



Gulf Stream Note # 1 - 2019

The Gulf Stream Near the Rhumb Line Newport-Bermuda May 6, 2019 An Analysis of Conditions

W. Frank Bohlen (Bohlen@uconn.edu)

Mystic, Connecticut

Those interested in getting an early start this year on their studies of the Gulf Stream in anticipation of a sail to Bermuda have been frustrated until recently by the extent of cloud cover affecting most of the areas adjoining the Newport- Bermuda rhumb line. Although some few individual composite satellite images of sea surface temperature (SST) were obtained in February and March the desired longer time series of both instantaneous and composite images only became available in April. It's fortunate that there remains a reasonable amount of time prior to the June races to study and define Stream structure and location sufficient to help with optimum routing. The mantra "start study early" continues to be good advice.

By way of review (see the "Gulf Stream Primer – Structure and Strategy" on the Race homepage), the Gulf Stream forms a portion of the western limb of the current system affecting much of the North Atlantic Ocean. This "western boundary current" serves to separate the cooler continental shelf waters adjoining New England from the warmer waters of the Sargasso Sea. Monitoring temperatures is the best single way to know when you are in the Stream. Satellite images of SST provide the background necessary to define the probable location of the main body of the Stream and any associated eddies or rings. These latter features are characteristic of turbulent flows and often represent a significant navigational challenge. The Gulf Stream flows to the northeast beyond Cape Hatteras and on approach to the region adjoining the rhumb line Newport to

Bermuda often displays a meandering pattern which migrates sometimes to the east, sometimes to the west with varying amplitude. On occasion the meander amplitude will grow to a point of instability resulting in a “pinching off” of a portion of the meander much in the manner of an ox-bow feature in a river. This process is the primary mechanism producing the rings or eddies found inshore or offshore of the main body of the Stream. This combination of features displays significant spatial and temporal variability making time series observations essential in the determination of structure, probable current speeds and directions and rates of change. All subjects of strategic significance.

Throughout the late winter and early spring of this year the main body of the Gulf Stream crossed the Newport-Bermuda rhumb line in the vicinity of 38° N, or approximately 240nm from Newport. The actual crossing point and the course of the current varied as a function of the presence or absence of meanders and their evolution. A prominent meander formed and crossed the rhumb line in February. By early March this feature had progressed to the east with only slight change in form similar to a wave travelling along a line or whip set in oscillation. The rate of advance was approximately 0.1 knot to the east, a trend often cited but frequently not observed. Experience indicates that meanders often display very different rates of advance sometimes remaining stationary and deepening or even moving to the west and require careful observation for a period of time in order to accurately predict future behavior.

The February meander was followed by another formed near $37^{\circ} 30' \text{ N}$ 72° W . This feature also migrated to the east and by April 16th had deepened significantly and was crossing the rhumb line (Fig.1). Over the next eight days the meander trough crossed the rhumb line as the overall amplitude decreased and the wavelength increased (Fig.2). This evolution favored currents proceeding from the northwest to the southeast immediately west of the rhumb line. The observed rate of advance was approximately 0.06 knot to the east.

Although clouds have limited satellite SST observations over the past ten days, examination of the daily composites from the Rutgers site (Fig.3) and longer period composites from Johns Hopkins (http://fermi.jhuapl.edu/sat_ocean.htm) and from the Ocean Prediction Center, (a new site of particular value) (https://ocean.weather.gov/Loops/ocean_guidance.php?model=GOES&area=MidAtl&plot=sstrec&day=0&loop=1)

indicates that the trough of the meander remains in close contact with the rhumb line. This feature clearly has the potential to affect small boat course and speed and should be carefully watched over the next month or so to define evolution and the effect on boats both going to Bermuda and coming back to the U.S. .

As expected, the meandering main body of the Gulf Stream has associated with it a number of rings or eddies both to the north, or inshore, and south, towards Bermuda. The Navy product issued on May 4th (Fig.4) shows two warm (https://ecowatch.ncddc.noaa.gov/JAG/Navy/data/satellite_analysis/gsnofa.gif?id=3110). core features, one well west of the rhumb line and the other in contact with the line as well as a single cold core ring well east of the rhumb line near 36° N 65° W. Recall that both warm and cold core rings drift to the west towards Cape Hatteras at a rate of typically 0.1 kt. The warm rings display a clockwise rotation and the cold rings a counterclockwise rotation. Maximum currents of approximately 3kts can be expected in both. The warm rings have a relatively short life on the order of months due to dissipation in the shallower waters leading to the U.S. continental shelf. Cold rings sited in much deeper water have a significantly longer life often in excess of two years. Although both warm and cold core eddies can affect boat course and speed cold core features are typically the more challenging since they are often obscured in satellite IR images since being colder they can sink down a bit and be covered by a thin layer of warmer water. Add to that the possibility of “operator error” or lack of attention to detail due to fatigue after a thrash through the Stream and it should not be surprising that cold core rings might cause problems.

Today we are fortunate that in addition to direct satellite observations of SST we have additional satellite sensors looking at sea surface elevations. These measurements (<https://cwcarribbean.aoml.noaa.gov/CURRENTS/index.html>) use radar making them insensitive to cloud cover. The resulting “altimetry” provides an accurate basis for the development of a computer model of ocean currents which in combination with the available SST images provides the navigator with a comprehensive view of Gulf Stream location and structure. Comparing the altimetry based product for May 5 (Fig. 5) to the SST composite of May 3rd (Fig.3) (two day delay to allow time for data reduction) shows the warm core feature straddling the rhumb line near 39° N 69° W. The ring appears to be in contact with the main body flow and as a result may not drift west but rather be

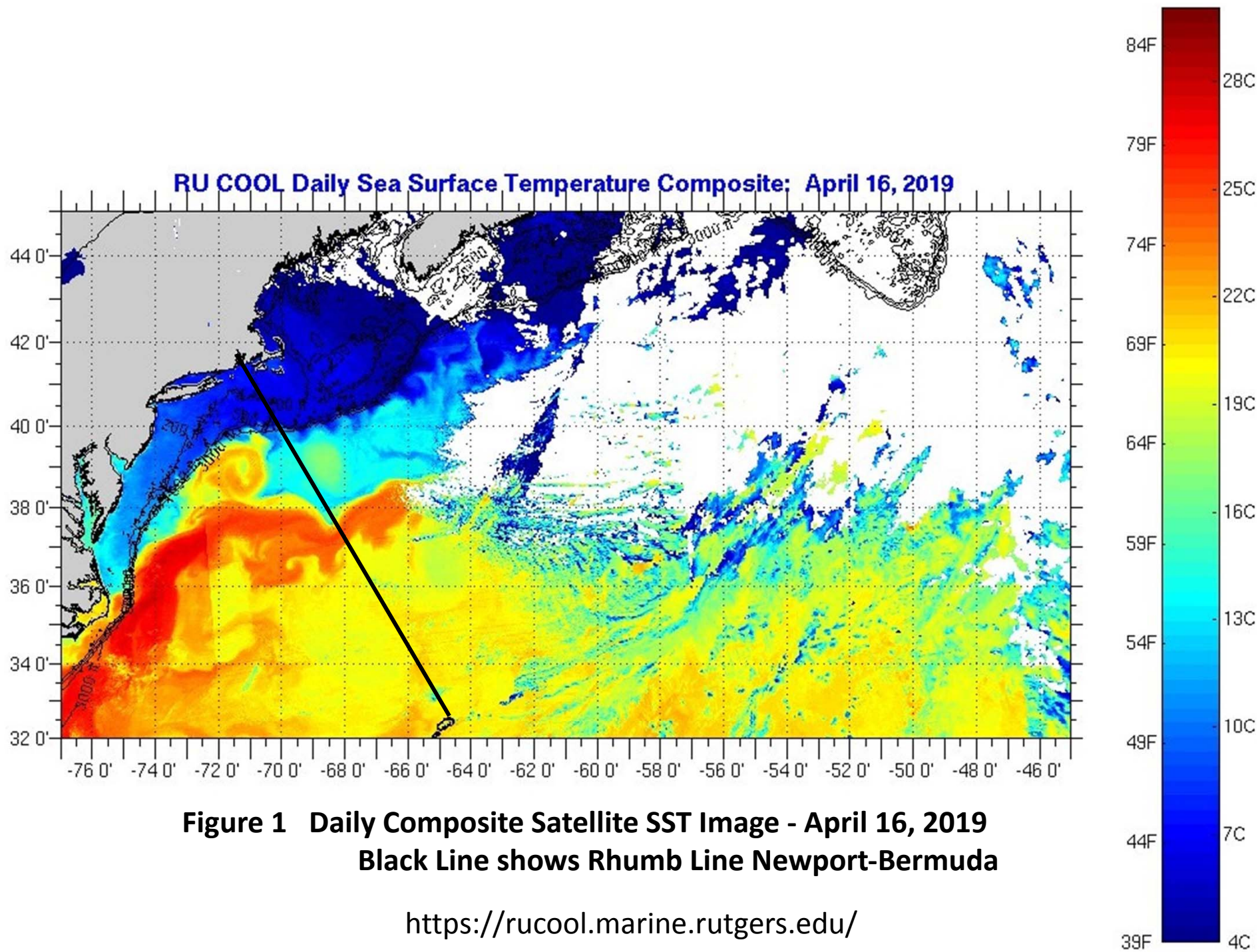
carried with the Gulf Stream flow to the east. We will watch this carefully over the next month.

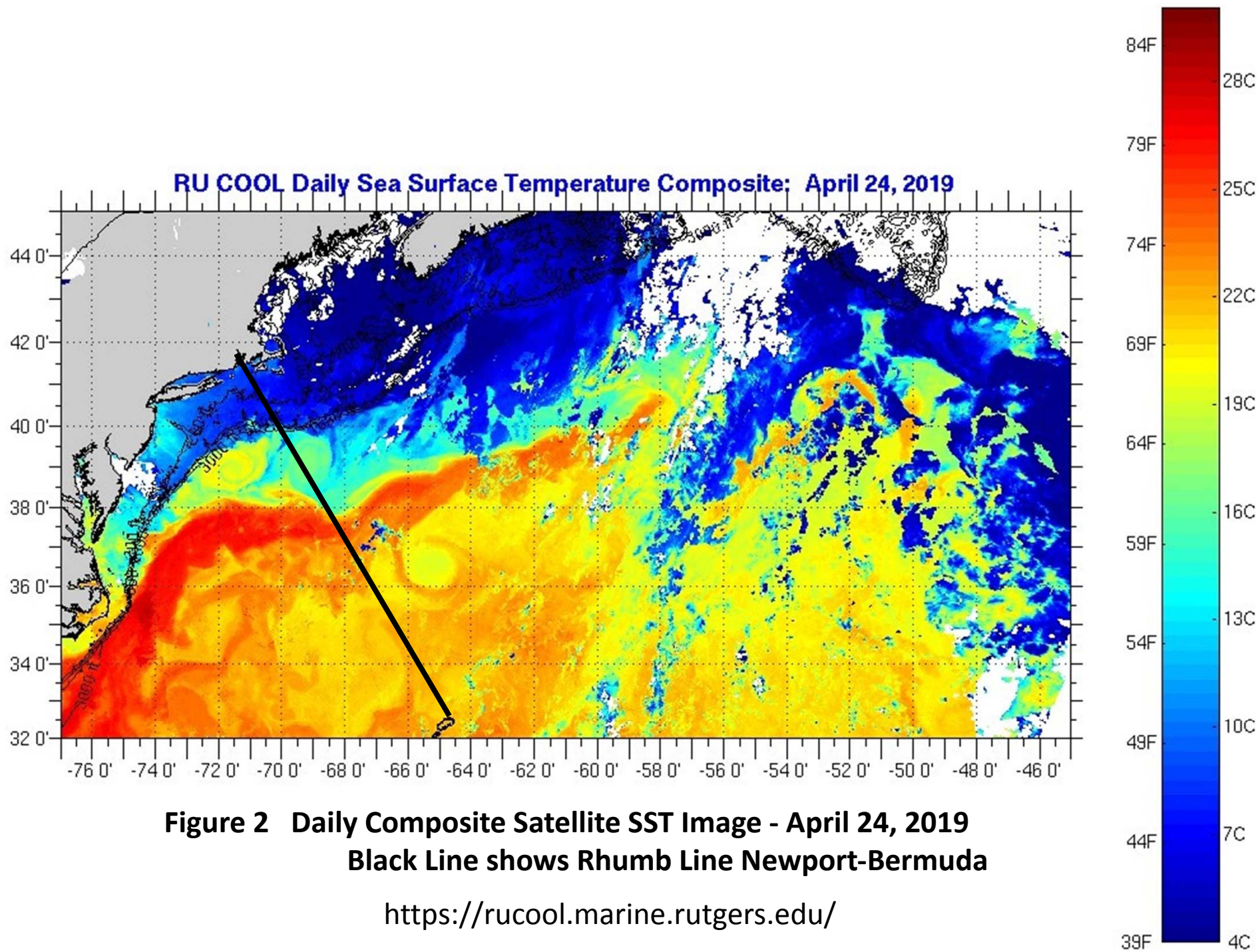
The altimetry based model shows a rather complex flow pattern with the trough of the meander quite a bit deeper than shown by the SST image (Fig.3) and flow maxima positioned along a line nearly parallel to but 60nm to the west of the rhumb line (Fig.5). Given the expected easterly migration of the meander this pattern might change significantly over the next month. The combination of a warm core ring immediately to the north and the meander associated flows represent an interesting challenge in terms of optimum routing in this area.

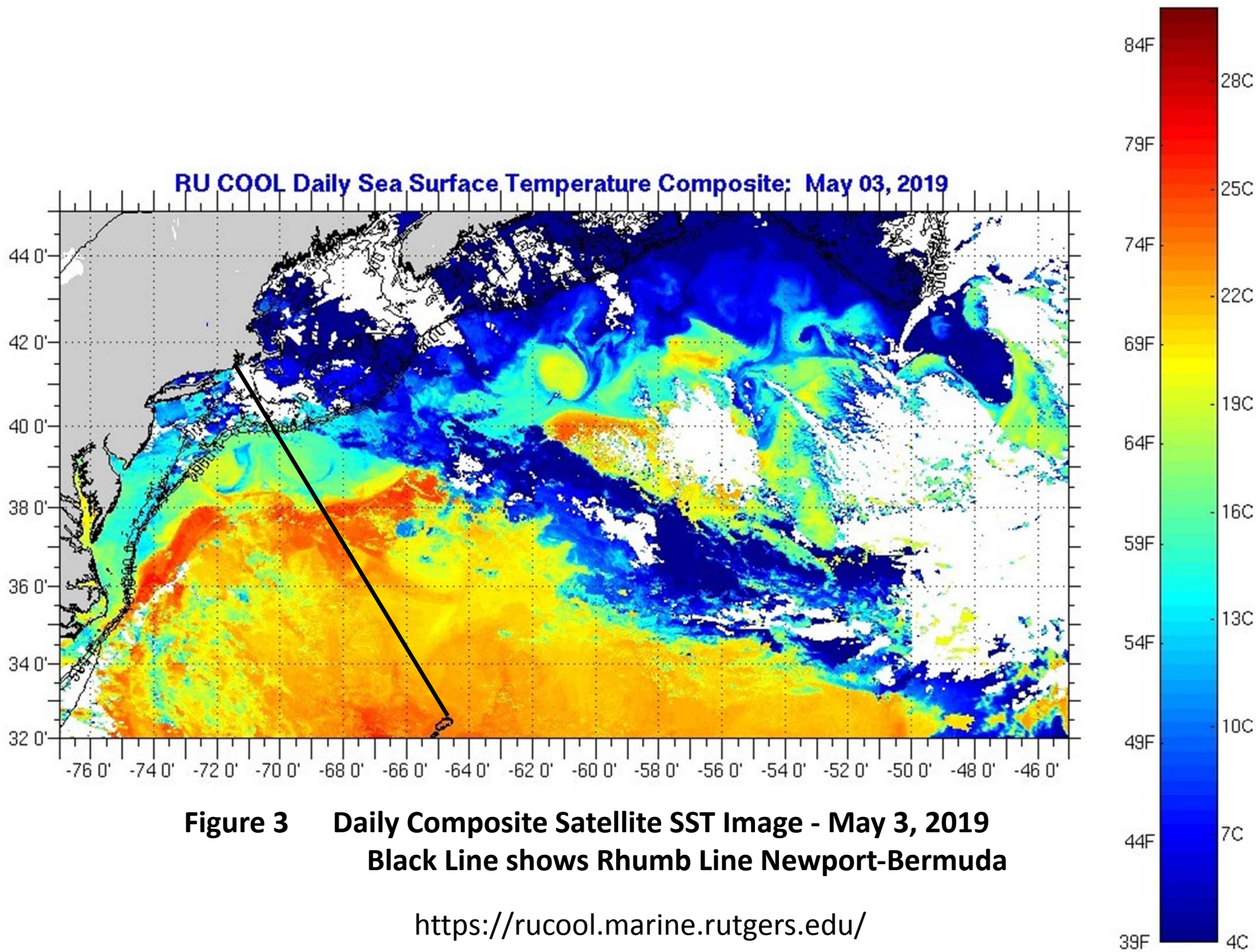
In comparing the altimetry based model results to the SST images it is important to remember that current maxima are typically located at some distance “in” from the point at which water temperatures begin their increase. For the Gulf Stream current maxima are typically found along lines nearly 20 to 30 nm to the south of the “north wall” or inshore edge of the Stream. Similarly, current maxima in the warm and cold core rings are found well in from the outer circumference of the ring. The difference between the altimetry based model and the SST images should not be surprising.

Proceeding south towards Bermuda, the altimetry based model shows a cold core (counter-clockwise rotating) ring centered near $36^{\circ} 30' \text{ N } 65^{\circ} 30' \text{ W}$ or approximately 120nm to the east of the rhumb line (Fig.5). The ring has a diameter in excess of 120nm and can be expected to drift west towards the rhumb line. It's like to be of navigational interest in early to mid June and warrants close watching. This feature was observed in the SST image of 24 April (Fig.2) but obscured by clouds in the more recent satellite views. This circumstance provides a graphic illustration of the value of the altimetry based product.

In addition to the large cold core ring, the altimetry based model also shows a number of other smaller and less well defined counter-clockwise rotating features as well as a region of clockwise current to the right and left of the rhumb line which in combination affects nearly 180nm of the course south of 35° N (Fig.5). If these conditions prevail it seems likely that all boats on approach to Bermuda will encounter some period of persistent adverse current. Navigational implications will depend on the exact position of this regime which will likely vary substantially over the next month.







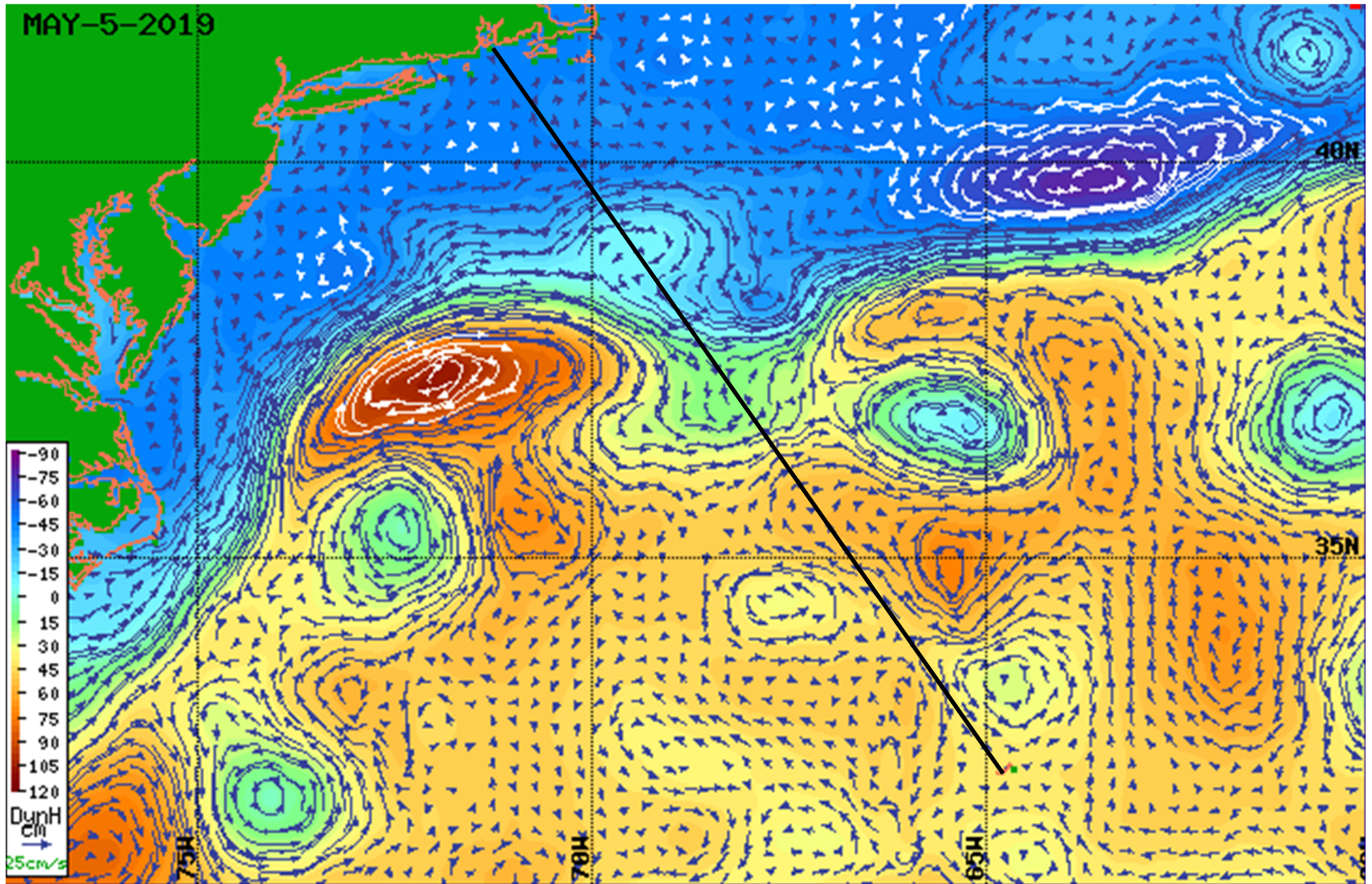


Figure 5 Satellite Altimetry Derived Surface Currents- NW Atlantic Region- May 5, 2019
Black Line shows Rhumb Line Newport-Bermuda

<https://cwcarribbean.aoml.noaa.gov/CURRENTS/index.html>