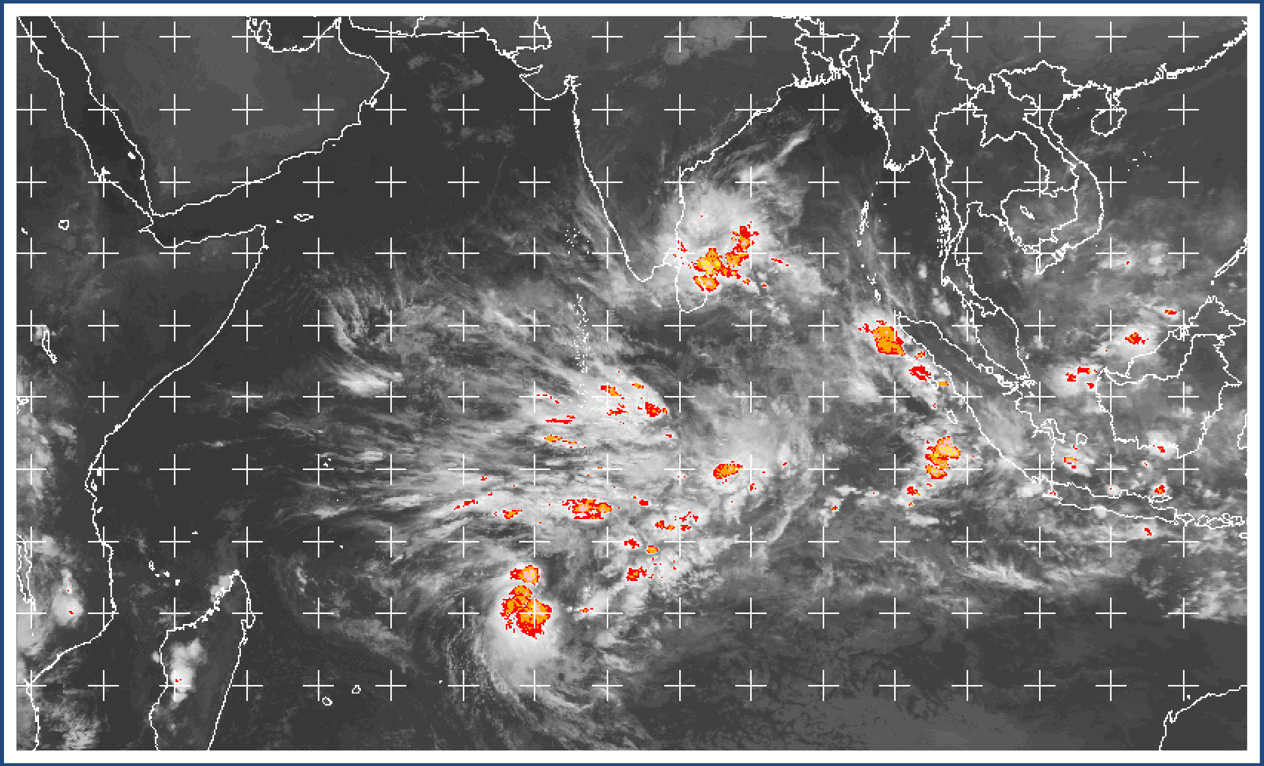
AMIE/CINDY/DYNAMO:

Observations of the Madden-Julian Oscillation for Cloud Modeling Studies



C. Long, R. Houze, S. Medina, C. Zhang

ASR Science Team Meeting, Bethesda, MD, 17 March 2010

AMIE

<u>A</u>CRF <u>M</u>JO <u>I</u>nvestigation <u>E</u>xperiment

<u>Two Components:</u>

- AMIE-Manus
- AMIE-Gan (with AMF2)

DYNAMO:

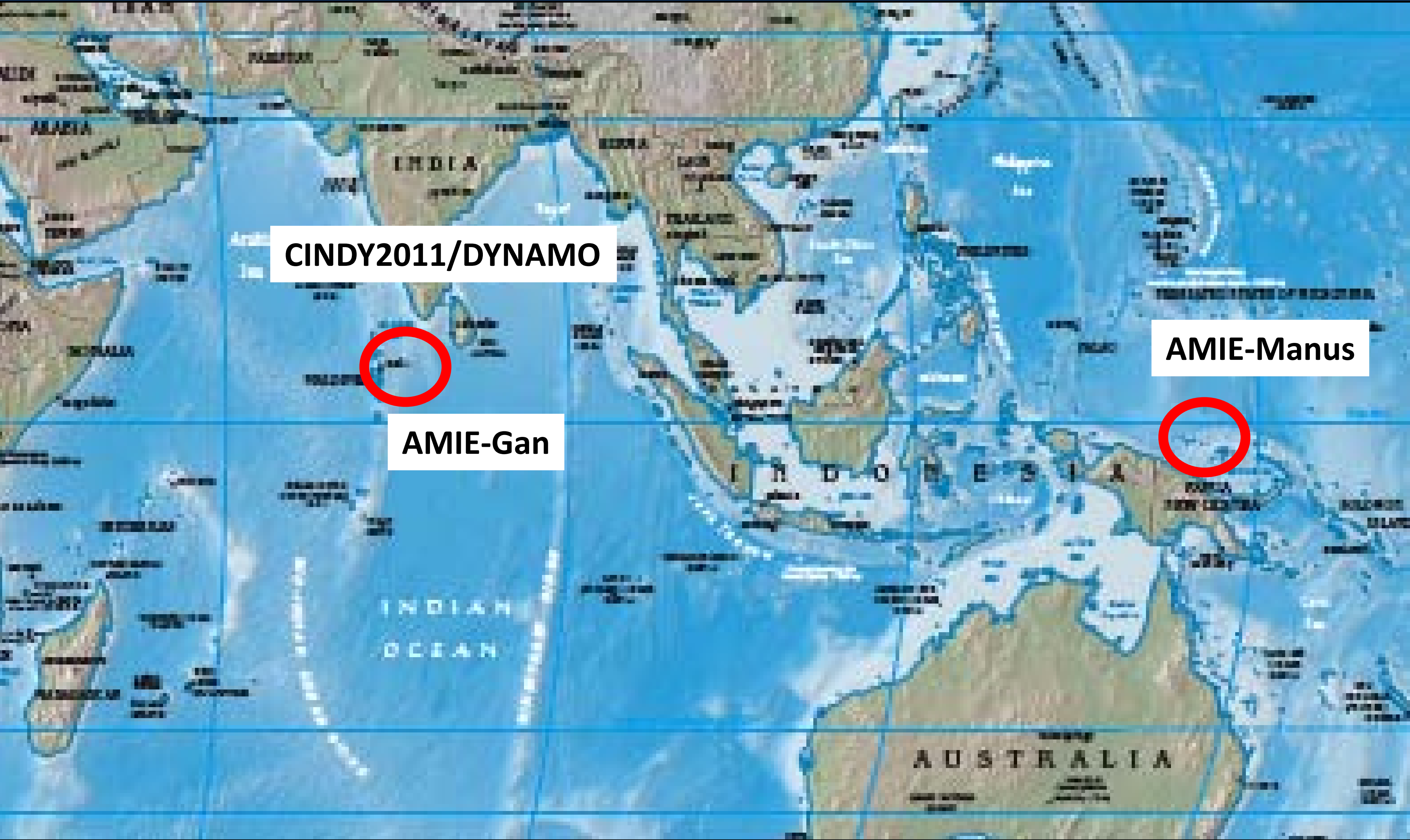
Dynamics of the Madden-Julian Oscillation

CINDY:

Cooperative Indian Ocean Experiment of Intraseasonal variability

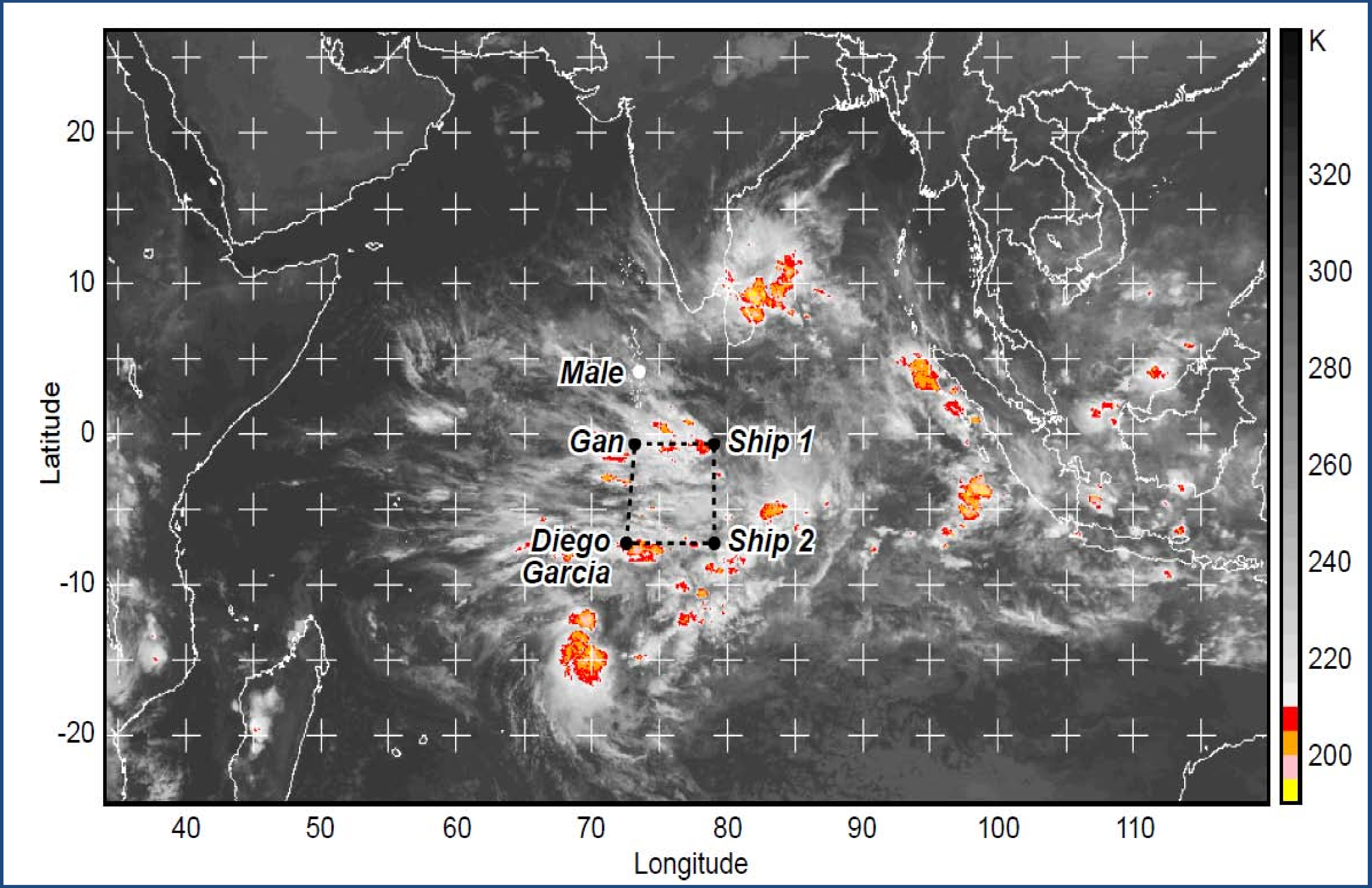
October 2011-January 2012

AMIE and CINDY/DYNAMO Sites



DYNAMO

A project to understand MJO initiation in the Indian Ocean



DYNAMO

GOAL:

- Improve the understanding of MJO **initiation** processes

OBJECTIVES:

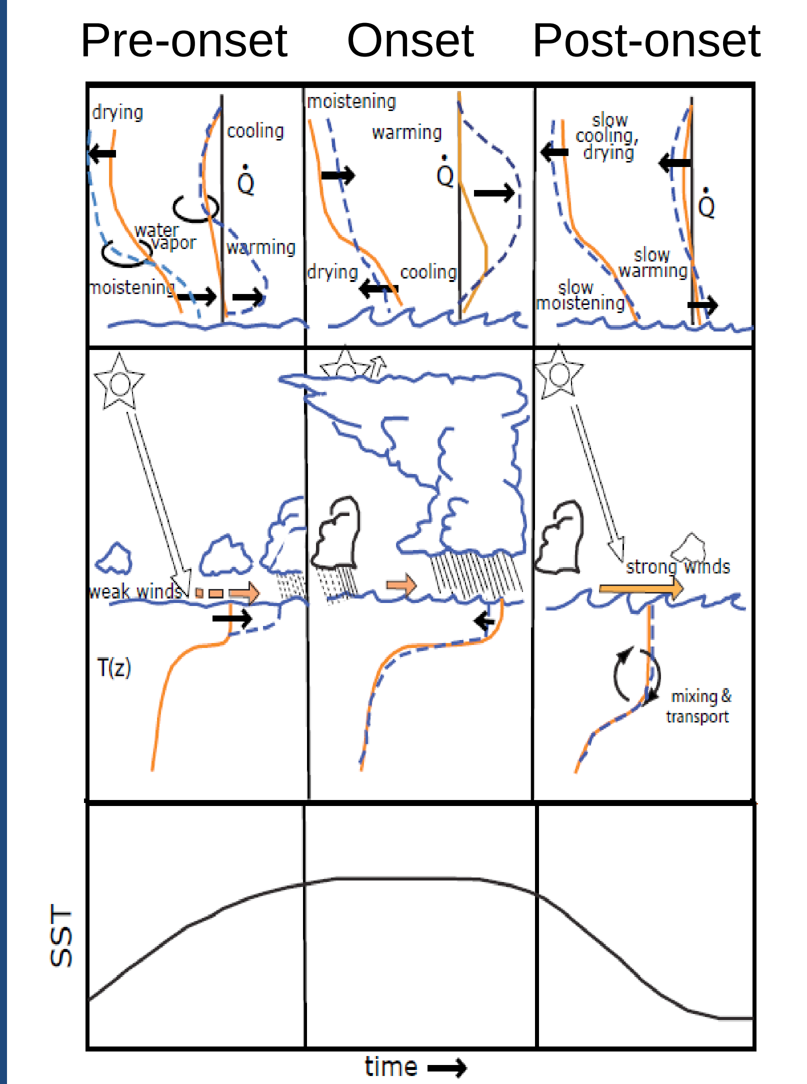
- **Collect observations in the equatorial Indian Ocean needed to understand MJO initiation**
- Identify critical deficiencies in numerical models responsible for the low prediction skill of MJO initiation
- Provide observations that will assist in the improvement of model parameterizations
- Provide information that will enhance MJO monitoring and climate predictions on intraseasonal timescales

Schematic conceptual model for MJO initiation at a fixed location in the Indian Ocean

Tendency of moisture and diabatic heating profiles

Clouds, surface winds, and upper ocean temperature profiles

SST evolution

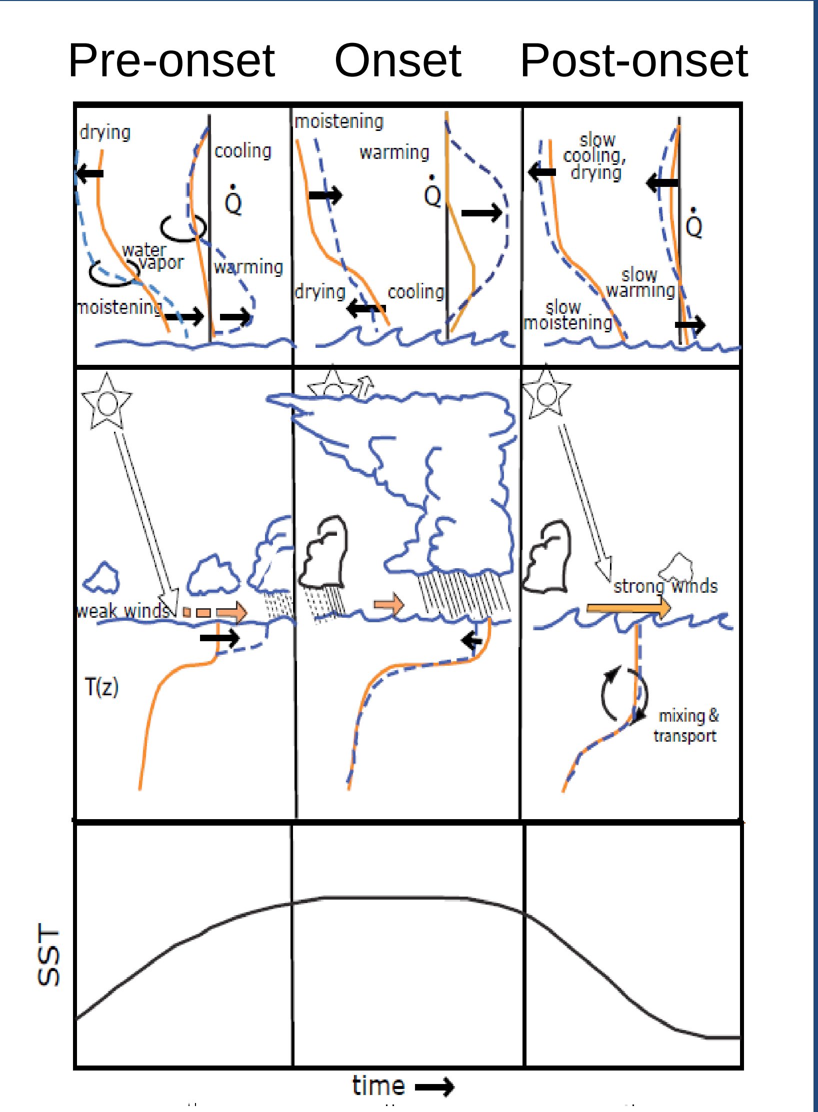


After Stephens et al. (2004)

Schematic conceptual model for MJO initiation at a fixed location in the Indian Ocean

DYNAMO Question:

What are the mechanisms that initiate, sustain, and cause the demise of each of these stages?



After Stephens et al. (2004)

The DYNAMO Hypotheses emphasize three aspects highlighted in the conceptual model:

1. Interaction between convection and environmental moisture
2. Evolution of cloud population
3. Air-sea interaction

DYNAMO Hypotheses

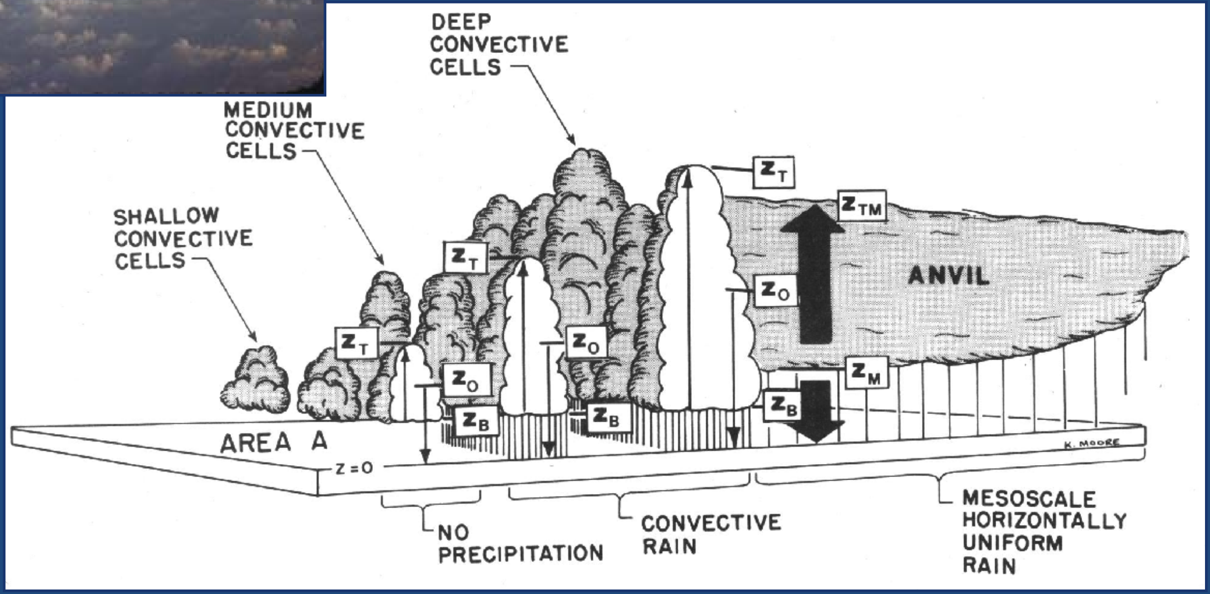
1. Deep convection can be organized into an MJO convective envelope only when the moist layer has become sufficiently deep over a region of the MJO scale
2. Specific convective population at different stages are essential to MJO initiation
3. Upper ocean processes play essential roles in MJO initiation in the Indian Ocean

Radar array in relation to DYNAMO Hypotheses

1. Deep convection can be organized into an MJO convective envelope only when the moist layer has become sufficiently deep over a region of the MJO scale
2. Specific convective population at different stages are essential to MJO initiation
3. The barrier layer, wind- and shear-driven mixing, shallow thermocline, and mixing-layer entrainment all play essential roles in MJO initiation in the Indian Ocean

Objective of the DYNAMO radar observations:

To fully characterize the ensemble of convection associated with each stage of MJO initiation



Houze et al. (1980)

Role of radar array in DYNAMO

Comprehensive description of convective population

to test DYNAMO hypotheses

Statistics of convective prop

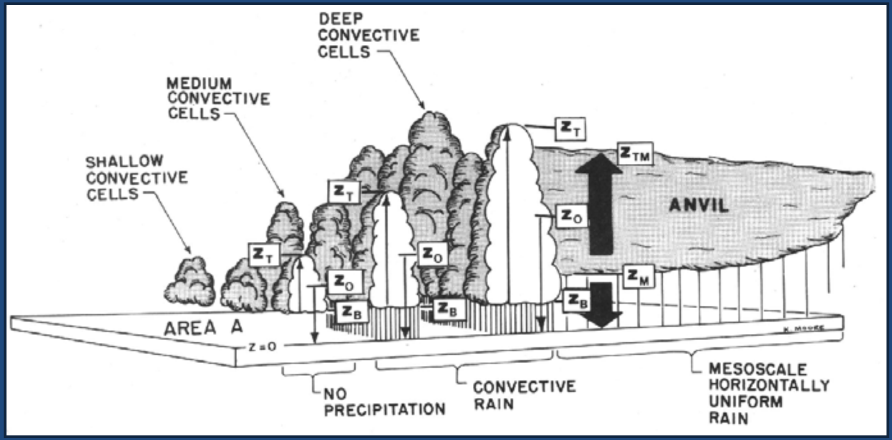
echo dimensions
types of hydrometeors
cloud internal air motions
propagation characteristics
non-precipitating clouds
convective and stratiform precip

Environment moisture

in relation to clouds!

Use a “supersite” approach

range of wavelengths
different scan strategies



Radar array

RV Revelle and RV Mirai:

- Scanning C-band and vertically-pointing W-band radars

Gan “Supersite”:

- DOE AMF2 radars: Could include scanning polarimetric X- and K_a-band radars and a vertically pointing W- or K_a-band radar
- Texas A&M SMART-Radar: Scanning C-band
- NCAR S-Polka radar: Scanning, polarized, dual wavelength (K_a- and S-band)

Strengths of individual radars

AMF2

- **Vertically pointing W-band Doppler radars (also in ships):**
  - Non-precip & precip clouds
  - Light rain
  - Radiative heating
- **X- and K_a-band polarimetric Doppler radars:**
  - Air motions in clouds
  - Liquid water

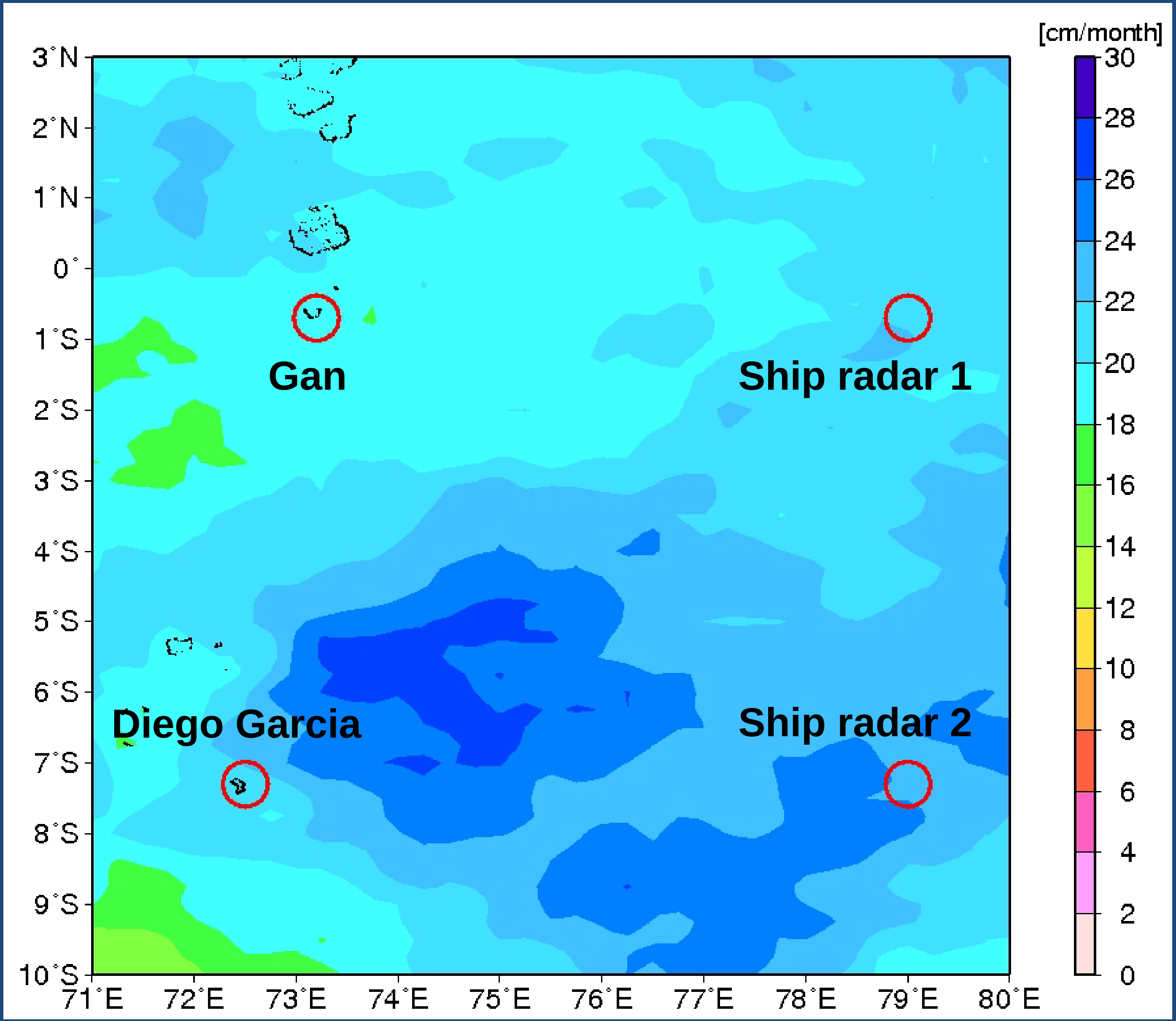
SMART-R and ships

- **C-band Doppler radars:**
  - Convective and stratiform precipitation
  - Mesoscale air motions

S-PolKa

- **S- and K_a-band polarimetric Doppler radar:**
  - Hydrometeor type
  - Non- precip & precip clouds
  - Air motions
  - Humidity profile in relation to clouds
  - Boundary layer

DYNAMO observing network and TRMM 3B43 Oct-Dec precipitation climatology



Geographic setting

Installation sites suggested by survey team

Operation of radars

- The plan is to operate all the radars 24 hours per day, with a mix of attended and unattended operations.
- The operation of the scanning radars will be coordinated to optimize the collected dataset.

Project Timeline

1-OCT	1- NOV	1-DEC	1-JAN	1-FEB	1-MAR	1-APR

EOP

AMF2, SMART-R, Darwin, Manus

IOP

S-PolKa, RV Revelle, RV Sagar-Kenya and RV Southern Surveyor (plus EOP observations)

SOP

RV Mirai (plus IOP observations)

End

Role of radar array in DYNAMO

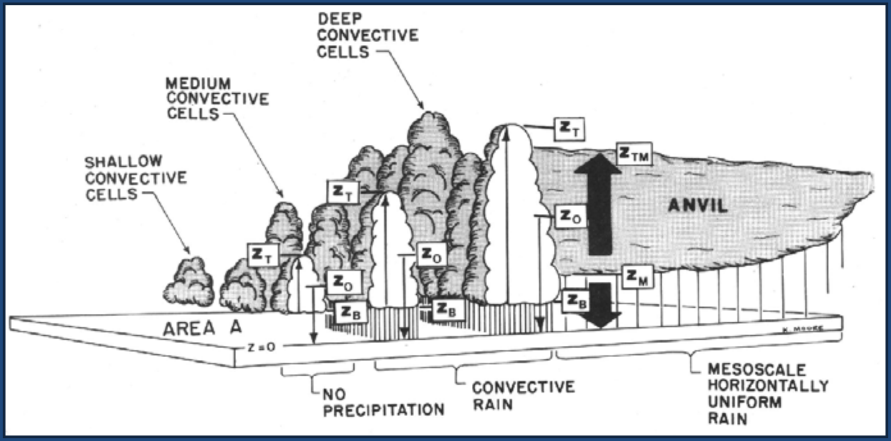
- To observe the **full spectrum** of convection (e.g., radar echoes areas and heights, types of hydrometeors, cloud internal motions, propagation characteristics, separation into precipitating and non-precipitating clouds, convective and stratiform partition, relationship with **environment moisture**, etc.)

- The radar array will measure these aspects **statistically** to determine how the cloud population evolves as the MJO transitions between the pre-onset, onset, and post-onset stages

- Surface-based radars are the only instruments that can routinely observe these features in **3D over large spatial and temporal domains**

- The diversity in the size and intensity of convection that characterizes all the MJO stages implies that **any individual radar can only document a subset of the convective spectrum**

- The DYNAMO approach is to use radars over a **range of wavelengths**, each contributing uniquely to diagnosing the convective populations and its properties



Houze et al. (1980)

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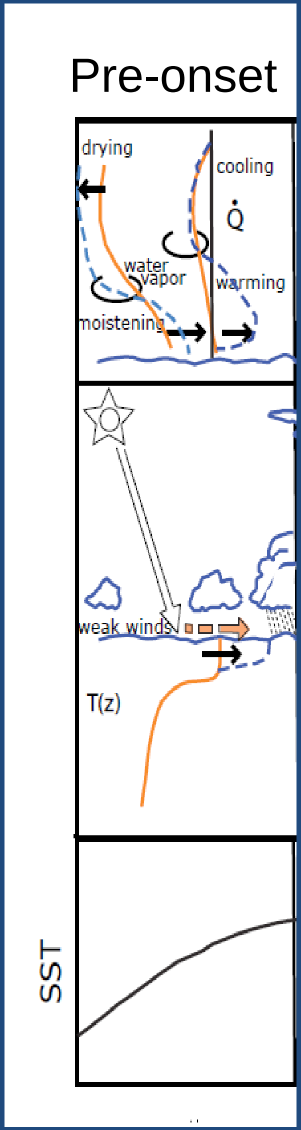

- Characterized by non-precipitating and precipitating shallow clouds or by scattered precipitating clouds
- Diabatic heating is concentrated in the lower troposphere
- Low-level moisture increases slowly due to shallow cloud detrainment and moisture convergence
- Upper ocean heat content and SST increase gradually as a result of strong solar heating
- The atmosphere is gradually destabilized

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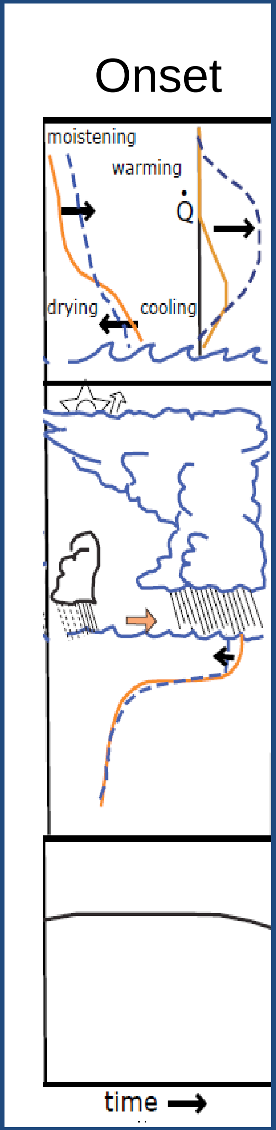

- Characterized by various types of convective clouds, including deep convection
- Diabatic heating peak is in the upper troposphere
- Moistening of the upper atmosphere and low-level drying
- SST decreases slightly due to moderate surface winds

After Stephens et al. (2004)

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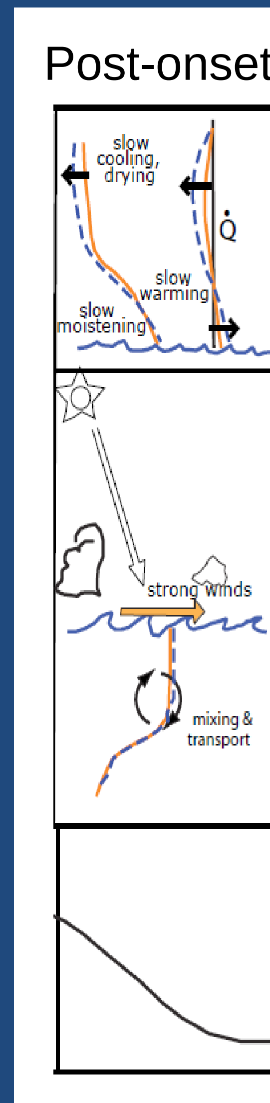

- The envelope of deep convection has moved out of the region toward the east
- Strong surface westerly winds and surface evaporation lead to low-level moistening
- Strong ocean mixing produces cooling at the bottom of the mixed layer and the upper ocean heat content and SST become anomalously low
- This condition persists for a long time, until this stage gradually transforms into the pre-onset stage

After Stephens et al. (2004)