Mid-latitude Rossby Wave Interaction on Indian Summer Monsoon Depression Days

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1.Introduction

The interaction between midlatitude disturbances and the monsoonal circulation is vital for Indian Summer Monsoon (ISM) rainfall, though the influence of extratropical weather on the ISM remains unclear. Samanta et al. (2016) emphasized the need to explore the role of Rossby wave dynamics in monsoon depressions. Krishnan et al. (2009) further showed that downstream Rossby wave dispersion in the summer westerlies is linked to suppressed monsoonal convection, with cyclonic anomalies over West Central Asia and anticyclonic anomalies over East Asia playing a role in the monsoon break (MB). These interactions highlight the complex dynamics that govern ISM variability. further studies are required to explore the full scope of these interactions and their implications for monsoon variability and prediction.

2. Data and Methodology

This study uses the Indian Meteorological Department (IMD) best track data (1990-2014) to identify monsoon depression (178 days) and non-monsoon depression (2872 days) events. NCEP–NCAR reanalysis data were used for analyzing wind patterns and calculating potential vorticity (PV).Monsoon depression and non-monsoon depression days were identified using IMD best track data based on low-pressure systems over the Bay of Bengal. These days were then categorized for analysis.The compositing of monsoon and non-monsoon depression days was performed using CDO (Climate Data Operators) and GrADS (Grid Analysis and Display System). Composites were created to examine the differences in atmospheric conditions between the two types of depression days. PV was calculated using the equation:

$$PV = \frac{1}{f}\left(\zeta + \frac{g}{\theta}\frac{d\theta}{dz}\right)$$

Where:

- f is the **Coriolis parameter** ($f = 2\Omega \sin\phi$, where Ω is the Earth's angular velocity and ϕ is the latitude).
- ζ is the **relative vorticity** (the curl of the wind field) in the isentropic coordinate system.
- g is the **acceleration due to gravity**.
- θ is the **potential temperature**.
- $\frac{d\theta}{dz}$ is the **vertical gradient of potential temperature**.

This calculation helps to investigate Rossby wave dynamics and large-scale atmospheric circulation during depression days.

This approach enabled the analysis of synoptic conditions, Rossby wave breaking, and other key atmospheric processes impacting monsoon depressions.

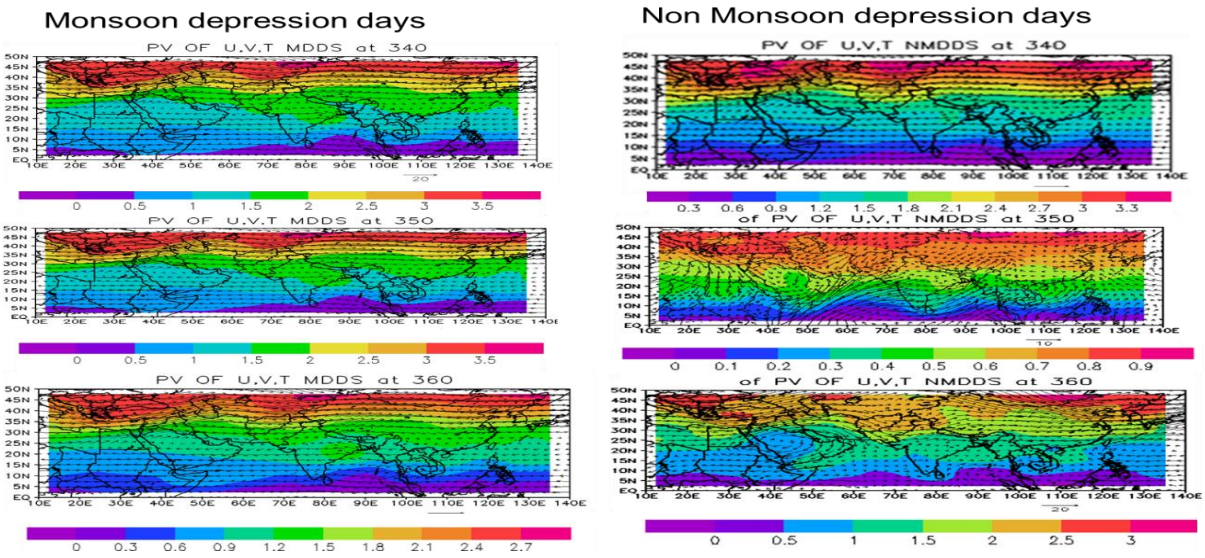

Figure 1 :potential vorticity (shaded, in PVU) and wind field (vector, in ms-1 at340ºK,350ºK,360ºK level derived from NCEP-NCAR data).

3. Results:

The study highlights the significant role of Rossby wave breaking (RWB) in modulating Indian Summer Monsoon (ISM) depressions. It finds a decreasing frequency but increasing intensity of monsoon depressions over the Bay of Bengal in recent decades. RWB causes the southward movement of high potential vorticity (PV) air, intensifying anticyclonic circulation and forming a blocking high over the Arabian region, which suppresses monsoon activity. These dynamics, particularly during non-monsoon depression days, likely contribute to the reduced frequency of monsoon depressions. The study emphasizes the need for further research to understand these interactions and their impact on ISM variability.

Conclusion:

This study highlights the role of Rossby wave breaking (RWB) in modulating Indian Summer Monsoon (ISM) depressions, showing a decrease in their frequency but an increase in intensity. RWB induces anticyclonic circulation and blocking highs, suppressing monsoon activity. Further research is needed to understand these interactions and their impact on monsoon variability and prediction.

References

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