Gulf Stream Characteristics

May 20, 2004

Note No.1

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In contrast to past years, I've chosen to start these notes later this year in the belief that they will better serve in your preparation for the upcoming Newport Bermuda Race. With less than a month to go to the start it's essential that tacticians and navigators have in place a regular observational routine dealing with both meteorological and Gulf Stream characteristics. These efforts might include examination of weather predictions and/or analyses from a number of sources, comparisons of the relative accuracy of each and consideration of the models being used. Similarly, data detailing Gulf Stream characteristics and its subsequent evolution should be studied. The resulting time series of observations provides the needed foundation for the most effective use and interpretation of any met or oceanographic data received just prior to or during the Race regardless of the source of this information. We have provided on the Race web site (www.bermudarace.com) a listing of selected web sites suitable for these analyses. This list is by-no-means complete but it does include many of the most popular and useful sites. Feel free to make recommendations for additional sites and please let me know of any errors or difficulties encountered. In addition to this listing, the web site includes all of the Gulf Stream Notes prepared for the past three Newport Bermuda Races. A review of these is recommended since they deal with the fundamental characteristics of the Stream and provide graphic illustration of the variety of conditions encountered in each Race. An apprciation of this variability is of particular value to the navigator/tactician.

To briefly review, the Gulf Stream is an energetic boundary current separating the warm waters of the Sargasso Sea (the area of the North Atlantic surrounding Bermuda) from the cooler continental shelf waters adjoining New England. The resulting thermal boundary represents one of the most striking features of this major ocean current and one that is most easily measured. From Florida to Cape Hatteras the Gulf Stream follows a reasonably well defined northerly track along the outer limits of the U.S. continental shelf . Beyond, to the north of Hatteras, Stream associated flows proceed along a progressively more northeasterly tending track with the main body of the current separating gradually from the shelf. Horizontal flow trajectories in this area becomes increasingly non-linear and wavelike often forming large amplitude meanders that propagate downstream towards Europe and grow in amplitude. On occasion these meanders will become unstable and "pinch-off" forming independent rotating rings or eddies in areas north and

south of the main body of the Stream. This combination of features has the potential to affect a significant portion of the rhumb line between Newport and Bermuda.

It's important to realize that the influence of the Gulf Stream on conditions affecting Race strategies is not limited to water currents. The marked difference in sea surface temperatures along the inshore edge of the Stream also affects atmospheric conditions. Air warmed over the waters of the Stream rises transporting heat and water vapor aloft. Subsequent cooling of this air often favors the formation of a prominent cloud mass paralleling the course of the Stream. This discrete formation is often visible from some distance and is for many the first indication of the presence of the Gulf Stream. In addition to the clouds however, this rising air mass may significantly affect local wind conditions particularly during frontal passage. Conditions, such as the passage of a cold front, sufficient to increase the speed with which the warm, moisture laden, air moves upward can lead to conditions favoring the formation of thunderstorm cells often accompanied by heavy rains and locally intense and variable winds. The spatial and temporal features of these systems (i.e. small size-limited duration) and their sensitivity to heat transport rates makes accurate modeling and prediction of their characteristics difficult. This factor represents one of the primary reasons for the often significant differences between forecast conditions and those actually encountered in the vicinity of the Stream. A comparison of expected wind/wave conditions, as shown by broadcast weather maps, to those observed by satellite (see Race Homepage list e.g. manati.wwb.noaa.gov/quikscat/) represents a useful and informative exercise and often provides clear illustration of the influence of the Gulf Stream on local meteorology.

Given the prominence of thermal gradients within the structure of the Gulf Stream studies of Stream characteristics typically begin by the examination of sea surface temperature (SST) data. Historically this was only available in text format (delimiting the position of the north "wall" and the position of major features such as "rings") or fax to a selected few. The emergence of web based communications and public access satellite data has changed all of this over the past ten years. There are now an abundance of sources providing SST data for the northwest Atlantic. The problem is more the matter of selection and interpretation than an absence of information.

Today I generally begin an examination of Gulf Stream characteristics by obtaining satellite SST images provided by one of several sites (see e.g. marine.rutgers.edu/mrs/, or fermi.jhuapl.edu/sat_ocean.html). These images are colored to more clearly illustrate temperature gradients and indexed geographically allowing the overlay of navigational data such as track lines or routes. The images generally are provided in one of two forms, instantaneous, or composite. The instantaneous image (Fig.1) represents the view from a single satellite pass taken at some discrete time. The composite (Fig.2) represents what might be considered an average of multiple passes over an extended period of time (typically one day to a week). The instantaneous-single pass image tends to provide higher spatial resolution and more accurate detailing of Stream features and/or structure but is necessarily subject to the presence of clouds. By focusing on selected features (e.g. the warmest picture element) over a number of passes, the composite process is able to reduce this sensitivity to cloud cover.

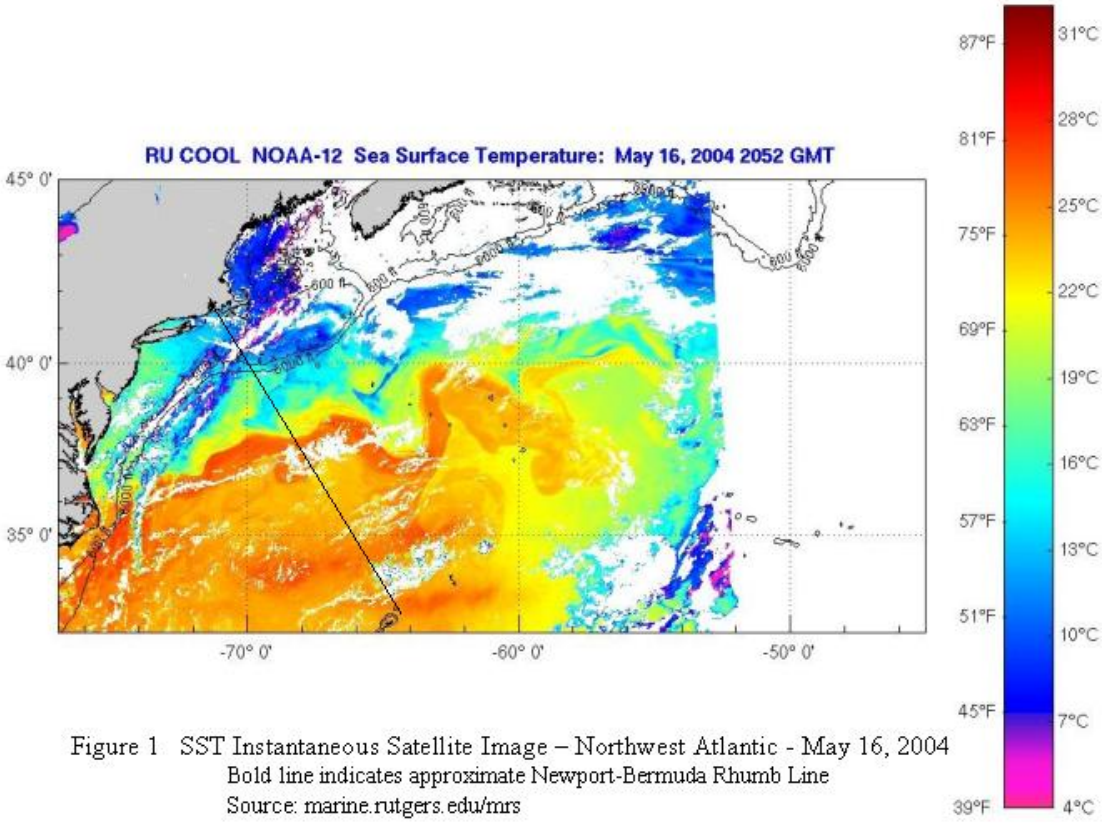

Figure 1 SST Instantaneous Satellite Image – Northwest Atlantic - May 16, 2004
Bold line indicates approximate Newport-Bermuda Rhumb Line
Source: marine.rutgers.edu/mrs

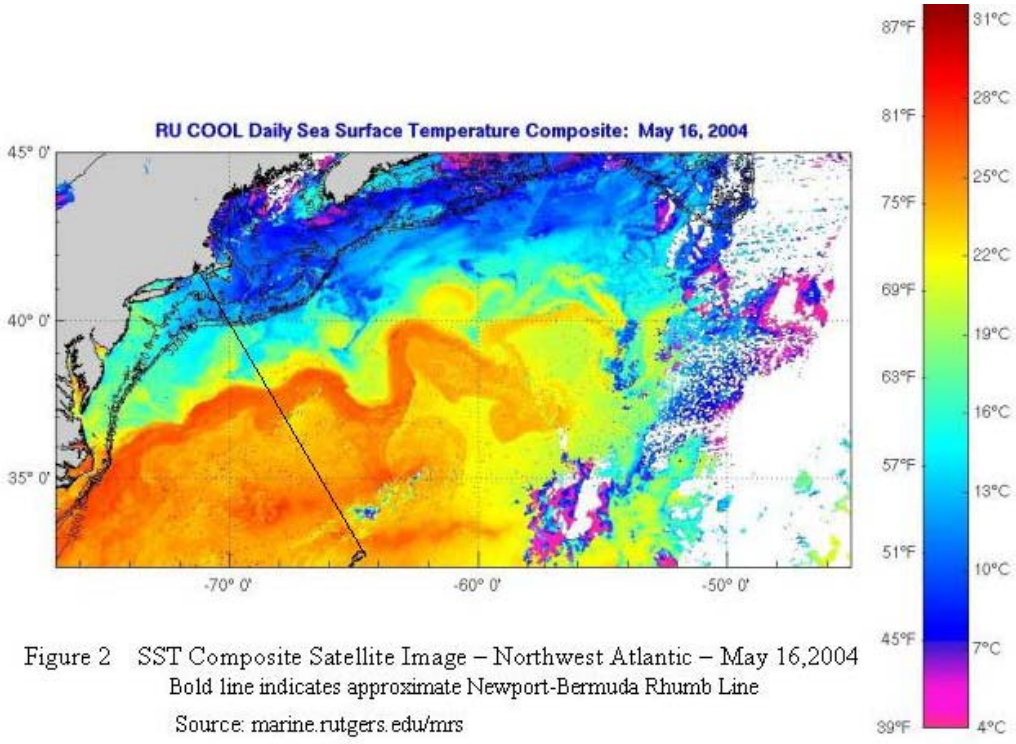

Figure 2 SST Composite Satellite Image – Northwest Atlantic – May 16,2004
Bold line indicates approximate Newport-Bermuda Rhumb Line
Source: marine.rutgers.edu/mrs

This focus or filtering however, sometimes provides a false impression of the coherence of Stream features making sharp thermal boundaries, such as those found along the inshore edge of the Stream, somewhat sharper while reducing the acuity of less prominent features. Attention paid to these slight and often subtle differences can be rewarding since they have the potential to influence interpretation of flow conditions particularly over the small spatial scales of interest to the racing navigator. For a brief discussion of these differences and illustrations see http://fermi.jhuapl.edu/avhrr/gallery/sst/stream.html .

One additional observation with regard to the single pass and composite images. In years past Newport-Bermuda navigators tended to place primary reliance on the one-day composite images. Many of these came from the Rutgers site. It's important to note that this site has been reconfigured resulting in some delay in the release of the composite images. Single pass images are released shortly after receipt. Any effect associated with this delay on Race strategy is best eliminated by time series observations over the next few weeks.

The SST composite image indicates that the northern limits of the Gulf Stream on May 16 th crossed the rhumb line at a point approximately 270 nm from Newport (Fig.2). A slight meander was evident in this area with flows proceeding from the northwest to the southeast. The character of these flows will be discussed in more detail in my next note. The width of the Stream was approximately 60 nm to the point where water temperatures began to fall from over 25 ^{0} C to 22-23 ^{0} C.

By May 19 th the northern edge of the Stream had moved to the north and was now located approximately 240 nm from Newport (Fig.3). A lobe of warm water found west of the rhumb line on the 16 th had moved to the east resulting in a substantial increase in Stream width along the track to Bermuda. The meander was slightly reduced in amplitude with dominant flows maintaining a northwest to southeast trajectory. This evolution shows how quickly some features of the Stream can change.

Beyond the main body of the Stream (defined by the region of highest water temperatures) the satellite images show an abundance of small scale detail but little coherent development. There is a suggestion of the presence of several rings to the north of the Stream and a single cold core ring to the south (Fig.4). As presently configured this latter feature has the greatest potential to affect Race strategy and will be tracked closely over the next few weeks. Its potential influence on flow characteristics will be discussed in the next Note.

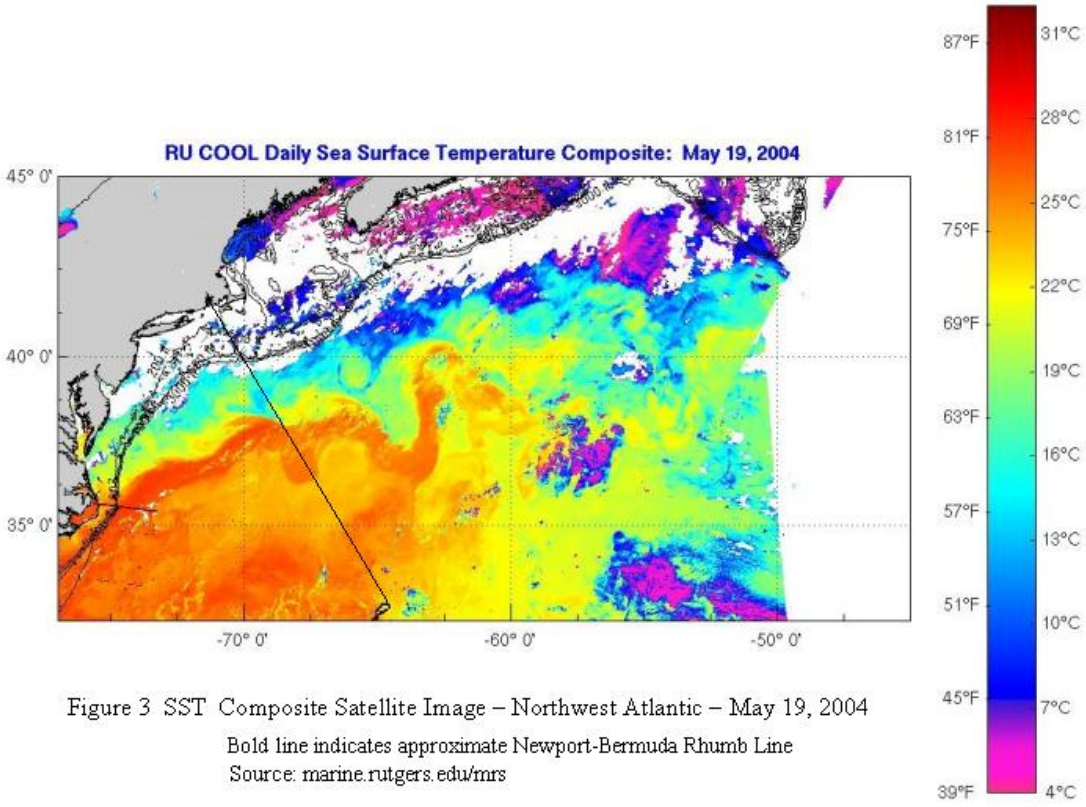

Figure 3 SST Composite Satellite Image – Northwest Atlantic – May 19, 2004

Bold line indicates approximate Newport-Bermuda Rhumb Line
Source: marine.rutgers.edu/mrs

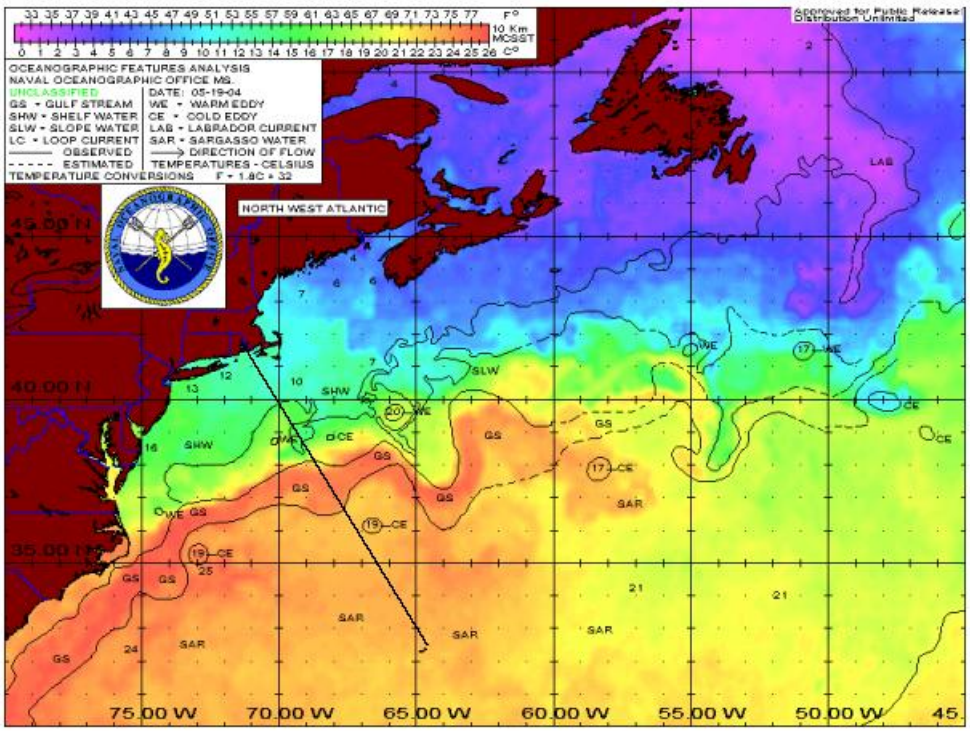

Figure 4 USN Gulf Stream Features Analysis – May 19, 2004

To summarize, time series observations of both weather and Gulf Stream conditions provide a valuable basis for the development of strategies for the upcoming Newport Bermuda Race. These factors are interdependent and should be studied concurrently. A variety of sources of information has been provided on the Race Homepage for this purpose. These may be supplemented in a number of ways including both home study and formal seminars. I call your attention to an interesting online seminar dealing with this subject being developed by Bill Biewenga (Weather4Sailors.com including some samples -seminarsamples.htm). One of these seminars specifically designed for the Newport-Bermuda Race is scheduled for June 10-11, 2004. Enjoy your reviews!