What is Responsible for the Low-level Moist Preconditioning of the MJO?

Baijun Tian

Joint Institute for Regional Earth System Science and Engineering (JIFRESSE)
University of California, Los Angeles (UCLA)
Jet Propulsion Laboratory (JPL), California Institute of Technology (Caltech)


AIRS Science Team Meeting, April 2008, Pasadena, CA
The MJO is characterized by slow eastward-propagating oscillations in tropical deep convection and large-scale circulation.

It is the dominant form of intraseasonal variability in the Tropics.

It impacts a wide range of phenomena (e.g., physical, biological and chemical components of the climate system).

Our weather & climate models have a relatively poor representation.

A comprehensive theory for the MJO is still lacking.

Madden & Julian [1971; 1972], Lau and Waliser [2005], Zhang [2005]
Equatorial enhanced MJO convection as indicated by positive rainfall anomaly.

Low-level Moistening Leads MJO Deep Convection.

What Physical or Dynamical Mechanism is Responsible for the Low-level Moist Preconditioning of the MJO?

\[
\frac{\partial W}{\partial t} = E - P + MC
\]
Hydrological Data

- **AIRS H2OVapMMR & TotH2OVap**
  V4, L3, global, 1.0° x 1.0°, 2xdaily, 09/01/2002-04/30/2007. Chahine et al. (2006)

- **TRMM 3B42 Rainfall:**
  40S-40N, 0.25° x 0.25°, 3-hourly, 01/01/1998-06/30/2007. Huffman et al. (2007)

- **QuikSCAT & TMI Moisture Transport**
  40S-40N, 0.25° x 0.25°, 2xdaily, 08/1999-12/31/2005. Liu and Tang (2005)

- **OAFlux Evaporation**
  65S-65N, 1.0° x 1.0°, daily, 01/01/1981-12/31/2002. Yu and Weller (2007)
General Analysis Methodology

(1) Perform an Extended EOF (EEOF) analysis on band-passed (30-90 day) rainfall data (e.g., TRMM).

(2) Identify MJO events from EEOF amplitude time series.

(3) Composite MJO events in band-passed rainfall and target quantities (e.g., moisture, evaporation and moisture convergence).

Tian et al. [2006; 2007; 2008]
Spatial-temporal Pattern of the 1st EEOF Mode of Rainfall MJO Anomaly
Amplitude Time Series of the 1st EEOF Mode of Rainfall MJO Anomaly

The x indicates the dates (x) of selected MJO events.

TRMM: 24  
AIRS: 15  
QuikSCAT&TMI: 14  
OAFlux: 10
Composite MJO Cycle

[Graph showing the composite MJO cycle with legend for colors and data sources.]
**Composite MJO Cycle**

- **lag -5**
  - Pressure (hPa)
  - Rainfall & QConv & QLH

- **lag -4**
  - Pressure (hPa)
  - Rainfall & QConv & QLH

- **lag -3**
  - Pressure (hPa)
  - Rainfall & QConv & QLH

- **lag -2**
  - Pressure (hPa)
  - Rainfall & QConv & QLH

- **lag 0**
  - Pressure (hPa)
  - Rainfall & QConv & QLH

- **lag +1**
  - Pressure (hPa)
  - Rainfall & QConv & QLH

Legend:
- **Black**: TRMM Rainfall (mm/day)
- **Green**: QuikSCAT QConv (mm/day)
- **Purple**: OAFlux QLH (0.1 mm/day)

**Comp AIRS H2OVapMMR (gm/kg)** MJO Anom

- Colors range from -0.3 to 0.3.
Composite MJO Cycle

- Lag -5
- Lag -4
- Lag -3
- Lag -2
- Lag 0
- Lag +1

Pressure (hPa) vs. Longitude (E)

Legend:
- Black: TRMM Rainfall (mm/day)
- Green: QuikSCAT QConv (mm/day)
- Purple: OARFlux QLH (0.1 mm/day)
Composite MJO Cycle
MJO Preconditioning Phase

- Large lower-troposphere moistening ($W>0$);
- Small precipitation anomaly ($P \sim 0$);
- Enhanced moisture convergence ($C>0$);
- Suppressed evaporation ($E<0$);

**The low-level moist preconditioning is due mainly to the enhanced (low-level) moisture convergence.**
Schematic of the frictional wave-CISK model of the MJO (Wang 1998, 2005; Salby et al. 1994)
Wind-Evaporation Feedback

Schematic of the wind-evaporation feedback model of the MJO (Emanuel 1987; Neelin et al. 1987)

- Tropics - Mean Low-level Easterlies

- Ubar < 0
- u’ < 0 to east of convection
- High wind speed => High Evaporation
- Favorable conditions for eastward propagation

- Low-Level Easterly Wind Anomalies = u’ < 0
AirS observation indicates that low-level moist anomaly leads the MJO deep convection and precipitation.

QuikSCAT & TMI moisture transport and OAFlux evaporation observations indicate that the low-level moist preconditioning of the MJO is due mainly to the low-level moisture convergence instead of the surface evaporation.

The satellite observations support the frictional wave-CISK theory instead of the wind-evaporation feedback theory of the MJO.
Near-equatorial low-level moisture anomalies tend to lead rainfall anomalies
Near-equatorial total column (low-level) moisture convergence anomalies tend to lead rainfall anomalies.
Near-equatorial surface evaporation anomalies tend to lag rainfall anomalies.