The curious case of
Indian Ocean warming

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Summary

The study reveals that the western tropical Indian Ocean has been warming for more than a century, at a rate faster than any other region of the tropical oceans, and turns out to be a major contributor to the overall trend in the global mean sea surface temperature [SST].

During 1901-2012, while the central-east Indian Ocean warm pool went through an increase of 0.7°C, the western Indian Ocean experienced anomalous warming of 1.2°C in summer SSTs. The warming of the generally cool western Indian Ocean against the warm pool region weakens the zonal SST gradients, and has the potential to change the Asian monsoon circulation and rainfall, as well as to alter the marine food webs in this biologically productive region.

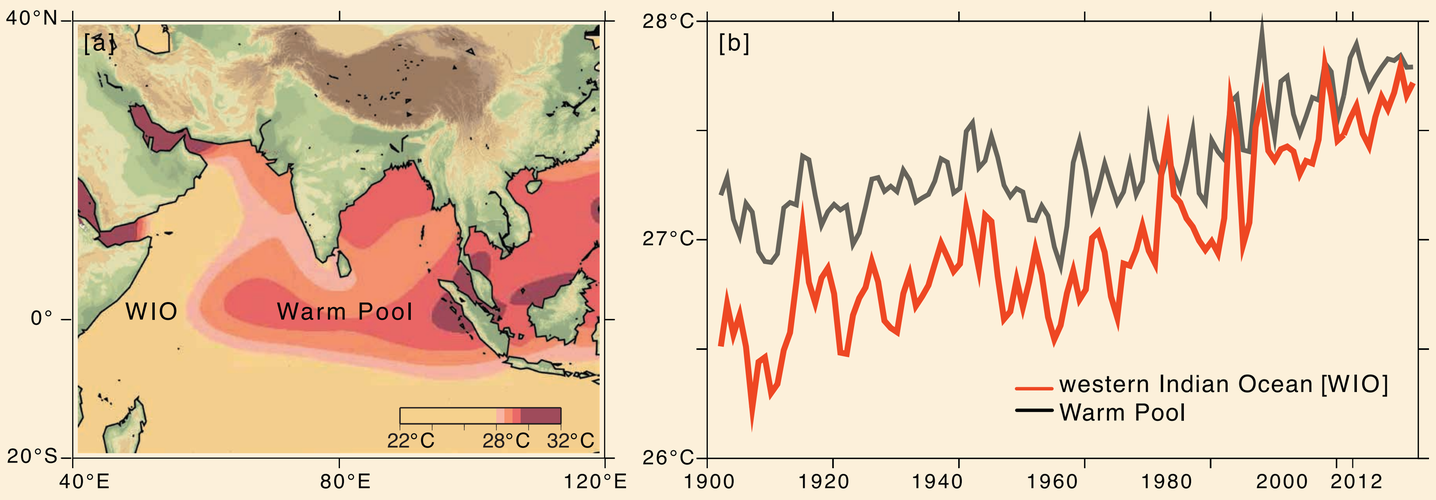
The analysis here gives compelling evidence that the long-term warming trend over the western Indian Ocean during summer is highly dependent on the asymmetry in the El Niño Southern Oscillation [ENSO] teleconnection, and positive skewness of ENSO during recent decades.

1. The warming over the western Indian Ocean

The western Indian Ocean [WIO] is generally cool, while the rest of the Indian Ocean is a warm pool region with SST greater than 28°C during summer [Fig.1a]. Studies on SST trends during the past half-century have pointed out substantial warming over this warm pool, though the reasons behind this monotonous warming have remained ambiguous.

However, our analysis of SSTs during 1901-2012 shifts the focus to the relatively cool WIO. We find that the WIO has been warming for more than a century, at a rate faster than any other region of the tropical oceans, and has attained the warm pool SST values of 28°C. While the warm pool went through a warming of 0.7°C, the western basin experienced anomalous increase of 1.2°C in summer SSTs [Fig.1b].

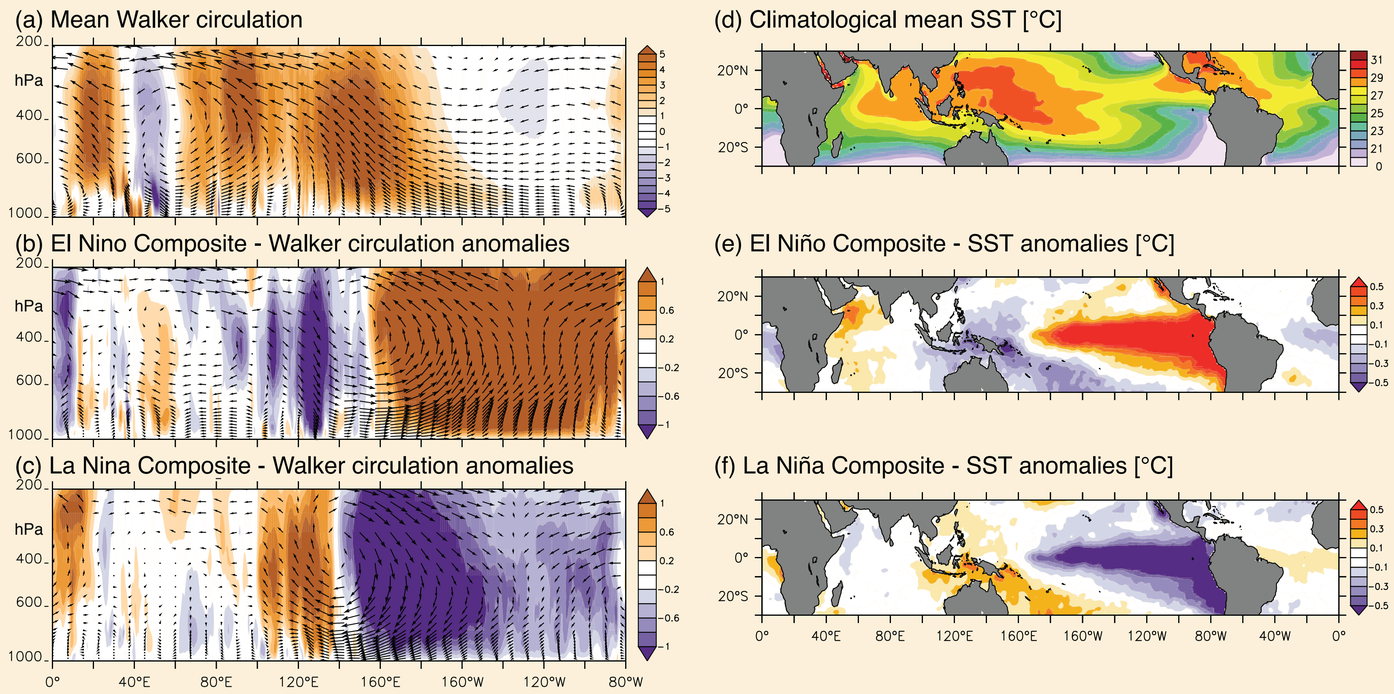
Fig.1. [a] Climatology and [b] annual means of SST for June-Sept 1901-2012



2. Asymmetry in the ENSO forcing

The study gives compelling evidence that the warming trend over the w.Indian Ocean during summer is highly dependent on the asymmetry in the ENSO teleconnection—the El Niños induce anomalous weakening of the mean low-level westerlies [Fig.2b], and subsequent warming over western Indian Ocean [Fig.2e], and La Niña fail to do the inverse [Fig.2c,f].

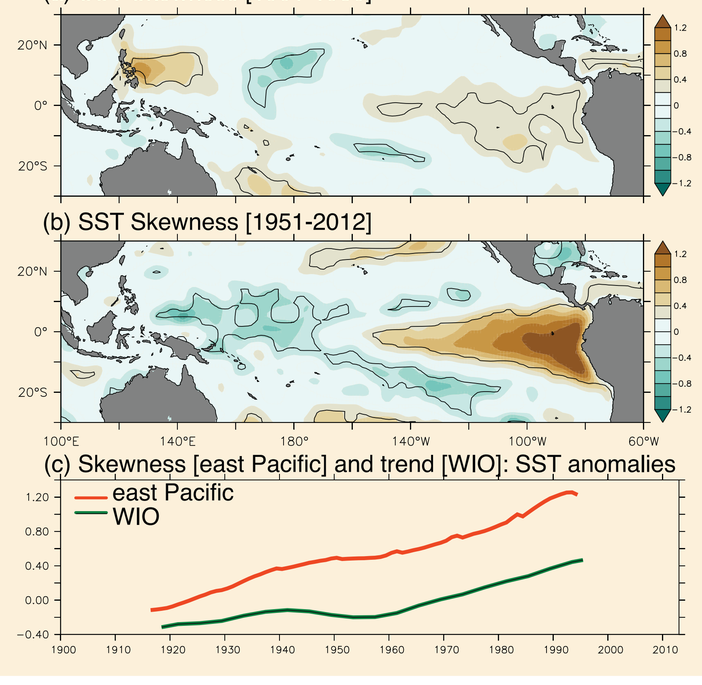
Fig.2. Walker circulation and SST during mean conditions, El Niño and La Niña [June-Sept]



3. Increase in the frequency and magnitude of El Niño events

A second, prominent reason is the positive skewness of ENSO, i.e. an increase in the frequency and magnitude of El Niños during recent decades [Fig. 3]. The trend in the WIO SST anomalies appear to increase along with the positive skewness in ENSO.

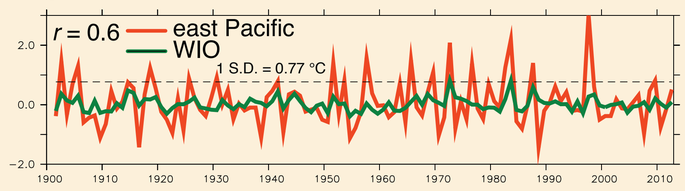
Fig.3. SST skewness and trend [June-Sept]



4. Asymmetry and skewness pile up the heat over w.Indian Ocean

Post-1950, a few warm events over the w.Indian Ocean have attained the threshold value for El Niño [Fig.4, SSTa > 0.77°C]. This places these warm events almost on par with the El Niños in magnitude.

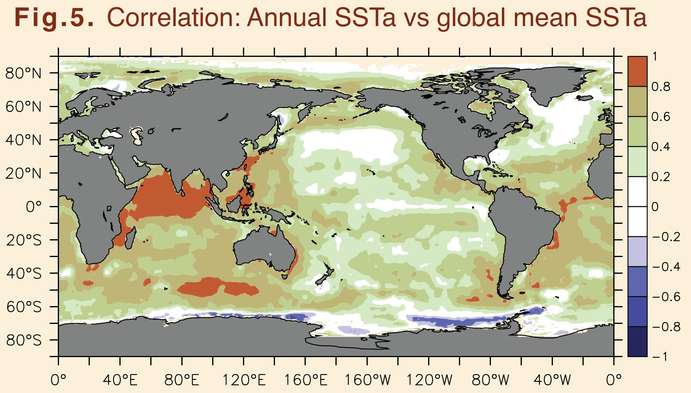
Fig.4. SST anomalies: e.Pacific vs WIO [June-Sep]



5. Major contributor to global ocean surface warming

The Indian Ocean warming turns out to be the largest contributor in phase with the overall trend in the global mean SST [Fig.5].

Fig.5. Correlation: Annual SSTa vs global mean SSTa



Reference

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