Variations in tropical Pacific climate on interannual to glacial-interglacial timescales: evidence from living & fossil corals

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In a previous study, we used analysis of living and fossil corals from the north coast of Papua New Guinea to investigate changes in the strength and frequency of the El Niño Southern Oscillation over a glacial-interglacial cycle (Tudhope et al., 2001). The study area lies in western equatorial Pacific 'Warm Pool' region, in the heart of an area known to play a pivotal role in ENSO dynamics. During the El Niño phase of the Southern Oscillation, the region experiences relative drought and slightly reduced SSTs, and these variations are faithfully recorded in the stable isotopic and trace element composition of the annually-banded aragonitic skeletons of massive reef building corals. The main findings of this previous study were that ENSO has existed for at least the last 130,000 years, operating even during 'glacial' periods of substantially reduced global temperatures and lowered sea level. However, ENSO strength has varied, with modern ENSO being stronger than during any of the other periods sampled. We concluded that ENSO strength may be controlled by the combined influence of precessional orbital forcing (cf., Clement et al, 1999), and a general dampening of ENSO dynamics during the cool glacial times. However, the mechanisms for the proposed 'glacial dampening' remain unclear, and our coral data are still sparse. Here we present further data from these and more recently collected corals from the region. In particular, we focus on the nature of the seasonal cycle and the seasonal migration of the ITCZ, and on evidence for changes in mean SST and salinity in the Warm Pool during Holocene and 'glacial' times.

Seasonality: Tropical corals grow throughout the year. Therefore, in contrast to some other natural archives of past climate, it is possible to use corals to investigate changes in the nature and amplitude of the seasonal cycle. Two conclusions are emerging from analysis of our Papua New Guinea coral data:

- For virtually all of the periods for which we have coral data (i.e.: modern; ~2.5 ka; ~6.5 ka; ~9 ka; ~38-42 ka; ~85 ka; ~112 ka; ~118-128 ka 'Last Interglacial'; and ~130 ka), the structure of the seasonal cycle is broadly similar, with evidence for a double peak in wet season rainfall and elevated SST. In the modern record, this double peak reflects the passage of ITCZ southwards over the area at the start of the wet season (austral summer), then northwards again at the end of the wet season. Therefore, we conclude that, for the periods examined, there have been no major changes in the wet season migration pattern and location of the ITCZ at this longitude (~145º E).
- Seasonality in coral skeletal $\delta^{18}O$ records the combined influence of SST and salinity, with light isotopic values in wet and warm conditions, and heavy values in dry and cool conditions. The amplitude of modern coral $\delta^{18}O$ seasonality is as high, or higher than in any of our other sampled periods. In particular, seasonality in our early-mid-Holocene and last Interglacial coral records is weak. The amplitude of seasonality in our most 'glacial' corals, which grew ~38-42 ka, is similar to, or slightly lower than modern values. Previously, it has been suggested that major changes in seasonality might explain some of the discrepancies between tropical temperature reconstructions for glacial times that are based on different, seasonally dependant, proxies. Our data suggest that this is unlikely to be the case, at least in the Warm Pool region.

Mean Conditions: Coral are particularly good recorders of interannual and seasonal variability. However, with enough replication, they are also useful for documenting changes in mean conditions (SST and salinity). Here we will assess evidence for changes in mean salinity in the Warm Pool area, focussing on the Holocene and on 'glacial' times.

REFS: Clement et al., *Palaeoceanography*, **14**, 441 (1999); Clement et al., *Palaeoceanography*, **15**, 731 (2000); Tudhope et al., *Science*, **291**, 1511-1517