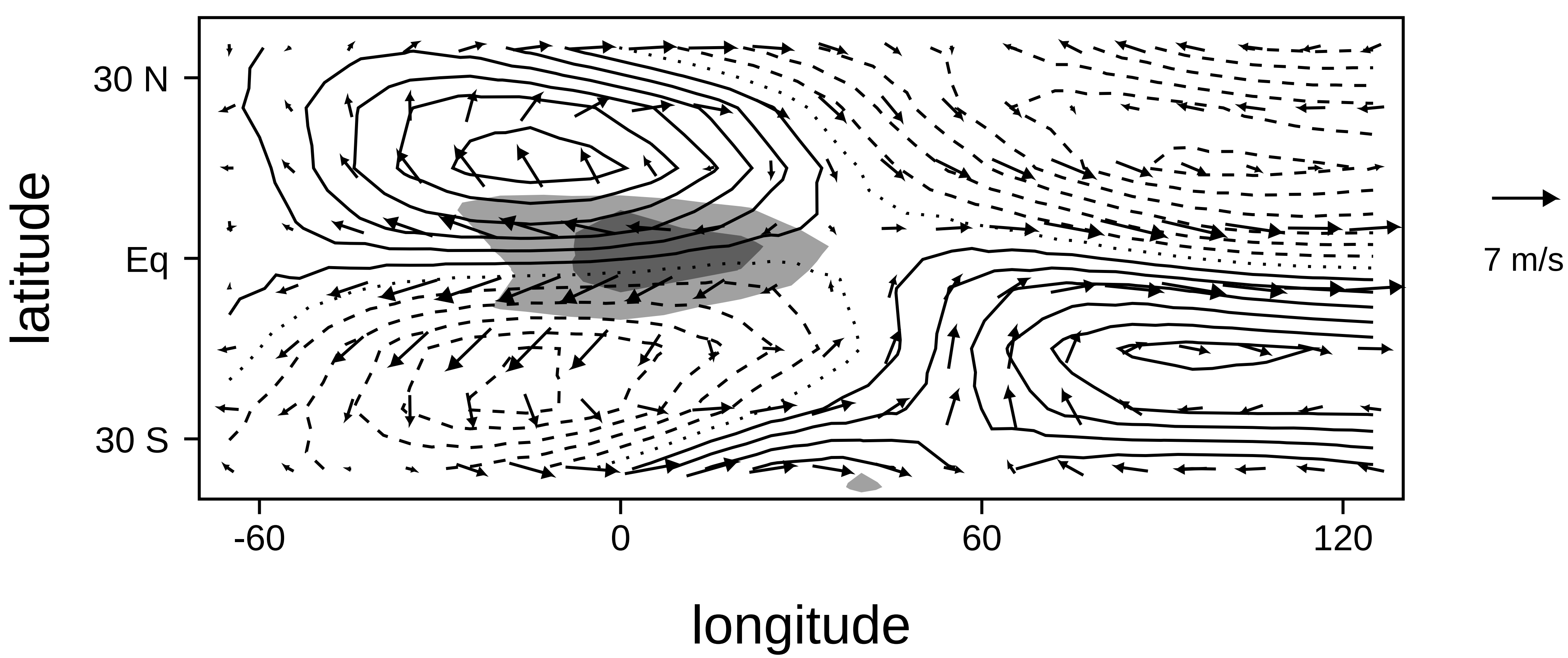
MJO Initiation within a Lagrangian Atmospheric Model

Patrick Haertel, Yale University



Collaborators

Kathy Straub, Susquehanna University

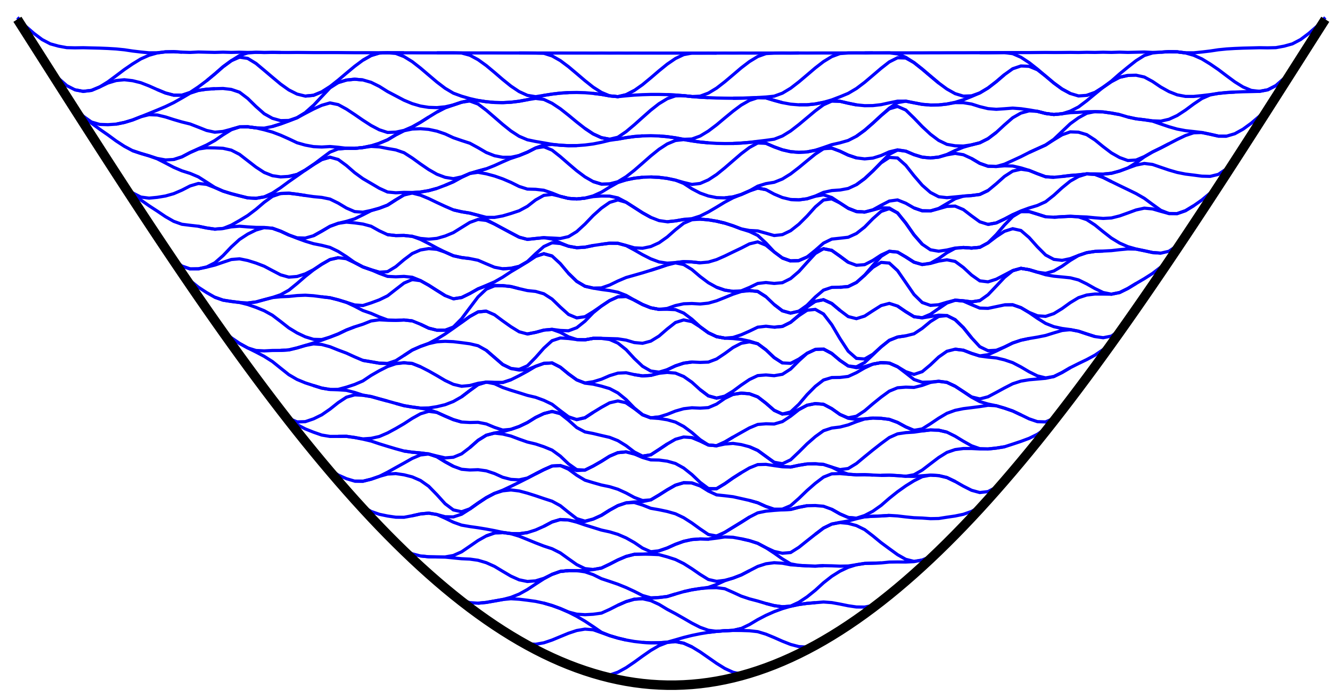
Alexey Fedorov, Yale University

Outline

1. Lagrangian Atmospheric Model
2. Simulations of MJOs
3. MJO Initiation

Lagrangian Atmospheric Model

Conforming Parcel Concept

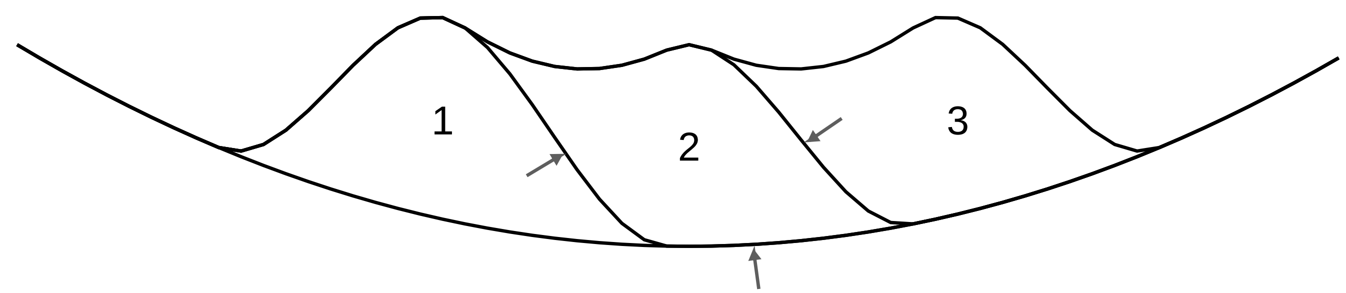


Equations of Motion

$$\frac{d\mathbf{x}}{dt} = \mathbf{v}$$

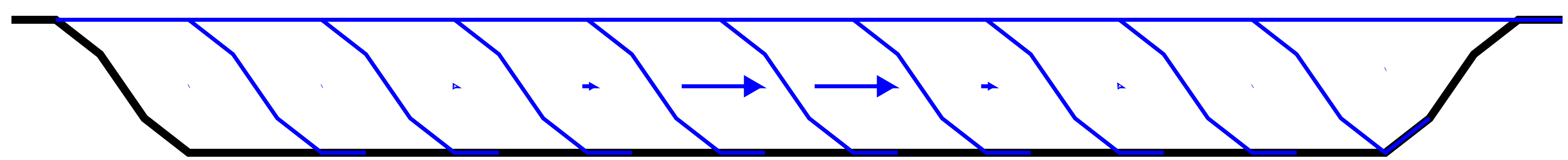
$$\frac{d\mathbf{v}}{dt} + f\ \mathbf{k} \times \mathbf{v} = \mathbf{A}_p + \mathbf{A}_m$$

Pressure Acceleration

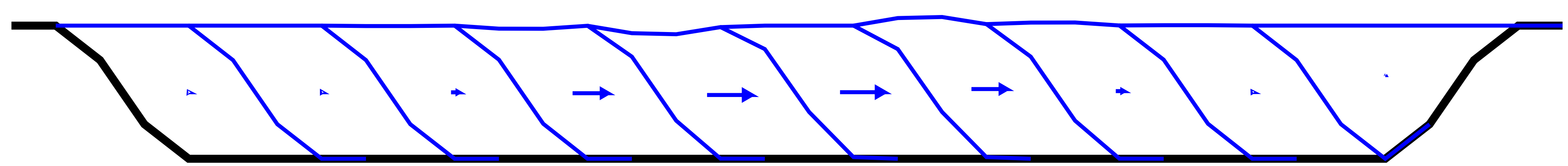


$$\mathbf{A}_p = \frac{1}{W} \int \nabla H \; M \; d\mu$$

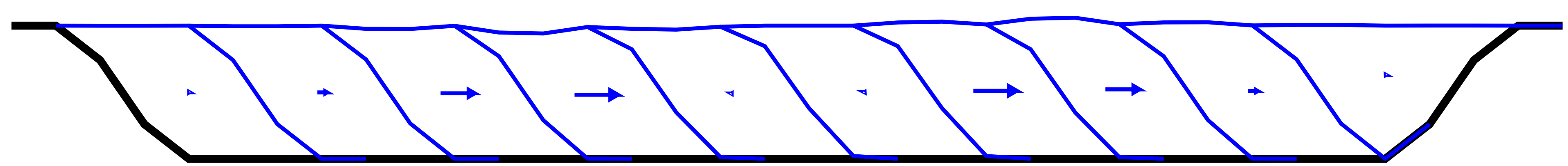
External Gravity Waves



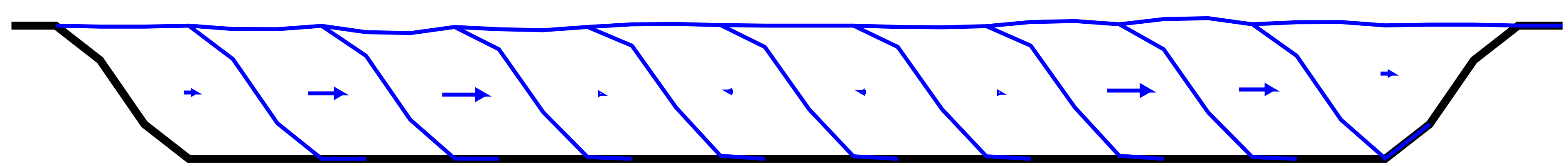
External Gravity Waves

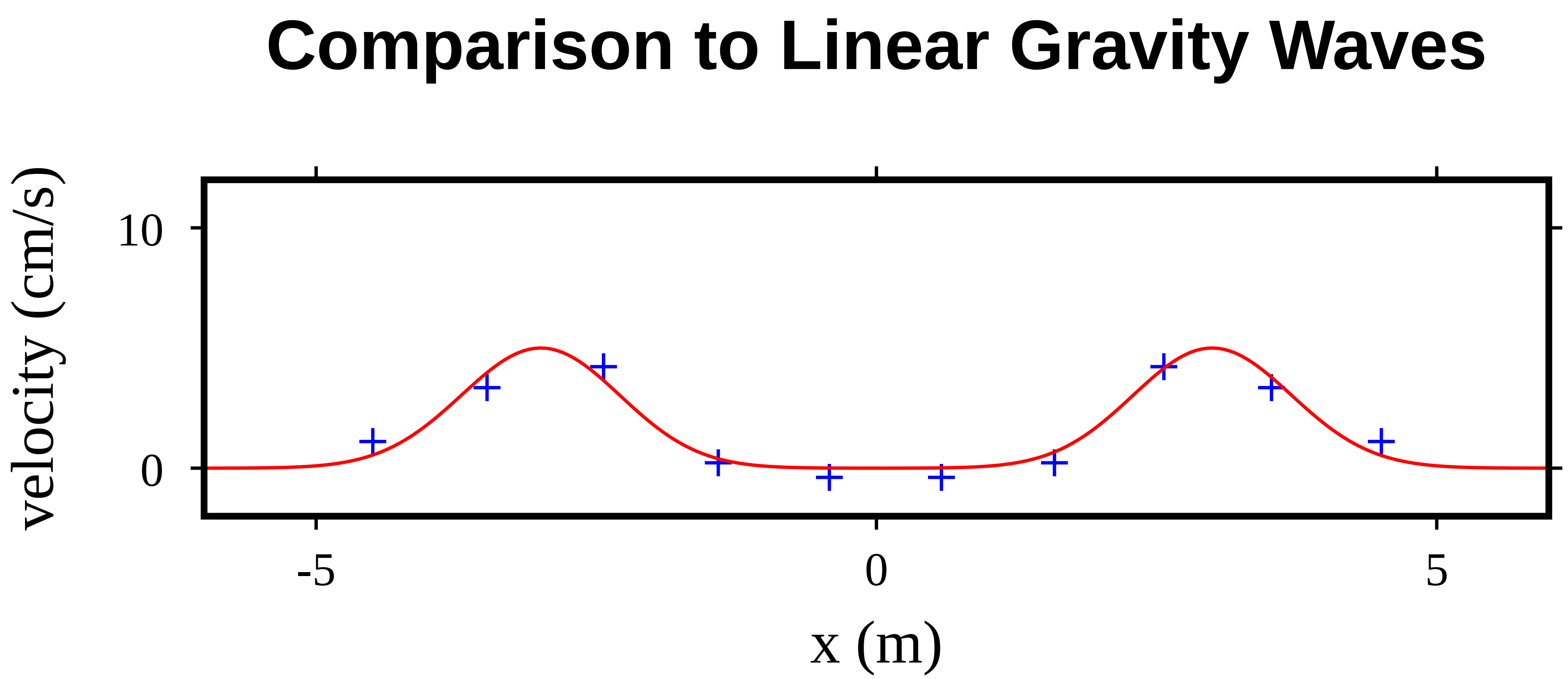


External Gravity Waves



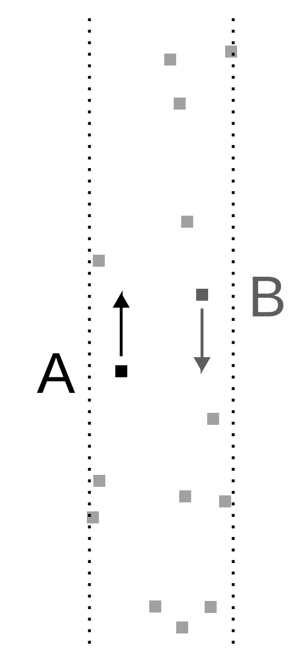
External Gravity Waves




Comparison to Linear Gravity Waves
velocity (cm/s)
10
0
-5
0
5
x (m)

Lagrangian Overturning

Suppose two overlapping parcels A and B are centered in the same column of the model domain with A beneath B. LO exchanges the vertical positions of A and B when $\theta(A) > \theta(B)$.

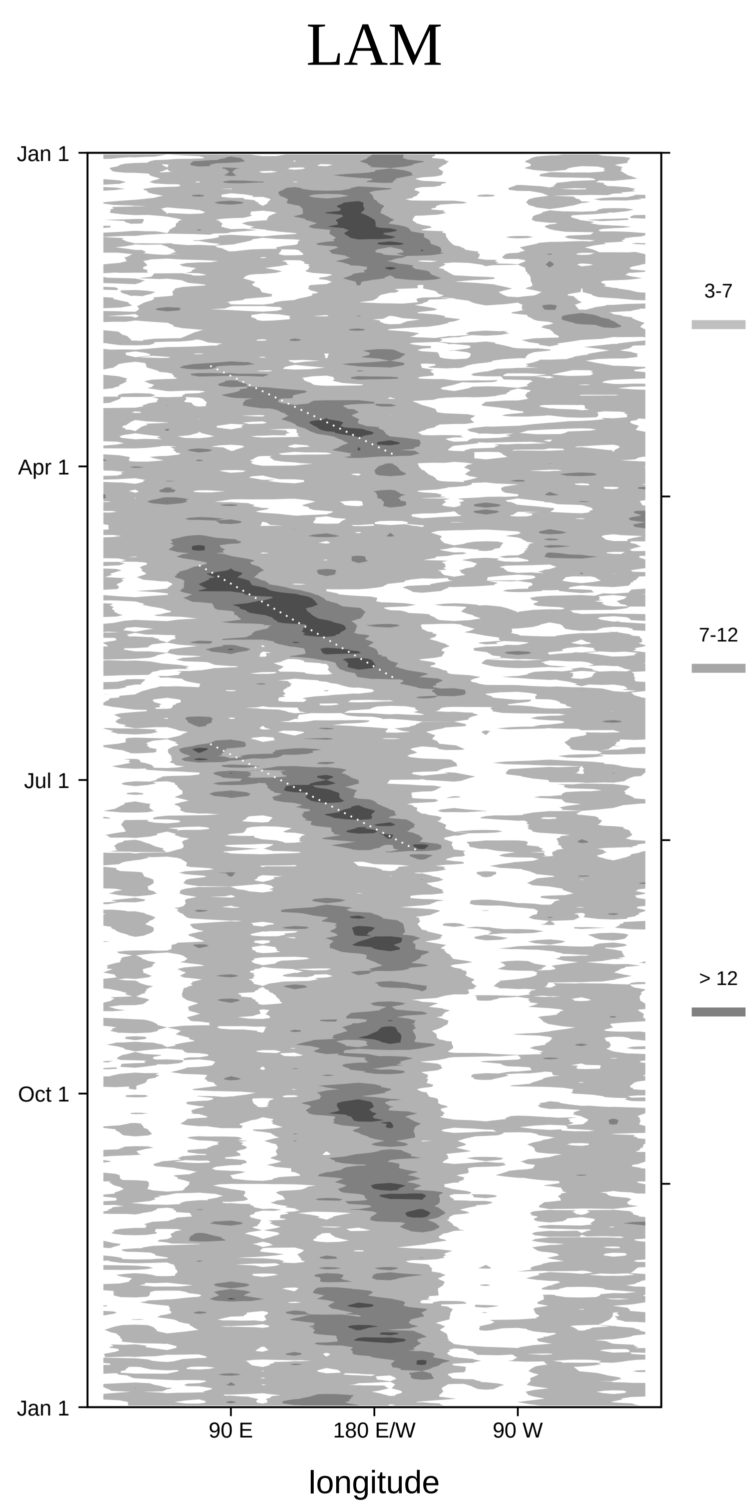


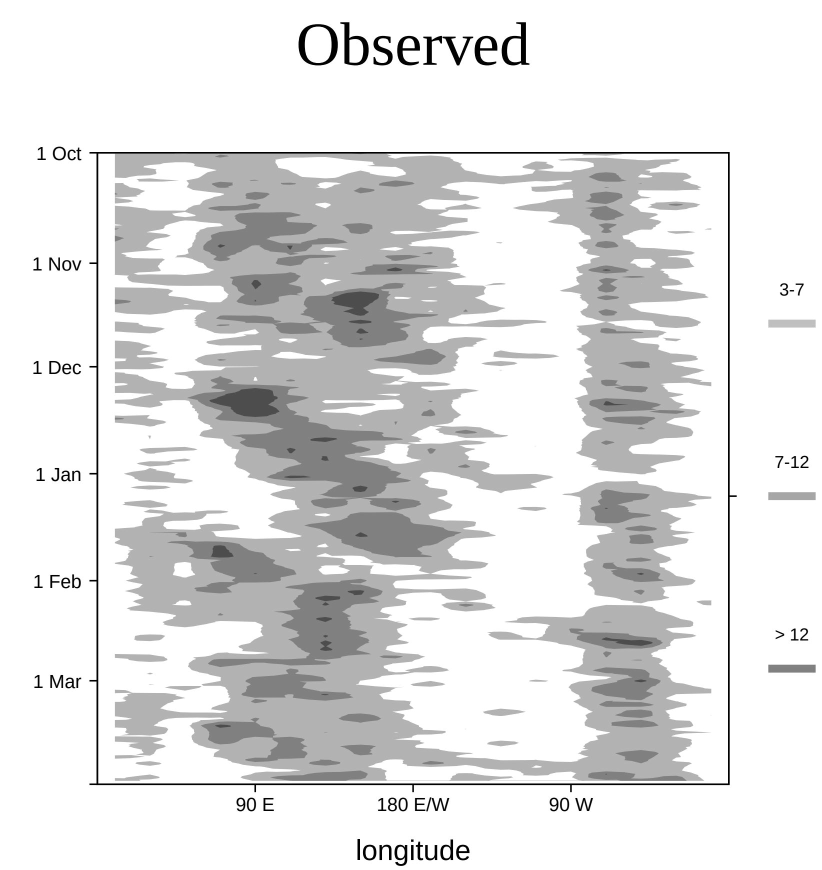
Simulations of MJOs

Configuration

- Aquaplanet with prescribed climatological SSTs
- Idealized radiative transfer (Frierson et al. 2006)
- Simple bulk microphysics

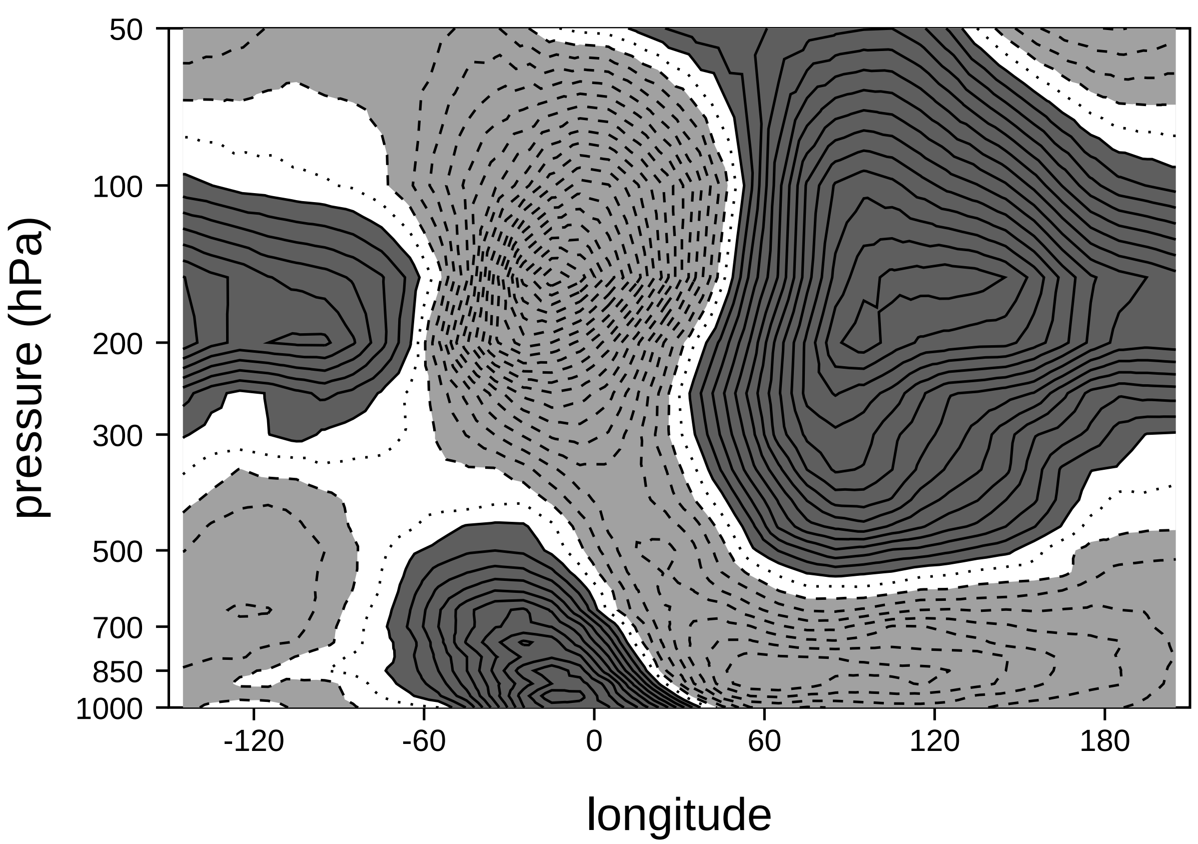
Time Pressure Series of Rainfall (mm/day)



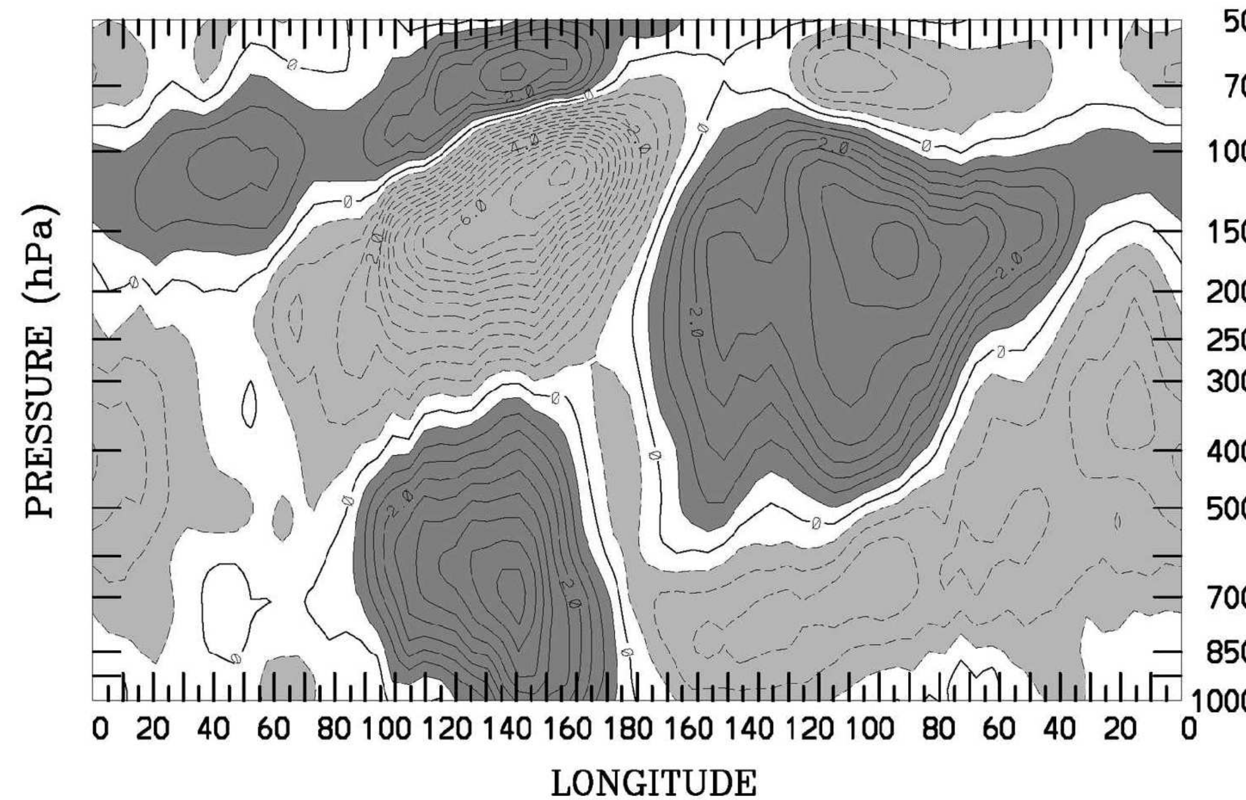


Vertical Cross Section of Zonal Wind (0.5 m/s)

LAM

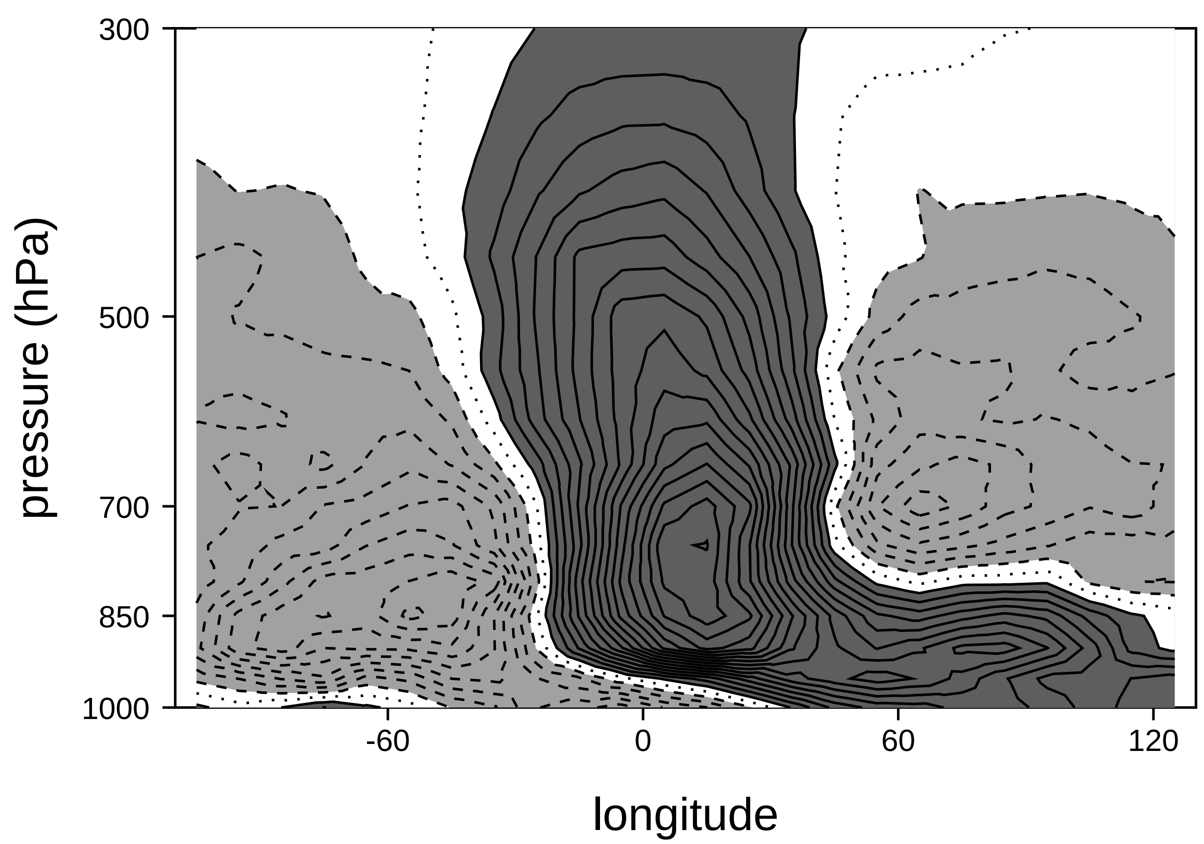


Observed (Kiladis et al. 2005)

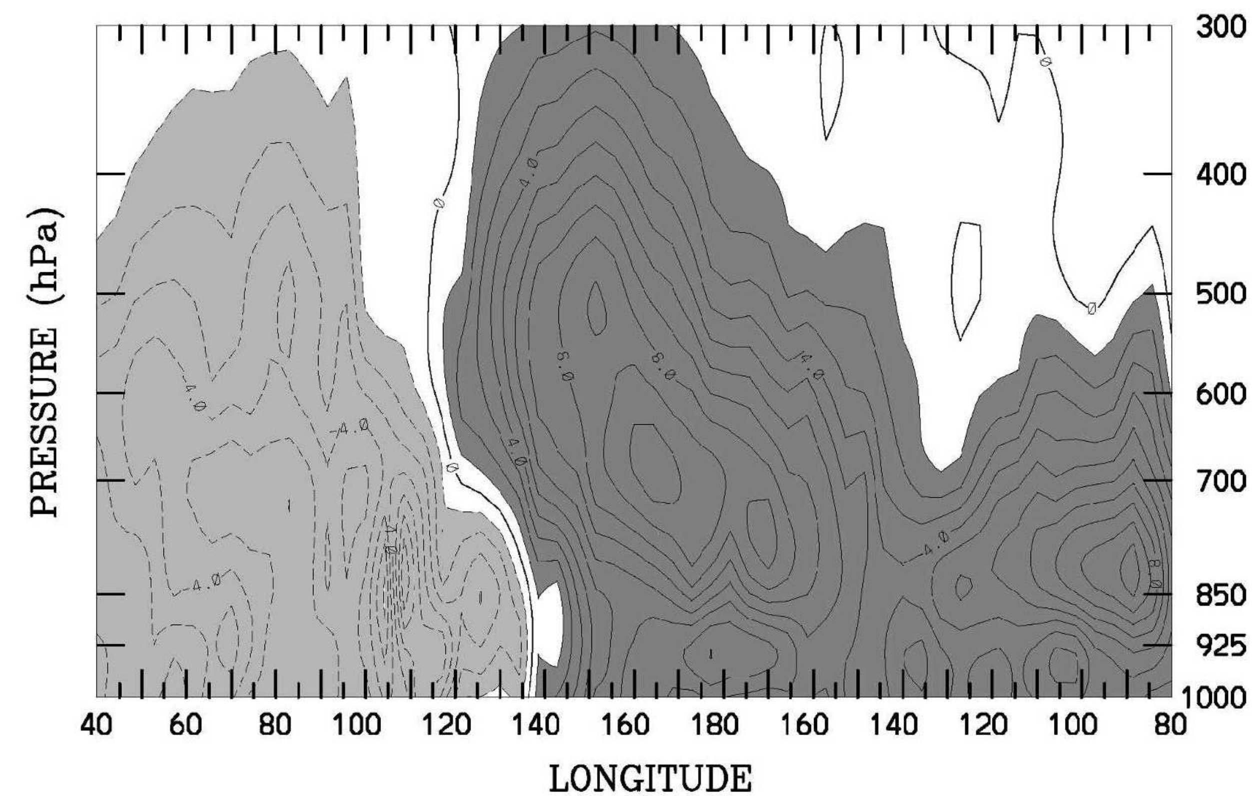


Vertical Cross Section of Moisture (0.1 g/kg)

LAM

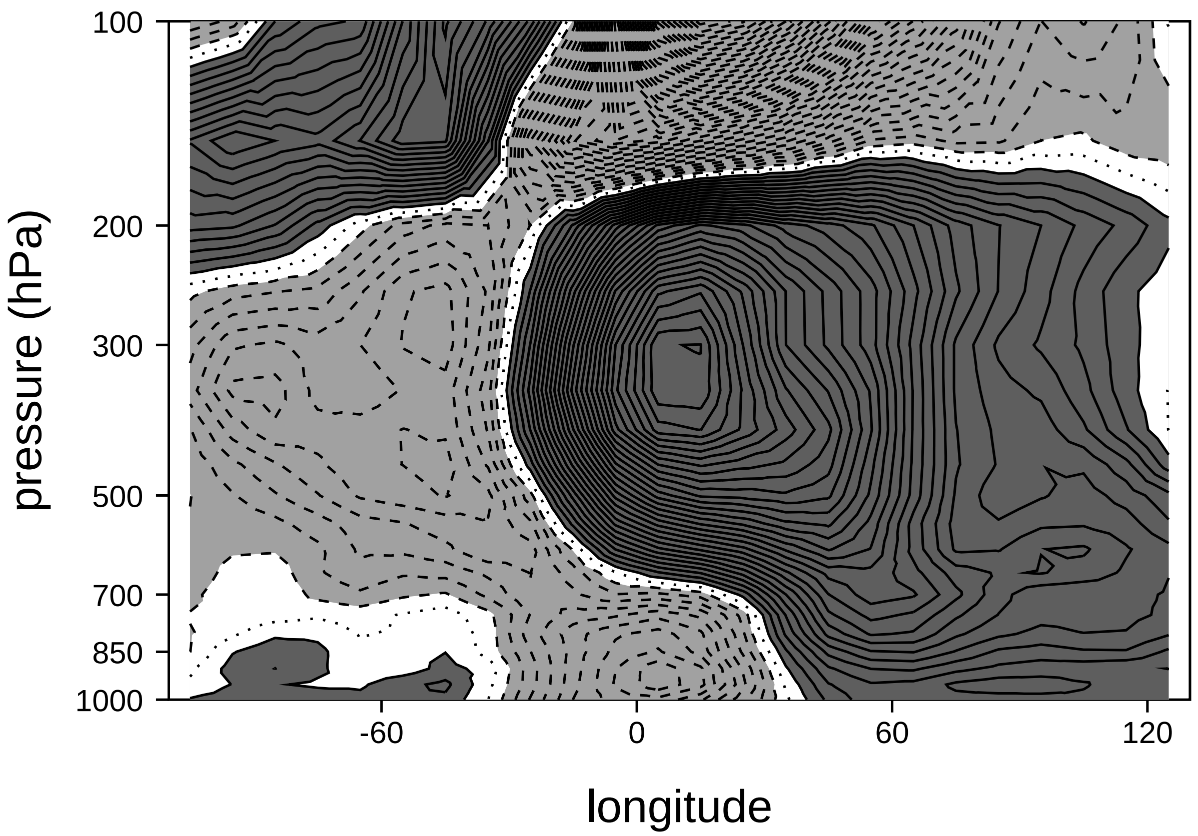


Observed (Kiladis et al. 2005)

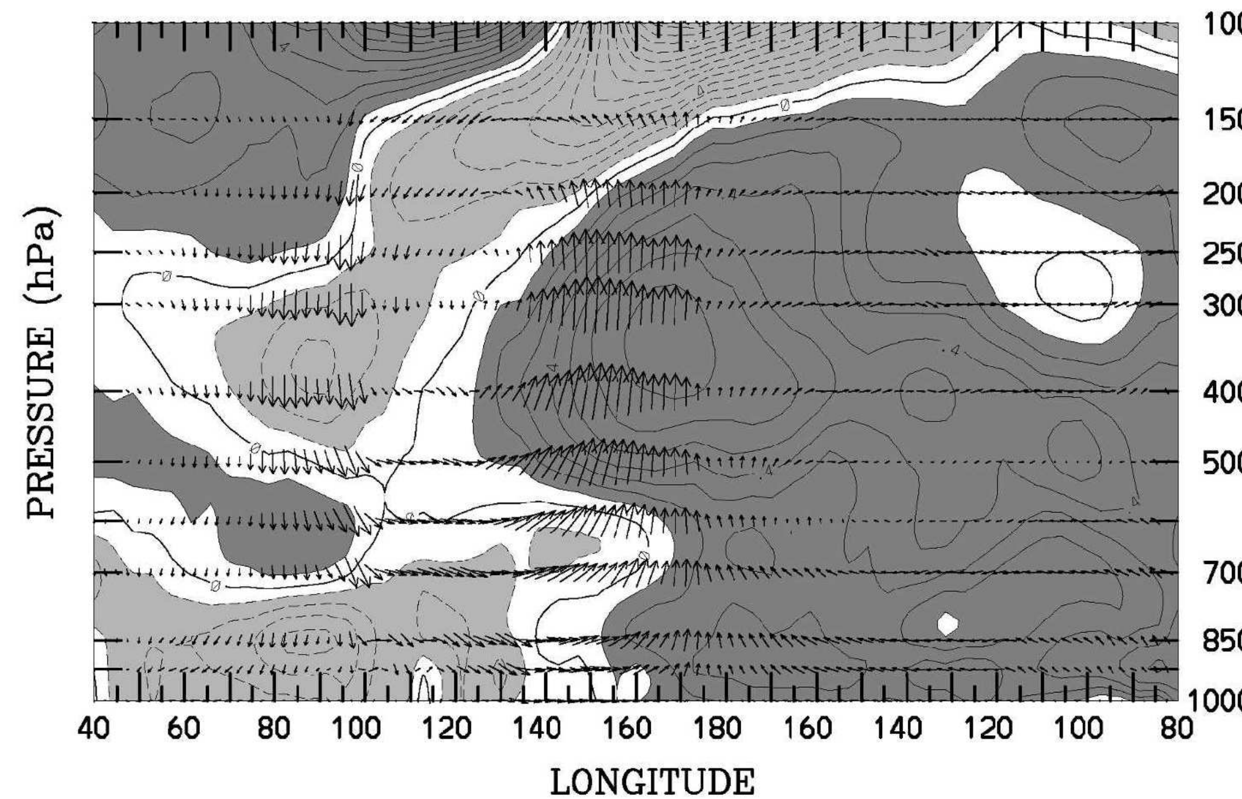


Vertical Cross Section of Temperature (0.1 K)

LAM

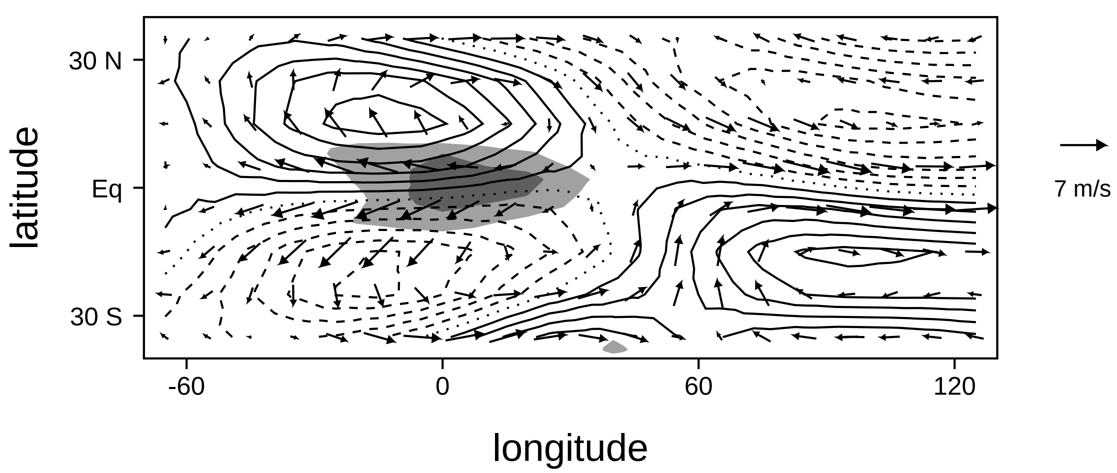


Observed (Kiladis et al. 2005)

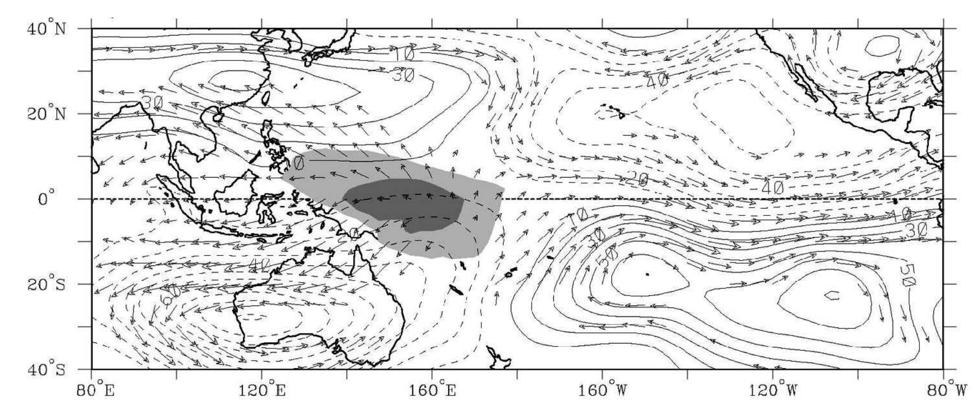


Upper Tropospheric Flow (200 hPa)

LAM



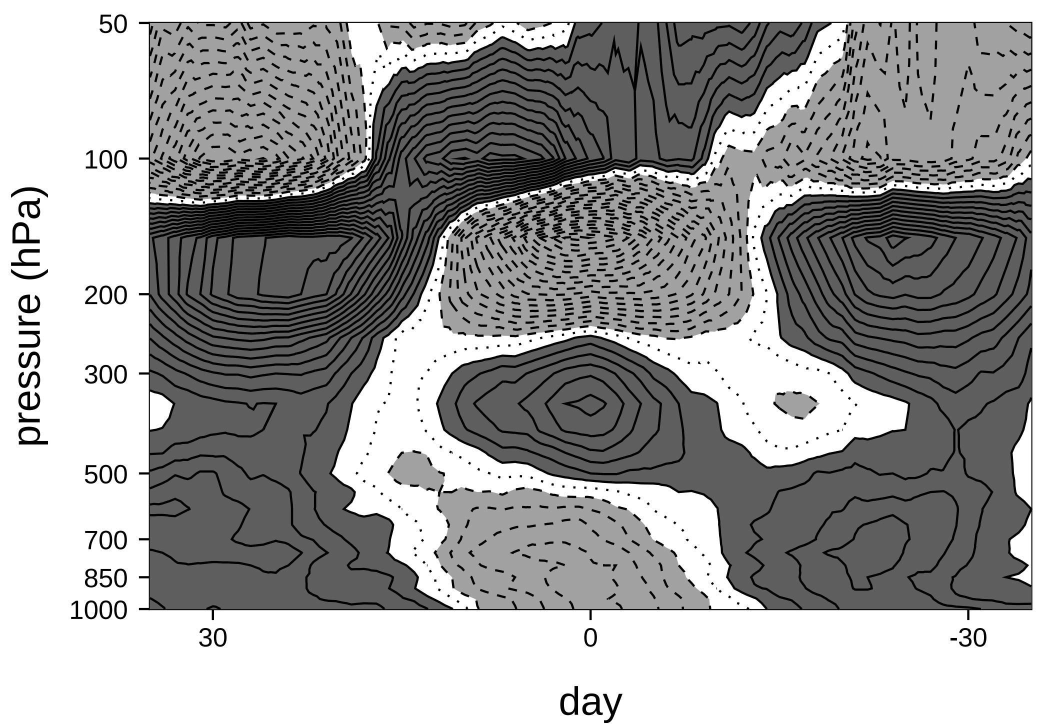
Observed (Kiladis et al. 2005)



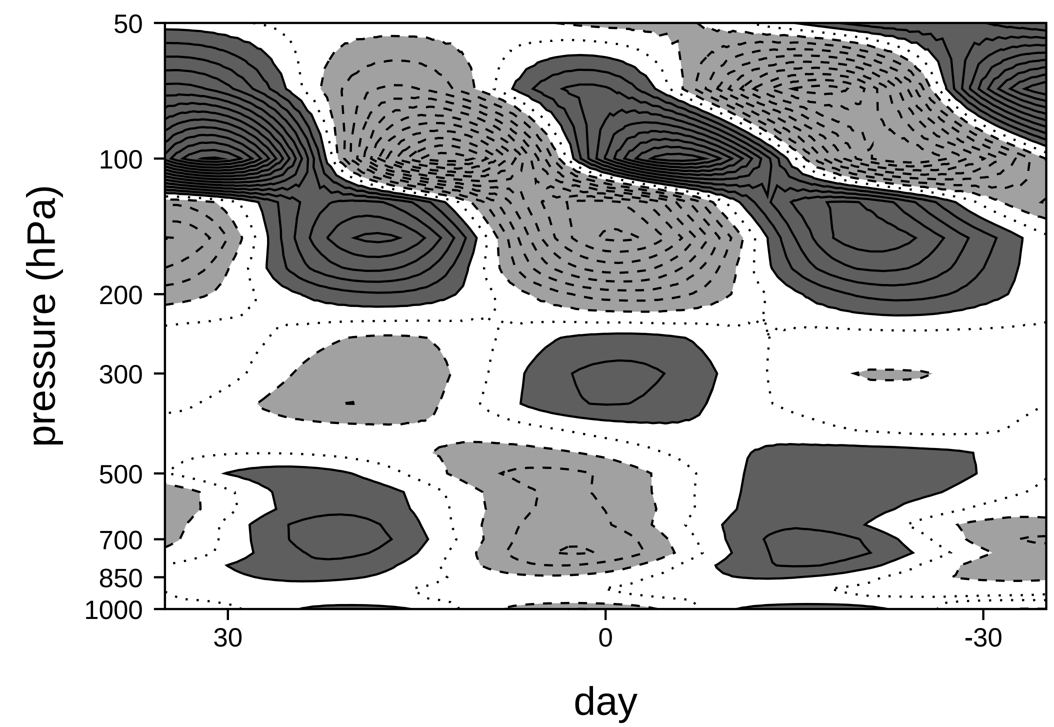
MJO Initiation

Time Series of Temperature (0.1 K)

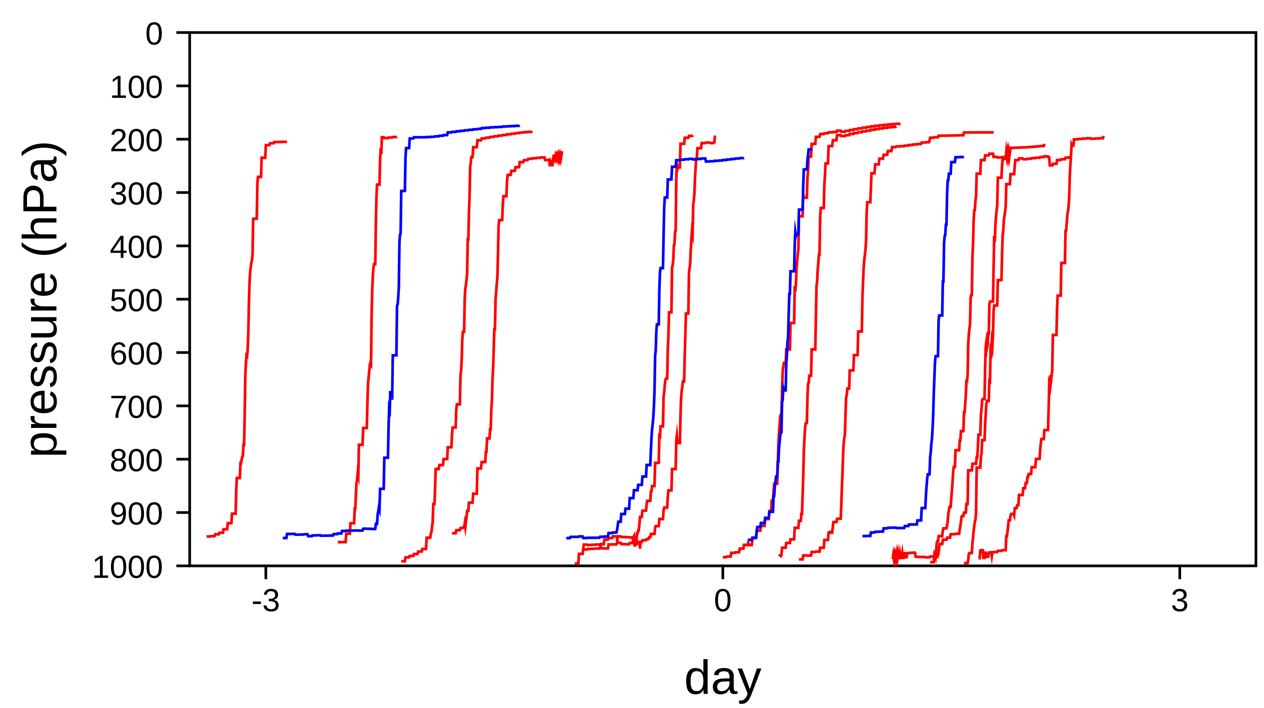
LAM (75 E, 2.5 S)



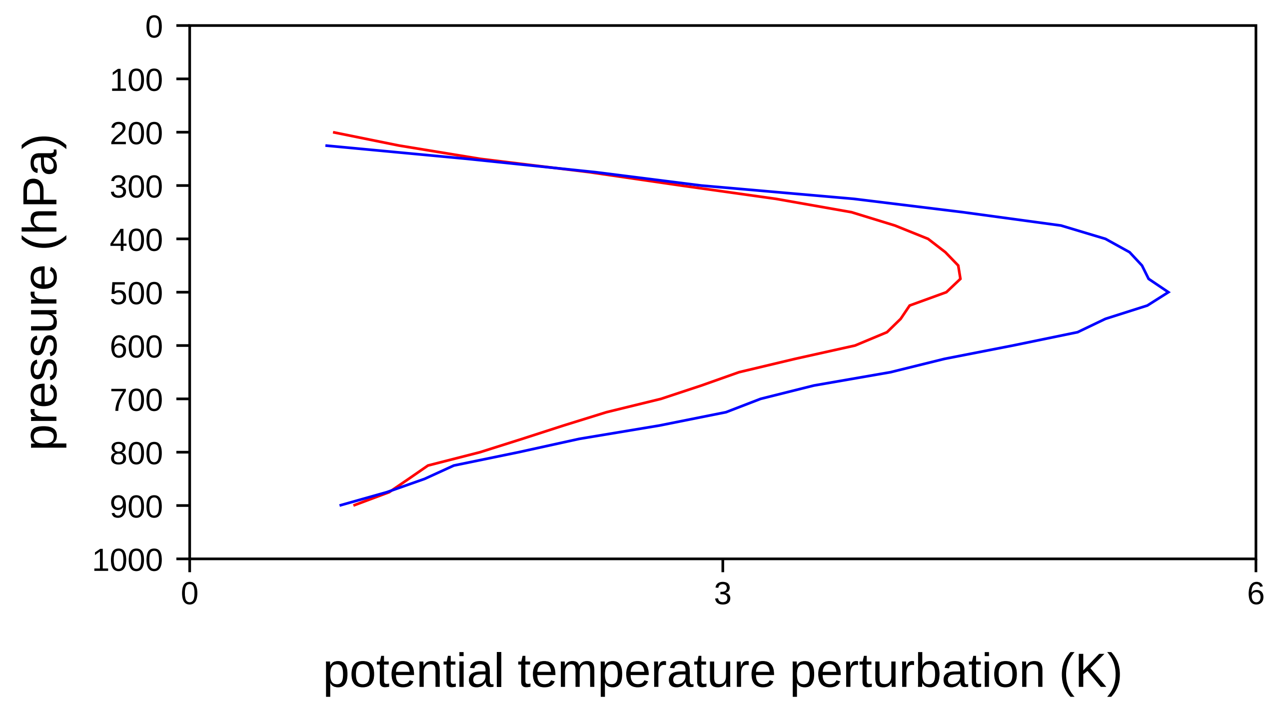
Observed at Gan (73 E, 1 S)



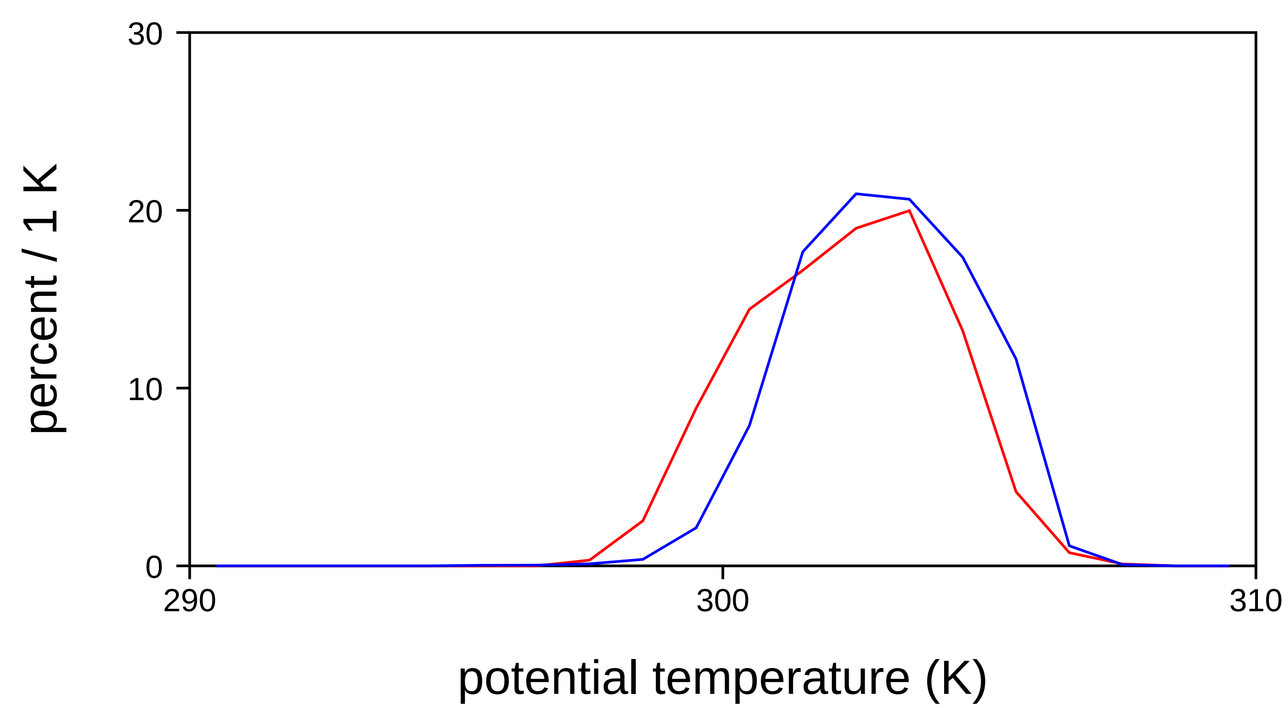
Updraft Trajectories during Active (Red) and Inactive (Blue) Periods



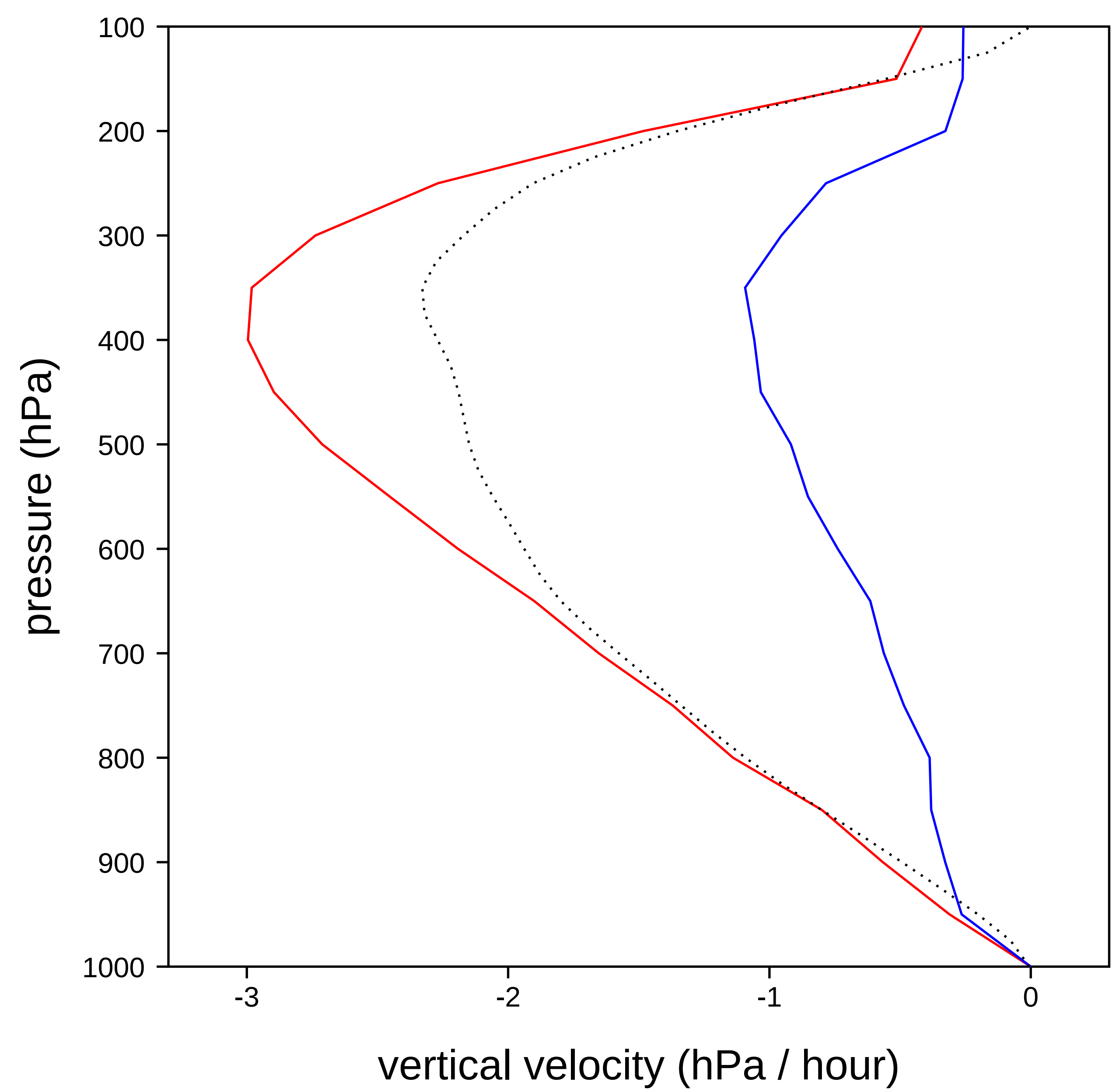
Updraft θ' during Active (Red) and Inactive (Blue) Periods



Boundary Layer θ during Active (Red) and Inactive (Blue) Periods



Vertical Velocity during Active (Red) and Inactive (Blue) Periods



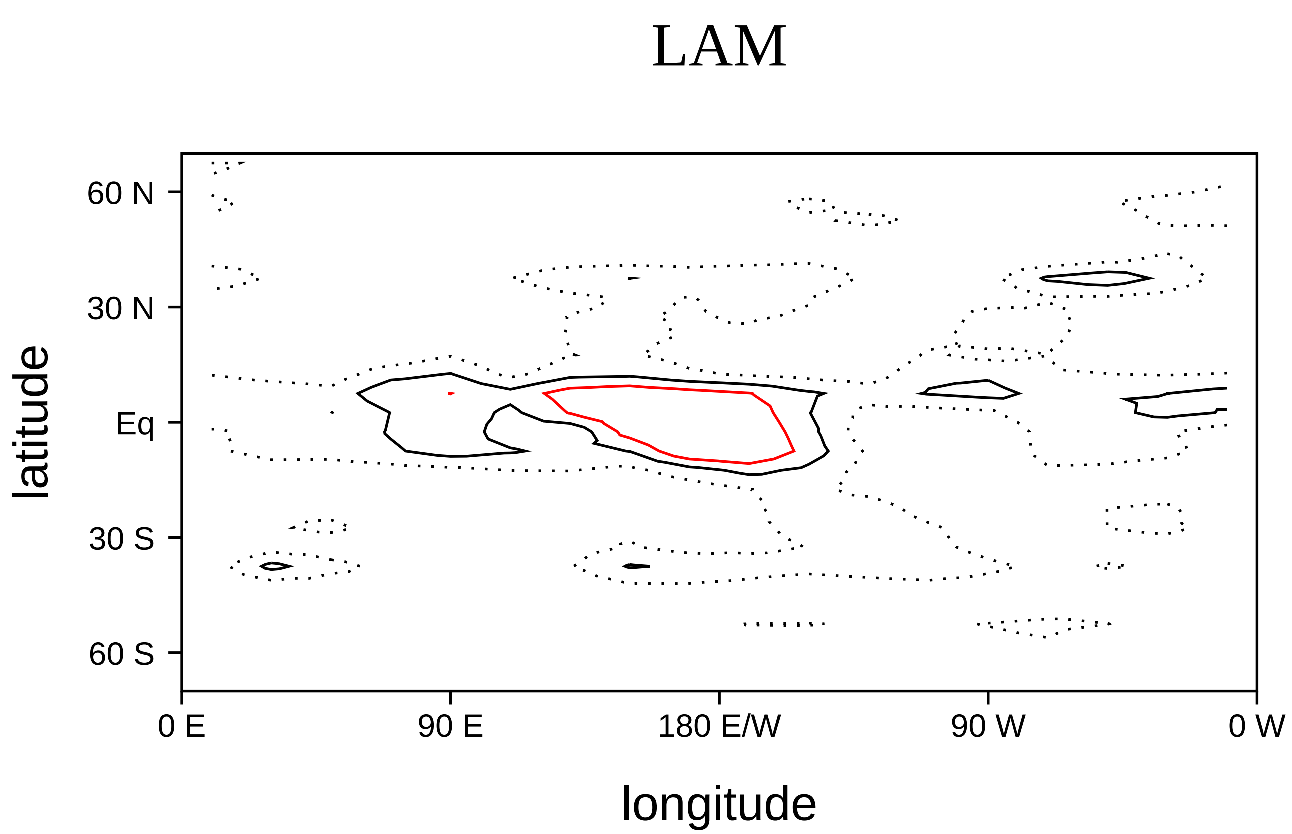
Conclusions

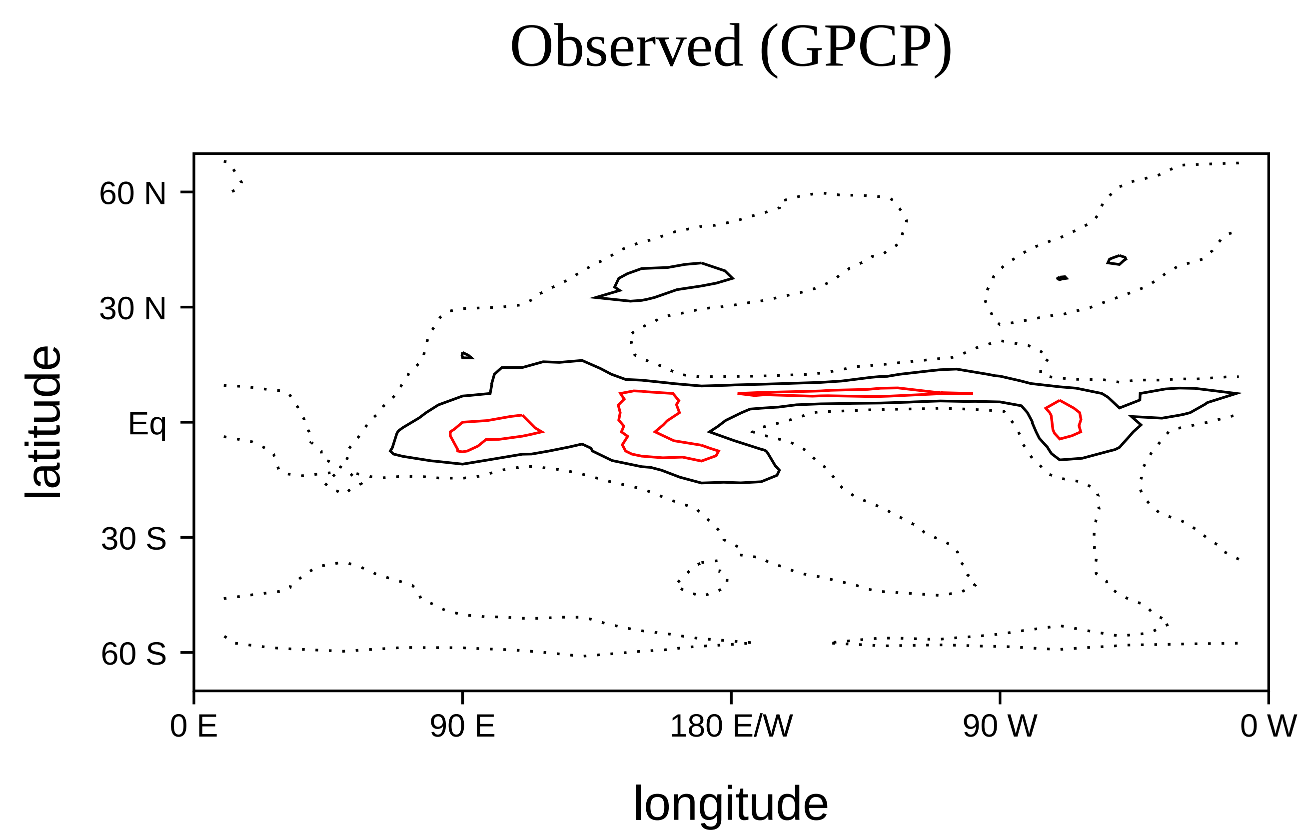
- Most Fundamental MJO Dynamics are a Coupling between Planetary Scale Circulations and Convective Vertical Transports

- Initiation equates to an Increase in Frequency of Deep Convective Updrafts.

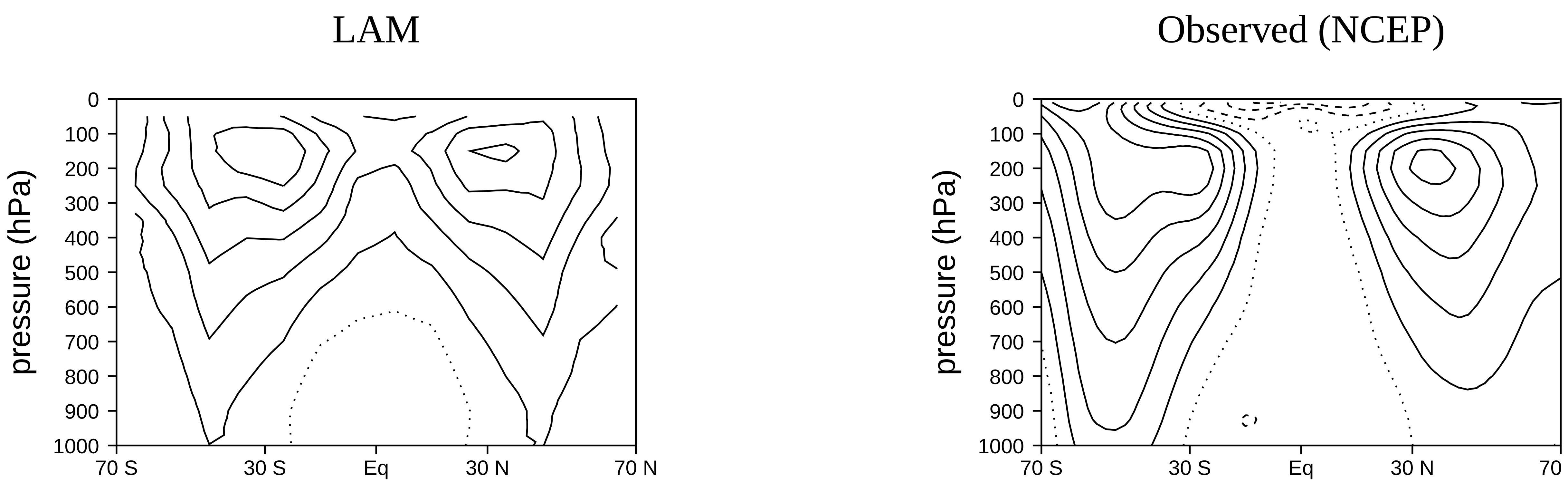
- Potential Causes Include Lower Tropospheric Cooling and/or Enhanced Large Scale Forcing

Rainfall Pattern (3, 5, 7 mm/day)



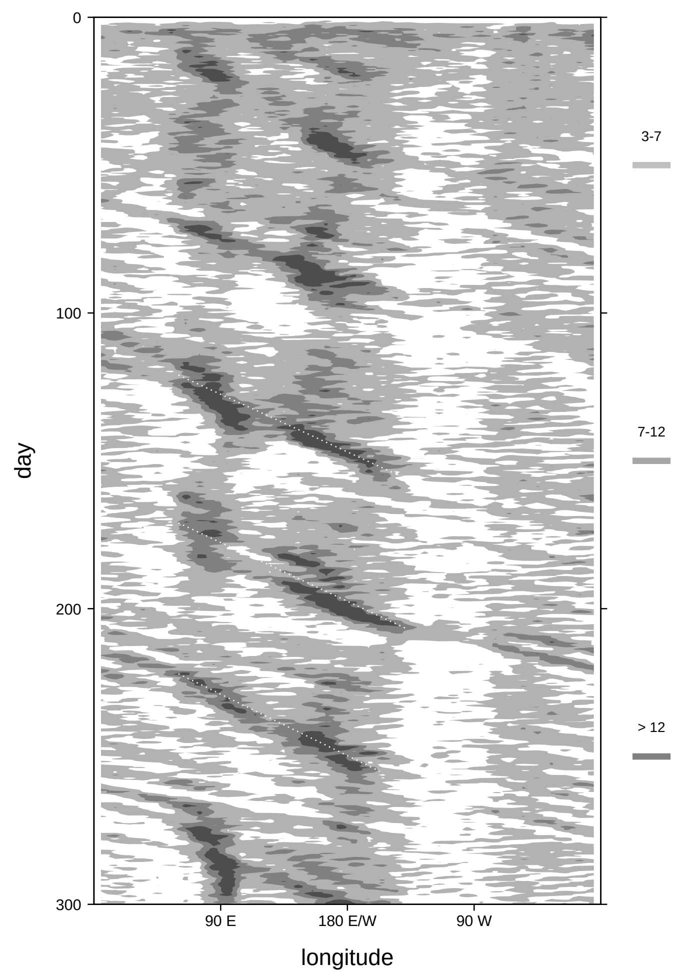


Zonal Wind (5 m/s)

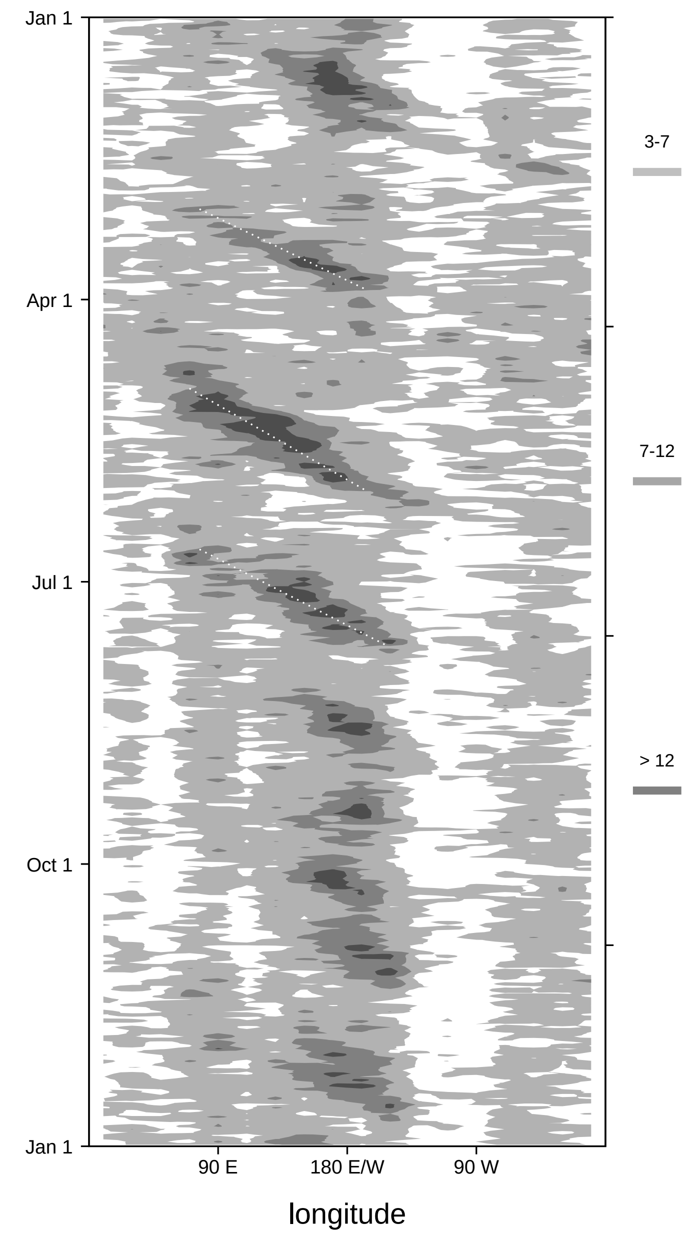


Higher Resolution: Rainfall Time Series (mm/day)

high resolution

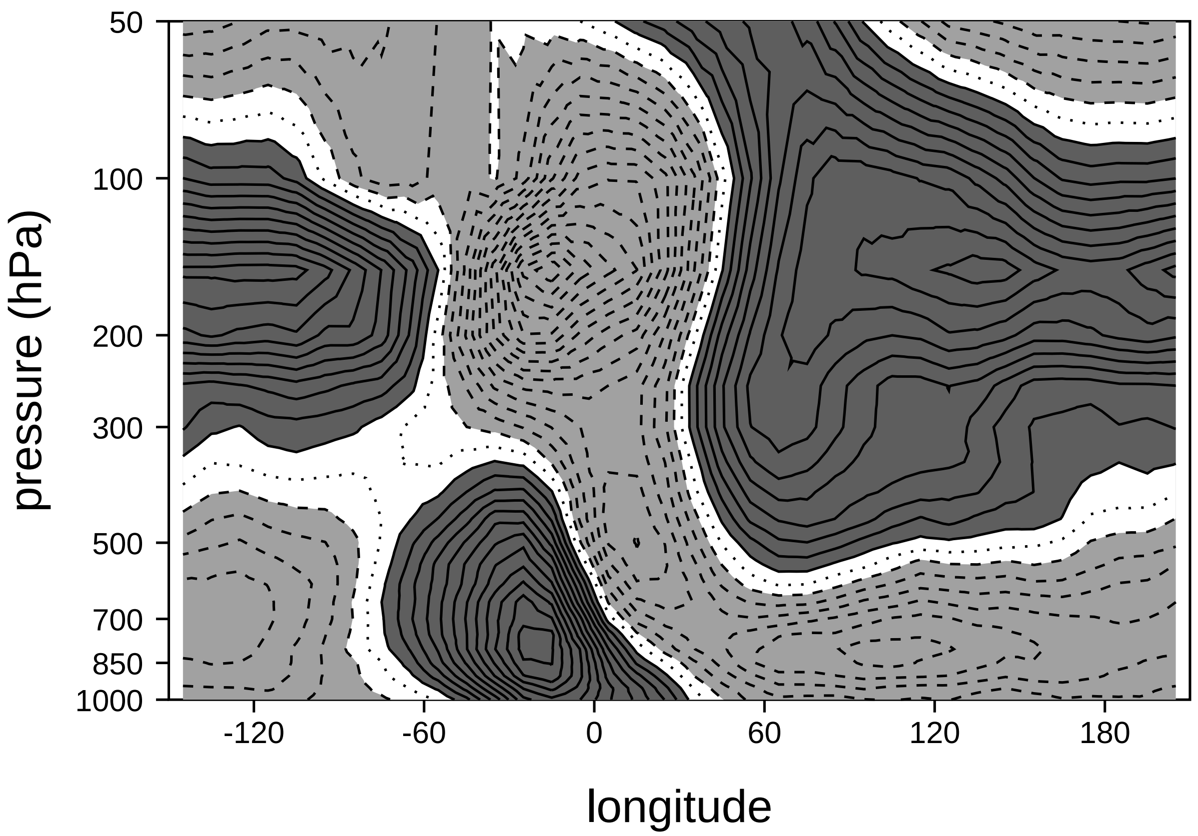


low resolution

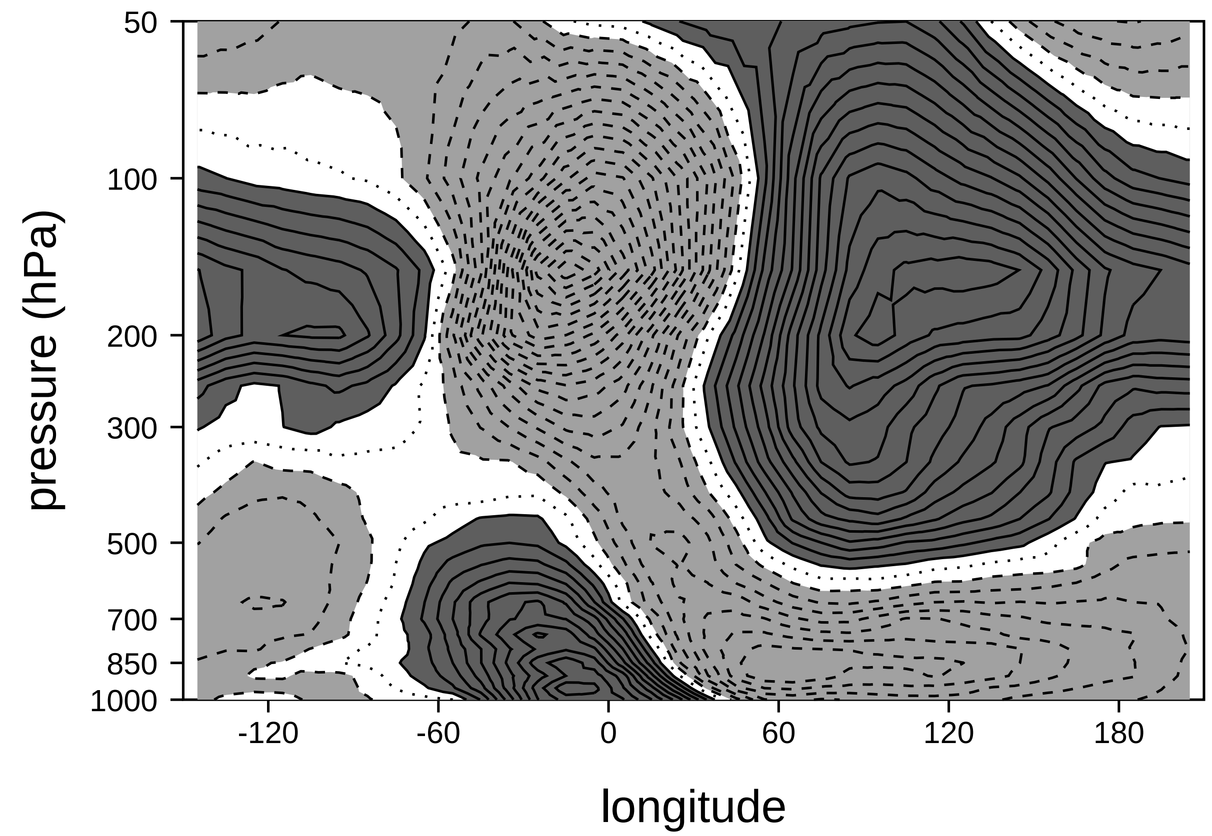


Higher Resolution: Zonal Wind (0.5 m/s)

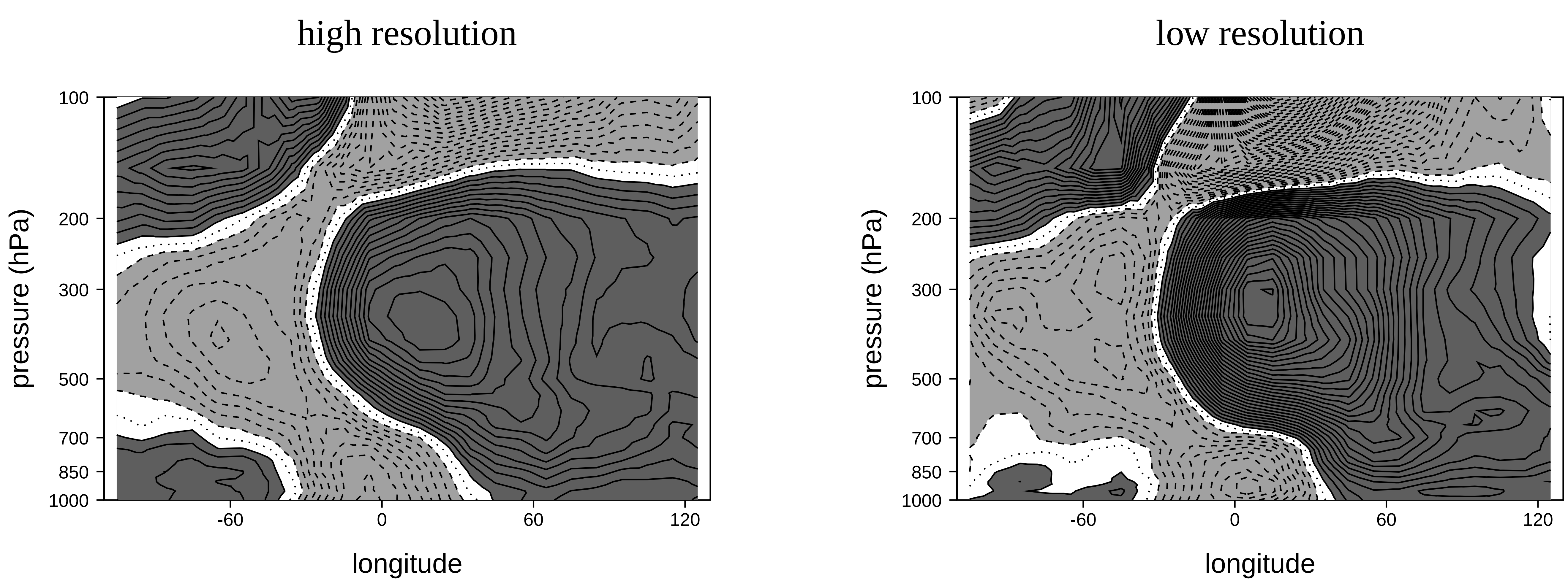
high resolution



low resolution



Higher Resolution: Temperature (0.1 K)



Higher Resolution: Moisture (0.1 g/kg)