An Upper-Tropospheric Role in MJO Convective Onset

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c.f. Gill (1980)
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Knutson and Weickmann (1987)
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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The Discharge-Recharge Mechanism

- Deepening cumulus heating & moistening, destabilization
- Convective and stratiform rainfall, stabilization
- Suppressed convection
Evolution of Cloud Population, Precipitation, and Humidity Fields
Powell and Houze (2013)
Top row: Gan rawinsonde data

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

150 hPa Zonal Wind Anomaly (m s$^{-1}$)

300 hPa Temperature Anomaly (m s$^{-1}$)
\( \nabla \cdot U' \) 

**300 hPa Vertical Velocity Anomaly (Pa s\(^{-1}\))**

-2 \times 10^{-6}

**150 hPa Divergence Anomaly (s\(^{-1}\))**

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

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

$R^2 = 0.02$

$R^2 = 0.52$

$R^2 = 0.78$

$R^2 = 0.55$
Vertical Velocity Anomaly (Pa s$^{-1}$)

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

$R^2 = 0.02$

$R^2 = 0.52$

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Conclusions
1. Variability in stratiform elements is a key part of the evolution of the cloud population during an MJO episode.
2. Humidity anomalies at various levels and depth of convection increase rapidly at MJO convective onset.
3. ~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.
5. Anomalies of vertical velocity are coupled with divergence and circumnavigate tropics.

6. MJO convective onset occurs when UT upward motion anomaly reaches Indian Ocean.
Suppressed Convection

Enhanced Convection

Tropopause

300 hPa

850 hPa

Warm, moist boundary layer

Surface

Heating rate (K day\(^{-1}\))

Pressure (hPa)
End
Adames and Wallace (2014)
Conclusions