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COLD ANOMALIES IN RECENT AND HOLOCENE SEA SURFACE TEMPERATURE DERIVED FROM CORAL RECORDS IN THE SOUTHWEST PACIFIC

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For many high latitude regions of the globe, it is now clear that the transition to modern climate following the last glacial maximum (LGM), 20 000 years before present, was characterised by a strong warming punctuated by rapid and substantial climate oscillations. In contrast, the tropical response to the deglaciation following the LGM was not so well-known and the results obtained using different records seemed not to be in strong agreement.

Twenty years ago, CLIMAP Programme findings, based on assemblages of foraminifera and oxygen isotopes ratio of foraminifera, advanced the view that the tropical ocean sea surface temperatures (SST) varied little, about 2°C only, between the LGM and the present (CLIMAP, 1981).

During the LGM, the size of the warm pool above 28°C was emphasised to have been reduced slightly and New Caledonia SST was suggested to be warmer in summer during the LGM than during the present. Such results were already not in agreement with those obtained using alpine glacier snow line in Papua New Guinea, oxygen isotope measurements of tropical glacier or pollen assemblages which suggest a much colder climate.

It seems that planctonic foraminifera could change their habits and that benthonic foraminifera live in deep water, the temperature of which did not vary to the same extent as surface water during the climate variation. As such, the probes which were used by CLIMAP Progamme do not appear to be fully reliable.

More recently, trace elements of corals appeared to provide a source of tropical climate records because coral can be easily and accurately dated using either ^{14}C and ^{230}Th, and also because sea surface temperature can be recovered from the Sr / Ca ratio in coral skeleton with an accuracy of greater than 1°C and a monthly, or sometimes a weekly resolution (Beck *et al.*, 1992). Annual growth band of massive corals *Porites* are 0.5–1cm wide, and it is possible to make a dozen or more micro samplings accross a year's band in order to reconstruct a sea surface monthly temperature record.

The calibration was obtained on a coral collected at the Phare Amédée close to Nouméa. The Sr / Ca calibration temperatures were obtained using the McConnaughey's isotope oxygene temperature relationship (McConnaughey, 1989) on these same samplings and this concurred with the instrumental temperature recorded during the growth of the coral.

The method has been applied on fossil corals from Espiritu Santo in Vanuatu at 15°S latitude. Corals were recovered by rotary drilling on the uplifted coral reef terraces. Annual cycles of sea surface temperature (figure 1) are preserved which give a qualitative test of the relialibility and preservation of the temperature record. The oldest sample, 10 000 years old, indicates a SST on average 4–6°C colder than the modern temperature (Beck *et al.*, 1997). The extreme winter temperature was 6.5°C below the extreme monthly mean of the modern temperatures.

The SST abruptly rose during the following 1500 years. At 4000 years before present, the SSTs are already similar to the modern ones (if you exclude the cold anomaly that we will discuss later).

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already similar to the modern ones (if you exclude the cold anomaly that we will discuss later).

The observations of SSTs much colder than the present ones in this region during the early Holocene are consistent with similar paleo-SST data obtained from coral in Papua New Guinea (McCulloch *et al.*, 1996) (figure 2). Coral SST temperatures in the North Atlantic, in Barbados (Guilderson *et al.*, 1994) (figure 2), indicate similar colder SST but the warming seems to have appeared 3000 years before that of South Pacific. Warming would not have been synchronised in both hemispheres.

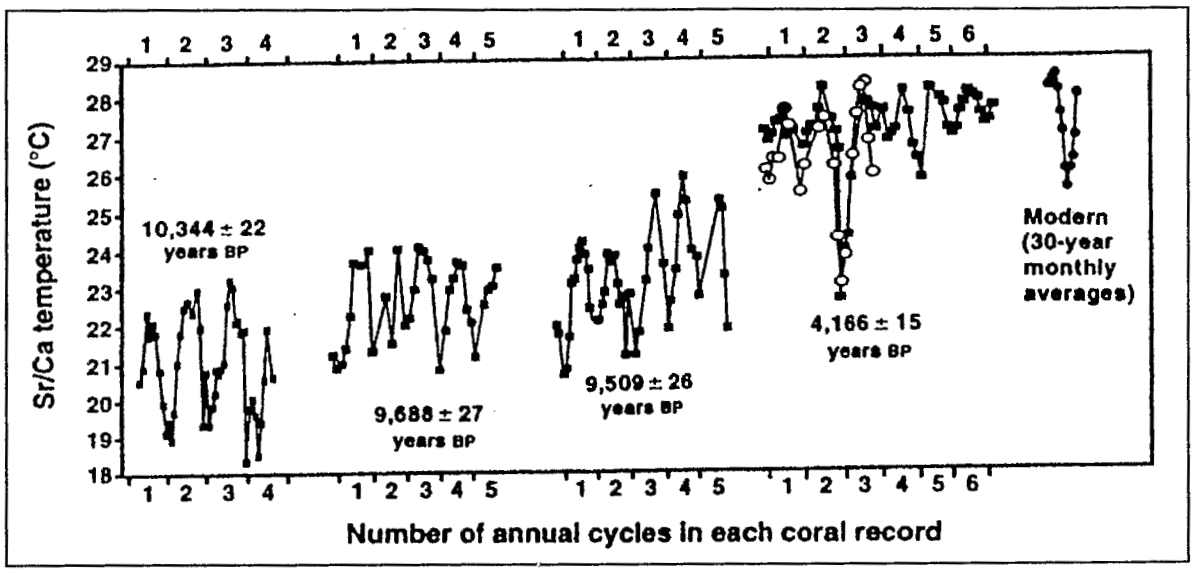

Figure 1. Coral Sr/Ca temperatures for four periods of time in south Santo, Vanuatu (Beck *et al.*, 1997)

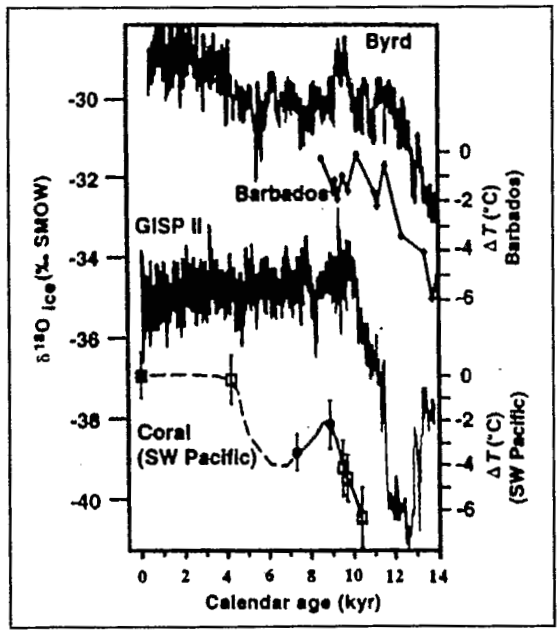

Figure 2. Comparison of the coral Sr/Ca records from the SW Pacific, the Atlantic (Barbados), the Groenland and the Antartic (Beck *et al.*, 1997)

Temperature was independently evaluated using another probe, an oxygen isotope paleothermometer. Using the relationship between the oxygen isotope ratio of coral and SST, we found that the temperature record based on the oxygene isotope shows the same large negative temperature anomaly as indicated by the Sr/Ca ratio paleothermometer. It is very unlikely that both tracers would respond to alteration of the coral in the same way, so we cite this as independent evidence of a major cold event, a half year in duration, occurring approximately 4,166±15 years ago.

Such a half-year wave length would exclude a volcanic event cause which would have disturbed SST during several years.

So it seems that this anomaly is related to a climatic event linked to ENSO variability. Delcroix and Lenormand (1997) have recently shown that in the vicinity of New Caledonia El Niño phases (SOI < O) are associated with a cooling of the SST and severe dryness. Conversely, La Niña phases (SOI > O) are associated with a warming of the SST and increased rainfall.

Instrumental records during the last decades have not shown the relationship between SST anomalies and ENSO events at southern latitudes of 15° as strongly as recent evidence, but a difference of 2°C can be observed between the mean monthly temperatures recorded during the colder months of El Niño and La Niña phases (figure 3).

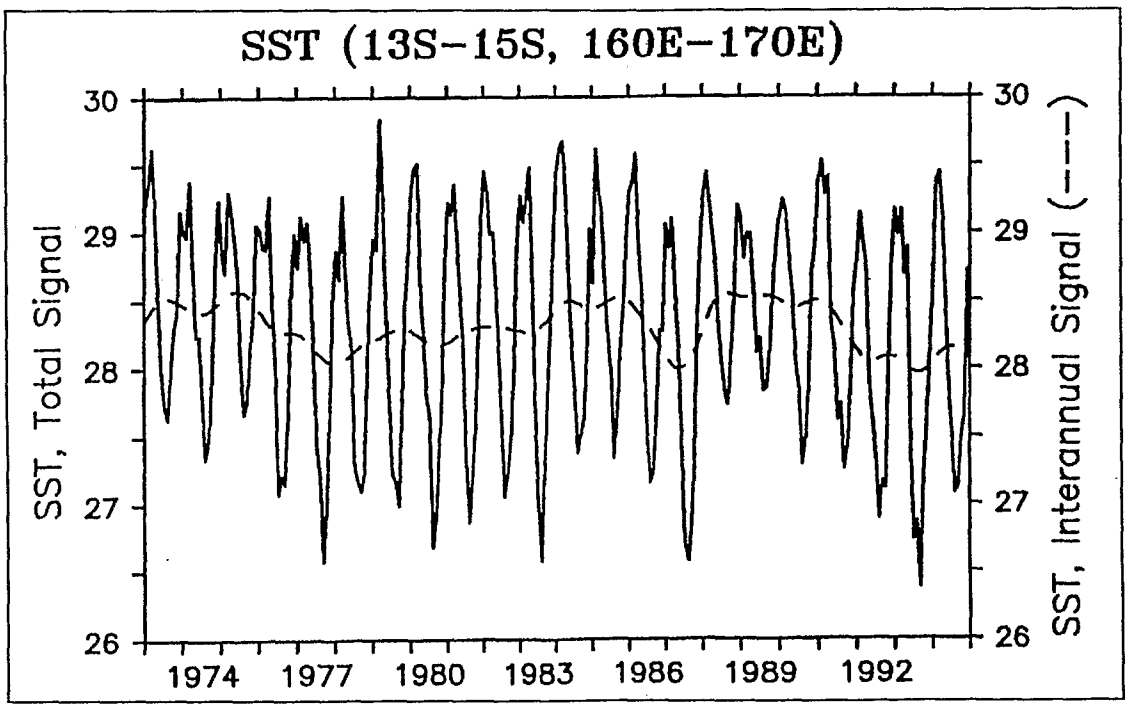

Figure 3. Monthly mean sea surface temperatures recorded from 1974 to 1994 in the area by the merchant ship network (Data bases of ORSTOM NOUMEA)

CONCLUSION

So there is are currently two explanations for the 4000 year cold anomaly. It might be a millenary or more rare event, and in this case it is not a serious risk requiring human intervention. However, it might be also a huge regional response to a minor global change during the last 5000-year period, called a modern stable climate period.

In that case it is important to know with which small global variation of climate such an anomaly is linked. We need to know if the present possible global warming will induce stronger or more

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In that case it is important to know with which small global variation of climate such an anomaly is linked. We need to know if the present possible global warming will induce stronger or more frequent El Niño or La Niña events. For the southwest Pacific region the answer would be more dryness or more rainfall. For the answer to that important question coral records will replace or complement the limited period of instrumental records.

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