Understanding the Relationship between El Niño and its Global Environment

The time-mean global climate defines the environment in which El Niños grow and decay. The collective effect of El Niños in turn contributes to the shaping of the time-mean global climate. Understanding the relationship between El Niño and its global environment is central for a better understanding of the variability of El Niño and its response to global climate change. Two pieces of research in this direction are highlighted below. One is a theoretical analysis of what determines the amplitude of El Niño, suggesting that El Niño is fundamentally driven by the surface heat flux into the equatorial ocean. The other is an observational study of the role of El Niño in the heat balance of the tropical Pacific, revealing that El Niño is a basic process by which the Pacific ocean transports heat poleward.

An analytical model for the amplitude of El Niño

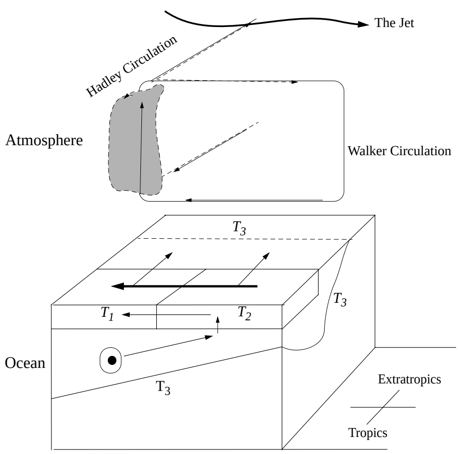

Fig. 1: A schematic diagram of the coupled model. The wind-driven currents are constituted by the poleward Ekman flow, the westward surface frictional flow, the eastward equatorial undercurrent, and the subsurface equatorward flow from the higher latitudes.

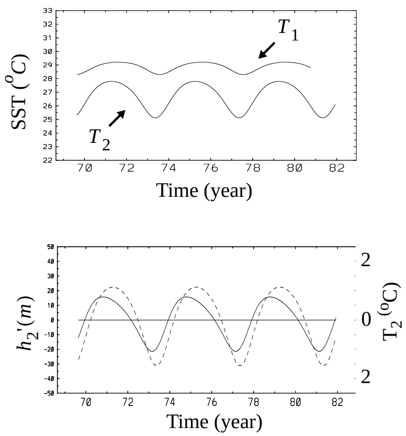

Fig. 3: Phase relationships (a): variations of T_1 and T_2. (b): variations of the thermocline depth at the eastern Pacific. Dashed line is anomalies of T_2.

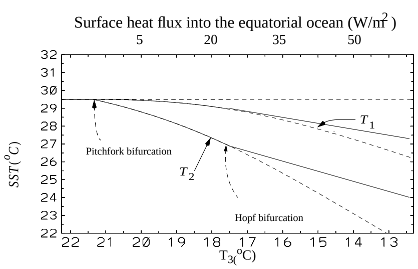

Fig. 2: Time-mean SST of the equatorial Pacific as a function of the extratropical SST T_3. The corresponding surface heat flux into the equatorial ocean is also marked.The value of tropical maximum SST is fixed at 29.5 ^oC. The equatorial Pacific starts to oscillate after the Hopf bifurcation. Dashed lines are the unstable equilibrium SST.

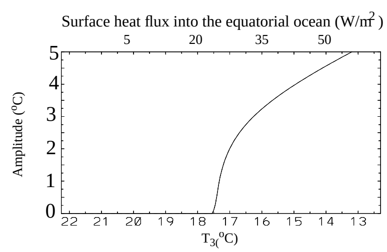

Fig. 4: Amplitude of the oscillation as a function of T_3. The corresponding surface heat flux into the equatorial ocean is also marked. The amplitude is defined here as the half value of the difference between the maximum and minimum value of T_2. Other parameters are the same as in Fig. 2.

El Niño and the heat balance of the Pacific

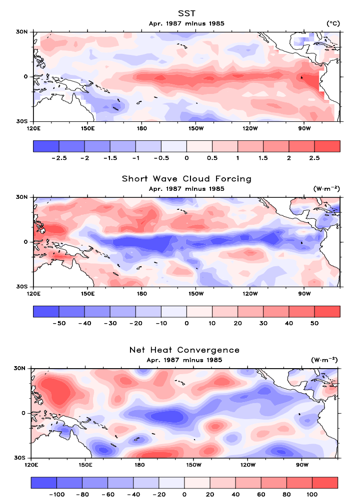

Fig. 5: Differences in SST, short-wave cloud forcing (C_s), and convergence of moist static energy (D_a) between April 87 and April 85 (87 minus 85).

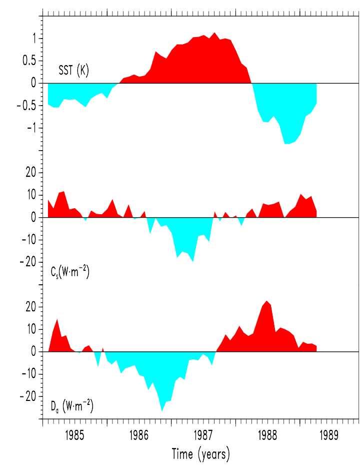

Fig. 7: Variations of SST, short-wave cloud forcing (C_s), and convergence of moist static energy (D_a) over the period of ERBE. Plotted are their anomalies averaged over the equatorial Pacific (5S-5N, 120E-70W).

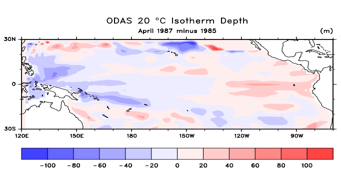

Fig. 6: Difference in the depth of the 20 ^oC isotherm, a proxy for the upper ocean heat content. With the eastward displacement of warm water, the thermocline below the warm-pool becomes shallower and the equatorial upper ocean loses heat to the higher latitudes.

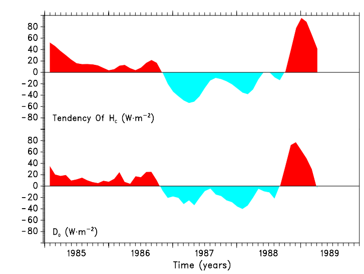

Fig. 8: Variations of the tendency of the equatorial upper ocean heat content and convergence of heat into the equatorial upper ocean.

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