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Equatorial Counter Current

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The **Equatorial Counter Current** is an eastward moving, wind-driven surface current found in the Atlantic, Indian, and Pacific Oceans. More often called the **North Equatorial Countercurrent (NECC)**, this current flows west-to-east at about 5°N in the Atlantic and Pacific basins, between the North Equatorial Current (NEC) and the South Equatorial Current (SEC). The NECC is not to be confused with the Equatorial Undercurrent (EUC) that flows eastward at the equator but at some depth. In the Indian Ocean, circulation is dominated by the impact of the reversing Asian monsoon winds. As such, the current tends to reverse hemispheres seasonally in that basin.[1] The NECC has a pronounced seasonal cycle in the Atlantic and Pacific, reaching maximum strength in late boreal summer and fall and minimum strength in late boreal winter and spring. Furthermore, the NECC in the Atlantic disappears in late winter and early spring.[2]

The NECC is an interesting case because while it results from wind-driven circulation, it transports water against the mean westward wind stress in the tropics. This apparent paradox is concisely explained by Sverdrup theory, which shows that the east-west transport is governed by the north-south change in the curl of the wind stress.[3]

The Pacific NECC is also known to be stronger during warm episodes of the El Niño-Southern Oscillation (ENSO).[4] In fact, an early hypothesis of well-known physical oceanographer Klaus Wyrtki suggested that a stronger NECC led to a buildup of warm water in the East Pacific that is eventually observed as El Niño.

There is also a South Equatorial Countercurrent (SECC) that transports water from west to east in the Pacific and Atlantic basins between 2°S and 5°S in the western basin and farther south toward the east.[5][6] While the SECC is geostrophic in nature, the physical mechanism for its appearance is less clear than with the NECC; that is, Sverdrup theory does not obviously explain its existence. Additionally, the seasonal cycle of the SECC is not as defined as that of the NECC.

Contents

Theoretical Background

The NECC is a direct response to the meridional change of the wind stress curl near the Intertropical Convergence Zone (ITCZ). In part the NECC owes its existence to the fact that the ITCZ is not located at the equator, rather several degrees latitude to the north. The change in the coriolis parameter (a function of latitude) moving across the equator combined with the ITCZ being located north of the equator leads to areas of convergence and divergence in the oceanic mixed-layer. This result is obtained from Ekman theory. Using the larger Pacific basin as an example, the resulting dynamic height pattern consists of a trough at the equator, and ridge near 5° degrees north, a trough a 10°N, and finally a ridge closer to 20°N.[7] From geostrophy (the perfect balance between the mass field and velocity field), the NECC is located between the ridge and trough at 5°N and 10°N, respectively.

Sverdrup theory succinctly summarizes this phenomenon mathematically by defining a geostrophic mass transport per unit latitude, M, as the east-west integral of the meridional derivative of wind stress curl, minus any Ekman transport. The Ekman transport into the current is typically negligible, at least in the Pacific NECC. The total NECC is found by simply integrating M over the relevant latitudes.[8]

Atlantic North Equatorial Countercurrent

The Atlantic NECC consists of the eastward zonal transport of water between 3°N and 9°N, with typical widths on the order of 300 km. The Atlantic NECC is unique among the equatorial currents in that basin because of its extreme seasonality. The maximum eastward flow is attained in late boreal summer and fall while the countercurrent is replaced by westward flow in late winter and spring. The NECC has maximum transport of approximately 40 Sv (10^6 m3/s) at 38°W. Transport reaches 30 Sv two months per year at 44°W, while farther east at 38°W the transport reaches that level five months per year. The magnitude of the NECC weakens substantially east of 38°W due to water being absorbed by the westward equatorial current south of 3°N.[9]

While the variability of the Atlantic NECC is dominated by the annual cycle (weak late winter, strong late summer), there is also interannual variability as well. The strength of the Atlantic NECC is notably stronger in years following El Niño in the tropical Pacific, with 1983 and 1987 being notable examples.[10] Physically, this implies that the altered convection in the Pacific Ocean due to El Niño drives changes in the meridional gradient of wind stress curl over the equatorial Atlantic.

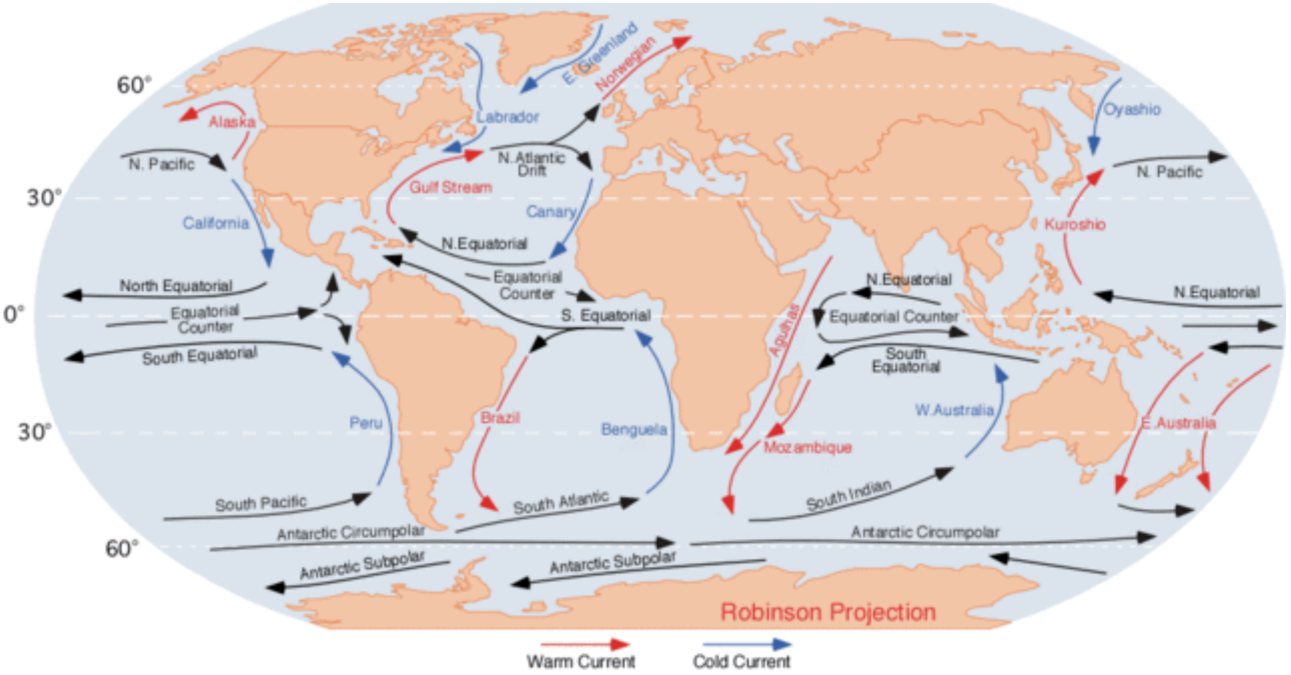
Pacific North Equatorial Countercurrent

The Pacific NECC is the major eastward moving surface current that transports more than 20 Sv from the West Pacific warm pool to the cooler East Pacific. In the western Pacific the countercurrent is centered near 5°N while in the central Pacific it is located near 7°N.[11] The northern boundary of the Pacific NECC is easily defined by the adjacent westward flow found in the North Equatorial Current (NEC). The southern boundary, however, can be more ambiguous. The southern boundary in the central Pacific is clearly defined by the westward South Equatorial Current (SEC) at the surface, but at depth it merges with the North Subsurface Countercurrent (NSCC). In the western basin, the NECC may merge with the Equatorial Undercurrent (EUC) below the surface. Generally, the current weakens to the east in the basin, with estimated flows of 21 Sv, 14.2 Sv, and 12 Sv in the western, central, and eastern Pacific, respectively.[12]

Like the Atlantic NECC, the Pacific NECC undergoes an annual cycle. Unlike the Atlantic however, the eastward Pacific NECC does not generally disappear. During late boreal winter and spring, the current is weaker as the northeasterly trade winds are shifted south, and oppose the current. When the northeasterly trades are shifted north and weaker in the later summer and fall, the NECC is stronger. These seasonal fluctuations are in phase with that of the NEC, but opposite in phase to the SEC.[13]

Fluctuations of the Pacific NECC with El Niño

The Pacific NECC is known to be stronger during El Niño events where there is anomalous warming of the eastern and central Pacific that peaks in boreal winter. Klaus Wyrtki hypothesized in the early 1970s that an unusually strong NECC in the western Pacific would lead to an anomalous accumulation of warm water of the coast of Central America and, thus, El Niño.[14] The sea surface temperatures in the eastern equatorial Pacific and the transport of the NECC are indeed highly correlated. This does not, however, exclude other atmospheric and oceanic factors from contributing to anomalous warming. ENSO is a complicated, coupled ocean-atmosphere phenomenon in which basin-wide changes in sea surface temperatures, trade winds, and atmospheric convection are intimately related.



See also

- Coral bleaching
- Ocean current
- Oceanic gyres
- Physical oceanography
- Walker circulation
- Humboldt Current

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External links

- The North Equatorial Counter Current Barbie Bischof, Arthur J. Mariano, Edward H. Ryan
- Fundamentals Of Physical Geography Michael Pidwirny *includes map*