Towards Advancing the MJO Forecasting in the NGGPS

(A R2O Project Contributing to NGGPS)

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NOAA/NCEP/EMC

Cecelia Deluca
NOAA/ESRL

NOAA/NCEP, Aug. 02, 2017

Objective and Approaches

The proposed study aims to better understand the impacts of cumulus parameters and underlying SST conditions and to improve the MJO and 1-30-day weather forecasting in the prototype NGGPS system (and GFS/GEFS).

Three steps are planned to achieve the proposed goal:

- ***Understand the impacts of cumulus parameters and SST conditions on the MJO and 1-30-day weather forecasting;***

- ***Document the systematic SST errors in the NGGPS: mean state, interannual variability, intra-seasonal variability and diurnal cycle;***

- ***Understand the causes of systematic SST errors and assess their impacts on the MJO and 1-30-day weather forecasting.***

UH Sub-seasonal Forecasting System

Global Model Physics

- Shallow convection (Fu et al. 2008)
- Stratiform rainfall (Fu and Wang 2009)

Sub-seasonal Prediction

- Multi-Model Ensemble (MME) (Fu et al. 2013)

Sea Surface Conditions

- Air-sea Coupling (Fu et al. 2003; Fu and Wang 2004; Fu et al. 2007; 2013)
- Forecasted Daily SST (Fu et al. 2008; Fu et al. 2015)

Initial Conditions

- Nudging strategy and signal-recovering method (Fu et al. 2009, 2010)

http://iprc.soest.hawaii.edu/users/xfu

How will <u>Cumulus Parameterizations</u> and <u>SST Conditions</u> Influence MJO Forecasting in the GFS?

NCEP GFS Forecast Experiments

1. Model
- Atmosphere-only GFS (May 2011 version)
- T126/L64

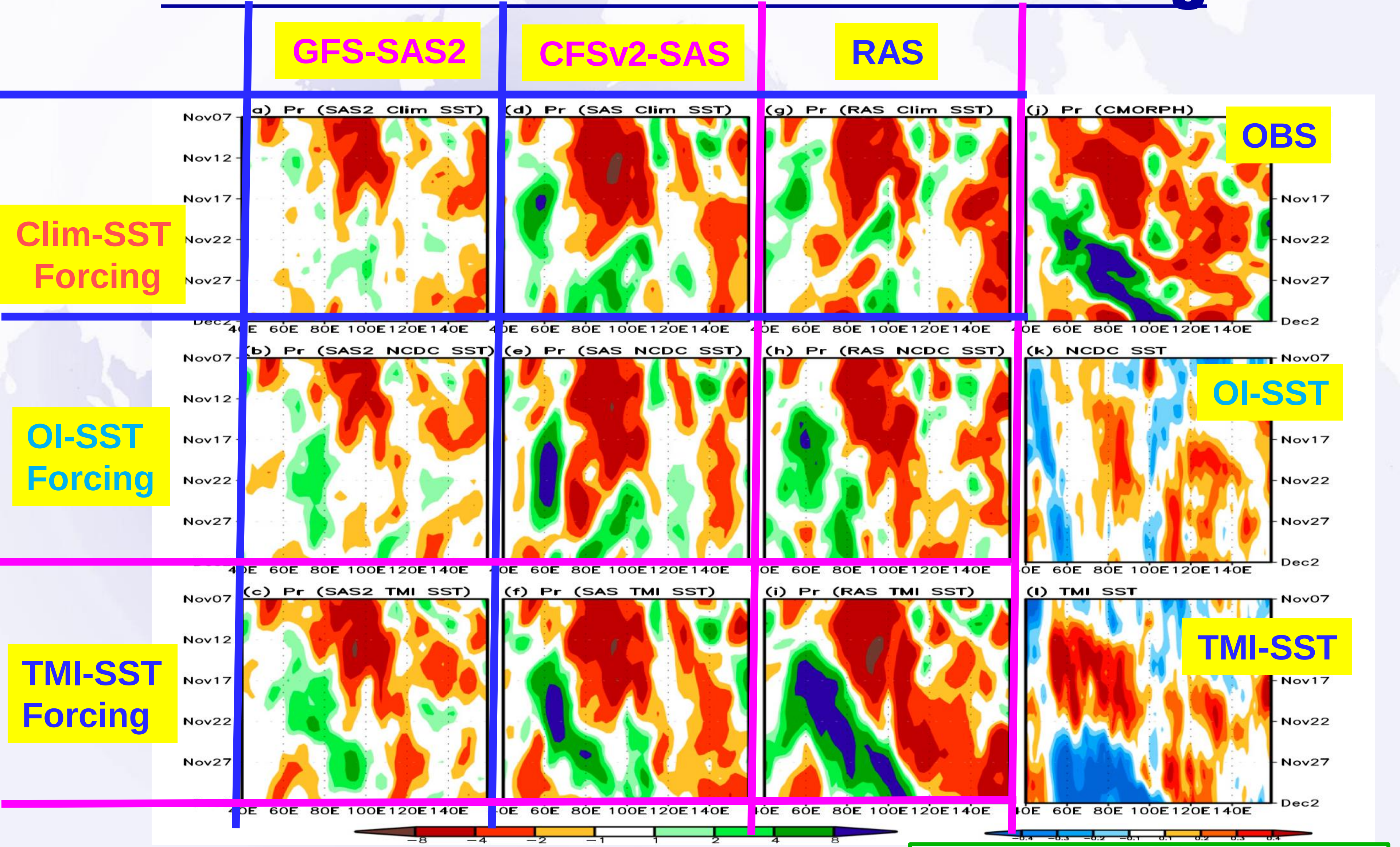
2. SSTs
- Clim (no intra-seasonal SST anomalies)
- NCDC OI analysis (weak intra-seasonal SST anomalies)
- TMI (TRMM Microwave Imager) (strong intra-seasonal SST anomalies)

3. Convection parameterizations
- SAS (Simplified Arakawa Schubert (Pan&Wu 1995)): Operational CFSv2
- SAS2 (Revised Simplified A-S (Han&Pan 2011)): Operational GFS
- RAS (Relaxed A-S (Moorthi and Suarez (1999))

4. Forecast runs
- Initial conditions: CFSR
- Initial 4 times daily: 1 Oct 2011 to 15 Jan 2012 (DYNAMO-IOP: Oct-MJO & Nov-MJO)
- Integrate 31 days

Wang et al. (2015)

Sensitivity of Nov-MJO to Cumulus Parameterizations and SST Forcing



Wang et al. (2015)

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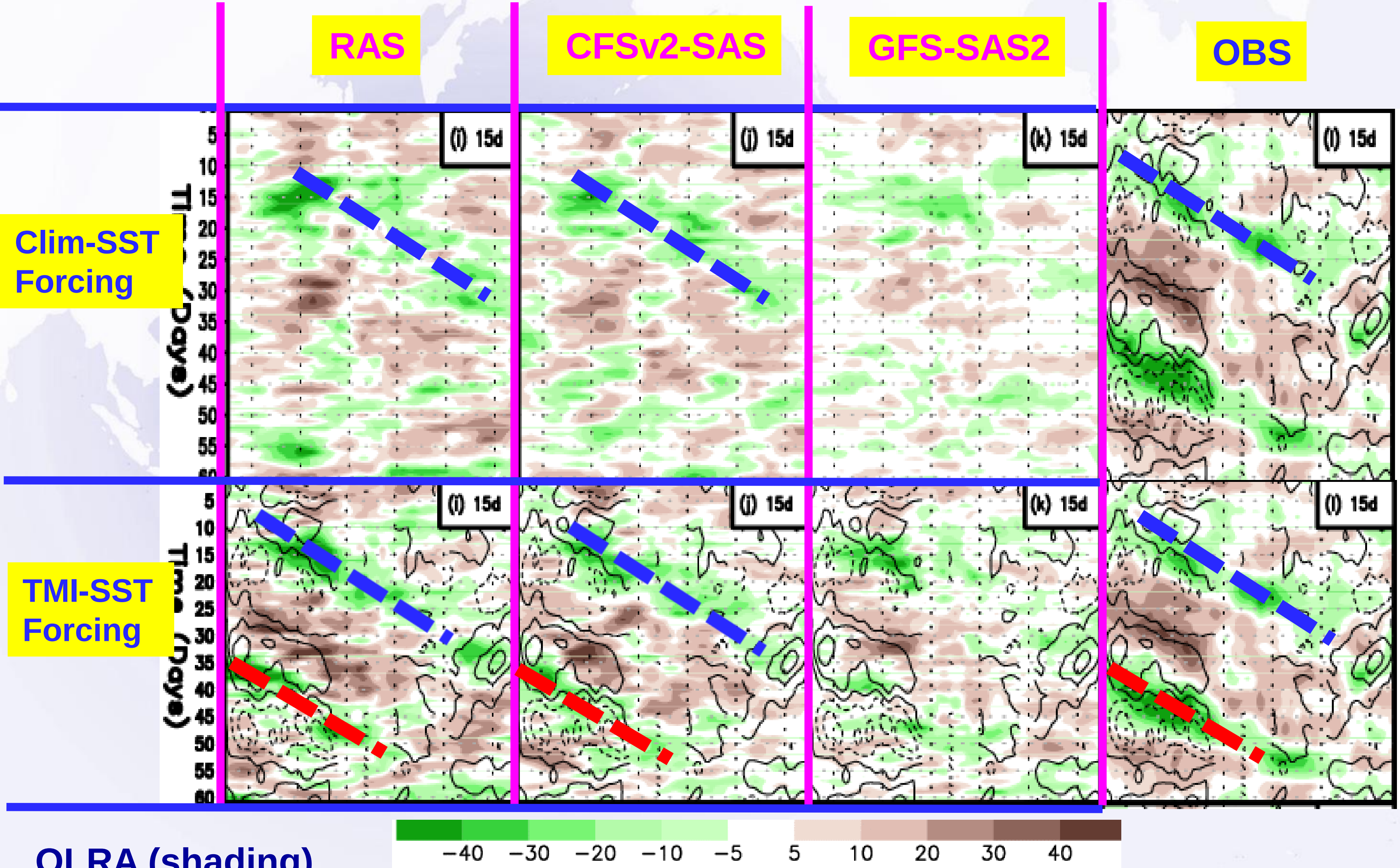
Ocean coupling has stronger influences on some MJOs than on other MJOs

Fu et al. (2015, 2017a)

Forecasting Oct-&Nov-MJO Events During DYNAMO IOP



OLRA (shading)
SSTA (contours, CI: 0.2^{o}C)

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MJO Diversity

Year-around:

- Primary vs. Successive (Matthews 2008)
- Propagating vs. Non-propagating (Kim et al. 2014)
- Coupled vs. Uncoupled (Fu et al. 2015)

Boreal-Winter:

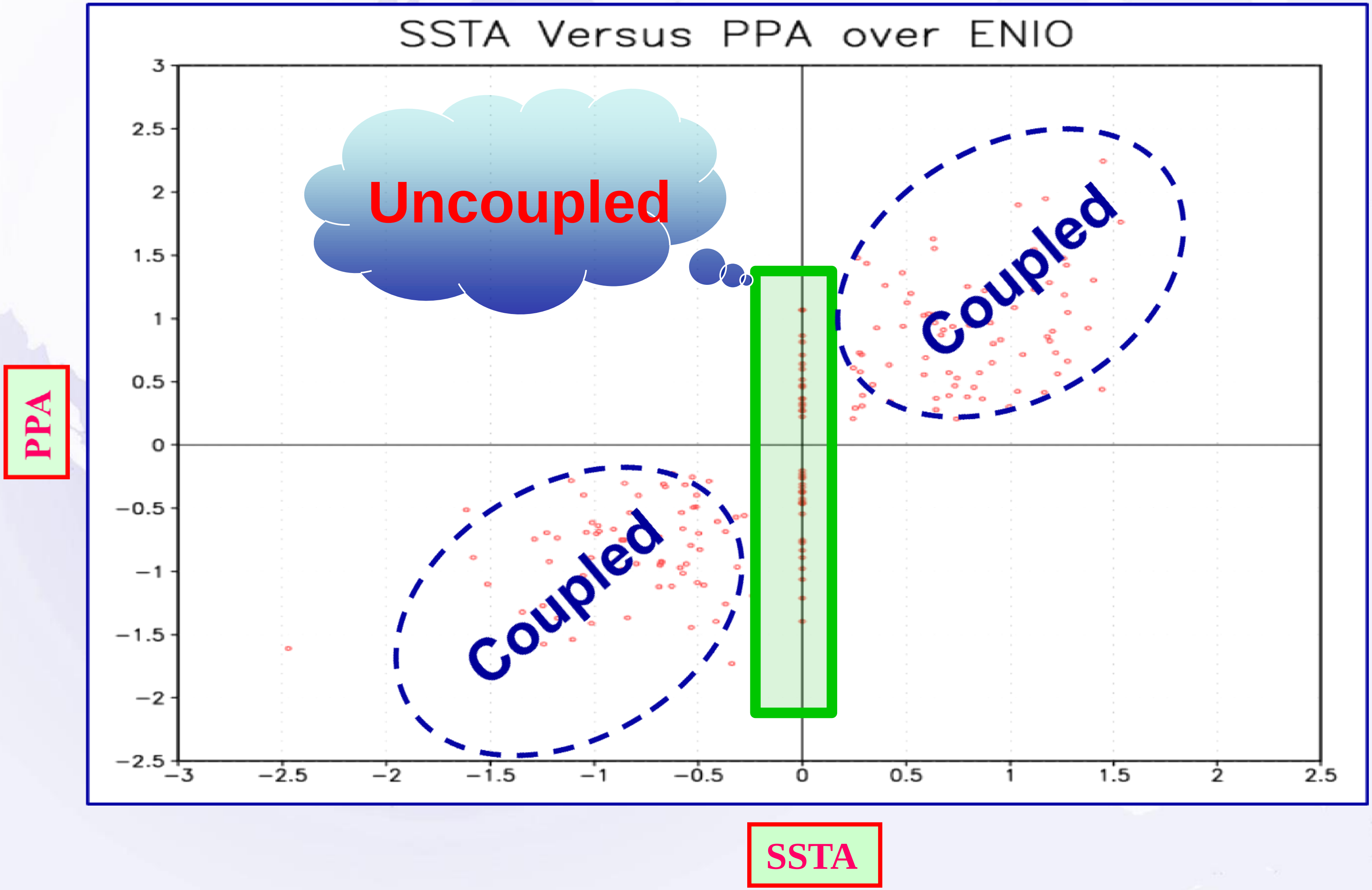
- Three MJO types (Hirata et al. 2013)

During Entire DYNAMO Period (Oct. 01,2011-Mar. 31, 2012)

Five MJO events are observed in which only two of them have robust SST anomalies associated.

- **The October-MJO** is largely controlled by atmospheric internal dynamics.
- **The November-MJO** is strongly coupled to underlying ocean.

Different Air-Sea Coupling Regimes from Long-term Observations



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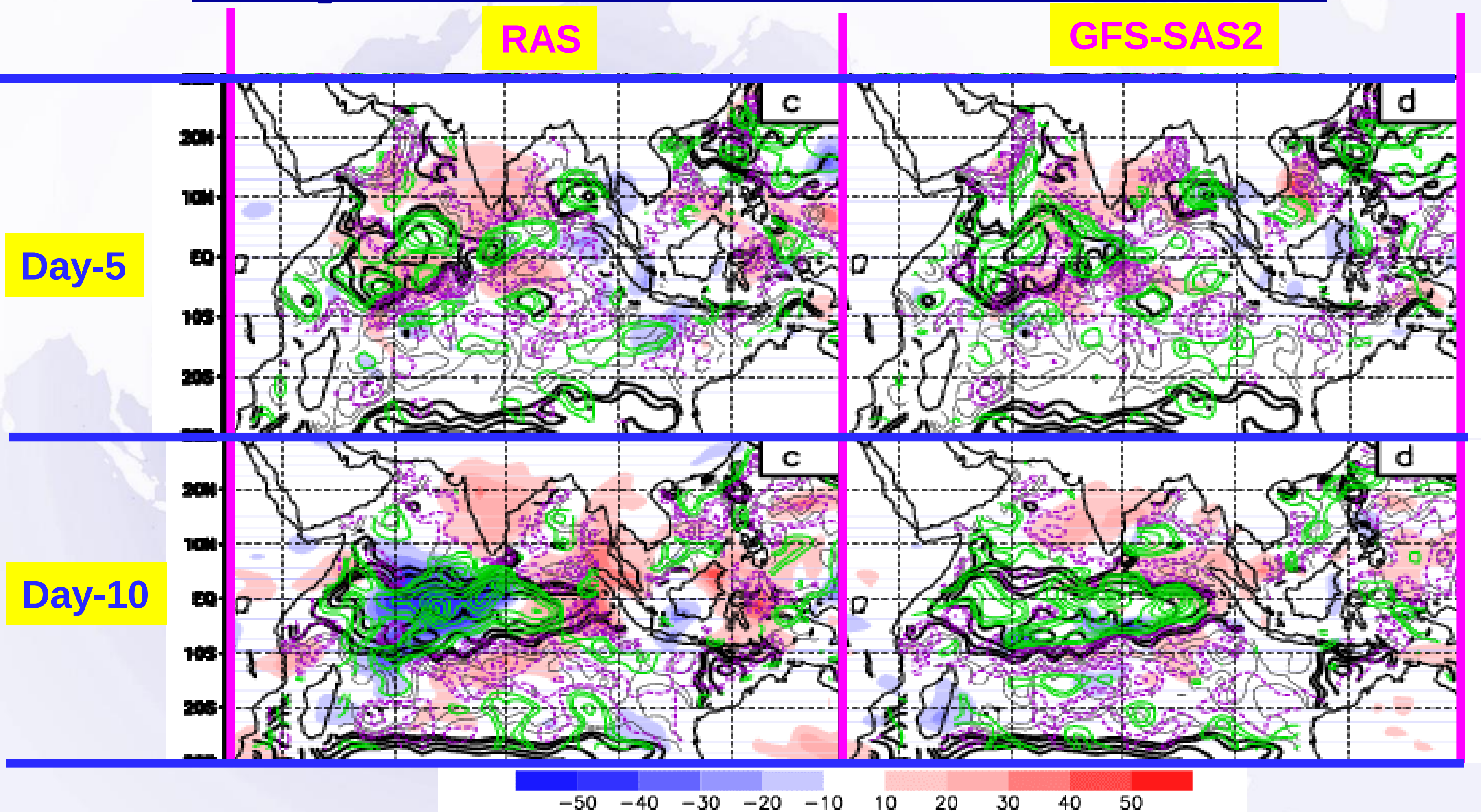
Why are the impacts of SST-feedback on Nov-MJO so different in the RAS and SAS2?

Fu et al. (2017b)

OLR and Surface Convergence in Response to Same SST Anomalies



OLR (shading)

Positive SSTA

Negative SSTA

Convergence

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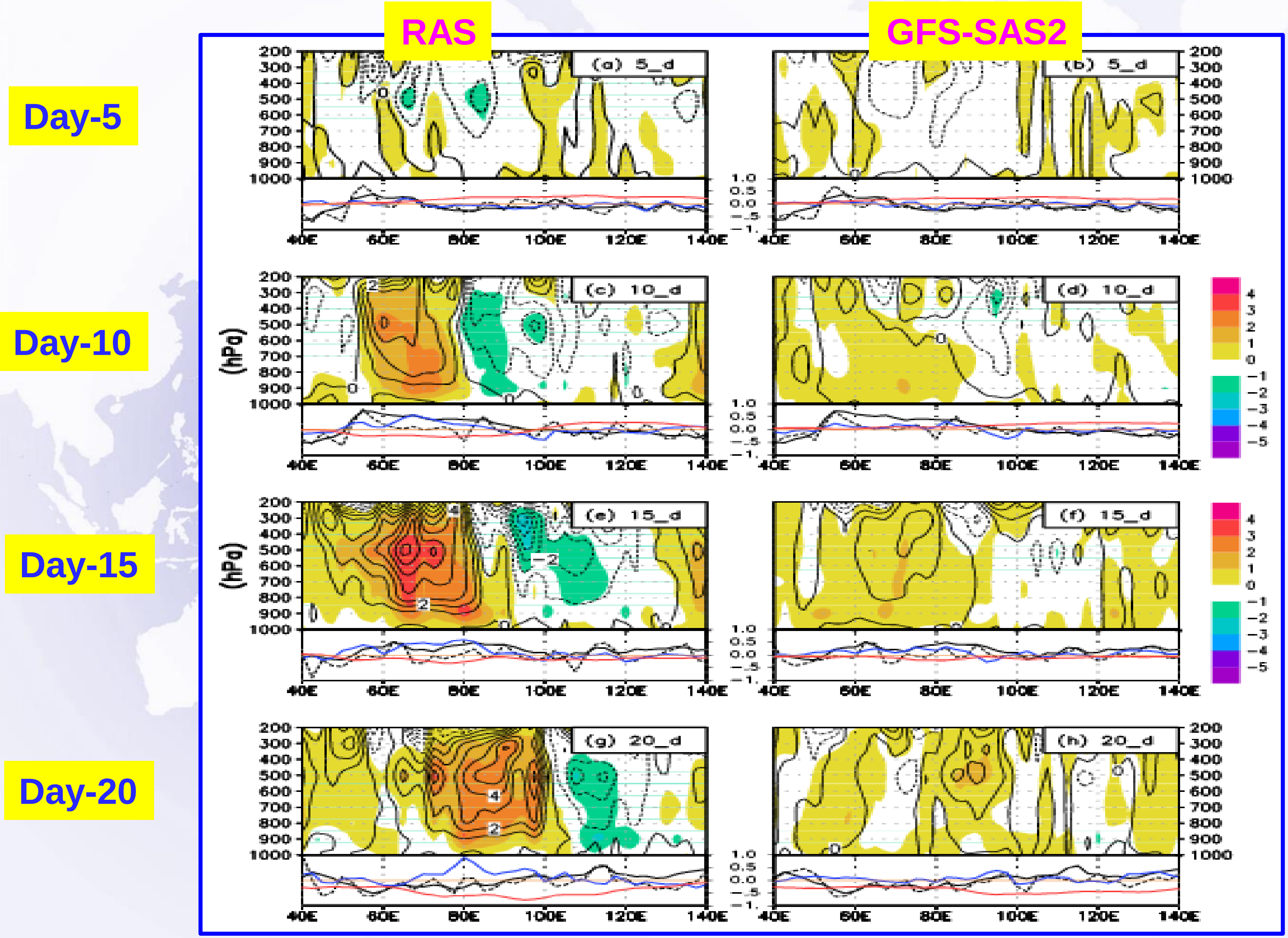
Q1 and Q2 in Response to Same SST Anomalies



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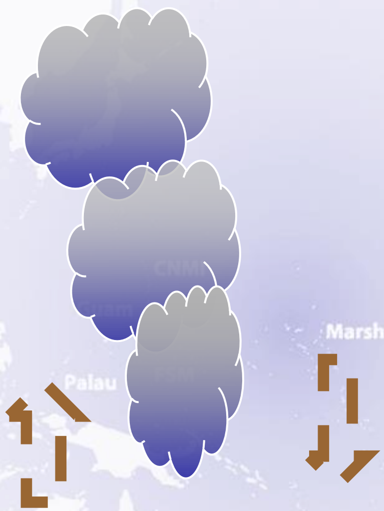
Schematics of SST-Feedback Processes

GFS-SAS2



- Convergence ↑
- Evaporation ↑
- Convective Instability ↑
- **Weak upward-downward feedback**

Positive SSTA

RAS

- Convergence ↑
- Evaporation ↑
- Convective Instability ↑
- **Strong upward-downward feedback**

Positive SSTA

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Three-type
Boreal-summer MJOs

Another example of MJO diversity

Fu et al. (2017c)

Three Different MJO Types

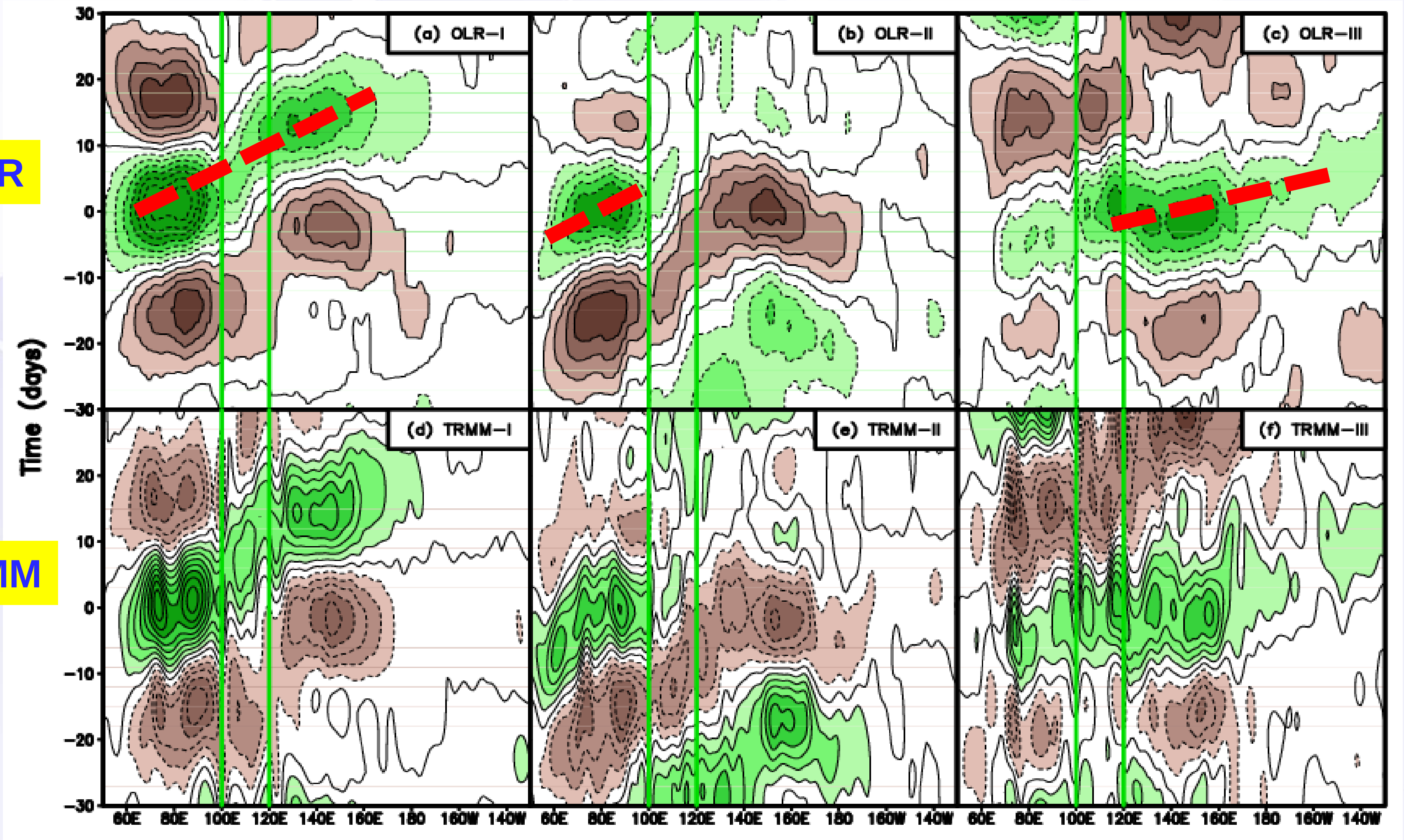
Type-I

Type-II

Type-III

OLR

TRMM



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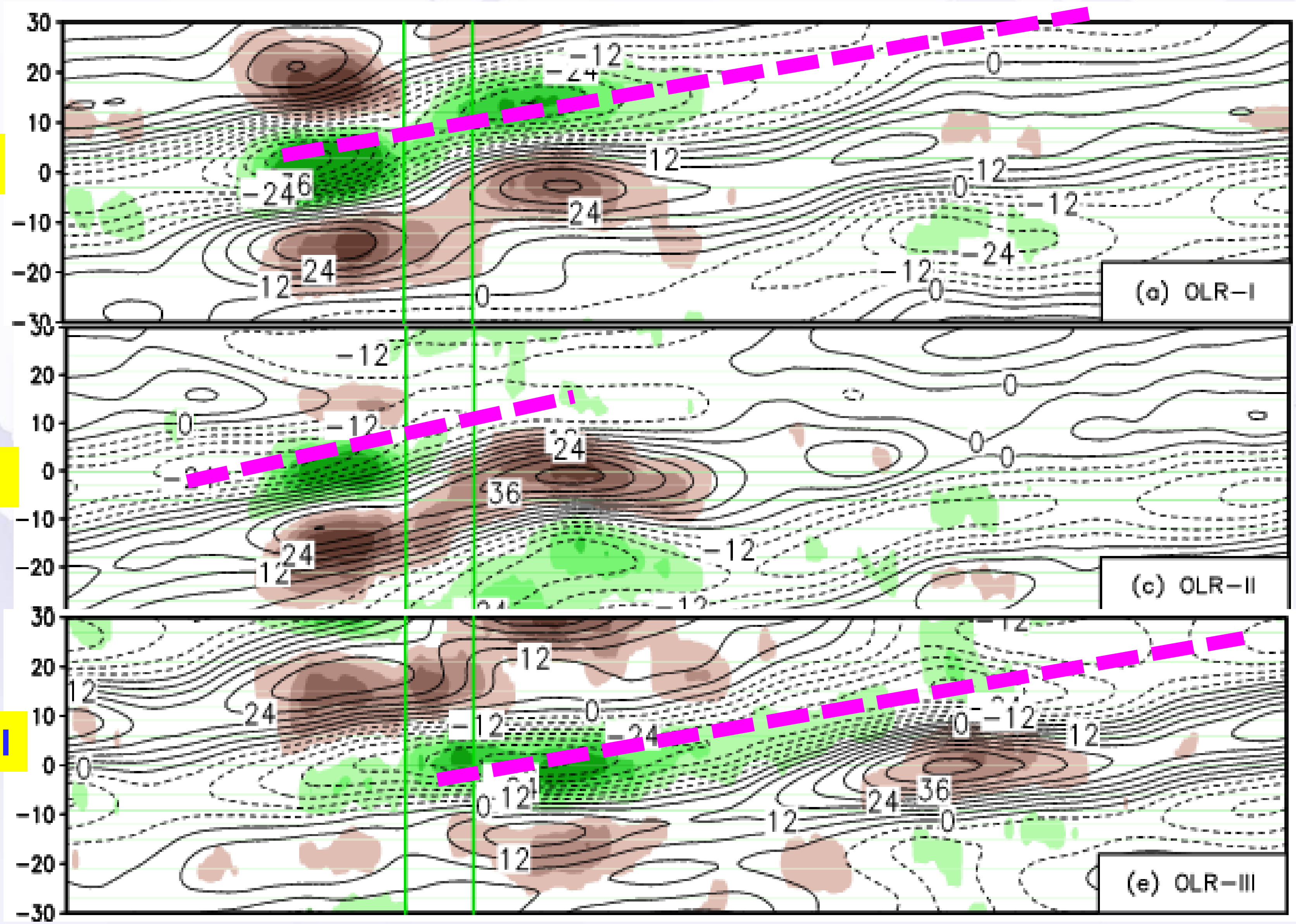
Different Downstream Impacts

Type-I

Type-II

Type-III



200hPa-VP (contours)

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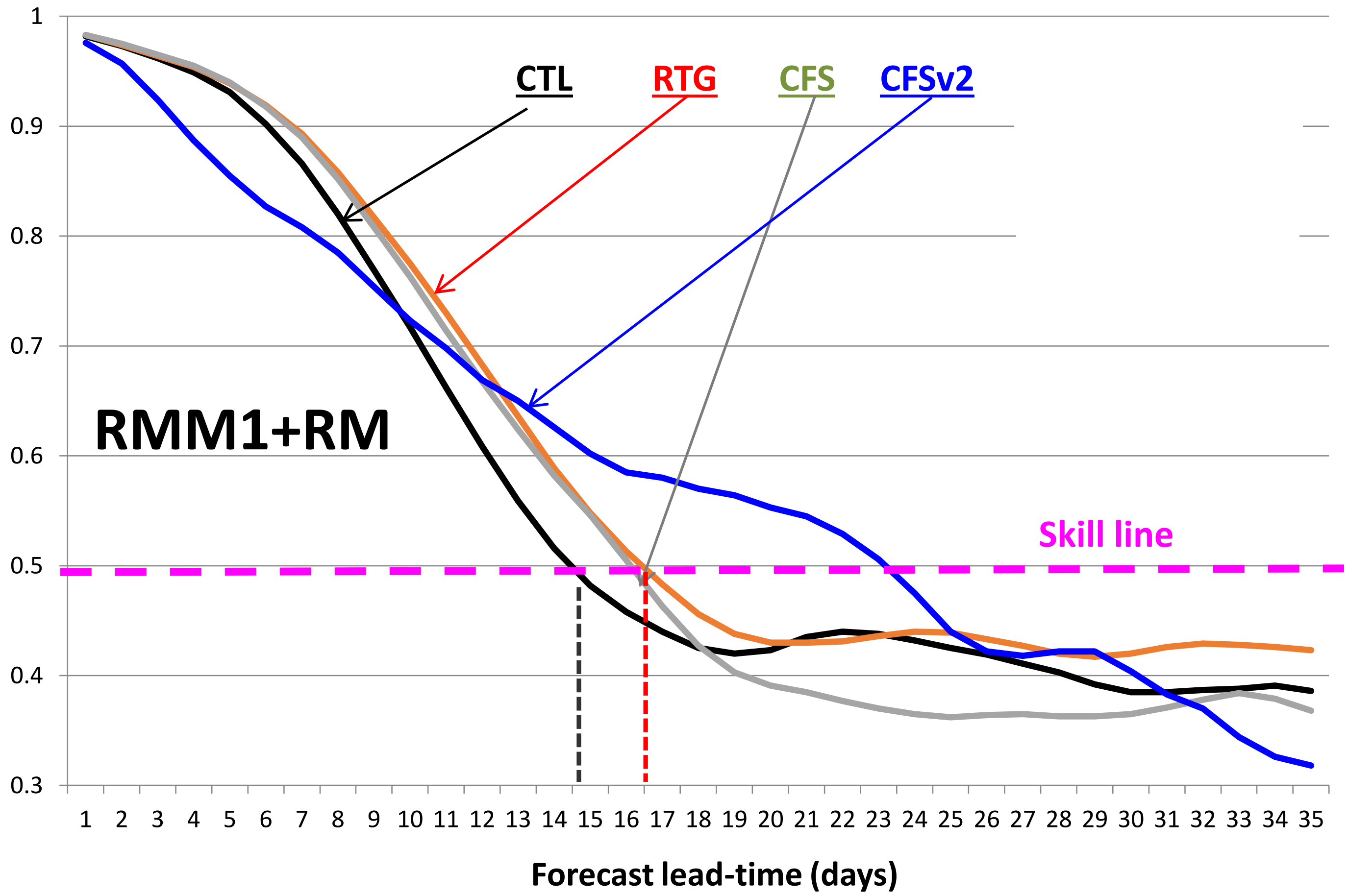
Recent Progresses Made on MJO Forecasting with GFS/GEFS at NCEP/EMC

Courtesy of Yuejian Zhu's group

Intra-seasonal SST forcing (RTG) improves MJO Forecasting of the GFS



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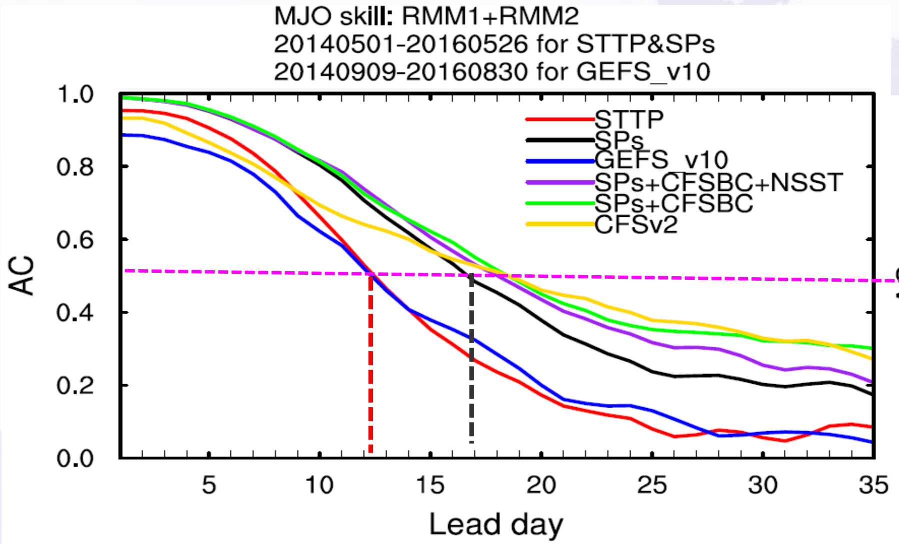
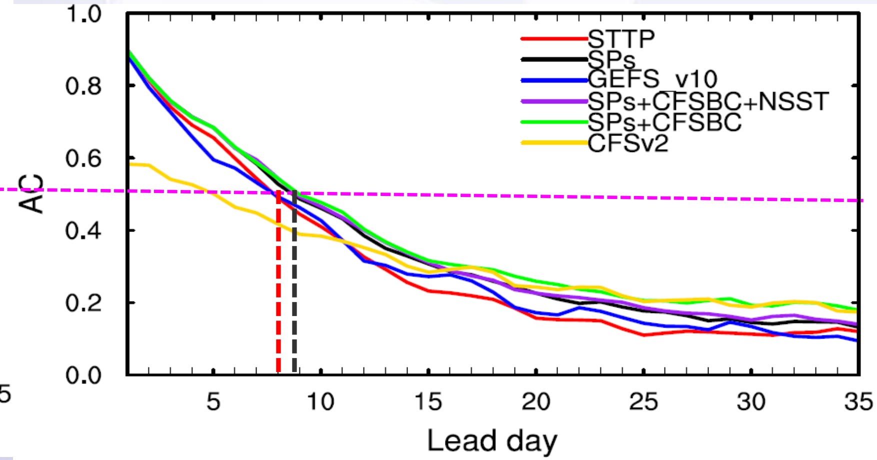
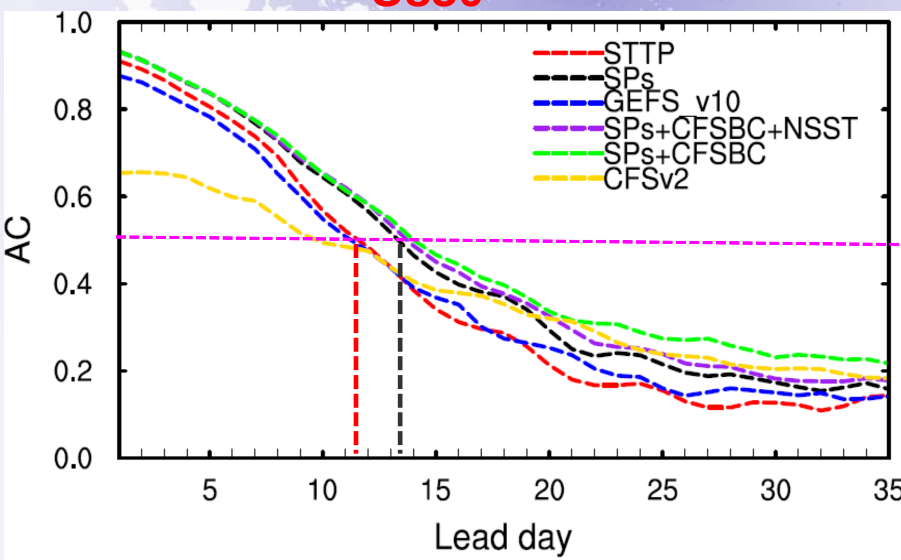
Updated Stochastic Physics Further Improves MJO Forecasting of the GFS



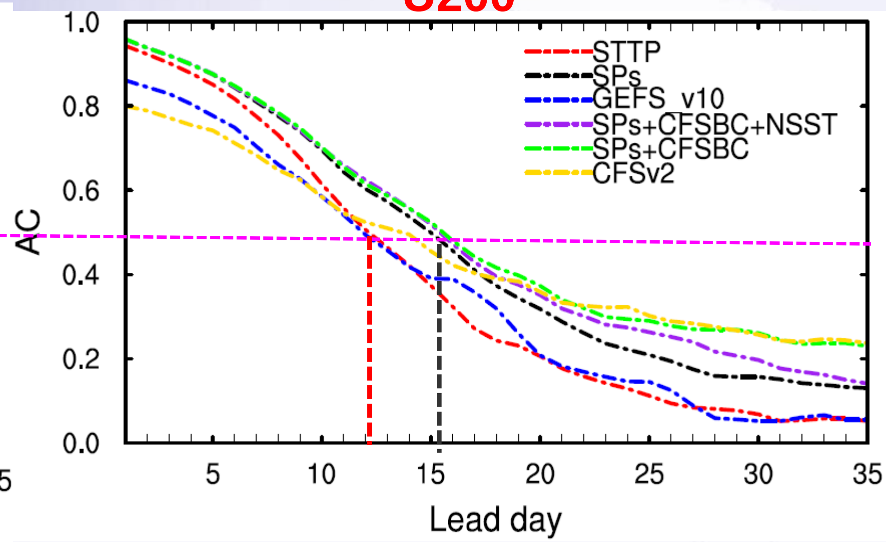
OLR



U850



U200



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Summary

● Major Accomplishment in FY17:

- A suite of hindcasts with the GFS under three different cumulus schemes and SST conditions during DYNAMO IOP is used in this study.
- Reveal MJO diversity in ocean coupling: The Oct-MJO is largely controlled by atmospheric internal dynamics while the Nov-MJO is strongly coupled to underlying ocean.
- Cumulus parameterization plays an essential role in capturing the impacts of ocean coupling on the MJO.
- There are three different boreal-summer MJO types: Type-I&III have robust downstream impacts in Pacific and Atlantic sectors while Type-II is limited in Indian sector.

● Priority Focus for FY18

- Continue to collaborate with NCEP/EMC team to better understand the impacts of cumulus schemes and SST and explore the ways to improve MJO and 1-30-day weather forecasting in the GFS/GEFS and NGGPS.

● Key Issue

- Availability of NGGPS model and outputs.
- NOAA computing resources for research.

Thank You Very Much!

CNMI
Hawaii
Guam
Marshalls
Palau
FSM

SCHOOL OF OCEAN AND EARTH SCIENCE AND TECHNOLOGY

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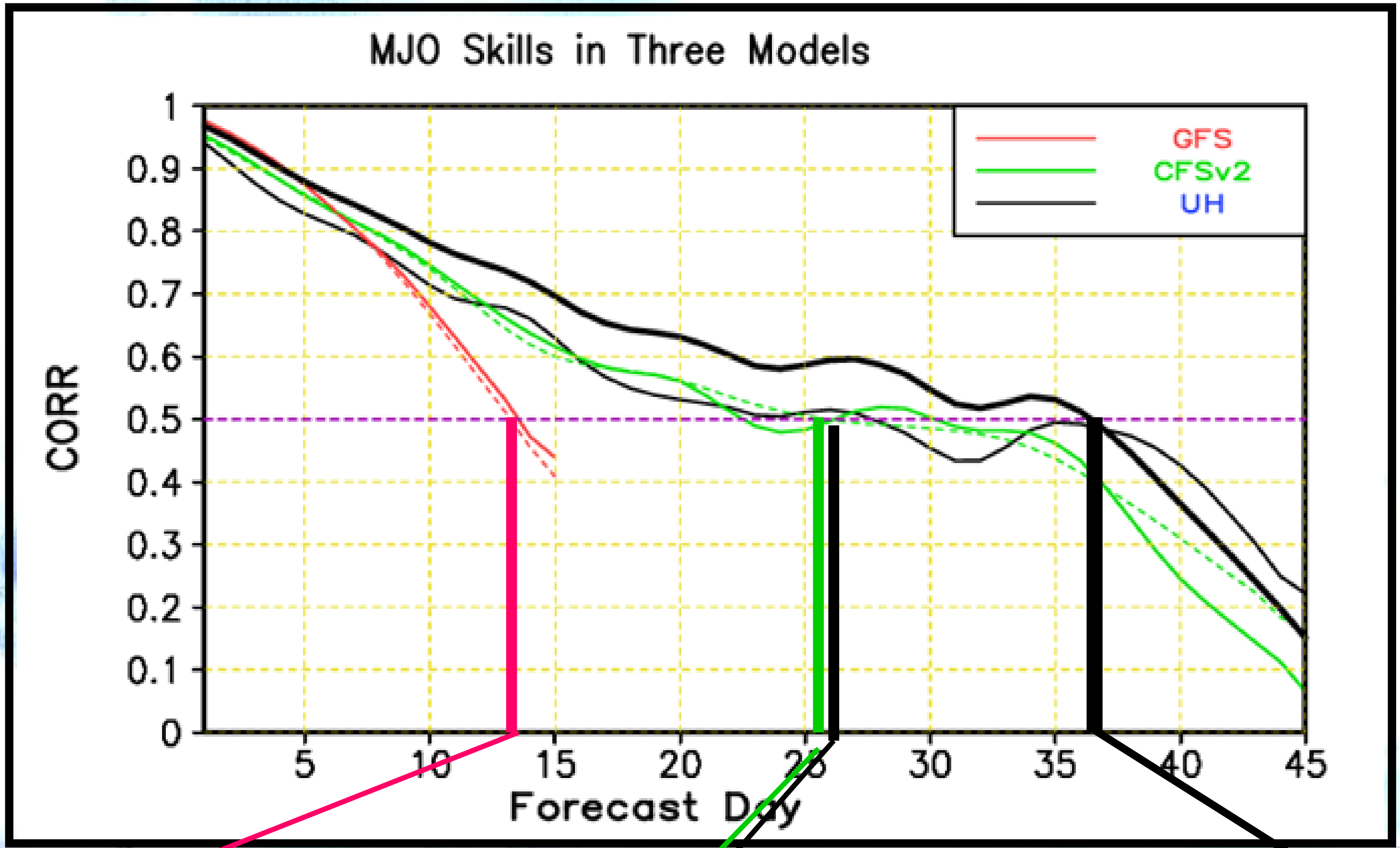
Extra Slides

MJO Skills in Three GCMs during DYNAMO Period

(Wheeler-Hendon Index) **(Sep 2011- Mar 2012)**



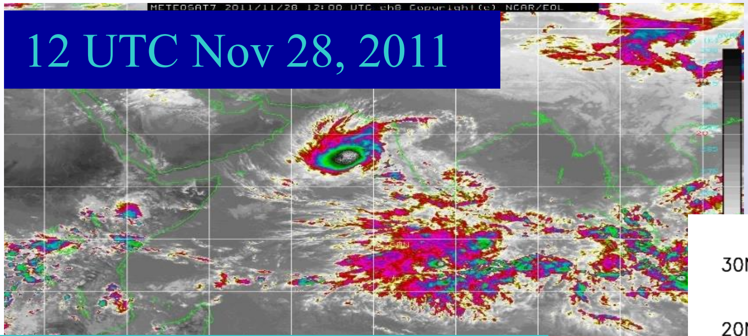
GFS/GEFS: 14 days
(Hamill and Kiladis 2014)

CFSv2&UH: 25/25 days

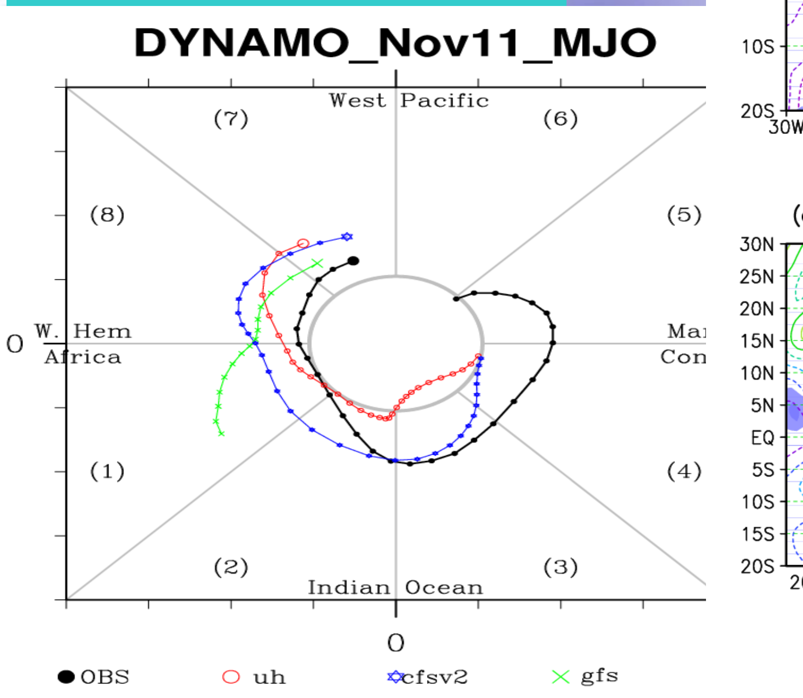
CFSv2&UH MME: 37 days

Fu et al. (2013)

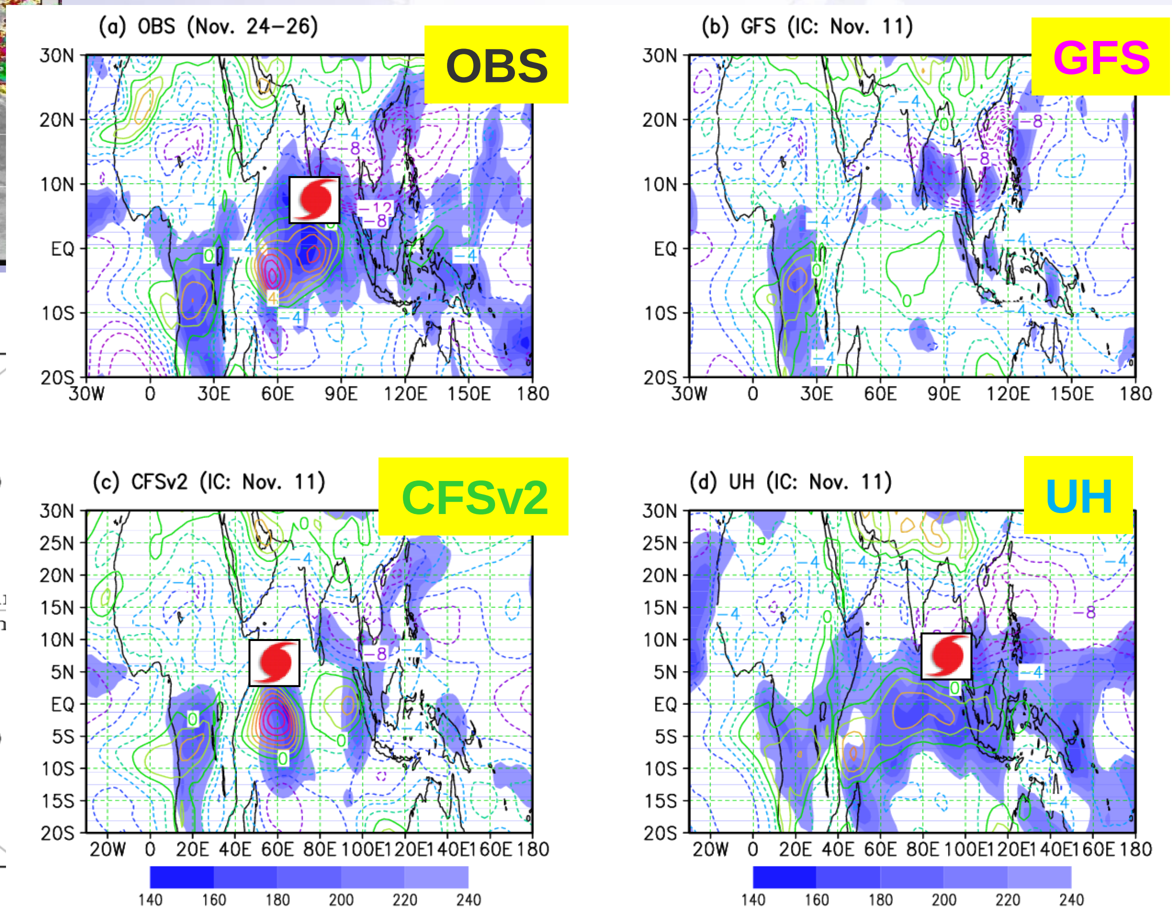
Forecasts of GFS, CFSv2 and UH with IC on Nov. 11



November-MJO & Thanks-giving TC



Observed and forecasted U850 and OLR averaged for days-13-15



Fu et al. (2013)

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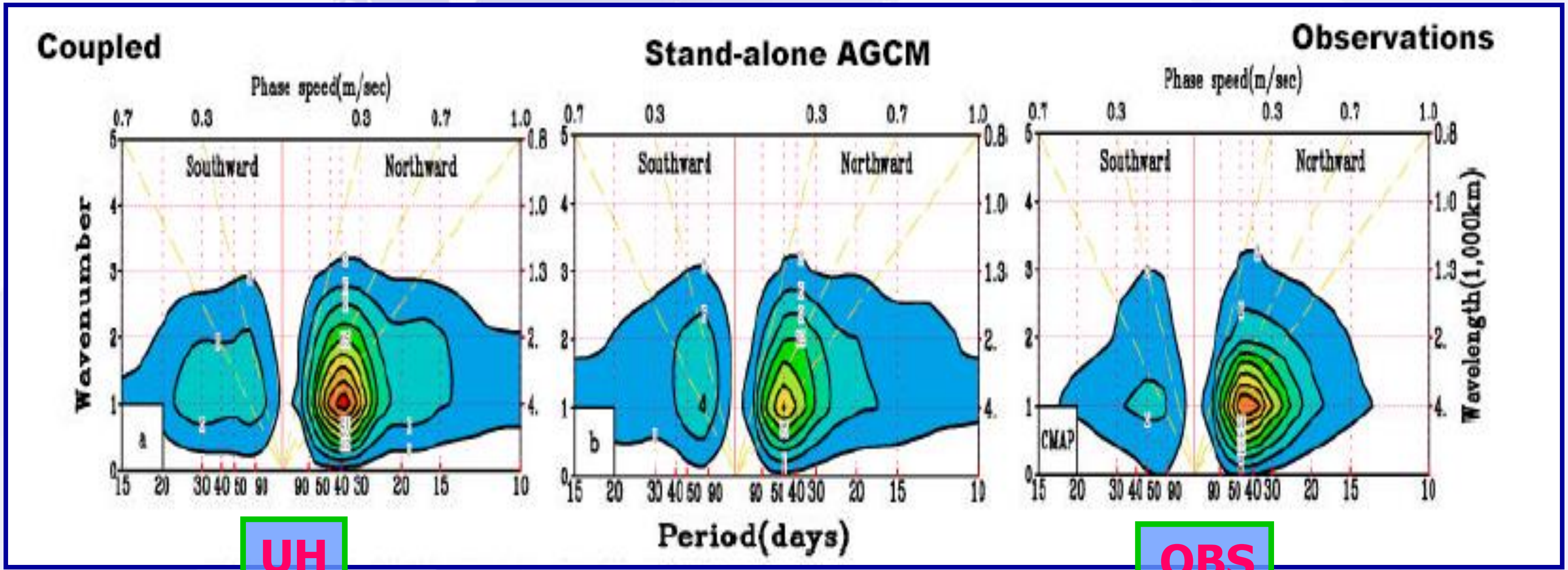
Air-sea Coupling Doubles the MJO/ISO Intensity



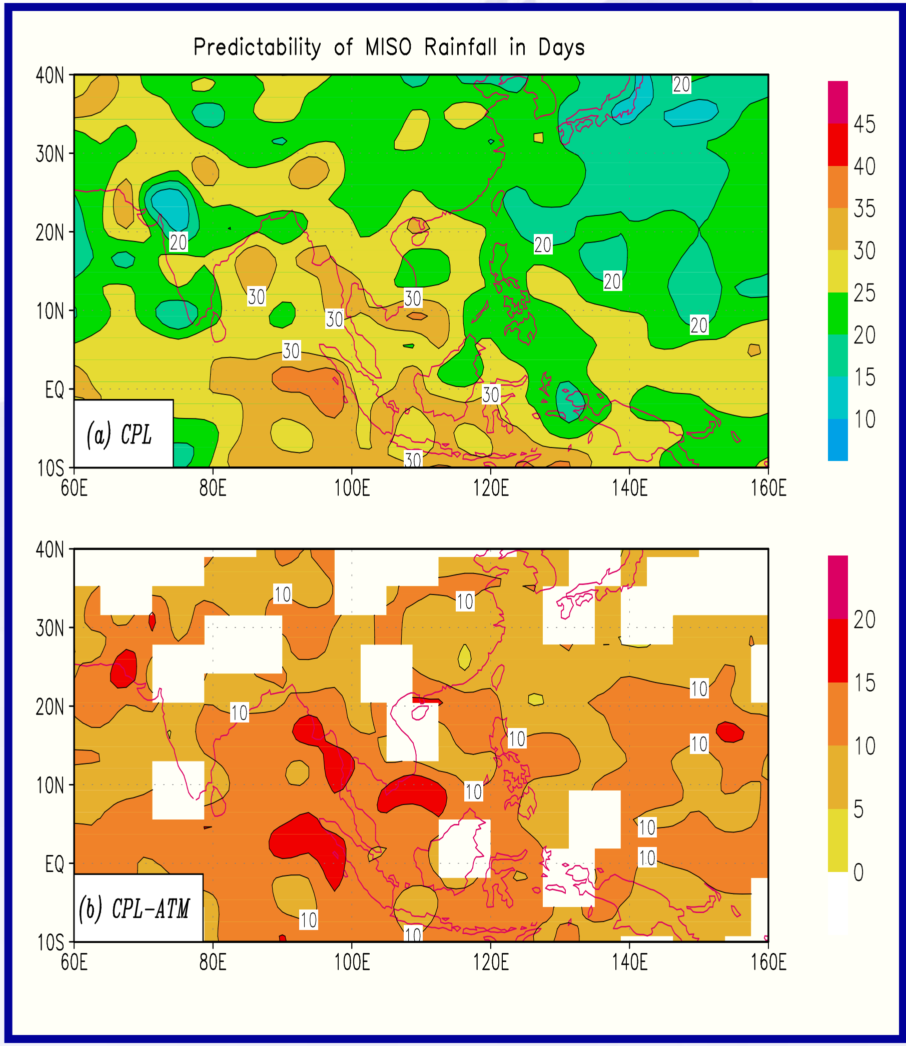
UH

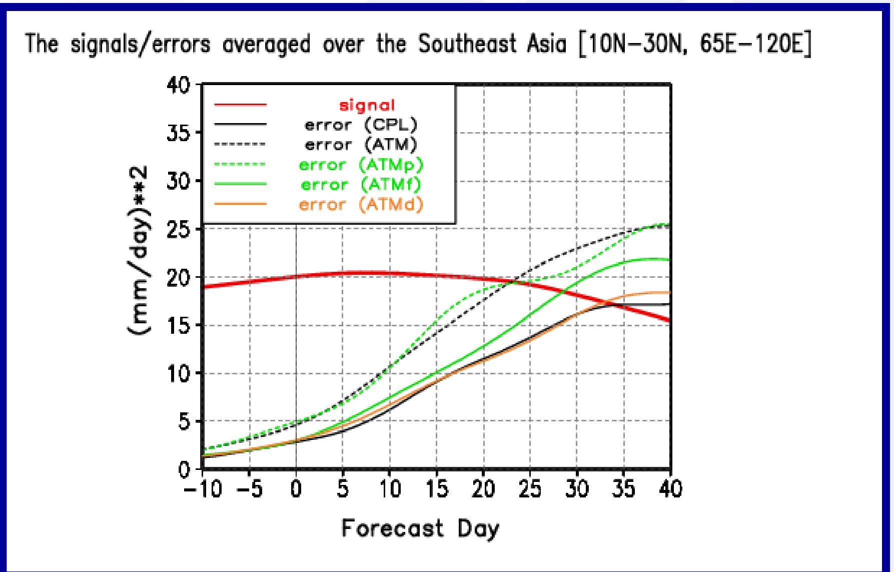
OBS

ECHAM-4 AGCM + UH IOM

Fu et al., 2003 ; Fu and Wang 2004

Air-sea Coupling Extends the Predictability of the MJO/ISO by at least One Week

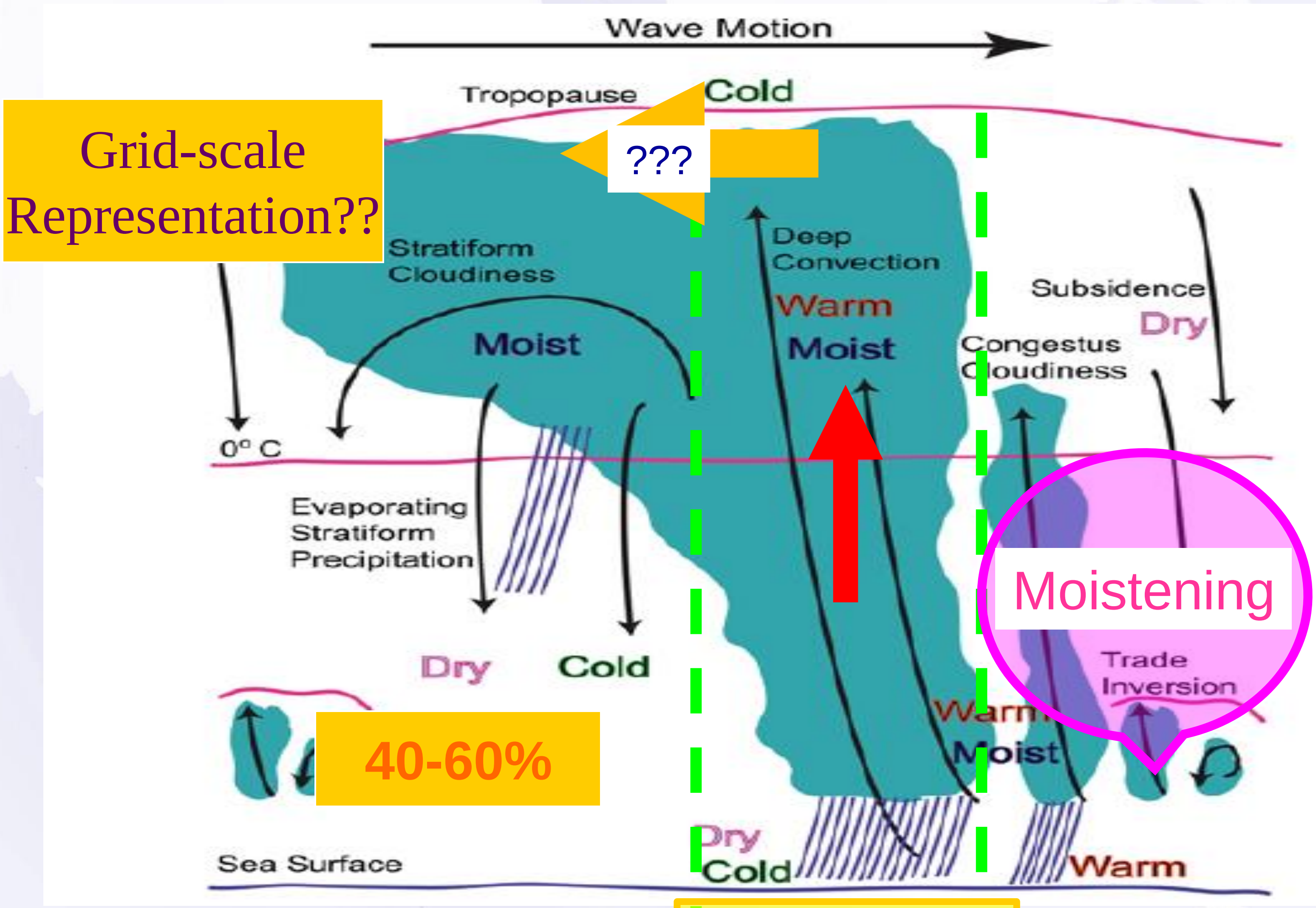




We first discovered that ***forcing the atmosphere-only model with the forecasted daily SST*** from the coupled model can reach the same sub-seasonal forecasting skill as the fully coupled model.
Fu et al. (2015); Wang et al. (2015)

Fu et al. (2007, 2008) along with Vitart et al. (2007) and Woolnough et al. (2007)

Schematics of MJO Vertical Structure

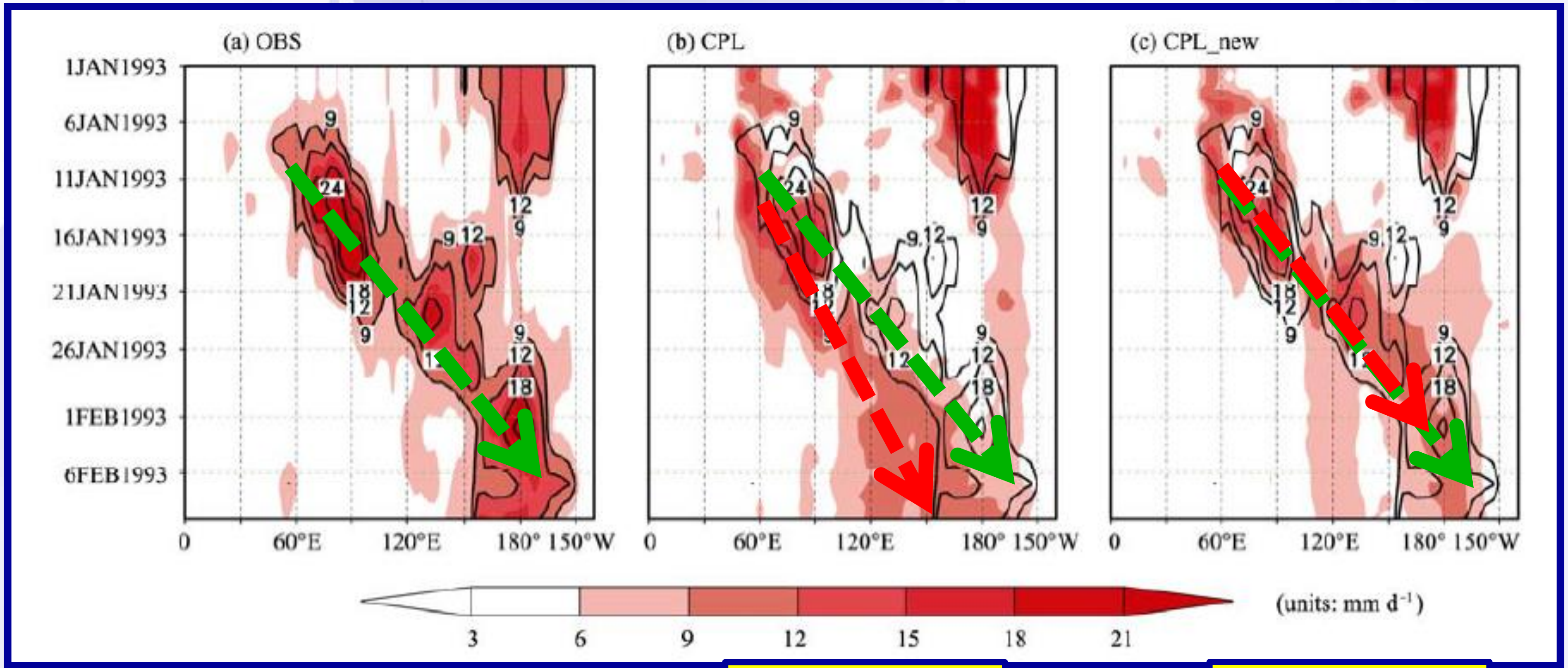


Kiladis et al. (2009)

Classic Cumulus Parameterization

Model Physics

Enhanced Shallow-Convection Moistening Speeds up Model MJO Propagation



OBS

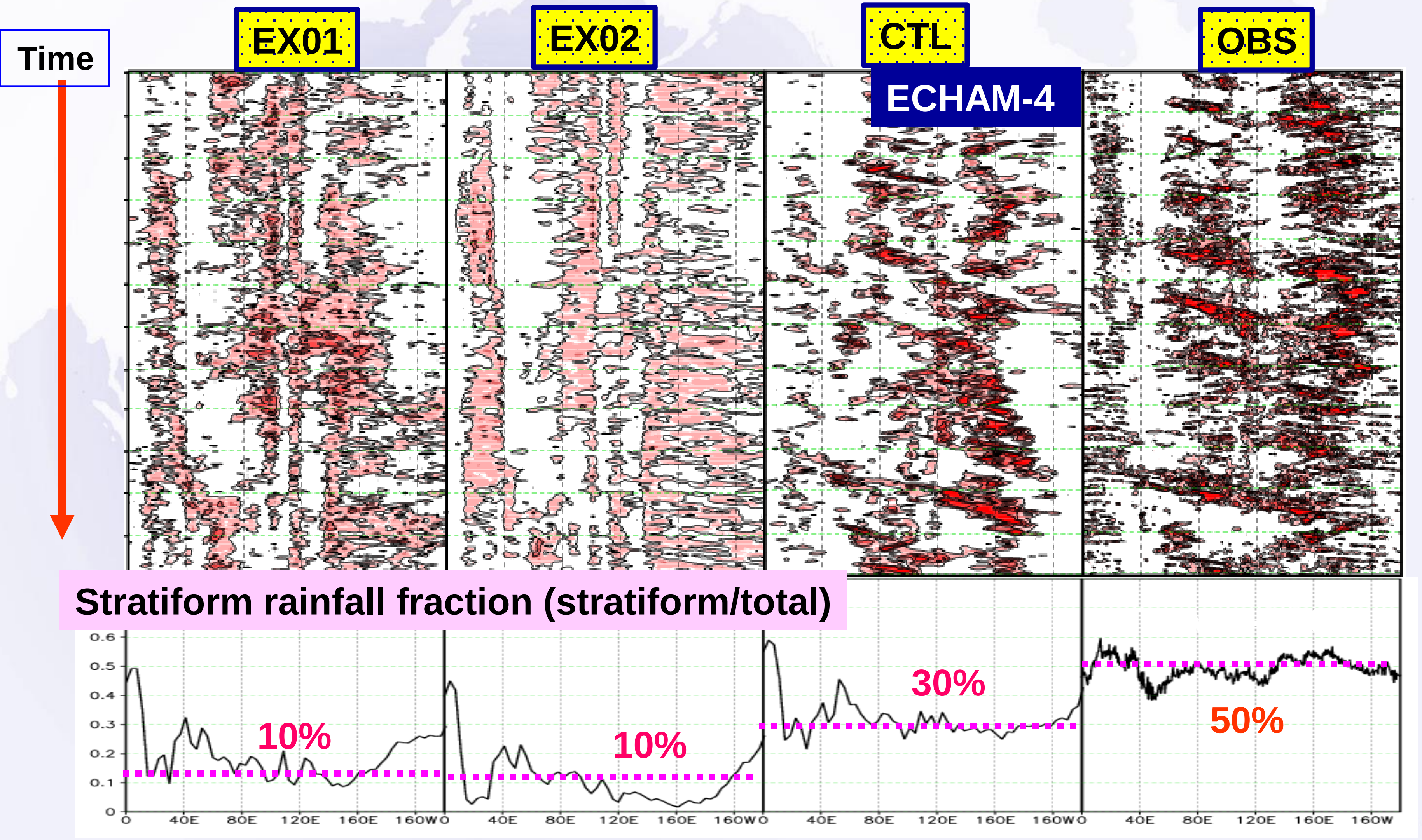
Weak Shallow Convection

Strong Shallow Convection

Fu et al. (2008)

Model Physics

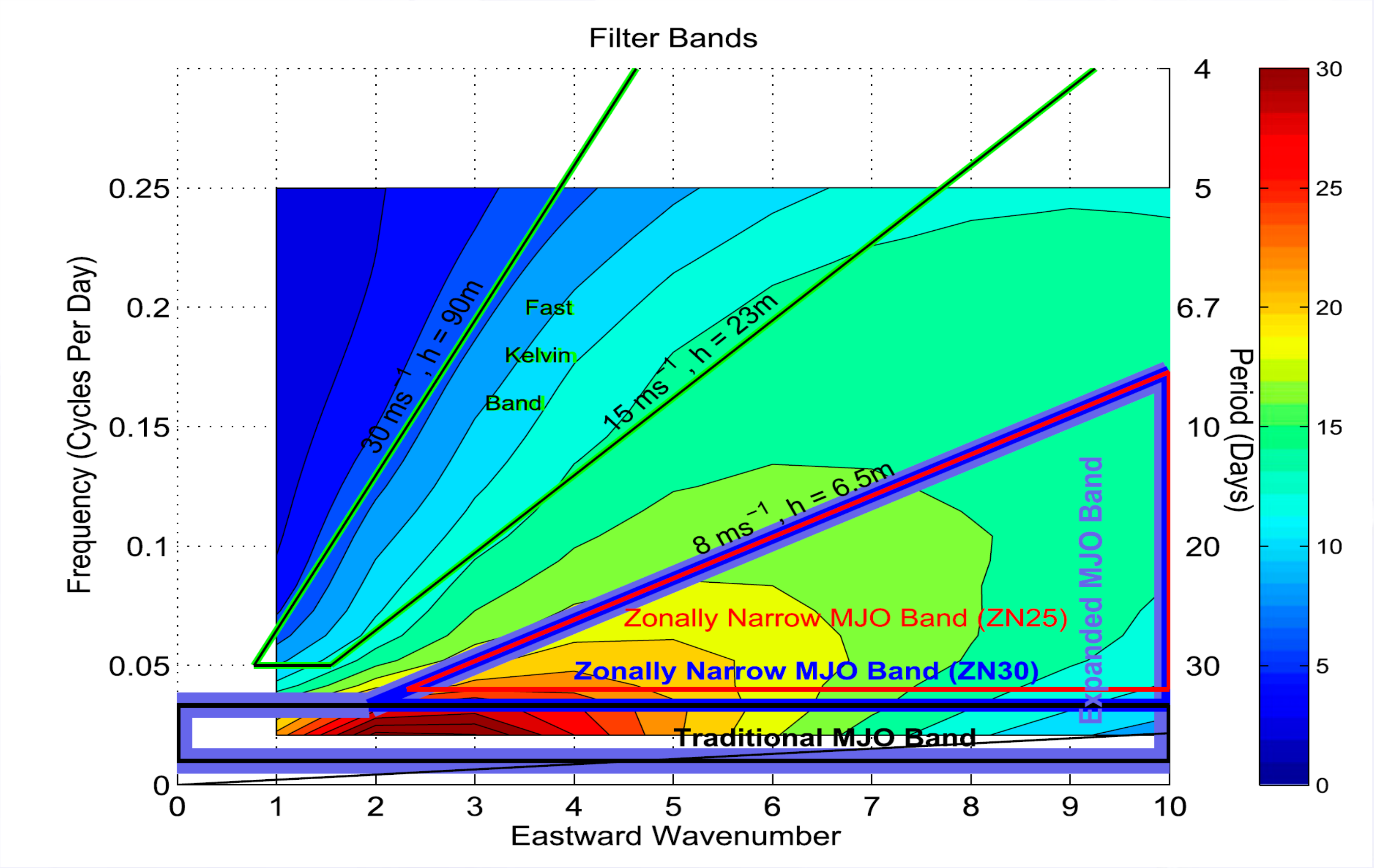
Stratiform Rainfall Fraction is an Essential Factor for MJO Simulation



Fu and Wang (2009)

Model Physics

The MJO has broad wavenumber-frequency bands



Paul Roundy (2004)