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Recent asymmetric tropical ocean warming has altered regional propagation of Madden–Julian Oscillation

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Tropical sea surface temperature (SST) warming displays regionally distinct patterns, yet its role in modulating Madden-Julian Oscillation (MJO) propagation remains unclear. Here, we investigate how La Niña-like SST shift around 1999 has influenced MJO propagation characteristics by comparing two periods: Period 1 (1979–1998) and Period 2 (2003–2022). We find that MJO propagation has accelerated by 7.1% over the Indian Ocean and 5.4% over the Maritime Continent but slowed by 17.6% over the Pacific Ocean in the later period. These divergent responses reflect the influence of regional SST patterns and associated atmospheric changes. In the Indian Ocean, enhanced low-level moisture gradients, stronger upward motion, and increased upper-tropospheric stability support faster MJO propagation. In contrast, a weakened moisture gradient and suppressed convection hinder propagation over the Pacific Ocean. Despite the complex terrain and atmospheric interactions over the Maritime Continent, the combined effects of mean-state changes, regional atmospheric conditions, and atmospheric stability still support faster MJO propagation in the recent period. These findings highlight the sensitivity of MJO behavior to regional SST pattern and atmospheric conditions, offering new insights into the physical mechanisms linking SST changes to MJO propagation. Improved understanding of these processes has implications for MJO prediction and long-term climate forecasts.

Keywords: Madden-Julian Oscillation, uneven SST warming, propagation speed, moisture distribution, dry static energy

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