An Upper-Tropospheric Role in MJO Convective Onset

Scott W. Powell
University of Washington, Seattle
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c.f. Gill (1980)
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Hypothesis: Gradual moistening leads to systematic build-up of convection, ultimately resulting in MJO (“discharge-recharge”; Bladé and Hartmann (1993), Kemball-Cooke and Weare (2001), Benedict and Randall (2007), and others.)
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Evolution of Cloud Population, Precipitation, and Humidity Fields
Powell and Houze (2013)

Xu and Rutledge (2014)
Top row: Gan rawinsonde data

Bottom row: ERA-Interim (3°N – 3°S, 68°E – 78°E)
Upper-Tropospheric Dynamics
\[ U = \nabla \chi \]

\[ \chi_{150}^' \]
150 hPa $u'$
Blue: Easterly
Red: Westerly
150 hPa $u'$
Blue: Easterly
Red: Westerly
150 hPa $u'$
Blue: Easterly
Red: Westerly
Longitude | Date
---|---
15-Sep | 01-Oct
15-Oct | 01-Nov
15-Nov | 01-Dec
15-Dec | 01-Jan
15-Jan | 01-Feb
15-Feb | 01-Mar
15-Mar |

300 hPa Specific Humidity Anomaly ($\text{kg} \text{ kg}^{-1}$)

300 hPa Relative Humidity Anomaly (%)
300 hPa Vertical Velocity Anomaly (Pa s$^{-1}$)
300 hPa

Vertical Velocity Anomaly (Pa s$^{-1}$)

Divergence Anomaly (s$^{-1}$)

$R^2 = 0.78$

500 hPa

Vertical Velocity Anomaly (Pa s$^{-1}$)

Divergence Anomaly (s$^{-1}$)

$R^2 = 0.55$

700 hPa

Vertical Velocity Anomaly (Pa s$^{-1}$)

Divergence Anomaly (s$^{-1}$)

$R^2 = 0.02$

850 hPa

Vertical Velocity Anomaly (Pa s$^{-1}$)

Divergence Anomaly (s$^{-1}$)

$R^2 = 0.52$
Vertical Velocity Anomaly (Pa s$^{-1}$)

Divergence Anomaly (s$^{-1}$)

$R^2 = 0.78$

$R^2 = 0.55$

$R^2 = 0.02$

$R^2 = 0.52$

300 hPa

500 hPa

700 hPa

850 hPa
Conclusions
1. Humidity anomalies at various levels and depth of convection increase rapidly at MJO convective onset.
2. \(~30\) day variability in fields observed by radar and rawinsonde are consistent with that over larger domain in Indian Ocean where initial MJO convective onset occurs.
3. Large scale semi-global structures of anomalous zonal wind (and other fields) enters Indian Ocean from west.
5. Anomalies of vertical velocity are coupled with divergence and sometimes circumnavigate tropics.

6. MJO convective onset occurs when UT downward motion anomaly moves out of Indian Ocean.
Adames and Wallace (2014)
Barnes and Houze (2013)
1. Variability in stratiform (and deep convective) elements is a key part of the evolution of the cloud population during an MJO episode.