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Indian Ocean heat content changes masked by multi-decadal variability: Is the Indian Ocean warming or not?

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The Indian Ocean has sustained robust surface warming in recent decades, with warming rates exceeding those of other tropical ocean basins. Significant, non-uniform trends in Indian Ocean sea surface temperatures – both in observations and projections for the 21st Century – have the potential to impact regional climate, through variations in the monsoon circulation, characteristics of Indian Ocean Dipole events, and the associated hydroclimate across the wider Indo-Pacific. However, it remains unclear what role decadal to multi-decadal variability in upper-ocean Indian Ocean thermal characteristics play in these trends.

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. Sensitivity experiments, where interannual atmospheric forcing variability is restricted to thermal or wind-stress forcing only, support the interpretation of forcing mechanisms for the evolution of temperature characteristics across the Indian Ocean, focusing on the top 700m. Simulated temperature changes across the Indian Ocean in the hindcasts are consistent with those recorded in observational products, as well as ocean reanalyses.

Assessment of Indian Ocean heat content since the 1950s suggests extensive (subsurface) cooling for much of the tropical Indian Ocean. The presence of substantial multi-decadal variability in its heat content further implies caution in interpreting linear trends in thermal properties, as long-term trends can be masked. The sensitivity experiments reveal that cooling trends in Indian Ocean heat content since the mid-1960s to the late 1990s are largely driven by wind-stress forcing, likely due to remote Pacific wind forcing associated with the Pacific Decadal Oscillation (PDO). As such, multi-decadal wind-forcing has masked increases in Indian Ocean heat content due to thermal forcing since the 1960s. However, wind and thermal forcing both contribute positively to Indian Ocean heat content since 1999 and thus drastic increases in Indian Ocean heat content in coming decades are likely, with implications for regional climate and vulnerable societies in Indian Ocean rim-countries.