Vertical motions in the central equatorial Pacific

Currents
Vertical motions
Continuity equation
Central Pacific

Courants
Vitesses verticales
Équation de continuité
Pacifique central

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ABSTRACT

Using long-term current observations from 10 moorings in the central Pacific (1°30'N-1°30'S, 163°15'W-167°W) in February-March 1980, estimations of vertical velocities are made from numerical integration of the continuity equation over the box model. Vertical motion in the upper 300 m layer is directed upwards, and its velocity ranges 1.0 to 8.0×10^{-3} cm.s^{-1}.

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RÉSUMÉ

Les vitesses verticales dans le centre de l'Océan Pacifique

Des observations de courants ont été réalisées en dix mouillages dans le centre du Pacifique (1°30'N-1°30'S, 163°15'W-167°W) en février et mars 1980 ; elles ont permis d'évaluer les vitesses verticales, à l'aide de l'équation de continuité. La vitesse verticale est orientée vers le haut dans la couche superficielle de 0 à 300 m et varie dans une gamme de 1,0 à $8,0 \times 10^{-3}$ cm.s^{-1}.

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INTRODUCTION

Upwelling in the upper ocean layers in the vicinity of the Equator due to wind-driven, near-surface Ekman divergence constitutes an important ocean dynamic, leading to a minimum of surface temperature and increased biological productivity. This short note presents the results of upwelling velocity computations in the central Pacific, based on current observations carried out in February-March 1980 during cruise 24 of the R/V " Dmitry Mendeleev ".

MATERIALS AND METHODS

Ten mooring were located on two meridional sections along 167°W and 163°15'W near 1°30'N, 0°40'N, O°, 0°45'S and 1°30'S. Each mooring was supplied with 7-10 current meters placed in the uppermost 300 m. Synchronous measurements continued during 28 days.

Vertical velocity estimates were obtained from numerical integration of the equation of continuity over the box model.

RESULTS AND DISCUSSION

Meridional and zonal transports were greater on each downstream side of the box than on the upstream side, *i.e.* the horizontal flow pattern produced a mass deficit within the box (Fig. 1, Tab.). This deficit was supplemented by upwelling from lower layers, except in the 0-50 m layers where eastward inflow slightly exceeds the outflow (Tab.). However the 0-50 m layer meridional flow created a significant deficit resulting in upward motion across the lower boundary of this layer.

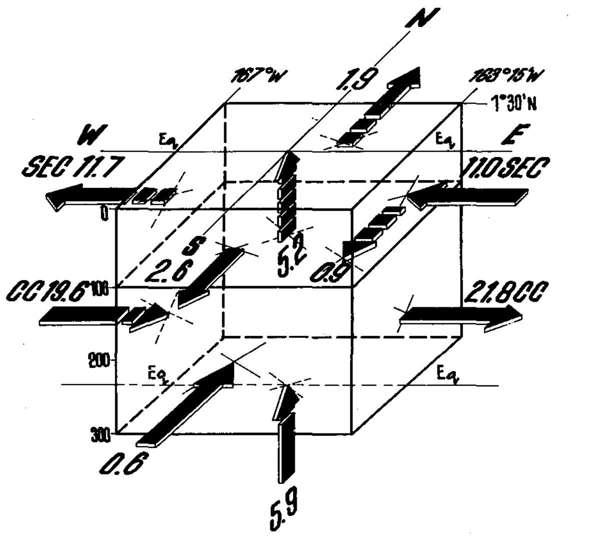

Figure 1

Mean volume transports (in 10^6 $m^3.s^{-1}$) across the boundaries of the test area. SEC = South Equatorial Current (layer 0-100 m) ; CC = Cromwell Current (layer 100-300 m).

Practically the same results are produced from the equation of continuity (Fig. 2). Almost the entire meridional section is characterized by upward motion with velocities ranging from 1-2 × 10^{-3} cm.s^{-1} in the upper 100 m layer to 5-8 × 10^{-3} cm.s^{-1} between 100 and 300 m. Velocities decreased slightly immediately at the Equator. Below the core of the Cromwell Current (150-160 m), there appeared weak downstream motion (1 × 10^{-3} cm.s^{-1}).

More intensive upwelling occurred 65-80 km north and south of the Equator ; further from the Equator, velocities decreased quickly.

The vertical circulation pattern is determined primarily by the meridional velocity component of the divergence, although the zonal component of divergence makes a considerable contribution, especially in the vicinity of the Equator.

A noticeable temperature decrease occurred in the upper quasi-homogeneous layer during the period from February to March (Fig. 3). This feature can be considered as a consequence of intensive upwelling.

Table

Mean transports Q ($10^6 m^3.s^{-1}$) across the boundaries of the equatorial test area and mean vertical velocity W (10^{-3} cm.s^{-1}) at the lower boundary of estimated volume.

Layer	Zonal transports			Meridional transports				Vertical velocity		
m	Q_W	Q_E	$Q_W + Q_E$	Q_N	Q_S	$Q_N + Q_S$	Q_B	W_z	W_m	$W = W_z + W_m$
0-50	− 8.59	+ 8.87	+ 0.28	− 1.17	− 2.33	− 3.50	+ 3.22	+ 0.20	− 2.52	− 2.32
0-100	− 11.73	+ 11.01	− 0.72	− 1.90	− 2.65	− 4.55	+ 5.27	− 0.52	− 3.28	− 3.80
0-150	− 6.97	+ 5.49	− 1.48	− 2.10	− 2.44	− 4.54	+ 6.02	− 1.06	− 3.27	− 4.33
0-170	− 3.17	+ 1.39	− 1.78	− 1.85	− 2.60	− 4.45	+ 6.23	− 1.28	− 3.20	− 4.48
0-200	+ 2.71	− 4.06	− 1.35	− 1.48	− 2.60	− 4.08	+ 5.43	− 0.97	− 2.94	− 3.91
0-250	+ 7.28	− 9.25	− 1.97	− 1.38	− 2.19	− 3.57	+ 5.54	− 1.42	− 2.57	− 3.99
0-300	+ 7.96	− 10.79	− 2.83	− 1.27	− 1.77	− 3.04	+ 5.87	− 2.03	− 2.19	− 4.22

Note : Q_W, Q_E, Q_N, Q_S, Q_B — transports across the western, eastern, northern, southern and bottom boundaries of the estimated volume, accordingly. For transport : (+) — into the contour of the test area ; (−) — from the contour of the test area. For vertical velocity : (+) — downward, (−) — upward ; W_z — input of zonal transports, W_m — input of meridional transports.

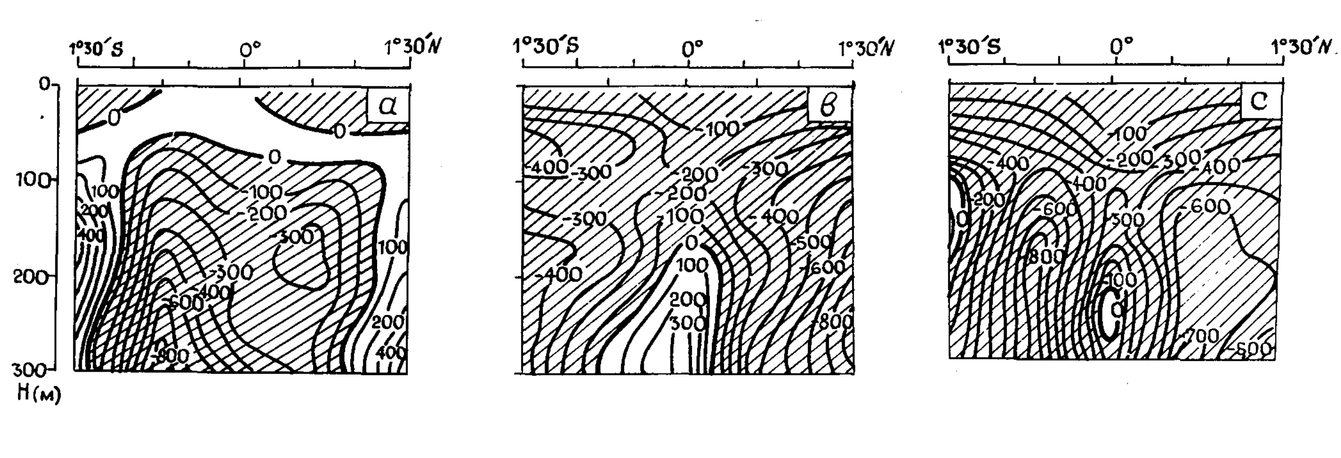

Figure 2

Mean vertical velocity (in 10^{-5} cm.s^{-1}) at the meridional section through the test area : a) input of zonal velocity divergence ; b) input of meridional velocity divergence ; c) total vertical velocity. Areas of upward motion are shaded.

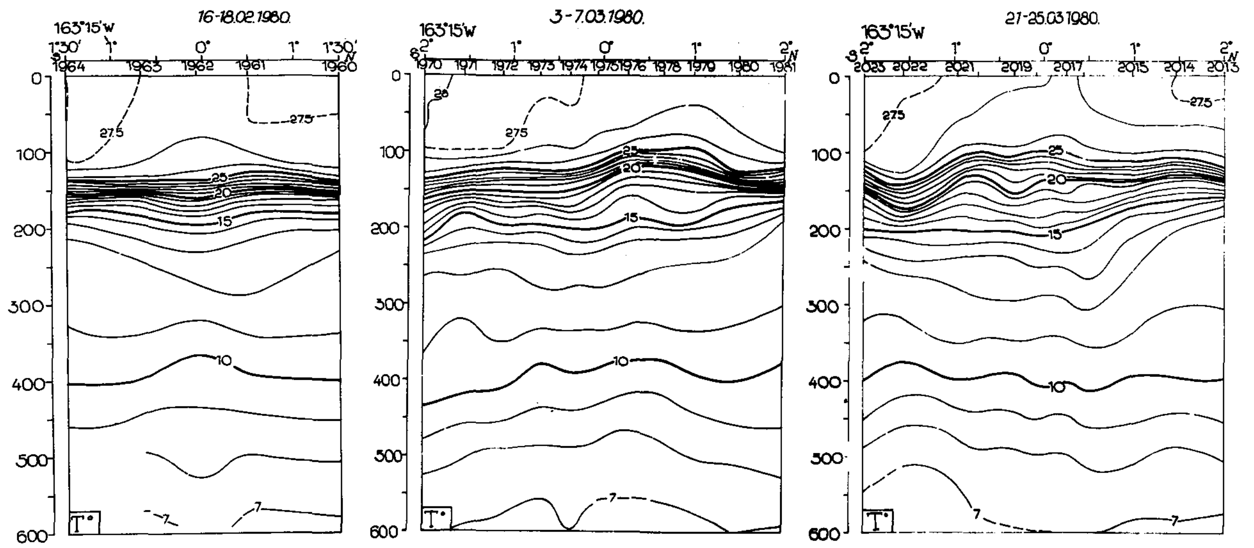

Figure 3

Distribution of water temperature (in °C) at the section along 163°15'W in February-March 1980.

The results of our computations are in agreement with most estimates of equatorial upwelling velocities (*e. g.*, Knauss, 1966 ; Burkov, Monin, 1974 ; Halpern, 1980 ; Wyrtki, 1981). However, for the depths of the Cromwell Current (100-300 m) our vertical velocities seemed slightly higher. This is the result of strong zonal divergence at the depth of the Cromwell Current (Fig. 1, Tab.).

REFERENCES

Burkov V. A., Monin A. S., 1974. Study of Cromwell Current and data of the 5-th cruise of the R/V Dmitry Mendeleev (in Russian), in : *Hydrophysical and hydrooptical researches in the Atlantic and Pacific Ocean*, Moscow, Nauka, 39-79.

Halpern D., 1980. Vertical motion at the equator in the eastern Pacific (abstract), *EOS*, **61**, 998.

Knauss J. A., 1966. Further measurements and observations on the Cromwell Current, *J. Mar. Res.*, **24**, 205-240.

Wyrtki K., 1981. An estimate of equatorial upwelling in the Pacific, *J. Phys. Oceanogr.*, **11**, 1205-1214.