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Impact of Indo-Pacific Feedback Interactions on ENSO Dynamics Diagnosed Using Ensemble Climate Simulations

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This present study investigates the link between Indo-Pacific feedback interactions and the dynamics of El Nino Southern Oscillation (ENSO). Our study is motivated by the shift in ENSO dynamics toward a more prominent thermocline mode since the late 1970s, as accompanied by an increase in ENSO variability and Indian Ocean Dipole (IOD) co-occurrences. Entangling this epochal link is difficult due to the relatively sparse observational records and the strong dependence of Indian Ocean climate variability on ENSO. Here we utilise a millennial integration of a fully coupled climate model to perform an ensemble set of 100-yr long Indian Ocean 'decoupling' experiments. It is found that by artificially eliminating air-sea interactions over the Indian Ocean, the strength of ENSO variability across epochs is enhanced to various extents, with a shift in the underlying dynamics toward a more prominent thermocline mode. The decoupling experiments thus reveal that the net effect of the Indian Ocean in the control simulation is a damping on ENSO. The extent of this damping appears to be negatively correlated to the coherence between ENSO and the IOD, that is, the damping is weaker during epochs with stronger ENSO-IOD co-occurrences. This relationship emerges because developing ENSO in the model often coincides with Indian Ocean basin-wide mode (IOBM) anomalies during non-IOD years, similar to the peculiar situation possibly observed in the pre-1976 period.

Using atmospheric model experiments, we demonstrate that the IOBM enhances western Pacific wind anomalies that counteract ENSO-enhancing winds farther east. In the ENSO recharge-oscillator framework, this weakens the equatorial Pacific air-sea coupling that governs the ENSO thermocline feedback. Relative to the IOBM, the IOD is more conducive for ENSO growth. The net damping by the Indian Ocean in the control simulation is thus dominated by the IOBM effect which is weaker with stronger ENSO-IOD coherence. The stronger ENSO thermocline mode in the decoupled simulations is consistent with the absence of any IOBM anomalies. Our study suggests the plausibility that the occurrences of IOBM during ENSO prior to 1976 or the lack of IOD thereof, as opposed to the more prevalent IOD post-1976, may be linked to the epochal shift in ENSO dynamics. This study overall demonstrates that feedbacks from the Indian Ocean can significantly influence ENSO behaviour, thus supporting the notion that the Indian Ocean should be regarded as an integral component of ENSO.