

Tropical Variability - Supplement: Indian Ocean Dipole

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1 COMMENT: SetUp

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2 COMMENT: Review: BAMS vol 95 No. 11, November 2014 (10.1175/BAMS-D-13-00028.1)

3 Summary

This paper is an overview of some of the latest observations and research on the Indian Ocean surface temperature, bulk temperature and heat content,

salinity, circulation and sea level since the 1950s as observed from satellite, buoys, ships and model analysis. It describes some of the annual, decadal and longer term variation of these parameters, in particular the dipole of SST, and discusses some possible mechanisms and dependencies on wider global scale processes.

4 Mean Indian Ocean

Important to understand the large scale 'nominal' conditions. Salient features:

1. Indo-Pacific Walker circulation, center over Indonesia with surface westerlies between east Africa and Indonesia, and surface Easterlies over much of the Pacific.

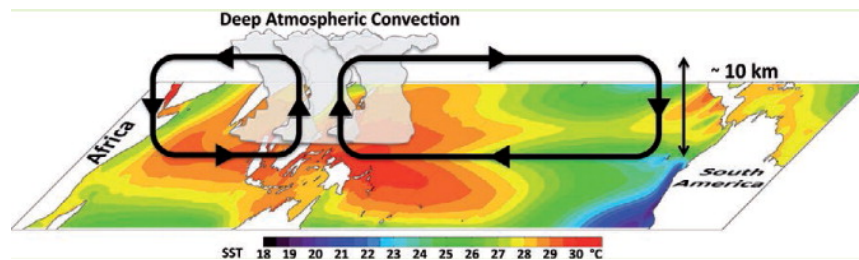


Figure 1: Walker Cell.

1. Upwelling ocean near Horn of Africa, cooler surface waters in west Indian Ocean (IO) than in east.
 2. Wind stress generates cross equatorial ocean surface current North to South and a southern overturning cell. But not also that the annual cycle of surface winds rotates in response to the Monsoon and related processes.
1. Strong annual variation in continent to the north drives SW monsoon.
 2. Large amplitude of SST annual variation across the IO basin - examine figure 3 closely.

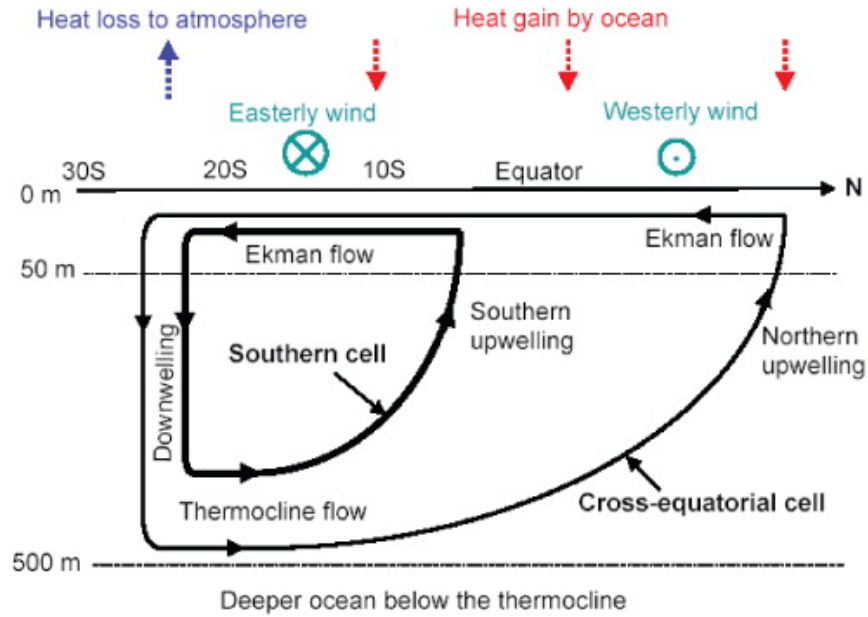


Figure 2: Upper Ocean cross Equator circulation.

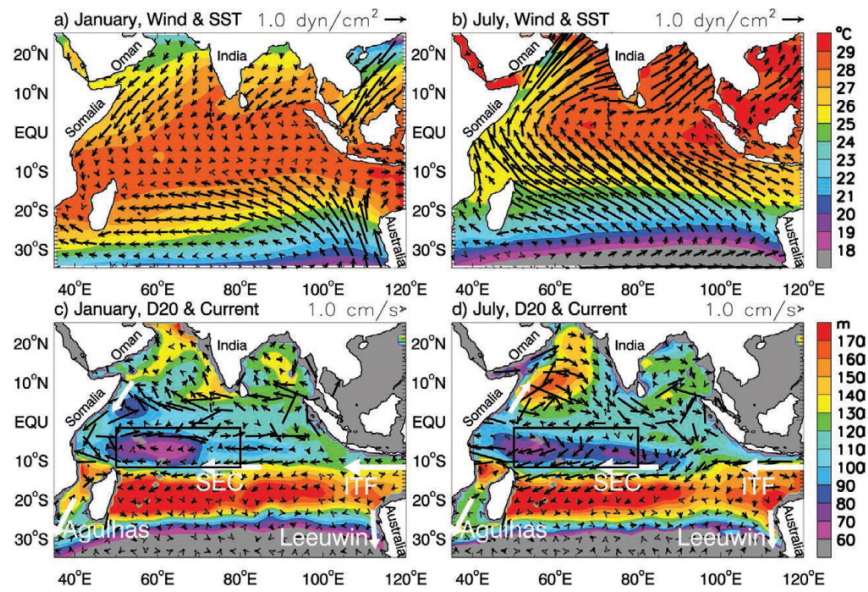


Figure 3: Indian Basin, wind, SST, current and thermocline depth, winter and summer.

5 Summary of the Indian Ocean Dipole:

Defined as the detrended, sea surface temperature anomaly (SSTA) for September to November average difference between the western pole (10°N to 10°S, 50°E - 70°E) and eastern pole (10°S to 0°, 90°E - 110°E). In the paper, figure 4 (left) shows the 1997 event - which was particularly large.

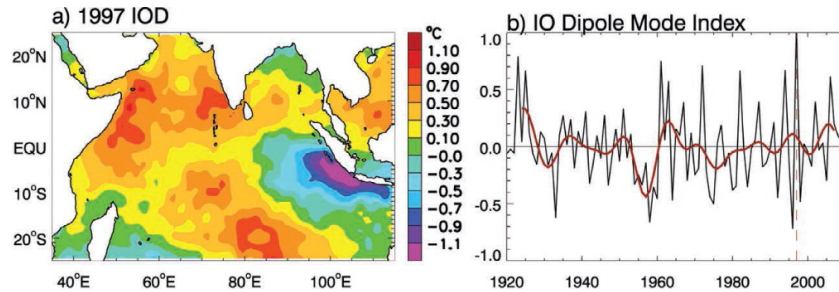


Figure 4: Record of the Indian Ocean Dipole Oscillation.

Also observed in SST record from 1950s are:

1. IO basin-wide warming and cooling related to ENSO (and other), with long term warming.
2. Long term warming IO basin more evident in southern IO than Northern (examine figure 5).

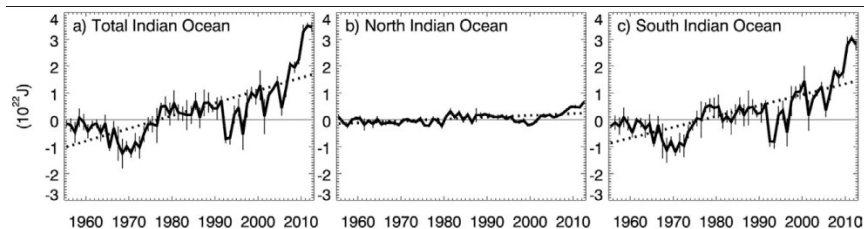


Figure 5: Long term SST temperature record.

1. An inter-annual variability in SSTA between SW IO (south of Madagascar) and the east southern IO (off western Australia), which may be driven by the Antarctic circumpolar ocean wave.

You can see that there are a variety of variable forcing processes that could excite modes in the IO basin.

6 Causes

There appears to be general consensus that the overall warming trend is consistent with increase greenhouse gases and water vapour feedback. There are problems reproducing wind stress changes and upwelling impacts and some of the detailed structural changes.

In the northern IO, the suppressed warming appears consistent with increased evaporative cooling and increased asian aerosol loading.

The spatial (horizontal and vertical) distribution of warming patterns is complex and not well understood, but is related to changes in surface wind stress and ocean circulation.

There is suggestion that the pacific decadal oscillation (PDO) and inter-decadal pacific variation (IPO) modulates the IOD, the asian monsoon and ENSO. The effect of IOD on these others is not known.

You can see that inappropriate sampling over the IO basin will give different signals of linear trend, decadal and inter-annual variability. Notwithstanding lumping all equatorial SSTs into some sort of amalgamated zonal mean (not wise). This is IMPORTANT for remote sensor bias estimation.

7 Conclusion

Models suggest that some of the IOD variability can be attributed to internal processes via Walker cell changes, wind and ocean circulation patterns (and coupling thereof) and so forth, and some can be attributed to larger scale changes including global warming trends and probably to Pacific ocean variability. Recent work on predicting the IOD has been encouraging, but much more is required.