

A Mechanism for Long-Term Changes in El Niño and the Southern Oscillation

In the 1970s, properties of the El Niño-Southern Oscillation (ENSO) changed notably: periods between warm and cold SST states grew longer, the SST differences between these two states grew larger, and the region of maximum variability shifted eastward. The research team of **Soon-Il An** and **Bin Wang** at the IPRC undertook to understand the causes of this change. Observations had shown that the most significant changes in the tropical Pacific from the pre-shift (1961-1975) to the post-shift (1981-1995) period had occurred in the surface winds and SST (See *Searching for the Cause of Slow Changes in the Equatorial Pacific Ocean*, p. 3), whereas changes in thermocline structure remained uncertain.

Using the coupled atmosphere-ocean model of Cane and Zebiak, An and Wang demonstrated that the observed changes in the surface winds associated with the Pacific climate shift can reproduce qualitatively the observed changes in the ENSO properties mentioned above (See Figure 3). The fundamental factor that altered the modeled ENSO's properties was a change in the background equatorial winds (i.e., an eastward shift in the wind stress anomalies) and associated upwelling. Observations had shown that the mean SST gradient from west to east across the Pacific was smaller during

the post-shift than the pre-shift period, whereas the mean upwelling in the eastern Pacific was stronger. The stronger upwelling increased vertical heat transfer and reduced horizontal transfer. As a result, the prevailing westward propagation of the SST anomaly was replaced by a stationary oscillation or eastward propagation. Changes in the mean winds also affected ENSO properties by shifting the region of anomalous atmospheric heating and the zonal SST gradient eastward along the equator. An and Wang demonstrated with a conceptual model how such an eastward displacement will prolong the oscillation period and amplify the ENSO cycle by enhancing the growth rate of the unusual cold or warm ocean-atmosphere state and by delaying the transition from one state to the other.

Panels (a) and (b) of Figure 3 show the model's simulations of ENSO properties for the pre- and the post-shift periods respectively. A comparison of the panels shows that, during 10 years of a model run simulating the pre-shift state, there are four anomalous warm SST events, which usually reach a maximum of about 2°C and occur around 130°W. On the other hand, the post-shift state simulation shows for the same time span only three anomalous warm SST events, which range from 3.5°C to 5°C and occur about 105°W.

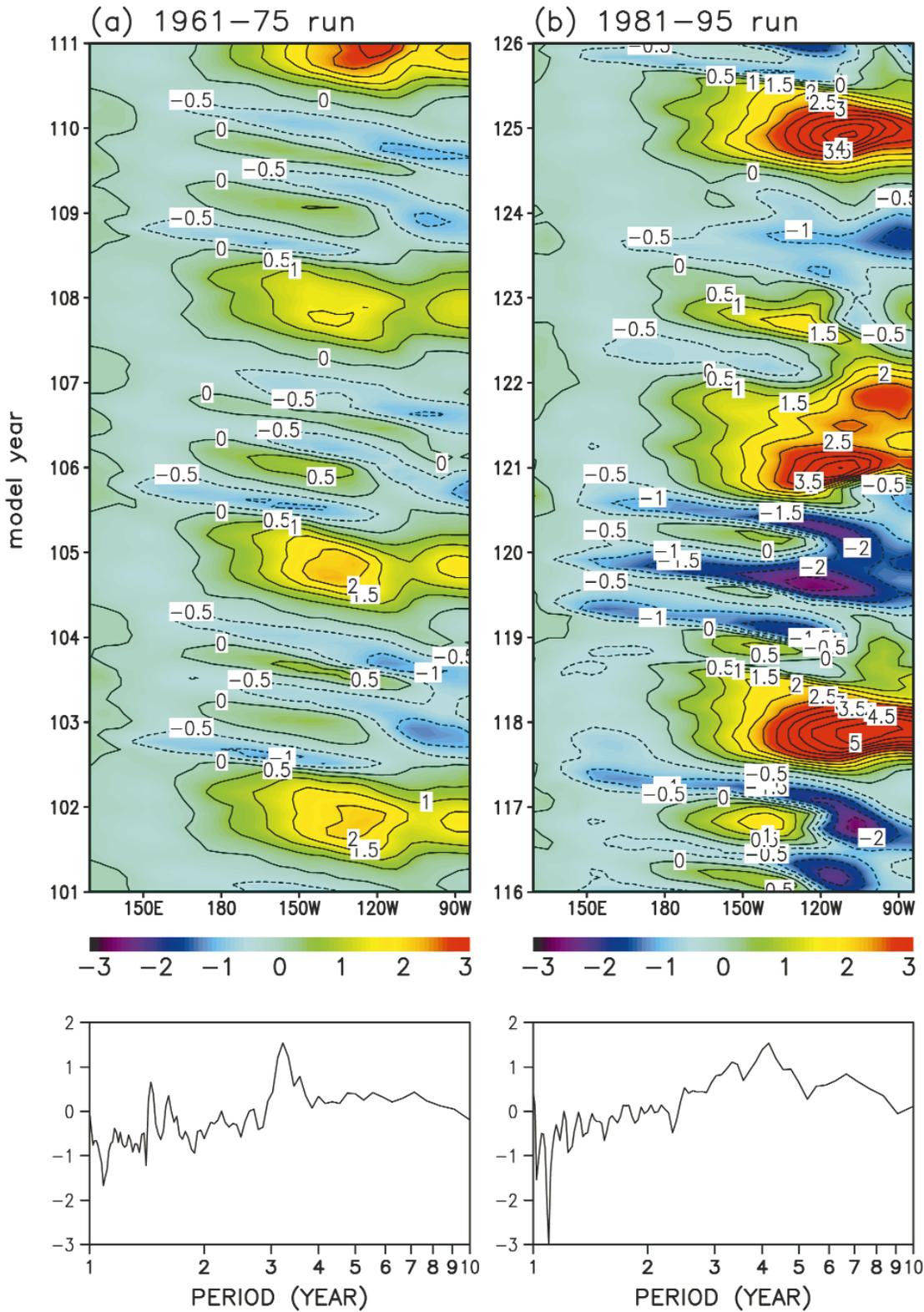


Figure 3. Time series of SST anomalies averaged from 5°S to 5°N for solutions to the Cane-Zebiak model using two background states of the Pacific Ocean. Power spectra of NINO3 SST anomalies in log units (averaged over 5°S to 5°N; 150° to 90°W) corresponding to the solutions shown directly above.