Abrupt shift in subsurface temperatures in the eastern tropical Pacific associated with recent changes in El Niño

D. P. Schrag
T. P. Guilderson

Department of Earth and Planetary Sciences, Harvard University, Cambridge, MA 02138, USA

Previous studies have noted that the pattern of ENSO variability changed in 1976, with warm (El Niño) events becoming more frequent and more intense (Trenberth, and Hoar, 1996). This '1976 Pacific climate shift' has been characterized as a warming in sea surface temperatures through much of the eastern tropical Pacific, and has yielded the two largest warm events in the last 100 years (1982-83 and 1997-98), as well as three additional warm events (1976-77, 1987, and 1992-94). A recent study (Zhang *et al.*, 1998)) reported that this shift originated as a subsurface warming in mid-latitudes in the North Pacific, which penetrated through the subtropics and into the tropics, consistent with previous studies that have noted the association of the shift in tropical temperatures with changes in North Pacific sea level pressures. However, the temporal resolution of the subsurface hydrographic data does not allow for precise determination of timing or mechanisms.

We have measured radiocarbon variability in a coral from the Galapagos Islands in the eastern tropical Pacific. Our new $\Delta^{14}C$ timeseries extends from 1957 through 1982 (when the colony died, during the 82/83 El Niño) and has an average resolution of 8 samples per year (Fig. 1). The $\Delta^{14}C$ values increase linearly from pre-1960 values of −70 to −80‰, consistent with previous measurements of Galapagos corals, through maximum values of +60‰ in 1982. Low $\Delta^{14}C$ values occur during July through September, with higher values in Jan. through March. The amplitude of the seasonal cycle grows from 20 to 30‰ in the early 60's to 50 to 100‰ in the mid-70's.

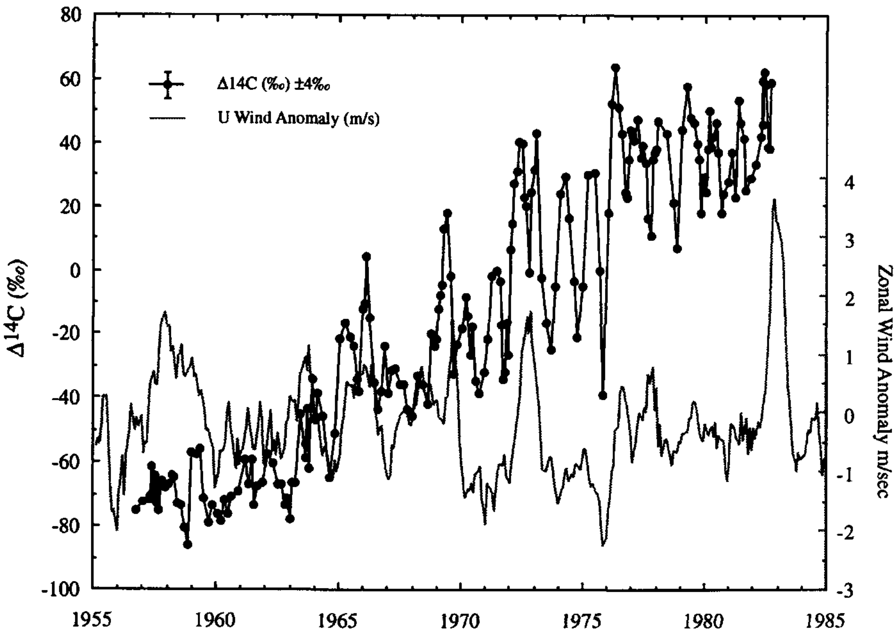

FIG. 1. Galapagos coral $\Delta^{14}C$ (‰) record 1957-1983 (1-sigma error bars).

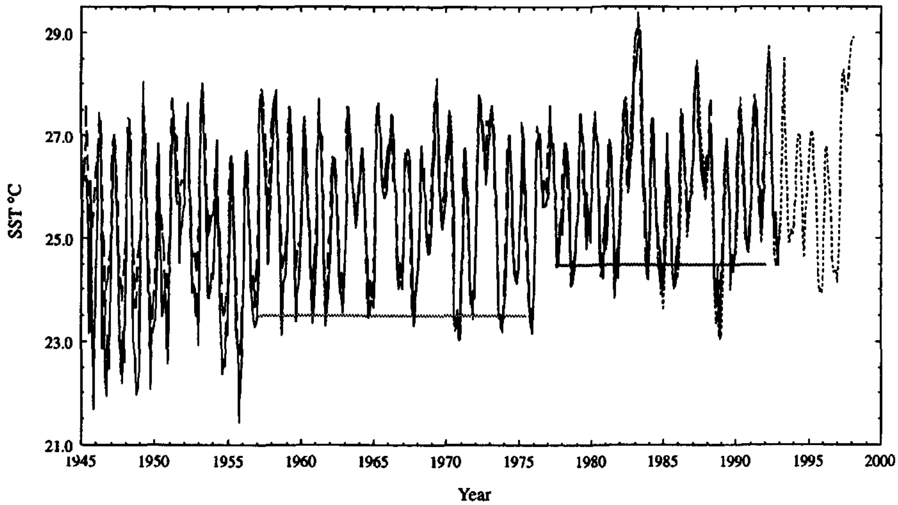

FIG. 2. Niño-3 (90-150°W ±5°) region SSTs as observed in the COADS (solid), GOSTA (dashed), and NMC/IGOSS (dotted) databases.

After 1976, the seasonal variability decreases to a fairly constant range of 40‰, and is caused by an abrupt increase in minimum values.

The abrupt increase in minimum (upwelling season) $\Delta^{14}C$ values occurs at the same time as the shift in SST in the eastern tropical Pacific associated with more frequent and intense ENSO warm phases. More careful scrutiny of the SST record (Fig. 2) reveals that the shift in average temperature defined by previous workers has a strong seasonal bias, and is also confined to the upwelling season. This implies a persistent shift in temperature and $\Delta^{14}C$ of the upwelling water in the subsurface. We argue that some adjustment of the vertical density structure along the equator occurred in 1976 so that the contribution of deeper, colder, lower-$\Delta^{14}C$ water to the upwelling water was reduced.

A critical question is whether the change we observe in the eastern tropical Pacific in 1976, and the associated changes in ENSO, are related to global warming from anthropogenic emission of greenhouse gases. If warm anomalies from the mid-latitudes are responsible for the persistence of warm temperatures in the subsurface of the eastern tropics, whether from the South or North Pacific, then a potential connection may exist as predictions for greenhouse warming of the sea surface are greatest for the extratropics. Although no similar periods to the recent warm conditions are observed in instrumental records, most studies refer to the 1976 climate shift as decadal variability, which avoids the question of whether the change can be explained by natural variability. Our data, while not identifying any direct connection between global warming and the changes in ENSO, focus attention on a sensitive region in the subsurface of the eastern tropical Pacific. We suggest that better understanding of the processes that control the vertical temperature and density structure of this region, including assymetries in interhemispheric exchange, is essential for determining whether such a connection exists.

References

Trenberth, K.E and Hoar, T.J. (1996) *Geophys. Res. Letts.*, **23**, 57–60.

Zhang, R-H., Rothstein, L.M. and Bussiacchi, A.J. (1998) *Nature*, **391**, 879–83.