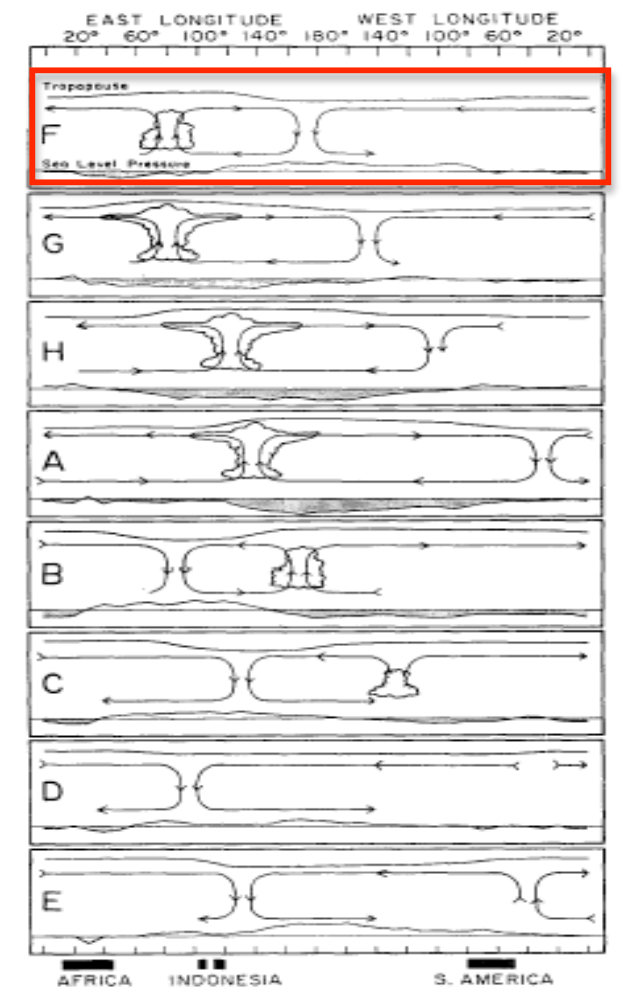
# DYNAMO
# (Dynamics of the MJO)

*The US Participation in CINDY2011*

(Cooperative Indian Ocean Experiment on Intraseasonal Variability in Year 2011)



## Background I: Importance of the MJO

*Societal benefit:*

- monsoons, ENSO
- teleconnections, extratropical circulation/weather
- extreme events (flood, tropical storm/cyclones)
- seamless weather-climate prediction (2-4 weeks)

*Additional scientific values:*

- Indian Ocean Dipole and Indonesian Throughflow
- atmospheric and oceanic chemistry and biosystem (ozone, $CO_2$, aerosols, chlorophyll)
- global angular momentum, Earth's rotation rate, length of the day

# Background II: Challenges presented by the MJO

- inability to consistently/knowingly reproduce the MJO in global weather and climate models

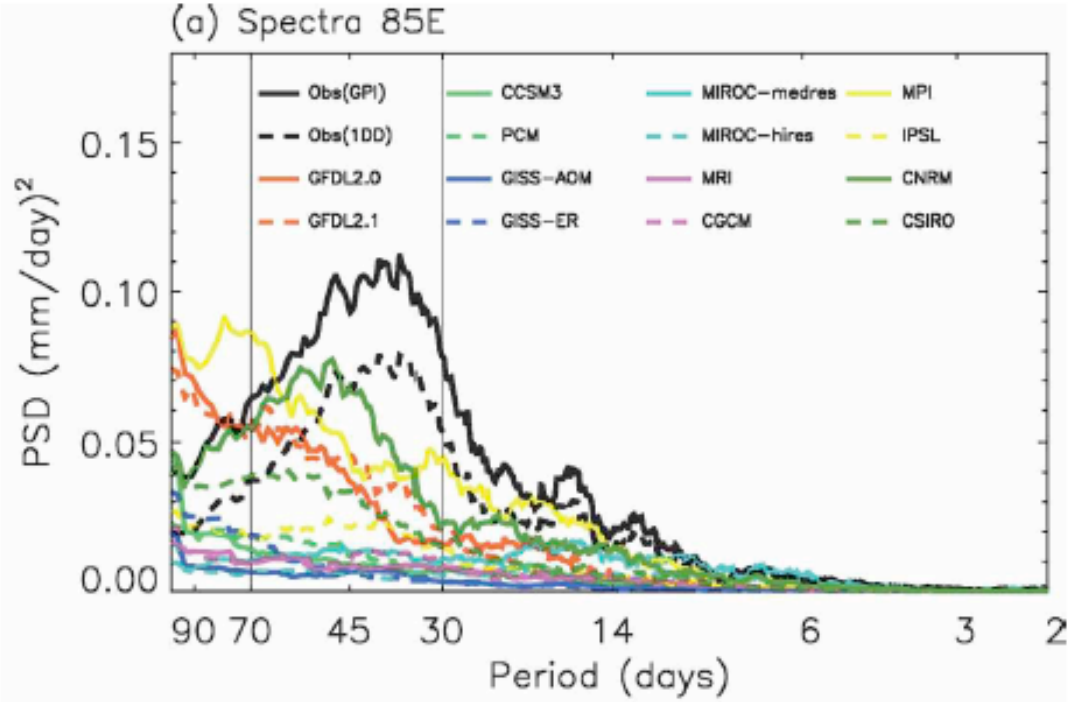
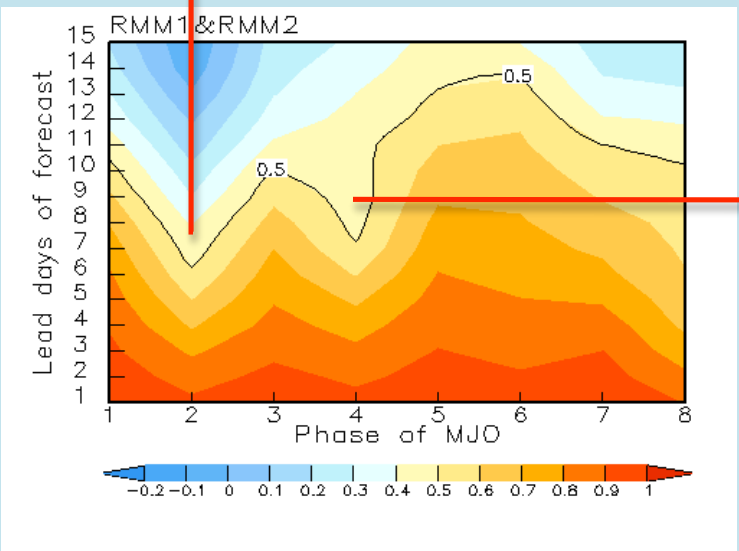



FIG. 12. Spectrum of the eastward wavenumber 1–6 component of equatorial precipitation (5°N–5°S) at 0°, 85°E for two observational datasets and 14 models: (a) raw and (b) normalized spectrum. Frequency spectral width 1/100 cpd.

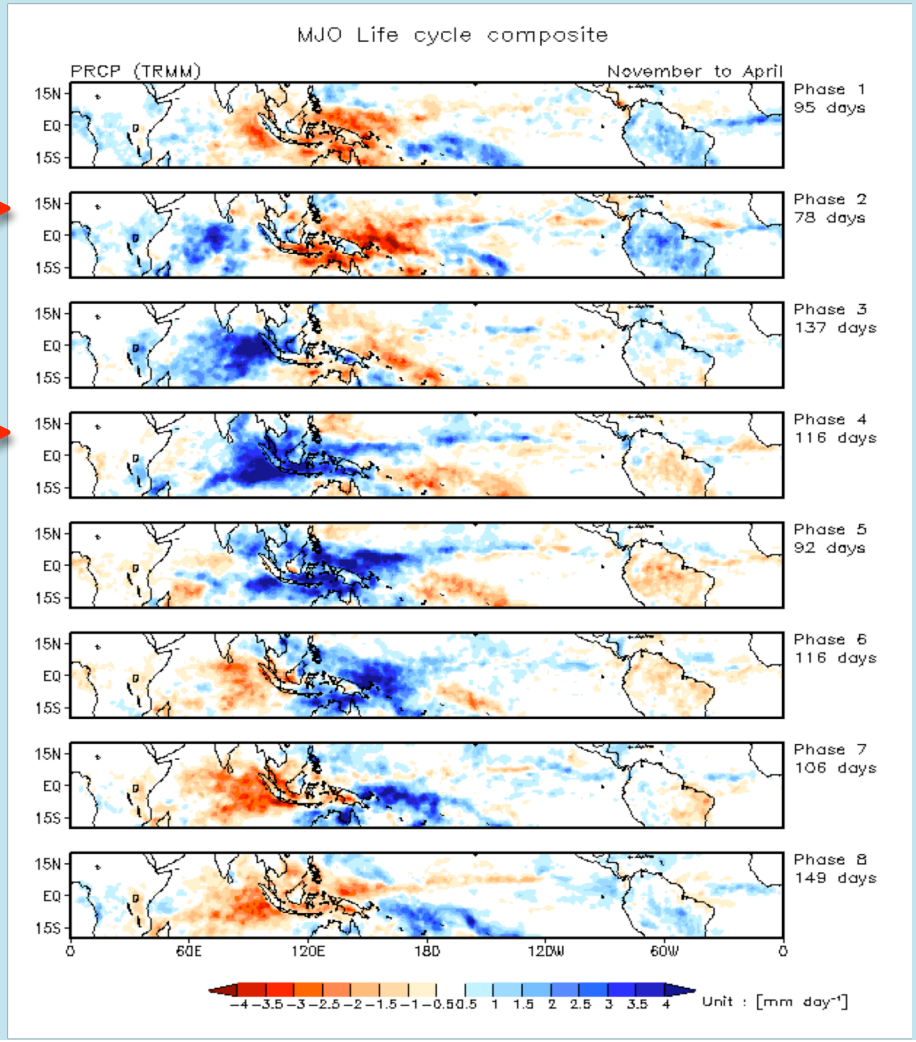
Lin et al 2006

# Background II: Challenges presented by the MJO

- limited intraseasonal prediction skill (< 15 days) – particularly low during the initiation of the MJO in the Indian Ocean and during the passage of the MJO over the Maritime Continent.




Correlation between predicted (by CFS) and observed MJO indices (Courtesy of Jon Gottschalck and Qin Zhang)



# Hypotheses on MJO Initiation

A <u>Dynamical (or external) Initiation</u>: Perturbations from either the extratropics or upstream (west) lead to changes in the large-scale circulation and/or thermodynamics over the tropical Indian Ocean. Deep convection subsequently organizes into large-scale patterns that feed back to the large-scale circulation, giving rise to the MJO.

B <u>Convective (or local) Initiation</u>: The MJO is initialized over the tropical Indian Ocean through local interaction between the large-scale circulation and convective activity that self-organizes into large-scale patterns through atmospheric energy buildup, multi-scale interaction, air-sea interaction, or other processes.

## Scientific Rationale for DYNAMO/CINDY2011

• Hypothesis testing and model improvement requires continuous and simultaneous time series of
– *tropospheric heating and moistening profiles*
– *structures and evolution of cloud and precipitation systems (shallow, deep, stratiform)*
– *air-sea fluxes, turbulence and mixing in the atmospheric boundary layer and upper ocean*
<u>which are available only from field campaigns</u>;

• No such time series in the equatorial Indian Ocean region is currently available

# DYNAMO Objective:

Through an integrated modeling-observation-forecast approach, to

(a) collect in situ observations from the equatorial Indian Ocean that are urgently needed to advance our understanding of the processes key to MJO initiation and to facilitate testing existing hypotheses and forming new ones on these processes;
(b) identify critical deficiencies in current numerical models that are responsible for the low prediction skill and poor simulations of MJO initiation and to assist the broad community effort of improving model parameterizations.

•*Modeling* – Hypothesis testing, field experiment design, parameterization improvement

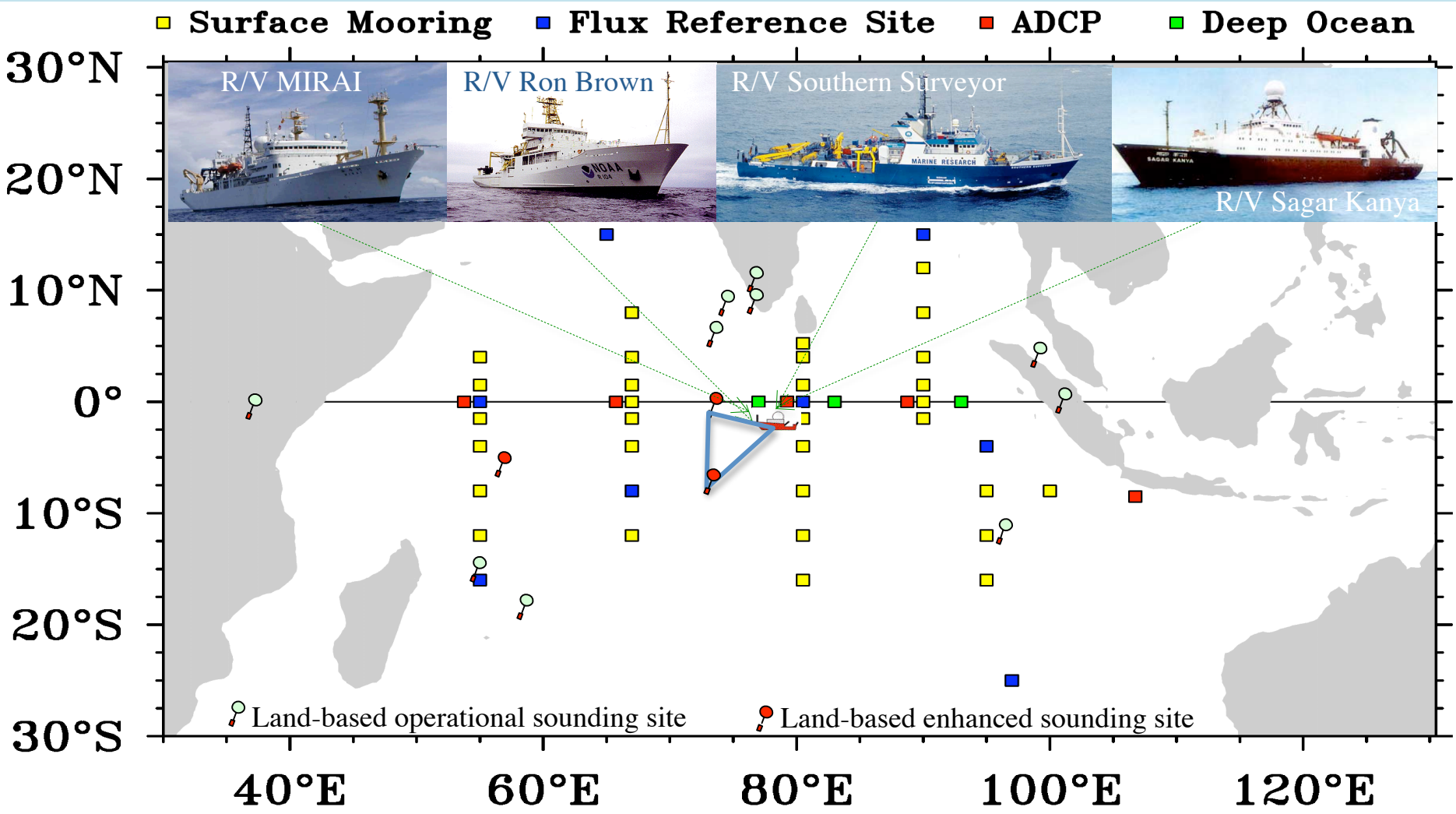
• *Observations* – field campaign in 2011-2012 (following slides)

• *Forecast and Application* – measure of prediction skill and its improvement, intraseasonal monitoring and prediction capacities for risk management and decision making

Intensive Observation Period (3-4 months): Sounding-Radar Array (a triangle option illustrated)

Extended Observation Period (6 months) : an island radar-sounding site, enhanced RAMA moorings, drifters

Long Term Monitoring: RAMA, IndOOS, operational soundings



# Program Synergy


AMIE (late 2011 – early 2012): radiation, cloud, atmospheric profiles

HARIMAU (2004 - ?): cloud, atmospheric boundary layer

PAC$^3$E-SA/7SEAS (2011): aerosol, convection

ONR Air-Sea (late 2011): meso-scale air-sea-wave interaction

CINDY2011/DYNAMO (September 2011 – January 2012): atmospheric heating and moistening profiles, cloud and precipitation, air-sea interaction, aerosol

# Expected Outcome of DYNAMO

(i) a unique in situ data set available to the broader research and operations communities,

(ii) advancement in understanding of the MJO dynamics and initiation processes,

(iii) identification of misrepresentations of processes key to MJO initiation that are common in models and must be corrected to improve MJO simulations and predictions,

(iv) provision of baseline information to develop new physical parameterizations and quantify MJO prediction model improvements, and

(v) enhanced MJO monitoring and prediction capacities that deliver climate prediction and assessment products on intraseasonal timescales for risk management and decision making.