Boreal Summer ISO

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I. BSISO VS. MJO:

Bimodal representation of ISO

II. Mechanism of BSISO:

Tilted rain band, NE propagation,

Genesis, Monsoon ISO

III. Multi-model prediction of BSISO

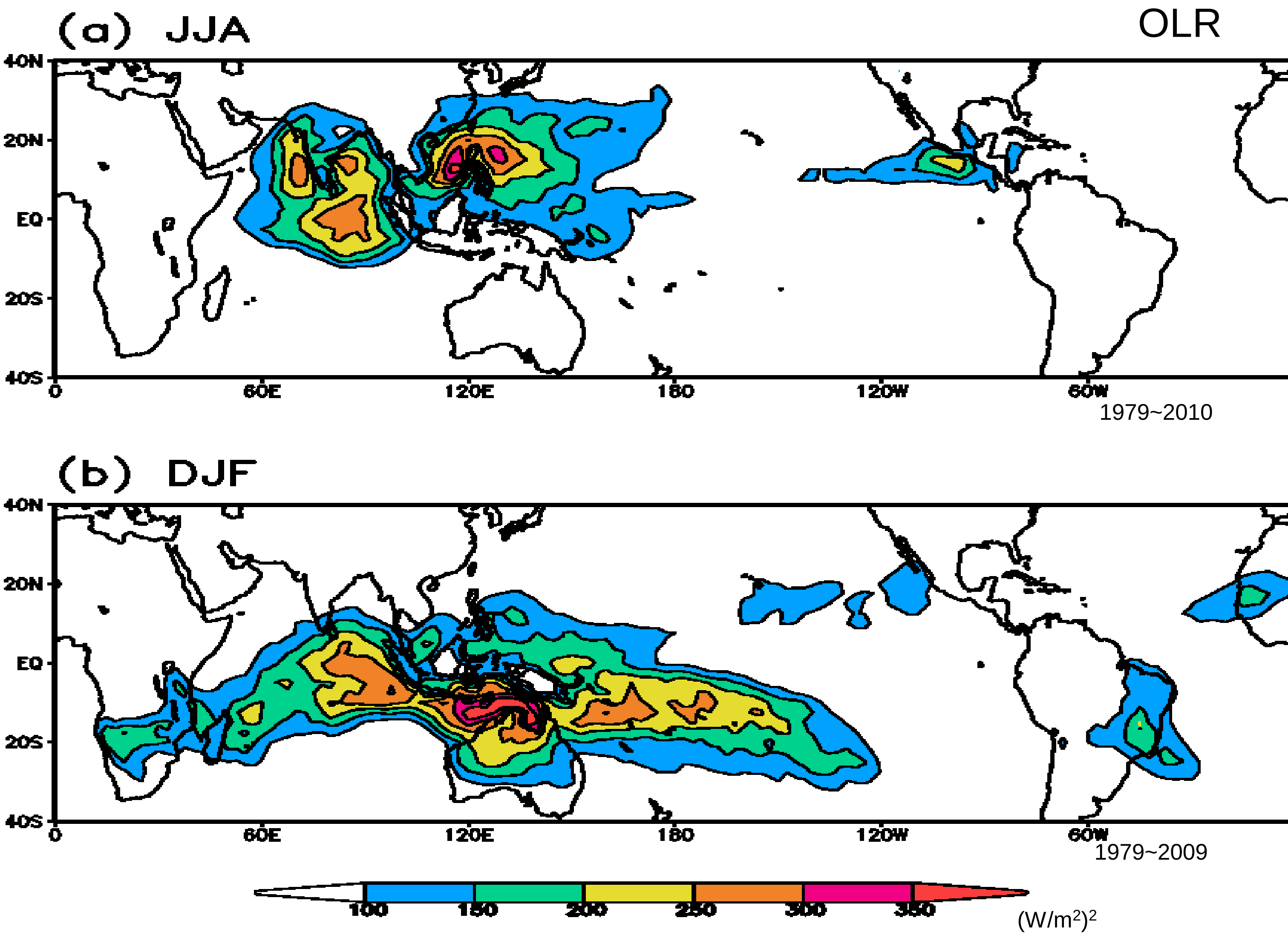
ISVHE, MME prediction

I. BSISO VS MJO

1. Variability centers
2. Leading modes
3. Propagation pattern
4. Initiation
5. Monsoon ISO

   Quasi-Biweekly,Teleconnection, and regulation to synoptic activity

Intraseasonal Variance



1979-20010

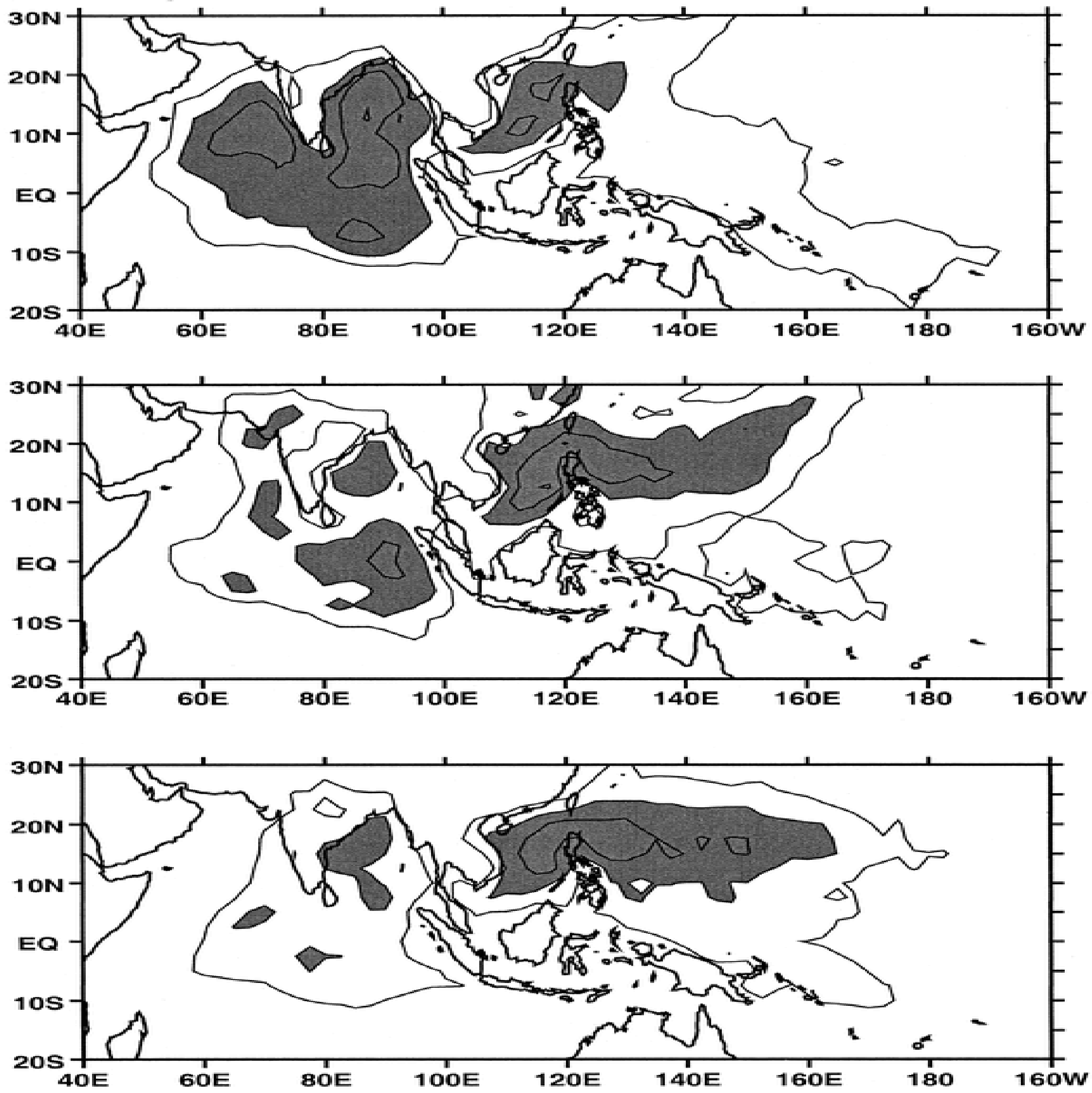
Subseasonal variation of BSISO

IS Variance-OLR

MJ

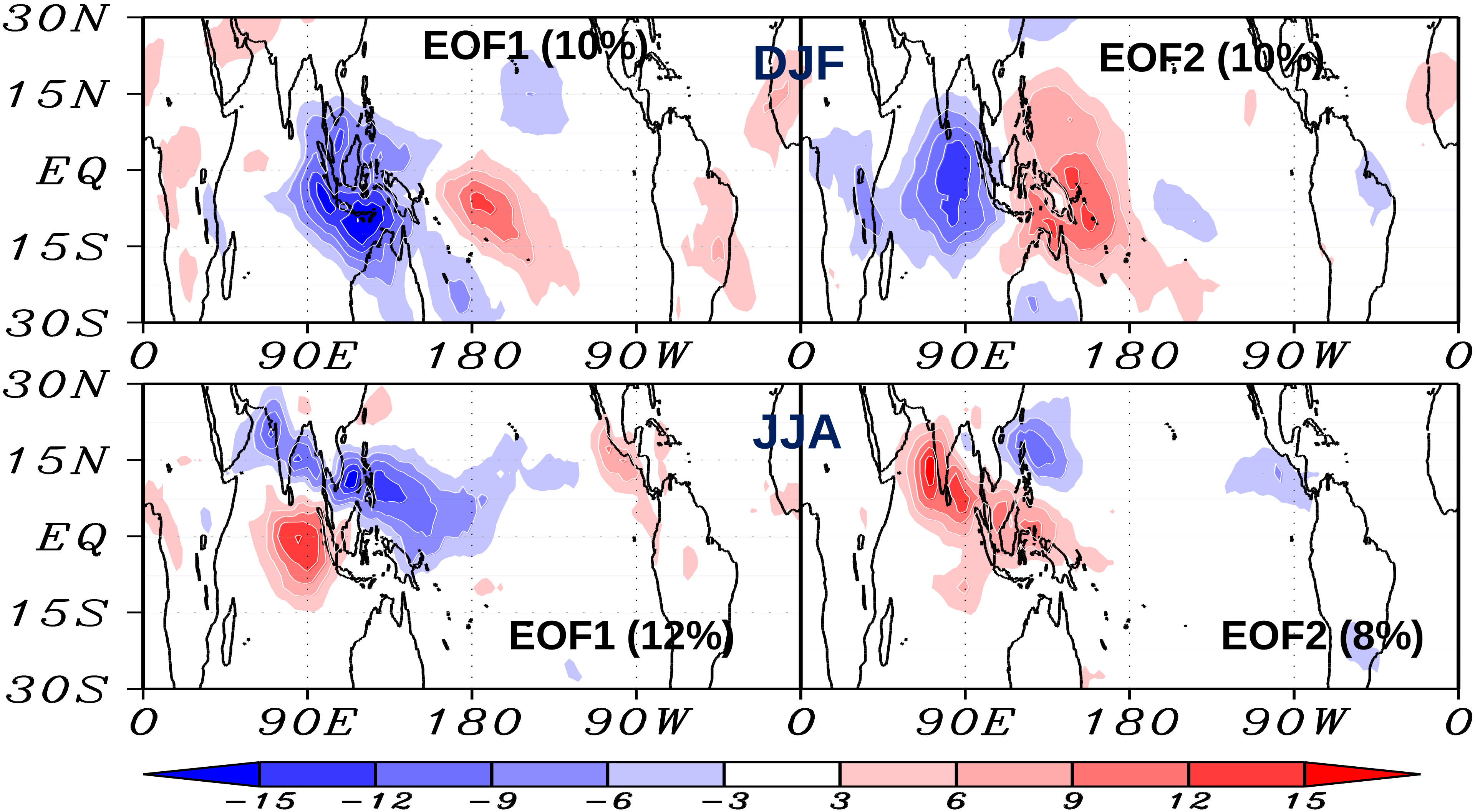
July

ASO

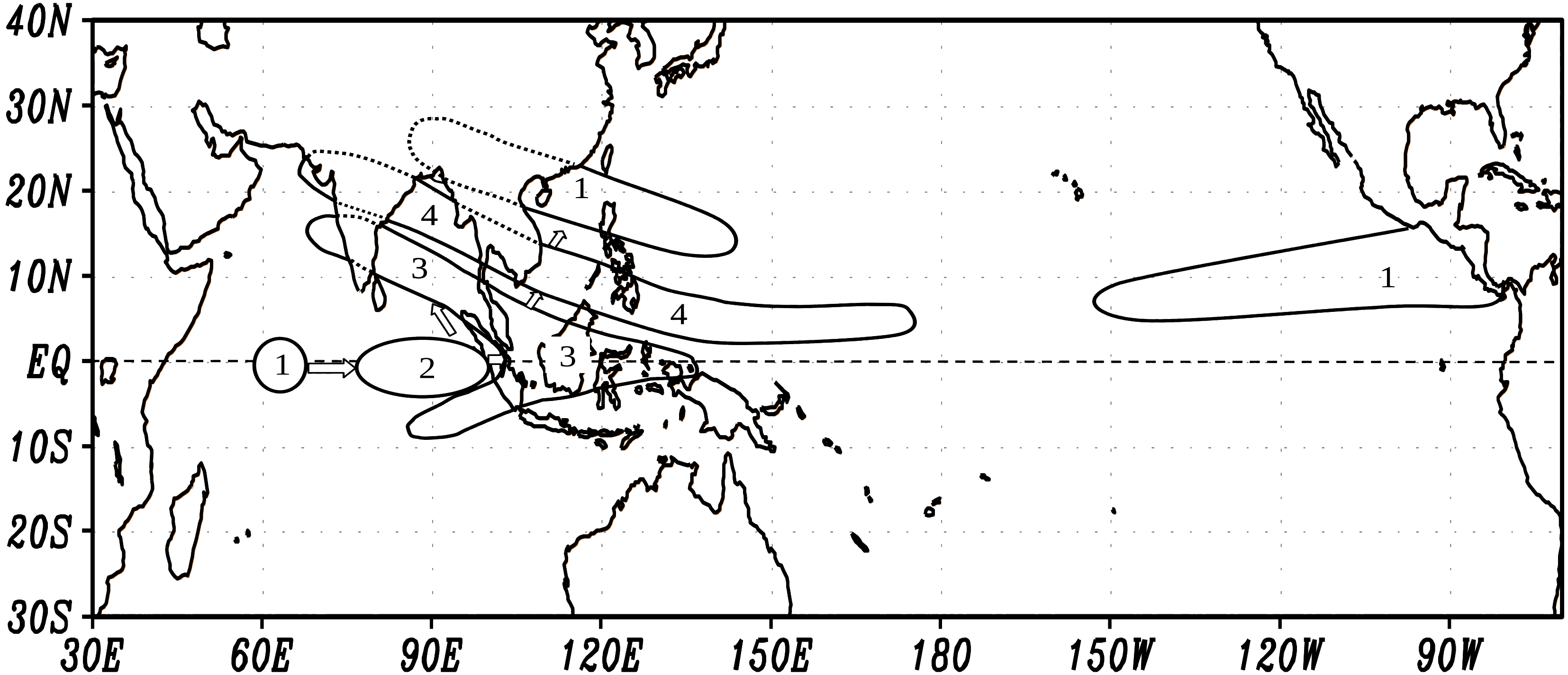


Camball-Cook and Wang 2001

Principal Modes: ISO (30-60 day), 1979-2010



Schematic evolution of tropical ISO rain anomalies



A four-stage evolution

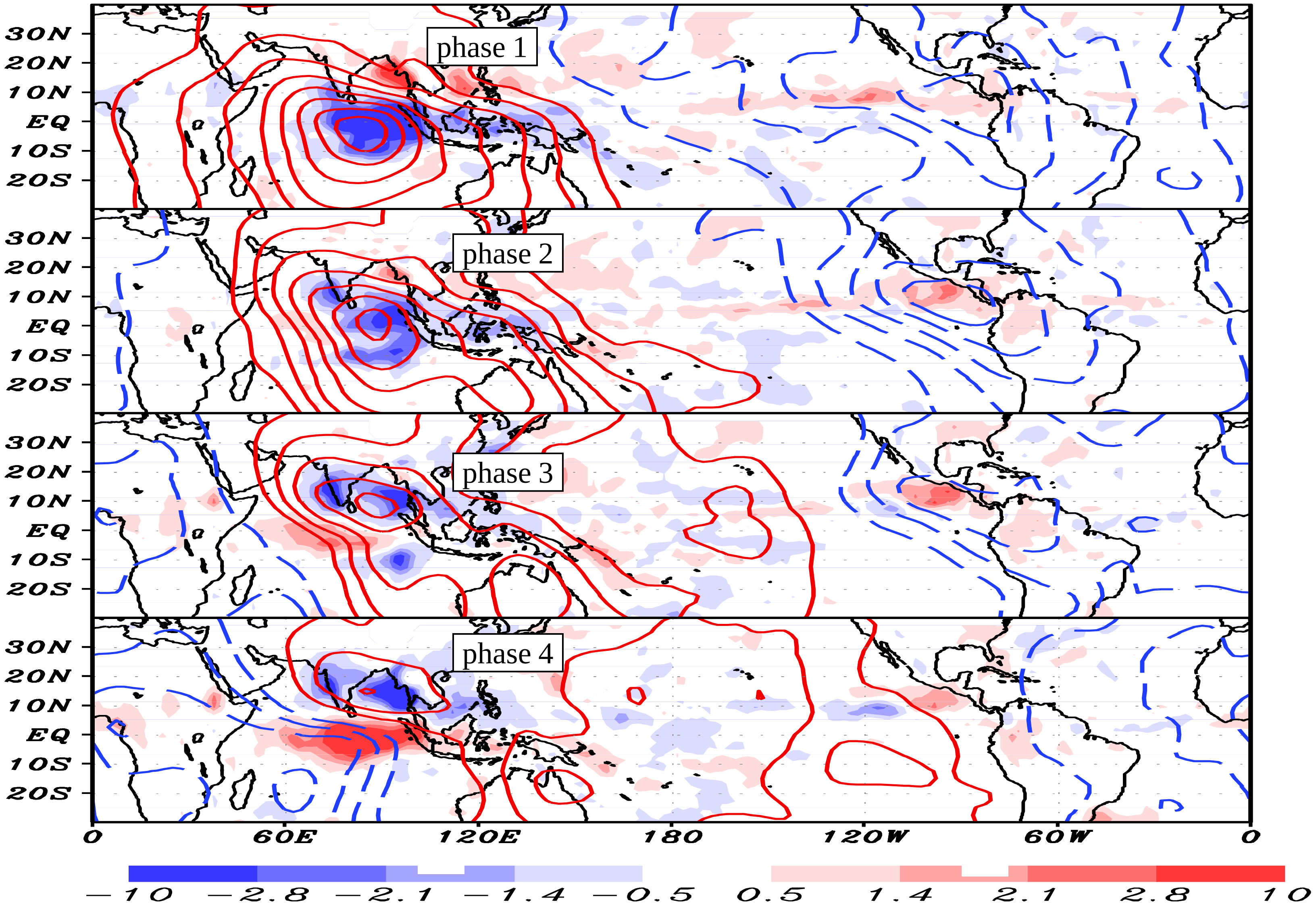
1. The **initial ISO rainfall anomalies** occur in the EIO around 60-70E at Phase 2.

2.After the equatorial rainfall anomalies reach Indonesia, a major rain band extends outward from the convective region of Sumatra-Borneo **tilting northwestward** to eastern Arabian Sea (Phase 6).

3.The slanted rain band then moves **northeastward** (Phase 7-8), 4 Meanwhile the equatorial WP anomalies **rapidly traverse the ITCZ in Pacific and migrate northward slowly to Philippine Sea**.

Wang et al. (2006)

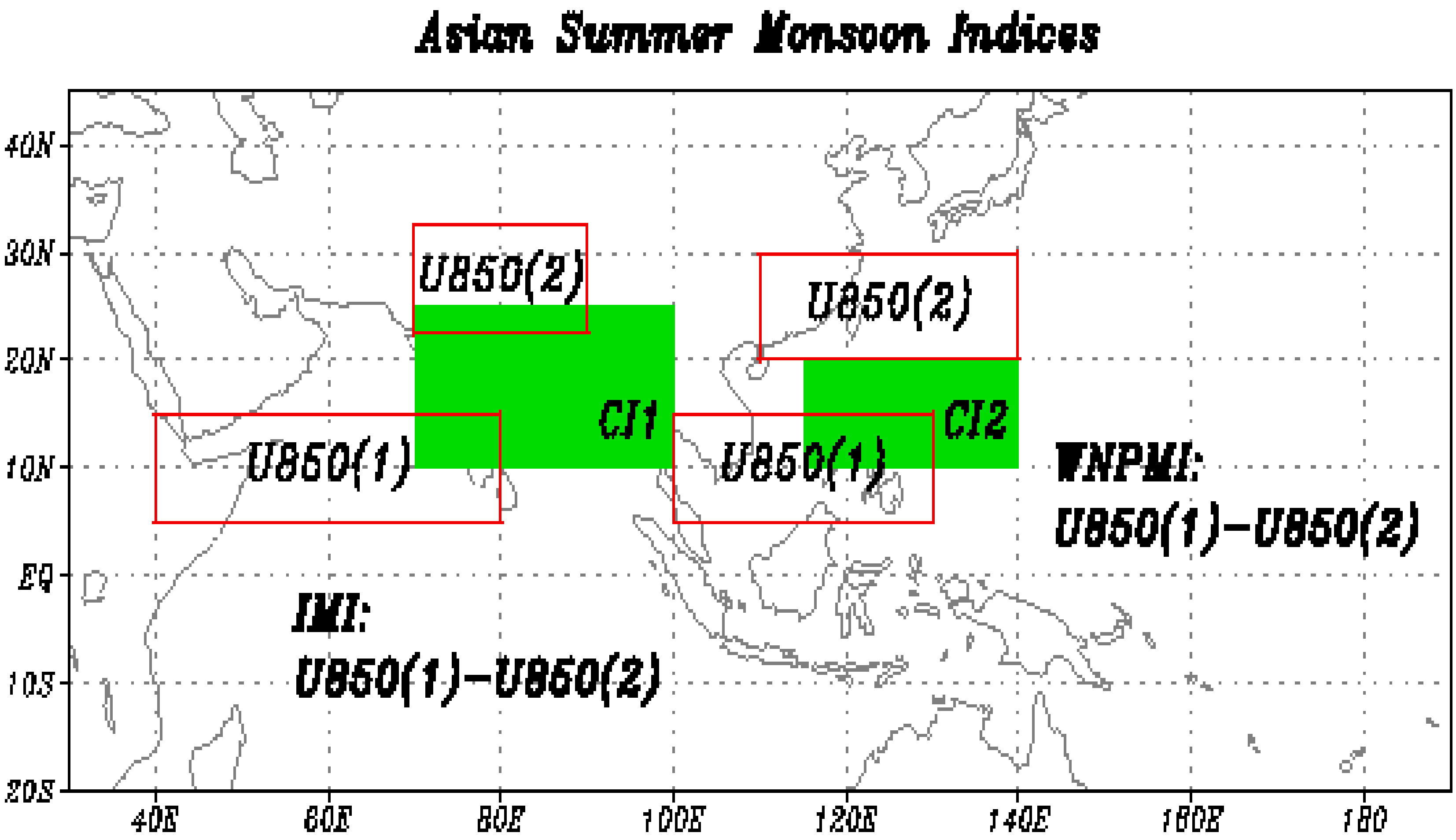
Initiation: Upper-level divergence waves may not be essential



200 hPa velocity potential has a salient stationary component

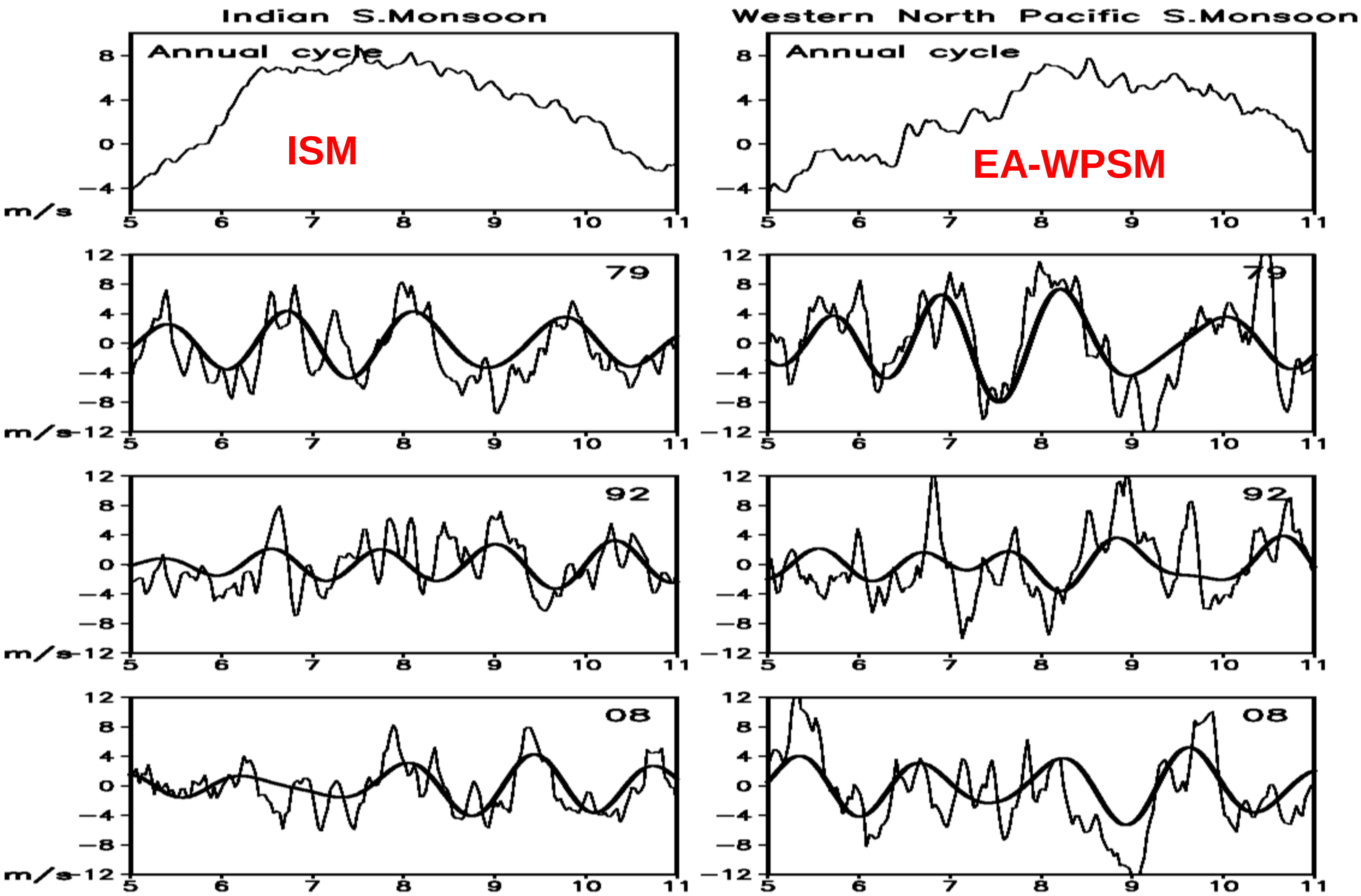
Asian summer monsoon ISO:

Monitoring BSISO Using monsoon circulation indices

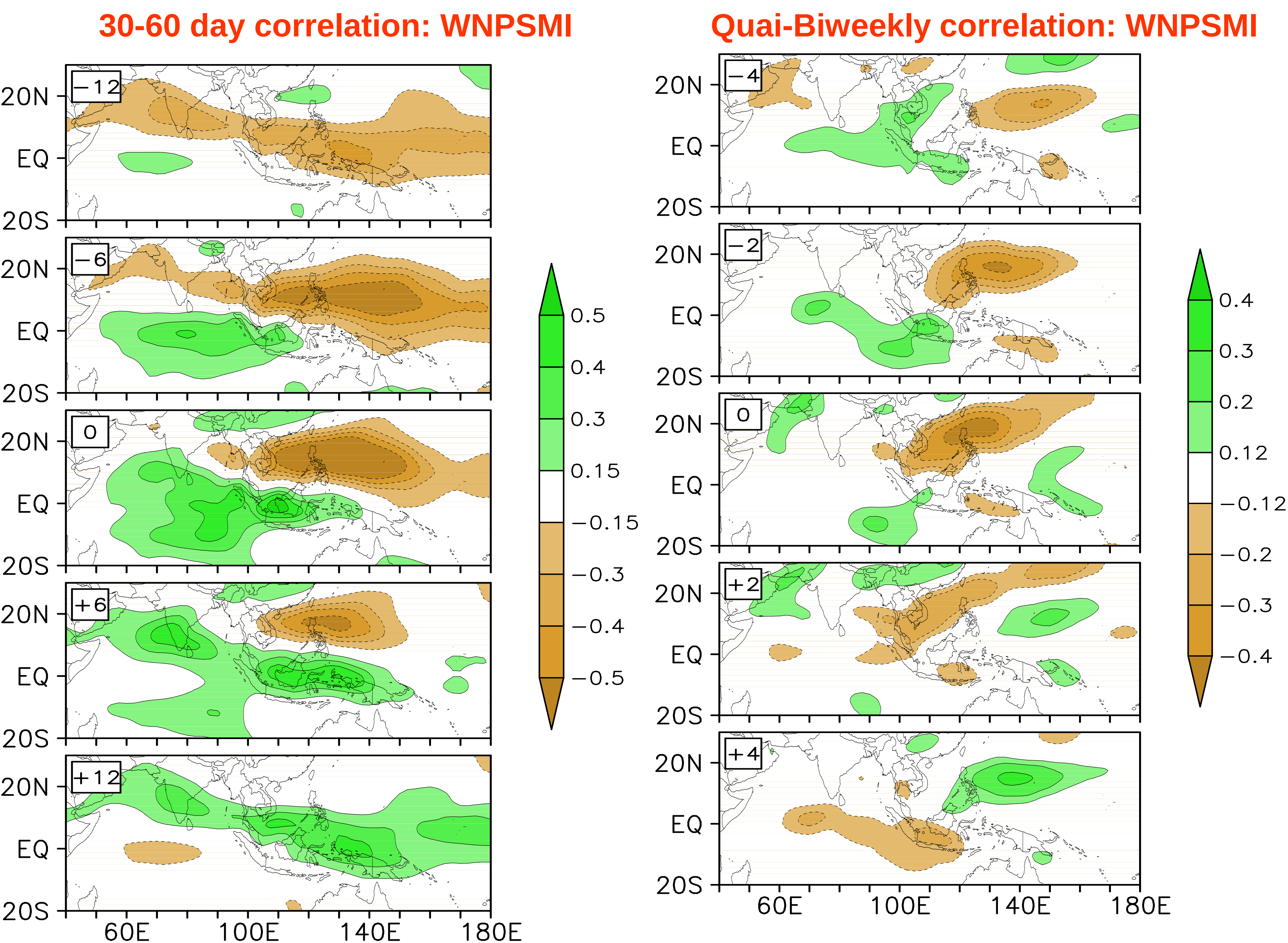


Wang, Wu, Lau 2001, JC

ISO of Monsoon circulation



Time series of Indian Summer Monsoon Index (left)Western North Pacific Summer Monsoon Index (right).(top) Mean 365-day annual cycle (lower three panels) The thin lines are daily anomaly values, the thick lines are 30-60 day band-passed values for the years 1979, 1992 and 2008.



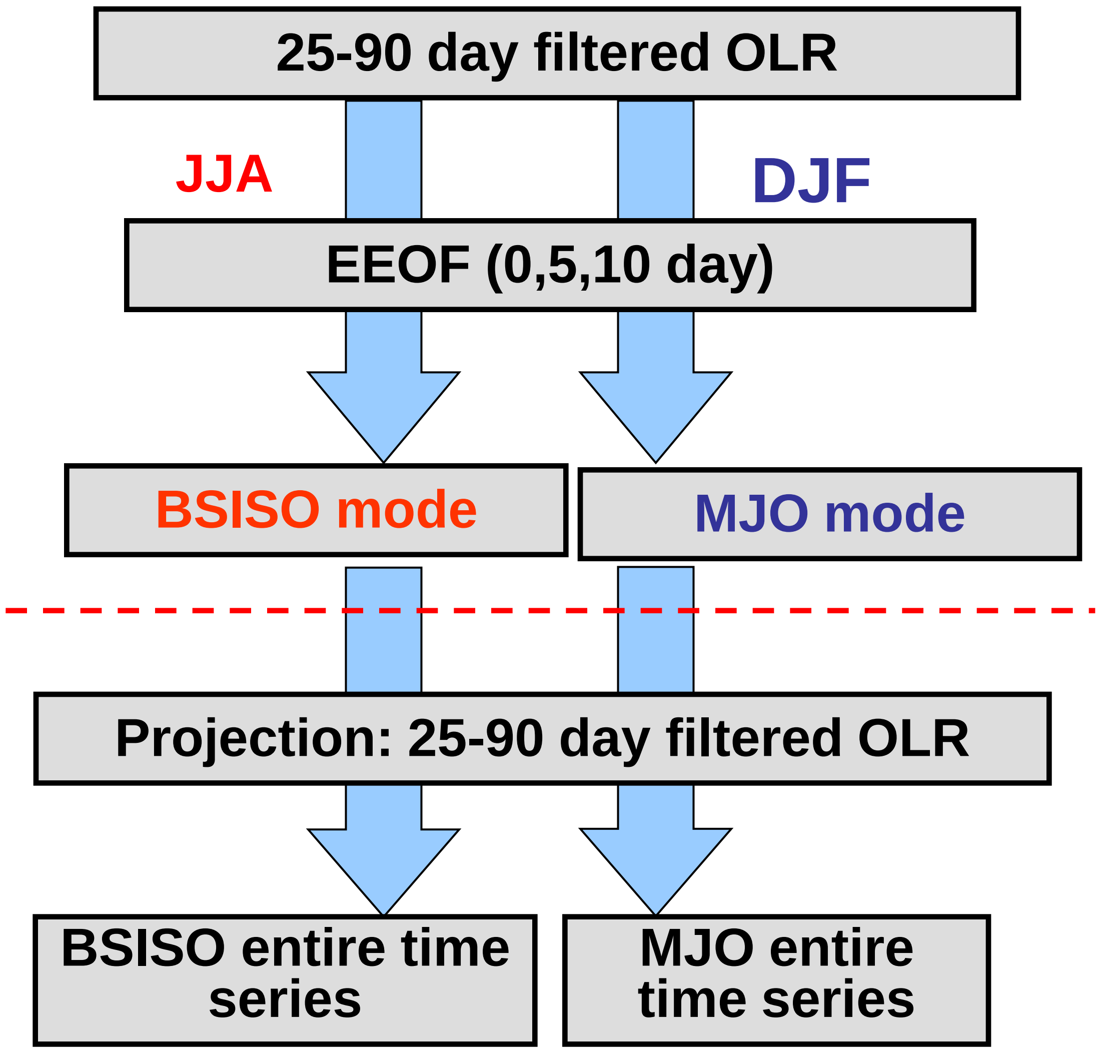
30-60 day correlation: WNPSMI
Quai-Biweekly correlation: WNPSMI
−12
−6
0
+6
+12
−4
−2
0
+2
+4
20N
EQ
20S
60E
100E
140E
180E
0.5
0.4
0.3
0.15
−0.15
−0.3
−0.4
−0.5
0.4
0.3
0.2
0.12
−0.12
−0.2
−0.3
−0.4

Do we need a bimodal representation of MJO and BSISO?

Bimodal Representation of the Tropical Intraseasonal Oscillation

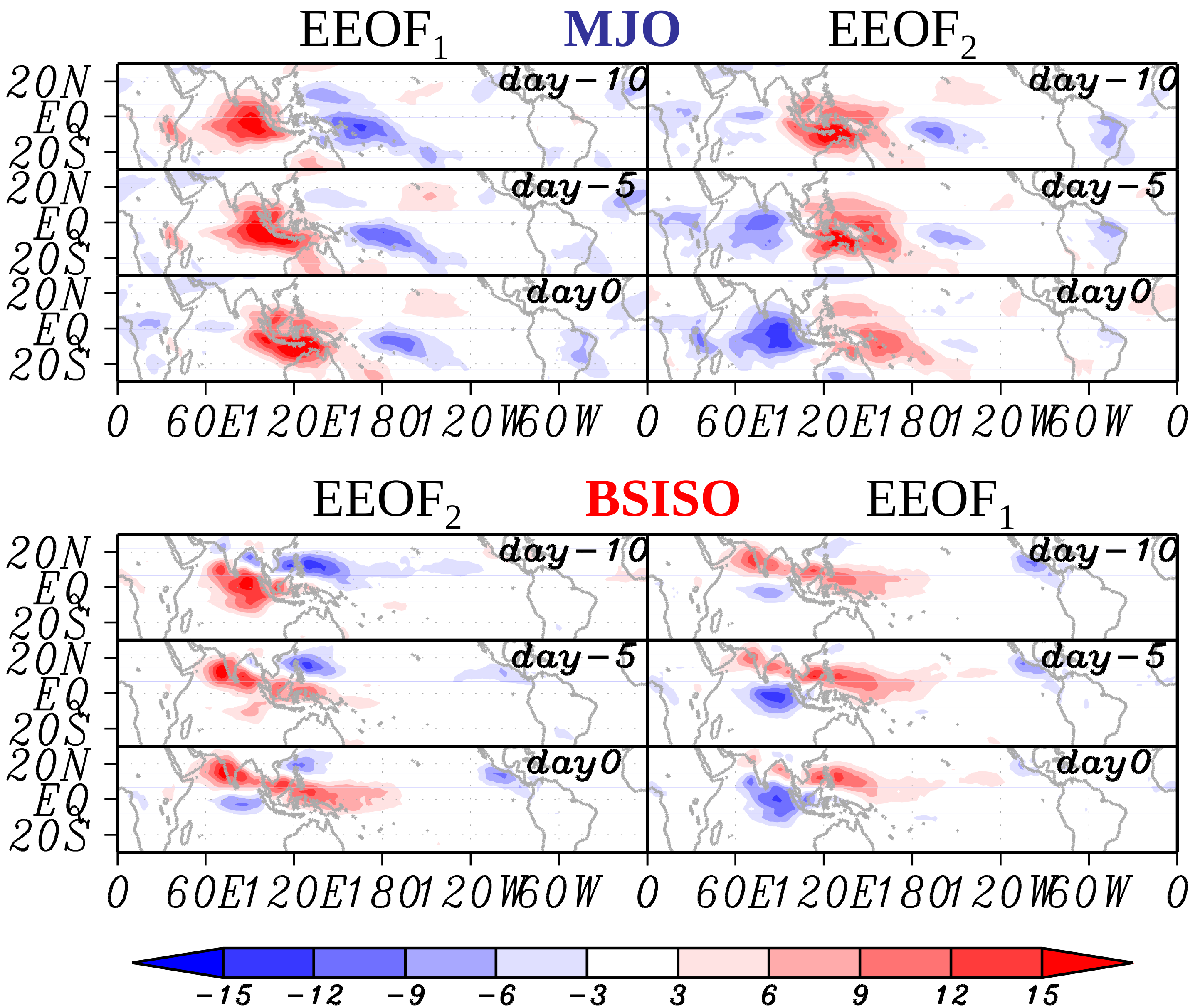
Kikuchi, Wang, Kajikawa

Method

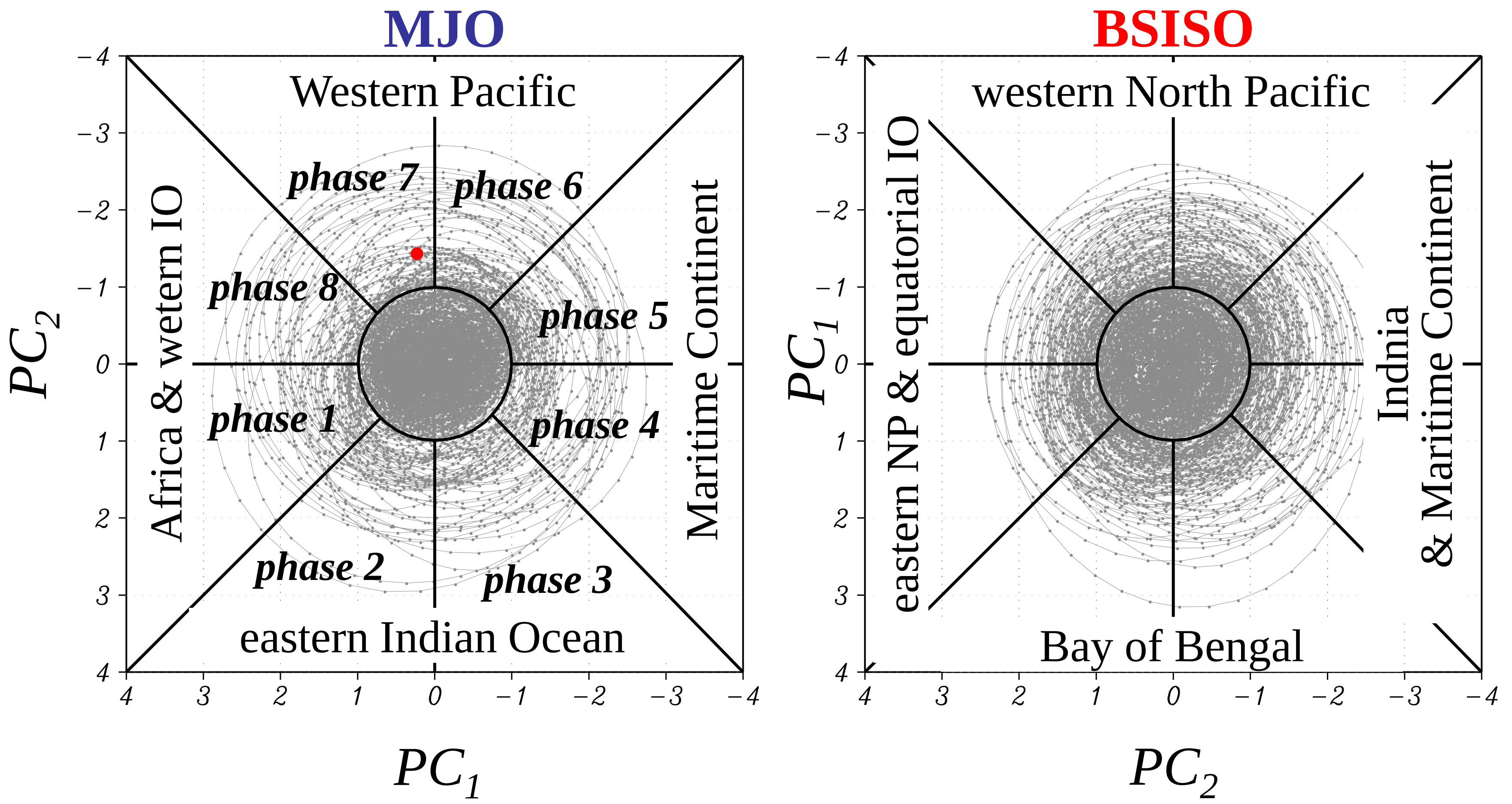


*BSISO: Boreal Summer ISO

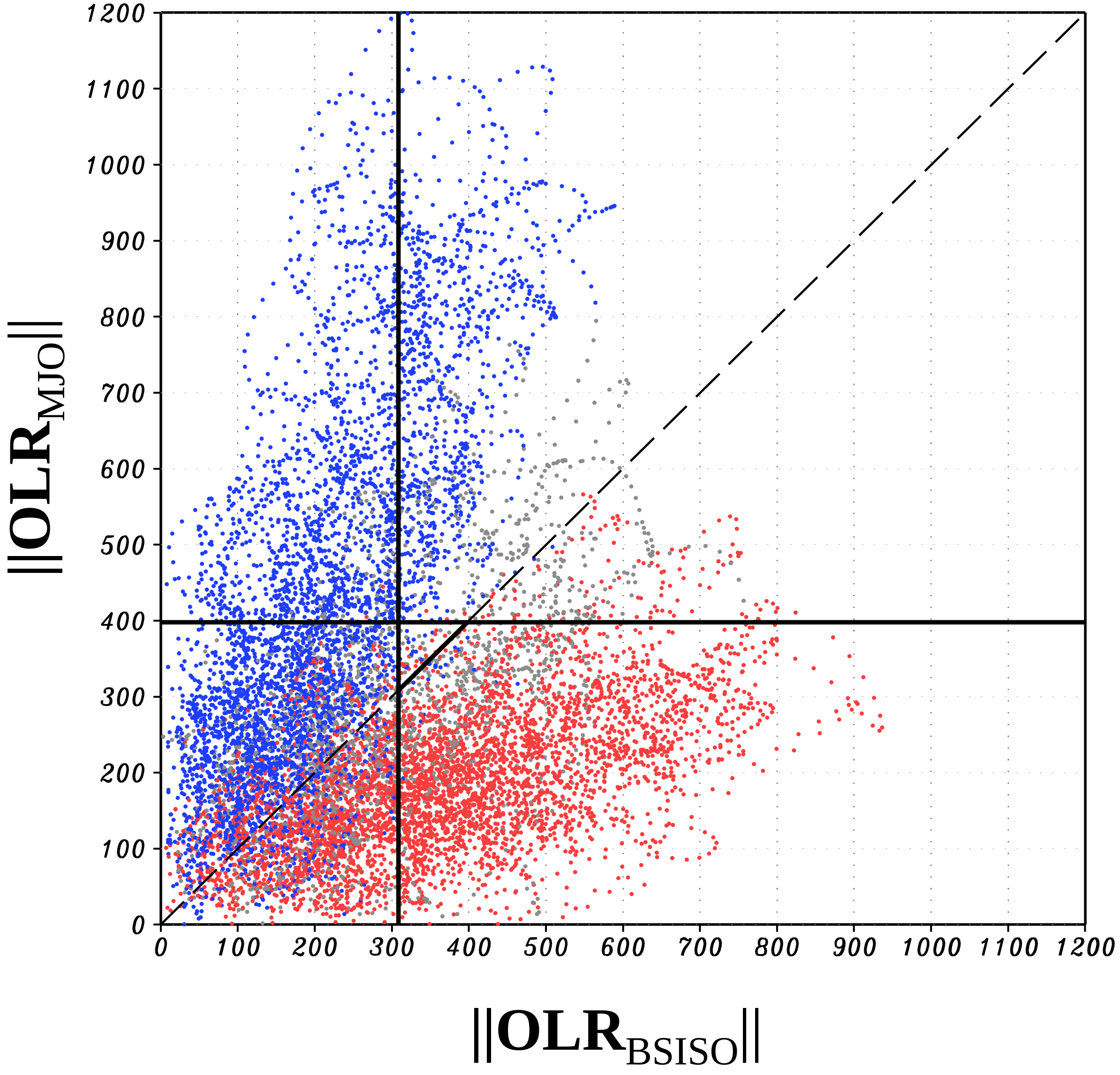
Bimodal ISO modes: MJO and BSISO



Phase space and category

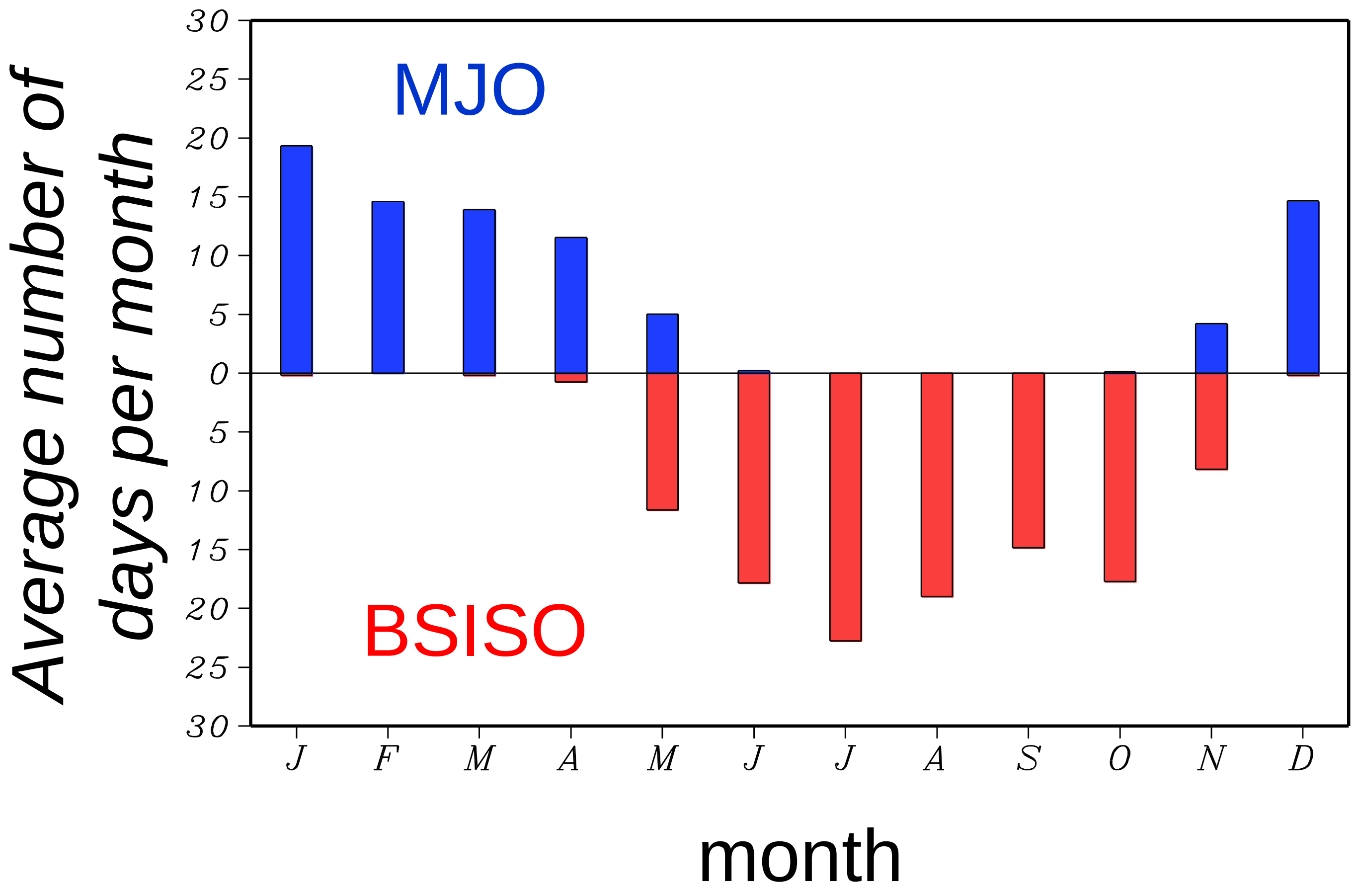


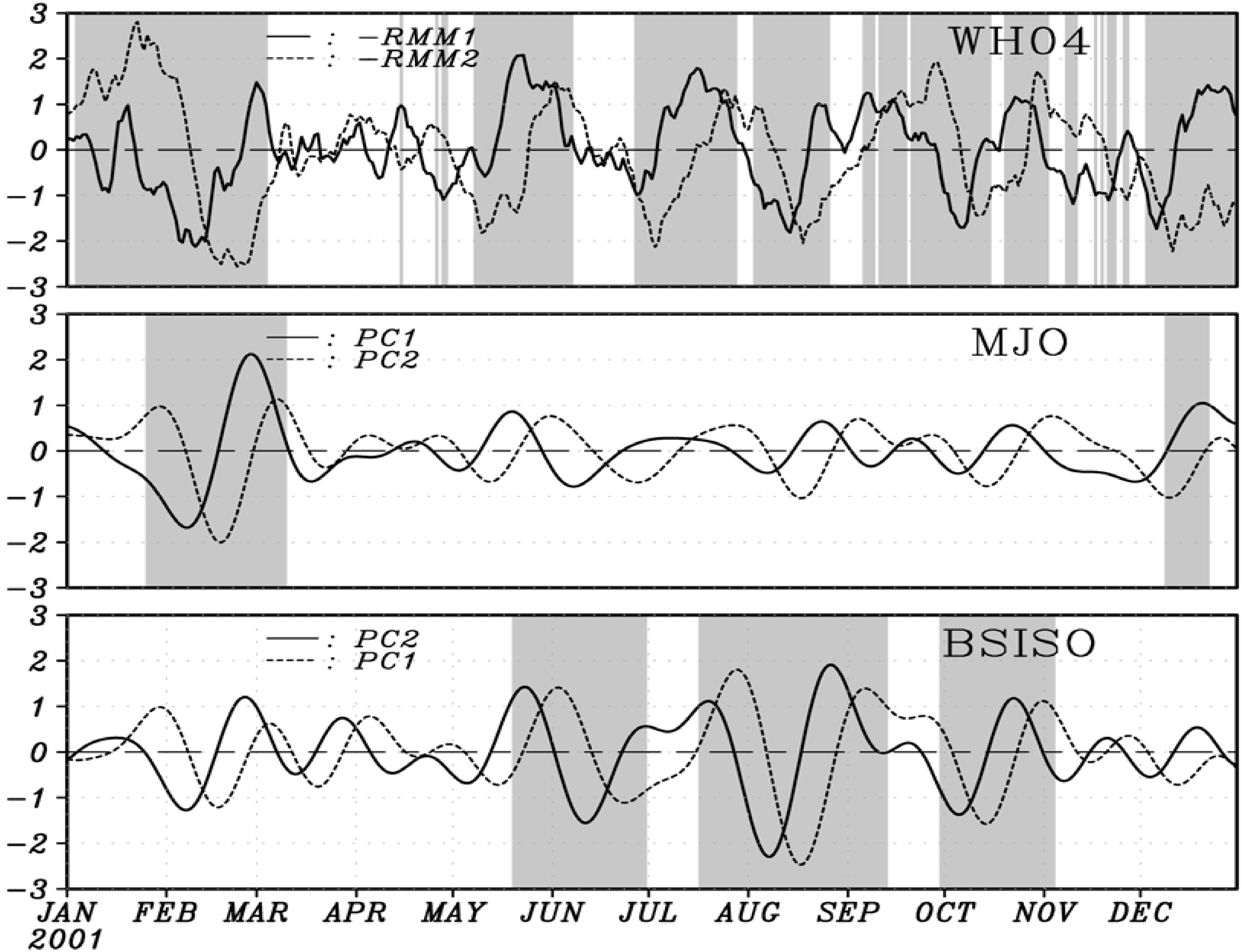
MJO vs BSISO



1200
1100
1000
900
800
700
600
500
400
300
200
100
0
0 100 200 300 400 500 600 700 800 900 1000 1100 1200
$||\mathbf{OLR}_{\mathrm{MJO}}||$
$||\mathbf{OLR}_{\mathrm{BSISO}}||$

Seasonal variation of the two ISO modes



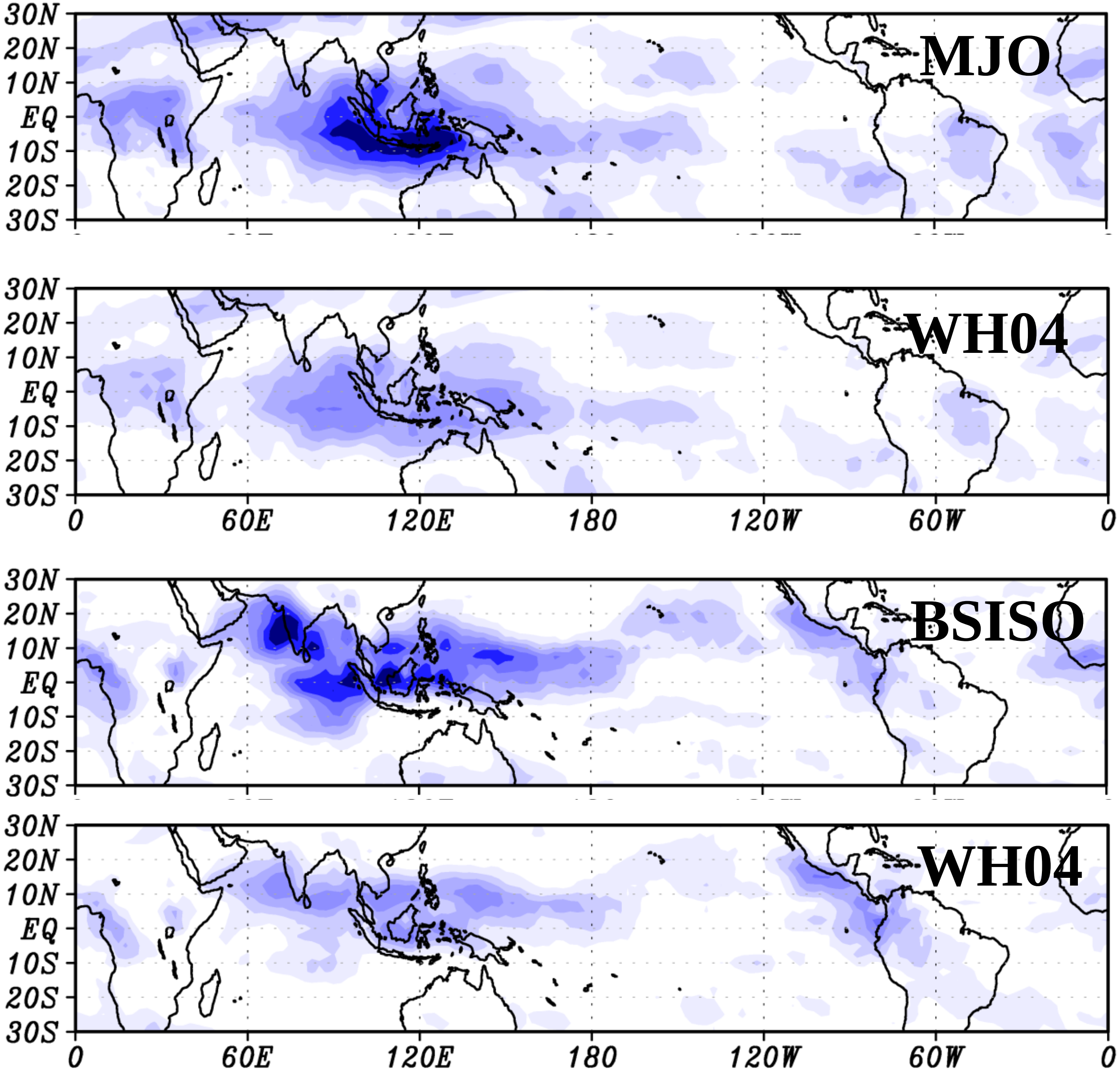


WH04
−RMM1
−RMM2
MJO
PC1
PC2
BSISO
PC2
PC1
3
2
1
0
−1
−2
−3
JAN
2001
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

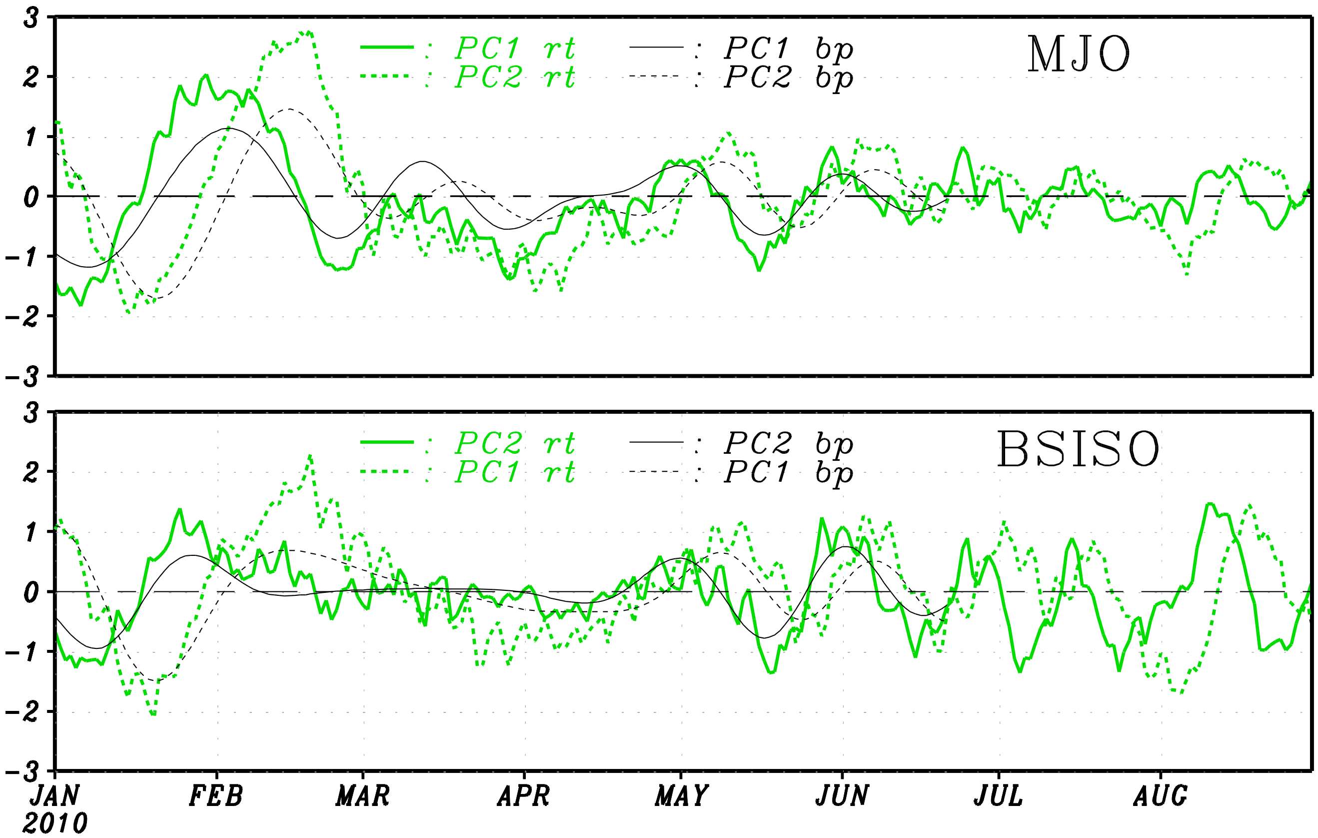
Fractional variance

DJF

JJA



Real time monitoring



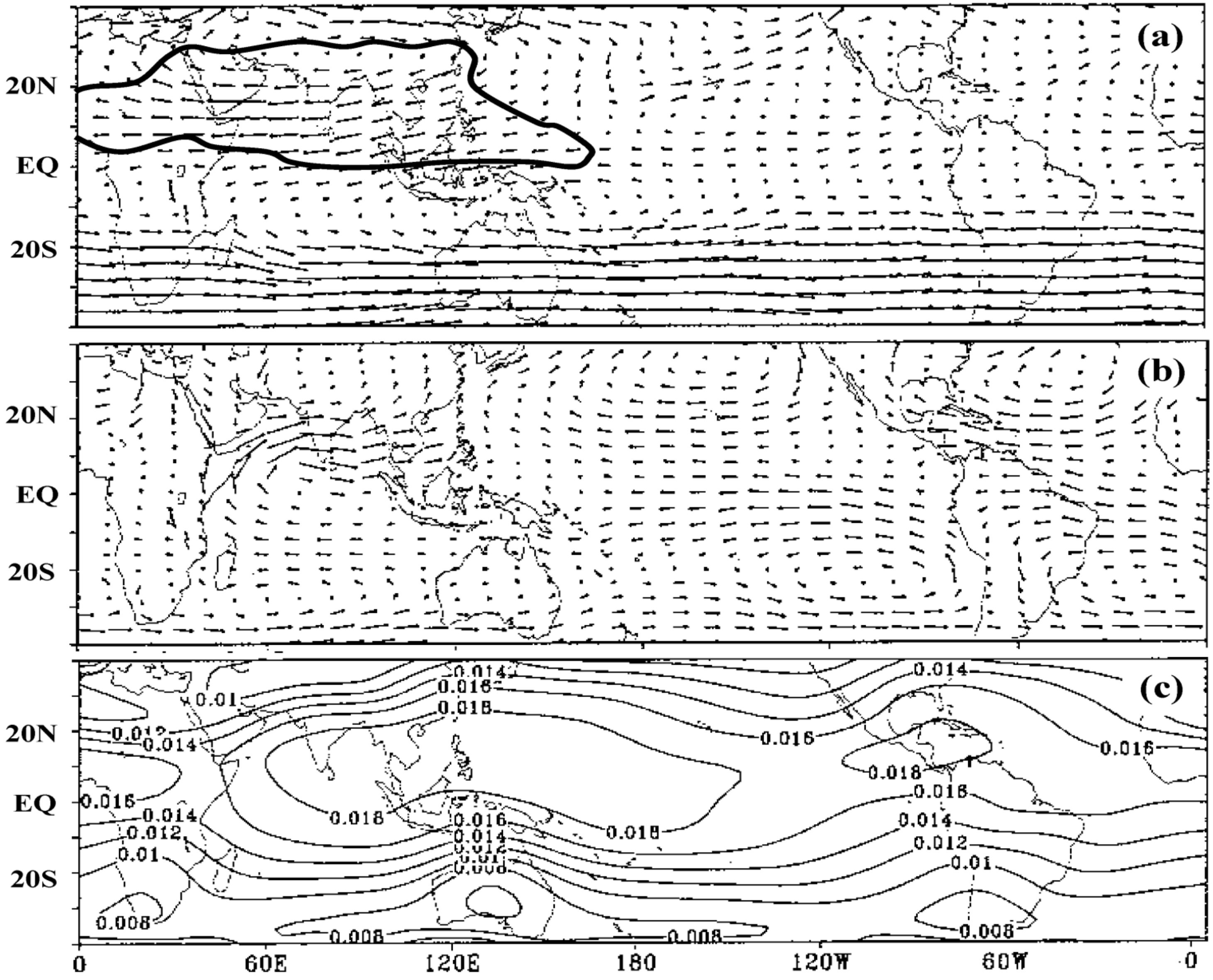
Subtraction of

- climatological annual cycle and mean
- 40-day mean of the previous 40 days

II. Mechanisms

1. Formation of titled rain band
2. Northward propagation
3. Initiation
4. Monsoon ISO

Fundamental controlling: Monsoon mean state



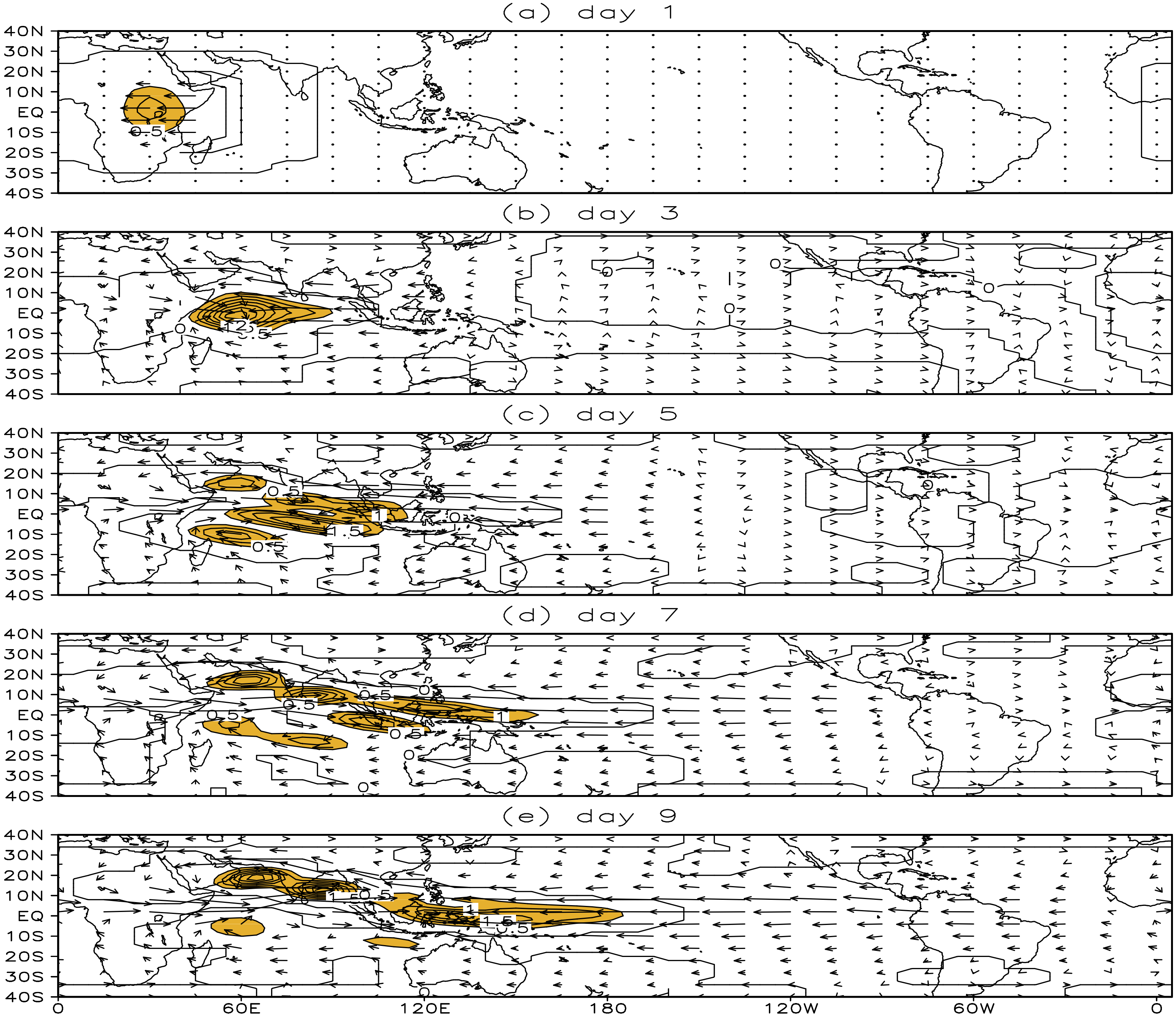
July mean state (ER40)

How does the tilted rain band form?

Emanation of Rossby waves from the equatorial rainfall anomalies over maritime continent.

Essential Role of the easterly vertical shear

(Wang and Xie 1997 hypothesis)



Drhoblav and Wang 2007

What determines the northward propagation of BSISO convective complex?

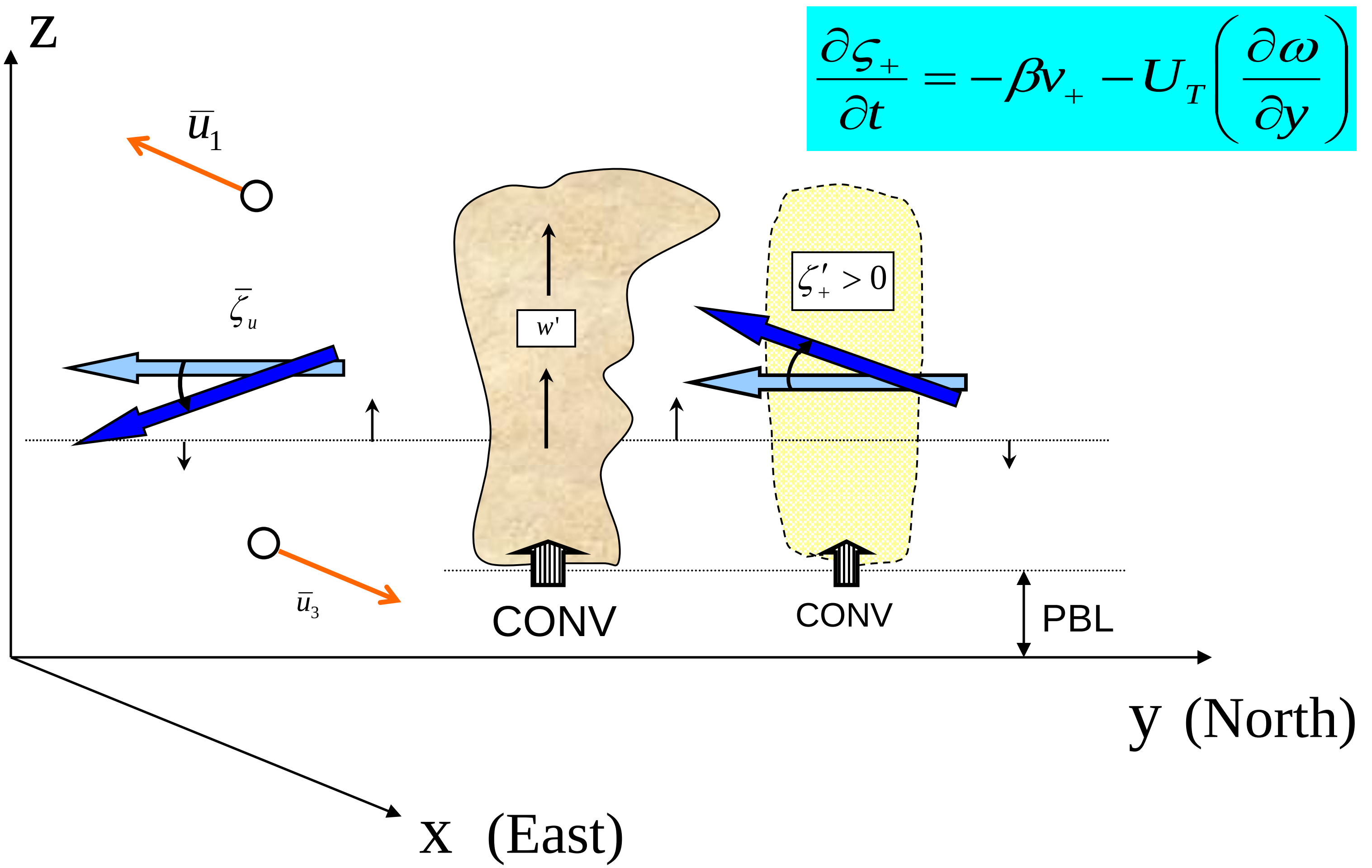
Easterly vertical shear effects- Easterly wind shear is a necessary condition, providing an environment favorable for the emanation of Rossby waves

- Simple and complex GCM's produce northward propagation when easterly shear is evident (Wang and Xie 1997, Kemball-Cook et al. 2002, Annamalai and Sperber 2005)

Air-sea interaction-forces or feedbacks to promote northward propagation of convection

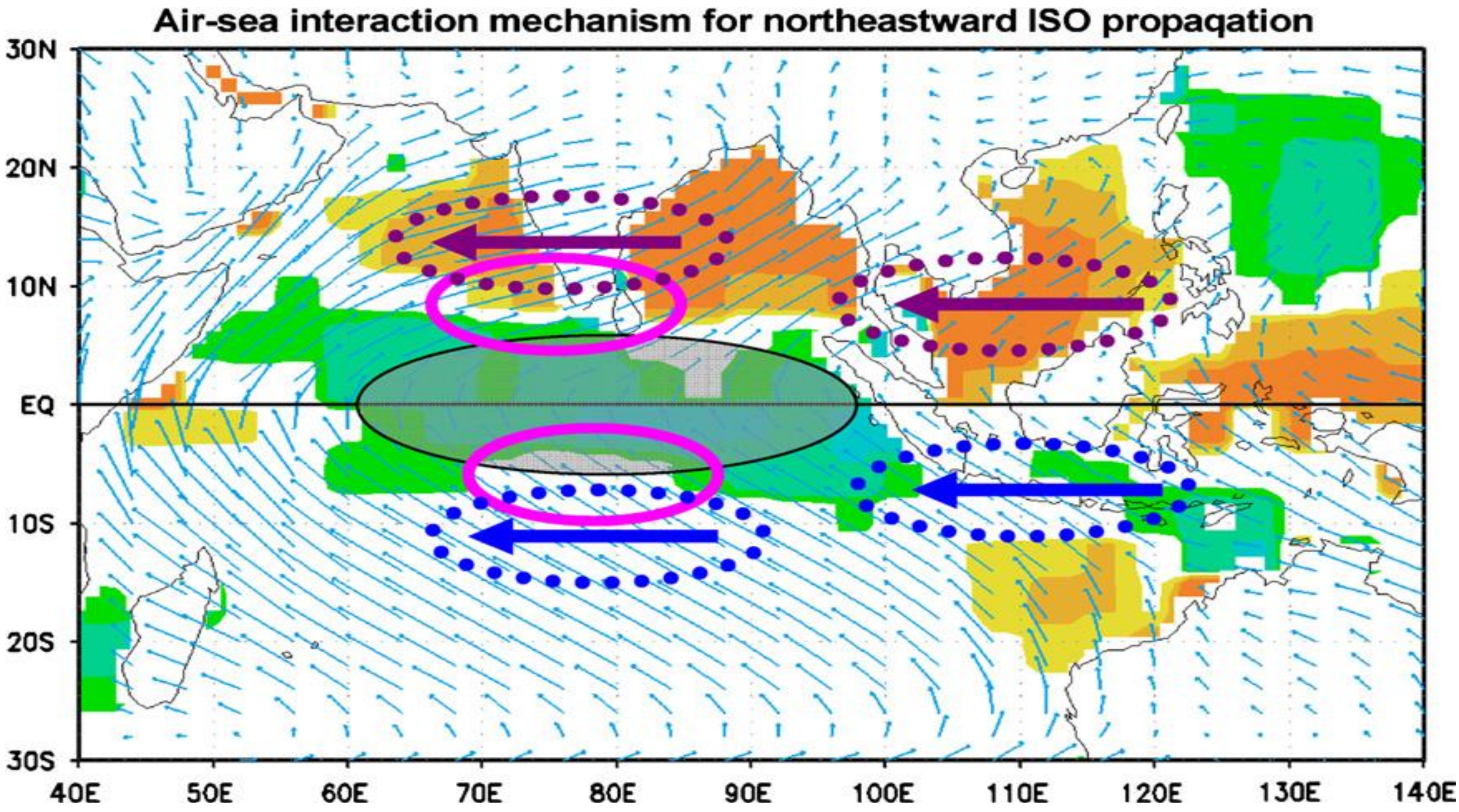
- Kemball-Cook et al. (2002), Fu et al. (2003), Rajendran and Kitoh (2006)

Easterly vertical shear mechanism



Monsoon easterly vertical shear provides a vorticity source, which, upon being twisted by the north-south varying vertical motion field associated with the Rossby waves, generates positive vorticity north of the convection, creating boundary layer moisture convergence that favor northward movement of the enhanced rainfall.

Propagating Air-sea interaction mechanism



Fu et al. (2003), Wang et al. (2009)

Issue: How are the active/break cycles of ISM re-initiated or MISO maintained?

Hypotheses

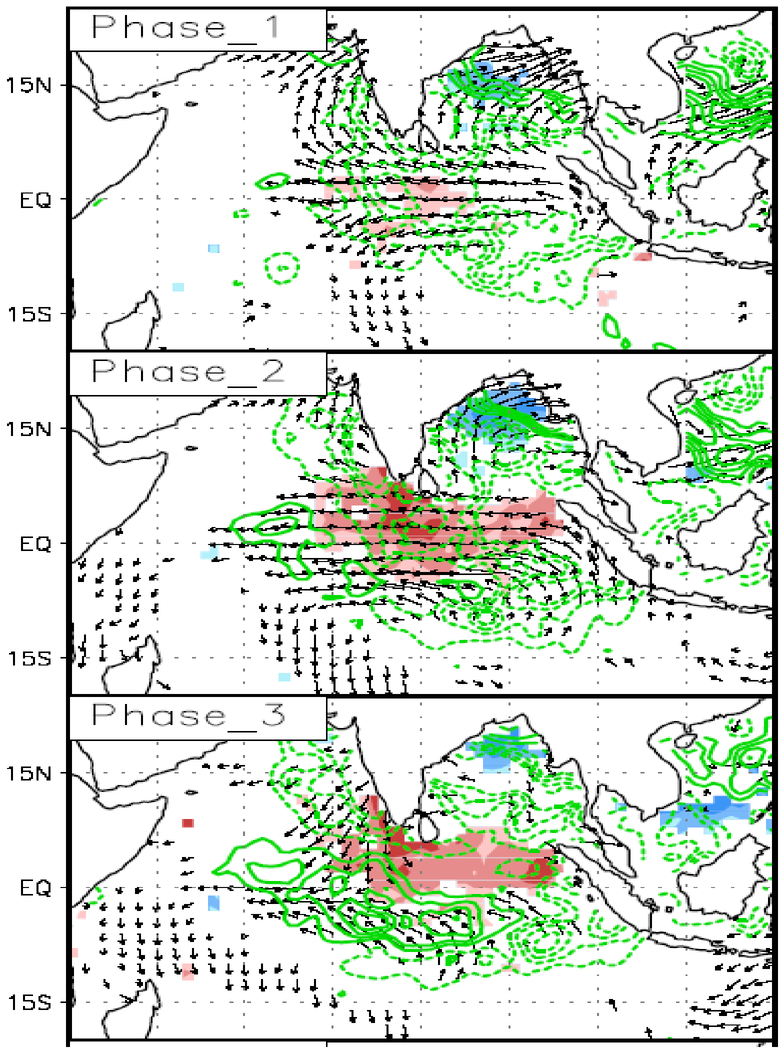
1. **Circumglobal propagation** of the upper-level divergent waves of MJO (Julian and Madden 1981, Lau and Chan 1986 among many others)

2. **Midlatitude forcing**: Forced by midlatitude Rossby wave train (Hsu et al. 1990) or by injection of PV from SH (Rodwell 1997)

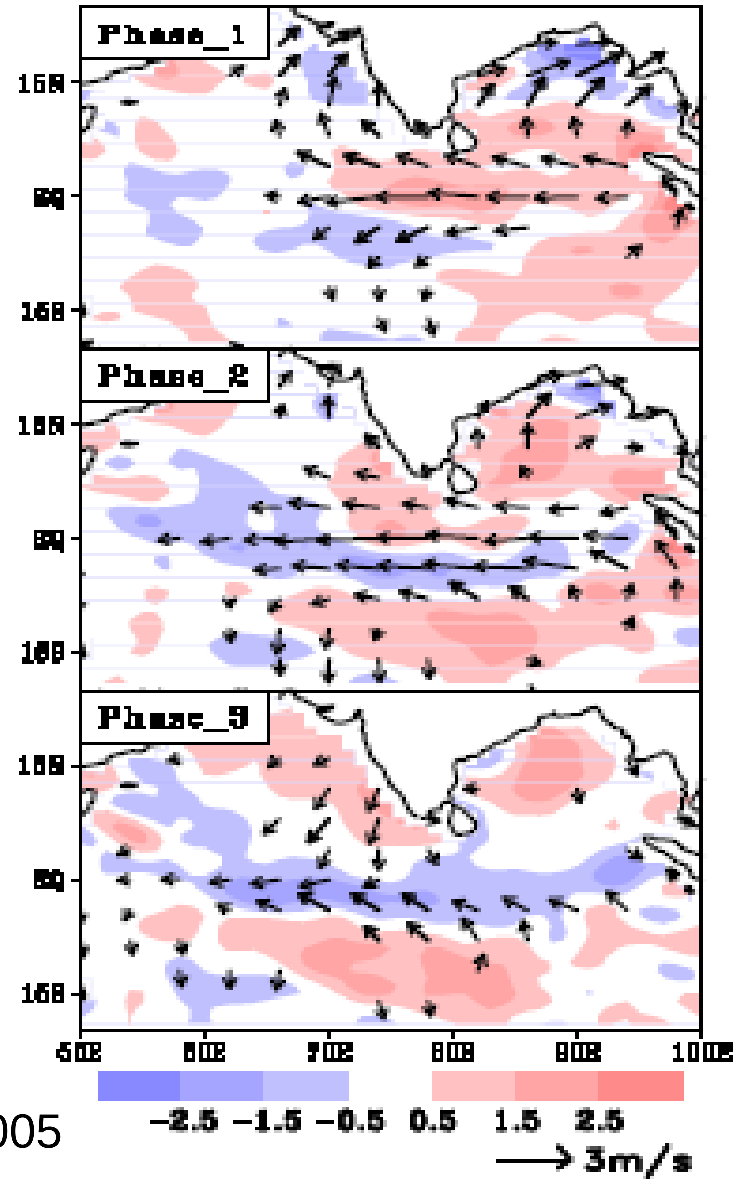
3. **Self-induction mechanism** (Wang, Webster, Teng 2005)

Re-initiation process

Rainfall (contours) and SST (color)



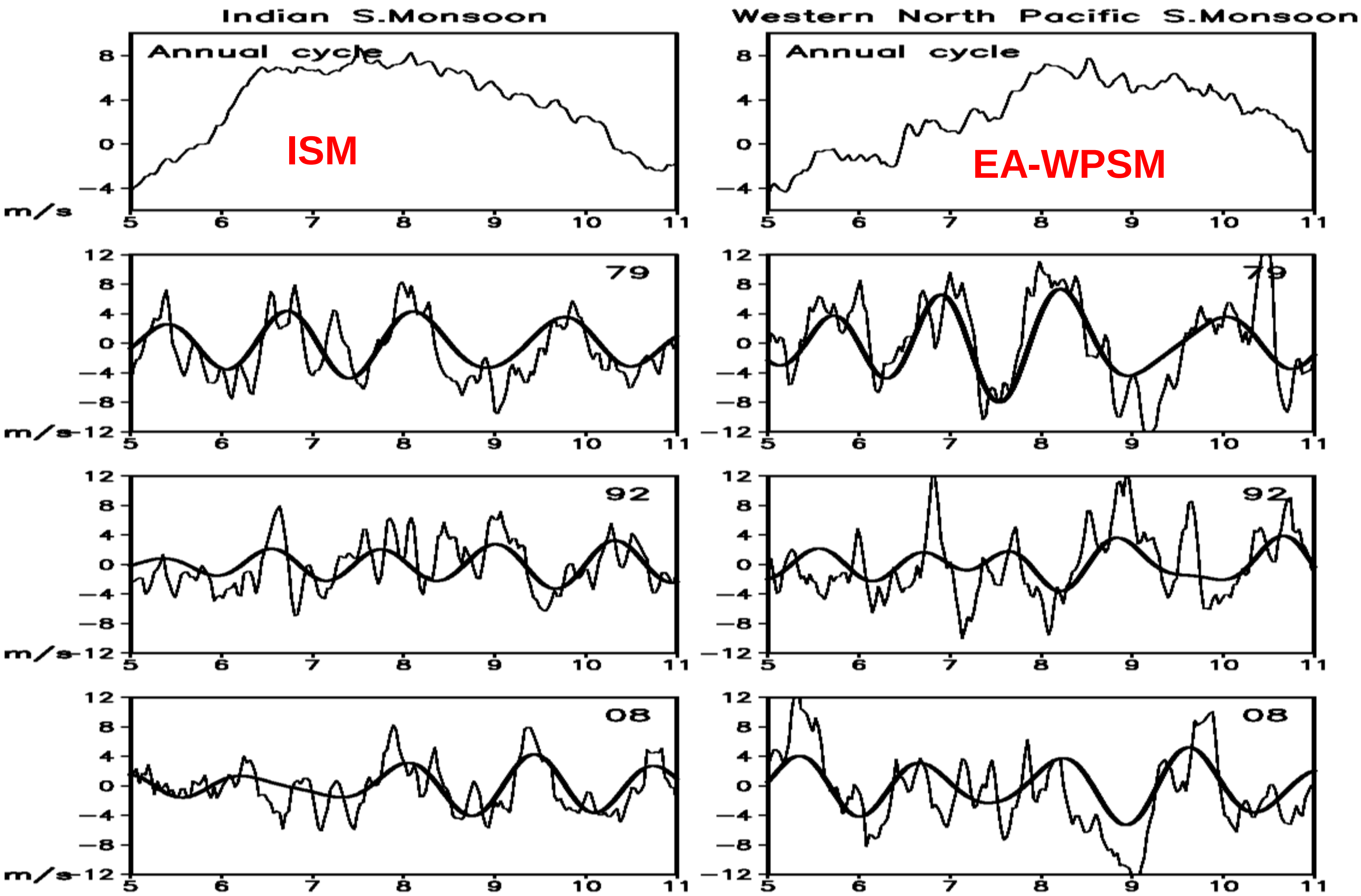
Surface winds and divergence



The *in situ* **surface wind convergence** and **sea surface warming** that initiate new rainfall anomalies result from the forcing of the previous active monsoon, suggesting a **self-Induction mechanism to sustain BSISO.**

Wang, Webster, Teng 2005

ISO of Monsoon circulation: why so strong?



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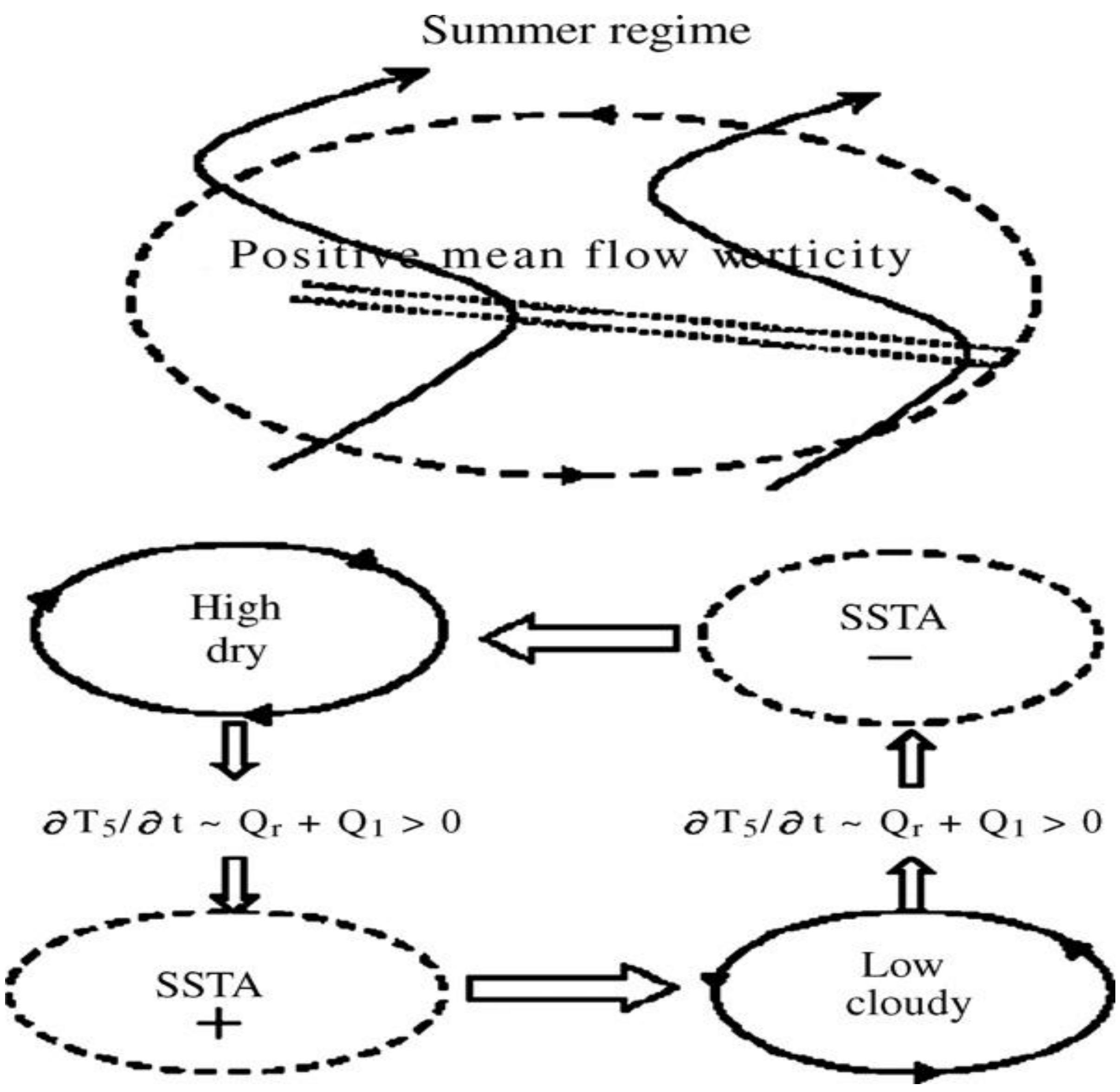
Stationary air-sea interaction: Monsoon trough ISO



Wang and Zhang 2002

III. Prediction

ISVHE

Prediction skill of BSISO

Issues on predictability study

CliPAS

Climate Prediction and its Application to Society

Multi-institutional ISO Hindcast Experiment

Bin Wang, J.-Y. Lee, I.-S. Kang, H. Hendon, D. Waliser, J. Shukla and CliPAS ISO Team

CliPAS

Experimental Design

EXP1: Control Simulation

Free runs with coupled OGCMs or forced AGCM simulation with specified boundary conditions are requested for at least 20 years. The period for the forced AGCM run should be consistent with the hindcast period.

EXP2: 21-year (January 1 1989-Oct 31 2009) ISO Hindcast

Re Forecast Period	20 years from 1989 to 2008
Initial Date	Every 10 days on 1st, 11th, and 21st of each calendar month
The Length of Integration	At least 45 days
Ensemble Member	At least 5 members
Initial condition	Initial conditions may use 12-hour lags

No uniform specification regarding model resolution and initialization procedures. (for AGCM experiments, the ERA, NCEP 2 were recommend for initial conditions)

No information from "future" is used , for AGCM experiments, SST must be forecasted.

Description of Model and Experimental Design

One-Tier System

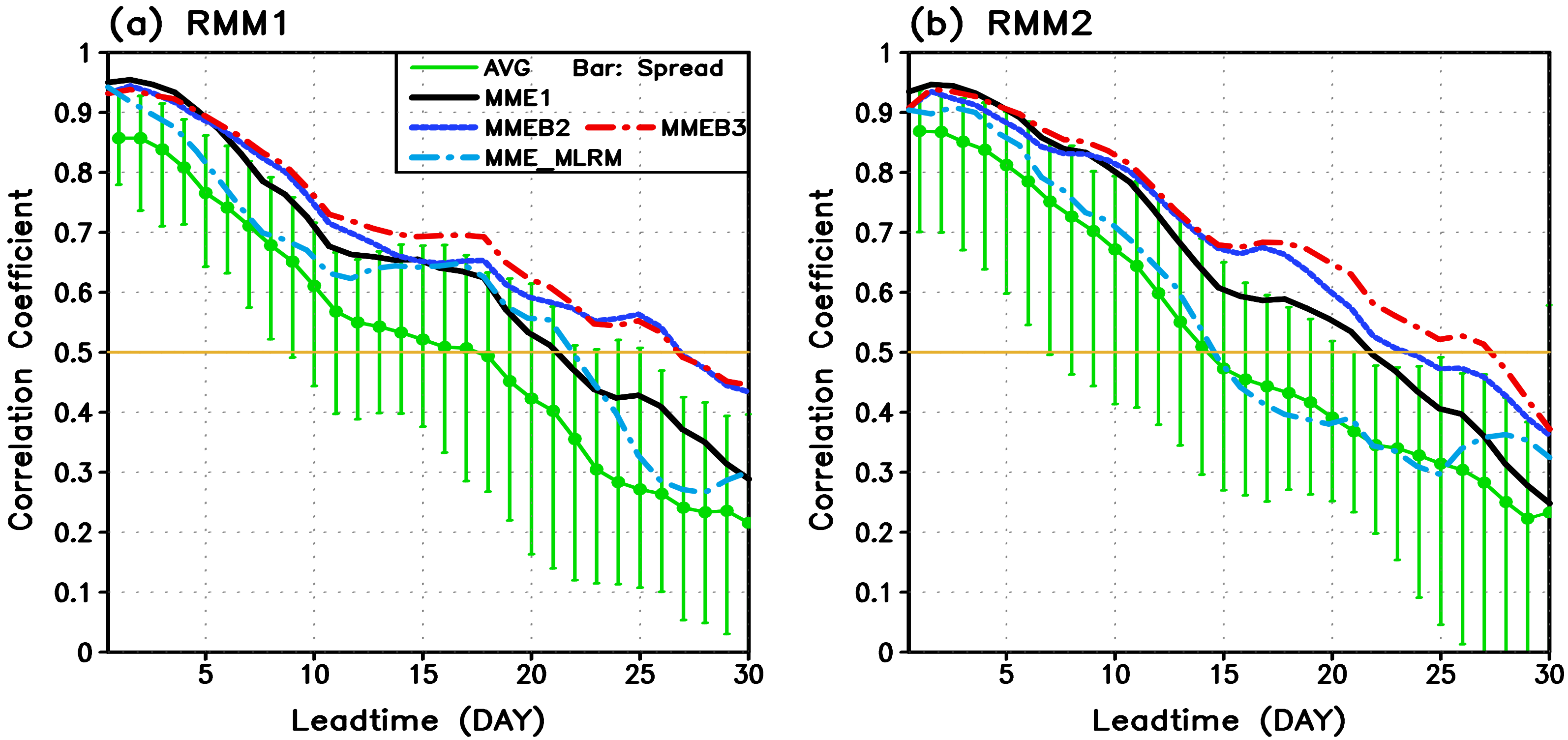
	Model	Control Run	ISO Hindcast		
			Period	Ens No	Initial Condition
ABOM	POAMA 1.5 (ACOM2+BAM3)	CMIP	1980-2006	10	The first day of every month
CMCC	CMCC (ECHAM5+OPA8.2)	CMIP (20yrs)	1989-2008	5	Every 10 days
ECMWF	ECMWF (IFS+HOPE)	CMIP(11yrs)	1989-2008	15	The 15th day of every month
GFDL	CM2 (AM2/LM2+MOM4)	CMIP	1982-2008	10	The first day of every month
JMA	JMA CGCM	CMIP (20yrs)	1989-2008	6	Every 15 days
NCEP/CPC	CFS (GFS+MOM3)	CMIP (100yrs)	1981-2008	5	Every 10 days
PNU	CFS with RAS scheme	CMIP (13yrs)	1981-2008	3	The first day of each month
SNU	SNU CM (SNUAGCM+MOM3)	CMIP (20yrs)	1989-2008	1	Every 10 days
UH/IPRC	UH CM (ECHAM4+IOM)	CMIP	1989-2008	6	The first day of every month

Two-Tier System

	Model	Control Run	ISO Hindcast		
			Period	Ens No	Initial Condition
CWB	CWB AGCM	AMIP (25yrs)	1981-2005	10	Every 10 days
MRD/EC	GEM	AMIP (21yrs)	1985-2008	10	Every 10 days

TCC Skill for RMM Index/ ONDJFM

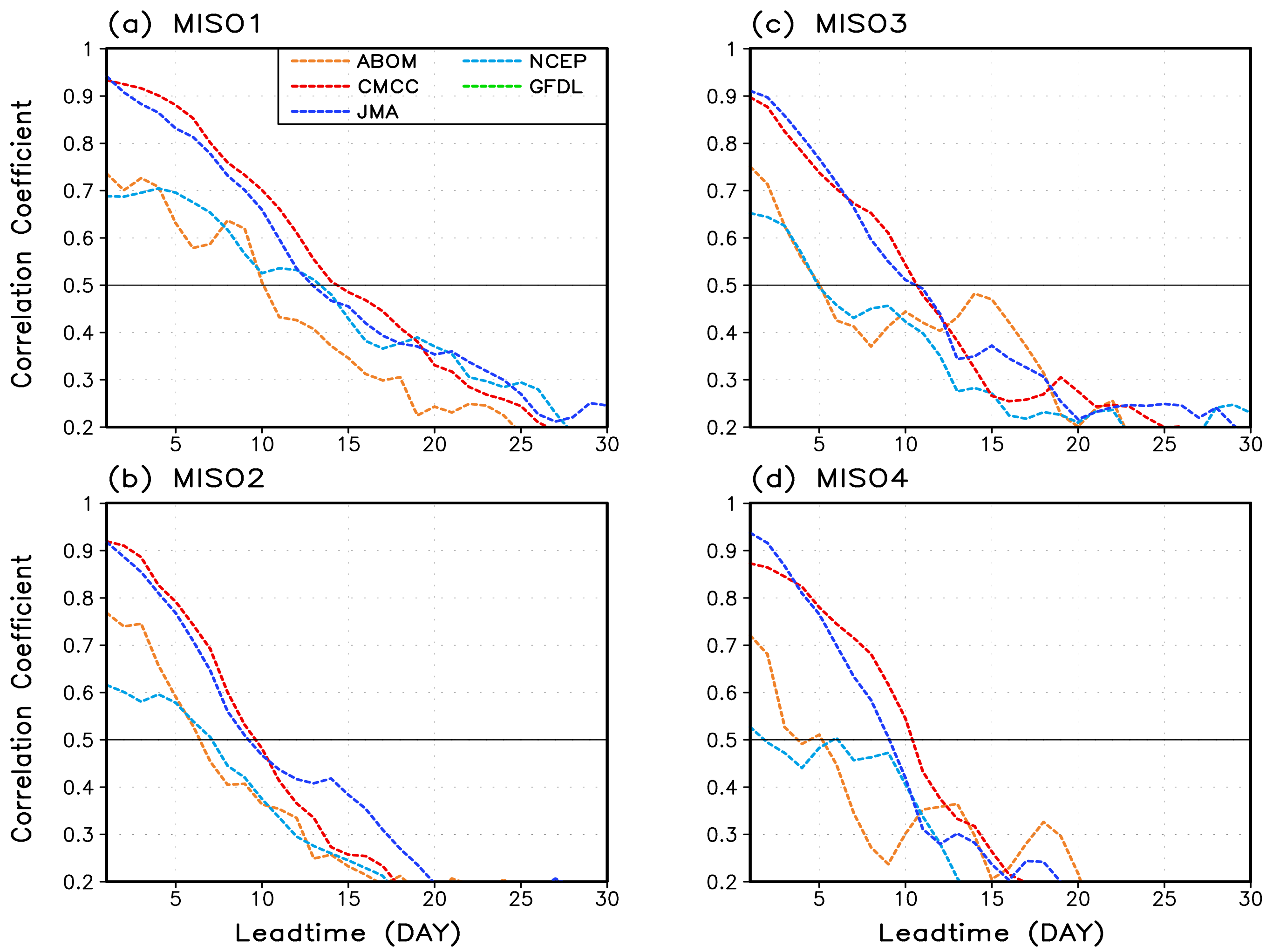
Can the MME approach improve MJO forecast?



Common Period: 1989-2008
Initial Condition: 1st day of each month from Oct to March
MME1: Simple composite with all models
MMEB2: Simple composite using the best two models, MMEB3: Simple composite using the best three models
MME_MLRM: MME with weighting ft.

Independent forecast (1999-2006) skill using MME_MLRM is not better than the simple MME skill.

TCC Skill for the MISO Index/ MJJAS



Objectives

- ***Better understand physical basis for intraseasonal prediction.***

- ***Estimate potential and practical predictability of ISO in a multi-model frame work.***

- ***Developing optimal strategies for multi-model ensemble (MME) ISO prediction system***, including effective initialization schemes and quantification of the MME's ISO prediction skills with forecast metrics under operational conditions.

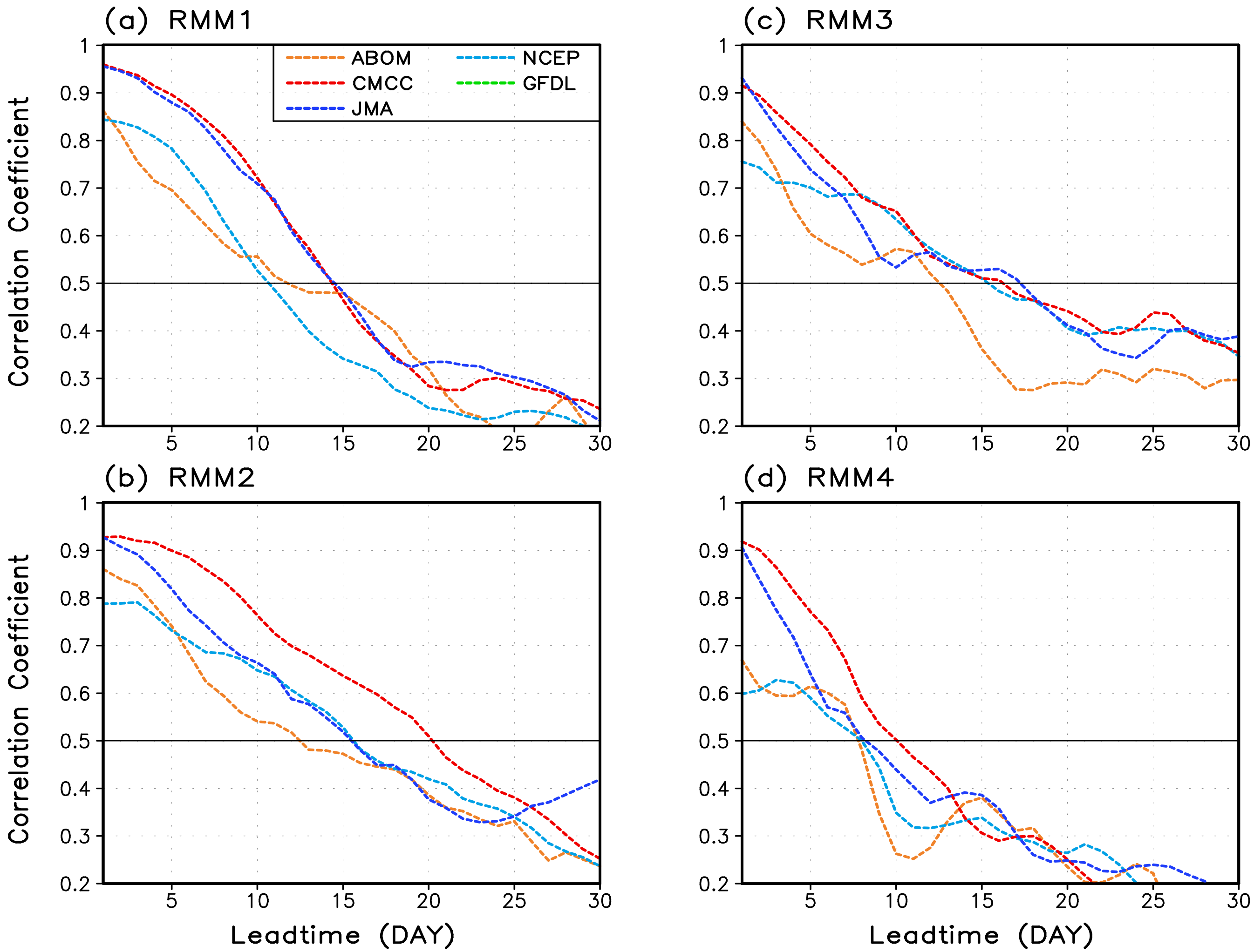
- ***Identify model deficiencies in predicting ISO and suggest ways to improve models' convective and other physical parameterizations*** relevant to the ISO through development of model process diagnostics.

- ***Revealing new physical mechanisms associated with ISV*** that cannot be obtained from analyses of a single model.

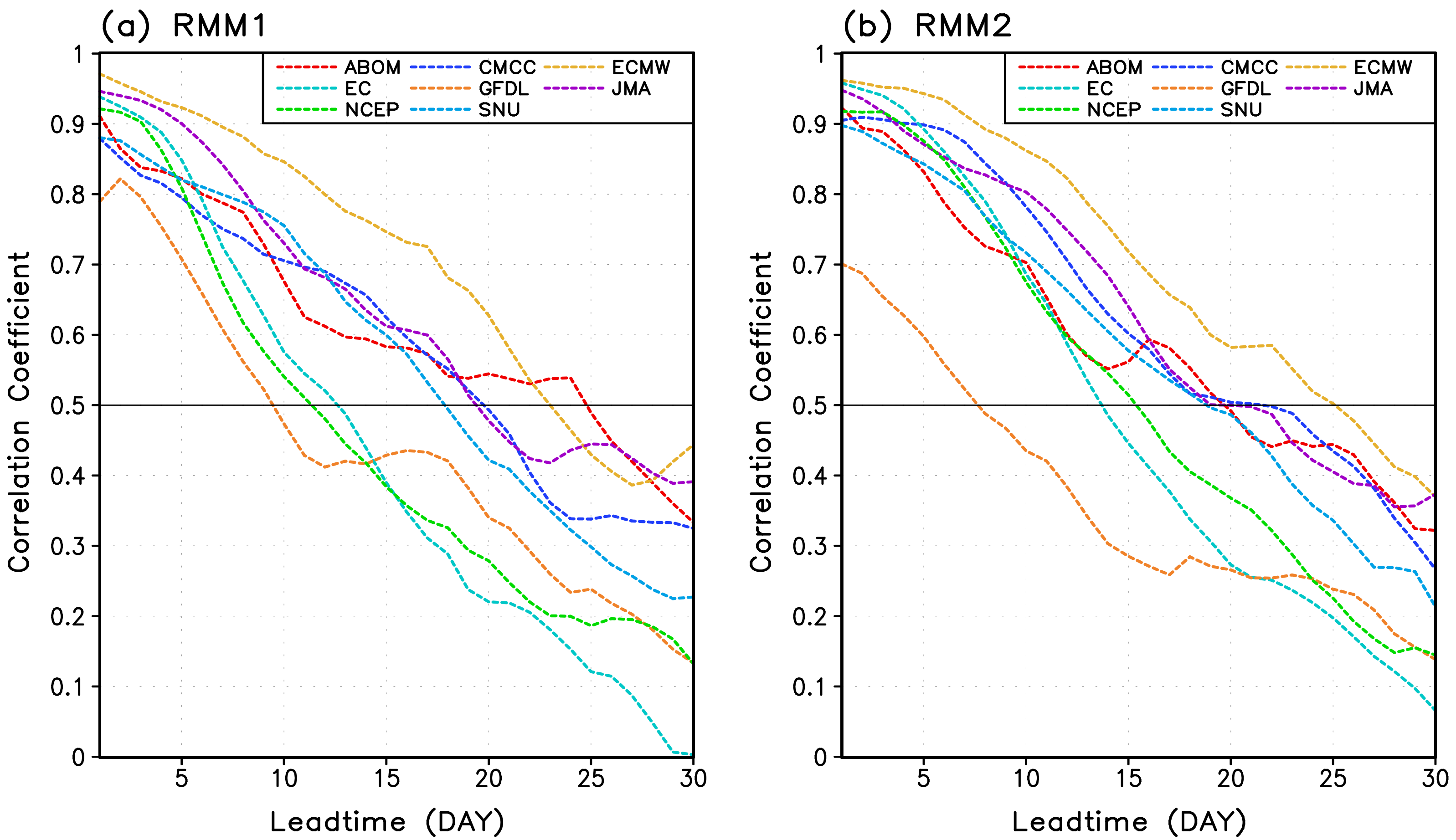
- ***Study ISO's modulation of extreme hydrological events*** (e.g., midlatitude weather, monsoon depressions, and tropical cyclones) and ***its contribution to seasonal and interannual climate variation.***

Thank you

TCC Skill for the RMM Index/ MJJAS

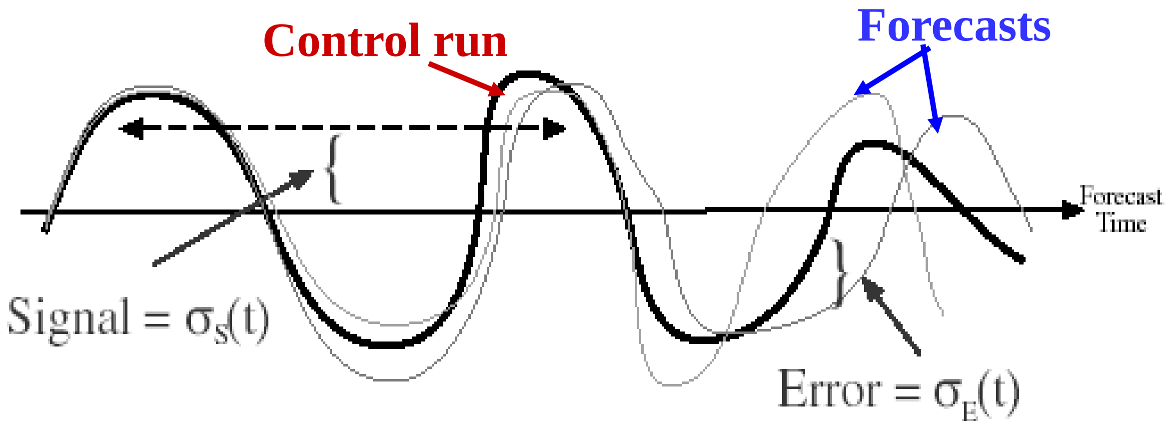


TCC Skill for RMM Index/ ONDJFM



- Evaluation of the temporal correlation coefficient (TCC) skill for the RMM1 and RMM2 using available hindcast data
- Validation dataset: NOAA OLR, U850 and U200 from NCEP Reanalysis II (NCEPII)
- Each model has different initial condition and forecast period.

▪ Signal & Forecast Error



Signal: Mean amplitude of the ISO variance

Forecast Error: Mean variance between ensembles

$$\sigma_{s_{ij}} = \frac{1}{2L+1}\sum_{\tau=-L}^{L}(X^{0}_{i,j+\tau})^2$$

$$\sigma_{e_{ij}} = \frac{1}{M}\sum_{m=1}^{M}(X^{m}_{ij} - X^{0}_{ij})^2$$

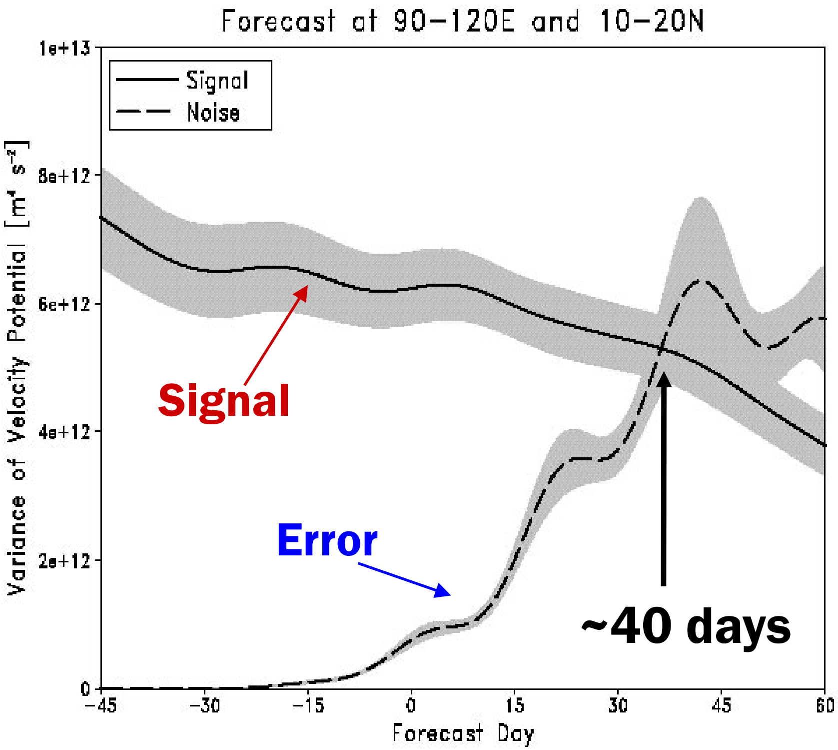
*** Waliser et al. 2003**

* Perfect model assumption

Model	Studies
NASA/GLA AGCM	Waliser et al. (2003)
ECHAM5 AGCM	Liess et al. (2005)
ECHAM4 AGCM, CGCM	Fu et al. (2007)

Predictability : Signal to Error Ratio
Signal: Mean variance within ISO period
Error: Mean variance between ensembles

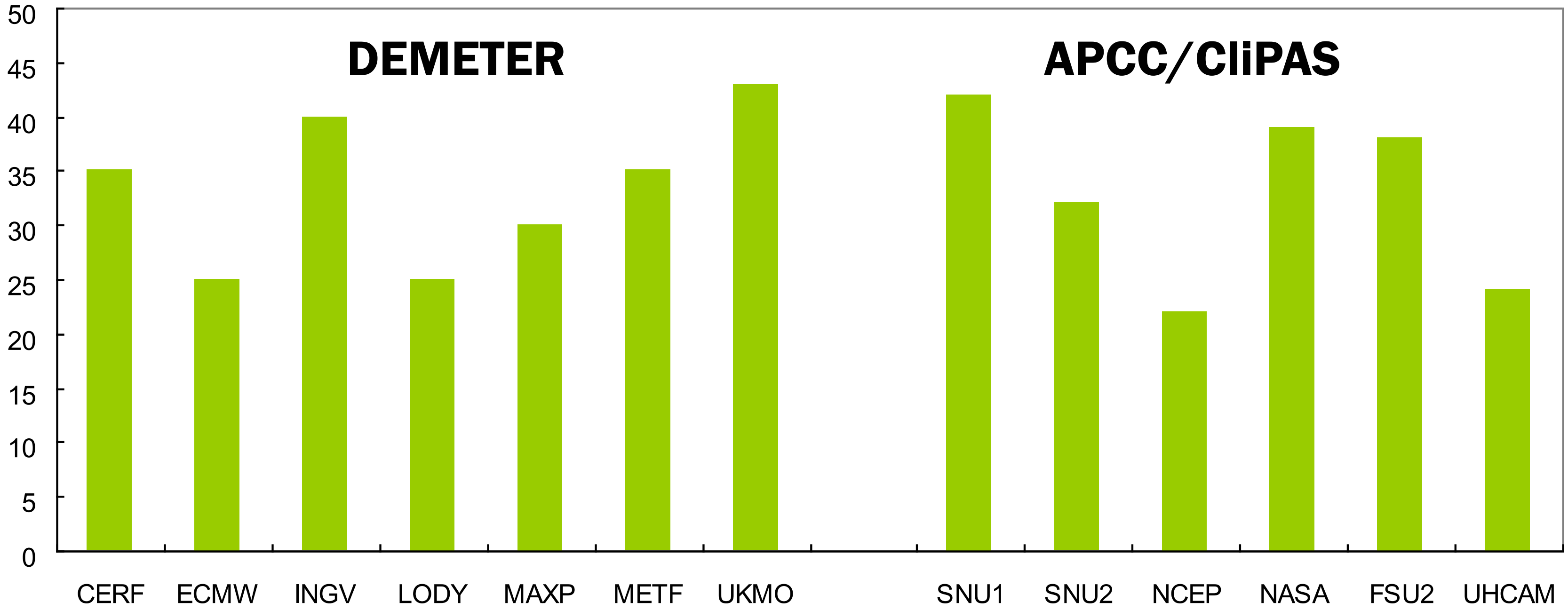
200h Pa Velocity Potential



* Liess et al 2005

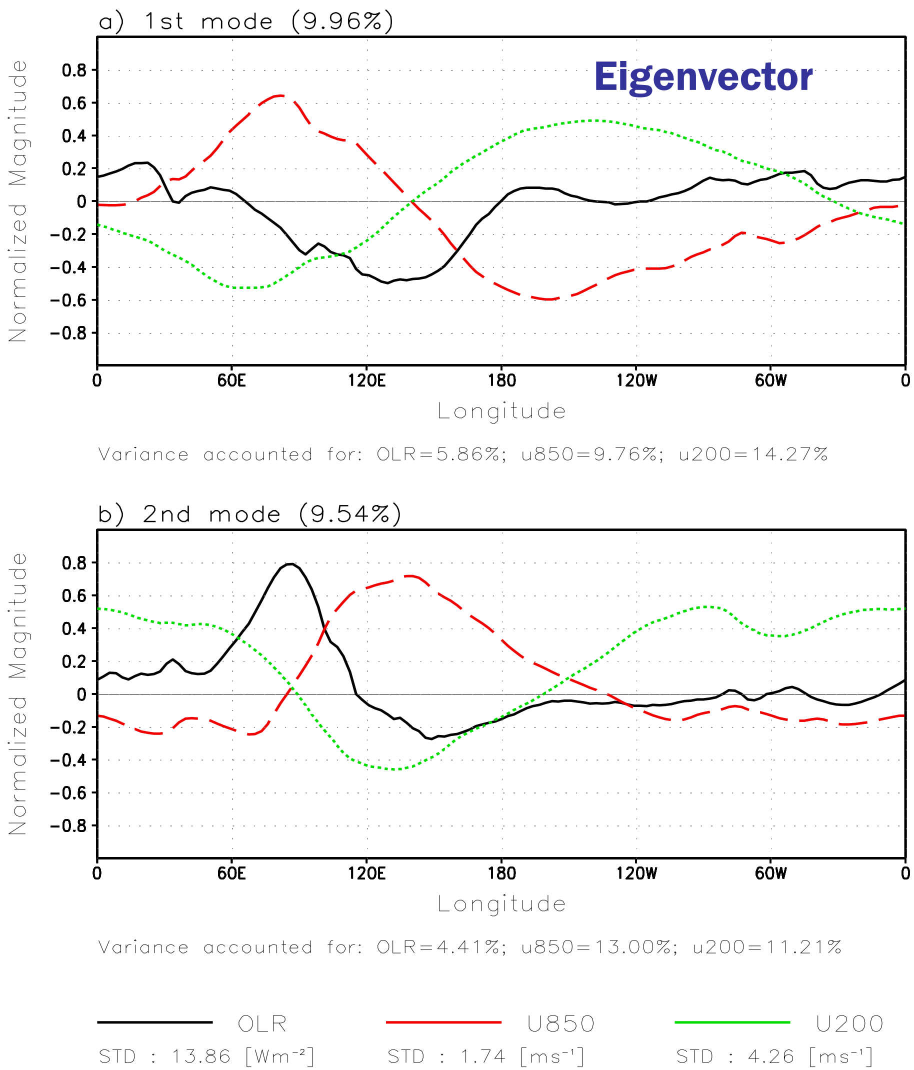
Dynamical models has potential for ISO prediction

Number of forecast days until the signal equals the noise



Real-time Multivariate MJO (RMM) index (Wheeler and Hendon04)

Observed RMM



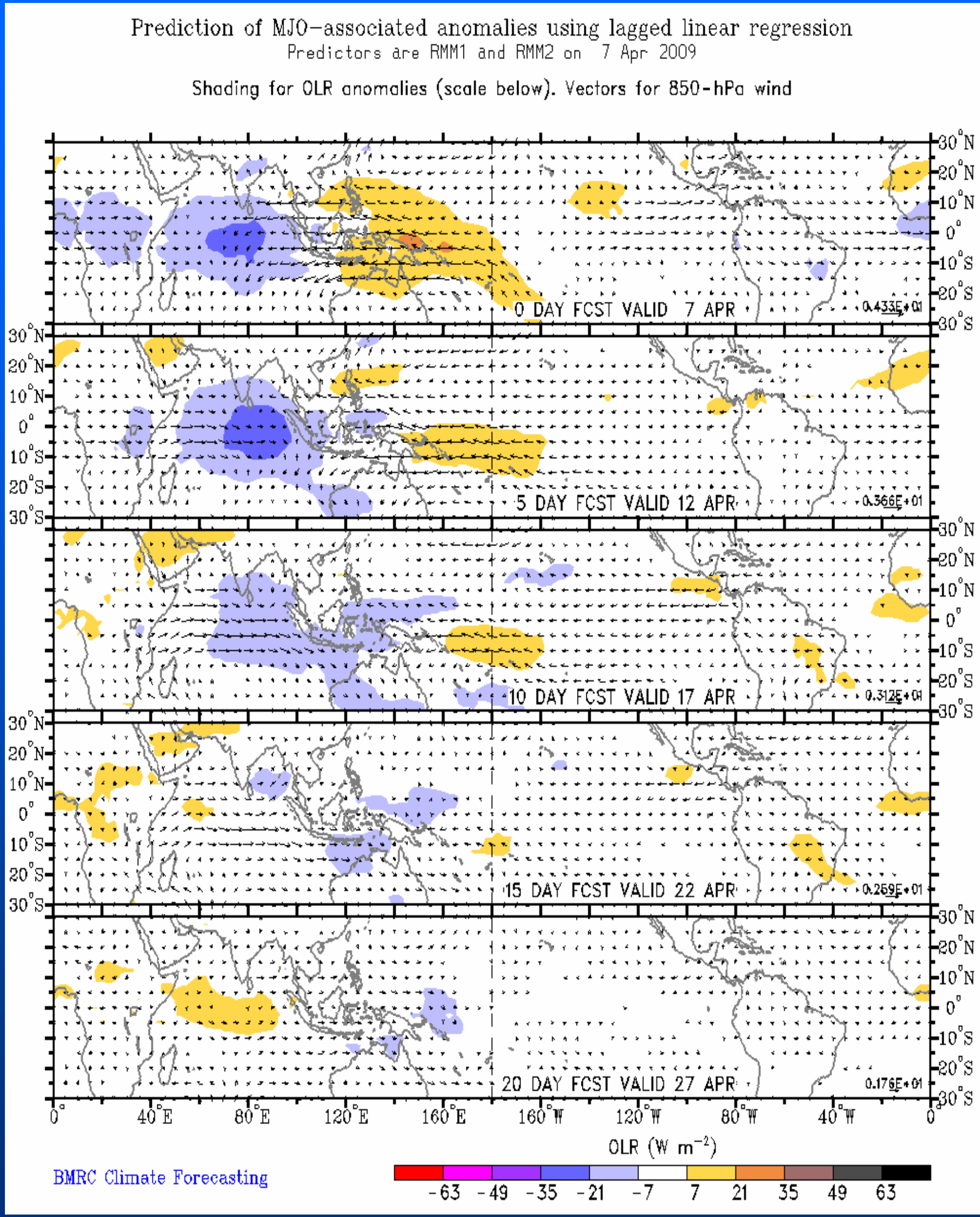
Forecasted RMM

Project the combined eigenvector to predicted variables (daily OLR, U850,U200)

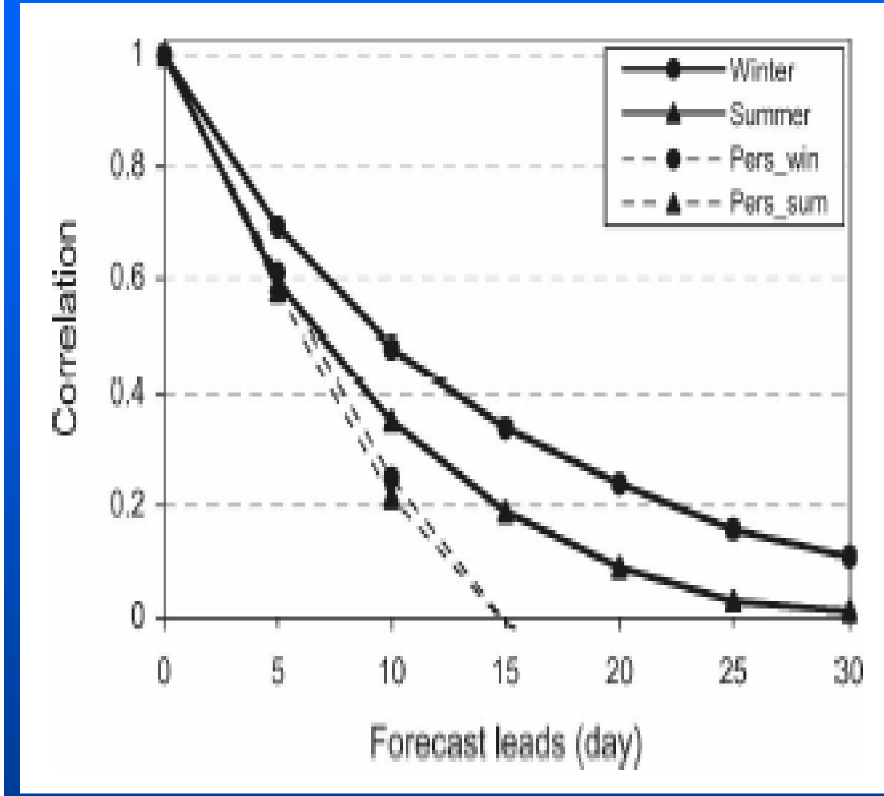
↓

Forecasted PC1, PC2 (RMM index)

Statistical Predictions – WH Lagged Linear Regression



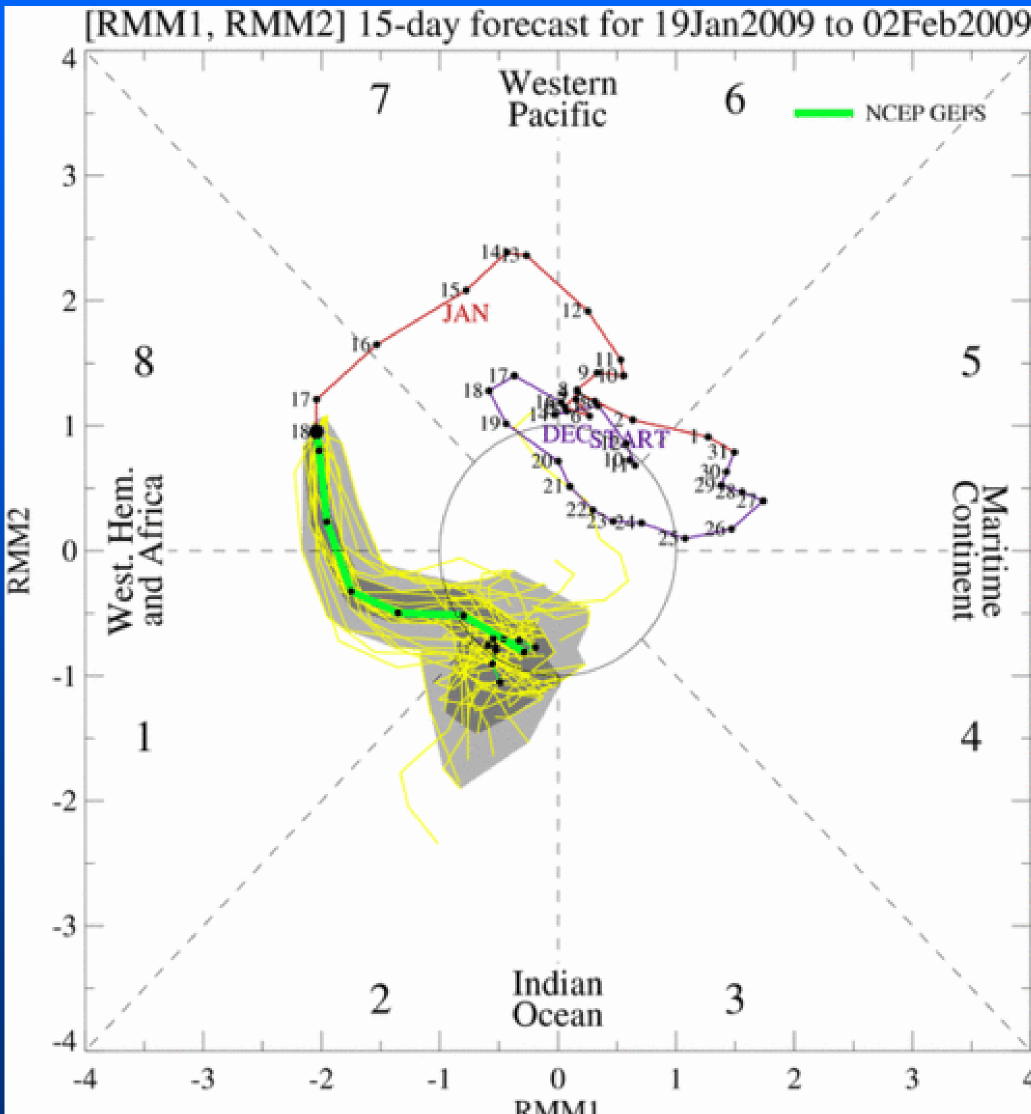
Forecast Skill



From Gottschalck

Dynamical Predictions – GEFS

Yellow Lines – 20 Individual Members
Green Line – Ensemble Mean



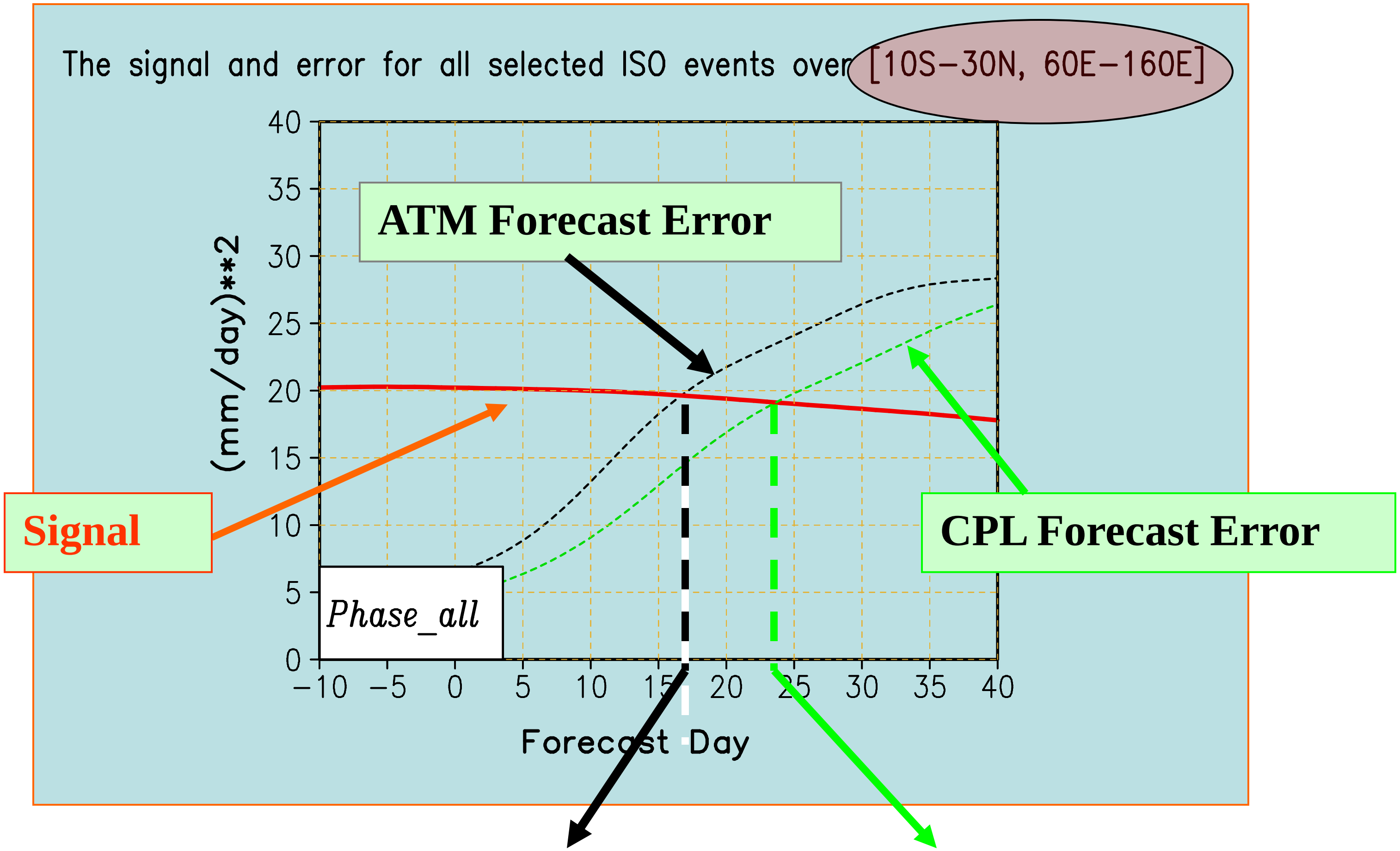
RMM1 and RMM2 values for the most recent 40 days and forecasts from the ensemble Global Forecast System (GEFS) for the next 15 days

light gray shading:
90% of members

dark gray shading:
50% of forecasts

From Gottschalck

Air-Sea Coupling Extends the Predictability of Monsoon Intraseasonal Oscillation



[ATM: 17 days; CPL: 24 days]

Fu et al. (2007)

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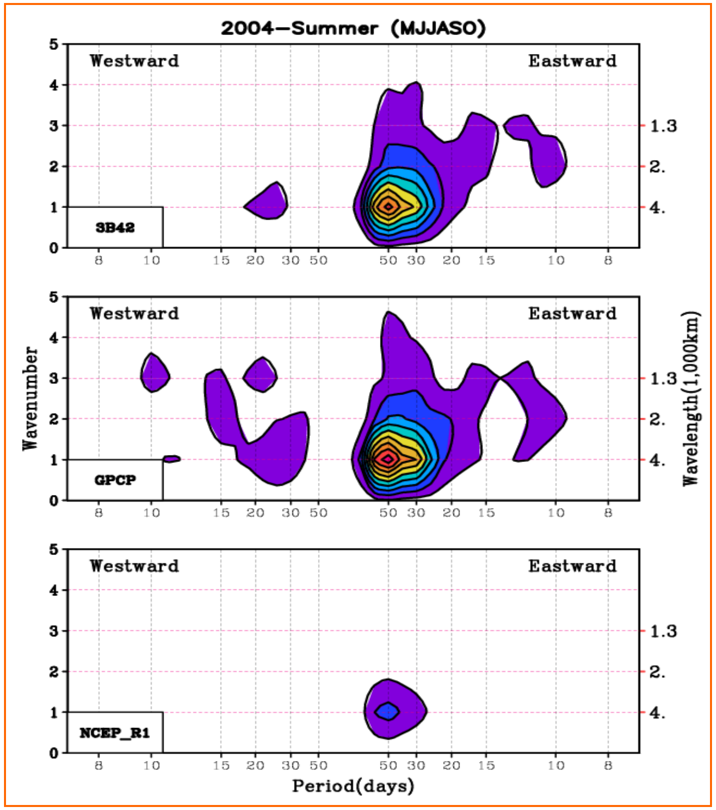
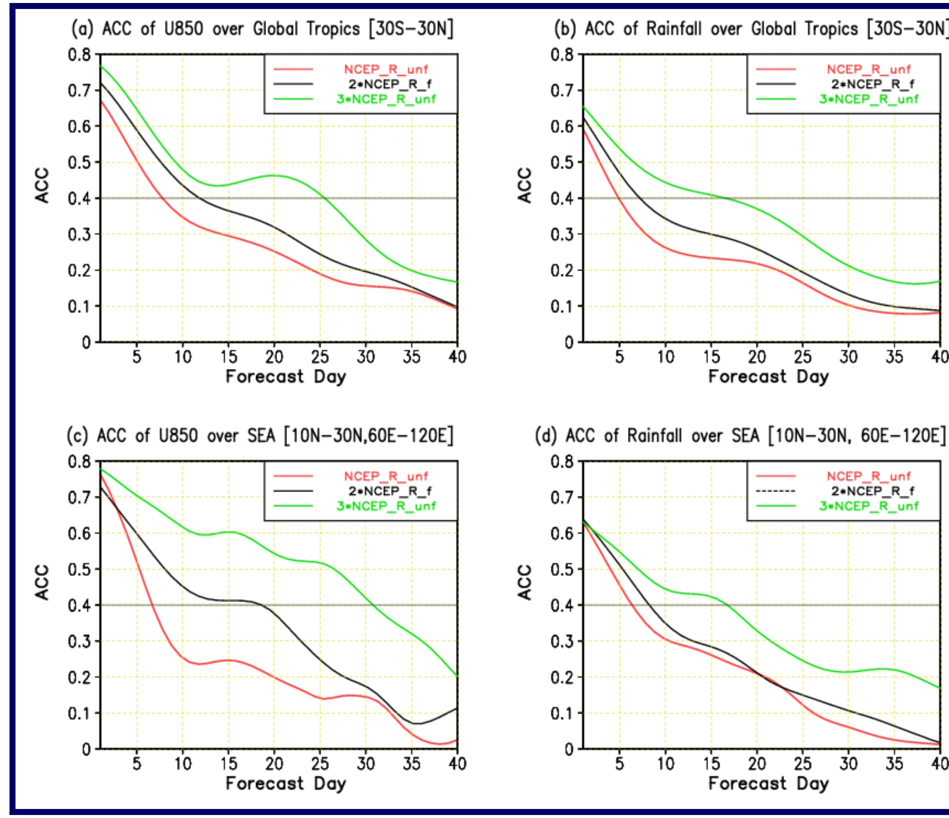
INTERNATIONAL PACIFIC RESEARCH CENTER

Better Initial Conditions Boost Intraseasonal Forecast Skill

Fu et al. (GRL, 2009)





The amplitude of convective activities in the NCEP reanalysis (left panel, bottom) was found to be less than observed (left panel: top, TRMM 3B42; left middle: GPCP) by a factor of two to three. Three forecasting experiments were conducted to explore the impact of strengthening the signal in the NCEP initial conditions on forecasting aspects of the monsoon intraseasonal oscillation (right panel). With the original NCEP reanalysis as initial condition, the 850-hPa zonal winds and rainfall are predictable with some skill only about a week in advance over the global tropics (30S–30N) and Southeast Asia (10N–30N,60E–120E). Predictability increases steadily with increasing the amplitudes to 2 times and 3 times the NCEP initial conditions. When the signals in initial conditions are recovered to a level similar to that in the observations (the last experiment), monsoon forecast skill reaches 25 days for 850-hPa zonal winds and 15 days for rainfall over both the global tropics and Southeast Asia.

Background

- Determination of ISO prediction skill and estimate ISO predictability in current AOGCMs is a pressing scientific need for developing 2-6 week subseasonal prediction.
- Forecast of MJO and MISO is one of the major concerns of APCC, YOTC, CLIVAR/AAMP and AMY(2007-2012). It is also a central theme for WCRP cross-cutting monsoon research.
- Launching a coordinated ISO hindcast experiment was recommended at the Nov 2007 CLIVAR MJO Workshop, endorsed and supported by APCC, CLIVAR/AAMP, and the SSC of AMY (2007-2011), and echoed by THORPEX.

Need for a Coordinated ISO Hindcast Exp.

Development of an MME is intrinsic need for lead-dependent model climatologies (i.e. multi-decade hindcast datasets) to properly quantify and combine the independent skill of each model as a function of lead-time and season.

There are still great uncertainties regarding the level of predictability that can be ascribed to the MJO, other subseasonal phenomena and the weather/ climate components that they interact with and influence.

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- ***Developing optimal strategies for multi-model ensemble (MME) ISO prediction system***, including effective initialization schemes and quantification of the MME's ISO prediction skills with forecast metrics under operational conditions.

- ***Identify model deficiencies in predicting ISO and suggest ways to improve models' convective and other physical parameterizations*** relevant to the ISO through development of model process diagnostics.

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- ***Study ISO's modulation of extreme hydrological events*** (e.g., midlatitude weather, monsoon depressions, and tropical cyclones) and ***its contribution to seasonal and interannual climate variation.***

Current Participating Group

Institution	Participants
ABOM, Australia	Harry Hendon, Oscar Alves
BCC/CMA, China	Zhang Peigun, Chen Lijuan
CMCC/Italy	Tony Navarra, Annalisa Cherichi, Andrea Alessandri
COLA and GMU, USA	Emilia K. Jin, J. Kinter, J. Shukla
CWB, Taiwan	Mong-Ming Lu
ECMWF, EU	Franco Molteni, Frederic Vitart
GFDL, USA	Bill Stern
IAP/LASG, China	T. Zhou, B. Wang, Y. Q. Yu
IITM, India	A. K. Sahai
JAMSTEC/APL, Japan	T. Yamagata, J.-J. Luo
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SNU, Korea	In-Sik Kang
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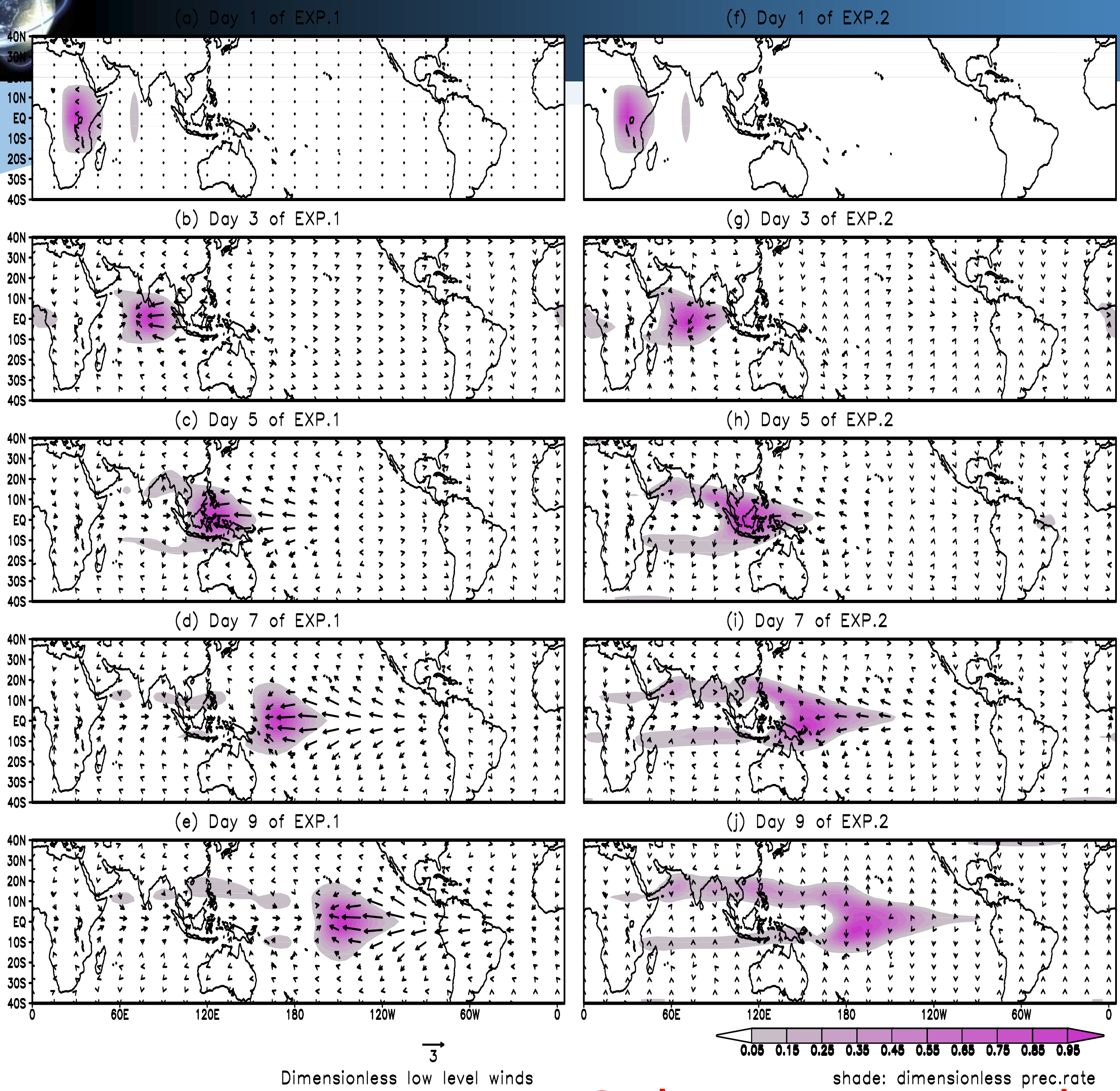
Contact Information

If you have any questions regarding the experiment design and data submission, please contact coordinator
Dr. June-Yi Lee
(jylee@soest.hawaii.edu).

Detailed information are posted on the website
(http://iprc.soest.hawaii.edu/~jylee/clipas/iso.html)



Interaction between moist Rossby wave and the vertical shear of the mean monsoon provides a mechanism for the formation of the slanted ISO rain band.

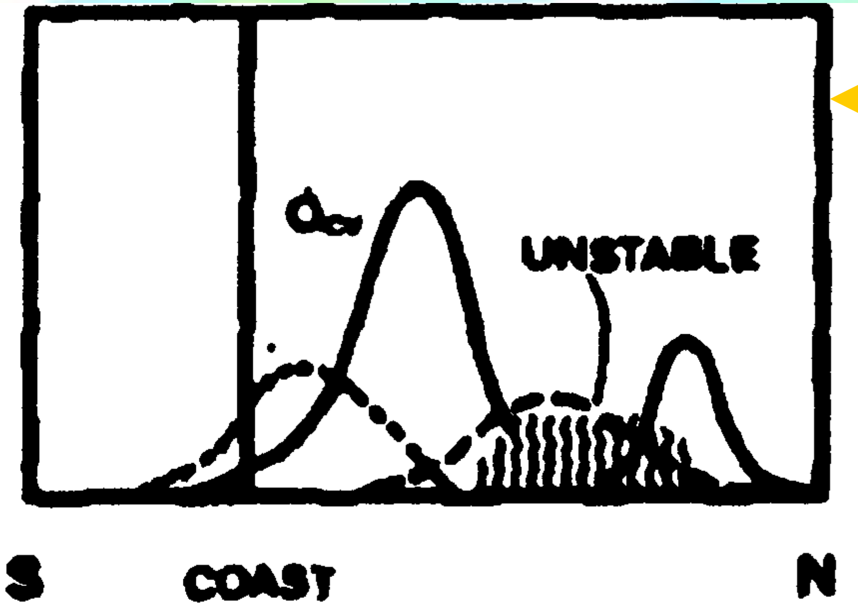
Mean flows removed

Uniform SST

Only Monsoon vertical Shear included

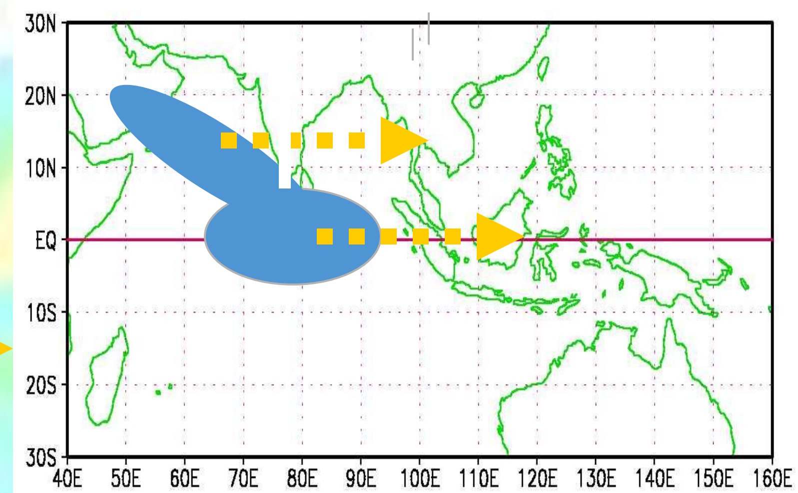
Drbohlav and Wang, 2007

Review northward propagation of boreal summer ISO



Webster et al. 1983

The land surface heat fluxes into the boundary layer can destabilize the atmosphere ahead of ascending zone, causing a northward shift of the convection zone



Wang and Xie 1997
Lawrence and Webster 2001

Northward propagation is a component of eastward movement of the slated rain band

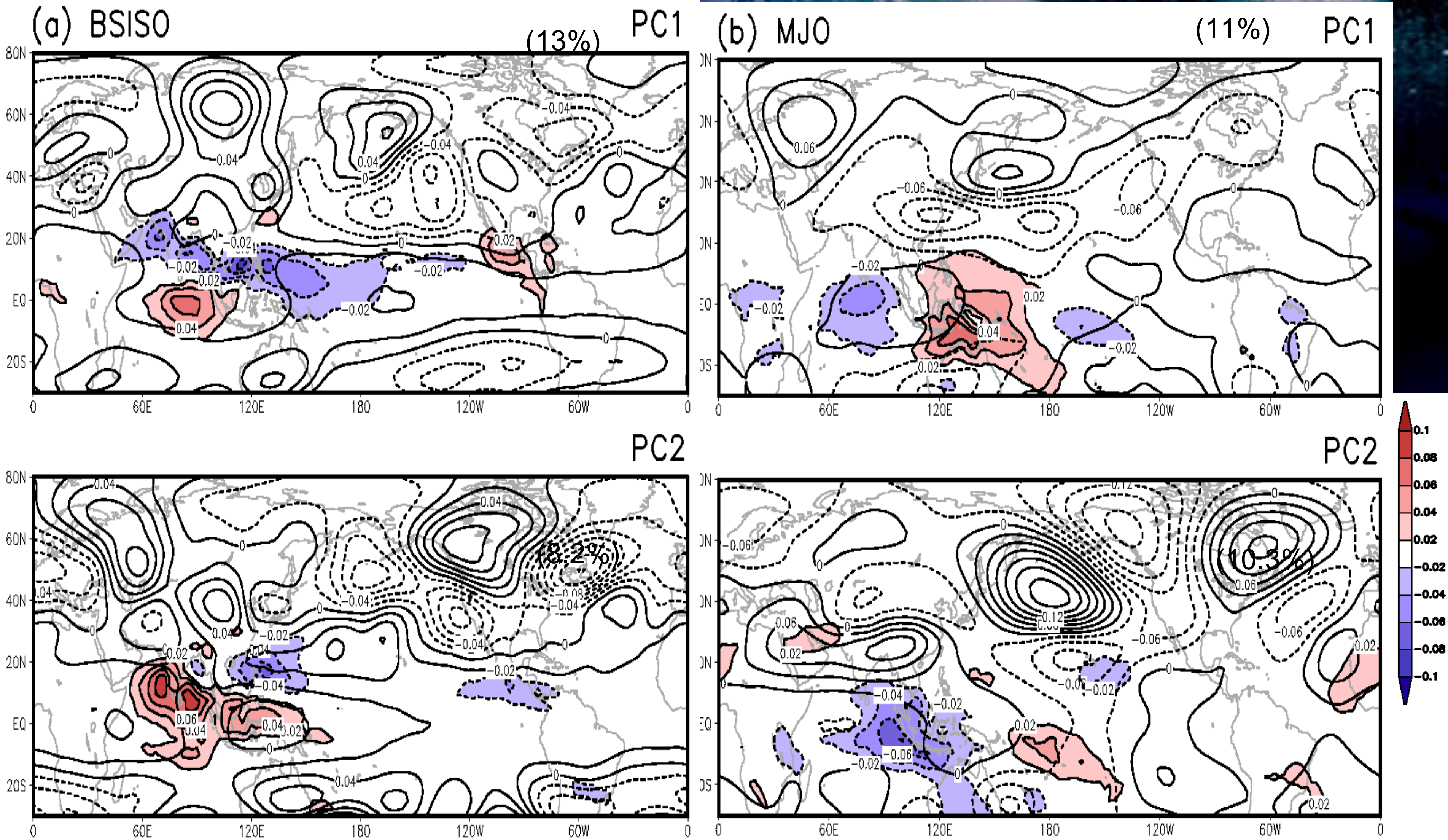
Jiang et al. 2004; Drbohlav and Wang 2005

Interaction between vertical shear and convection

Fu et al. 2003

Air-sea interaction

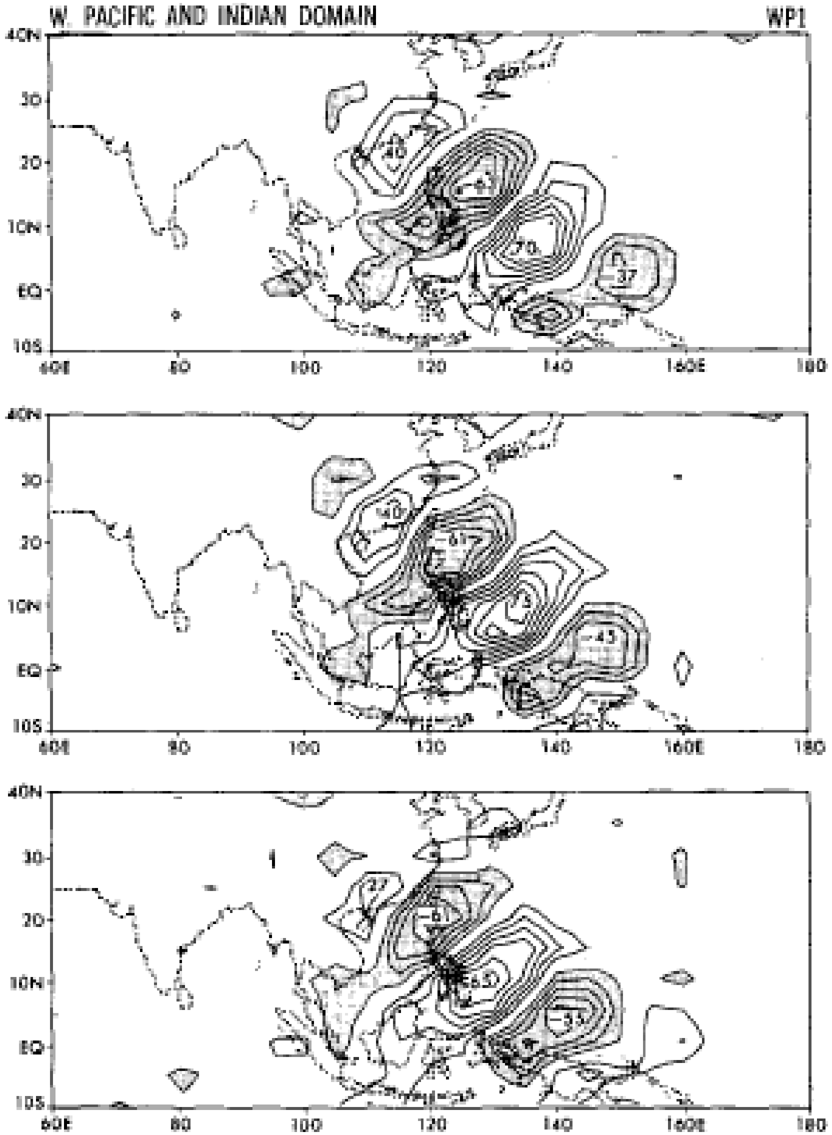
Intraseasonal Oscillation (30~60d) - teleconnection



1979~2010 (JJA)

1979/80~2009/10 (DJF)

Origin of Synoptic-Scale Wave Train (SWT) in WNP

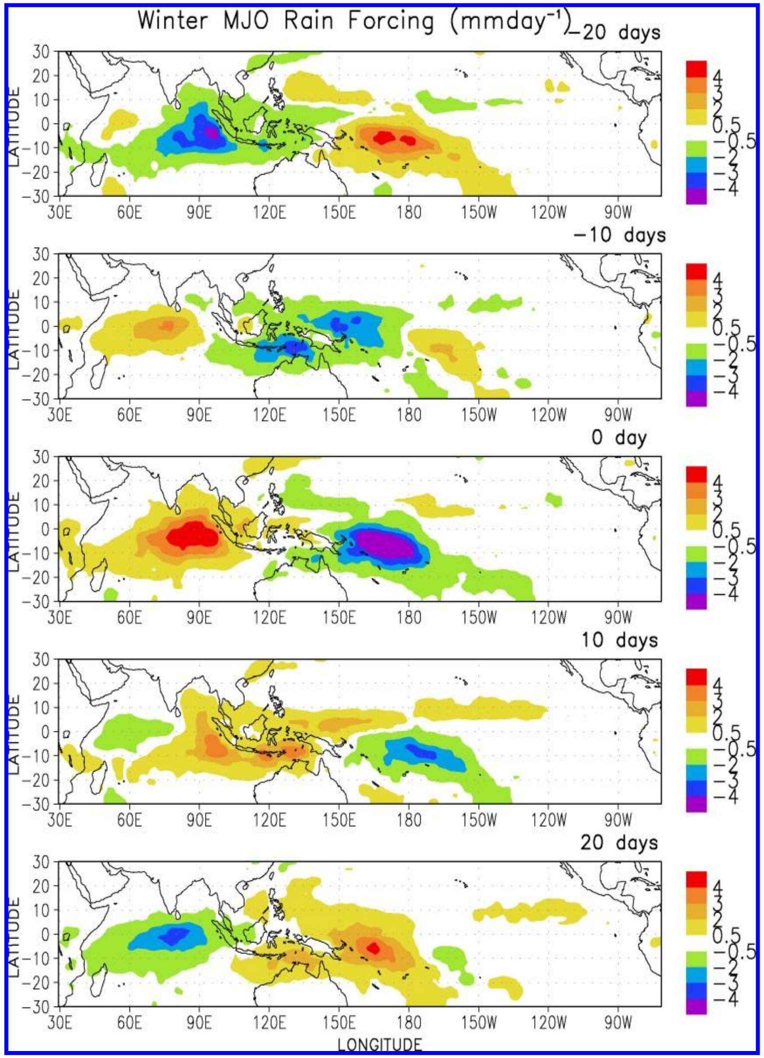


Lau and Lau (1990) :
An alternative positive and negative vorticity wave train with
timescale: 2-8 days,
wavelength: 2500 km,
propagation: northwestward.

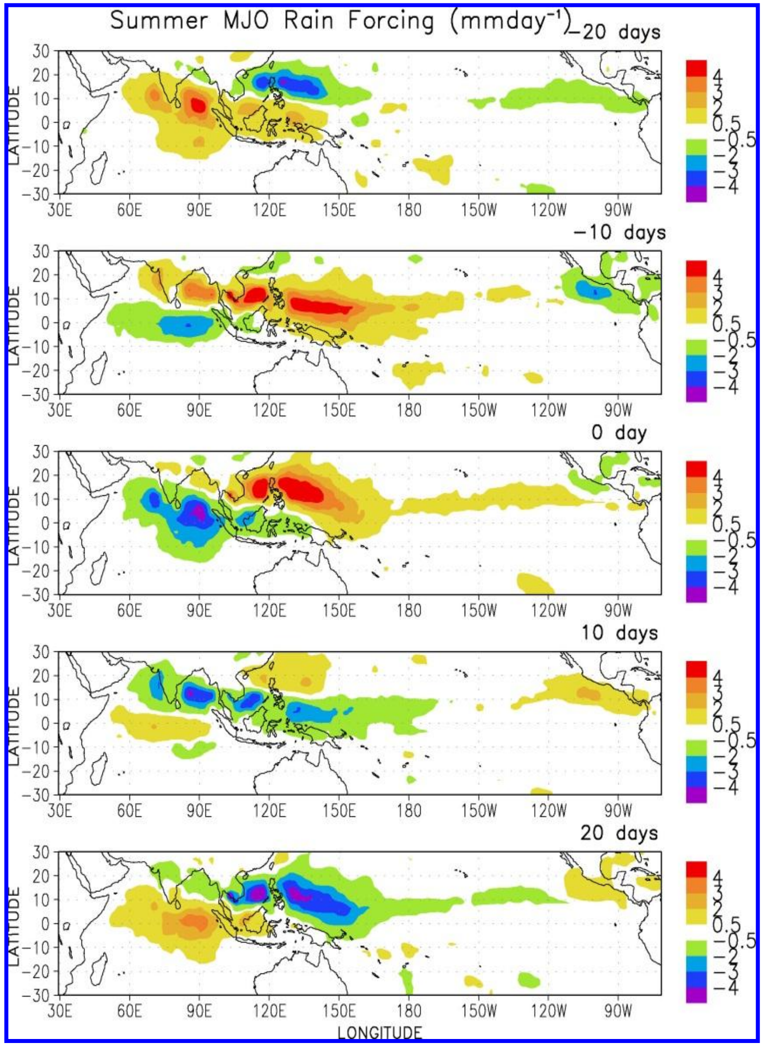
Questions:
What is the origin of the synoptic wave train? What determines its zonal wave-length and phase propagation?

Propagation

MJO in N.H. Winter



MJO in N.H. Summer



From MJO working group website