

# EFFECT OF TROPICAL AND SUBTROPICAL INDIAN OCEAN DIPOLES IN DRIVING PRECIPITATION AROUND INDIAN OCEAN RIM COUNTRIES

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## 1. Motivation

The importance of the Indian Ocean sea surface temperature (SST) anomalies in modulating regional climate has recently received increasing recognition. Surface variability has been implicated in widespread changes to precipitation around Indian Ocean rim countries, including East Africa, India, Indonesia, and Australia. Non-uniform warming of the Indian Ocean has recently been described (e.g., Alory et al. 2007, Ihara et al. 2008) and characteristics of the dominant mode of tropical Indian Ocean variability are suggested to be changing (Abram et al. 2008). These factors highlight the need for a better understanding of the mechanisms by which Indian Ocean variability modulates regional rainfall. This has major implications for seasonal rainfall forecasting and will ultimately aid in improvements to water and agricultural management.

## 2. Results

In a series of atmospheric general circulation model experiments, the potential impact of Indian Ocean SST anomalies in modulating low-to mid-latitude precipitation around the Indian Ocean-rim countries is examined (Ummenhofer et al. 2008, 2009a,b). SST anomalies closely resembling a leading mode of Indian Ocean variability with features of both tropical and subtropical Indian Ocean dipoles induce a basin-wide re-organization of the atmospheric circulation. This induces significant changes to precipitation distributions over the surrounding landmasses (Fig. 1).

This work quantifies the relative contribution of regional SST anomalies associated with various characteristic tropical and subtropical Indian Ocean SST poles, both individually and in combination, to these precipitation changes. The role of these poles and the associated meridional gradients are assessed in modulating the strength and position of the Walker circulation. Furthermore, the mechanisms behind the modulation of precipitation over the adjacent landmasses are investigated via changes to the large-scale circulation, the thermal properties of the atmosphere, moisture flux advection, and the strength of the Walker circulation.

Precipitation over southern and western regions of Australia is modulated by variations in the meridional temperature gradients in the eastern tropical/subtropical Indian Ocean by affecting thermal winds and moisture flux as well as baroclinicity over the region (Ummenhofer et al. 2008, 2009b). The relative importance of regional Indian Ocean SST anomalies is assessed for precipitation around Australia. Implications for seasonal forecasting in connection with the evolution of Indian Ocean SST anomalies in characteristic regions are also discussed.

## 3. References

- Abram N. J., M. K. Gagan, J. E. Cole, W. S. Hantoro, M. Mudelsee, 2008: Recent intensification of tropical climate variability in the Indian Ocean. *Nature Geoscience*, 1, doi:10.1038/ngeo357.
- Alory G., S. E. Wijffels, G. Meyers, 2007: Observed temperature trends in the Indian Ocean over 1960-1999 and associated mechanisms. *Geophys. Res. Lett.*, 34, L02606.
- Ihara C., Y. Kushnir, M. A. Cane, 2008: Warming trend of the Indian Ocean SST and Indian Ocean Dipole from 1880 to 2004. *J. Climate*, 21, 2035-2046.
- Ummenhofer, C. C., A. Sen Gupta, M. J. Pook, M. H. England, 2008: Anomalous rainfall over southwest Western Australia forced by Indian

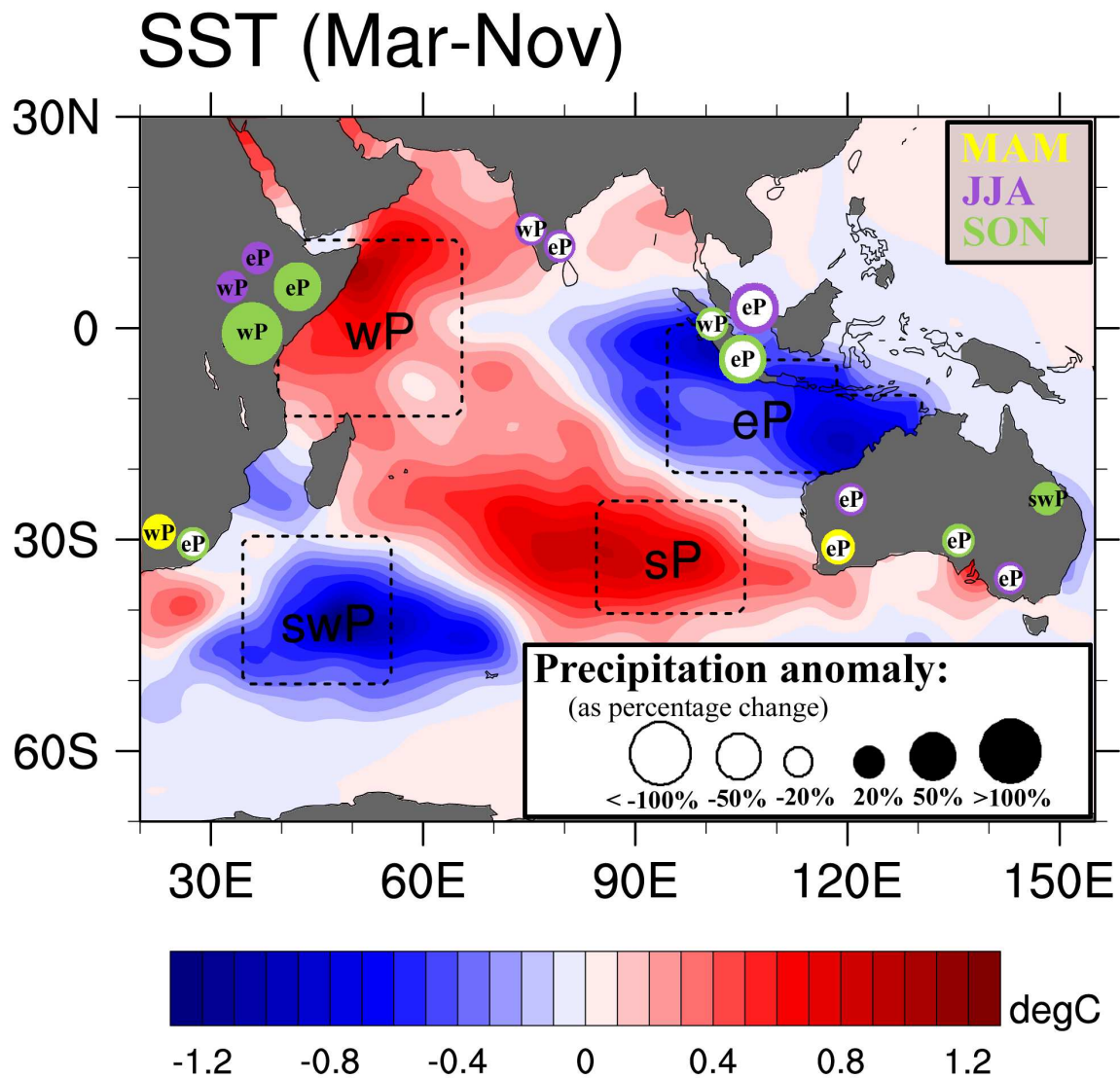
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Ocean sea surface temperatures. *J. Climate*, 21, 5113-5134.

Ummenhofer, C. C., A. Sen Gupta, M. H. England, C. J. C. Reason, 2009a: Contributions of Indian Ocean sea surface temperatures to enhanced East African rainfall. *J. Climate*, in press.

Ummenhofer, C. C., A. Sen Gupta, A. S. Taschetto, M. H. England, 2009b: Modulation of Australian precipitation by meridional gradients in East Indian Ocean sea surface temperature. *J. Climate*, submitted.



**Fig. 1:** Schematic of Indian Ocean SST anomalies on precipitation in Indian Ocean rim countries in AGCM simulations for the March-May (MAM), June-Aug. (JJA) and Sep.-Nov. (SON) seasons. The SST anomalies ( $^{\circ}\text{C}$ ) are shown as the average over the March-Nov. months. Specific regions ("poles") of SST anomalies, characteristic of various tropical and subtropical Indian Ocean dipoles, are employed in the AGCM experiments, with the poles indicated by the dashed boxes. The anomalous rainfall associated with these regions of SST anomalies is shown by circles around the Indian Ocean rim countries. Filled (empty) circles denote an increase (decrease) in precipitation (as percentage change), with the size of the circle reflecting the magnitude of change and the color of the circle the season.