Abstract View

Volume 7, Issue 1 (January 1977)

Journal of Physical Oceanography
Article: pp. 50–61 | Abstract | PDF (1011K)

Annual Forcing of Baroclinic Long Waves in the Tropical North Pacific Ocean

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(Manuscript received December 27, 1975, in final form September 10, 1976)

DOI: 10.1175/1520-0485(1977)007<0050:AFOBLW>2.0.CO;2

ABSTRACT

From an analysis of the bathythermograph (BT) data files for the entire tropical North Pacific Ocean, the annual vertical displacement in the main thermocline from 10°−20°N is observed to propagate Westward as baroclinc long waves, with a phase speed and wavelength twice that of baroclinc Rossby waves, the latter emanating from the coast of Central America. For a closer investigation into the behavior of these long waves, a unique set of data is considered, consisting of BT observations taken monthly for 16 months in a rectangular grid from 11°−18°N, 148°−157°@. In this data set the vertical displacement in the main thermocline of the North Equatorial Current also displays a westward propagating annual signal; the annual signal (with an rms vertical displacement of 34 m) did-not appear in phase everywhere over the grid, but rather indicated a wave propagating through the observational BT network toward the northwest, with an average wavelength of about 2700 km and an average speed of 8 cm s^{-1}. The zonal wave speed was faster at the southern end of the grid than on the northern, with a zonal wavelength that was nearly three times as large. This indicates the wave was being refracted from the west direction into the north direction.

These observations are consistent with theory where the annual forcing on the general circulation by the wind stress is found to generate baroclinic Rossby waves emanating from the eastern boundary which, when superimposed upon the local forced response, yields a baroclinic long wave that propagates westward at a phase speed of $c_{px} = 2g' H_0\beta/f^2$, or twice the speed of nondispersive Rossby waves. Because the zonal phase speed of these long waves is latitude dependent, the quasi-meridional wave front is refracted as it travels westward, the wavenumber vector progressively rotating anticyclonically into the northward direction. The magnitude of the zonal phase speed at 11°N is calculated to be approximately 40 cm s^{-1} and at 18°N is ~ 15 cm s^{-1}. This is in quantitative agreement with observation. In addition, the zonal wavelength is determined by the distance traveled to the west during the annual cycle of wind forcing. At 11°N this is calculated to be approximately 12 000 km, at 18°N it is ~ 5000 km, both also in quantitative agreement with observation.

From refraction principles inherent within the theory, the annual baroclinic long waves observed in the observational

BT network near 153°W, 15°N were traced eastward to their point of origin. These waves were found to have originated at the coast of Central America nearly one year earlier, with the wave crest aligned parallel to the coast. This was what is expected from the generation theory. On the basis of this understanding, the expected phase and relative amplitude of these waves over the entire tropical North Pacific from 10°−20°N are mapped schematically.

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