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(DELCROIX T.)

EOF Analysis of the Thermocline Depth in the Tropical Atlantic Ocean

The topography of the thermocline is an important feature in the tropical oceans because it directly influences equatorial currents and is thermodynamically connected to heat storage in the surface layer. Recently Merle and Delcroix (1984) described the seasonal variations of the thermocline in the tropical Atlantic Ocean from about 135,000 temperature profiles recorded prior to 1978. Monthly mean temperature values were computed at standard levels in 2° latitude by 4° longitude subdivisions of the 30°N-20°S, 80°W-20°E region. Each subdivision contained about thirty observations per month. An Empirical Orthogonal Function (EOF) analysis of these data was made to describe thermocline variations.

The thermocline depth $H(x,y,t)$, which is assumed to be the depth of the 20°C isotherm, is given by

$$H(x,y,t) = S(x,y) \sum_{n=1}^{\infty} Tn(t)\, Vn(x,y) + \langle H(x,y) \rangle$$

where $\langle H(x,y) \rangle$ and $S(x,y)$ are, respectively, the annual mean and the standard deviation at the grid point (x,y). Vn and Tn are, respectively, the spatial distribution or eigenvector and the associated temporal (t) coefficient for mode n. Vn and Tn for $n = 1,2,3$ were computed over the 60°W-20°E, 20°N-16°S region.

The first eigenvector $V1$ (Figure 1A) accounts for 40% of the total variance of the thermocline depth. Two large regions of maximum correlations (isolines -10 and 10) are found west of 15°W. The associated temporal function $T1$ (Figure 2A) shows the predominance of an almost sinusoidal variation of one year period in the western part of the basin. Because the depth is maximum when the product $V1T1$ is maximum, the temporal variations of the two regions of maximum correlations are 180° out of phase. Thus, $V1$ illustrates the meridional tilt of the thermocline along a pivot line which is approximately representative of the mean annual position of the wind convergence zone (Merle, 1983; Merle and Delcroix, 1984). This meridional oscillation is associated with the migration of the Intertropical Convergence Zone (or, more exactly, the wind convergence zone), which induces change in the Ekman pumping velocity and is responsible for the reversal of the North Equatorial Countercurrent (Delcroix, 1983; Garzoli and Katz, 1983). This explanation fails near the equator where the Coriolis parameter goes to zero.

The second eigenvector $V2$ (Figure 1B) accounts for 28% of the total variance. Similar to the first EOF, there are also two regions of

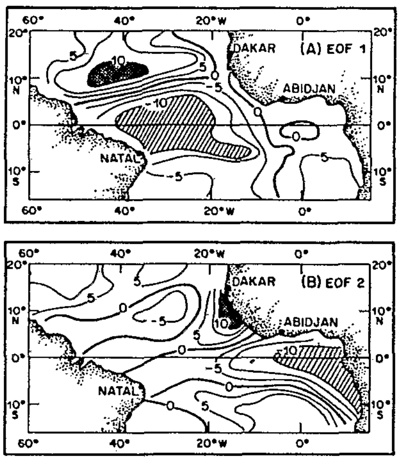

FIGURE 1 (*Delcroix*)
Distributions of the (A) first and (B) second eigenvectors.

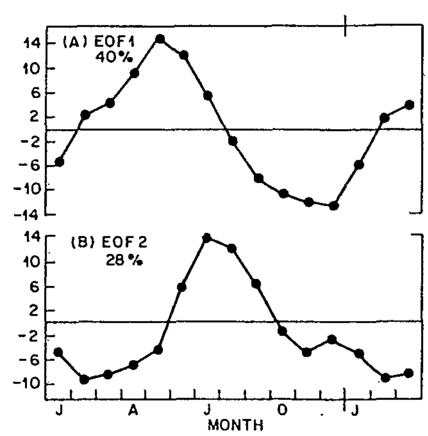

FIGURE 2 (*Delcroix*)
Temporal functions associated with the (A) first and (B) second eigenvectors.

large, spatial correlations associated with the temporal function $T2$ (Figure 2B). One area, which is located between 8 and 14°N in the east Atlantic, shows the subsurface (10-50 m) signal of the strong sea surface temperature (SST) gradient, or front, which migrates between 10 and 20°N during the year according to analyses of historical data (Wooster *et al.*, 1976) and satellite observations (Citeau, personal communication). Note that there are no data north of 14°N because the SST in this region is less than the temperature chosen for defining the thermocline. The second region, which is characterized by the −10 isoline in Figure 1B, illustrates the rapid (1-2 month) variations of the vertical displacement of the 20°C isotherm in the Gulf of Guinea. This displacement occurs in the equatorial upwelling zone within 2° of the equator and in the coastal upwelling zone along the west African coast from 2°N to 10°S. Since this abrupt rise is deduced from the climatological annual mean distribution, the interannual variability must be much smaller than the annual variability, as was previously reported by Houghton (1983). The forcing mechanism responsible for the rapid vertical displacement of the thermocline in the Gulf of Guinea is described by Picaut (1983) and Houghton (1983).

The third eigenvector $V3$ (not shown) accounts for 12% of the total variance, and the shape of the associated temporal function $T3$ is very similar to a sinusoidal variation with a six month period. The thermocline oscillates with this period in (1) the western part of the basin between the two maxima of the first eigenvector $V1$; (2) the Gulf of Guinea between 0° and 10°W and from the Ivory Coast to 5°S; and (3) south of 10°S between 10 and 30°W, where the significance of this oscillation is reduced because the standard deviation $S(x,y)$ is smaller than in the other two regions.

In conclusion, this EOF analysis provides a clearer picture of the large-scale variability of the topography of the thermocline in the tropical Atlantic Ocean. It demonstrates that the variability in the western part, which is generated by the local wind, is distinct from the variability in the eastern part, which is probably linked to the wind system over the entire equatorial basin.

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