Influence of MJO on cyclone activity in the north Indian Ocean and Western North Pacific

R. Rahul*, J. Kuttippurath, A. Chakraborty, R. S. Akhila
CORAL, Indian Institute of Technology Kharagpur, 721302 Kharagpur, India.
*corresponding author: rahulraghudhas@gmail.com

Introduction

Madden Julian Oscillation (MJO) is a significant factor that affects the genesis and activity of tropical cyclones (TC) in the Indian and Pacific Oceans. The MJO is influenced by various factors such as Pacific Decadal Oscillation (PDO), El Niño Southern Oscillation (ENSO). Global warming has impacted the MJO-TC connection, with MJO activity migrating from the Indian Ocean to the Maritime Continent (MC) and Western North Pacific (WNP). The interdecadal variability of MJO activity is influenced by moisture, sea surface temperature (SST), and precipitation. The balance of adiabatic cooling against the latent heat release of the rising air reduces atmospheric static stability, causing the wave to slow down. The weakening and stalling of the propagation of MJO over MC due to the reduced surface fluxes or topographic interference is known as the barrier effect. The amplitude and phase of MJO also influence the intensification of cyclones.

Objectives

- Investigate changes in cyclogenesis and TC activity by the warped life cycle of MJO triggered by the two-fold expansion of the warm pool.
- Study the impact of MJO on TC genesis and activity using the genesis potential index (GPI), accumulated cyclonic energy (ACE), and frequency of cyclones in the active, moderately active, and non-active periods of MJO in the North Indian Ocean (NIO) and WNP.
- Analyze the basin dependency of TC activity and genesis over AS, BoB, and WNP due to the stalled propagation of MJO over MC by the extended Indo-Pacific warm pool (IPWP) driven by anthropogenic activities.

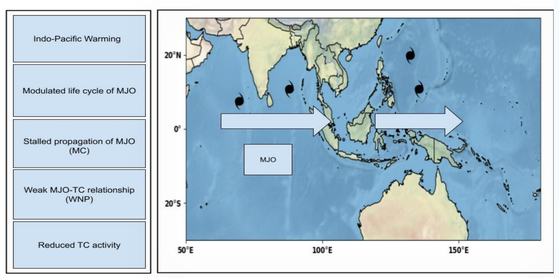

Figure 1: Graphical representation of the Influence of MJO on cyclone activity in the north Indian Ocean and Western North Pacific.

Methodology

- A 40-year dataset including relative humidity (RH), absolute vorticity (η), potential intensity (PI), vertical wind shear (V_s), vertical velocity (Ω) and sea surface temperature (SST) is used to investigate the basin dependency and interannual variation of TC genesis and activity. Data for 1-min sustained winds is obtained from the Joint Typhoon Warning Centre (JTWC) from 1979 to 2019 (during the post monsoon period). The GPI is calculated using data from ERA-5 for the study period.
- The frequency of TCs, ACE and GPI are used to study the cyclonic activity during the active, moderately active, and non-active periods of MJO.
- The study identifies active and non-active years based on the number of MJO active days in each year, as described by Tsuboi and Takemi (2014). The study calculates active, moderately active, and non-active years based on cyclogenesis over NIO and over WNP.

Results

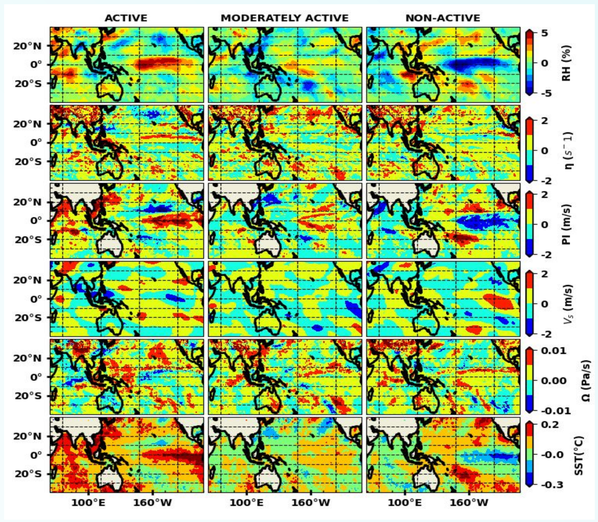

Figure 2a: Anomaly of relative humidity (RH), absolute vorticity (η), potential intensity (PI), vertical wind shear (V_s), vertical velocity (Ω) and sea surface temperature (SST) during the active years and moderately active years non-active years of Madden Julian Oscillation (MJO) from 1979 to 2019 based on MJO phases 2-5.

Results

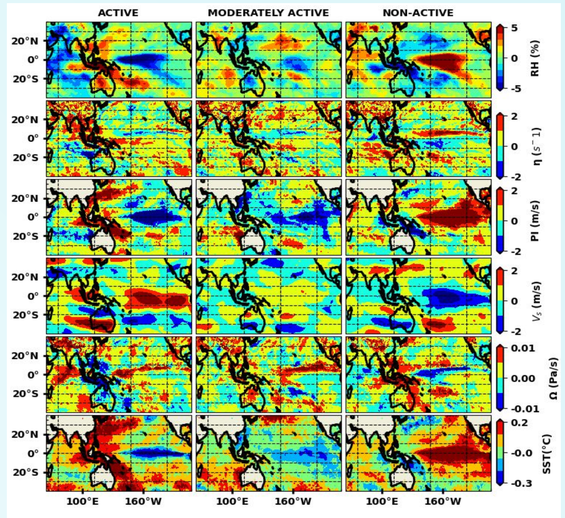

Figure 2b. Same as Figure 2a but based on MJO phases 5-7.

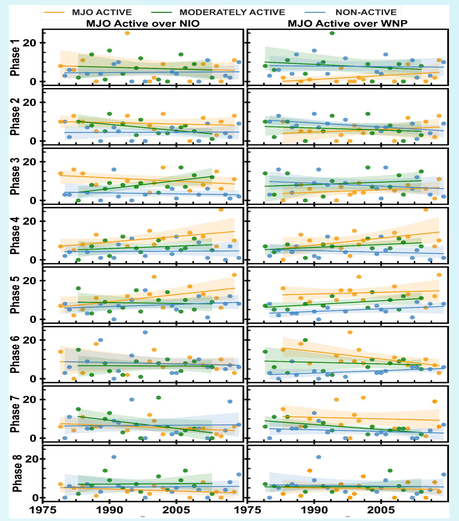

Figure 4: Phase duration for the active years of MJO (green), non-active years of MJO (orange), moderately active years of MJO based on the phases 2-5 (blue) (left) and the phase duration for the active years of MJO (green), non-active years of MJO (orange), moderately active years of MJO based on the phases 5-7 (blue) (right).

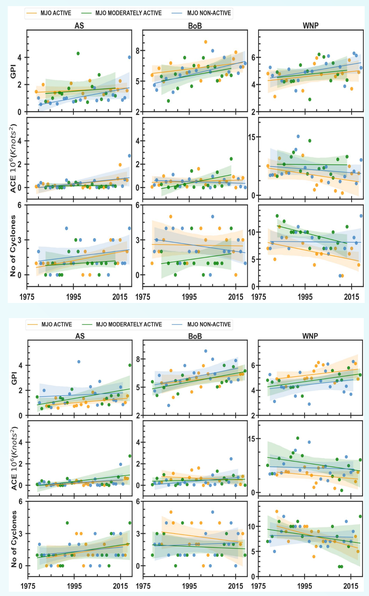

Figure 3a: Genesis potential index (GPI), accumulated cyclonic energy (ACE), number of cyclones (NC) over Arabian Sea (AS), Bay of Bengal (BoB) and the Western North Pacific (WNP) during the active years (orange), moderately active years (green) and non-active years (blue) of Madden Julian Oscillation (MJO) based on MJO phases 2-5.

Figure 3b: Same as Figure 3a but based on MJO phases 5-7.

BoB is more prone to cyclogenesis than AS, with a clear shift in GPI values from active years to non-active years towards 25°S from 30°N, except in certain regions (Rahul et. al., 2022).

Conclusion

- MJO has the strongest influence on TC activity over AS and BoB during the active years (based on NIO).
- The impact of MJO on TC activity over WNP is weaker compared to AS and BoB, with decreasing TC genesis and activity in the active years.
- The phase duration of MJO over MC increases during active and moderately active years, indicating stalling, and a decline in trend is noticed over WNP after phase 5 causes reduced TC genesis and activity.

References

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Acknowledgements

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