Convective Characteristics of the MJO Observed by Shipborne Radar during DYNAMO

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Hypotheses and Motivation

“Discharge-Recharge” MJO onset theory!

DYNAMO Hypotheses

Hypo. I: MJO convective envelop only develops when the moist layer is deep enough;

Hypo. II: Specific convective populations at different stages are essential for MJO initiation;

Hypo. III: Air-sea interaction plays very important roles;

Our goal: Examine convective population across MJO cycle, and link to environment transitions (e.g., moisture and SST).
Shipboard Operation of the NASA/TOGA Radar

DATA
~3 months (24/7) of radar measurements, Sounding, SST, and GLD360 Lightning

R/V Roger Revelle, SIO

Photo courtesy of T. Lang
Two MJO Definitions

Global Definition
WH 04 (RMM1, RMM2)

Local Definition
TRMM Rainfall

R/V Revelle Operating Days, by MJO Phase

Regional Mean TRMM Daily Rainfall

P 2-3, Active in Indian Ocean

Day 0: Rainfall Max
MJO progress consistently in both index!

WH phase 2 corresponds to rainfall maxima!
Overview: Conv. Properties and Environments

1. In phase: Echotop (20dbz) 
   RH, Rainfall, Strat. Rain.

2. In phase: Echotop (30dbz) 
   SST, Lightning, CAPE

How does convective population vary?
1. Driest period: *Phase 5-6*
2. Lower-level moistening: *Phase 7-8*
3. Upper-level moistening: *Phase 1-2*
4. Most moist: *Phase 3*
5. Upper drying: *Phase 4*
Cloud Population: Radar Features

20-dBZ radar clusters

Max Height (20, 30, 40 dBZ)

Conv./Strat. Info.

Feature Size Info.

Lightning Info.

Rain Rate Info.
Overall Statistics of Cloud Population

DYANMO vs. TRMM, and TOGA-COARE

PF Population, Feature SIZE

PF Population, 20dBZ HEIGHT

- DYNAMO_TRMM
- DYNAMO_TOGA
- TOGA_TRMM
- TOGA_TOGA
Precipitating Cloud Population

Small (< 200), Medium (200-1000), MCS (> 1000 km$^2$)
Shallow (< 5 km), Middle (5-8 km), Deep (> 8 km)

Total popu: Phase 2
Most inactive: Phase 5-6
Deep Conv.: Phase 1
Large MCSs: Phase 2-3
Population Breakdowns by height and intensity

(a) SHALLOW (20dBZ < 5km)

(b) MIDDLE (20dBZ 5-8km)

(c) DEEP (20dBZ > 8km)

(d) INTENSE (30dBZ > 8km)

“Vertically” intense: Max. at Ph. 1

Shallow to Middle feature always dominate

“Building-Block” concept (Mapes et al. 2006)

DeMott and Rutledge 1998, TOGA COARE
Horizontal Precipitating Area

Ph 2-3 have largest area;

100% increase from Ph 1 to 2;

100% decrease from ph 3 to 4

Mainly due to strat. growth!
Joint PDF of Horizontal Rain Cover (> 20dbz)

- **Top heavy** (deep)
- **Mid heavy** high % of Strat. Rain
- **Bot. heavy** (shallow)
“Typical” Case in Each MJO Phase

Phase 1
Time: 2011, 1017, 0920UTC; ASL: 2.0km

Phase 2
Time: 2011, 1023, 1020UTC; ASL: 2.0km

Phase 3
Time: 2011, 1128, 1810UTC; ASL: 2.0km

Phase 4
Time: 2011, 1221, 1030UTC; ASL: 2.0km

Phase 5-6
Time: 2011, 1227, 0050UTC; ASL: 2.0km

Phase 7-8
Time: 2011, 1012, 0920UTC; ASL: 2.0km
Conv. Statistics by Local MJO Definition

Peaks On/After Rain Max:
- Total Clouds
- MCS Popu.
- Precip. Area

Peaks Prior to Rain Max:
- Deep Conv.
- Intense Conv.
- Lightning