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MOORED CURRENT METER MEASUREMENTS IN THE ATLANTIC NORTH EQUATORIAL COUNTERCURRENT DURING 1983

P. L. Richardson

Physical Oceanography Department, Woods Hole Oceanographic Institution

Abstract. Current meters were moored at depths of 20, 50, 75 and 150 m near 6N, 28W from February 25 to September 13, 1983. From February to May the low frequency zonal velocity was slow and westward. From May to September the zonal velocity was eastward with peak (low passed) speeds up to 60 cm sec^{-1}. During July the eastward flow was approximately 40 cm sec^{-1} at all four depths. The surface and subsurface North Equatorial Countercurrent disappeared on a seasonal basis during 1983. Strong fluctuations were observed with periods in the bands 1-2 months and 4-5 days. The amplitude of these fluctuations appeared to be maximum during the period of swift eastward Countercurrent flow.

Introduction

During SEQUAL we sought an answer to the question -- Does the deep North Equatorial Countercurrent continue eastward throughout the year despite the seasonal reversal of near surface currents? The preliminary answer is that the subsurface Countercurrent does reverse direction seasonally. To learn this, surface drifters were launched and tracked at several locations in and near the Countercurrent, and current meters were moored near its center at 6N, 28W. This note reports the preliminary results from the first of three semi-annual current meter deployments. The velocity series extend from February to September 1983 and are the longest velocity series yet obtained in the Countercurrent. They are noteworthy because they show a significant portion of the subsurface seasonal variation of the Countercurrent and its vertical structure.

Earlier velocity measurements in the Countercurrent consist of some relatively short current meter series made during GATE [Bubnov et al., 1979; Halpern, 1980], a few drifting buoy trajectories [Cochrane, personal communication; Molinari, 1983], and historical ship drifts [Schumacher, 1940; Richardson and McKee, 1984]. There have been no direct current measurements sufficient to provide a good look at seasonal variability during a single year, although the ship drifts are capable of resolving the average seasonal variability.

Measurements

Four Vector Measuring Current Meters at depths of 20, 50, 75, and 150 m were deployed on a surface buoyed mooring near 6.1N, 27.9W in 4360 m of water. The mooring was in place from February 25 to September 13, 1983, and all meters functioned properly. The mooring was replaced in September 1983 and again in March 1984. Five other SEQUAL current meter moorings were deployed near the equator at 28W, 24W and 15W; these are discussed by Weisberg (1984a).

The location near 6N, 28W was chosen because it lies (a) near the central equatorial Atlantic and (b) near the meridional center of the Countercurrent as determined from ship drift velocities [Richardson and McKee, 1984], hydrographic measurements [Katz, 1981; Cochrane, Kelley, and Olling, 1979; Merle, 1978; Garzoli and Katz, 1983], and from GATE velocity measurements [Bubnov et al., 1979; Halpern, 1980].

Results

The velocity data from 6N, 28W are displayed in four figures; the first three show velocities from the four meters that have been smoothed to emphasize the low frequency variations. Figure 1 shows progressive vector plots, Figure 2 shows stick velocity series, Figure 3 shows the zonal and meridional velocity series, and Figure 4 shows the velocity and temperature series (unsmoothed) from the current meter at 20 m.

The average zonal velocity from each record was eastward at all levels. The low frequency variation of zonal velocity, which is interpreted to be the seasonal variation, consisted of a slow flow to the west from February to May and a rapid flow to the east from May to September. This is in basic agreement with the velocity measured by drifters and historical ship drifts [see Richardson, 1984].

The fastest westward velocity averaged over March and April was 8 cm sec^{-1} at a depth of 20 m. At this depth, the zonal velocity switched to eastward on May 5 (approximately) increasing to a peak of 60 cm sec^{-1} in June. The eastward velocity, which is the Countercurrent by definition, continued at least to mid-September, when the record stops. The first peak on June 8 was followed by a minimum of 13 cm sec^{-1} on July 1 and a second peak of 45 cm sec^{-1} on July 24. The first peak had considerable vertical shear, 40 cm sec^{-1} between 50 and 150 m, and the velocity was due eastward; the second peak was nearly barotropic from 20-150 m and the velocity was southeastward.

The variations in zonal velocity at 20, 50 and 75 m are strongly visually coherent with each other. The record from 150 m is slightly different from these in that the eastward velocity began about 15 days later and decayed sooner, and the second peak of eastward velocity in July was 40 cm sec^{-1}, larger than the first peak of 20 cm sec^{-1}.

The average meridional velocity was southward at all depths: 4.3 cm sec^{-1} at 20 m, 8.5 cm sec^{-1} at 50 m, 7.0 cm sec^{-1} at 75 m and 1.0 cm sec^{-1} at 150 m. During March and April when the zonal component was small the current at 50 and 75 m was southward at approximately 10 cm sec^{-1}, and the current at 20 m was south-

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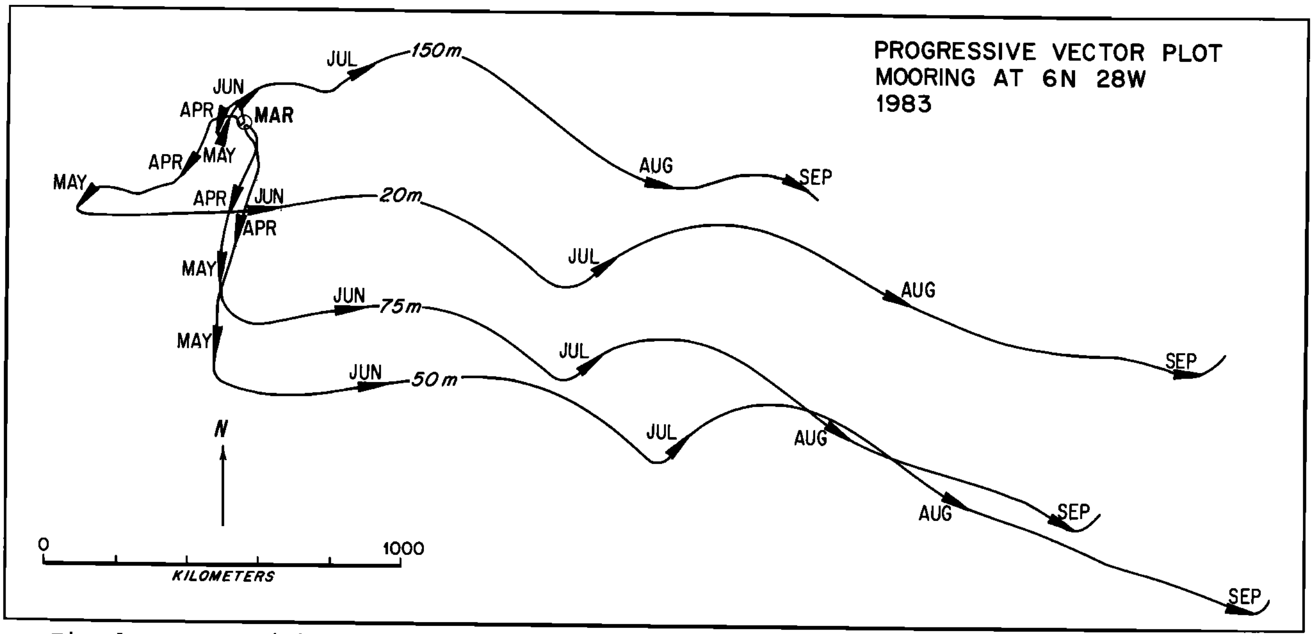

Fig. 1. Superposition of four progressive vector plots from current meters at 6N, 28W. Plots begin from a single point at the beginning of the records, February 25, 1983. Each arrow marks the beginning of the labelled month.

westward. Beginning in May, at the onset of the Countercurrent, the progressive vector plots were nearly zonal but the southward trend (7 cm sec^{-1}) continued. The maximum mean equatorward flow, 8.5 cm sec^{-1} located at 50 m, could be compensation for the divergence of flow in the Ekman layer near the equator and upwelling into this layer.

Superimposed on the seasonal variation were shorter period fluctuations whose period is approximately 1-2 months. These fluctuations in current velocity are similar to those measured in GATE near 6N, 23W during the months they overlap, July-September [see Bubnov et al., 1979]. The eastward velocity in the Countercurrent had peaks on June 8 and July 24 separated by a minimum on July 1. The meridional component at 20 m had southward maxima of 22 cm sec^{-1} on June 14, 24 cm sec^{-1} on July 26 and 10 cm sec^{-1} on August 30. The largest north-south fluctuations look like they began in June, coinciding with the maximum flow in the Countercurrent. They

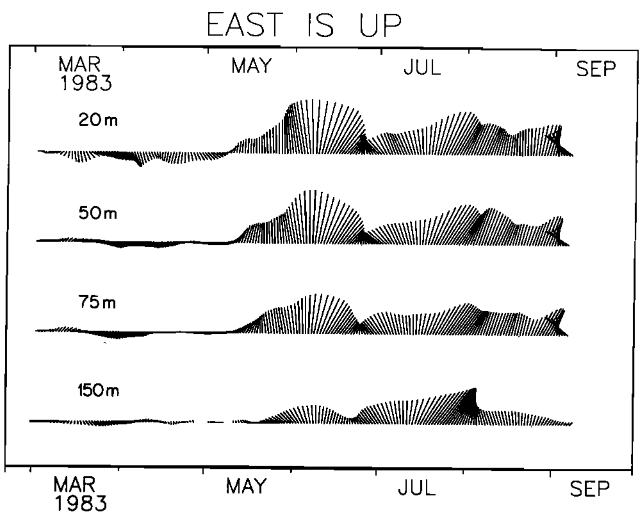

Fig. 2. Velocity sticks series from current meters near 6N, 28W. Eastward direction is oriented vertically upward in this figure to show the strongly zonal current. Maximum velocity is 60 cm sec^{-1} in June. Values were low-passed with a 10 day Gaussian filter to emphasize the low frequency variations.

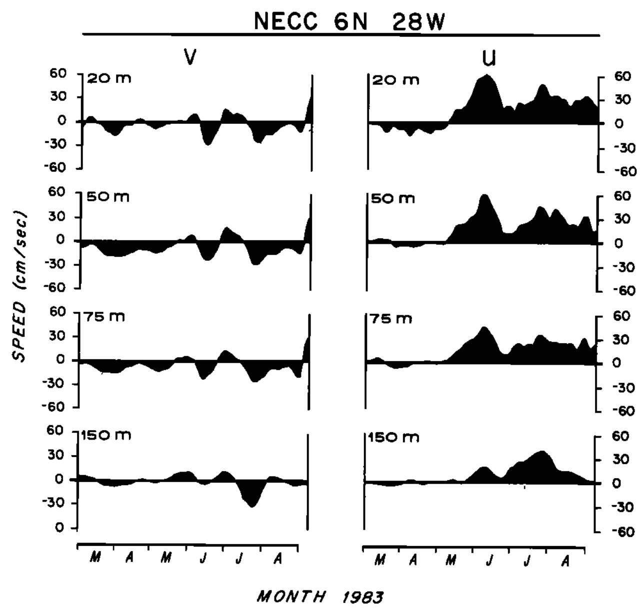

Fig. 3. Eastward and northward velocity time series from 20, 50, 75 and 150 m at 6N, 28W. Values have been low-passed with an 8 day Gaussian shaped filter to reduce high frequency oscillations.

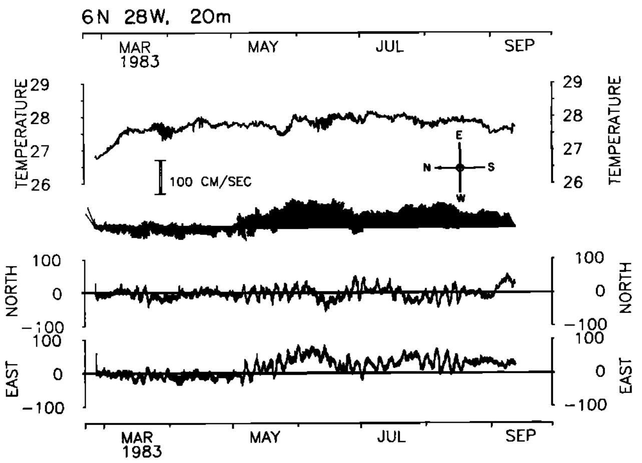

Fig. 4. Time series of hourly velocity and temperature from a current meter at 20 m, near 6N, 28W from February 25 to September 13, 1983. Stick vectors oriented toward the top of the page represent eastward velocities.

may have been produced by an instability associated with the strong latitudinal shear between the Countercurrent and South Equatorial Current [Philander, 1978; Weisberg, 1984b].

The unsmoothed record from 20 m (Figure 4) shows strong inertia-gravity waves with periods in the band 4-5 days and an anticyclonic rotation. These appear to increase slightly in amplitude in early May as the Countercurrent accelerated. They look like they decayed somewhat toward the end of August. The implication is that the variation of the amplitude of these waves was associated with the seasonal cycle of the Countercurrent. The amplitude of the waves was nearly equal at depths from 20-75 m, but significantly reduced at 150 m.

The 20°C isotherm, which lies close to the central thermocline in this region, was located between 75 and 150 m (Figure 5). The low frequency variation in temperature at these depths consisted of a period of nearly constant temperature from February to early May followed by a

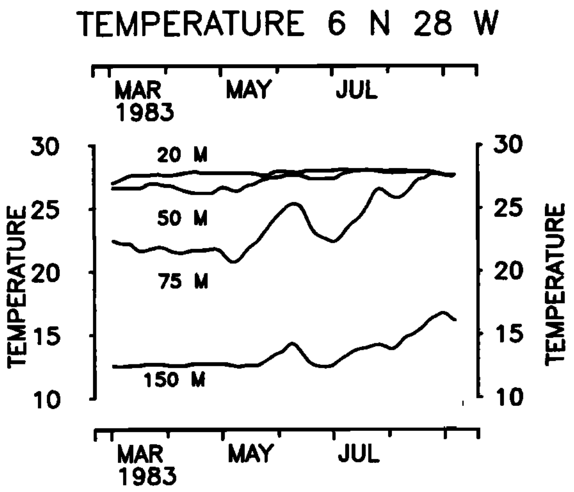

Fig. 5. Time series of temperature from 20, 50, 75 and 150 m at 6N, 28W. Values were low-passed with an 8 day Gaussian filter.

general increase of temperature -- 6°C at 75 m and 4°C at 150 m. This increase coincided with large fluctuations that have a period of 1-2 months. The first peak in temperature occurs in June and matches the peak in eastward velocity. The temperature increase is interpreted to be a subsidence of the thermocline. The mixed layer also increased in depth to at least 50 m in July and to 75 m in August.

In summary, the results from the first setting of the current meter mooring in the Countercurrent suggest a strong seasonal variation of zonal velocity at all depths sampled -- slow generally westward flow February to May, fast eastward velocity up to 40-60 cm sec^{-1} from May to September.

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P. L. Richardson, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts 02543

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