Moisture-based Interactions of Monsoon Low Pressure Systems with South Asian Monsoon in Reanalysis Data

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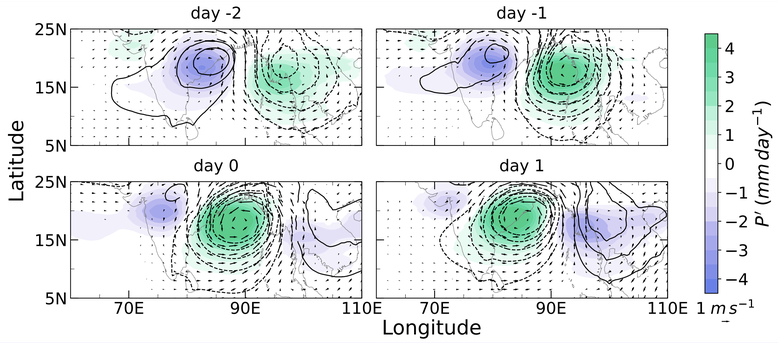
1. Introduction

- Westward-propagating synoptic-scale
- Form near the Bay of Bengal, monsoon trough

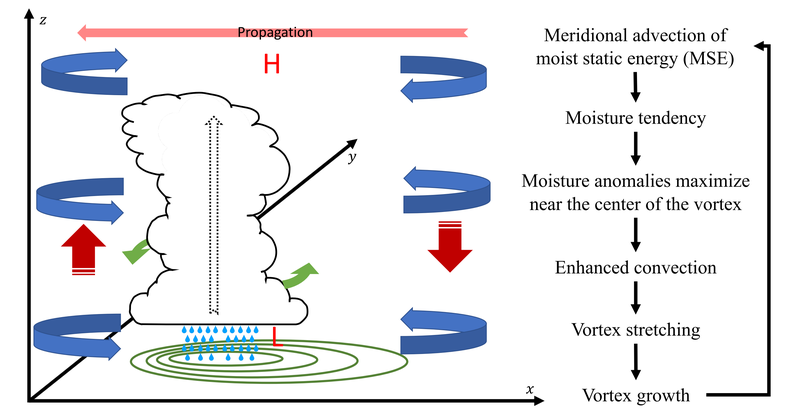
Data: ERA5 reanalysis, 1979-2019, 6-hourly

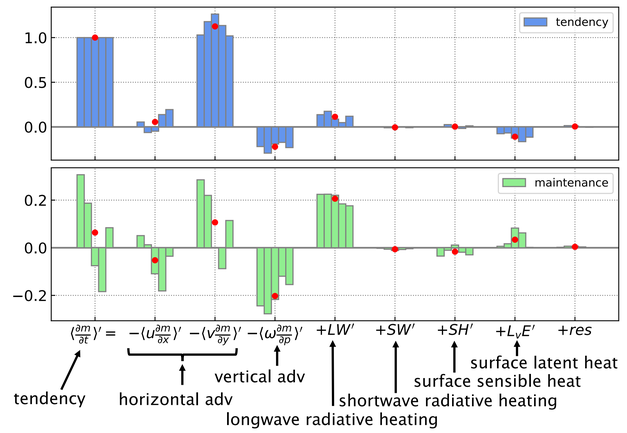
Methods:

1. Filter mean total precipitation rate Band:
   Frequency: 1/15 -- 1/2 day^{-1} Wavenumber: 3 – 25 westward
2. Average the filtered precipitation at the head of Bay of Bengal (85 – 90E, 15 – 20N)
3. Regress onto the averaged time series with lags



2. Moisture-vortex instability





$m = c_pT + \Phi + L_vq$

$C_p = 1004\ J \cdot K^{-1}kg^{-1}$

T: temperature

c_pT: dry enthalpy

Φ: geopotential

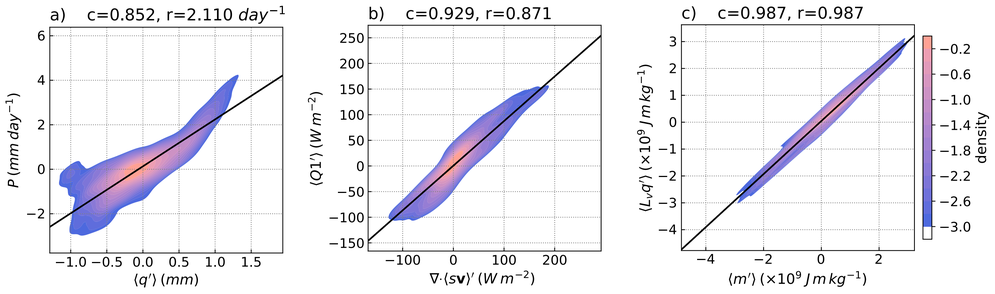
$L_v = 2.5{\times}10^6\ J \cdot kg^{-1}$

q: specific humidity

L_vq: latent energy

(Luo et al., 2023)

3. Moisture mode



1. High correlation between column water vapor and precipitation

$$< q' > \simeq P'$$

2. Weak-temperature gradient balance

$$\omega\frac{\partial s}{\partial p} \simeq Q$$

3. The moisture dominate the thermodynamics

$$m' = C_pT' + \Phi' + L_vq' \approx L_vq'$$

Non-dimensional number

$$N_{mode} \equiv \frac{C_pT}{L_vq} \simeq \frac{c_p^2\tau}{c^2\tau_c} \ll 1$$

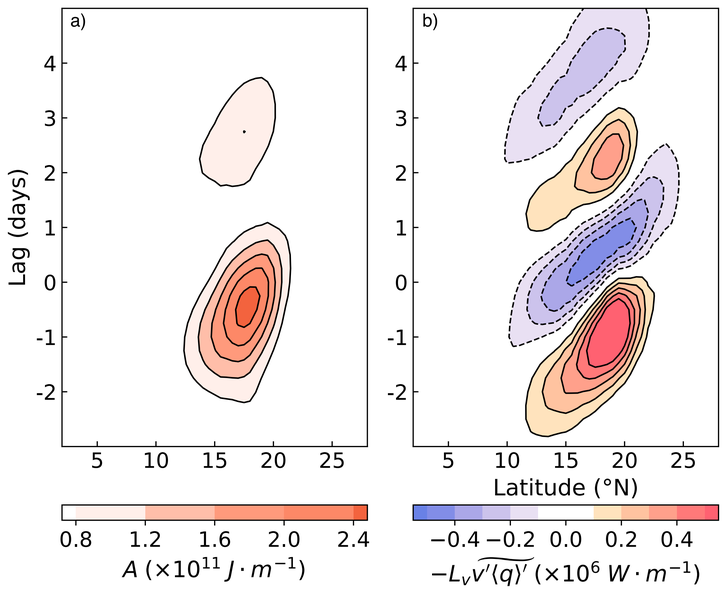
τ_c convective moisture adjustment time scale ~12 hrs

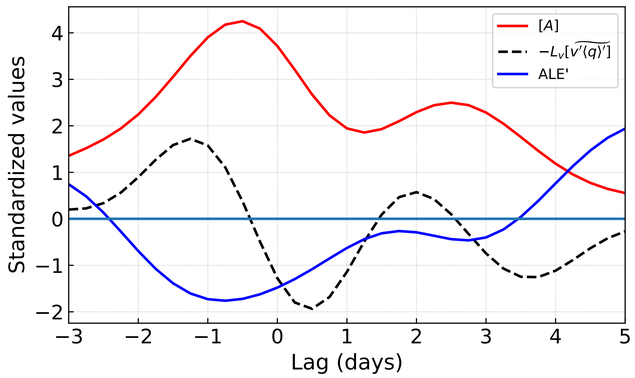
τ timescale of the wave ~ 4 days

c_p phase speed of the wave ~ 7 $m \cdot s^{-1}$

c gravity wave phase speed ~ 50 $m \cdot s^{-1}$

Moisture mode activity





Variations in the background: available latent energy

$$\mathrm{ALE}' \propto \frac{L_v\partial\widetilde{\langle q\rangle}'}{\partial y}$$

$$\frac{\partial ALE}{\partial t} = L_v\widetilde{v'\langle q\rangle}'$$

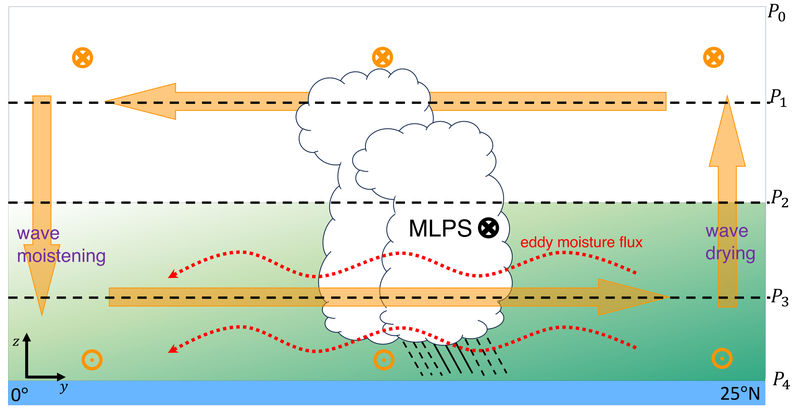
$$A = \frac{L_v\widetilde{\langle q'\rangle^2}}{2}\left(\frac{\partial\widetilde{\langle q\rangle}}{\partial y}\right)^{-1} \qquad \frac{\partial A}{\partial t} = -L_v\widetilde{v'\langle q\rangle}'$$

(Adames Corraliza and Mayta, 2023)

$-L_v\widetilde{v'\langle q\rangle}' > 0$ moisture mode grows

$-L_v\widetilde{v'\langle q\rangle}' < 0$ moisture mode decays

4. Summary



- The monsoon low pressure systems are consistent with the moisture mode theory.
- MLPSs grow from MVI at the cost of background monsoon.
- The equatorward eddy moisture flux flattens the background moisture gradient when disturbances grow.