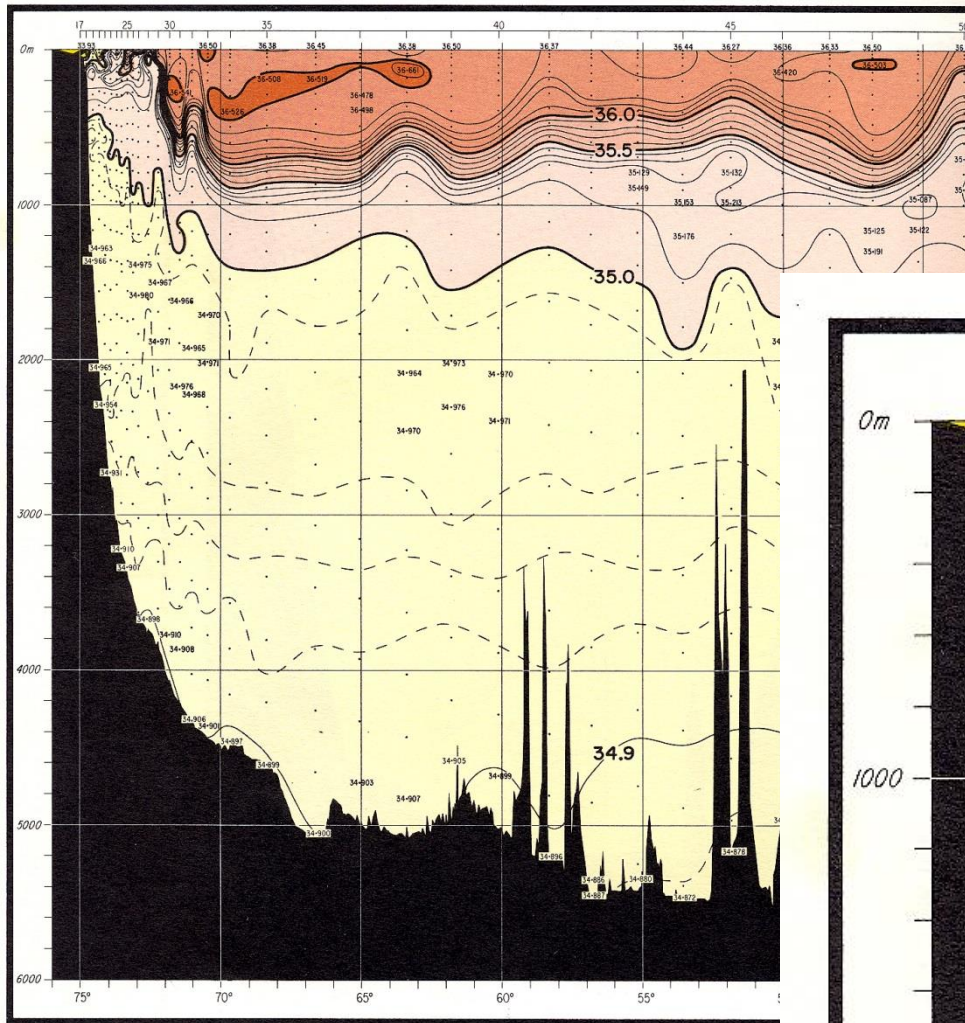
Water Temperatures ... *IMPORTANT* !!

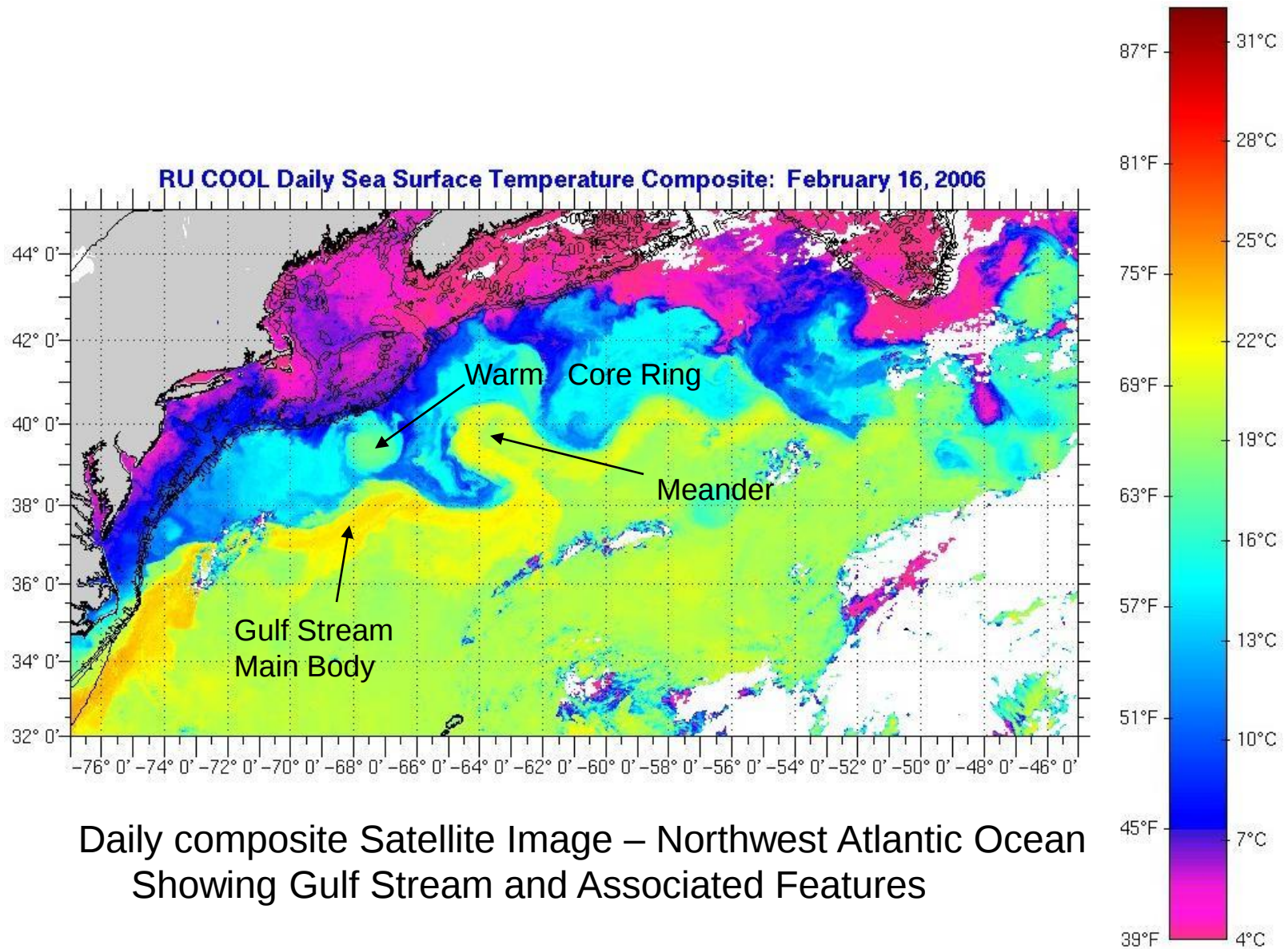


36° N.



and Salinity Gradients !

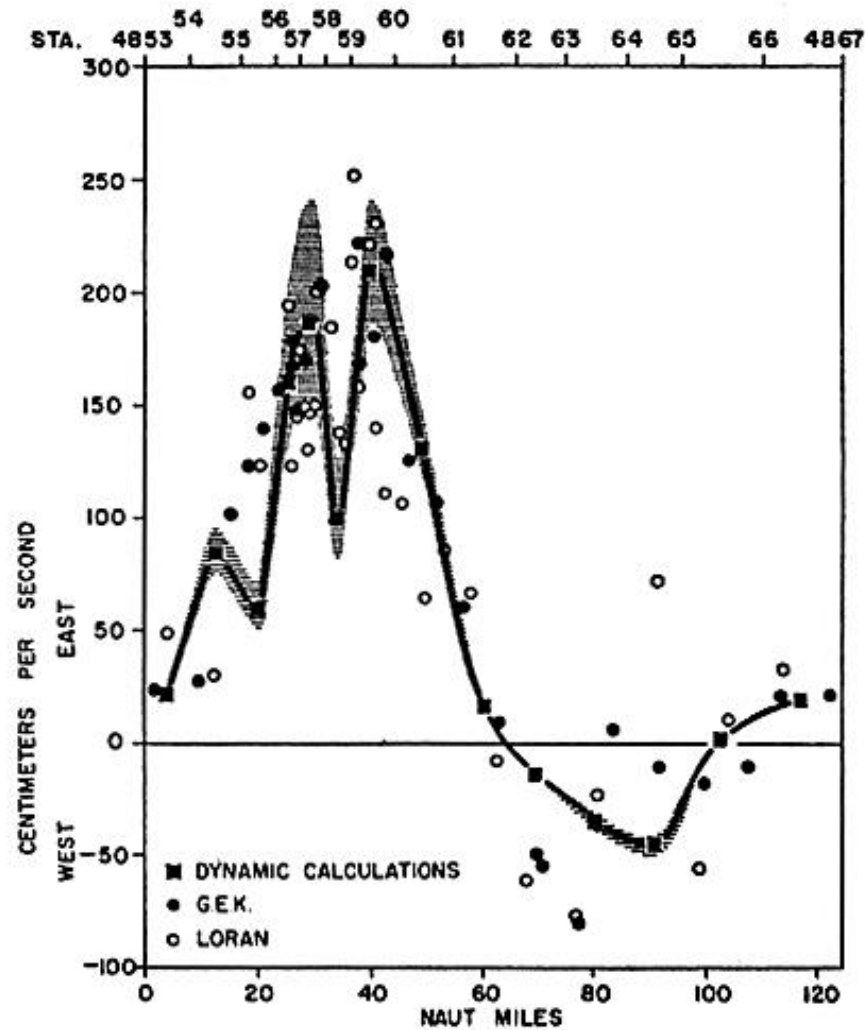




Daily composite Satellite Image – Northwest Atlantic Ocean
Showing Gulf Stream and Associated Features

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

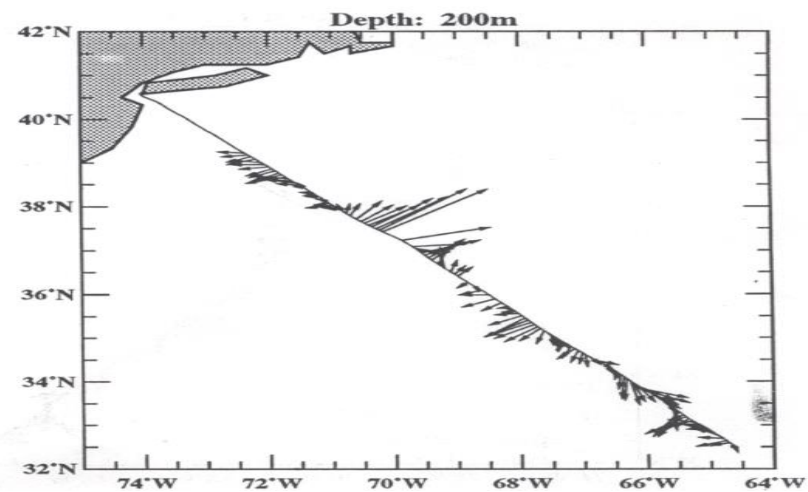
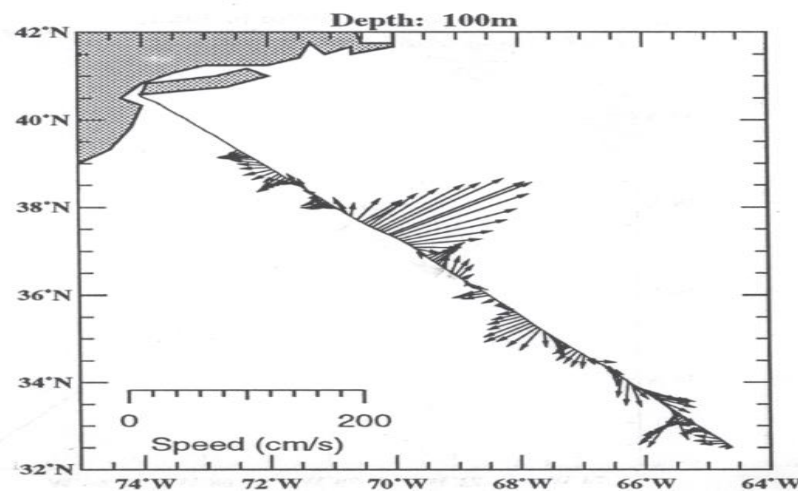
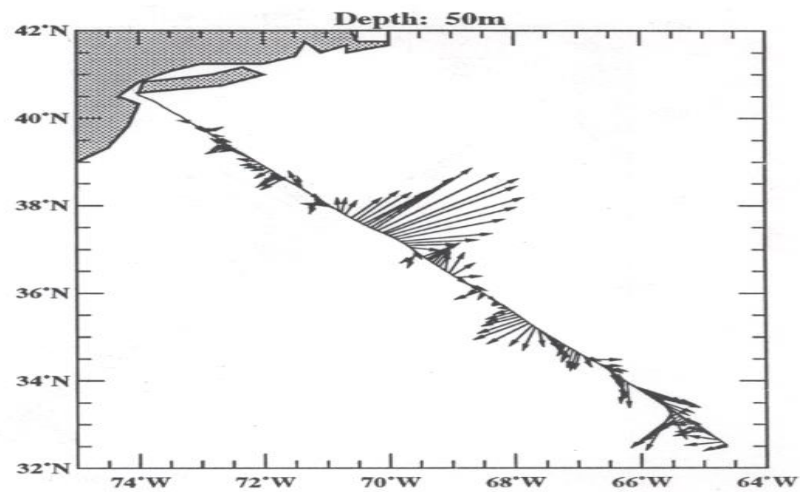
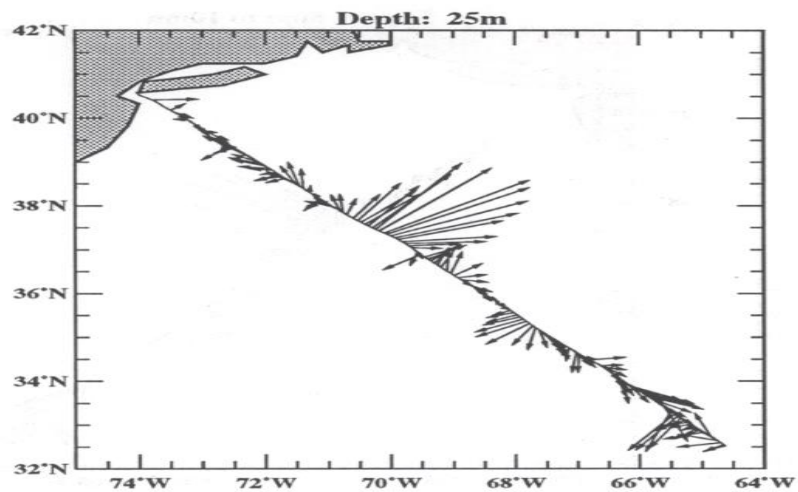
Typical Main Body Structure



From: Stommel, , The Gulf Stream , 1965

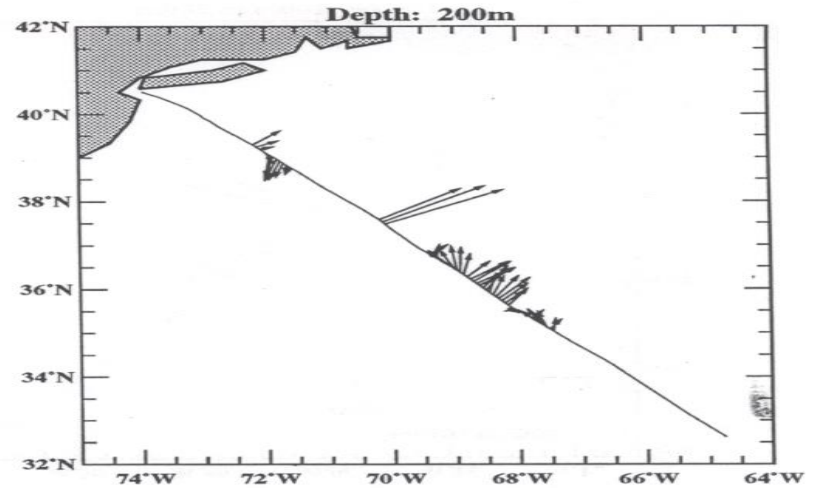
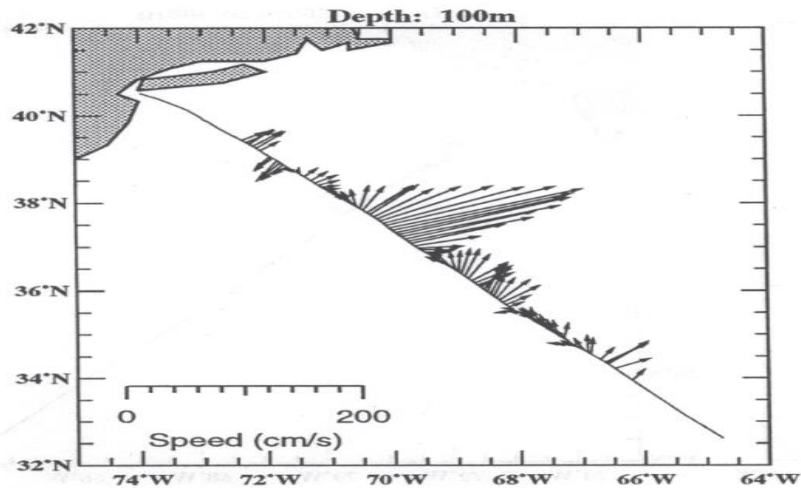
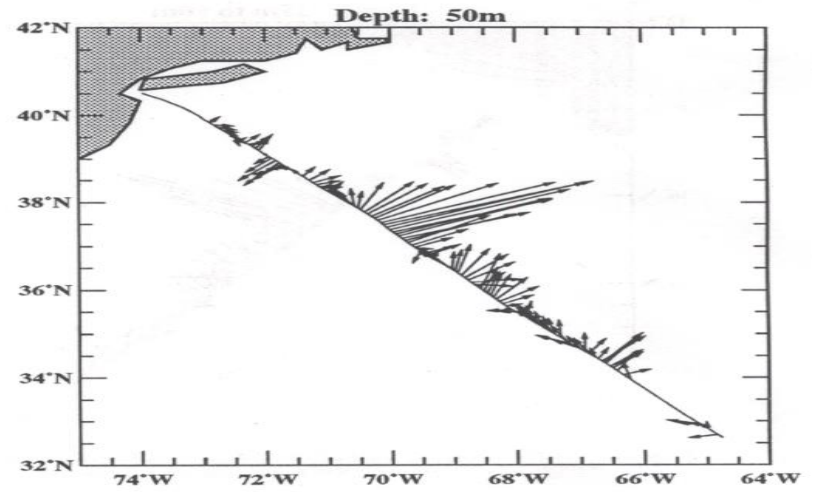
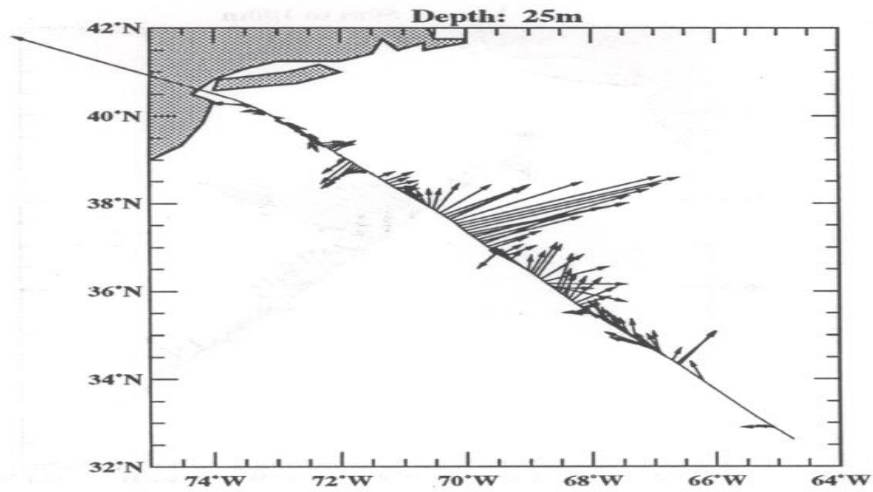
Oleander ADCP Velocities

Cruise # 059-061 (98/03/13 08:22:59 to 98/03/16 14:50:05 Outbound)



Oleander ADCP Velocities

Cruise # 062-064 (98/03/16 14:55:06 to 98/03/19 17:21:32 Inbound)



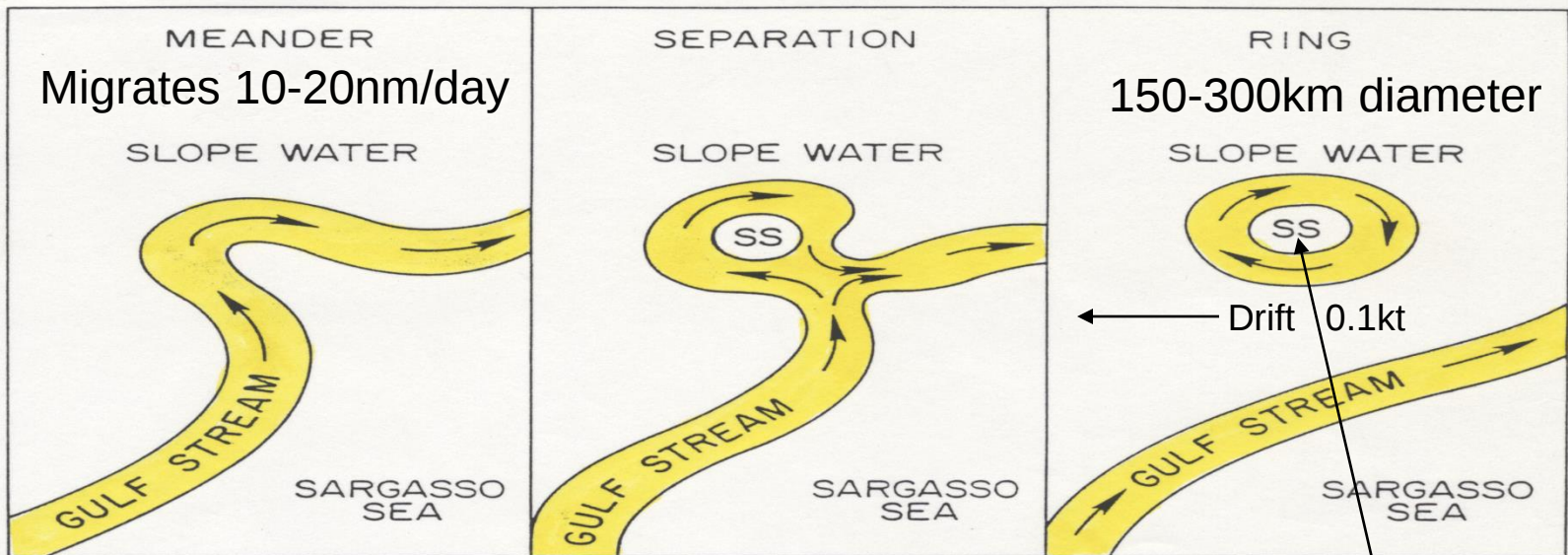


Figure 1. Three stages in the formation of a warm-core ring from a Gulf Stream meander. The core is water from the Sargasso Sea (SS).

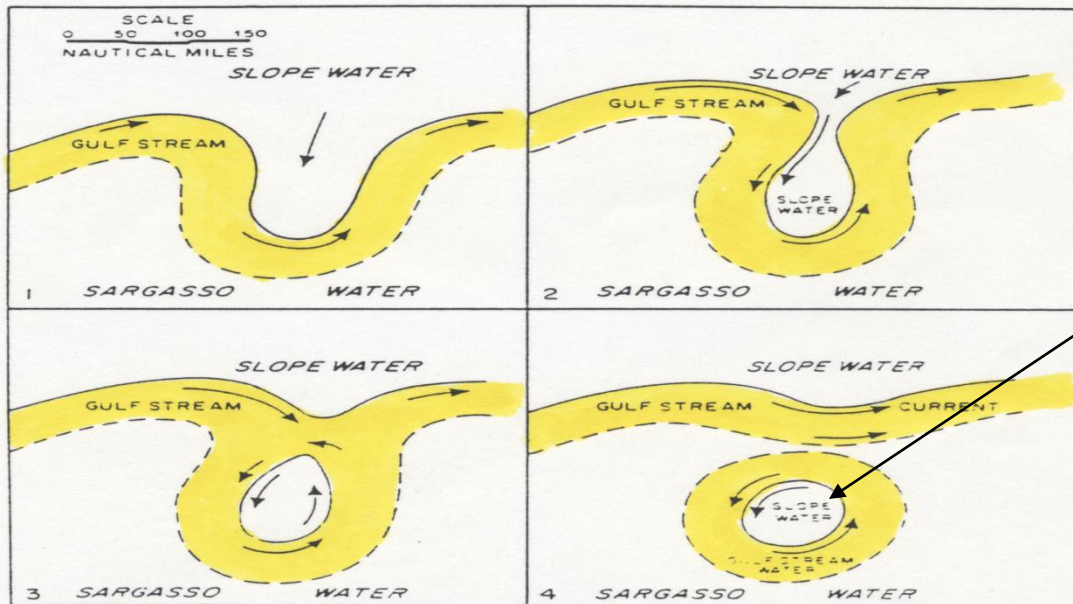
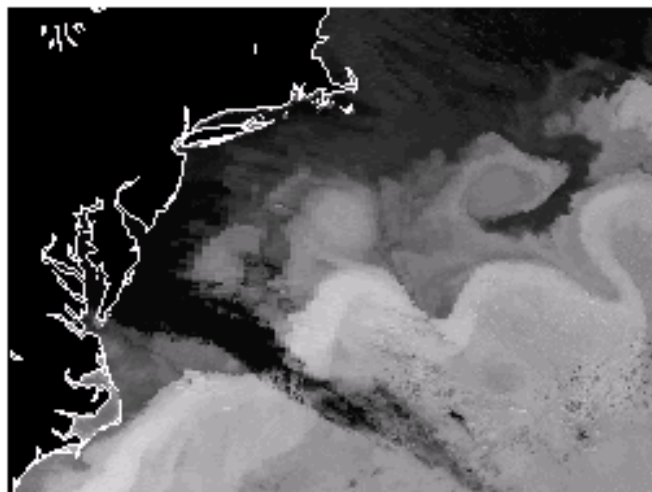


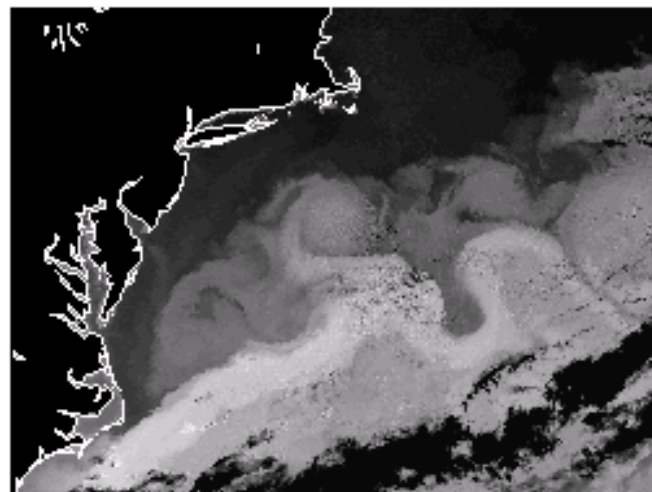
Figure 4.8 Diagram of Gulf Stream ring generation from meander formation to separation. (Parker, 1971.)

Warm Core

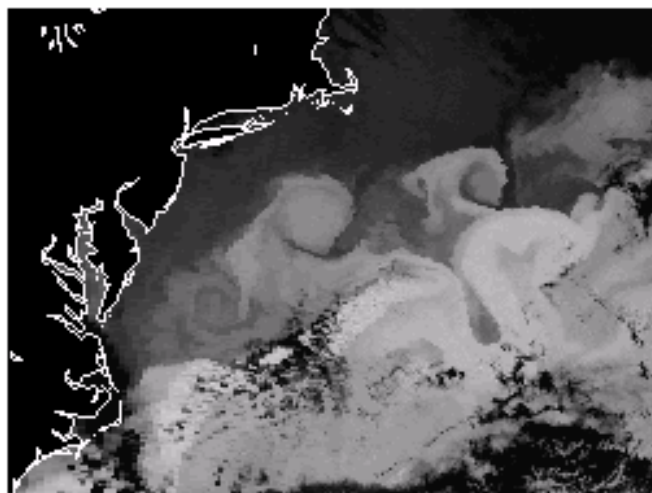
Cold Core



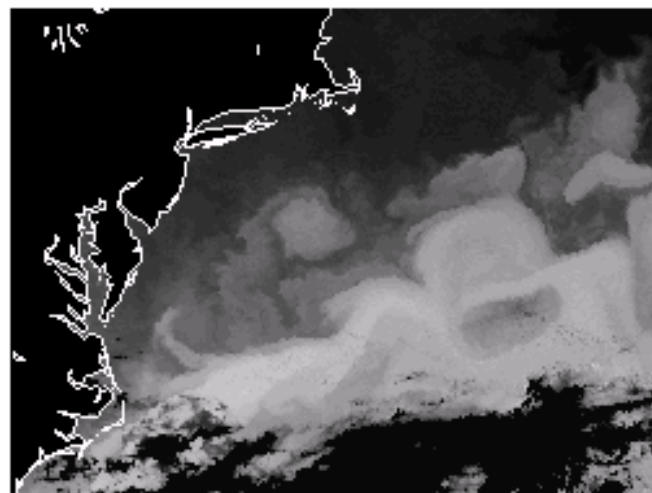
March 15, 1982



March 22, 1982



March 31, 1982



April 15, 1982

Sources of Information

Gulf Stream and Weather Information on the WEB

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Rev 3/17

***National Weather Service <http://www.nws.noaa.gov> or

<http://www.nws.noaa.gov/om/marine/home.htm>

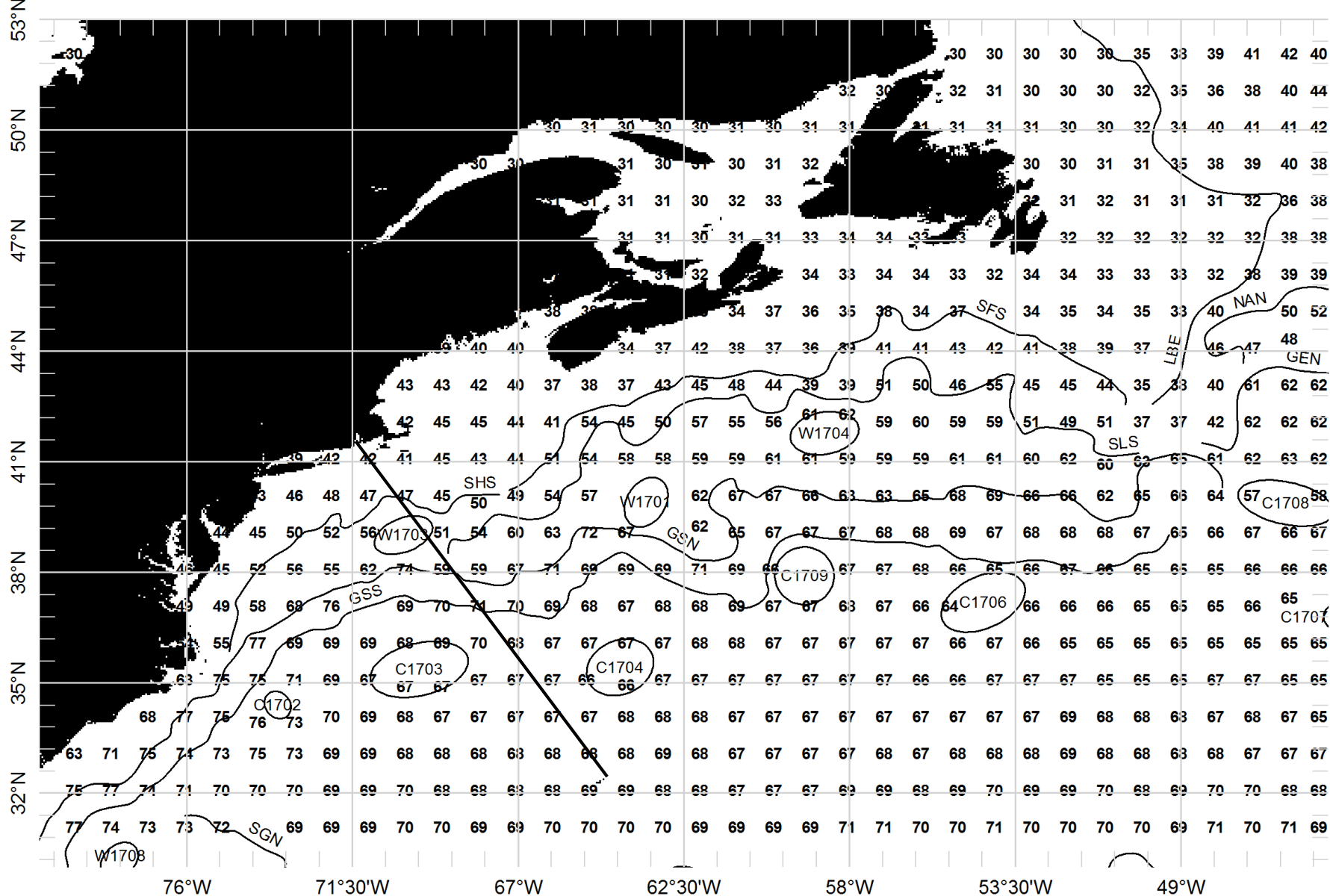
The National Weather Service site with an abundance of products including marine forecasts and satellite imagery. A valuable resource for the study of weather. Look particularly at the NWS Ocean Prediction Center sites. Check out the film loops at this site. **The place to start!**

NOAA/National Weather Service Environmental Modeling Center <http://polar.ncep.noaa.gov>

The National Weather Service's Environmental Modeling Center and home to the Real Time Ocean Forecast System model (RTOFS). Although this model's resolution is a bit coarse, covering for example most of the North Atlantic, its looping capabilities assist in the determination of how fast some ocean current features evolve. In addition this site allows comparison of model results to satellite data and other models such as those developed by the Navy. For particularly interesting comparisons see <http://www.opc.ncep.noaa.gov/GlobalOceanStart.shtml>.

U.S. Navy Research Laboratory <http://www7320.nrlssc.navy.mil/GLBhycom1-12/glfstr.html>

This site contains a variety of model results for all areas of the global ocean. These include indications of surface temperature distributions, sea surface heights and currents. Comparisons with observational data are also provided. These data allow comparisons with other models such as RTOFS as well as direct satellite observations

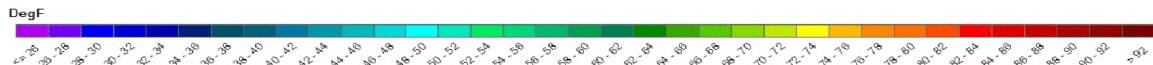
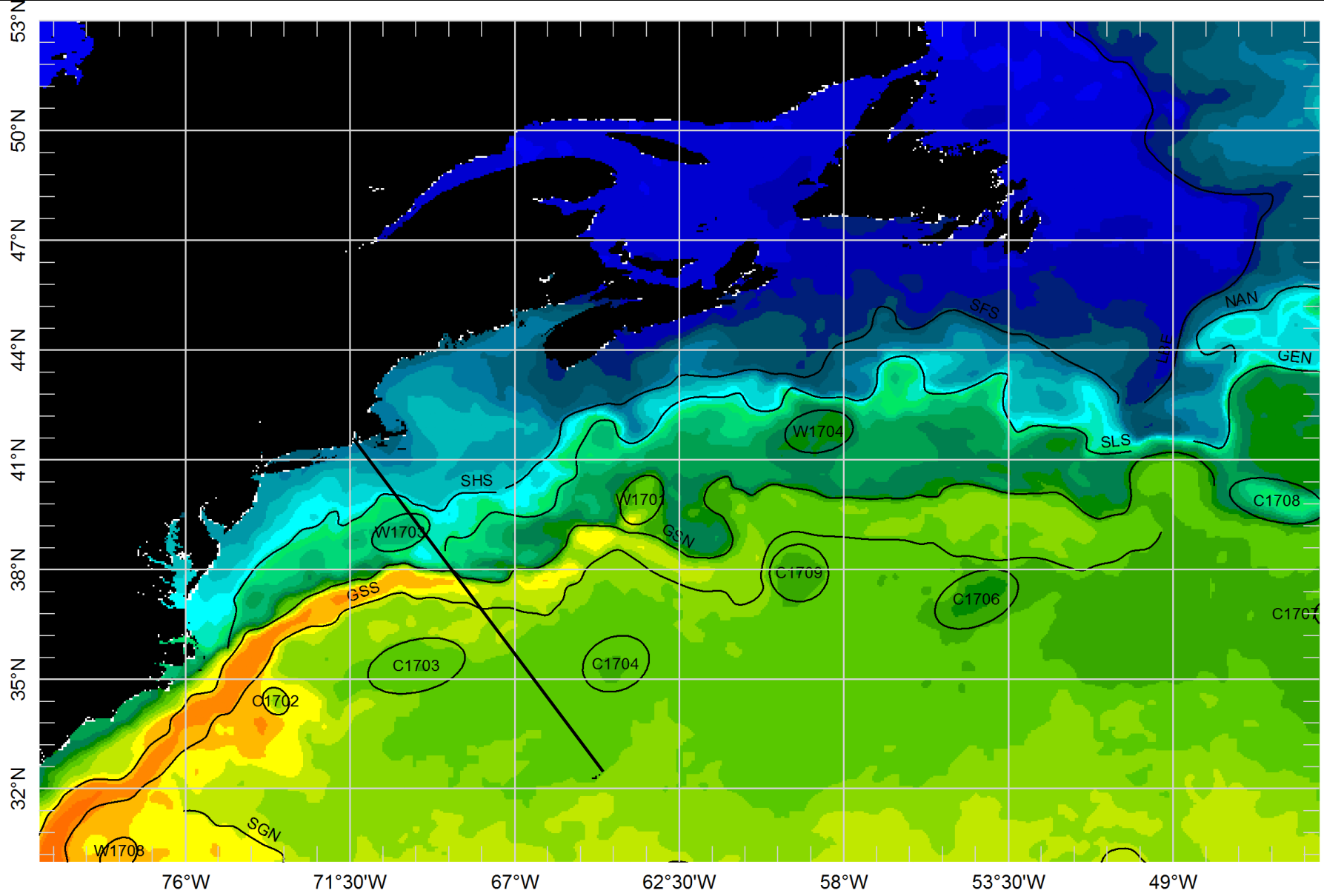


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Date: 2-28-2017

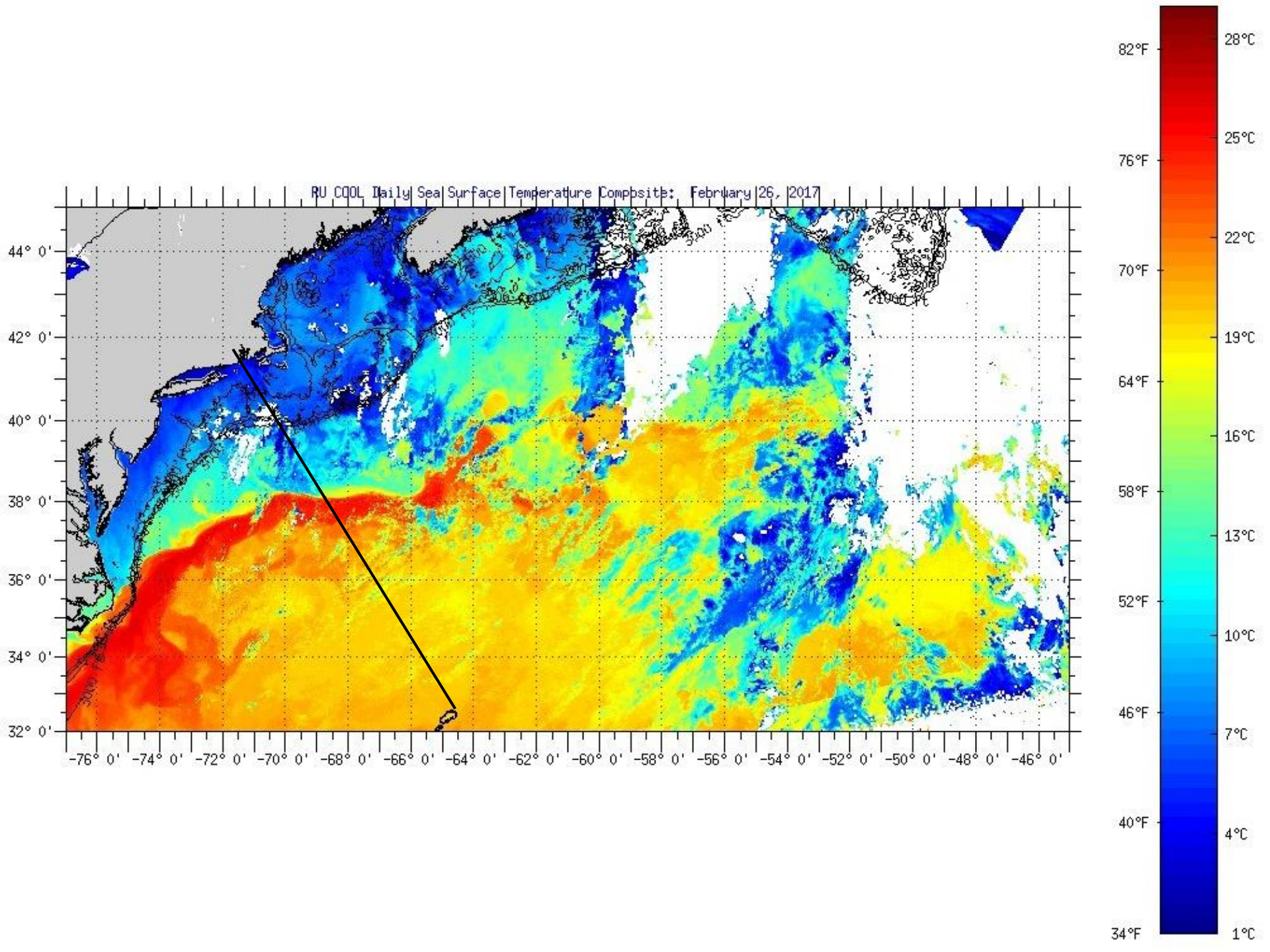
North Atlantic B&W



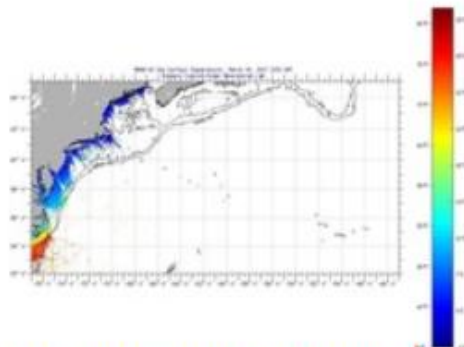


White Fill - No data
WYMW - Warm Eddy
CYMW - Cold Eddy
Front —

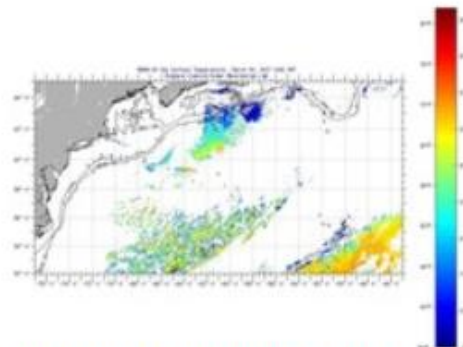




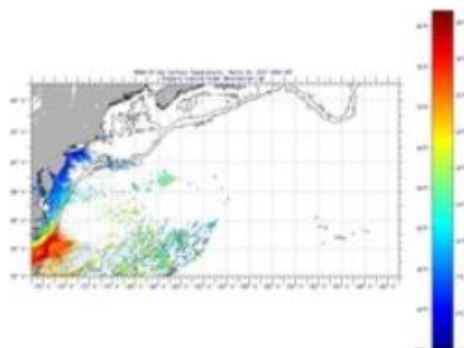
So... What do we see today ?



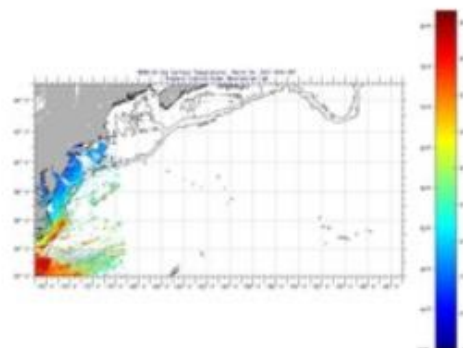
NOAA-18 March 04, 2017 12:22 152kb



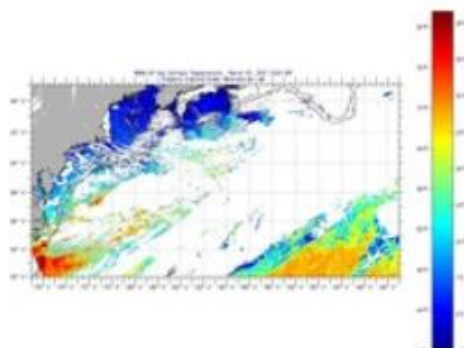
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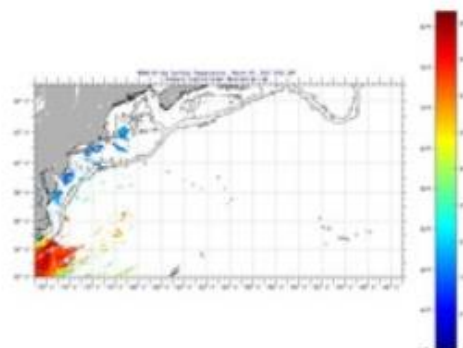
NOAA-19 March 04, 2017 08:44 177kb



NOAA-18 March 04, 2017 00:00 157kb

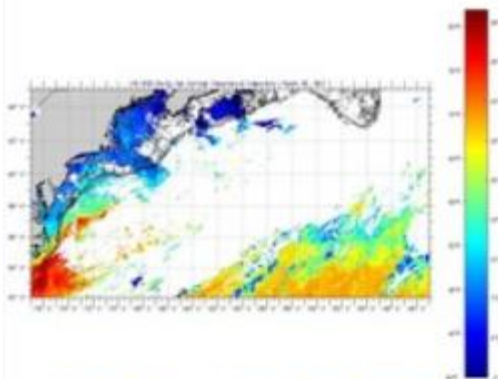


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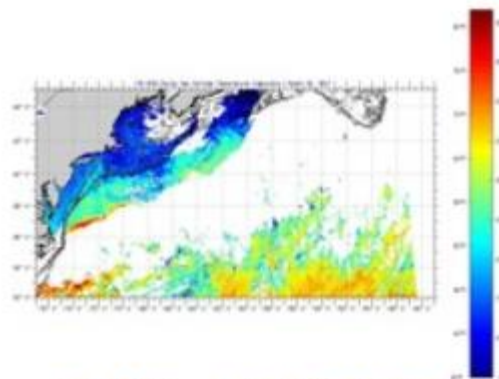


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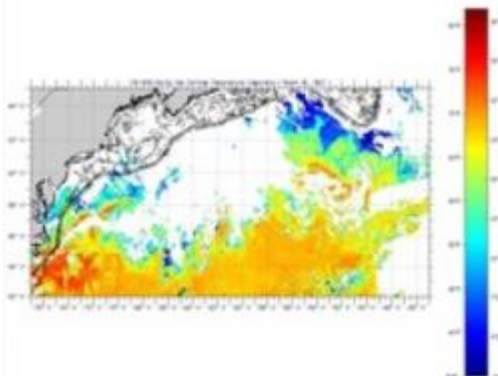
CLOUDS !!



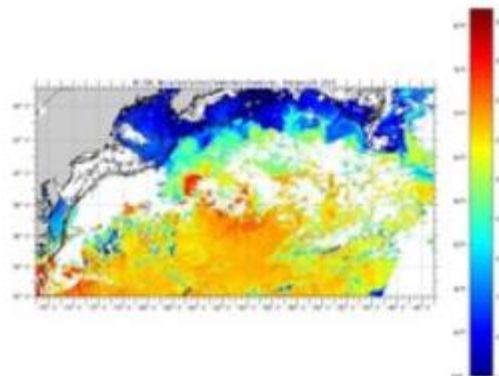
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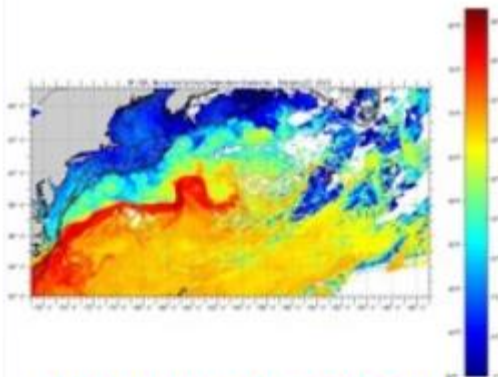
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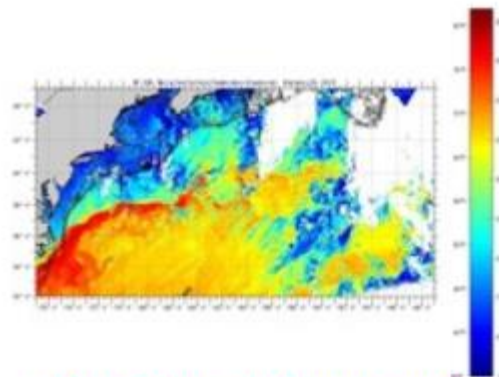
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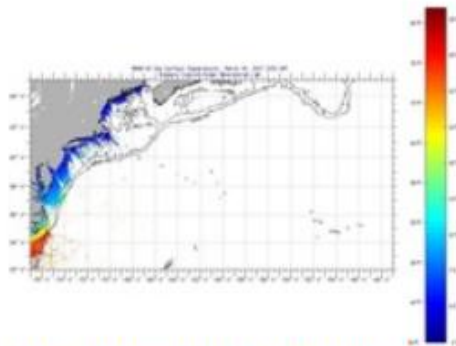
NOAA February 28, 2017 252kb



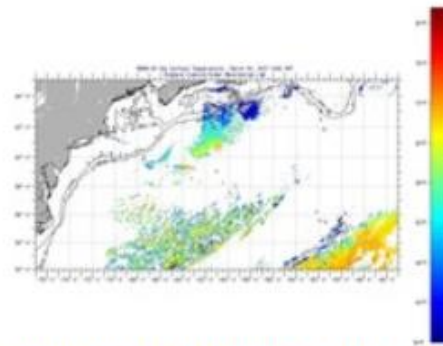
NOAA February 27, 2017 249kb



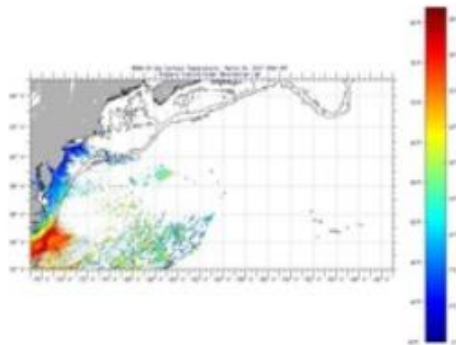
NOAA February 26, 2017 244kb



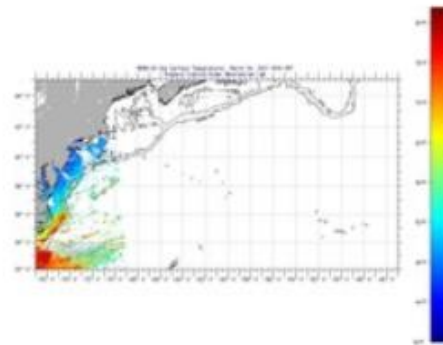
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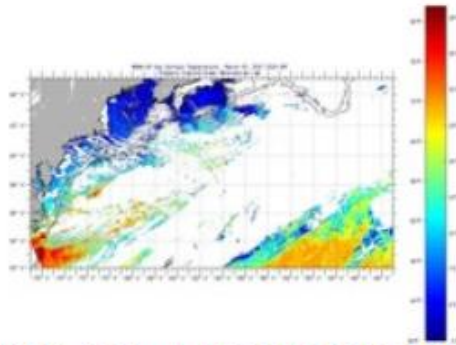
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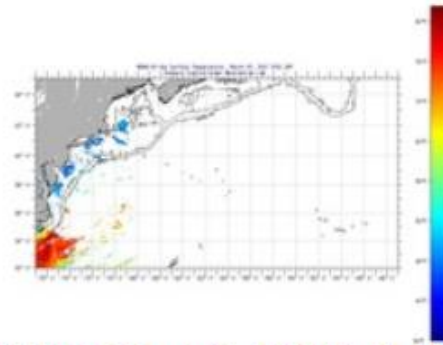
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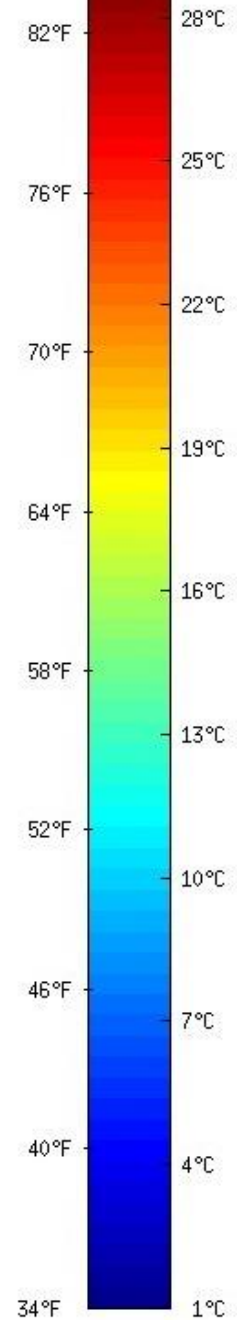
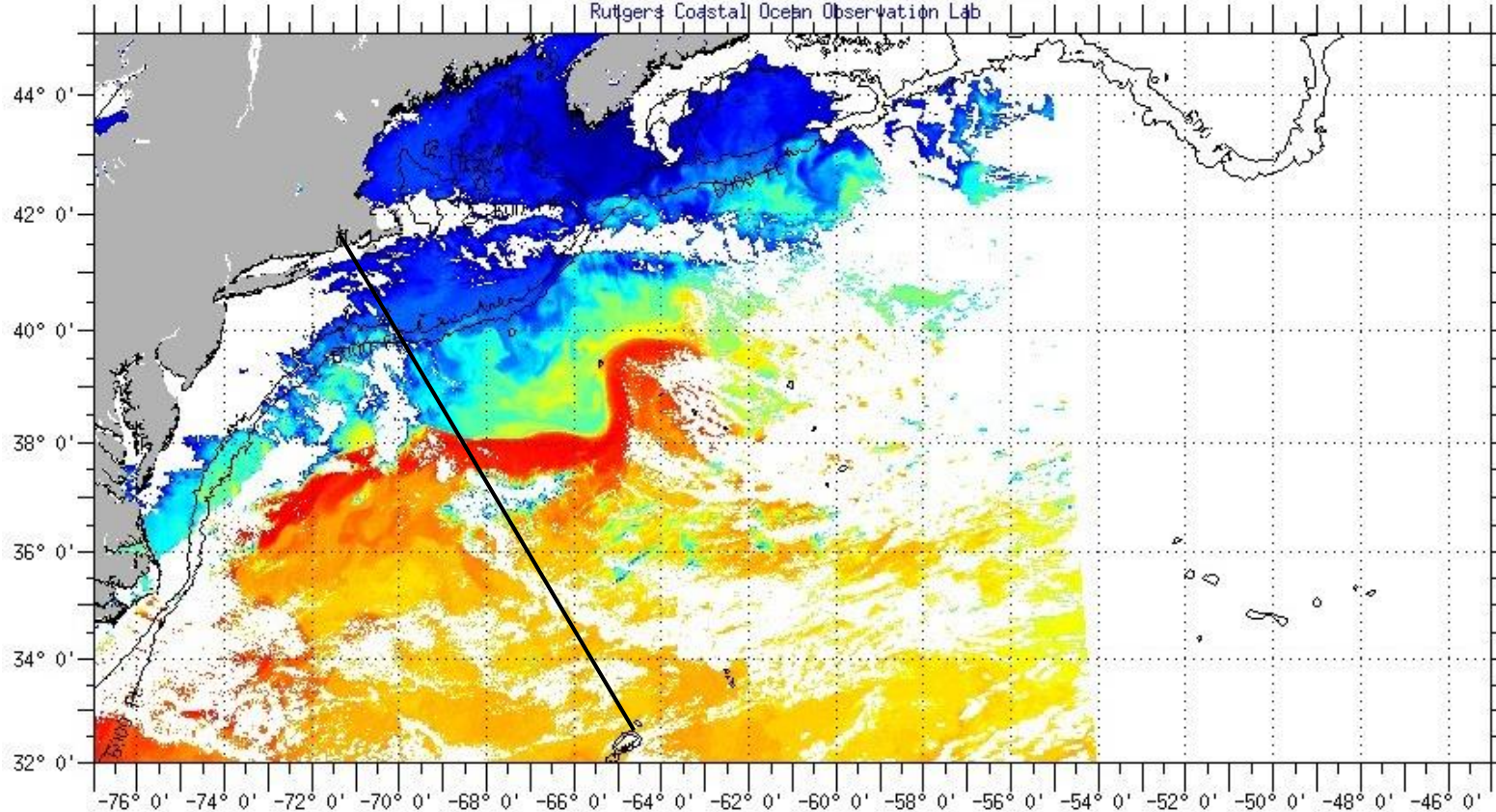
Lesson: START ANALYSIS EARLY !!

Using a Variety of Resources

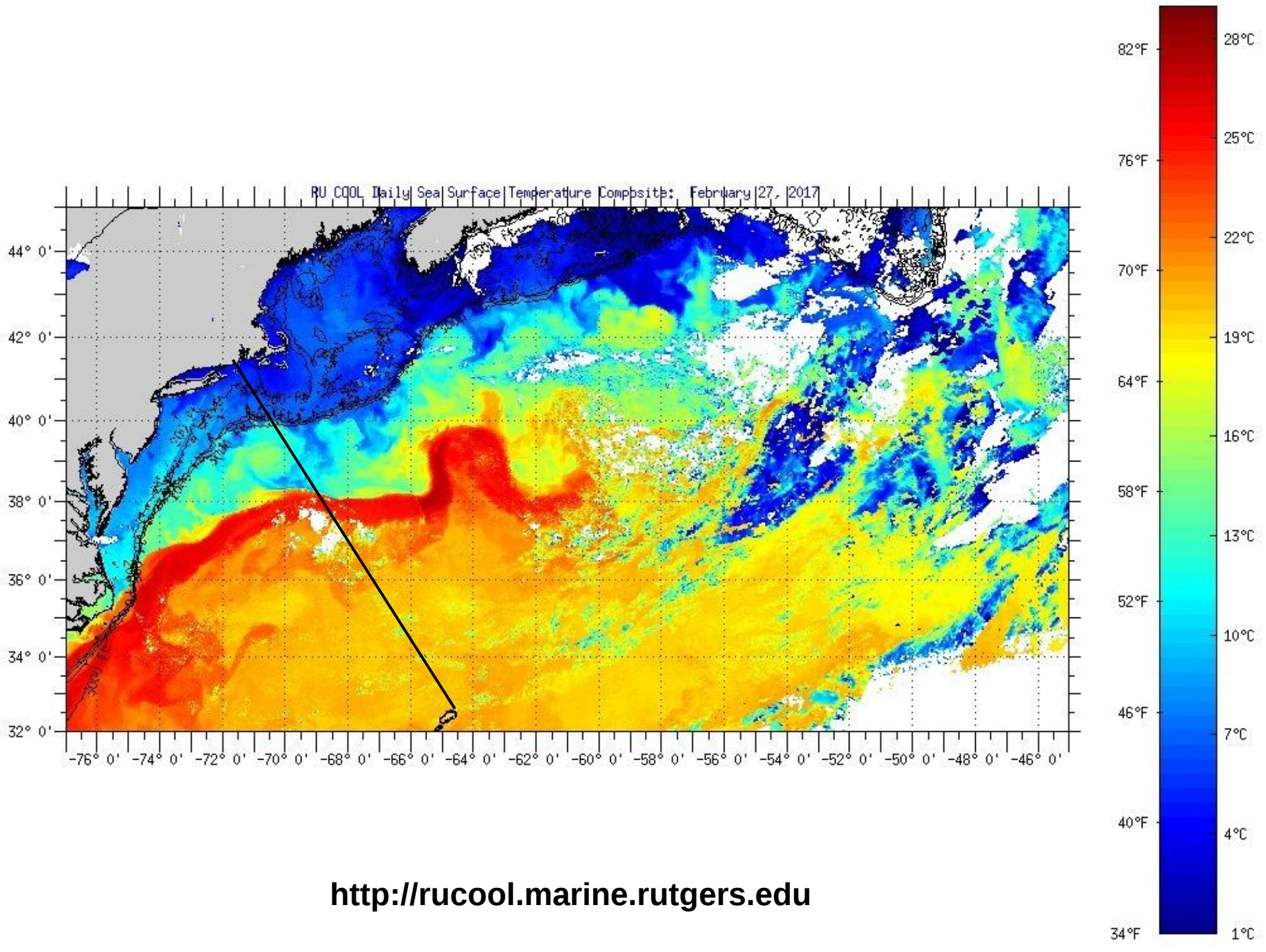
Keeping in mind.....

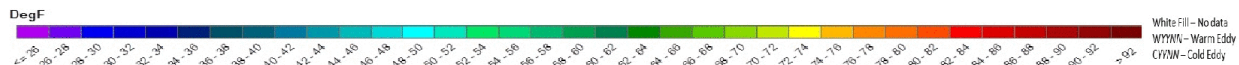
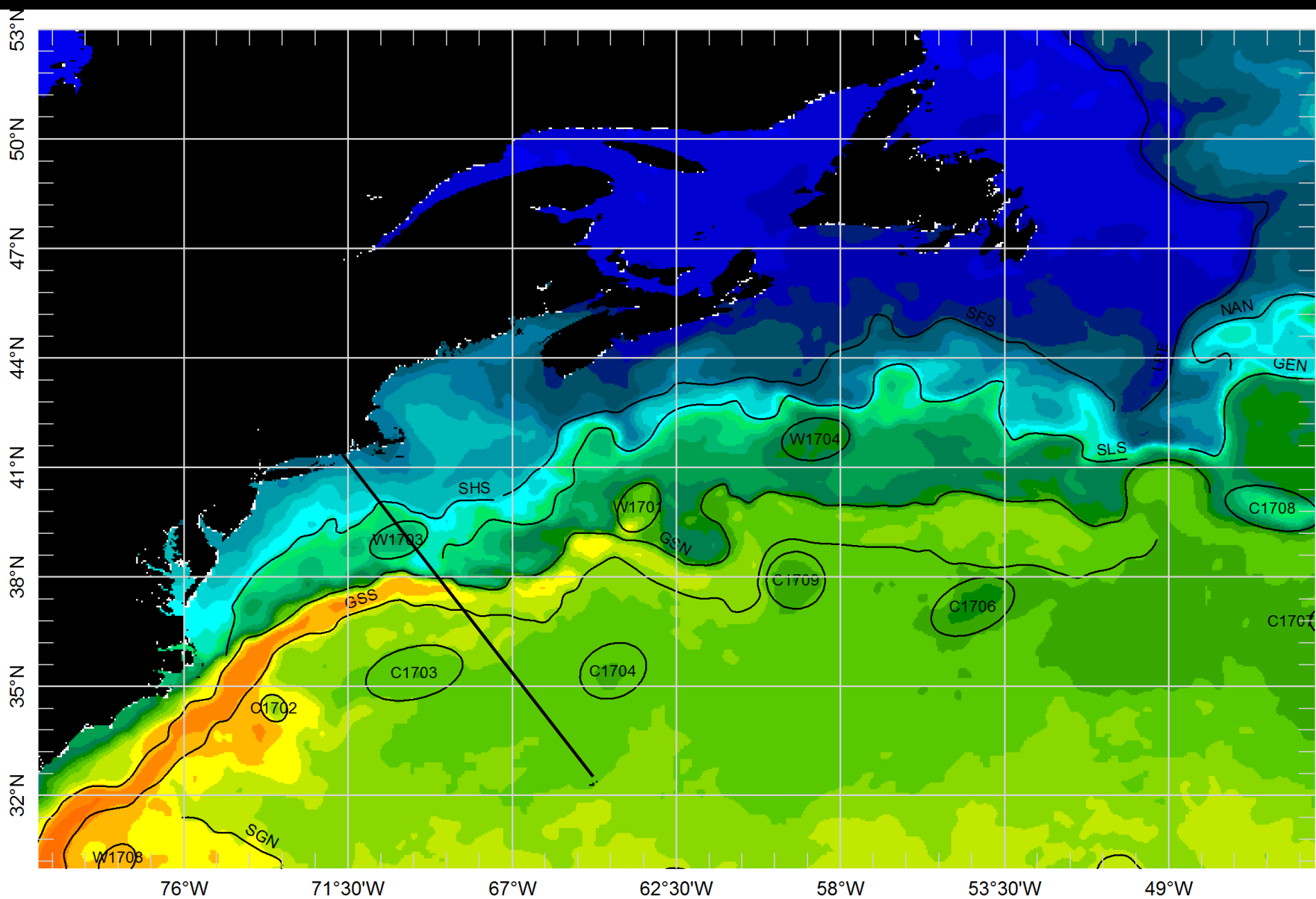
- Scales of Variability
- Needed/Desired Accuracy
- Reception Limitations
- Sensory Overload

NOAA-19 Sea Surface Temperature: February 27, 2017 1926 GMT
Rutgers Coastal Ocean Observation Lab



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





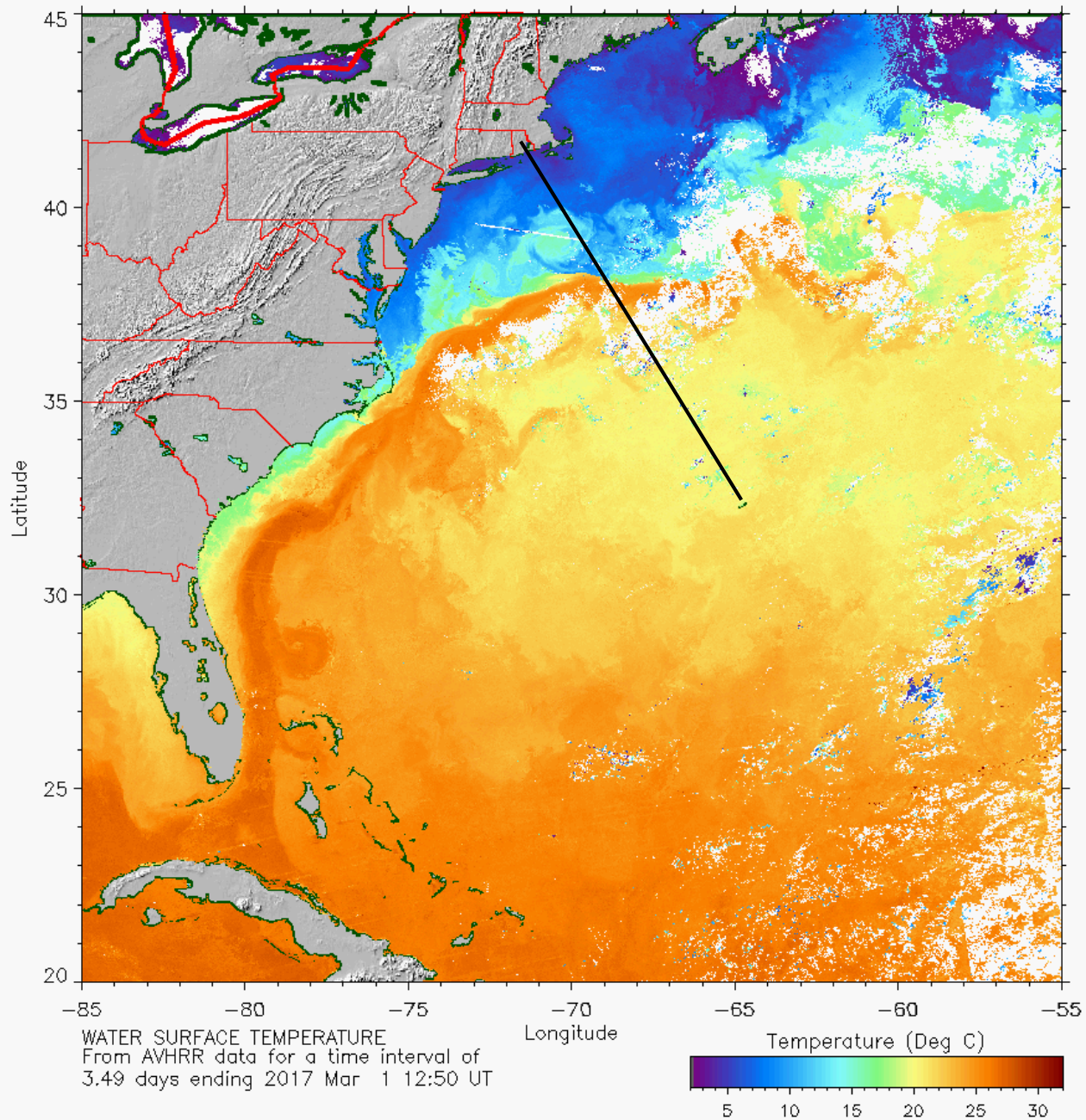
Front

Approved for Public Release: Distribution Unlimited

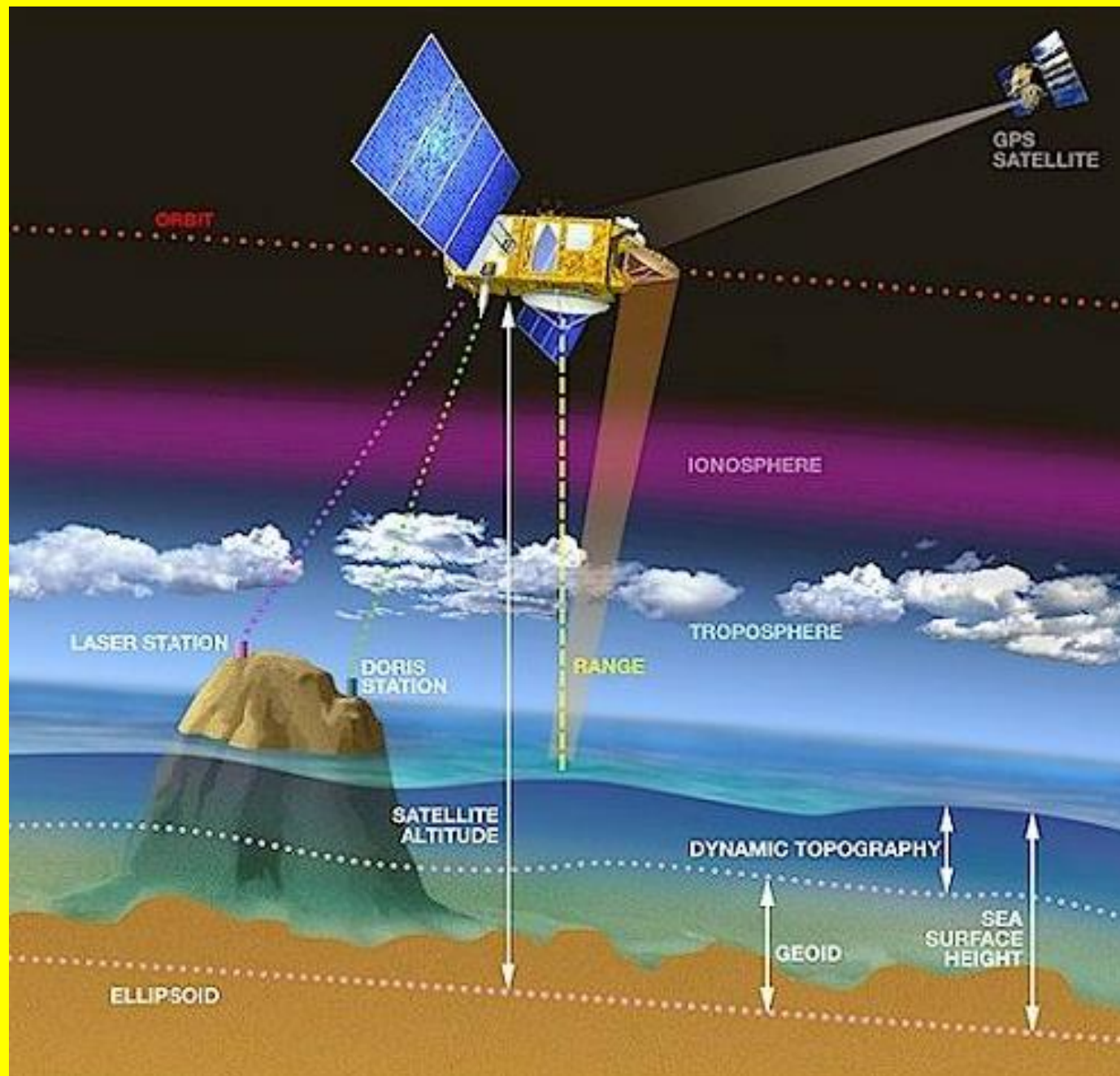
Date: 2-28-2017

North Atlantic Color

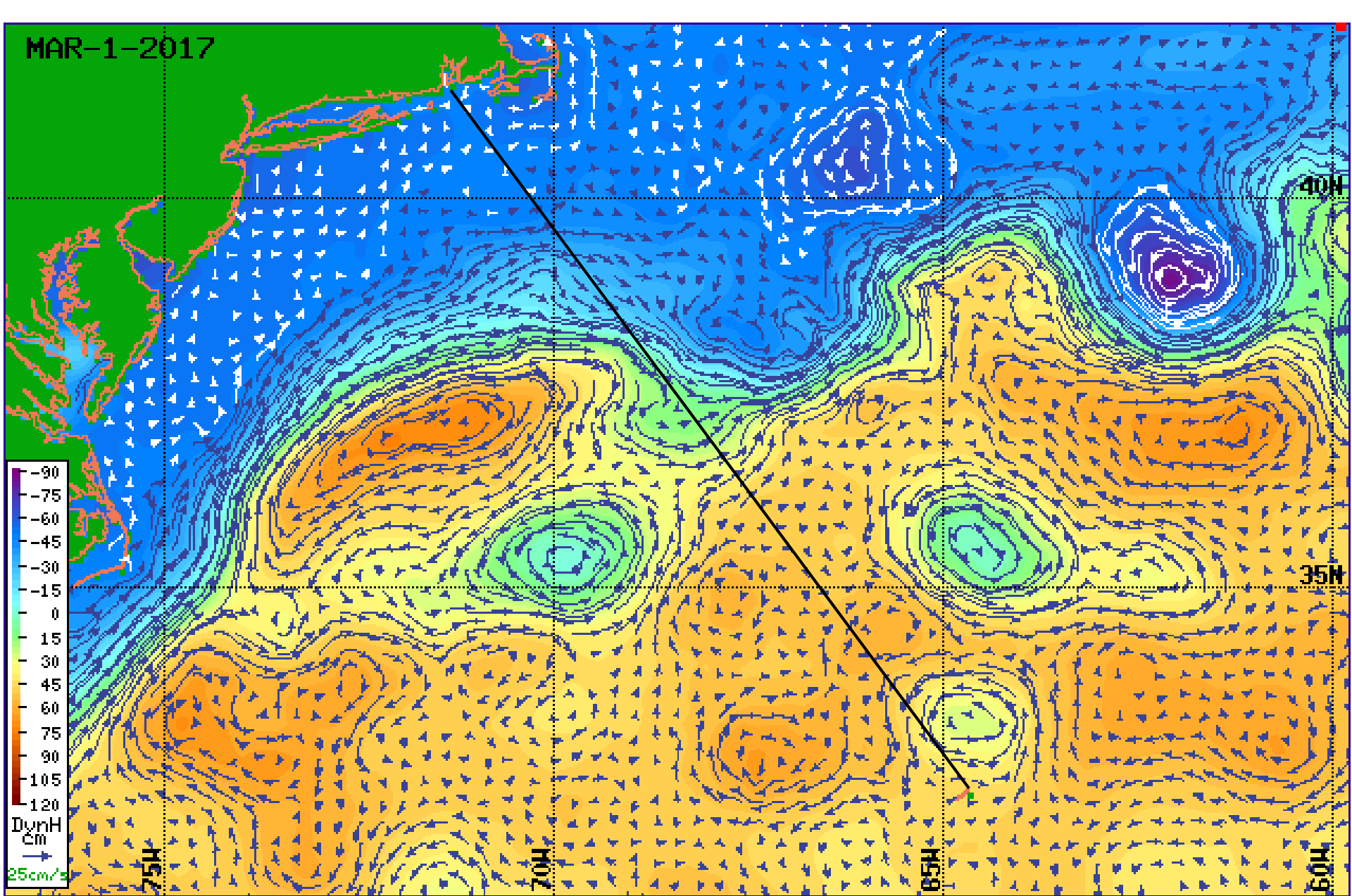
Source: <http://ecowatch.ncddc.noaa.gov/JAG/Navy/>

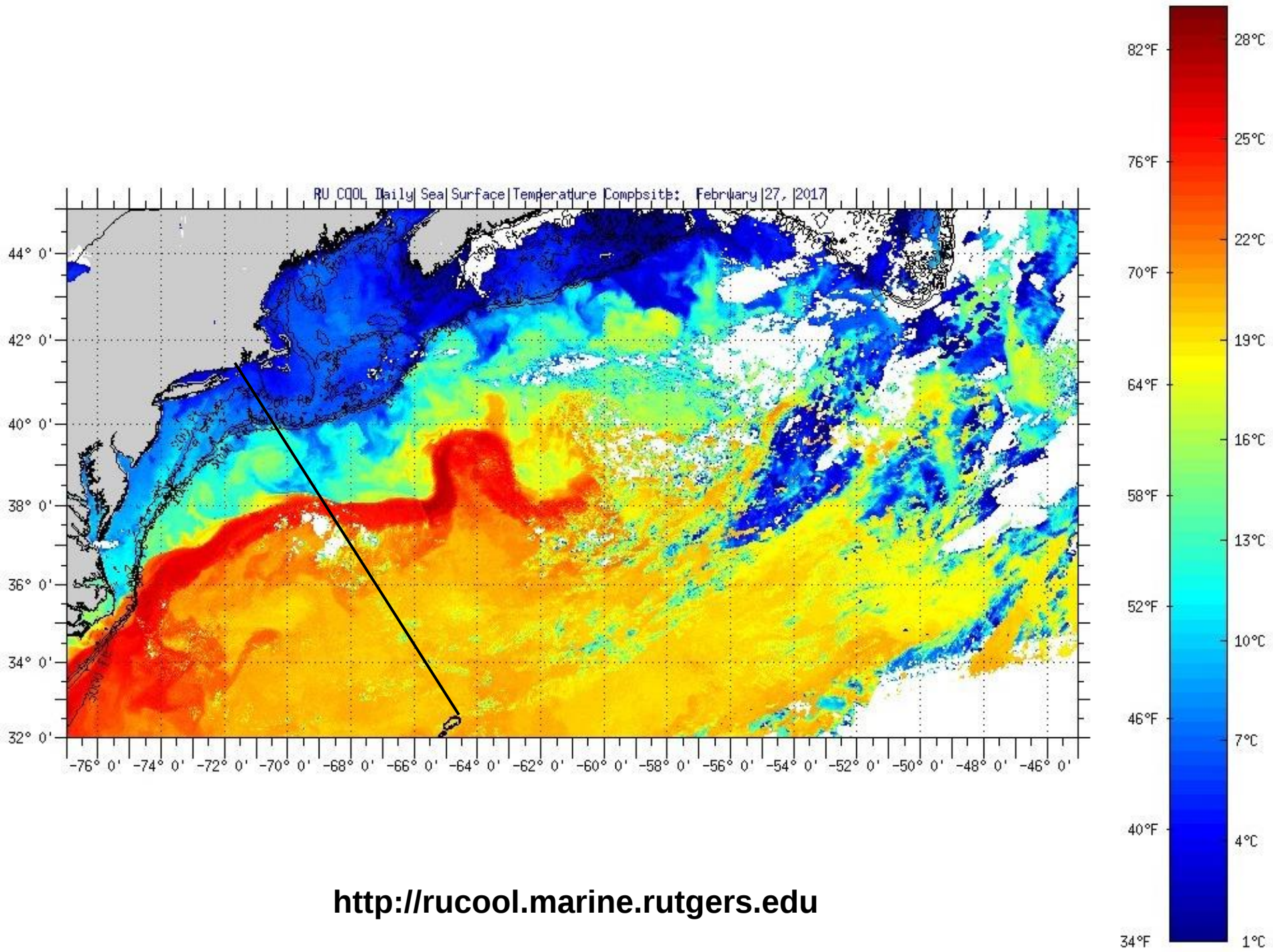


<http://fermi.jhuapl.edu/avhrr/gs/index.html>



Satellite Altimetry (Geodesy)





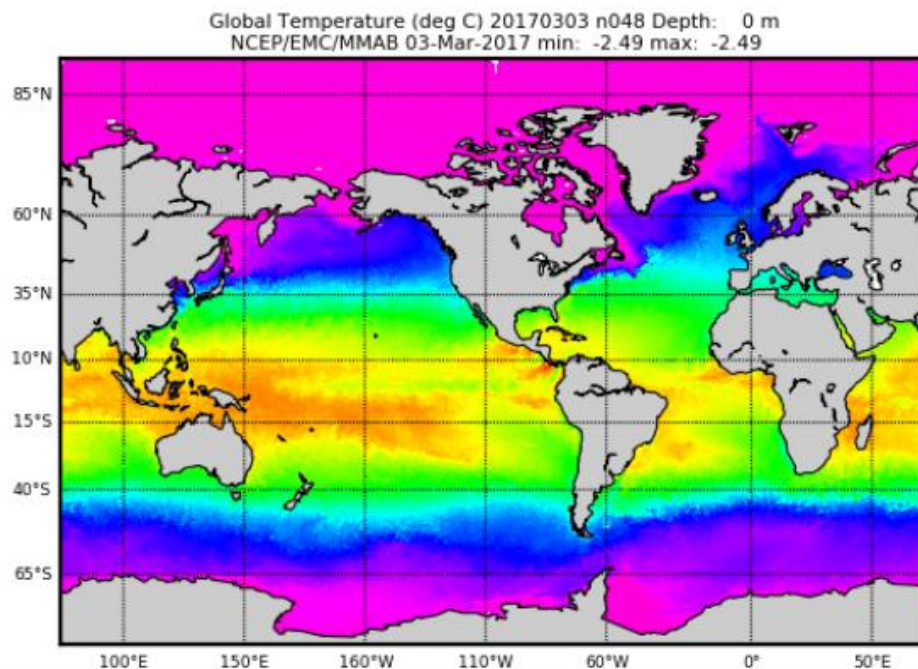
Marine Modeling & Analysis Branch

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Global Real-Time Ocean Forecast System

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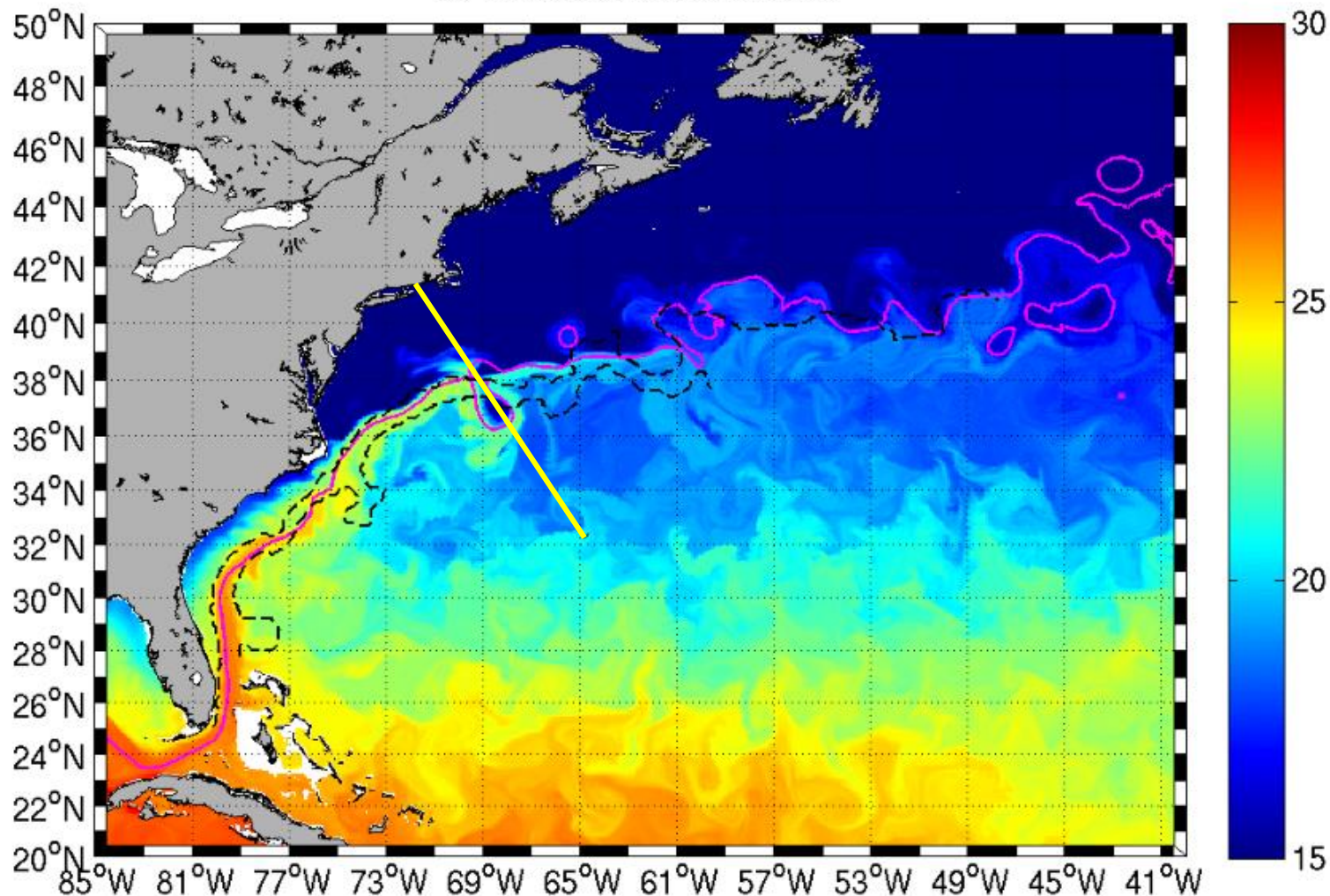
The global operational Real-Time Ocean Forecast System (Global RTOFS) at the National Centers for Environmental Prediction is based on an eddy resolving $1/12^\circ$ global HYCOM (HYbrid Coordinates Ocean Model) and is part of a larger national backbone capability of ocean modeling at the National Weather Service in a strong partnership with the US Navy.



<http://polar.ncep.noaa.gov/global/>

Global RTOFS GS Location for 02-Mar-2017

12°C isoth at 400m and SST



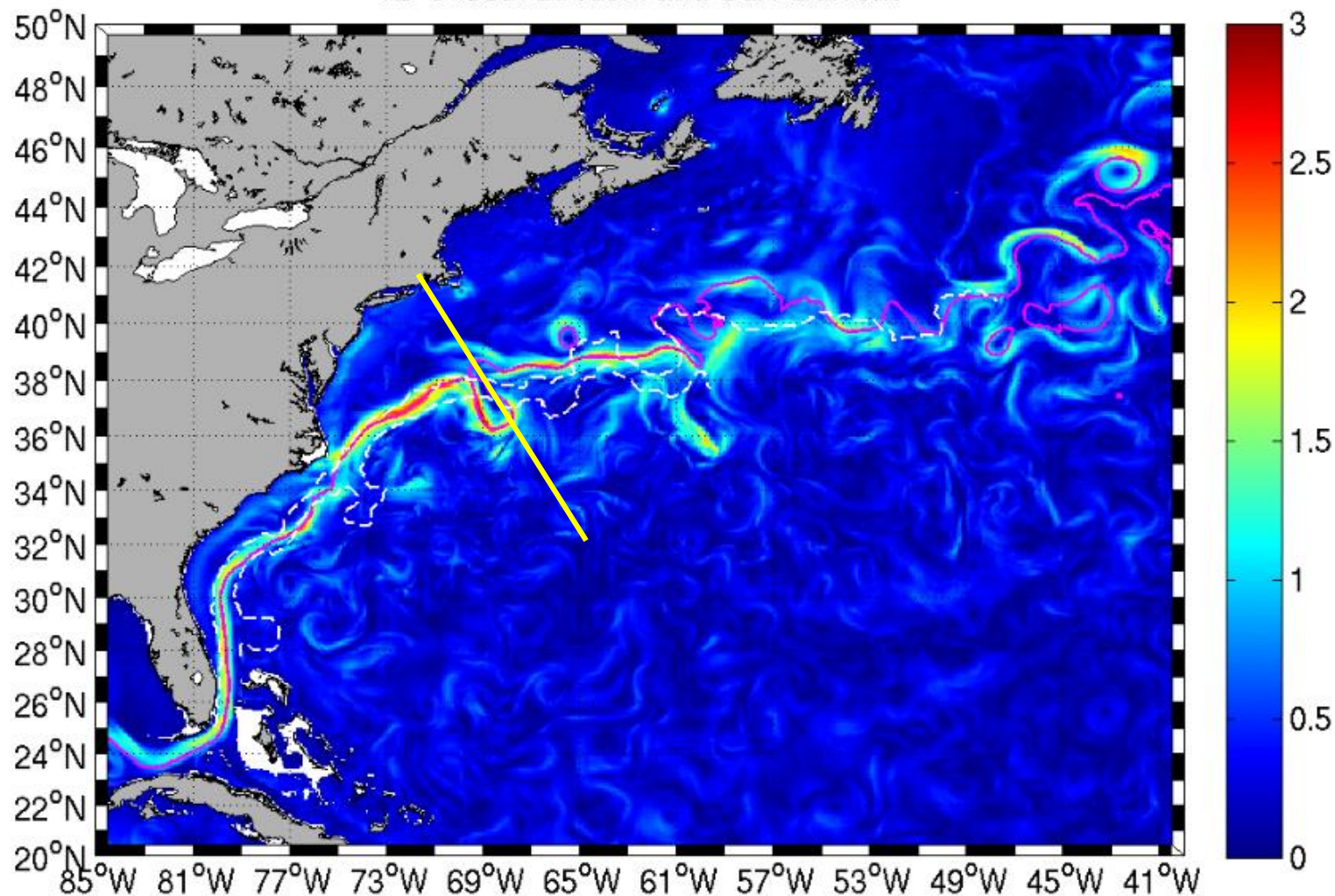
NAVOCEANO for North Wall Hausdorff: NaN° Modified Hausdorff: NaN°

NAVEASTOCEANCEN for 02-MAR-17 North Wall Hausdorff: 1.91° Modified Hausdorff: 0.51°

For the Hausdorff metrics, the RTOFS front was trimmed to approximately the region of the Navy fronts

Global RTOFS GS Location for 02-Mar-2017

12°C isoth at 400m and Surf Current



NAVOCEANO for North Wall Hausdorff: NaN° Modified Hausdorff: NaN°

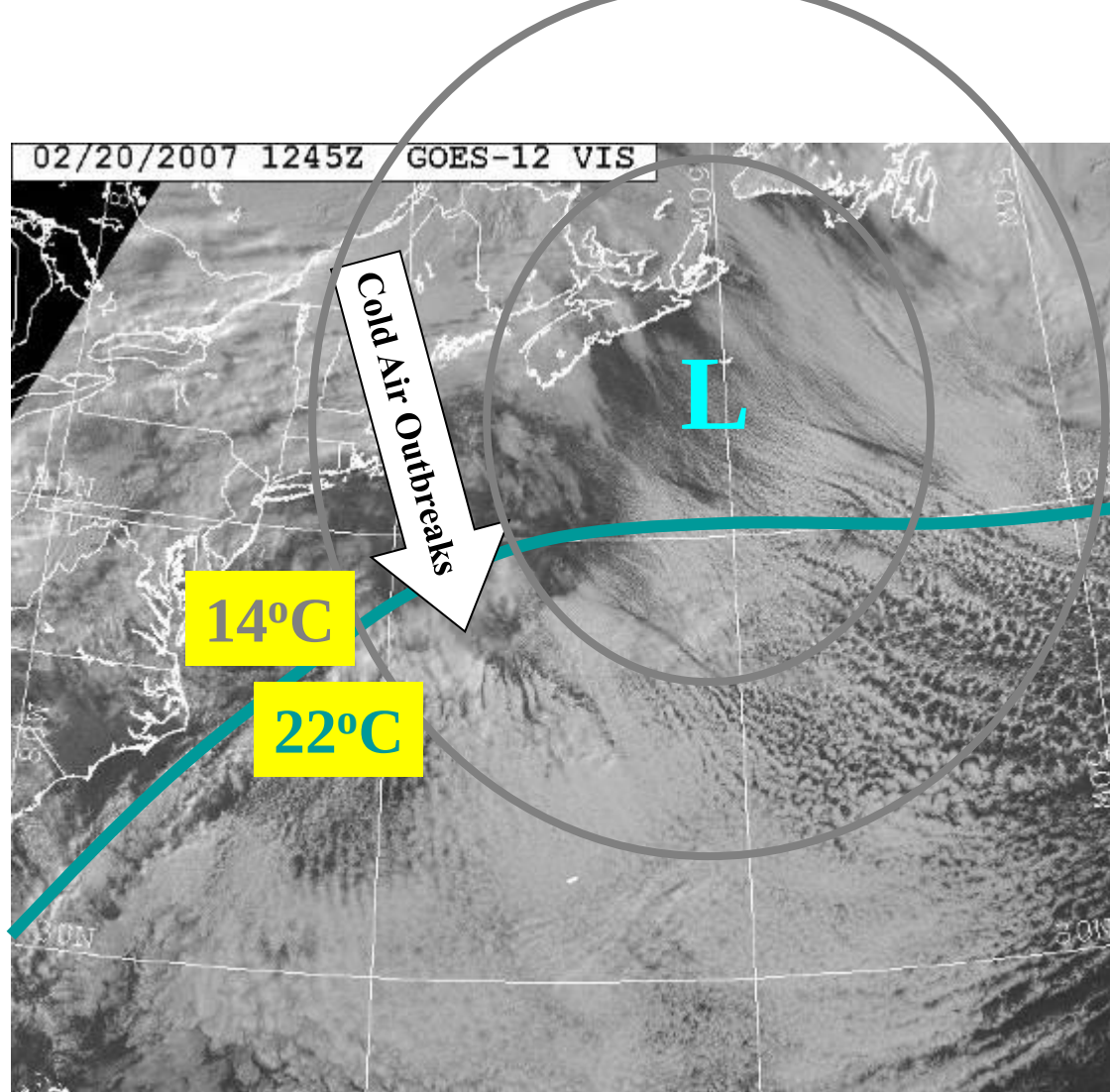
NAVEASTOCEANCEN for 02-MAR-17 North Wall Hausdorff: 1.91° Modified Hausdorff: 0.51°

For the Hausdorff metrics, the RTOFS front was trimmed to approximately the region of the Navy fronts

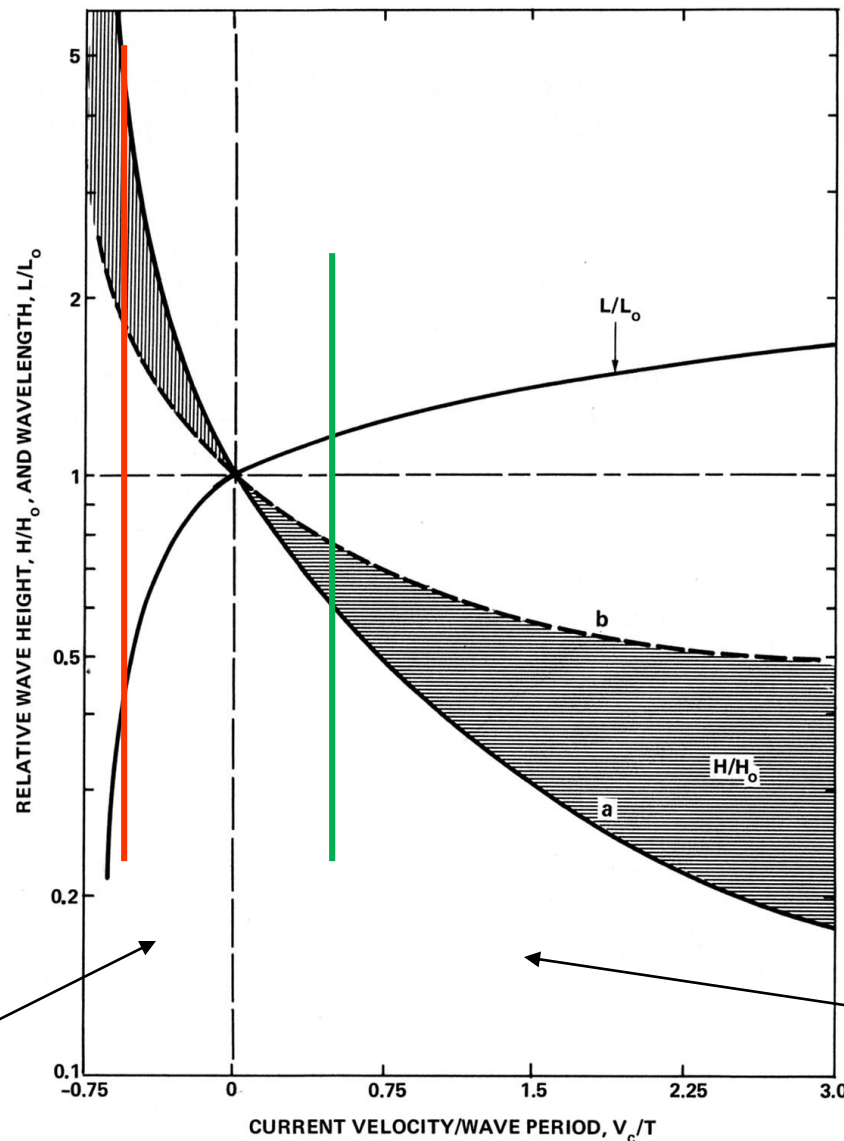


Important !!!

THE GULF STREAM IS A WEATHER BREEDER



- Cold air outbreaks drive extremely active convection over the region of the Gulf Stream. ***The same will be true anywhere we have similar conditions. IMPORTANT !!***



Winds against
the current

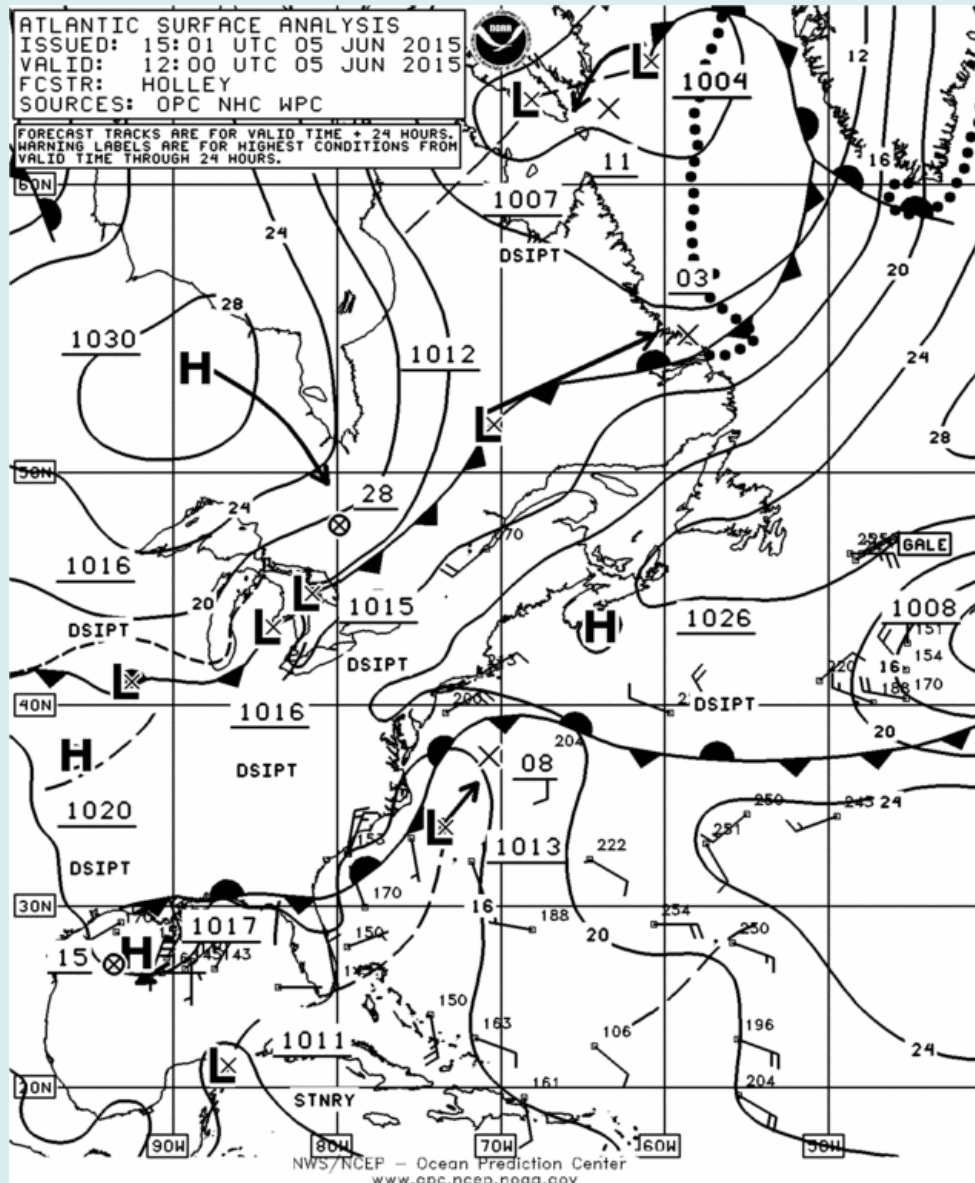
Winds with the
current

Ocean Wave Periods
 $T_{\text{typical}} = 10 \text{ sec}$
 $V_c = \sim 5 \text{ kts}$

Fig. 87. Influence of contrary (negative) and following (positive) currents of velocity V_c on relative wave height and wavelength, for waves of period T seconds. The shaded band gives the range of variation from pure, periodic swell (*a*) to a random sea (*b*). No swell can propagate against a current $V_c > 0.75T$ knots.

Source: van Dorn 1993 Oceanography and Seamanship 2nd ed.

Preparation might include review of previous race conditions...



<https://nomads.ncdc.noaa.gov/ncep/NCEP>

Summary

- North Atlantic winds drive a clockwise circulation in which the Gulf Stream forms the western boundary
- The Gulf Stream is a prominent thermal boundary, narrow in width, variable in space and time
- The main body of the Stream in the vicinity of the Newport-Bermuda Rhumb Line is often accompanied by a number of rings shed north and south of it
- Warm air rising from the Stream and its rings can significantly affect local weather
- The development of optimum strategies for crossing the Gulf Stream requires study over several months incorporating direct observations and models

- For me the place to start would be Instantaneous satellite images moving, if necessary, to composites (1-7 day)
- Determine the basic structure and location of the Gulf Stream i.e. presence of meanders, rings, etc. and rates of evolution
- Compare satellite imagery to altimetry based model and, if necessary RTOFS or other computer models.
- Evaluate probable sea state conditions existing and forecast
- Develop routing plan on the morning of the Race Start and print out latest satellite and/or altimetry (remember delays) along with key weather forecasts

ENJOY !!

