Multi-model Ensemble Prediction for Boreal Summer Intraseasonal Oscillation (BSISO)

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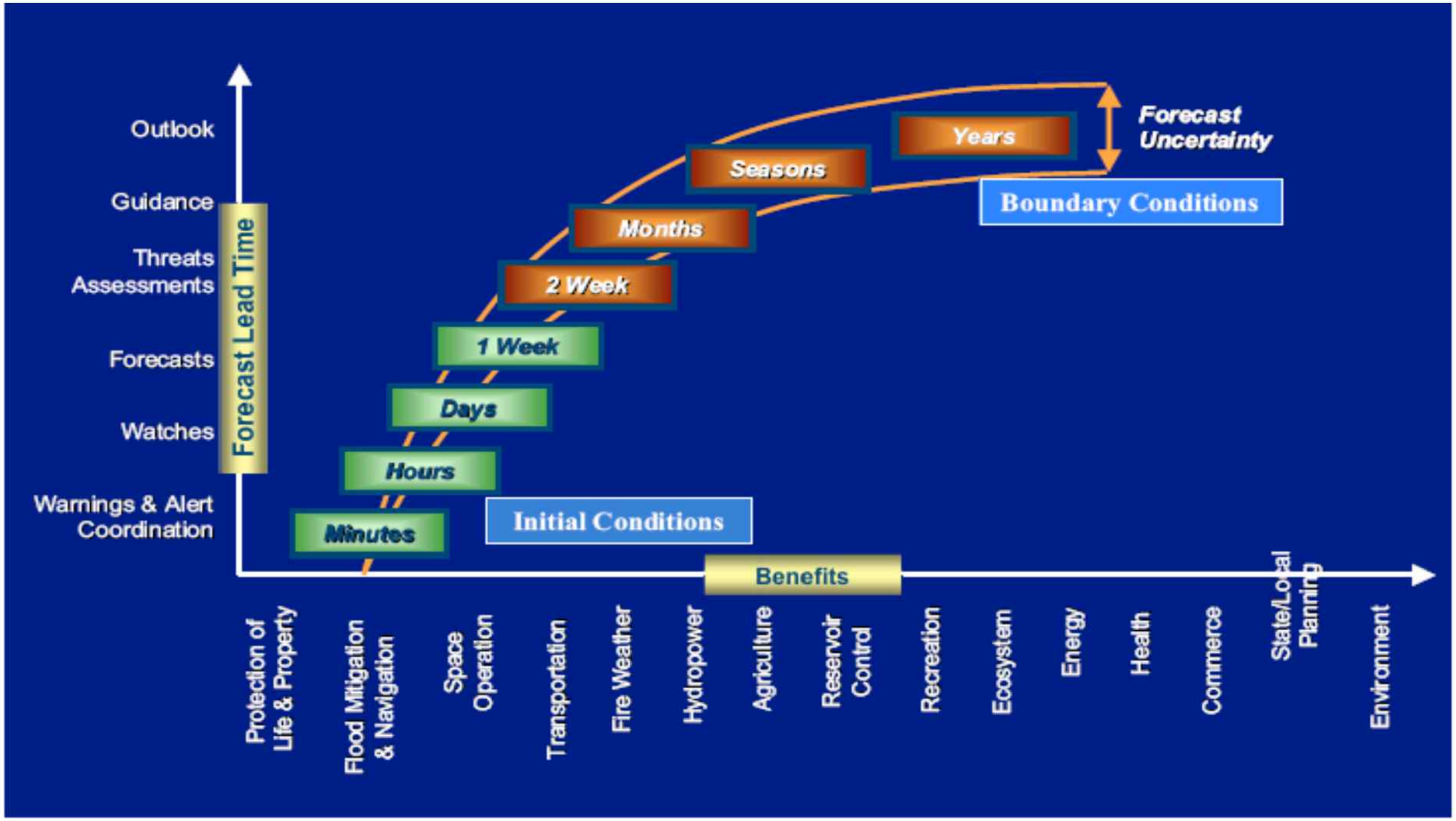
3. JIFRESSE, University of California, Los Angeles, USA
4. Seoul National University, Seoul, Korea

Seamless Suite of Forecasts



The World Climate Research Programme (WCRP) –
Coordinated Observation and Prediction of the Earth System (COPES)

Content

1 **Identification on Dominant Modes of the BSISO**

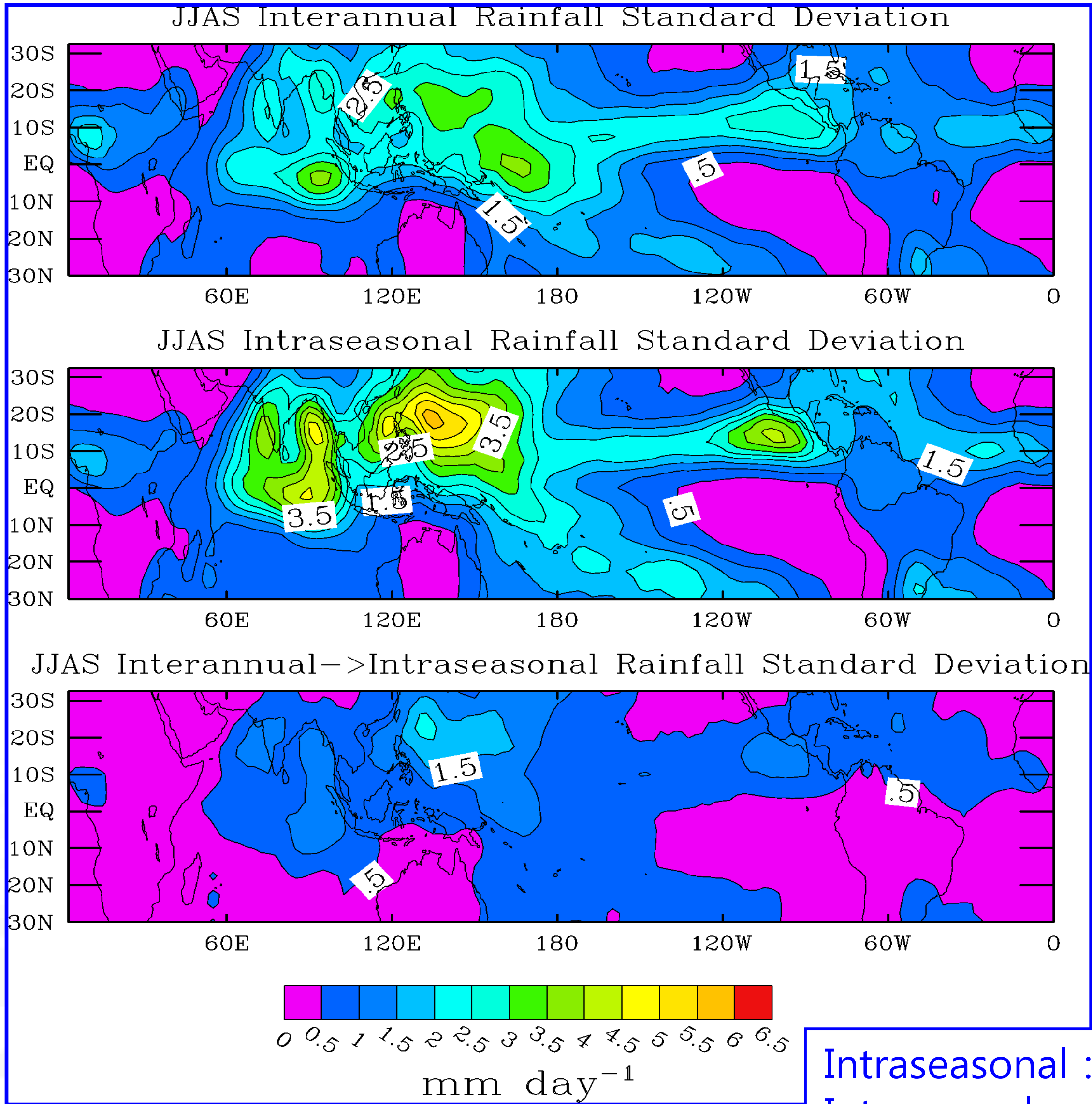
Lee, June-Yi, Bin Wang, Matthew C. Wheeler, Xiouhua Fu, Duane E. Waliser, and In-Sik Kang, 2012: **Real-time multivariate indices for the boreal summer intraseasonal oscillation over the Asian summer monsoon region**. Climate Dynamics in press. Doi: 10.1007/s00382-012-1544-4

2 **Multi-model Ensemble Prediction for the BSISO**

3 **Summary**

Interannual vs Intraseasonal Rainfall Variability during JJAS

CMAP Rainfall

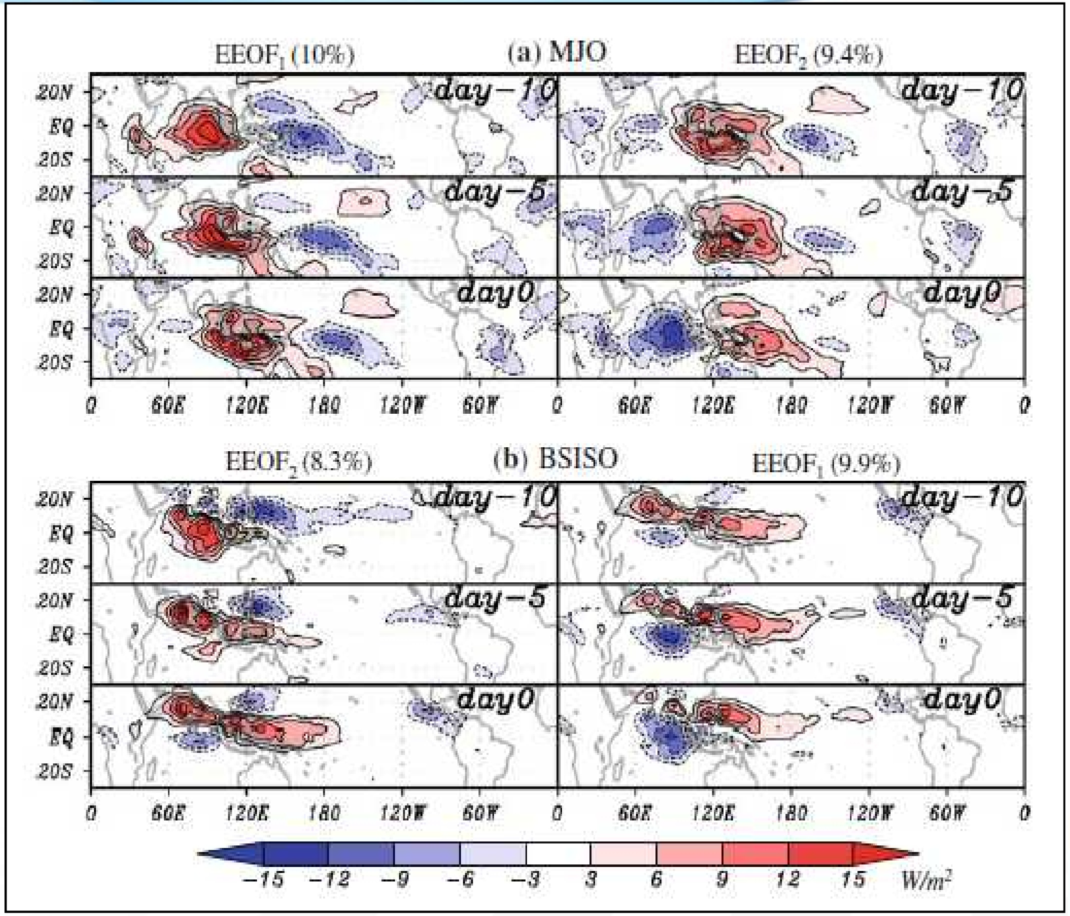


Intraseasonal : 30-90
Interannual : > 90

Courtesy of Duane Waliser

The gigantic **Asian summer monsoon** exhibits rich variability with time scales ranging from **synoptic (~ days)** and **intraseasonal (~ weeks)** to **interannual (~ years)** and beyond, which make efficient water management, agricultural planning, and disaster prevention very difficult. For the well-being of the societies affected by the monsoon, the capability of forecasting the Asian monsoon systems with lead times from days and weeks to years and beyond is very desirable.

Bimodal Representation of the Tropical ISO



Spatial-temporal pattern of OLR anomaly associated with the intraseasonal oscillation during (a) boreal winter (DJF, referred to as **Madden-Julian Oscillation (MJO) mod**e) and (b) boreal summer (JJA, referred to as **BSISO mode**) by means of the extended EOF (EEOF) analysis.

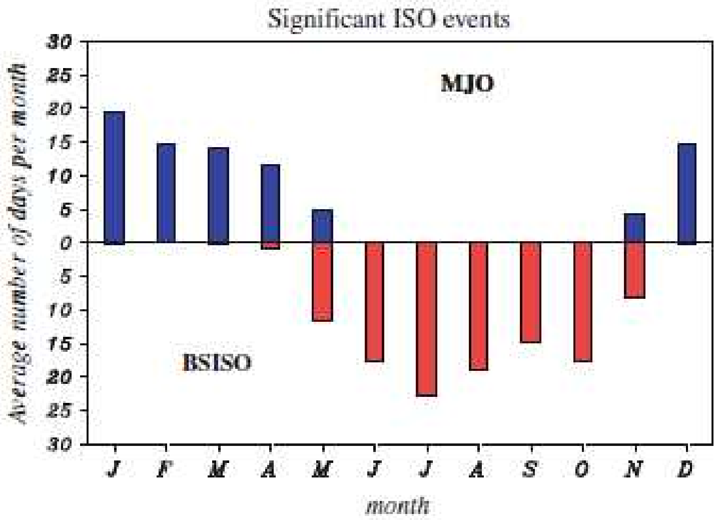
Kikuch et al. (2011, Clim Dyn)

Boreal Winter

Rainfall anomalies propagate in a n <u>eastward</u> fashion and mainly affect the Tropical eastern hemisphere

Boreal Summer

Rainfall anomalies propagate in a <u>northeast</u> fashion and mainly affect the Asian summer monsoon region

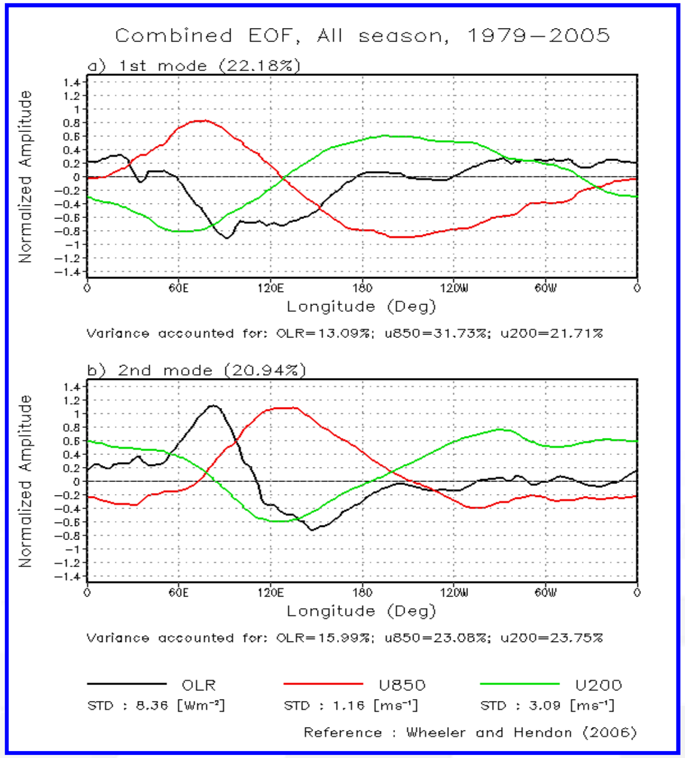


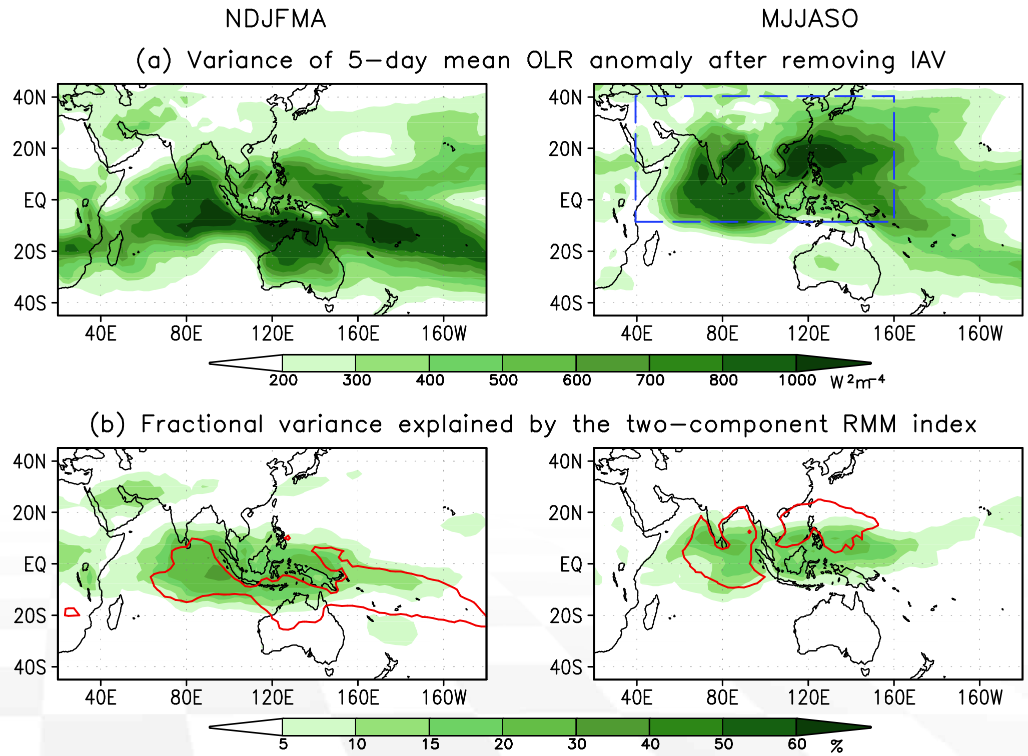
Motivation:

Limitation of the RMM index for representing BSISO

As a measure of the strength of the MJO, **Wheeler and Hendon (2004) Realtime Multivariate MJO (RMM) index** used the **first two leading multivariate EOF modes of the equatorial mean (between 15S and 15N) OLR, and zonal winds at 850 and 200 hPa**. This index captures equatorial eastward propagating mode, the MJO, very well and has been applied all year around to depict MJO activity.

Wheeler an Hendon (2004)





RMM index has limitation to explain ISO over off-equatorial monsoon domain during boreal summer.

Can one design a better index to describe boreal summer ISO?

Process to define the BSISO index

Data Process

- **Variables :** daily **OLR and U850**
- **Data Period**: **MJJASO 1981-2010**
- Removal of the first 3 harmonics in climatological annual cycle
- Removal of the effect of ENSO signal through subtracting last 120 day mean
- Normalization of each of two fields by area averaged temporal standard deviation (The ASM standard deviation is 27.58 W m^{-2} for OLR and 3.62 m s^{-1} for U850)
- **BSISO index:** The first four leading multivariate EOF modes of daily OLR and U850 over the ASM region (10^oS-40^oN, 40^o-150^oE)

✓ Filtering is not applied to define MISO index for monitor and forecast purpose

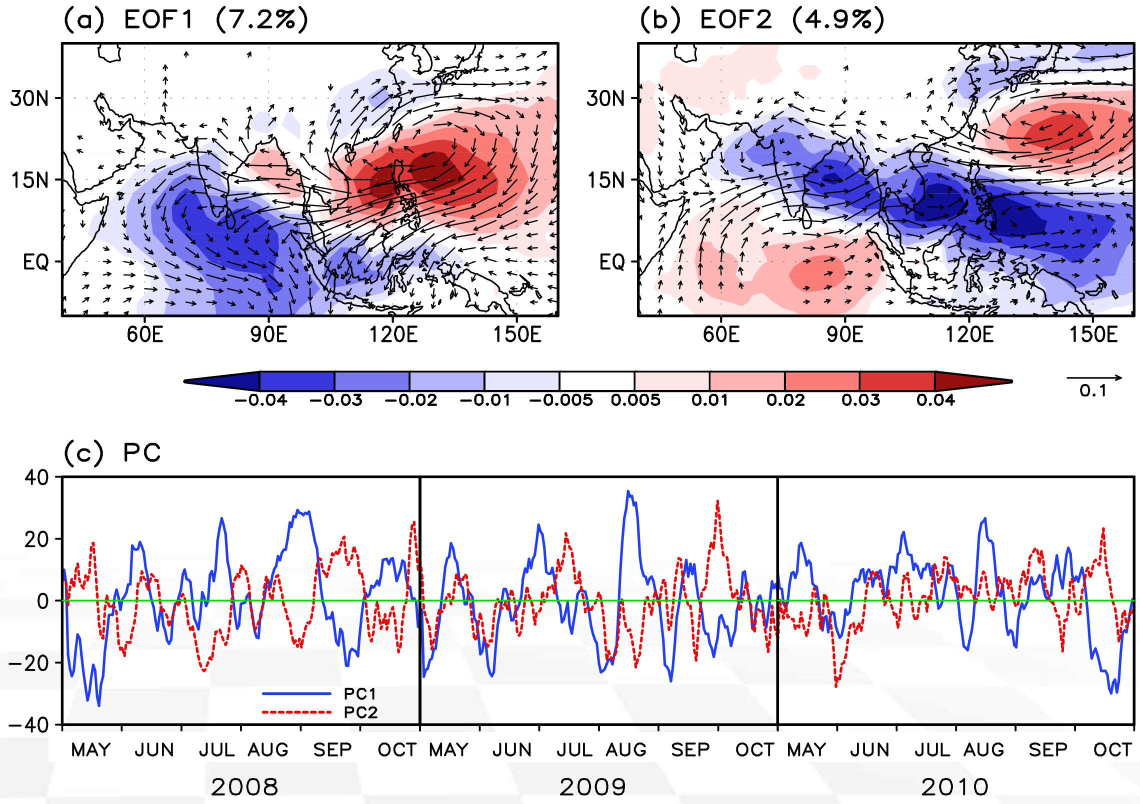
Criterion for Determining the BSISO Index

1. **Fractional variance explained by the reconstructed field from the BSISO index**
2. **Ability to capture the northward propagating ISO**

BSISO1: Canonical Northward Propagating BSISO Mode

- **BSISO1, consisting of EOF1 and EOF2**, represents the canonical northward and north-eastward propagating ISO over the ASM region during the entire warm season from May to October with quasi-oscillating periods of 30-60 days in conjunction with the eastward propagating MJO.

- Spatial Characteristics



Rossby wave like pattern with a northwest to southeast slope

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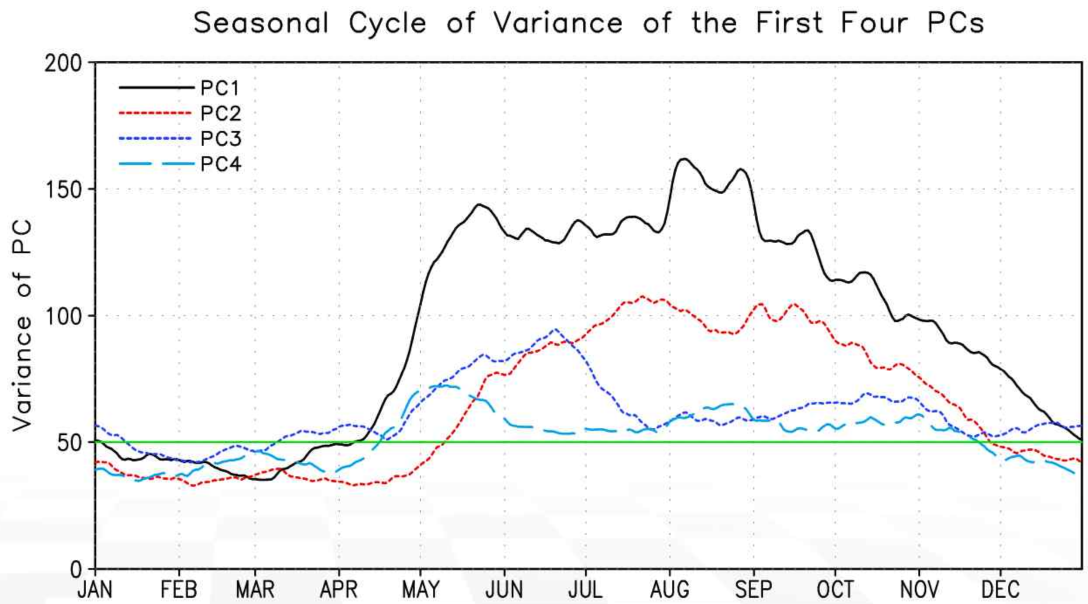
- Spatial Characteristics

- Seasonal cycle of variance



Large overall variance from May to October

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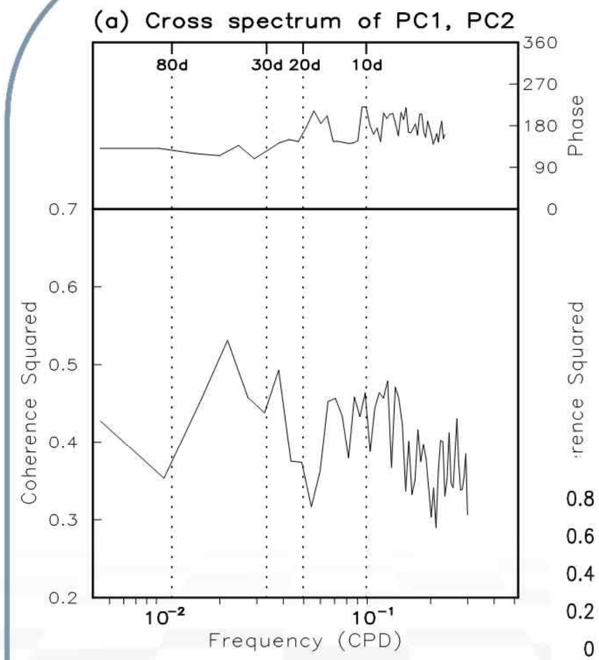
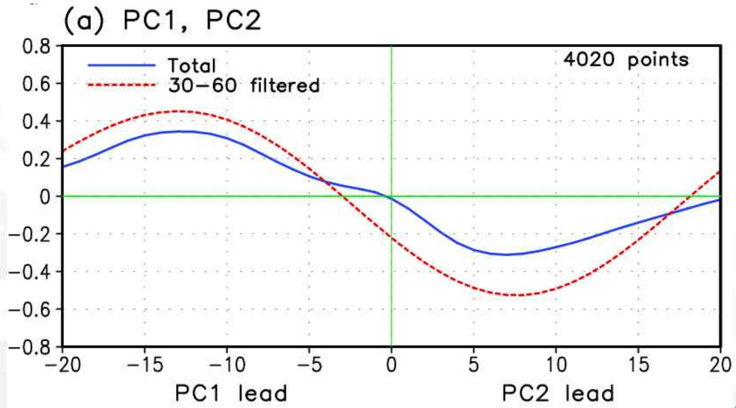
- Spatial Characteristics
- Seasonal cycle of variance
- Coherence and lead-lag relationship



The greatest coherence in the 30- to 60-day range with a 90° phase difference

PC1 tends to lead PC2 by about 13 days with a maximum correlation of 0.34 for non-filtered data.

PC1 (PC2) is more significantly correlated with RMM2 (RMM1).



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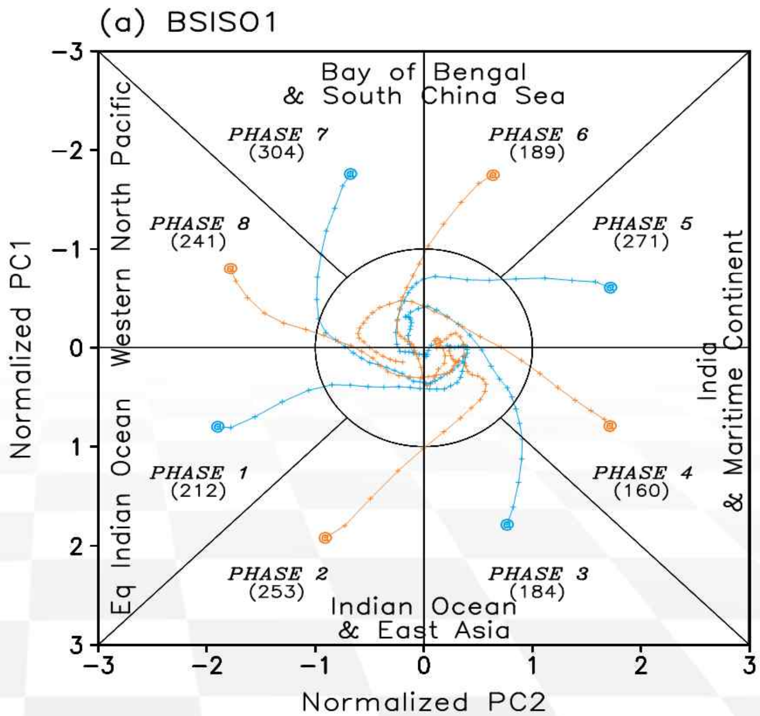
- Spatial Characteristics
- Seasonal cycle of variance
- Coherence and lead-lag relationship
- Phase space composite curves

Given the strong lead-lag behavior of PC1 and PC2, it is convenient to diagnose the state of BSISO1 as a point in the two-dimensional phase space.



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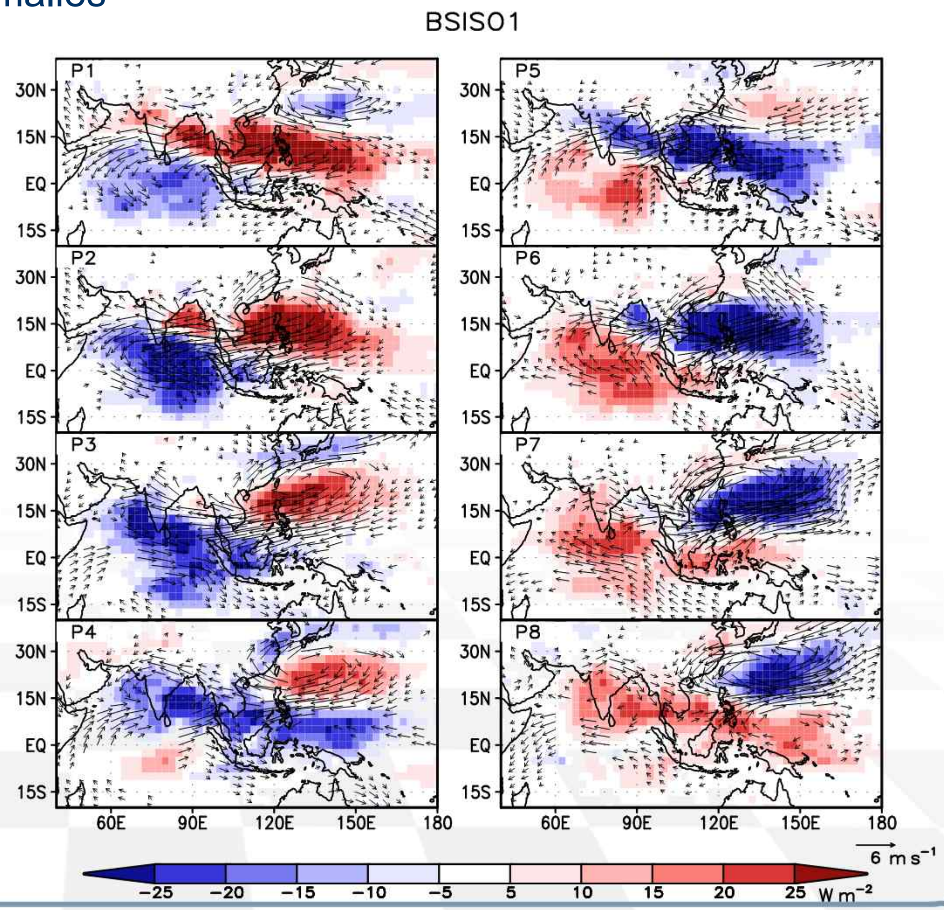
- Phase space composite curves
- Composite life cycle

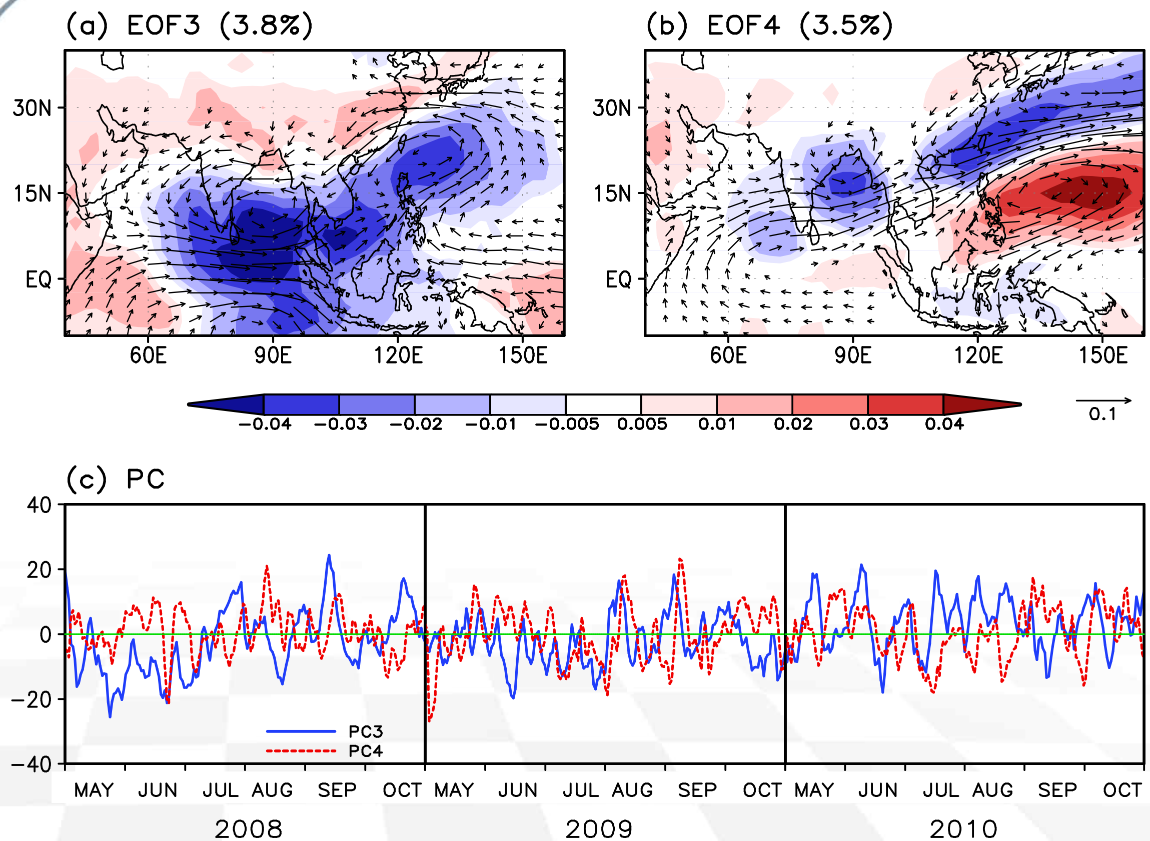
Life cycle composite of OLR (shading) and 850-hPa wind anomalies



BSISO2: The ASM pre-monsoon and onset mode

- **BSISO2, consisting of EOF3 and EOF4**, captures the northward/northwestward propagating variability with periods of 10-30 days during primarily the pre-monsoon and monsoon-onset season.

- Spatial Characteristics



Elongated and front-like pattern with a southwest to northeast slope

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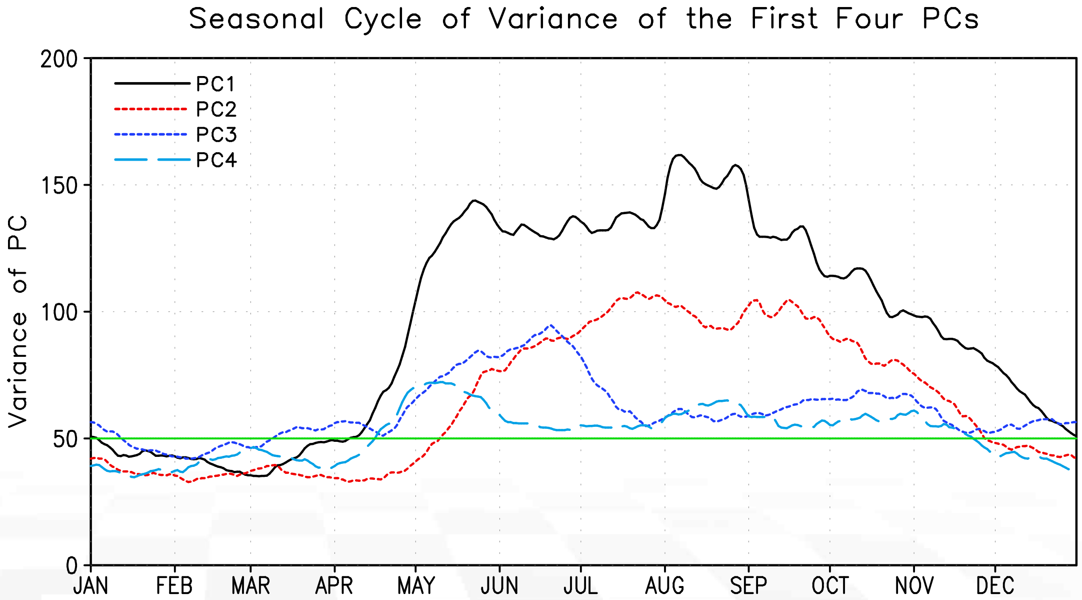

Maximum variance from late May to early July, corresponding to the pre-monsoon and onset period

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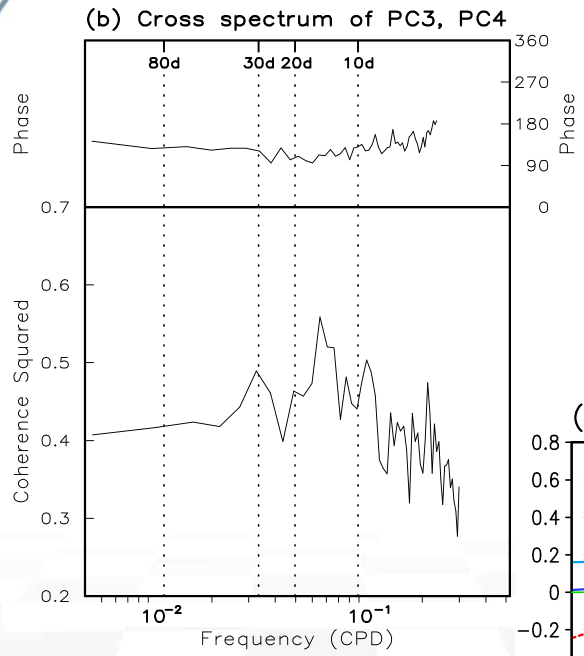
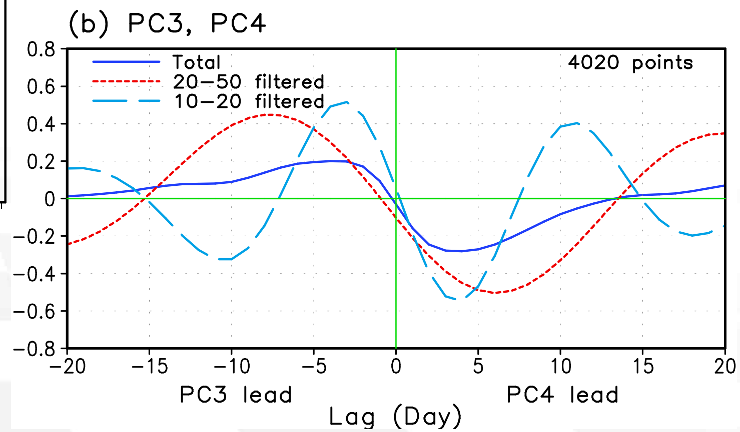


High coherence in the 10-20 day range and at ~30 days, with 90° phase difference

PC3 tends to lead PC4 by about 3-4 days for 10-20 period and 7-8 days for 30 day period.

BSISO2 is not correlated with MJO



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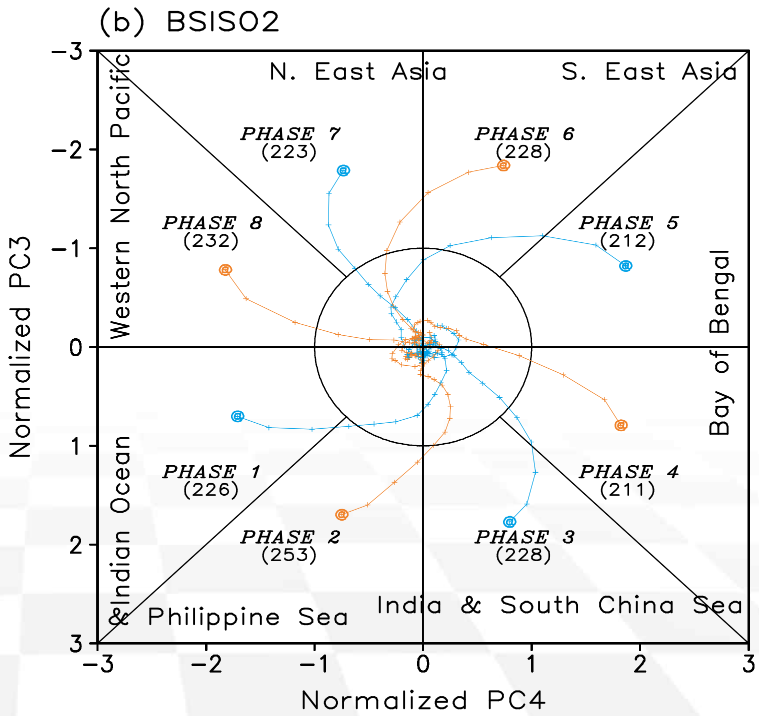
PC3 and PC4 phase space composite curves



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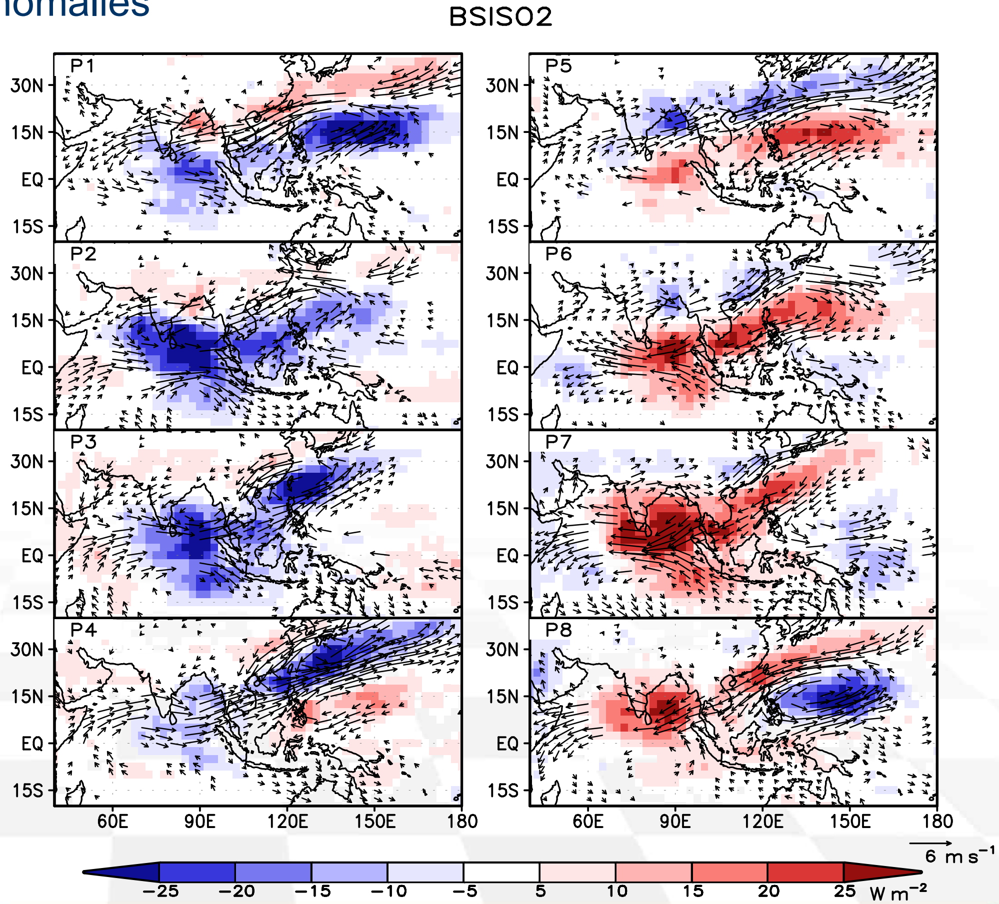
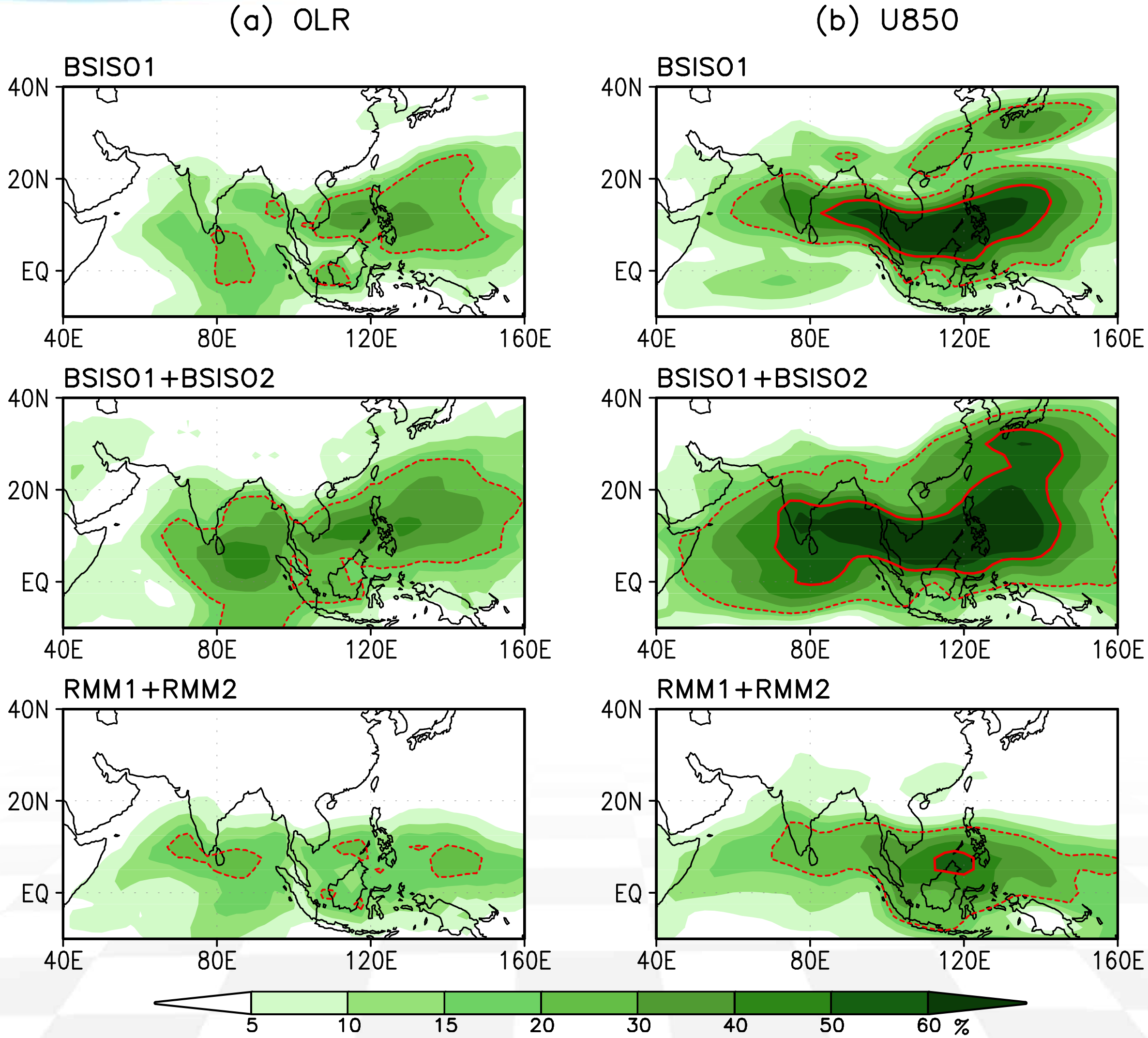
Life cycle composite of OLR (shading) and 850-hPa wind anomalies



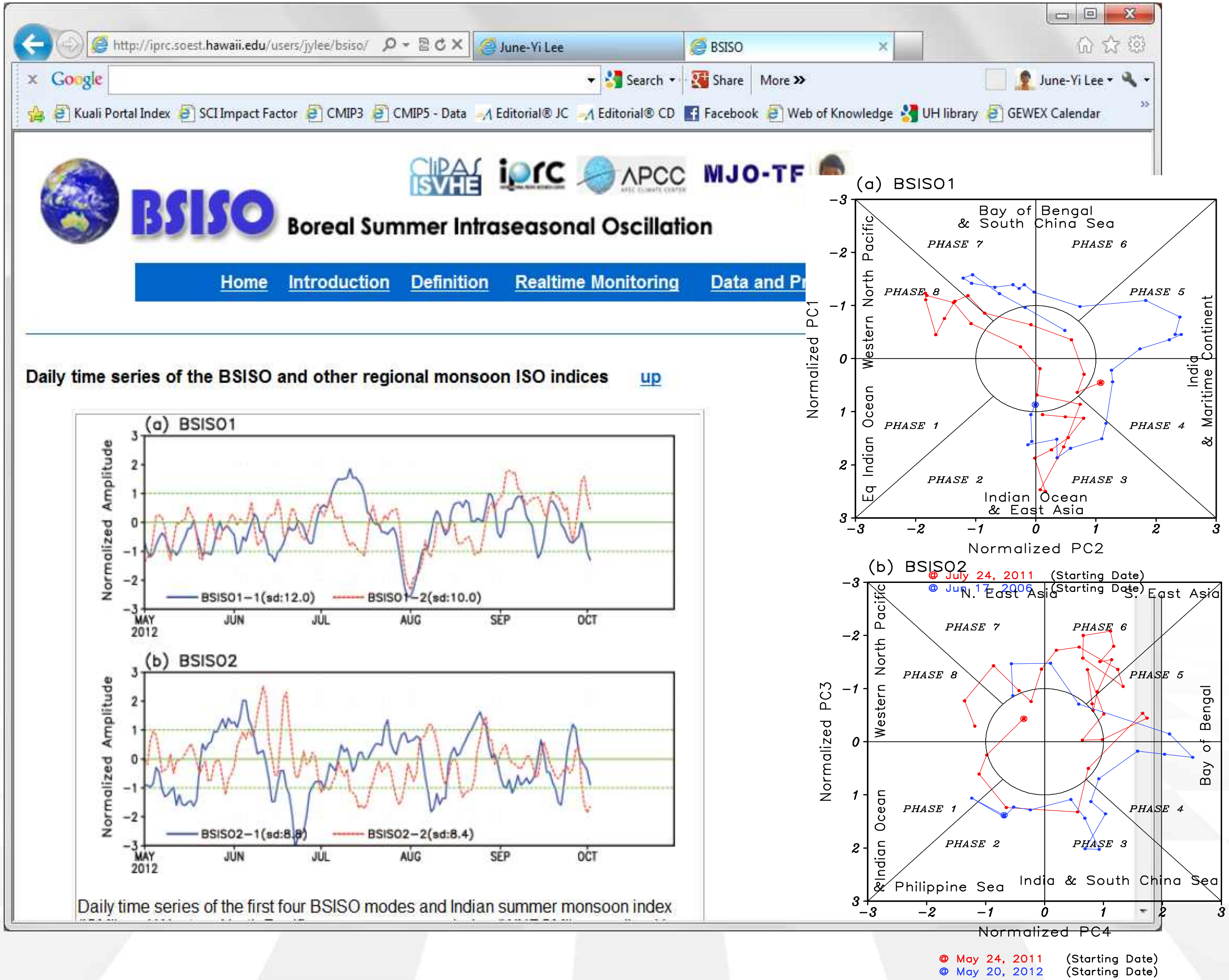
Fractional Variance
: Comparison between RMM and BSISO



BSISO1 and BSISO2 capture a significant portion of the total variance particularly over the WNP-EA region during boreal summer while the RMM describes the variance primarily in the equatorial region and only moderately captures variability over the ISM region.

BSISO Real-time Monitoring

http://iprc.soest.hawaii.edu/users/jylee/bsiso



ISVHE

The ISVHE Project

Intraseasonal Variability Hindcast Experiment

The **ISVHE** is a coordinated multi-institutional ISV hindcast experiment supported by **APCC, NOAA CTB, CLIVAR/AAMP & MJO TF, and AMY.**

http://iprc.soest.hawaii.edu/users/jylee/clipas.htm

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Description of Models and Experiments

ISVHE

ONE-TIER SYSTEM

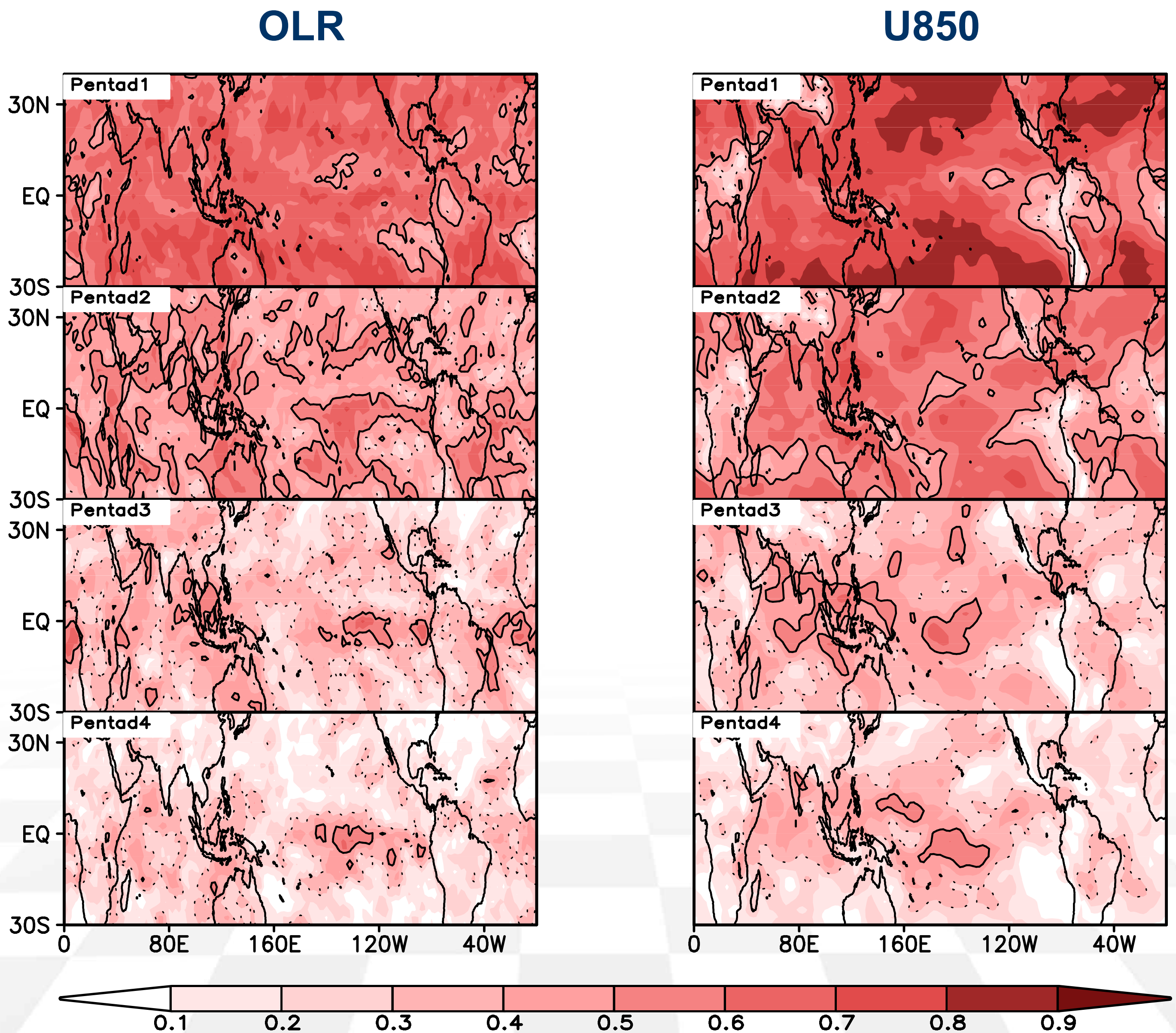
	Model	Control Run	ISO Hindcast		
			Period	Ens No	Initial Condition
ABOM	POAMA 1.5 & 2.4 (ACOM2+BAM3)	CMIP (100yrs)	1980-2006	10	The first day of every month
CMCC	CMCC (ECHAM5+OPA8.2)	CMIP (20yrs)	1989-2008	5	Every 10 days
ECMWF	ECMWF (IFS+HOPE)	CMIP(11yrs)	1989-2008	15	Every 15 days
GFDL	CM2 (AM2/LM2+MOM4)	CMIP (50yrs)	1982-2008	10	The first day of every month
JMA	JMA CGCM	CMIP (20yrs)	1989-2008	6	Every 15 days
NCEP/CPC	CFS v1 (GFS+MOM3) & v2	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 HCM	CMIP (20yrs)	1994-2008	6	Every 10 days

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

The MME's Skill for 5-day mean OLR and U850 Anomalies

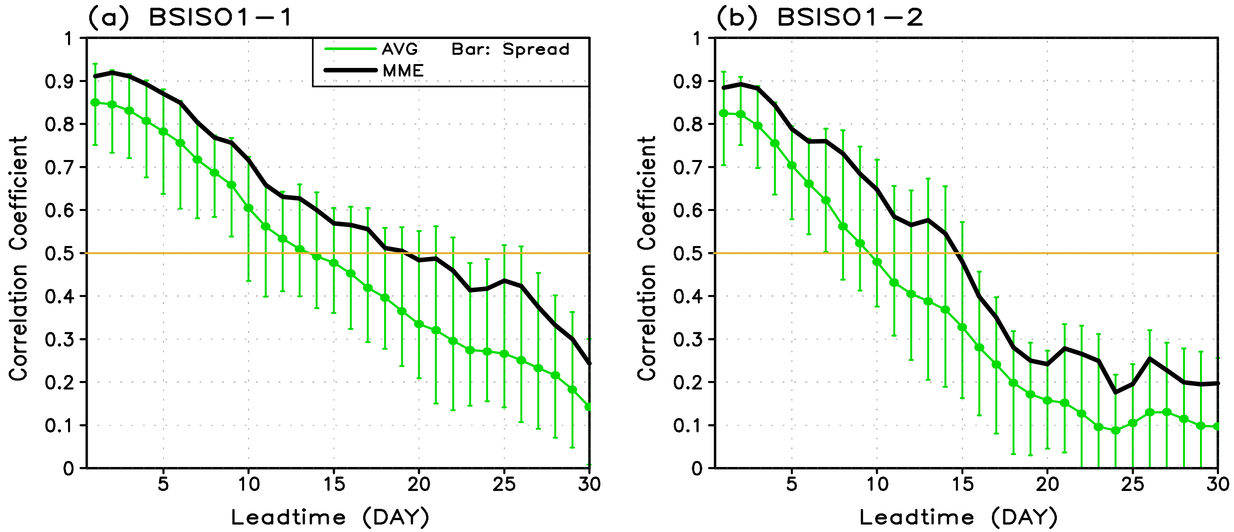
Anomaly Correlation Coefficients (1989-2008, MJJASO)



The MME and Individual Models' Skill for BSISO

Anomaly Correlation Coefficients (1989-2008, MJJASO)

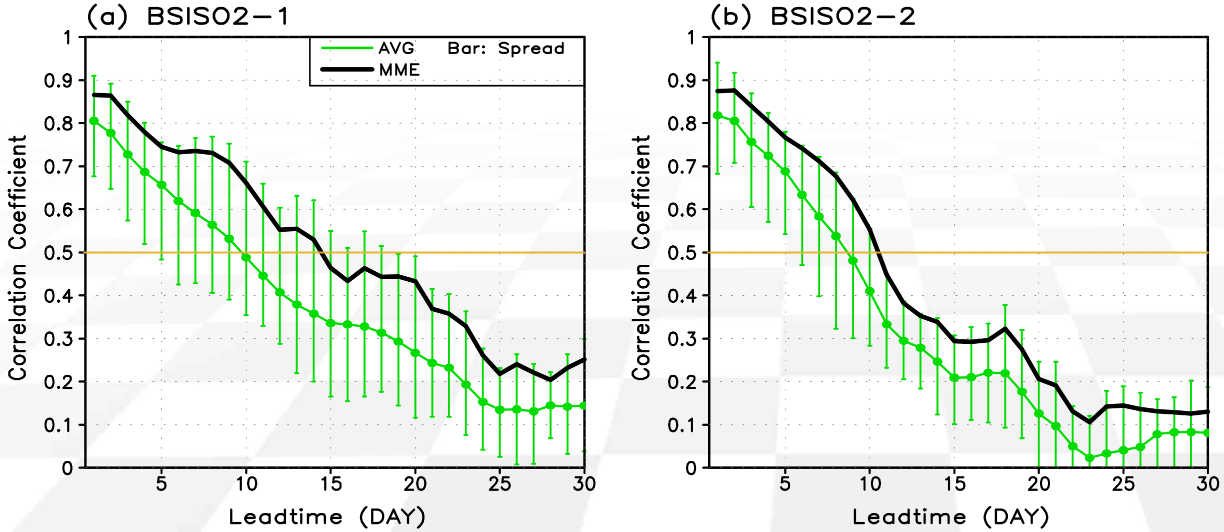
BSISO1



Common Period: 1989-2008
Initial Condition: 1st day of each month from Oct to March

MME: Simple composite with all models

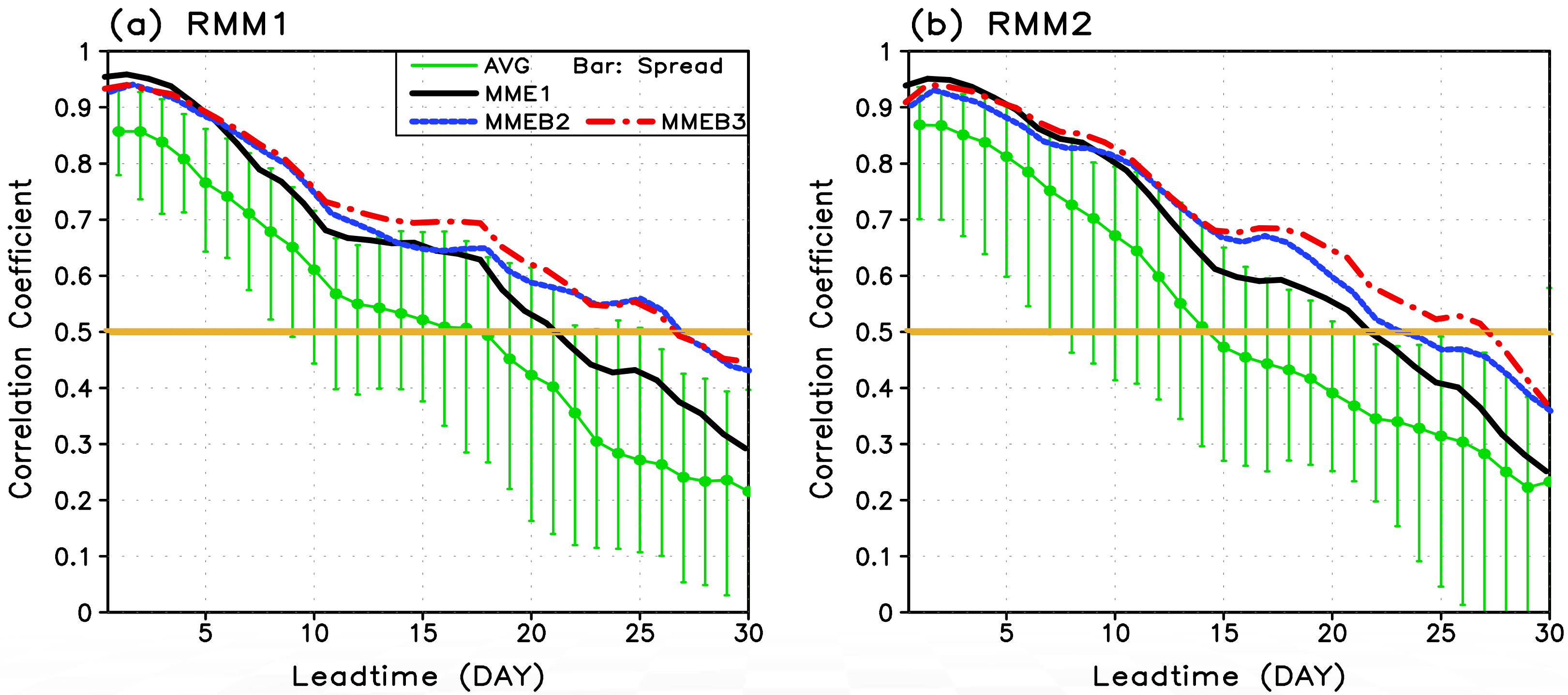
BSISO2



Using the MME, forecast skill for BSISO1 reaches 0.5 at 15 to 20-day forecast lead and for BSISO2 at 10- to 15-day forecast lead.

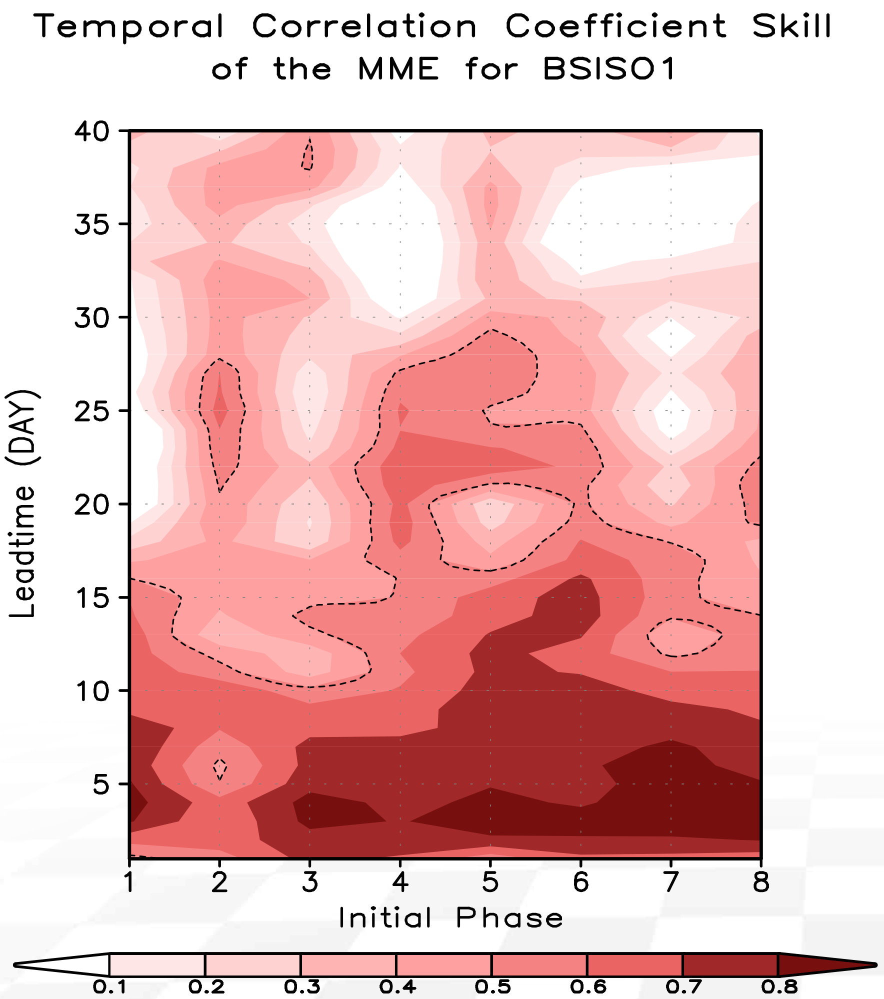
The MME and Individual Model Skills for MJO

Anomaly Correlation Coefficients (1989-2008, NDJFMA)

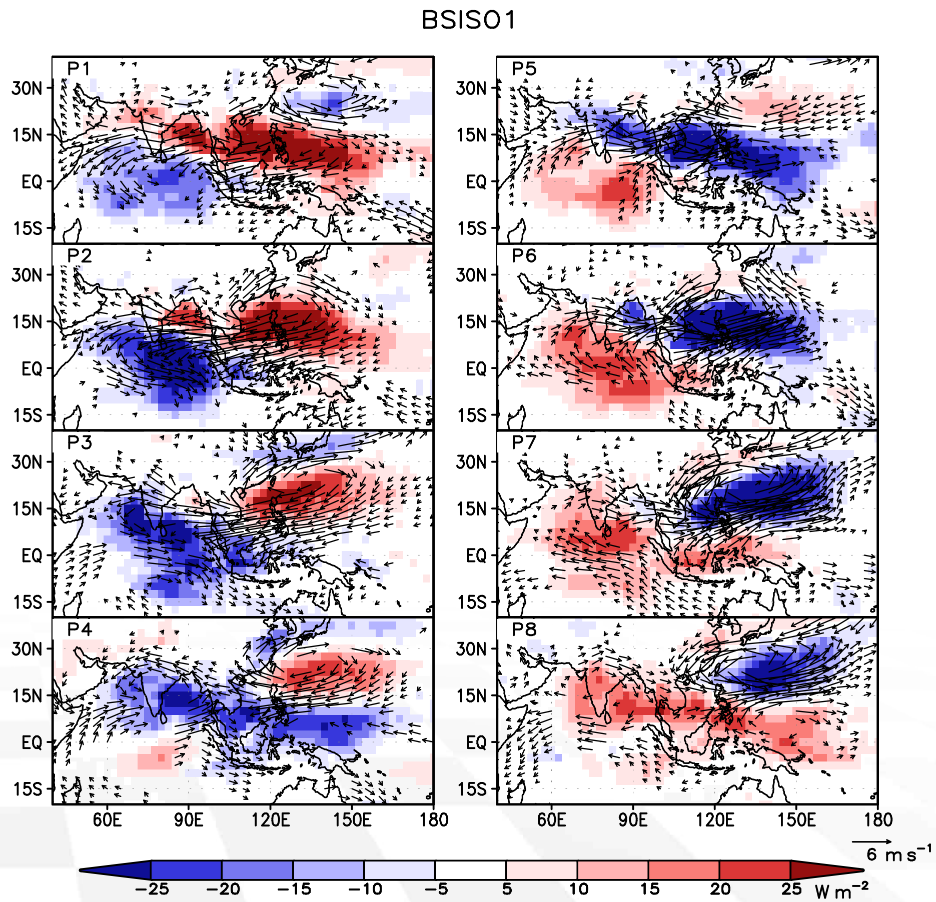


Common Period: 1989-2008
Initial Condition: 1st day of each month from Oct to March
MME1: Simple composite with all models
MMEB2: Simple composite using the best two models
MMEB3: Simple composite using the best three models

Phase Dependency of BSISO Forecast Skills



Life cycle composite of OLR (shading) and 850-hPa wind anomalies

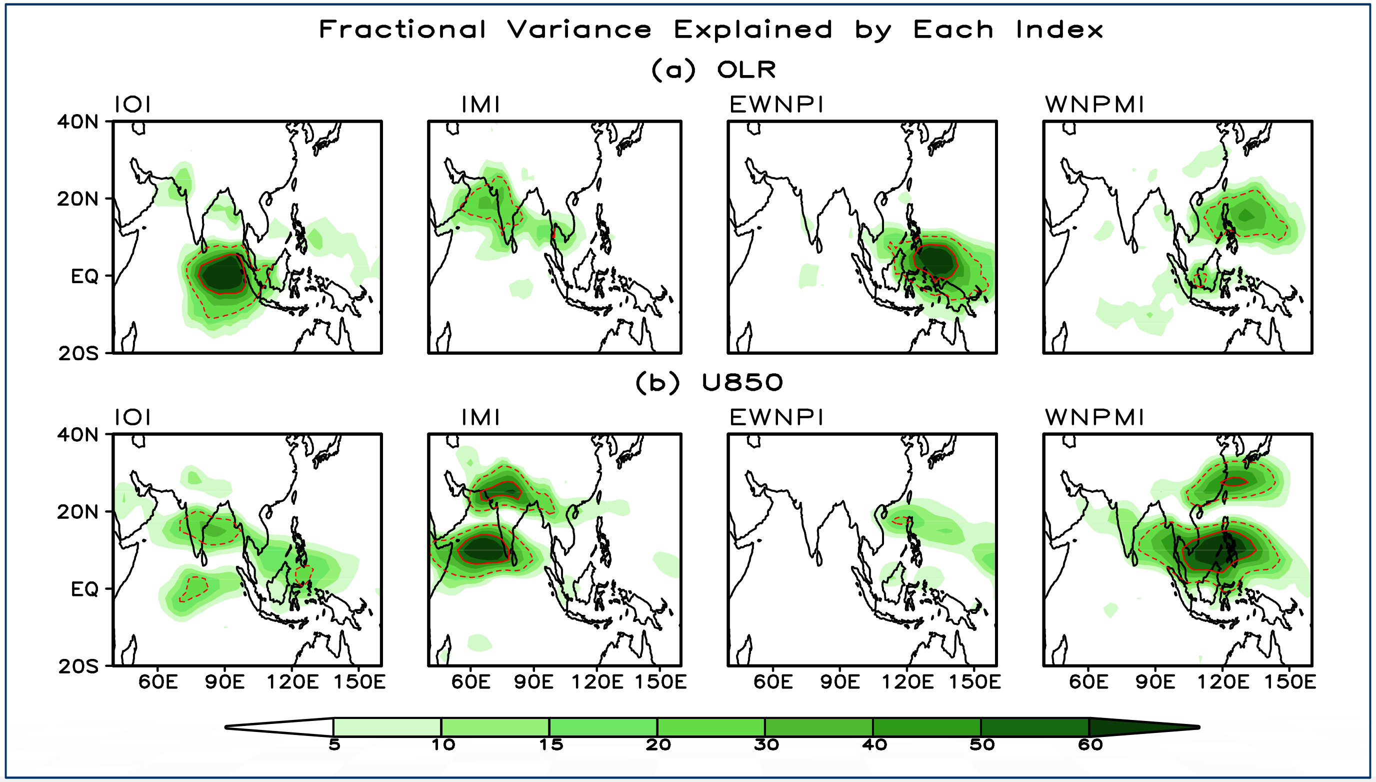


Summary

- Given the extreme importance of the BSISO, we have made an effort to define new indices to assist in real-time monitoring and forecast applications of the BSISO. The BSISO indices proposed in this study were designed to better represent fractional variance and the observed northward/northwestward propagating ISO over the ASM region than the RMM index.
- **BSISO1, consisting of EOF1 and EOF2**, represents **the canonical northward and north-eastward propagating ISO over the ASM region** during the entire warm season from May to October with quasi-oscillating periods of 30-60 days in conjunction with the eastward propagating MJO.
- **BSISO2, consisting of EOF3 and EOF4**, captures **the northward/northwestward propagating variability with periods of 10-30 days** during primarily the pre-monsoon and monsoon-onset season.
- The ISVHE has been coordinated **to better understand the physical basis for prediction and determine predictability of ISO**.
- **11 climate models' hindcast for ISO** have been collected from research institutions in **North America, Europe, Asia, and Australia.**
- Using the all models' MME, ACC skill for BSISO1 and BSISO2 reaches **0.5 at 15-20-day and 10-15-day forecast lead, respectively.**

Thank You!

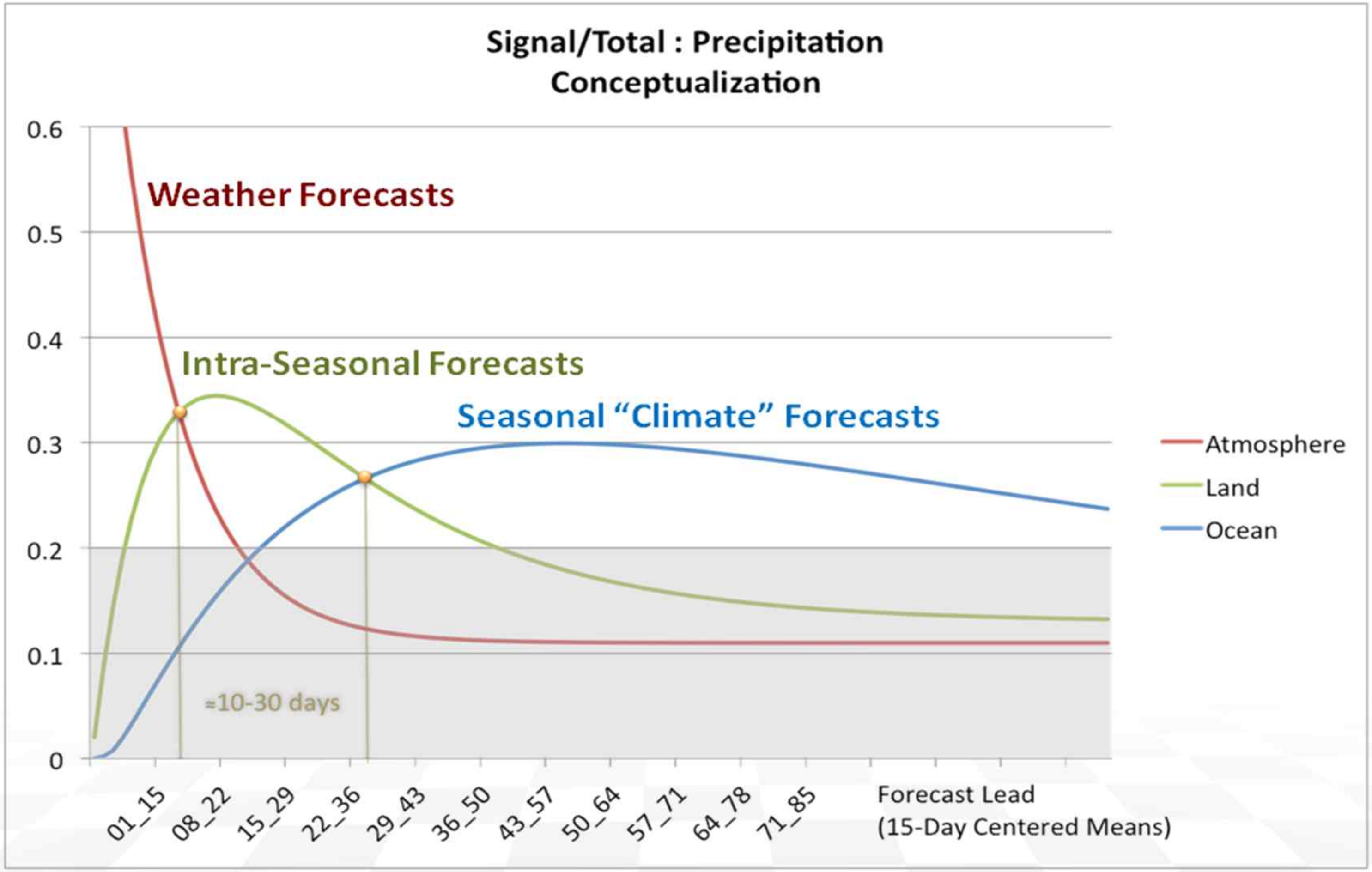
Motivation:
Limitation of the regional indices for representing BS MISO



Regional Monsoon ISO Indices

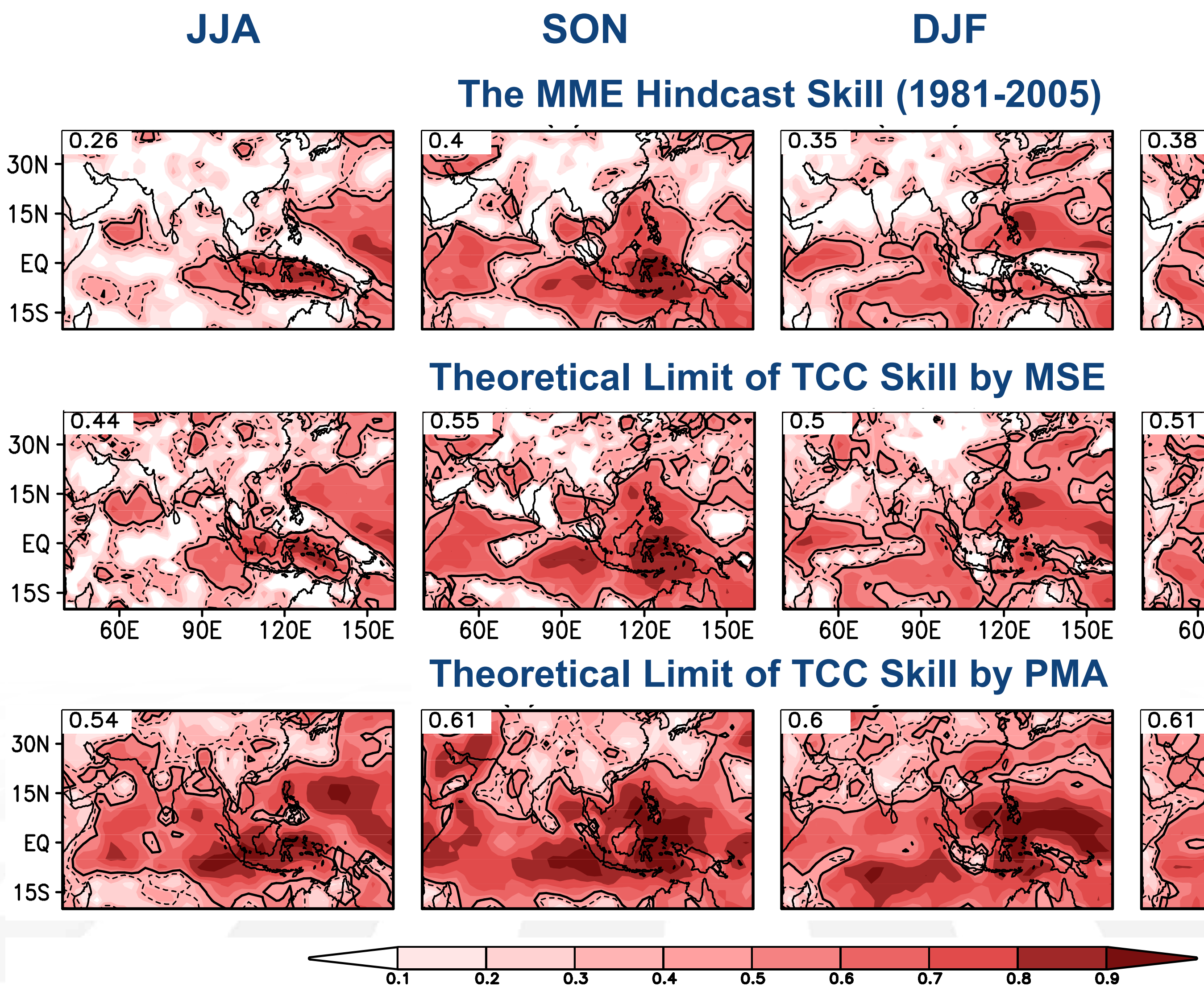
- IOI (Indian Ocean Index): OLR(80-100E, 5S-5N)
- IMI (Indian Monsoon Index, Wang et al. 2001): U850 (40-80E, 5-15N) – U850 (60-90E, 20-30N)
- EWNPI (Equatorial WNP Index): OLR(125-140E, Eq-7.5N)
- WNPMI (Western North Pacific Monsoon Index, Wang and Fan 1999):
  U850 (90-130E, 5-15N) - U850 (110-140E, 22.5-32.5N)

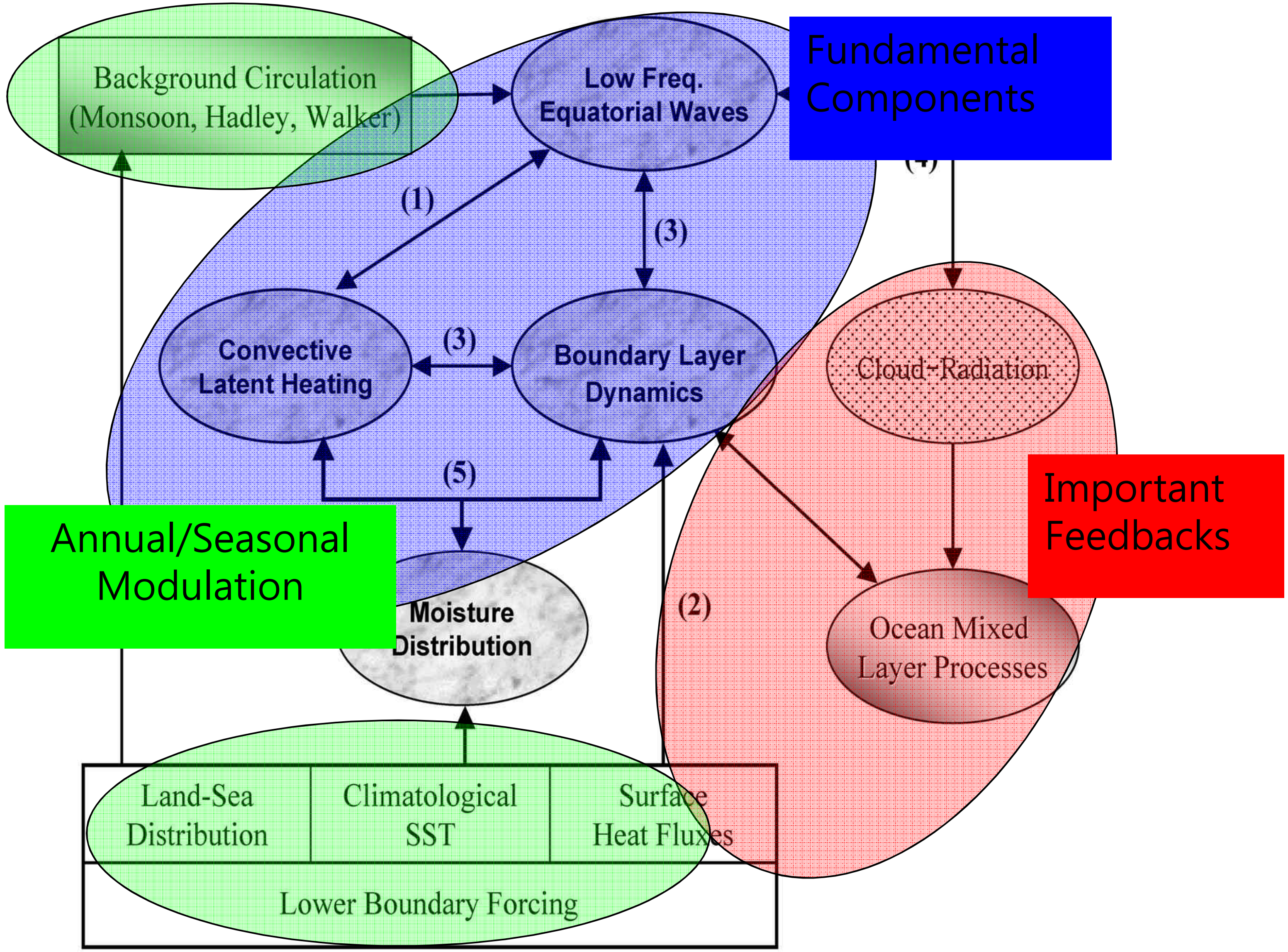
Can one design a better index to describe boreal summer MISO?



The conceptualization of the predictability of precipitation (Courtesy of Paul Dirmeyer).

Factors for Limiting Monsoon Prediction
: Predictability Limit





Background Circulation
(Monsoon, Hadley, Walker)
Low Freq.
Equatorial Waves
Fundamental
Components
(1)
(3)
Convective
Latent Heating
(3)
Boundary Layer
Dynamics
Cloud-Radiation
(5)
Important
Feedbacks
Annual/Seasonal
Modulation
Moisture
Distribution
(2)
Ocean Mixed
Layer Processes
Land-Sea
Distribution
Climatological
SST
Surface
Heat Fluxes
Lower Boundary Forcing

Summary

We suggest **a new MISO index that is defined by the first four multivariate EOF modes of daily OLR and U850 anomaly** over the ASM region (10°S-40°N, 40°-160°E).

The RMM index captures the OLR variability primarily in the equatorial region whereas **the MISO index captures large portion of the variability in the off-equatorial region**, yielding more realistic variance pattern.

The MISO index describes better ISO variability center and represents better northward as well as eastward propagating pattern in the ASM domain than the RMM index

The northward-propagating MISO component can be monitored using the phase diagram between the first and second PC similar as the eastward-propagating MJO. Taking into account distinct regional characteristics of MISO with smaller horizontal scale than MJO, the reconstructed field from the first four modes may provide more useful information.