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Multi-decadal Indian Ocean variability linked to the Pacific pre-conditions Indian Ocean Dipole events

Caroline Ummenhofer (1), Arne Biastoch (2), and Claus Boening (2)

(1) Woods Hole Oceanographic Institution, Physical Oceanography, Woods Hole, United States (cummenhofer@whoi.edu), (2) GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany

The Indian Ocean has sustained robust surface warming in recent decades, with warming rates exceeding those of other tropical ocean basins, but the role of multi-decadal variability remains unclear. Using high-resolution ocean model hindcasts building on the ocean/sea-ice numerical Nucleus for European Modelling of the Ocean (NEMO) framework forced with atmospheric forcing fields of the Coordinated Ocean Reference Experiments (CORE), the characteristics of Indian Ocean temperature changes are explored. Simulated upper-ocean temperature changes across the Indian Ocean in the hindcast are consistent with those recorded in observational products and ocean reanalyses.

Assessment of Indian Ocean temperatures shows strong warming trends since the 1950s limited to the surface and south of 30°S, while extensive subsurface cooling occurred over much of the tropical Indian Ocean. The temporal evolution of Indian Ocean subsurface heat content reveals distinct multi-decadal variations associated with the Pacific Decadal Oscillation. Transmission of the decadal signal occurs via an oceanic pathway through the Indonesian Throughflow and is manifest across the Indian Ocean centred along 12°S as westward propagating Rossby waves modulating thermocline and subsurface heat content variations. Resulting low-frequency changes in the eastern Indian Ocean mixed layer depth are associated with decadal variations in the frequency of Indian Ocean Dipole (IOD) events, with positive IOD events unusually common in the 1960s and 1990s with a relatively shallow mixed layer depth. In contrast, the deeper mixed layer depth in the 1970s and 1980s was associated with frequent negative IOD and rare positive IOD events. Changes in Pacific wind forcing in recent decades and associated rapid increases in Indian Ocean subsurface heat content can thus affect the basin's leading mode of variability. The research highlights opportunities for developing decadal forecasting capabilities for the Indian Ocean, with implications for regional climate and vulnerable societies in surrounding countries