

Seasonal Variability of Stratiform and Convective Rainfall Structure During MJO Phases Over the Maritime Continent (MC)

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Abstract

Over the Maritime Continent (MC), complex interactions among the Madden–Julian Oscillation (MJO) phases, seasonal variability, and regional topography play a critical role in shaping local rainfall extremes. However, it remains unclear which type of rainfall, stratiform or convective, is predominantly modulated by the MJO. This study investigates seasonal variations in stratiform and convective rainfall during different MJO phases using GPM-DPR data during 2014–2022.

The results show that over the Sumatra region, the occurrence of both stratiform and convective rainfall is higher than over western Java during both active and suppressed MJO phases. In Sumatra, stratiform rainfall frequency is dominant over both oceanic and inland areas. Over western Java and Sumatra, particularly during the wet season (DJF; December–February), suppressed MJO phases generally induce a higher occurrence of both rainfall types, compared to active phases. During both active and suppressed phases, inland regions exhibit a higher frequency of reflectivity associated with stratiform rainfall than with convective rainfall.

Notably, during suppressed phases, high frequencies of both stratiform and convective rainfall occur across most seasons, whereas during active phases, the highest frequencies are primarily observed in DJF. In the DJF suppressed phases, over the northern Java Sea, convective rainfall with reflectivity values of 20–30 dBZ extends up to approximately 11 km, indicating deeper convection compared to the western ocean and inland regions (~8 km). In contrast, during suppressed phases in DJF and MAM (March–May), inland western Java exhibits shallower convection, characterized by the highest frequency of 20 dBZ reflectivity below 4 km.

Overall, our findings suggest that suppressed MJO phases may produce heavier rainfall than active phases over parts of the MC. Accurately distinguishing between stratiform and convective rainfall is therefore essential for improving quantitative precipitation estimation and enhancing flood early warning systems.