Anomalous IOD and El Nino Forcing in the Tropical Indian Ocean and its Impact on the Indian Ocean Warming

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Basin-wide wintertime warming is observed in the Indian Ocean during El Nino years. The basinwide warming is found to be stronger when El Nino and Indian Ocean Dipole (IOD) co-occur. The mechanisms responsible for the basin-wide warming are different for the years with El Nino only and for the co-occurrence years. Strong westward propagation of downwelling Rossby waves is observed in the southern Indian Ocean during the IOD years, whereas such strong propagation is not seen in the case of El Nino-only years in the region north of 10^{o}S. Anomalous biennial Rossby waves are also observed in the Indian Ocean centered along 1.5^{o}S and 10.5^{o}S during the IOD years. The absence of these biennial waves during El Nino years (the one centered along 1.5^{o}S) indicates that the Indian Ocean internal dynamics play an important role in winter subsurface warming of the western Indian Ocean during the IOD years.

Argo observations show a pronounced up-westward propagation of subsurface warming along the sloping mean thermocline, resulting from a downwelling Rossby wave excited in the 5^{o}S– 15^{o}S band by equatorial zonal wind anomalies. The analysis reveals a robust westward propagation of barrier layer (BL) thickness, adding a new aspect to the dynamical Rossby wave forming. The downwelling Rossby wave helps form a BL by deepening the isothermal layer and increasing precipitation. A positive feedback between SST warming and BL development as follows: The warming along the Rossby wave path increases precipitation, for a change in freshwater flux favorable for BL formation in the region west of 75^{o}E. The BL may strengthen the surface warming by shielding the surface from the influence of colder thermocline water in the tropical SWIO. The Rossby wave-induced surface warming maintains active convection and a cyclonic circulation in surface wind over the SWIO. The anomalous deepening of thermocline in the Seychelles thermocline ridge region is forced by the Rossby waves. This deepening of thermocline and the subsequent warming in the western equatorial Indian Ocean are due to downwelling Rossby waves from the east and local Ekman convergence. Though the mean upwelling is dominating in the western basin, the anomalous convergence intensifies the downwelling waves during the IOD years.

The weak easterly wind anomalies in the El Nino-only years show no measurable impact on the Wyrtki Jets (the strong equatorial currents observed in the in the Indian Ocean during spring and fall), but weakening or reversal of these jets is seen in the IOD years. This strongly suggests that the variability related to surface circulation is due to the local IOD forcing rather than El Nino induced wind anomaly. Surface heat fluxes (mainly latent heat flux and short wave radiation) play an important role in maintaining the basin-wide surface warming during the El Nino-only years. However during the IODonly years (when there is no El Nino in the Pacific), such basin-wide warming is not seen (warming is confined only to the western region) because of the absence of El Nino induced subsidence over the eastern Indian Ocean. For the years in which both El Nino in the Pacific and dipole in the Indian Ocean co-occur, warming in the western Indian Ocean is due to the ocean dynamics and that in the eastern basin is due to the anomalous latent heat flux and solar radiation. The surface cyclonic circulation throughout the season is a result of the positive SST anomalies induced by the downwelling Rossby wave, aided by the BL development over the SWTIO. This suggests that the increased heat content in the downwelling Rossby wave, contributes to the unusually active tropical cyclone season. The downwelling Rossby wave induced anomalous positive heat content in the western basin assist intensification of the Findlater Jet during the years following an IOD and El Nino. The intensified Findlater Jet is favourable for good Indian summer monsoon rainfall. The basin scale Indian Ocean warming affects the Indian subcontinent and northwest Pacific through the atmospheric tele-connections, thereby making it an important process influencing the local climate.