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The Tropical Ocean Circulation's Role in Damping ITCZ Shifts

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The ocean's circulation plays an important role in the tropical energy balance, cooling the atmosphere by roughly 50 W/m2. Coupled to the atmosphere's Hadley cells by the surface wind stress, the ocean's sub-tropical cells transport more energy out of the tropics due to their greater vertical energy contrast. Also coupled to the Hadley cells is the inter-tropical convergence zone, or ITCZ, a band of intense precipitation that moves meridionally with those circulations' ascending branch. Since the Hadley cells dominate the atmosphere's meridional energy transport in the tropics, the ITCZ's position is tied to the atmosphere's hemispheric energy balance, lying in the Northern Hemisphere when the Hadley cells move energy southwards across the equator and vice-versa. By constructing a simple model of the atmosphere's hemispheric energy balance, we show that the ocean's sub-tropical cells are able to significantly damp ITCZ shifts by transporting relatively large amounts of energy across the equator. This is confirmed in runs of a coupled ocean-atmosphere general circulation model forced with an inter-hemispheric albedo contrast, where runs with an active ocean circulation show reduced ITCZ shifts by a factor of 2-3 relative to runs with a passive ocean circulation. Because the two fluids' circulations are coupled through the surface wind stress, the sub-tropical cells always act to damp ITCZ shifts, restricting the ability of the climate system to shift tropical precipitation patterns in past and future climates.