What the Southern Oscillation Is: An Atmospheric Perspective

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The Southern Oscillation (SO) is a basin-scale variation in sea-level pressure in the equatorial Pacific. The pressure differences between two weather observing stations that are typically in different regimes of the SO are used to fa the SO index. The variation of this index is plotted as the pressure anomaly difference between Darwin, Tahiti and Australia. An idea of the spatial extent of this variation can be seen by correlating the pressure anomaly at Darwin with other points in the Pacific Basin.

The measure of the strength of the SO is the magnitude of the difference in total pressure between the two stations -- when it is large, the index is positive and when it is small, the index is negative. Those extremes correspond to the two different phases of pressure variation which is called the Southern Oscillation (see Figure 1). The correlation of annual mean sea level pressures with Darwin (see Figure 2) is quite large across the western half of the Basin and also large, but negative, on the opposite side of the Basin. The pressure anomaly pattern is indicative of high pressure in the West and low pressure in the East; or the opposite phase low pressure in the West and high pressure in the East, with negative SO index in the first case and positive SO index in the second case.

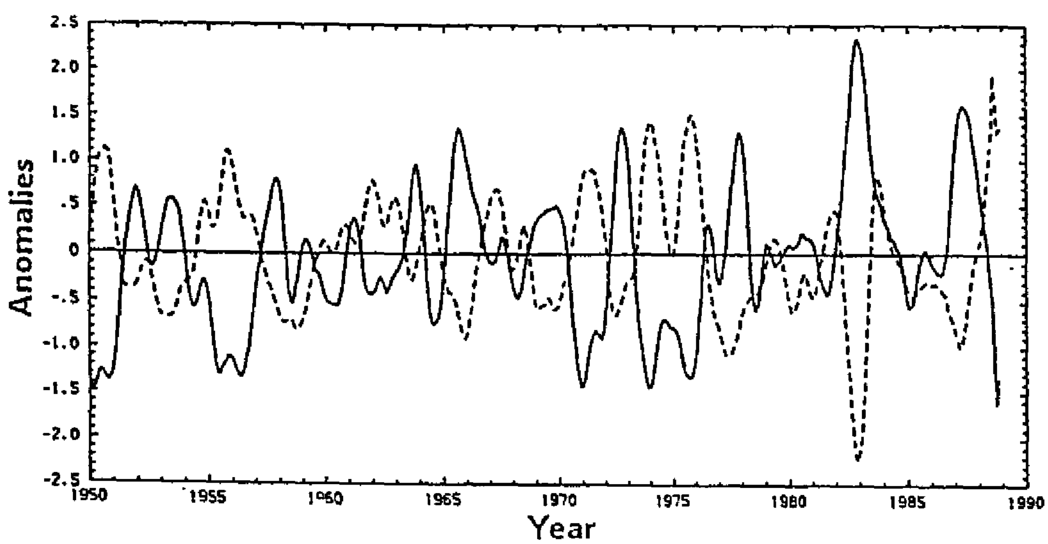

Figure 1. Time series of anomalies in sea level pressures at Darwin (solid) and Tahiti (dashed) from 1950 to 1988 smoothed with an 11-point filter designed to remove fluctuations of periods less than about a year.

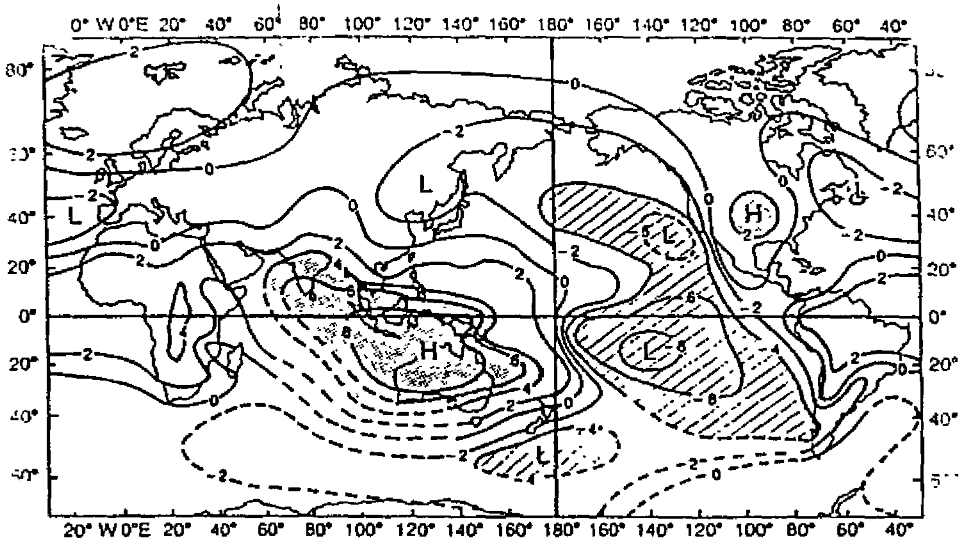

Figure 2. Composite of the correlations (x 10) of annual mean sea level pressures with Darwin (from Trenberth and Shea, 1987).

What causes it? How does it work? It is like the circulation in a room (Figure 3). The stove in the corner is heating up a portion of air in the room; the warmed air is lighter and rises to the ceiling of the room, traverses laterally towards the window and cools. It then sinks, reaches the floor, and is sucked back to the stove. The tropical atmospheric circulation is similar if the stove is in the west end of the Pacific Basin. During El Niño, however, [the] stove moves out to the middle of the room, so one would have rising motion in [the] middle of the room and sinking at the ends. Pressure is lower in the warm parts. In the El Niño-like room, there is low pressure in the center and higher pressure [at] the sides.

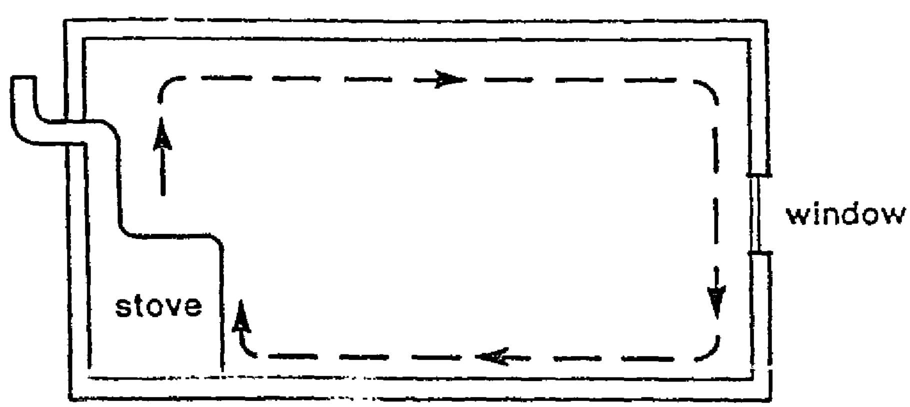

Figure 3. Idealized picture of global atmospheric circulation as compared to circulation in a room.

The same pattern drives the SO pressure pattern, but the real atmosphere is much more complicated than room/stove. The atmosphere behaves, not like a heat engine, but more like a steam engine. It is important to associate sea surface temperature, not with direct heating, but with a preferred locale for condensation. In a region of warmer water, pressure is slightly lower. That drives surface air to lower pressure, where it picks up moisture because it is dryer than the water that it is gliding over. Air converges and has no place to go but upward in the area of lower pressure. As air rides, it expands. As it expands, it cools and causes water to condense. As it condenses, it heats the atmosphere; and this heating of the atmosphere causes the pressure to decrease the circulation further (Figure 4).

Why should we care? Yet another coupled response is the key. In North America we might care because it turns out that the sea surface temperature anomalies of El Niño are the SO focus. Connected with the so called PNA (Pacific North America) teleconnection pattern [are] a progression of alternating high and low pressure anomalies over North America, persistent weather spells.

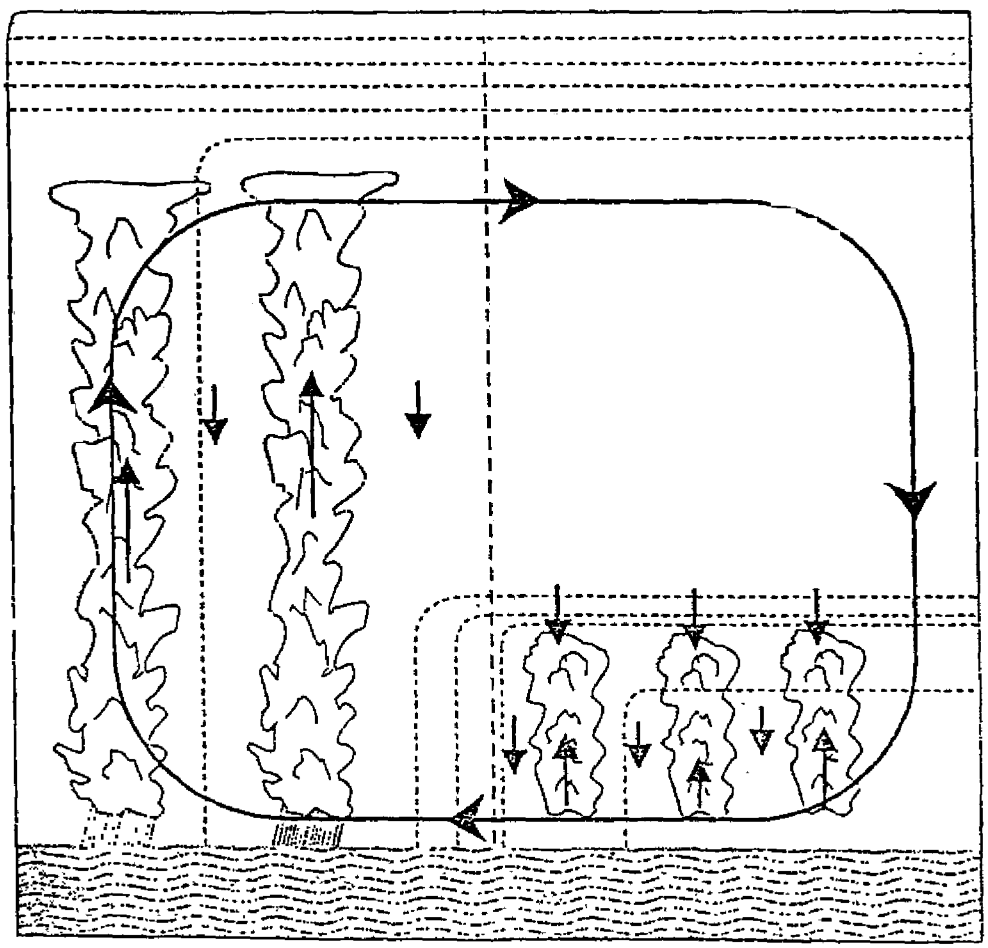

Figure 4. Idealized picture of global atmospheric circulation.