

# Triggering of Tropical Convection and MJO Initiation by Cold Surges over the Indian Ocean



## SATテクノロジー・ショーケース2026

### ■ Introduction

In this changing climate, extreme events such as tropical cyclones, heat waves, cold surges, and heavy rainfall are becoming more frequent and intense. Atmospheric wave processes including Rossby waves, Kelvin waves, and cold surges play a significant role in modulating tropical convection. Cold surges, which represent strong low-level outflows of cold, dry air from higher latitudes, affect surface fluxes and convection across the Indian Ocean and western Pacific. The Madden-Julian Oscillation (MJO), a dominant mode of tropical intraseasonal variability, comprises coupled eastward moving circulation and convection anomalies with typical periods of 30–60 days (Krouma et al., 2023). While the propagation of the MJO has been widely studied, its initiation especially over the Indian Ocean and Maritime Continent remains less well understood. Recent boundary layer analyses suggest that the mixed-layer characteristics and low-level convergence are pivotal for MJO onset (Johnson et al., 2023). Evidence further suggests that cold surges may pre-condition the lower atmosphere and trigger the onset of tropical convection and subsequent MJO initiation by enhancing low-level convergence and moisture fluxes. Understanding these extratropical–tropical interactions during the boreal post–monsoon (October–December) is therefore crucial for improving sub–seasonal forecasting and managing the impacts of tropical extreme events.

### ■ Research Objectives

Despite growing evidence of extratropical influences on tropical convection, the exact mechanisms linking cold surges and MJO initiation over Indian Ocean are still unclear particularly during the boreal post–monsoon season when North Indian Ocean Cyclone Season and North–East Monsoon begins. Therefore, this study aims to address the following research objectives:

**Objective 1:** To identify and characterize cold surge events and their role in preconditioning the MJO initiation phase in the Indian Ocean region.

**Objective 2:** To assess the predictive potential of cold surge events for MJO onset and associated cyclone formation.

### ■ Methodology

**Study Areas:** The study will cover the Western Asia and entire Indian Ocean, with a focus on:

- Cold Surge over the Western Asia; Initial convection over the southwestern Indian Ocean near Madagascar; North Indian Ocean: Bay of Bengal.

**Study Period:** The study will be done based on the 1970–2024.

### Data Sources

- ERA5 Reanalysis Data (ECMWF); NOAA OLR Data; NOAA–PSL RMM Index; Cold Surge Index

### Analytical Methods

- Algorithm Development for Cold Surge Detection; MJO Visualization and Mapping; Composite of Cyclone Formation, Track and Impact Detection

### ■ Novelty of the Study

- Investigates the underexplored role of cold surges in triggering MJO initiation during the boreal post–monsoon season over the North Indian Ocean.
- Integrates extratropical–tropical interaction analysis using multisource reanalysis (ERA5), OLR, and RMM indices to establish new physical linkages among cold surges, MJO onset, and cyclone genesis.

### ■ Expected Outcomes

- Quantifies the contribution of cold surges to tropical convection development and MJO initiation over the Indian Ocean.
- Develops a framework for integrating cold surge signals into sub–seasonal forecasting models, enhancing early warning systems for cyclones and extreme weather events.

### References:

1. Johnson, R. H. (2023). The Atmospheric Boundary Layer and the Initiation of the MJO. *Journal of Climate*, 36(22), 5615–5632. <https://doi.org/10.1175/JCLI-D-23-0210.1>
2. Krouma, M., Pohl, B., & Panthou, G. (2023). Ensemble forecast of an index of the Madden–Julian Oscillation using a stochastic weather generator based on circulation analogs. *Earth System Dynamics*, 14, 273–288. <https://doi.org/10.5194/esd-14-273-2023>

代表発表者 **ISLAM MD MONIRUL(モニルル イスラム)**  
所 属 **Engineering Mechanics and Energy,  
University of Tsukuba**  
問合せ先 **〒305-0006 茨城県つくば市天王台1-1-1  
TEL:029-853-4974**

### ■キーワード

1. Cold Surges
2. Madden–Julian Oscillation (MJO)
3. Indian Ocean
4. Tropical Convection
5. Sub–seasonal Forecasting

**■共同研究者:** 大樂 浩司  
筑波大学 システム情報系 准教授