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A proposal to force vertical mixing of the Pacific Equatorial Undercurrent to create a system of equatorially trapped coupled convection that counteracts global warming

J. Duke

John Duke Design, LLC, Providence, Rhode Island, USA (johnduke@johnduke.com / Phone: 401-277-9880)

Here I propose a geoengineered means to force vertical mixing of the Equatorial Undercurrent (EUC) to initiate a beneficial mode of ocean-atmosphere circulation similar to that of the extreme La Niña event of May-September of 1998. The proposed means is a mid-ocean anchored array of vertical axis turbines that employ EUC kinetic energy to combine the surface layer, EUC, and underlying thermostad into a cold surface countercurrent at the equator. The size of the array, to be determined, is sufficient to generate meridionally diverging sea breeze convection cells that can sustain themselves by continued upwelling as the eastward current proceeds across the basin. This defines a divergent system of equatorially trapped coupled convection (hereafter ETCC) powered by release of thermal potential and maintained by geostrophic separation of eastward and westward flows. The 1998 La Niña mode of circulation was an ETCC event that sustained itself for four months. Equatorially diverging wind vectors at 140ºW were northwestward at 2ºN, and southwestward at 2ºS (TAO/TRITON data). The EUC surfaced (OSCAR data), and SST fell below 23ºC (TAO/TRITON data) in an equatorially symmetric extension of the cold tongue.

During this May-September 1998 period the Hadley cells were divided at the equator by the above ETCC system. Converging warm air met diverging cold air, which slowed the rising branch of Hadley circulation. ETCC systems thereby directly oppose Hadley circulation, the dominant atmospheric means of poleward heat transport from the tropics. This is the basis of the proposal's immediate benefit in ice sheet preservation. Divergent ETCC systems are functionally distinct from cross-equator Walker circulation in two ways. Firstly, under cross-equator Walker circulation, the South Equatorial Current (SEC), driven by strong southeast trade winds, separates the North Equatorial Counter-Current (NECC) from the EUC. This creates a convergent zonal interface between the westward SEC and the eastward NECC (see Fig. 3a, Wyrtki and Kilonsky, 1984), which depresses the thermocline. To the north, the divergent NECC - North Equatorial (NEC) interface, which raises the thermocline, is therefore further from the Ekman zone at the equator and cannot aid upwelling. In comparison, an equatorial ITCZ consolidates counter-currents at the equator, which vertically expands the thermocline by geostrophic compression. Secondly, ETCC overturning delivers iron rich EUC water (Wells, 1999) to the HNLC surface, sustaining a plankton bloom that further raises the thermocline by bio-optical effect (Manizza et al., 2005). The 40-fold increase in chlorophyll (Chaves et al., 1999) caused by the 1998 ETCC event was the largest annual perturbation of the global carbon cycle ever observed (Turk et al., 2001). The thermocline is therefore relatively higher under an ETCC system, further aiding equatorial upwelling that counters Hadley circulation.

Other benefits of this proposal include: (1) Decrease in radiative forcing by increased production of marine aerosols (CLAW hypothesis); (2) Increase in planetary albedo by cloud cover over zonal atmospheric convection cells; (3) Reduction of CO2 flux by increased carbon utilization; (4) Reduction of CO2 flux by temperature effect, (5) Suppression of tropical cyclone formation by stabilizing the ITCZ within the ETCC; and (6) Support of a basin scale fishery by increased primary production. The mixer array incorporates a ballast control mechanism with which it can raise or lower itself as needed to provide reversibility.

A hypothesis that supports this proposal asserts that ETCC systems may have reinforced natural global cooling in the past. While the normal northern position of the ITCZ is determined by the shape of the Pacific Ocean (Philander, 1996), past periods of global cooling, which this proposal seeks to emulate, are associated with a southward shifted ITCZ (Koutavas and Lynch-Stieglitz, 2005). A southward ITCZ is necessary for natural ETCC formation. Similarly, periods of severe ENSO may favor ETCC because they are known to provide the equatorial waves that can initiate ETCC, as occurred in 1997-1998 (McPhaden and Yu,1999). Modeling by Kukla et al. (2002) showed that ENSO events were nearly twice as frequent in the early MIS 5d glacial than in the prior interglacial. A conclusive test of this hypothesis may be found in equatorial aeolian dust discontinuities at periods of past global cooling, for descending ETCC air would be cleaner than terrigenous trade wind air. Lea et al. (2000) have found that a tropical cooling at the last glacial onset occurred three thousand years prior to changes in continental ice volume, suggesting a possible causal ETCC role.

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