Great Barrier Reef sea temperatures are ENSO driven

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In light of Ove Hoegh-Guldberg recent request for sunshades over part or all of the Great Barrier Reef it's worth taking a look at what's been happening according to the observational data.

To answer that we can turn to NOAA's "Optimal Interpolation" sea surface temperature data [see footnote 1] and extract only the data for the grid cells that cover the reef.

When that data is averaged across the entire reef we find that the average sea surface temperature along the Great Barrier Reef (GBR) has an annual cycle very similar to that of Willis Island, a Bureau of Meteorology observation station on an island east of the middle of the reef. Sometimes the sea surface temperature is slightly higher than Willis Island and sometimes it's slightly lower. This confirms that the extracted sea surface temperature (SST) is reasonable and the extraction was accurate. [For more about Willis Island and the GBR SST see footnote 2.]

Using the average temperatures across the entire reef we can establish a 25-year average for each calendar month (1982-2006) and from that calculate the anomaly in each month of each year. That monthly anomaly is shown in Figure 1.

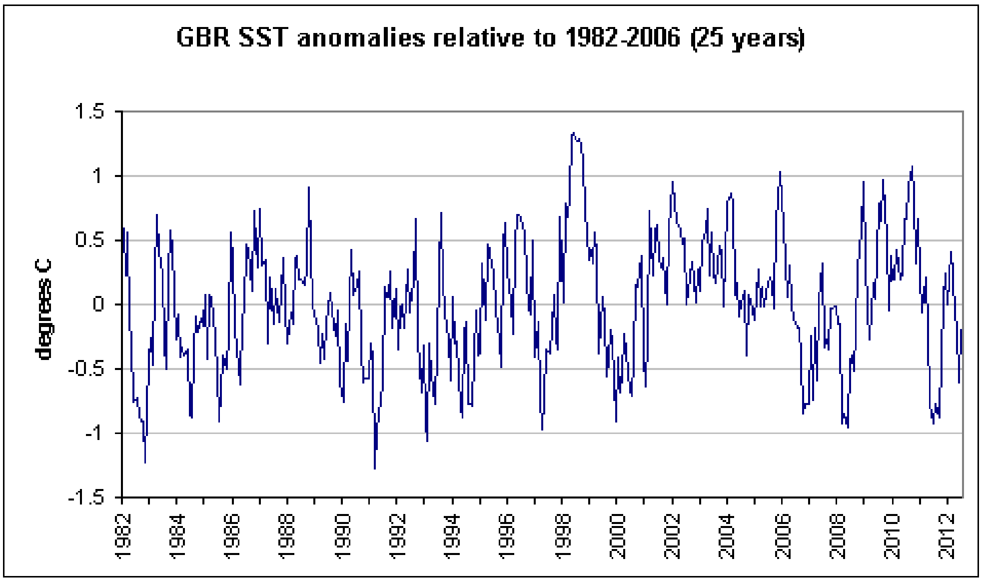

Figure 1 – Monthly temperature anomalies averaged across the Great Barrier Reef

At first glance that graph suggests a warming in recent years but before we rush to claim it is due to human activity, as Hoegh-Guldberg did, it's worth comparing to the major climate force in that part of the world, the El Nino Southern Oscillation (aka the ENSO). It's a force that's existed for more than 125,000 years and recognised as influencing climatic conditions around much of the world, so maybe it's the cause of the variation in sea temperatures on the Great Barrier Reef.

We measure the ENSO using the Southern Oscillation Index, with a sustained period (typically 3 months) above 8 regarded as a "La Nina" event and the same length of period below -8 being regarded as an "El Nino" event.

The drivers of the ENSO are still in dispute - the latest CSIRO marine climate report lists six candidates and I know of at least two others - but the situation is easily characterised. During neutral conditions easterly winds blow across the Pacific and warm water is found at the west side. During El Nino conditions the winds decrease or even cease and the warm water is found in the centre of the Pacific, typically at the intersection of the equator and international dateline, and incidentally very close to the Pacific Warm Pool mentioned above. During La Nina conditions the winds are stronger than normal and temperatures in the west are above normal. It's no wonder that El Nino events are often followed quickly by La Nina conditions; the warm water from an El Nino shift west with the wind.

This is a slightly simplistic description because the ENSO doesn't switch between three distinct states but is a continuous range of conditions over which arbitrary thresholds have been applied to divide the range into three states – La Nina at one end, neutral in the centre and El Nino at the other end.

What's this got to do with the Great Barrier Reef? The reef is west-southwest of the Pacific's centre and that means under normal conditions the reef water will be warm and the winds predominantly easterly. Under El Nino conditions the reef water will generally be cooler because there's little inflow of warm water and the water will cool by evaporation and convection. With La Nina conditions the heat from the east is greater than usual and GBR sea surface temperatures rise.

Figures 2(a) and 2(b) show the GBR monthly average sea surface temperature anomaly plotted with the SOI for that month

These are not easy graphs to interpret because of short term irregularities, caused by such things as variation in sea breezes, and because the impact of some ENSO events were suppressed by volcanic eruptions. We can however see cooling during abrupt shifts towards El Nino conditions (1982, 1991, 1997, 2006, 2008 and 2011) and the warming during shifts towards La Nina conditions (1983, 1988, 1990, 1998, 2005, 2009 and 2010).

The unusually strong El Nino in late 1997 spoilt this pattern somewhat because the warm pool of water normally in the central Pacific expanded so much that it encompassed at least part of the Great Barrier Reef. As it collapsed in 1998, the abrupt shift towards La Nina conditions meant the reef sea surface temperatures went even higher. Figure 2(b) shows that the ocean around the reef took about two years to cool after this warming.

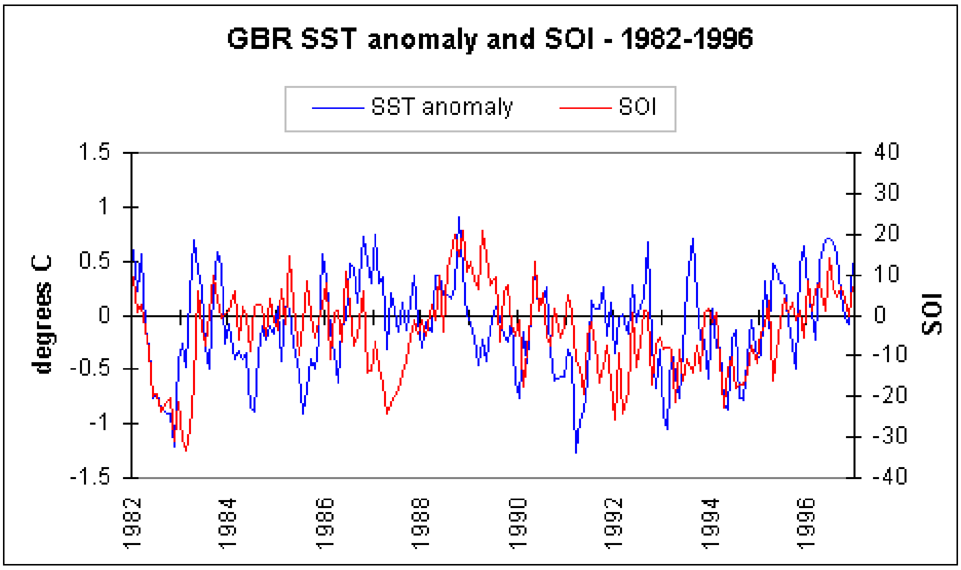

Figure 2(a) – SOI and GBR sea surface temperature anomalies 1982-1996.

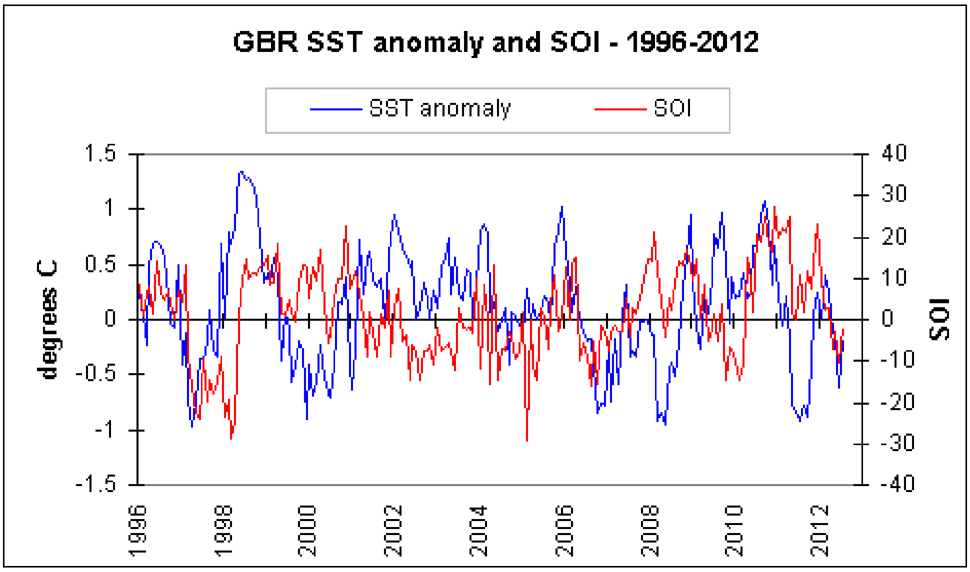

Figure 2(b) – as above but for 1996 - 2012

It's not human activity that's to blame for the sea surface temperatures on the Great Barrier Reef but the ENSO, a very natural and well recognised climate phenomenon.

Confirmation in principle of this can be found in a report published online in July 2012 by Australia's Bureau of Meteorology, titled "Record-breaking La Nina events" [footnote 3] included three figures that are relevant to this discussion of temperatures on the Great Barrier

Reef (see extracts in Figures 3a, b and c). I draw your attention in each case to the labels on the ocean near the GBR and which I've repeated in each caption.

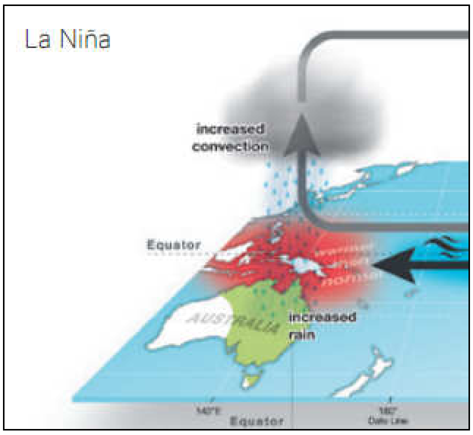

Figure 3(a) – La Nina: ocean near GBR labelled "warmer than normal"

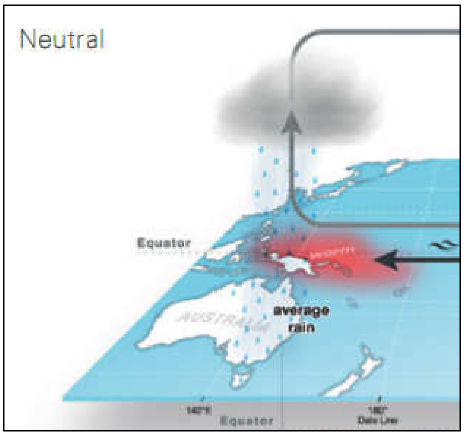

Figure 3(b) – Neutral: ocean labelled "warm" but away from the GBR

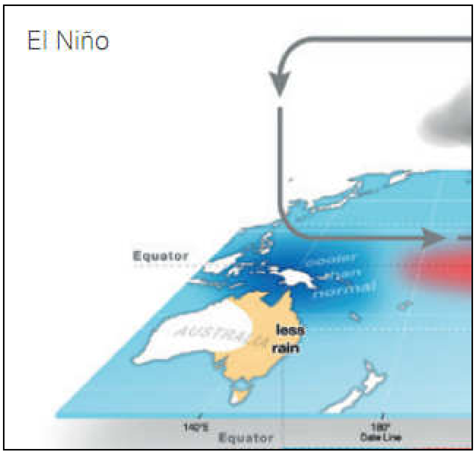

Figure 3(c) – El Nino: ocean near GBR labelled "cooler than normal"

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FOOTNOTES:

[1] NOAA's "Optimal Interpolation" sea surface temperature data is available at http://www.emc.ncep.noaa.gov/research/cmb/sst_analysis/)

[2] Willis Island and GBR temperatures are discussed at http://mclean.ch/climate/GBR_sea_temperature.htm

[3] "Record-breaking La Nina events", subtitled 'an analysis of the La Nina life cycle and the impacts and significance of the 2010-11 and 2011-12 La Nina events in Australia', available at http://www.bom.gov.au/climate/enso/history/ln-2010-12/