AD-A107 942 NORTH CAROLINA UNIV AT CHAPEL HILL F/G 8/3
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1980 J M BANE, D A BROOKS, K R LORENSON N00014-77-C-0354
UNCLASSIFIED NL

THREE-DIMENSIONAL VIEW OF A GULF STREAM MEANDER BETWEEN SAVANNAH, GA. AND CAPE HATTERAS, N.C.

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Synoptic views of large regions of the ocean are difficult to obtain. Conventional shipboard techniques require such long periods of time for data collection and ship travel that severe temporal aliasing can adversely affect a data set. This is the case with measurements made in the Gulf Stream along the southeastern United States, because the Stream has significant variations with periods ranging from a few days to many weeks. Recent synoptic observations of the sea-surface temperature field, made possible through the advent of satellite-borne thermal infrared sensors, indicate that the dominant mesoscale fluctuations in the Gulf Stream in that area are wavelike meanders. They have alongshore wavelengths of about 150 km and progress in the northeastward, or downstream direction at about 40 km day^{-1} (Legeckis, 1979). These properties of the surface thermal variability compare well with Webster's (1961) analysis of subsurface temperature data collected during 1 month off Onslow Bay, N.C. He showed the two dominant meander periods to be near 7 days and 4 days. The consistencies between these two sets of observations make a three-dimensional, synoptic picture of the Gulf Stream quite desirable.

To rapidly map the surface and subsurface thermal structure, a series of aircraft surveys of the Gulf Stream frontal zone between Savannah, Ga., and Cape Hatteras, N.C., was made during February 1979. The most extensiv of the series was on 14 February, with 94 AXBT's deployed over the grid shown in figure 1. Sea-s temperature was also measured along each of the stream flight lines with a precision radiation therm (PRT). The set of horizontal and vertical temperatu tions obtained from this day's survey provide an es ly synoptic picture, because the total time required survey was less than 8 hours. This article describe of the spatial features of the Gulf Stream thermal zone observed during that flight.

The surface temperature field measured by thr PRT is composed of two prominant, alongshore the mal The front closer to shore is centered approximately 15 °C isotherm and separates a very cool, nearshor mass (occasionally referred to as "Shelf Water") slightly warmer water mass (sometimes called Water"). Somewhat seaward of this is the Gulf Stre face thermal front, which is about coincident with th isotherm. The surface expression of a filament o Gulf Stream water parallels most of the inshore e the main Stream. The filament at the time of measurements had elongated and broken into a tinuous "shingle" structure, with the separated warm water centered at about 33 °N, 78 °W.

Just upstream of the filament and immediately adja the Stream is a narrow "ribbon" of relatively coo which has surface temperatures less than 18 °C. T ribbon occurs in the area of a persistent seaward tion of the Stream off Charleston, S.C. (Brooks an 1978; Legeckis, 1979). It is possible that the ribbon from upwelling along the shoreward Gulf Stream conjunction with the deflection proces. Alter lateral entrainment of shelf/slope water may prod feature. Measurements of temperature and salini downstream of Cape Hatteras show very narrow t cool, low-salinity water along the Stream's insho implying lateral entrainment, which could have upstream of the point of observation (Ford, Long Banks, 1952). Should simultaneous salin temperature observations off Charleston provid results, then lateral entrainment would be the m mechanism for producing the cool ribbon.

The temperatures immediately below the surface as measured by the AXBT's, reveal similar pattern that the coarser resolution of the AXBT data

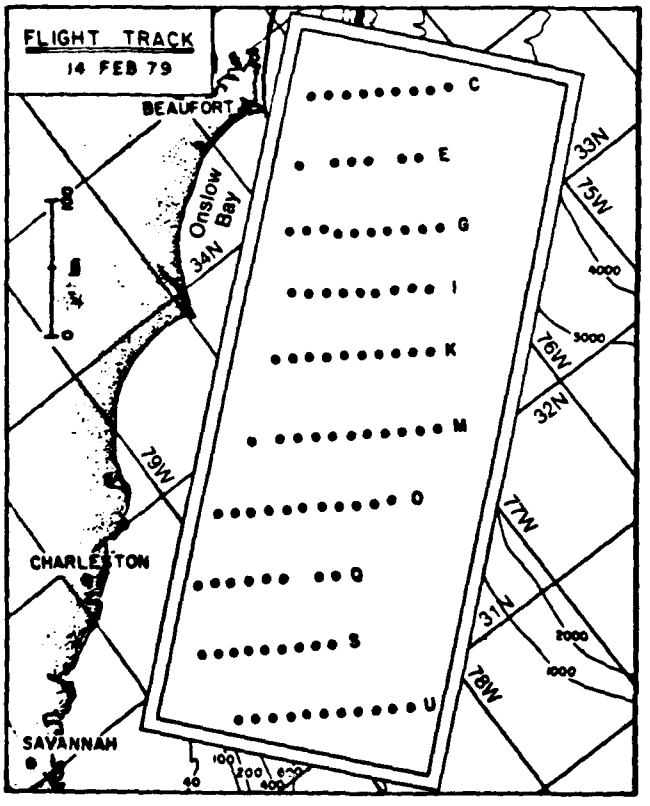


Figure 1. AXBT stations for the 14 February flight. Cr station spacing is 12.5 km, and alongshore spacing Occasional "dud" AXBT's cause gaps in the lines (e.g tions are missing on line E). Total duration of the sur began at the offshore end of line C, was 7 hours 30 m

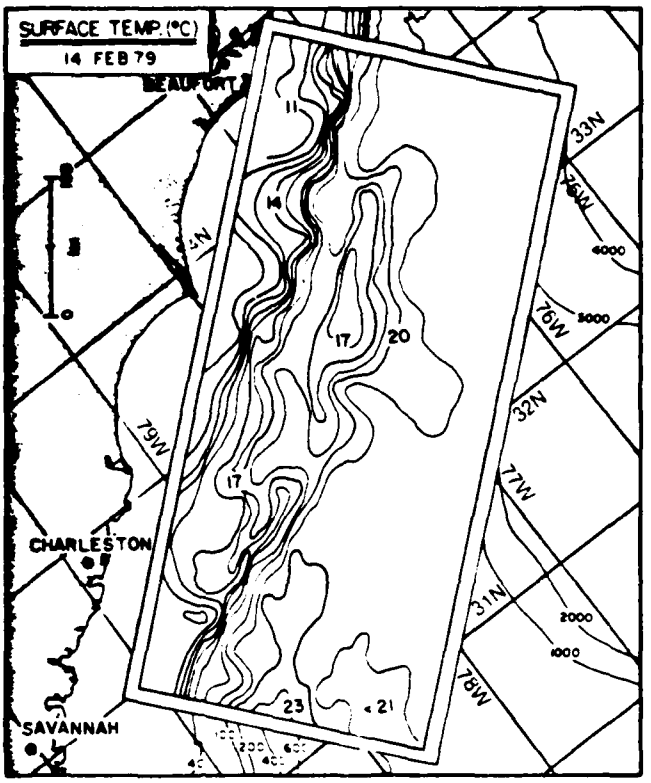
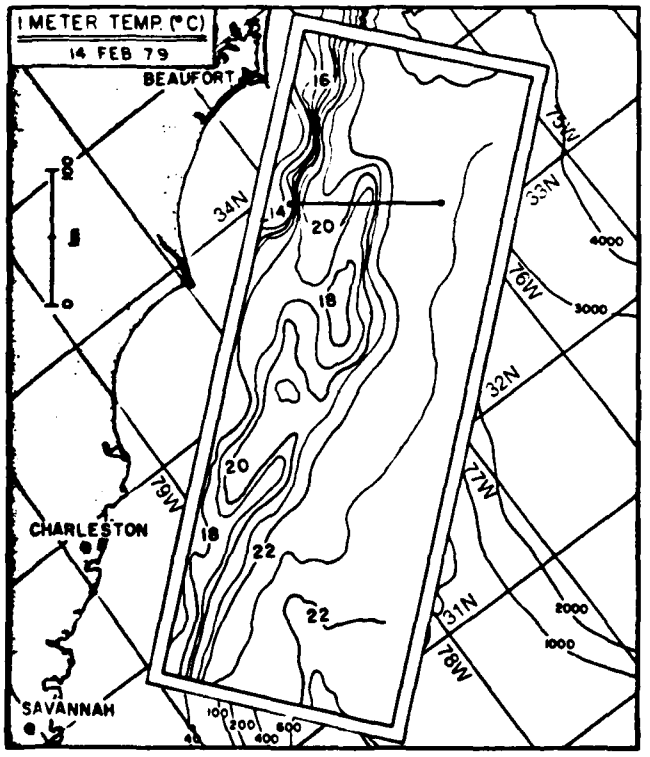


Figure 2. Surface temperature measured by the Barnes PRT-5 IR thermometer. Temperature calibration information collected between cross-stream lines has been used to give an estimated accuracy of ±0.5°C.



define the narrow cool ribbon off Charleston definite meander pattern is evident in the r Stream front (21°C isotherm at this level), with a crest* occupying the northeastern one-fifth of area. The water in the meander trough* is cooler at this level. Figure 4 shows a vertical section al line G which "slices" through the warm filament water in the trough, and into the main body of th Severe "doming" of the isotherms has resulted upwelling of cool, deep Gulf Stream water t volume between the upper continental slope and body of the Gulf Stream in the meander trough. filament over the outer continental shelf is quite extending only to a depth of about 40 m.

Temperature patterns at the 100-m and 250-m lev and 6) reflect the meander pattern apparent in the face fields, with a crest in the northeastern port area, and a trough occupying most of the centr This vertical coherence of the meander thermal is consistent with current fluctuations measur area. The velocity variations above the 400-m is Onslow Bay, which are associated with the pas meander, are vertically in-phase, with maximu eastward ("downstream") velocity occurring duri passage (Brooks and Bane, 1980).

From the single, daily view provided by the AXBT data described here, the Gulf Stream frontal zone ed to have a complex thermal structure, with feat ing in size from a few kilometers (e.g., the width c row, cool ribbon) to a few hundred kilometers alongshore length of a meander). Similar tempera collected during seven other flights in February flights in November 1979 are now being proce should provide further enlightenment, especial areas of meander evolution and propagation.

*A meander crest (trough) is taken here to be the shore (seaward-most) excursion of the Gulf Stream front meander wavelength.

Acknowledgments: This work was supporte Office of Naval Research under c N00014-77-C-0354 and the National Science tion under grant OCE77-25682. The Naval graphic Office provided flight time. We wou thank the crews of Navy squadron VXN-8 personnel of the NAVOCEANO Airborne Oc phy group for their enthusiastic support. A thanks to Jeffrey Kerling for continuous eff ing the February flights.

Figure 3. The temperature 1 m below the sea surface m the AXBT's. The patterns at this level are essentially th those seen in the PRT data; however, AXBT 1-m tempe consistently higher than PRT temperatures, probably surface cooling caused by evaporation and conduc AXBT-PRT temperature difference ± one standard de found to be 1.3 ± 0.3°C for the 94 stations.

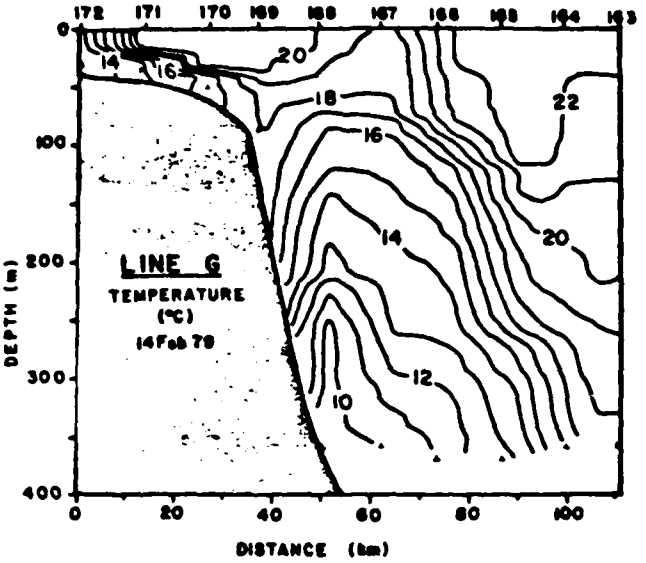


Figure 4. Vertical temperature section along line G, the position of which is indicated by the solid cross-stream line in fig. 3. The main Gulf Stream subsurface thermal front, centered approximately around the 19°C isotherm, is about 45 km offshore of the upper continental slope. This is typical of a meander trough. The vertical structure of the warm filament extending along the inshore edge of the main body of the Stream is clearly see over the outer continental shelf.

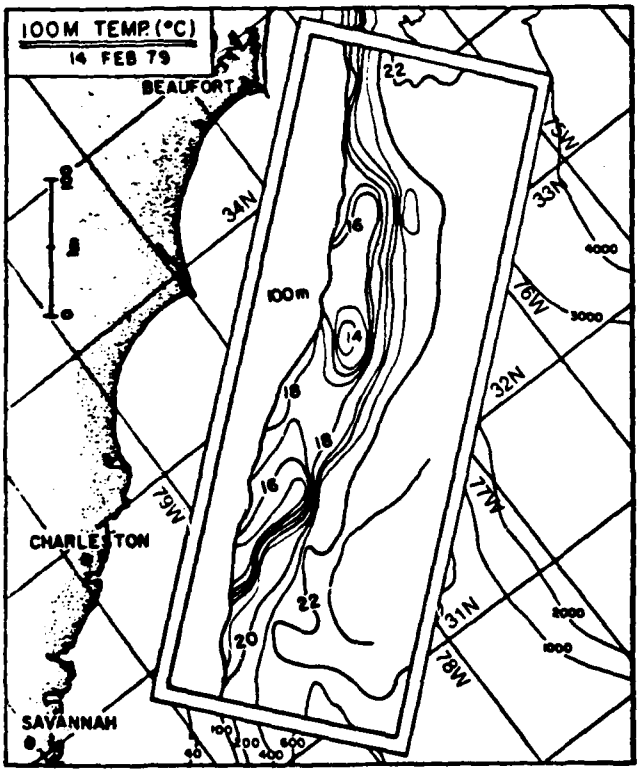


Figure 5. Temperature on the horizontal surface at 100 m depth. The skewed meander pattern is apparent at this level, with the subsurface thermal front (~19°C isotherm) trending gently offshore in the downstream direction, then turning back sharply onshore. Cool water fills the trough between the front and the 100-m isobath; the lowest temperature at this level is less the 14°C.

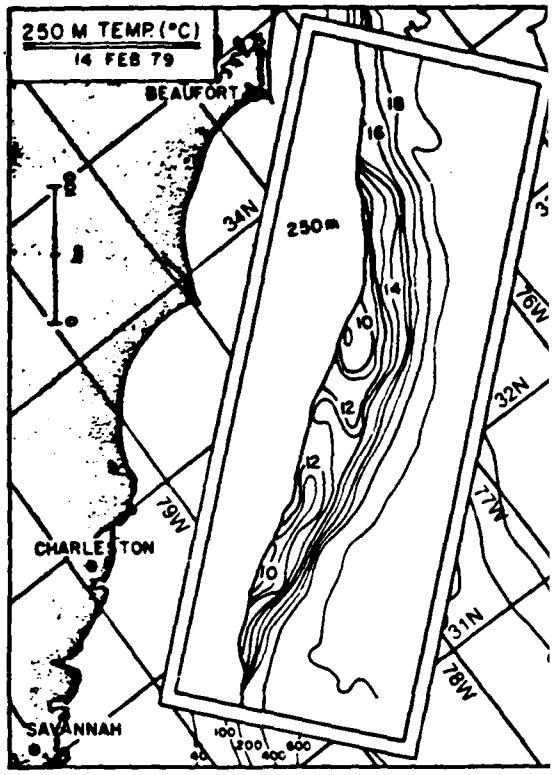


Figure 6. Temperature on the horizontal surface at 250 The meander pattern at this level is quite similar to that providing an indication of the vertical coherence of the motions.

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