Statistical and Dynamical Prediction of Monsoon Intraseasonal Oscillation

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1. Introduction

Boreal summer Monsoon Intraseasonal Oscillation (MISO) is one of the most prominent short-term climate variability in the global monsoon system and more complex in nature than the Madden-Julian Oscillation (MJO) due to the interaction between the basic monsoon circulation and tropical ISO. It is to note that the Real-time Multivariate MJO (RMM) index (Wheeler and Hendon, 2004) has a limitation to explain large ISO variability over the Asian Monsoon region (40º-160ºE, 10ºS-40ºN) in boreal summer. Moreover, statistical MISO prediction based on RMM index has limited skills especially over the Western North Pacific and East Asian monsoon region. In the previous study, we designed the new MISO index defined by the first four PCs of multivariate EOF analysis of OLR and U850. Statistical model for the MISO index has been developed and compared with six coupled models' predictions which participate in CliPAS ISO hindcast intercomparison project.

2. Staistical Prediction

Statistical Model for MISO

Statistical Model – STEP I: Prediction of the Four Modes of MISO Index 24

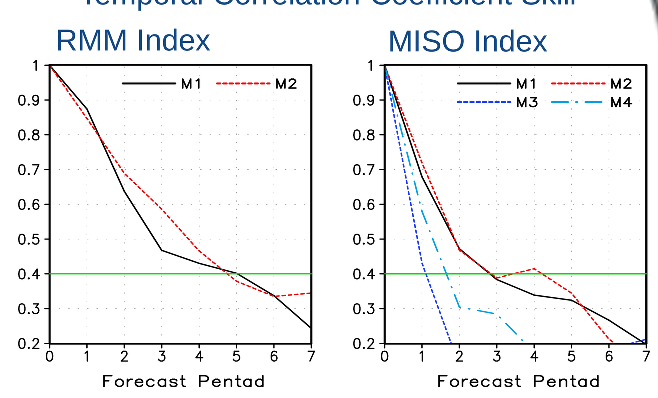
Lagged Multiple Linear Regression Model (Jiang et al. 2008)

$$X(t_0+\tau)=\sum_{k=1}^{N}\sum_{j=1}^{M}C_{j,k}\bullet PC_k(t_0-j+1)$$

$X(t_0+\tau)$: Predictant X at forecast lead time
t_0 : the time at the forecast point: the forecast lead
N : the number of total PCs included in the model
M : the number of lagged days used for the prediction

Forecast Period : 1996 – 2009
Training Period : Last 10 years from target year
Target Months : MJJAS

Temporal Correlation Coefficient Skill



Statistical Model –
STEP II: Reconstruction of Anomaly Field from the MISO Index

(1) Reconstruction of pentad OLR and U850 anomalies from MISO modes over the ASM domain using multiple linear regression model (fitting)

$$Y(lon,lat,t_0)=\sum_{i=1}^{N}\alpha_i(lon,lat)\bullet X_i(t_0)$$

$Y(lon,lat,t_0)$: Reconstructed field from PCs at reference time t_0
$X_i(t_0)$: The i[th] PC at reference time t_0
N : the number of selected PCs
$\alpha_i(lon,lat)$: Weighing coefficient s determined by the least square fitting

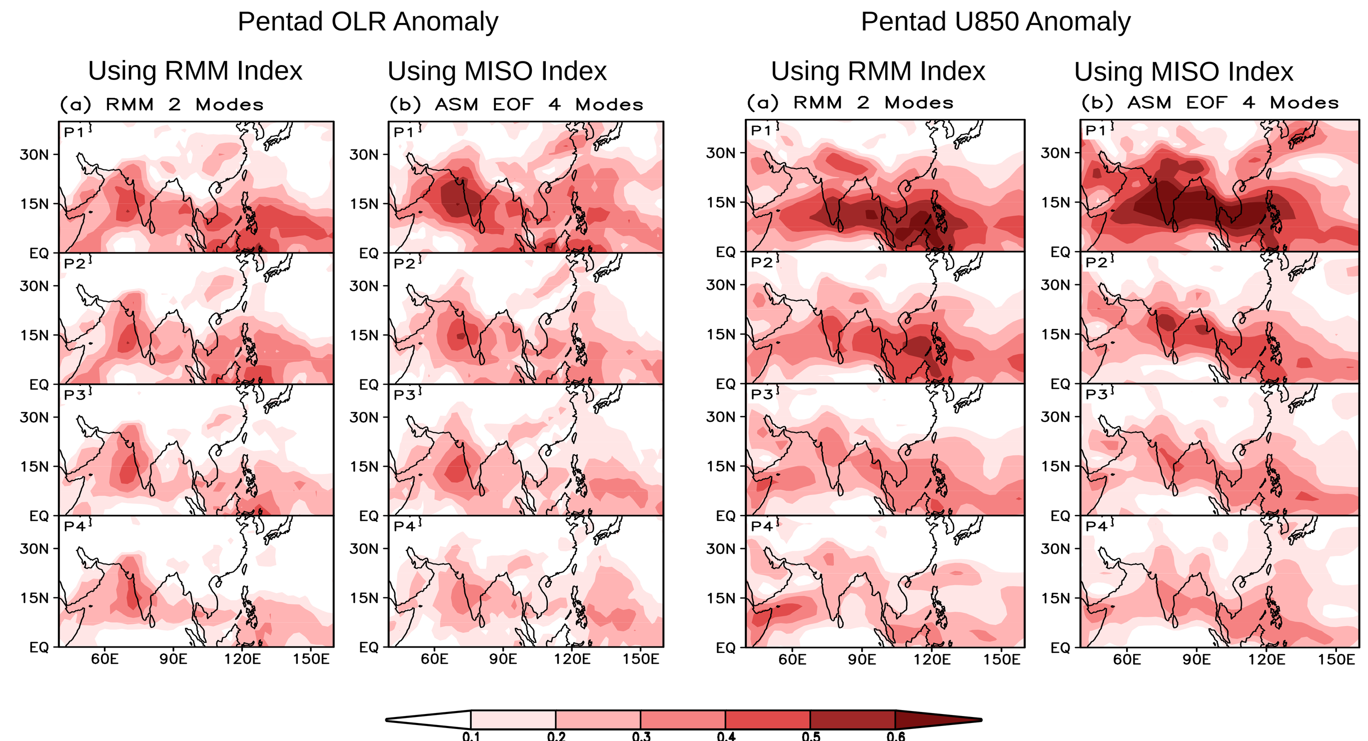
(2) Reconstruction of the predicted pentad OLR and U850 anomalies from the predicted MISO modes as a function of forecast lead time

$$Y(lon,lat,t_0+\tau)=\sum_{i=1}^{N}\alpha_i(lon,lat)\bullet X_i(t_0+\tau)$$

τ : forecast lead time

Temporal Correlation Coefficient Skill

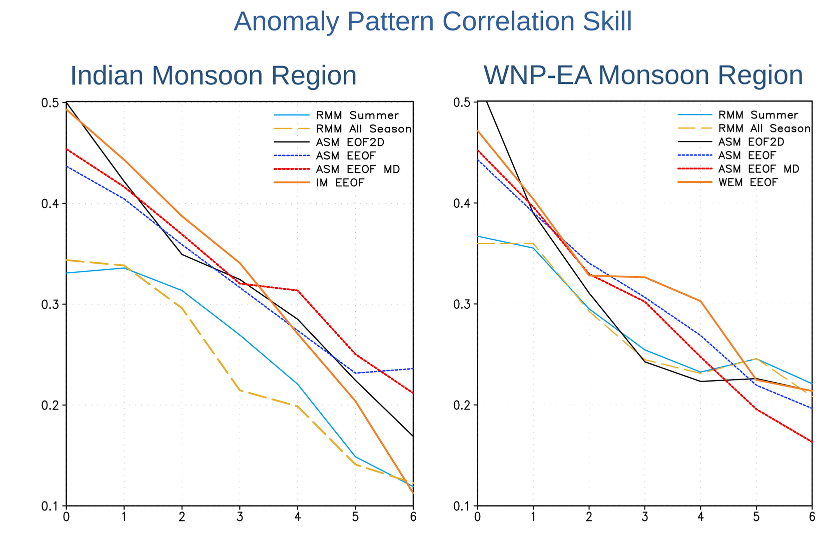
Pentad OLR Anomaly | Pentad U850 Anomaly



Sensitivity Test for the MISO Index : Simple vs Complicated Approach

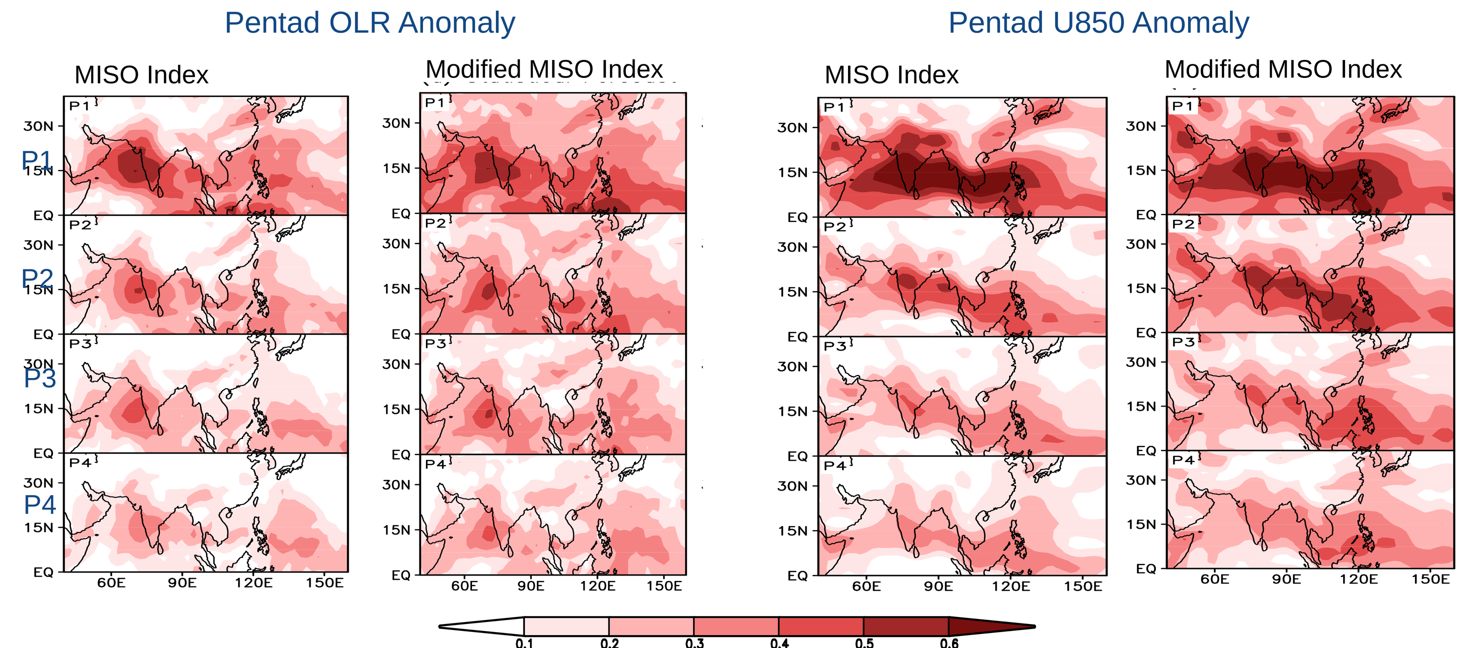
Region	EOF 1D	EOF 2D	EEOF
Equatorial Region (15S–15N)	**RMM** (latitudinal mean) **OLR, U850, U200**		
Asian Summer Monsoon Region (ASM) (40-160E, 10S-40N)		**ASM EOF OLR, U850**	**ASM EEOF OLR, U850, V850**
Indian Monsoon Region (IM) (40-100E, 10S-30N)	**IM EOF1D** (longitudinal mean) **OLR, U850, V850**	**IM EOF2D OLR, U850, V850**	**IM EEOF OLR, U850, V850**
Western North Pacific – East Asian Region (WEM) (100-160E, 0-40N)	**WEM EOF1D** (longitudinal mean) **OLR, U850, V850**	**WEM EOF2D OLR, U850, V850**	**WEM EEOF OLR, U850, V850**

Anomaly Pattern Correlation Skill



Temporal Correlation Coefficient Skill

Pentad OLR Anomaly | Pentad U850 Anomaly



3. Dynamical Prediction

Numerical Design for ISO Hindcast

EXP1: Control Simulation

A long simulation allows us to better understand the dependence of the prediction on initial conditions and better define metrics that measure the "drift" of the model toward their intrinsic MJO/MISV modes

Free coupled runs with AOGCMs or AGCM simulation with specified boundary forcing (e.g., observed SST and Sea ice distribution) are requested for at least 20 years. The period for the forced AGCM run should be consistent with the hindcast period

EXP2: 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 6 members
Initial condition	Initial conditions may use one day lag or 12 hours

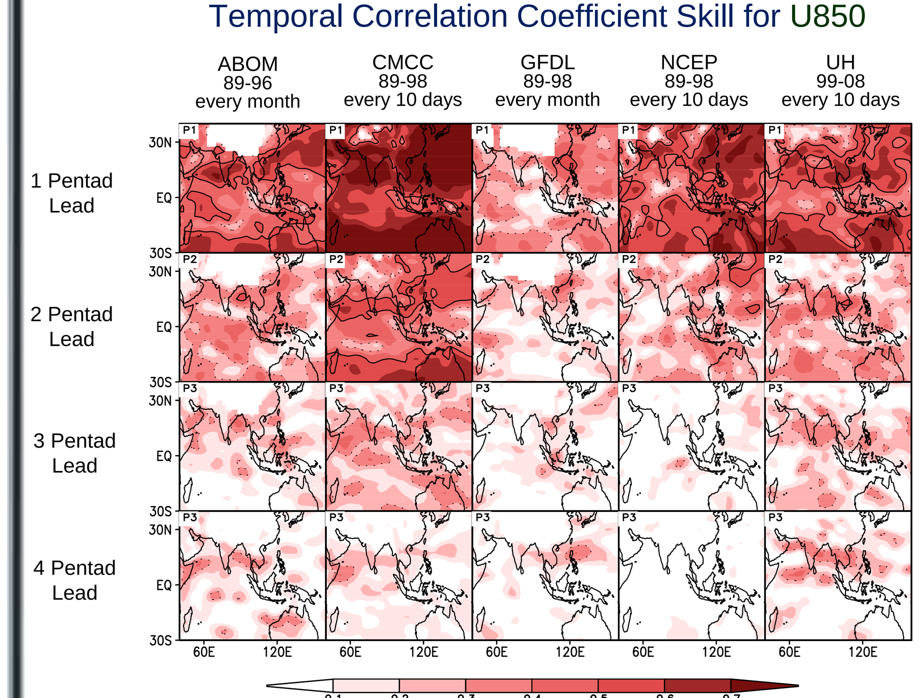
One-Tier System

	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	INGV (ECHAM4+ OPA8.1)	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
NCEP/ CPC	CFS (GFS+ MOM3)	CMIP (100yrs)	1981-2008	5	Every 10 days
SNU	SNU CM (SNUAGCM +MOM3)	CMIP (20yrs)	1981-2001	6	Every 10 days
UH/ IPRC	UH HCM	CMIP	1989-2008	6	Every 10 days during MJJAS

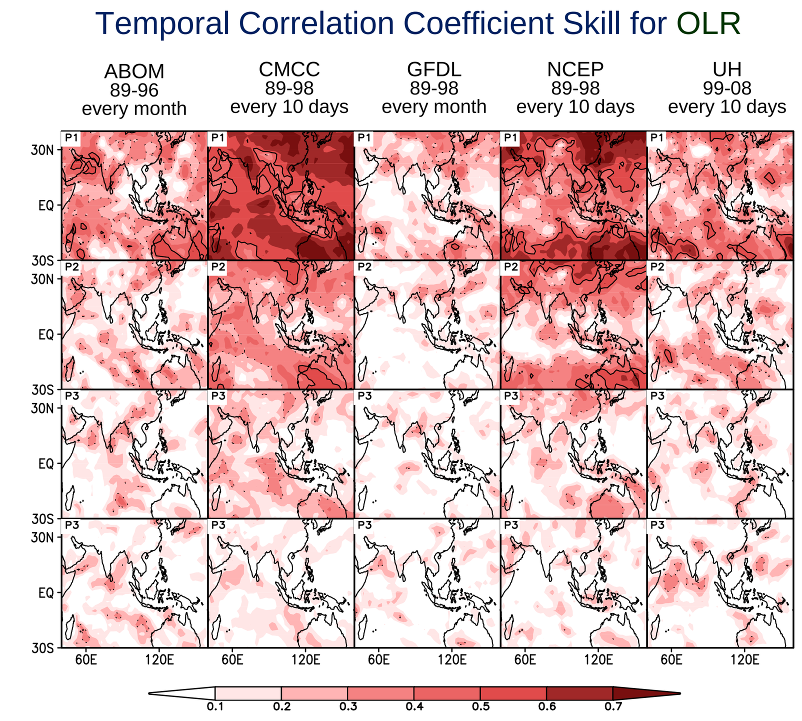
Current Status of the ISO Hindcast

Institution	Participants	Model	Current Status	
ABOM	Harry Hendon	POAMA 1.5 CGCM	26-year integration initiated the first day of every month with 10 ensemble simulations (1980-2006)	Collected
CMCC	A. Navarra A. Alessandri	CMCC CGCM	20-year integration initiated every 10 days (1989-2008)	Collected
CWB	Mong-Ming Lu	CWB AGCM	25-year integration initiated every 10 day (1981-2005)	Collected
ECMWF	F. Molteni, Frederic Vitart	ECMWF CGCM	20-year integration initiated the 15th of every month (1989-2008)	Collected
GFDL	W. Stern	CM2.1 CGCM	27-year integration initiated the first day of every month (1982-2008)	Collected
JMA	K. Takahashi	JMA AGCM	20-year integration initiated every month (1989-2008)	
NASA/ GMAO	S. Schubert P. Pegion	GMAO AGCM	20-year integration initiated every day (1989-2008)	
NCEP/ CPC	A.Kumar J.K.E. Schemm	CFS CGCM	26-year integration initiated every 10 days (1981-2008)	Collected
SNU	I.-S. Kang	SNU CGCM	21-year integration initiated every five days during NDJFM season (1981-2001) and MJJAS season (1998-2008)	Collected
UH/IPRC	X. Fu J.-Y. Lee	UH CGCM	20-year integration initiated every 5 day during MJJAS (1989-2008)	Collected
MRD/EC	Gilbert Brunet Hai Lin	MRD AGCM	24-year integration initiated every 10 days (1985-2008)	Collected

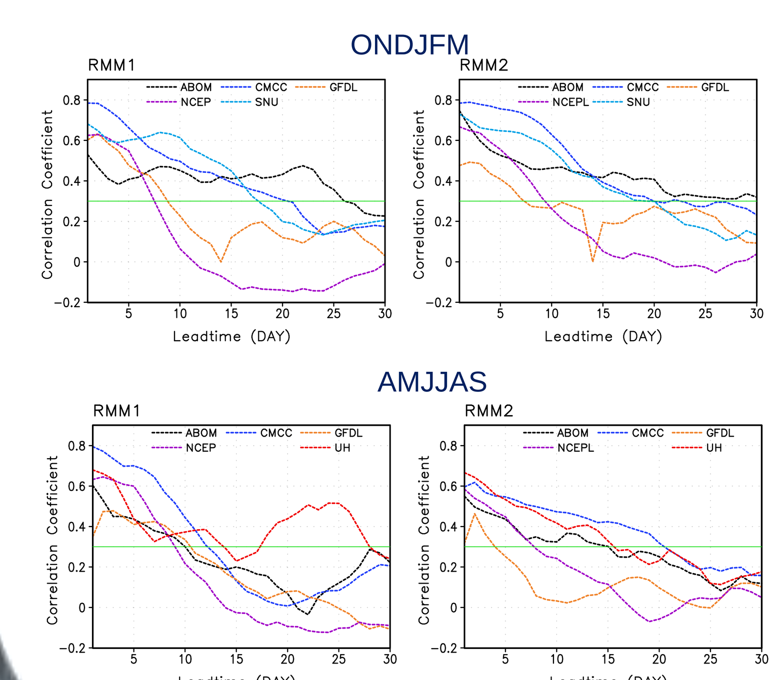
Temporal Correlation Coefficient Skill for U850



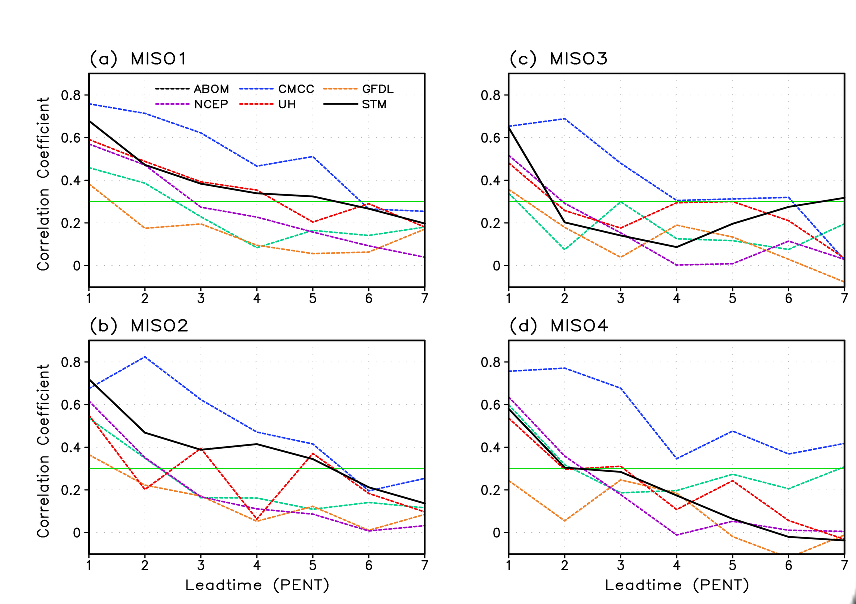
Temporal Correlation Coefficient Skill for OLR



Temporal Correlation Skill for the RMM1 and RMM2



Forecast Skills for the MISO Index
: Dynamical vs Statistical Prediction



Summary

- A statistical forecast model for the MISO index has been developed based on multivariate lag-regression model. The statistical model has a useful skill up to lead time of 15-20 days for each PCs of the MISO index. The reconstructed forecast of pentad OLR and U850 anomaly from the MISO index has a useful skill up to 10-20 days depending on region.
- Multi-institutional ISO hindcast experiment has been coordinated to determine potential and practical predictability of ISO in a multi-model frame work. Nine hindcast outputs has been collected from seven coupled and two atmospheric models.
- Five coupled models have skills for the four PCs of the MISO index up to 10 to 25 days depending on models and PCs. CMCC model outperforms the other coupled models and statistical model. Statistical model has slightly better skill for the first and second PCs than and comparable skill for the third and fourth PCs to other four coupled models.

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