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NOTE

Equatorial deep jets in the Atlantic Ocean

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Abstract—We report here a vertical profile of velocity measured in the equatorial Atlantic (0°00′N, 30°22′W) which reveals short vertical scale zonal jets with amplitudes of 10–20 cm s^{-1} over the upper 2500 m, alternating in the east–west direction with depth. Particularly prominent was an eastward jet centered at a depth of 1000 m with an amplitude of 28 cm s^{-1}.

INTRODUCTION

ZONAL jets are a dominant feature of the deep circulation in the equatorial Pacific and Indian Oceans (LUYTEN and SWALLOW, 1976; ERIKSEN, 1981; PONTE and LUYTEN, 1989, 1990), but evidence for their presence in the Atlantic has only been indirect (ERIKSEN, 1982). Previous observations in the Pacific and Indian Oceans have characterized the deep jets as being strong zonal flows, trapped to within one degree of the equator, with typical vertical scales of 100–300 m and time scales of the order of one year or longer (ERIKSEN, 1981; PONTE and LUYTEN, 1989, 1990). Interpretation of these features in terms of linear equatorial wave and wave-mean flow models has been attempted (e.g. MCCREARY and LUKAS, 1986), but the results are ambiguous. In particular, the energy source for the jets is still uncertain, given the difficulty in having surface generated waves (at the jet scales) propagate to great depth (e.g. PONTE, 1988). Understanding of these flows is still far from satisfactory.

Analysis of hydrographic data from the tropical Atlantic (ERIKSEN, 1982) revealed an enhancement of potential energy near the equator consistent with the presence of Kelvin waves. Eriksen interpreted his findings as indirect evidence for the existence in the equatorial Atlantic of zonal jets similar to the ones found in previous observations from the western Pacific (ERIKSEN, 1981). The first vertical profile of absolute velocity collected in the equatorial Atlantic, and reported here, confirms the truly ubiquitous character of the deep jets in the equatorial circulation.

THE DATA

In early 1989 an opportunity arose for getting a first, exploratory look at the vertical structure of the equatorial Atlantic flow fields, as part of the Tropical Atlantic Sofar Float

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Experiment. A single velocity profile was measured on 17 January 1989, west of the mid-Atlantic ridge at 0°00'N, 30°22'W, with a Pegasus profiler (SPAIN *et al.*, 1981), a free-falling instrument tracked acoustically by means of two transponders resting on the ocean floor. Velocities were obtained by differentiating the profiler's horizontal position with respect to time. One drop of the instrument provided two vertical profiles of east and north velocity, one in its descent and another in its ascent.

The raw sound travel times were edited and translated into velocity measurements using the software prepared by LILLIBRIDGE and ROSSBY (1987). The downward cast was free of spurious records, but a fair amount of editing and interpolation across noisy records was needed on the upward cast. Therefore, only the velocity fields obtained from the downward profile are shown in Fig. 1. The flow structure was similar on both casts, although significant differences in amplitude occurred at some depths due to noise and possibly high frequency motions in the records (total time for descent and ascent was 3 h).

The zonal currents in Fig. 1 are in general stronger (by a factor of 2 or so) than the meridional currents. A large region of eastward flow occurs between 800 and 1400 m (using the approximate one-to-one correspondence between decibars and meters), including a prominent 28 cm s^{-1} jet at 1000 m. Over the upper 2000 db, a well-developed pattern of alternating eastward and westward flows is apparent, starting with the eastward flowing Equatorial Undercurrent reaching a speed of 75 cm s^{-1} at a depth of 70 m. Relative maxima in the westward current occur at 370, 690 and 1560 m, eastward maxima occur at 540, 970 and 1980 m. The variable distances between these consecutive peaks suggest the presence of several different vertical scales in the zonal velocity records. Meridional currents also show a similar oscillatory pattern with depth, over the upper 2200 m, but no correlation is apparent between the east and north velocity components.

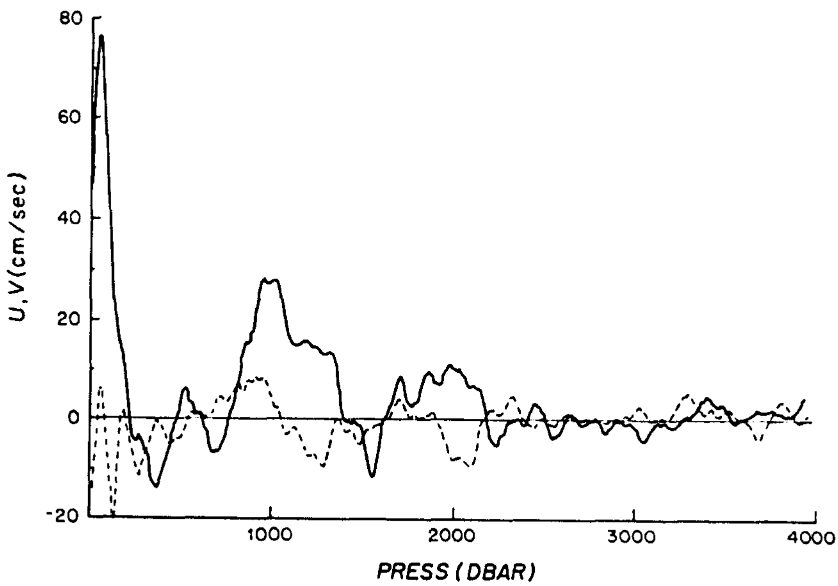

Fig. 1. East and north velocity (cm s^{-1}) as a function of pressure (decibars), observed on 17 January, 1989 in the equatorial Atlantic at 0°00'N, 30°22'W. The profile reached down to 4000 m (approximately 200 m off the bottom).

Experience in Indian and Pacific Oceans suggests that meridional flows are dominated by shorter time scale processes associated with mixed Rossby-gravity waves.

DISCUSSION

The structure of the zonal currents in Fig. 1 is fairly similar to typical profiles from the other two equatorial basins (e.g. PONTE and LUYTEN, 1989, 1990), although the Atlantic features seem to have larger vertical scales (especially below 700 m) and larger amplitudes. The westward jet located below the Undercurrent is also seen in observations in the Pacific and Indian Oceans (PONTE and LUYTEN, 1989, 1990).

Tongue-like, deep tracer signals [e.g. chlorofluoromethanes (CFMs)] have been observed to extend eastward along the equator from the western boundary (WEISS *et al.*, 1985), where cross-equatorial fluxes of deep water masses are known to exist at several depths. Correlations between the velocity and the tracer fields have not been established observationally, but Weiss *et al.* were able to infer average advection rates of 1.4 cm s^{-1} for the CFM plume centered between 1500 and 1700 m. Our records show westward flows from 1400 to 1600 m, and eastward flows between 1600 and 2200 m. Furthermore, amplitudes in the eastward band (6–8 cm s^{-1} around 1700 m) are considerably larger than the Weiss *et al.* estimates. Thus, the role of the zonal flows of Fig. 1 in the equatorial spreading of tracers from the western boundary region is unclear, and will depend on their (as yet unknown) zonal coherence scales and time dependence.

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