Variation of Energy Transfer to the Atmosphere associated with the MJO

Eric Tromeur and William B. Rossow

NOAA/CREST at the City College of New York
Remote Sensing of Climate Group
ISCCP D1 data covering 21.5 years
Identification of 6 Weather States in the Tropics
RFO as a function of longitude
Strongest convective activity in the Indo-Pacific region

Cluster Analysis + ISCCP D1 data
WS1: Deep cumulus clouds
WS2: Anvils clouds
WS3: Congestus clouds
WS4: Cirrus clouds
WS5: Shallow cumulus clouds
WS6: Stratocumulus clouds

Rossow et al, GRL, 2005
Background

MJO Index Threshold

- MJO Index based on 200 mb velocity potential anomalies
- MJO signal present all over the year
- Definition of Index thresholds for weak/strong MJO events

Tropical cloud regimes and MJO phase

- Characterization of organized and disorganized convection
- Less to more organized convection on the MJO scale
RFO of each cloud regime in 60E-180E region / 5S-5N latitude band
(MJO events in November-April periods from 1983 - 2004)

Cloud regimes

- Convective cloud regimes
  - WS1
  - WS2
  - WS3
  - WS4
  - WS5
  - WS6
  - WS7

- Cirrus regime

- Suppressed cloud regimes

- Clear sky
Outline

1. Data sources
2. Diabatic heating during MJO
3. Variation of total energy transfer
4. Tests for models
### Atmospheric diabatic heating

\[
TV_j = \sum_{i=1}^{7} [RFO_{ij} \times Var_{ij}]
\]

<table>
<thead>
<tr>
<th></th>
<th>GPCP</th>
<th>ISCCP-FD</th>
<th>GSSTF2</th>
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<tbody>
<tr>
<td>Space resolution</td>
<td>1° x 1°</td>
<td>2.5° x 2.5°</td>
<td>1° x 1°</td>
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<td>Time resolution</td>
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<td>Temporal domain</td>
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<td>31 Dec 2004</td>
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<td>31 Dec 2000</td>
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<td>Vertical levels</td>
<td>Surface</td>
<td>TOA, Surface, and Atmosphere</td>
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<td>Variables</td>
<td>Precipitation</td>
<td>Radiative net fluxes</td>
<td>Surface fluxes</td>
</tr>
</tbody>
</table>

- **GPCP**: Global Precipitation Climatology Project
- **ISCCP**: International Satellite Cloud Climatology Project
- **GSSTF2**: Goddard Satellite-Based Surface Turbulent Fluxes, version 2
Composite Total Precipitation Anomalies in 60E-180E region / 5S-5N latitude band
(MJO events in November-April periods from 1997 - 2004)

Asymmetry of total precipitation anomalies

Hint showing us that convection leads MJO

$\langle P_{\text{weak}} \rangle = 6.75$
$\langle P_{\text{strong}} \rangle = 7.94$
Temporal asymmetry of total precipitation anomalies due to WS1

Convection could strengthen the wave
Composite total radiative net flux anomalies in 60E-180E region / 5S-5N latitude band
(MJO events in November-April periods from 1997 - 2004)

Latent Heat Flux Anomalies

- Maximum of total Latent Heat Flux anomalies at lag 2
- Latent heat fluxes lag the convection
- Hint showing a weakness of the WISHE theory

Sensible Heat Flux Anomalies

- Fluctuate around zero
- Not dependent with the MJO signal and the MJO phase
Composite Latent Heat Flux Anomalies in Tropics

Latent Heat Flux Anomalies

Near Surface-Air Specific Humidity Anomaly Difference

Moistening/Drying of the lower troposphere

Negative/Positive latent heat flux anomalies

Latent heat fluxes reacts to humidity

LHF are not driving the MJO cycle
Variation of Energy Transfer associated with the MJO

Anomalies of Total Heating in the Atmosphere (60E–180E)

THATM = P + LWATM + SWATM + SHF

Index < -1.0
<TH*> = 232.50

Index < -2.2
<TH*> = 263.69

Anomalies of Total Heating at the surface (60E–180E)

THSRF = LWSRF + SWSRF - SHF - LHF

Index < -1.0
<TH*> = 318.22

Index < -2.2
<TH*> = 301.36
Test Amplitude & Phase of atmospheric diabatic heating terms

- Most of precipitation come from WS1
- Temporal asymmetry of total precipitation anomalies
- Surface latent heat fluxes lag convection
- Total heating in the atmosphere mainly due to precipitation
- Passive response at the surface, which is directly linked to cloud net anomalies

Verify behavior in Observations
Things to do …

- Finer Time Resolution (daily lags)
- Link between weak and strong MJO events
- Vertical structures
- Convective Tracking life cycle