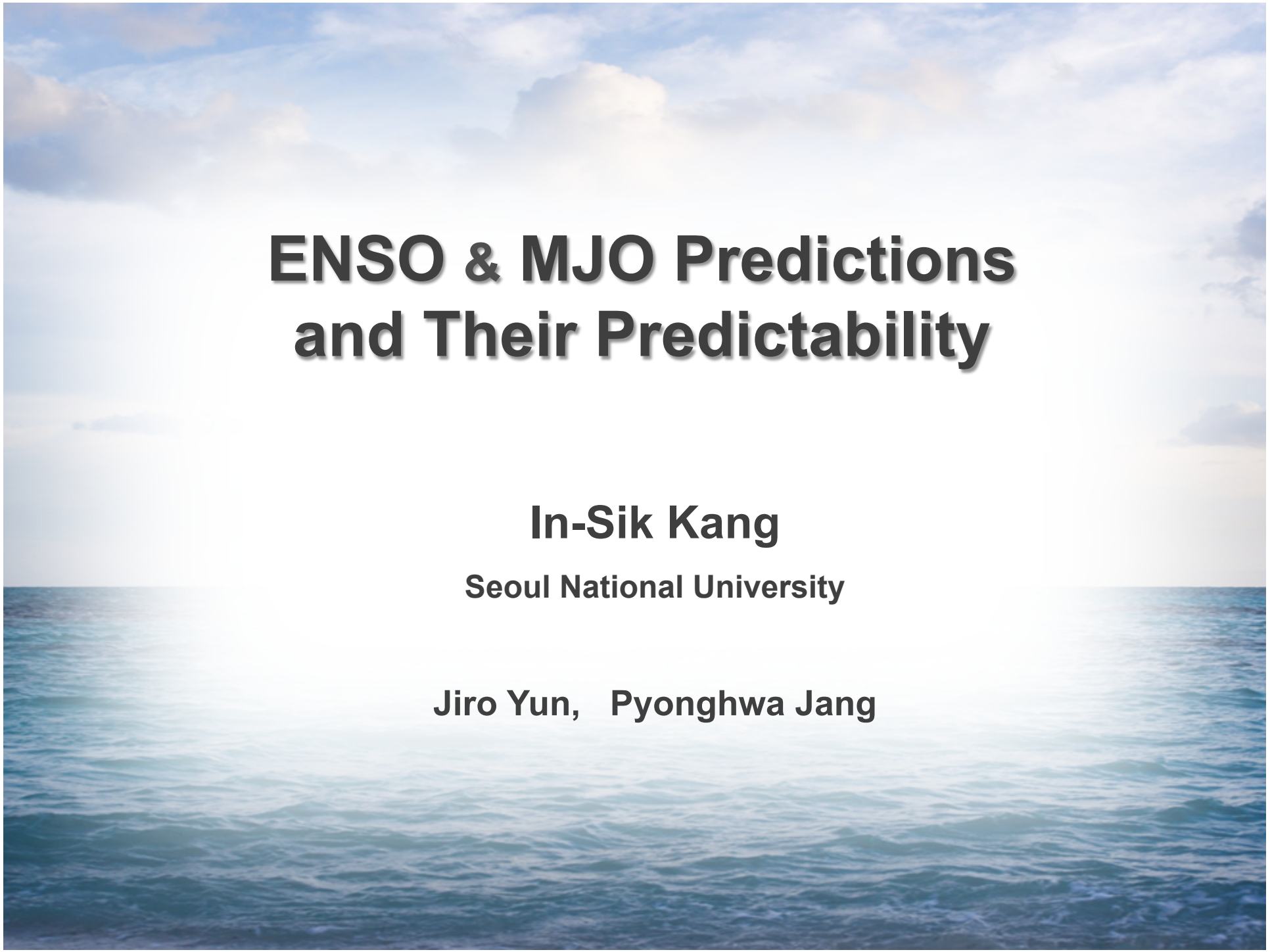


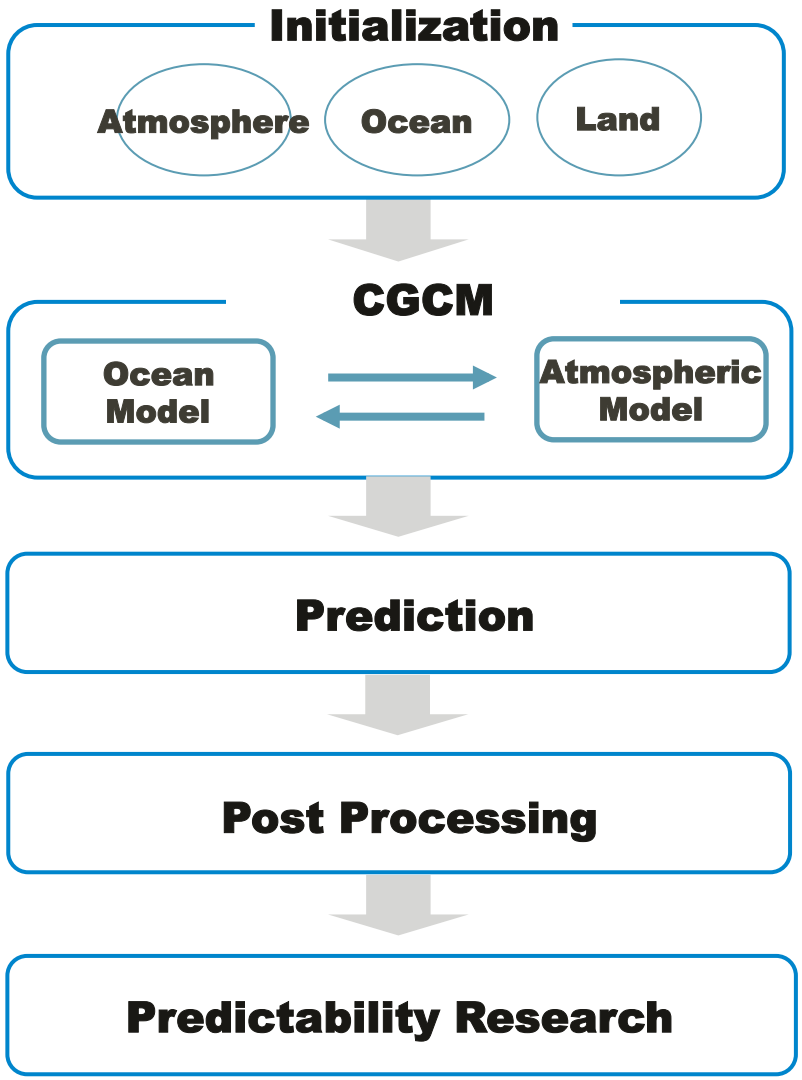
ENSO & MJO Predictions and Their Predictability

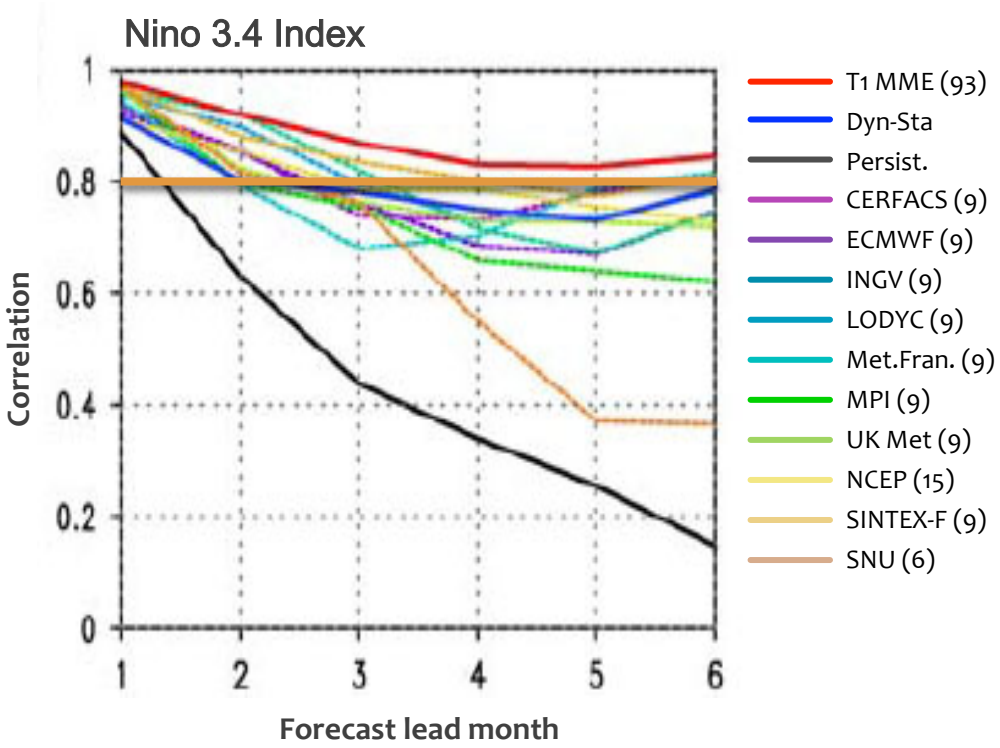
In-Sik Kang

Seoul National University

Jiro Yun, Pyonghwa Jang

Seasonal Prediction System



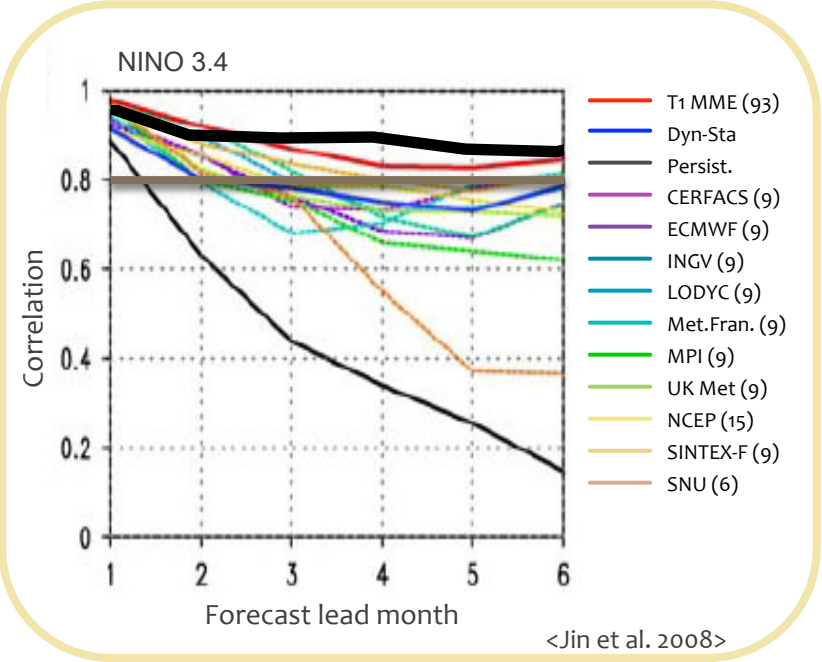


<Jin et al. 2008>

※ numbers in parenthesis refer to the number of ensemble members

Contents

Seasonal Prediction - Result



<Jin et al. 2008>

numbers in parenthesis refer to
the number of ensemble members

SNU CGCM v1

	Model	Description	References
AGCM	**SNU AGCM**	**T42, 21 levels (2.8125X2.8125)** **SAS cumulus convection** **2-stream k-distribution radiation** **Bonan (1996) land surface**	Kim (1999) Kang et al. (2002) Kang et al. (2004) Kim et al. (2003) Lee et al. (2003)
OGCM	**SNU OGCM**	**MOM2.2 + Mixed Layer Model** **1/3° lat. x 1° lon. over tropics (10S-10N),** **Vertical 32 levels**	Noh and Kim (1999) Noh et al. (2003a) Noh et al (2003b) Kim et al. (2004) Noh et al. (2004) Noh et al. (2005)
CGCM	**SNU CGCM**	**SNU AGCM + MOM2.2**	

Mixed Layer Model

Vertical Eddy Viscosity $K_M = S_M q l$

Vertical Eddy Diffusivity $K_H = S_H q l$

where S_M, S_H: empirical Constant

$q^2/2$: TKE

l : the length scale of turbulence

Coupling Strategy

-1-day interval exchange

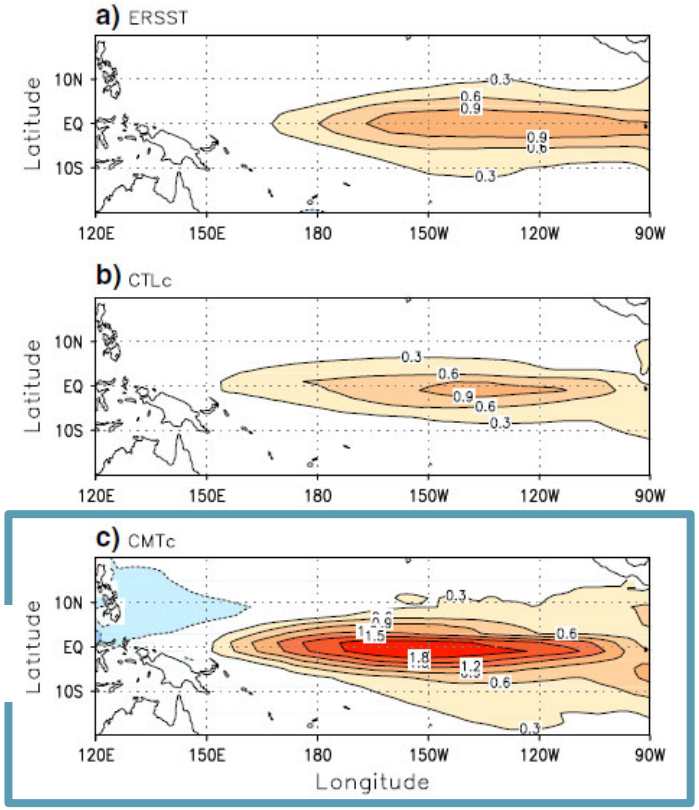
- Ocean : SST
- Atmosphere : Heat, Salt, Momentum Flux
- No Flux Correction is applied

Improvement

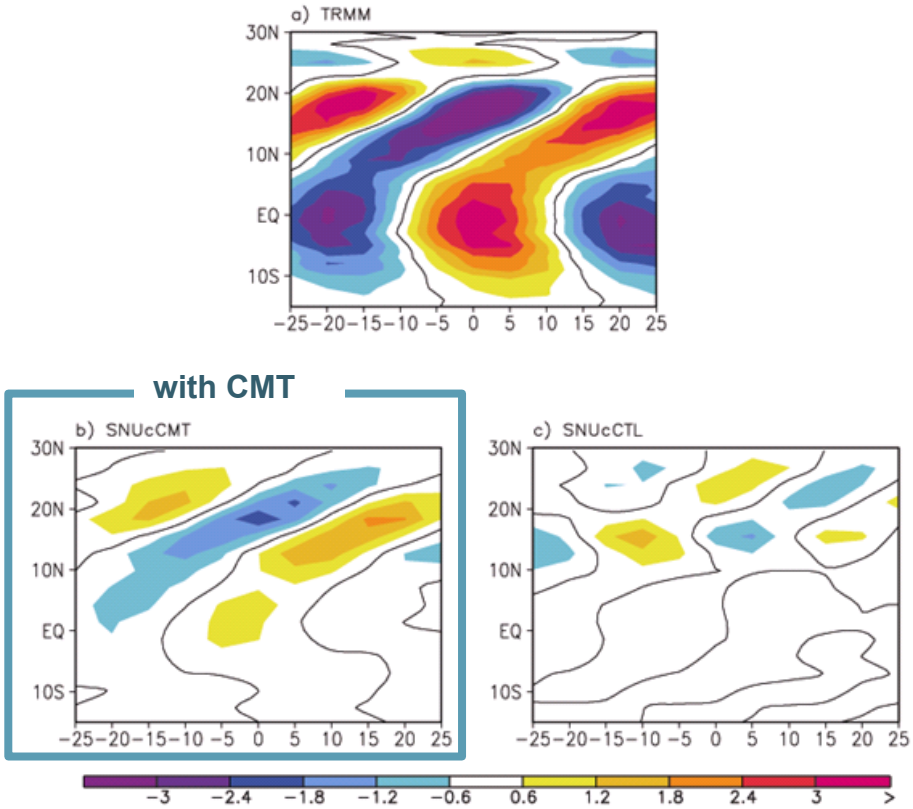
Ham et al. (2011, Climate Dynamics)

- Cumulus Momentum Transport
- Convective triggering (Tokioka constraint)
- Reduced auto-conversion time scale (tau=3200s)
- Diurnal air-sea coupling

SST regressed onto the Nino3.4 index and then multiplied by the STD of Nino3.4 index



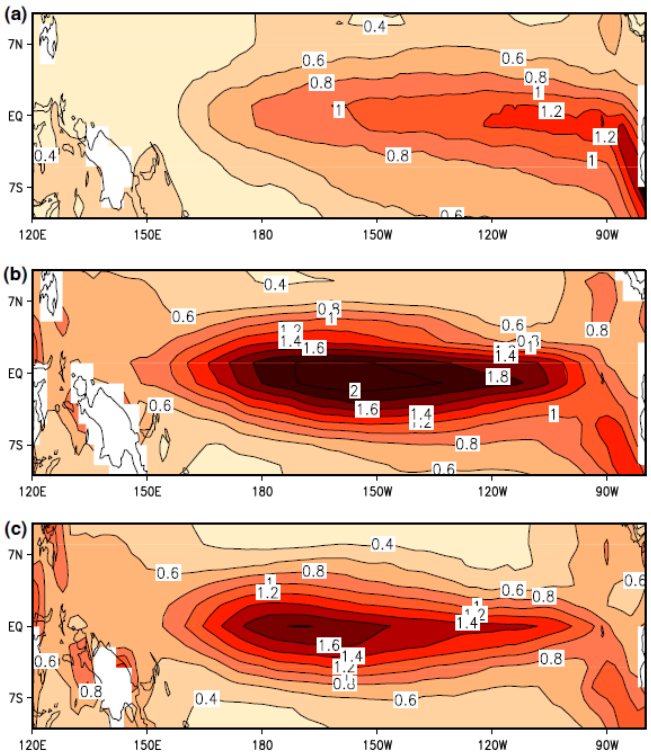
85°-95°E averaged 20-100 day precipitation anomaly(mm day^{-1}) latitude-lag regression



Improvement

- Cumulus Momentum Transport
- Convective triggering (Tokioka constraint)
- Reduced auto-conversion time scale (tau=3200s)
- Diurnal air-sea coupling

The standard deviation for monthly mean SST



(a) OISST

(b) CNTL

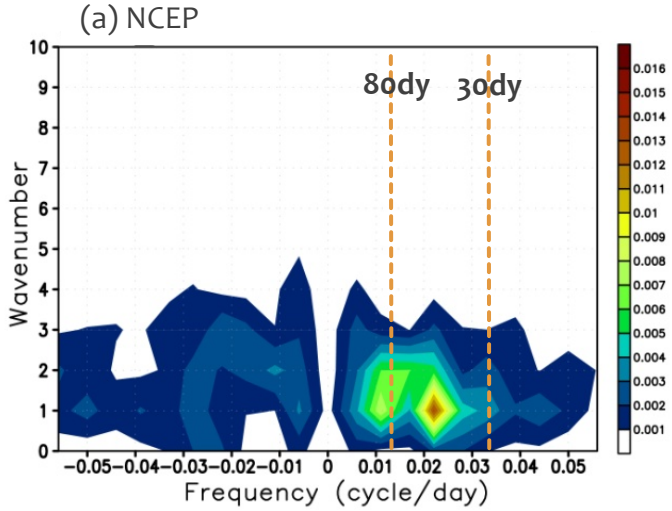
(c) Diurnal coupling

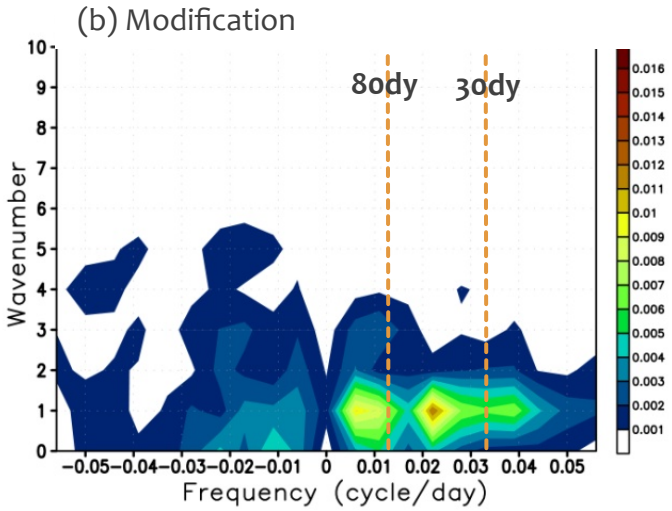
√ **Coupling frequency = 2 h**

Improvement

- Cumulus Momentum Transport
- Convective triggering (Tokioka constraint)
- Reduced auto-conversion time scale (tau=3200s)
- Diurnal air-sea coupling

Space-time power spectrum U850, winter (Nov-Apr)





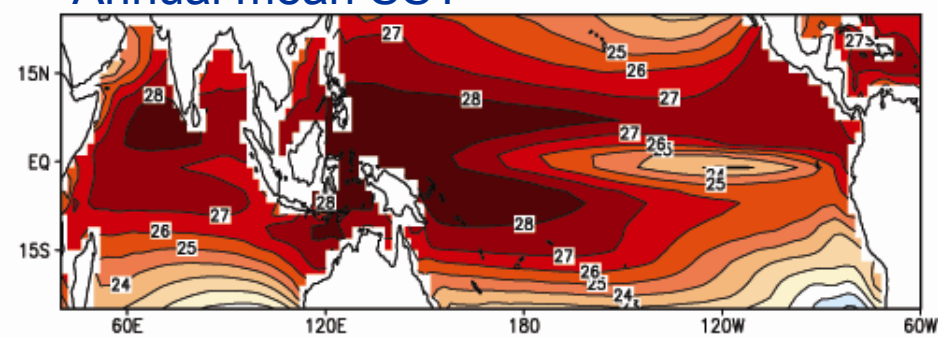
√ **Tokioka constraint coefficient (alpha) = 0.1**

√ **Convective adjustive timescale = 3200 s**

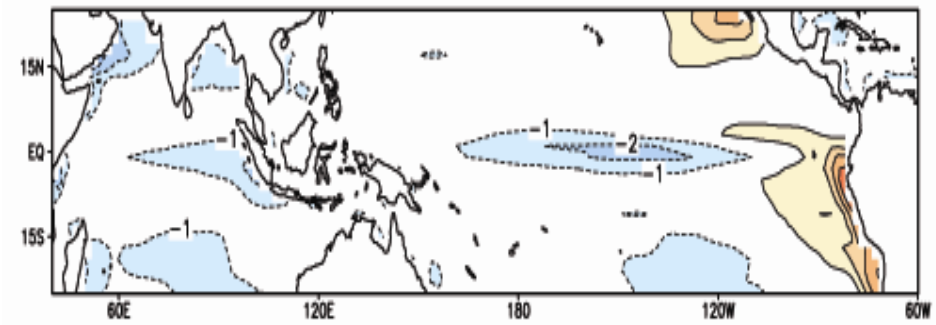
Improvement

CNTL CGCM

Annual mean SST

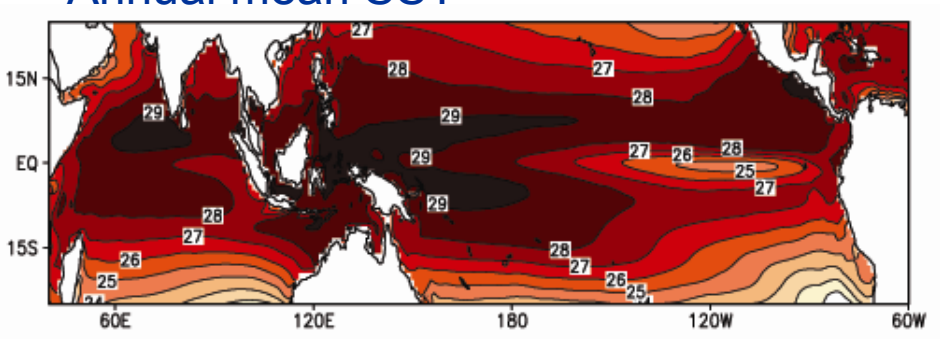


Bias

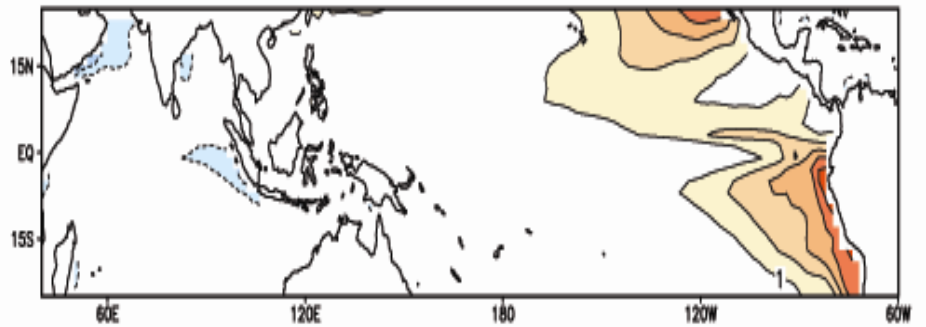


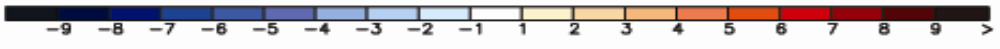
Improved CGCM

Annual mean SST



Bias





- Convective momentum transport
- Diurnal coupling
- Tokioka constraint (alpha=0.1)
- Auto conversion time scale (3200s)

Seasonal / Intra-seasonal Prediction System

Coupled GCM

SNU CGCM V.2

SNU AGCM + MOM2.2
T42, 20 levels resolution

Initialization

Data for Nudging

Atmosphere

ERA interim
-U, V, T, Q, Ps Nudging
(relaxation time: 6hr)

Ocean

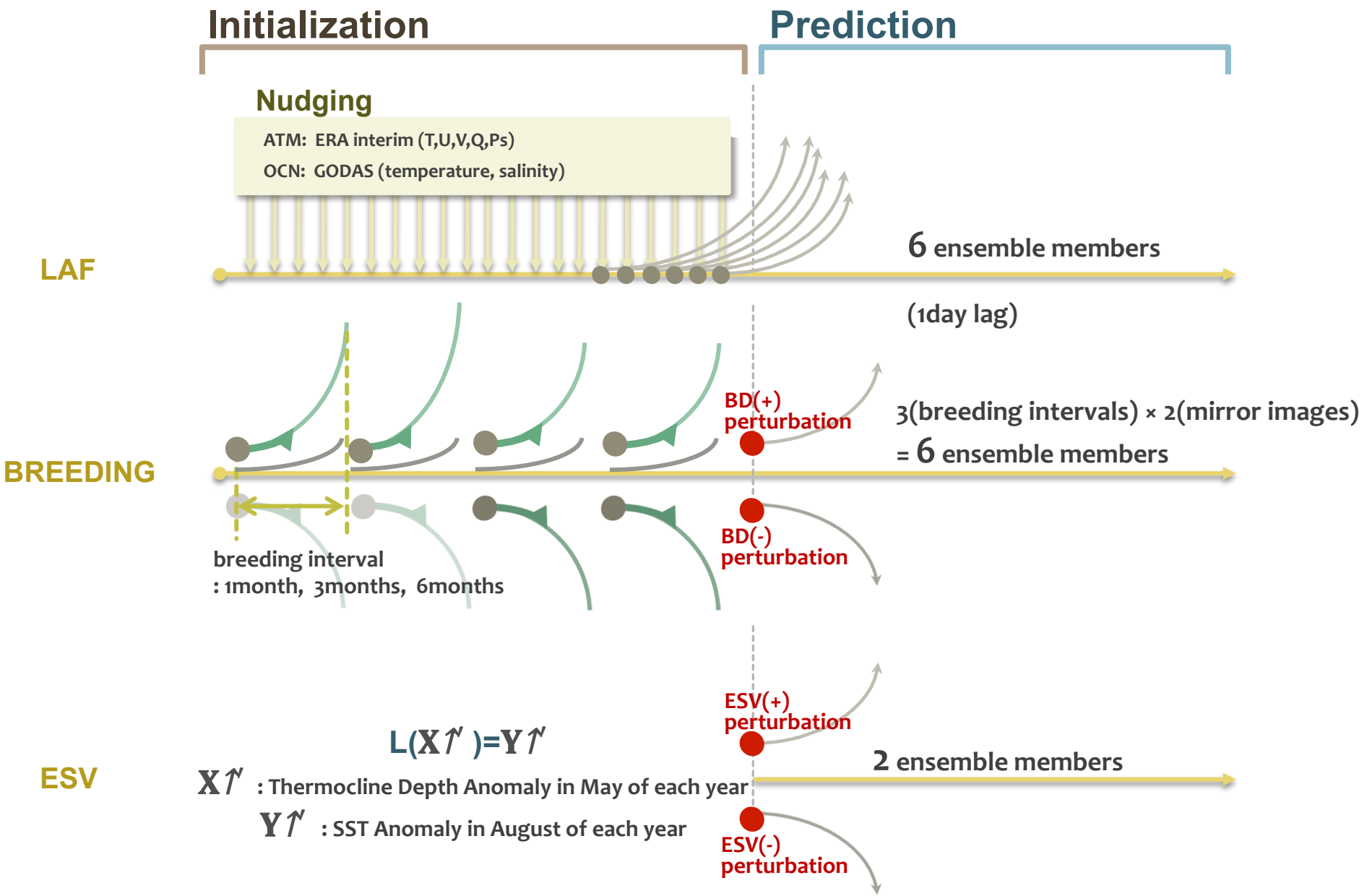
GODAS
-SST & salinity Nudging
(relaxation time: 5 day)

+

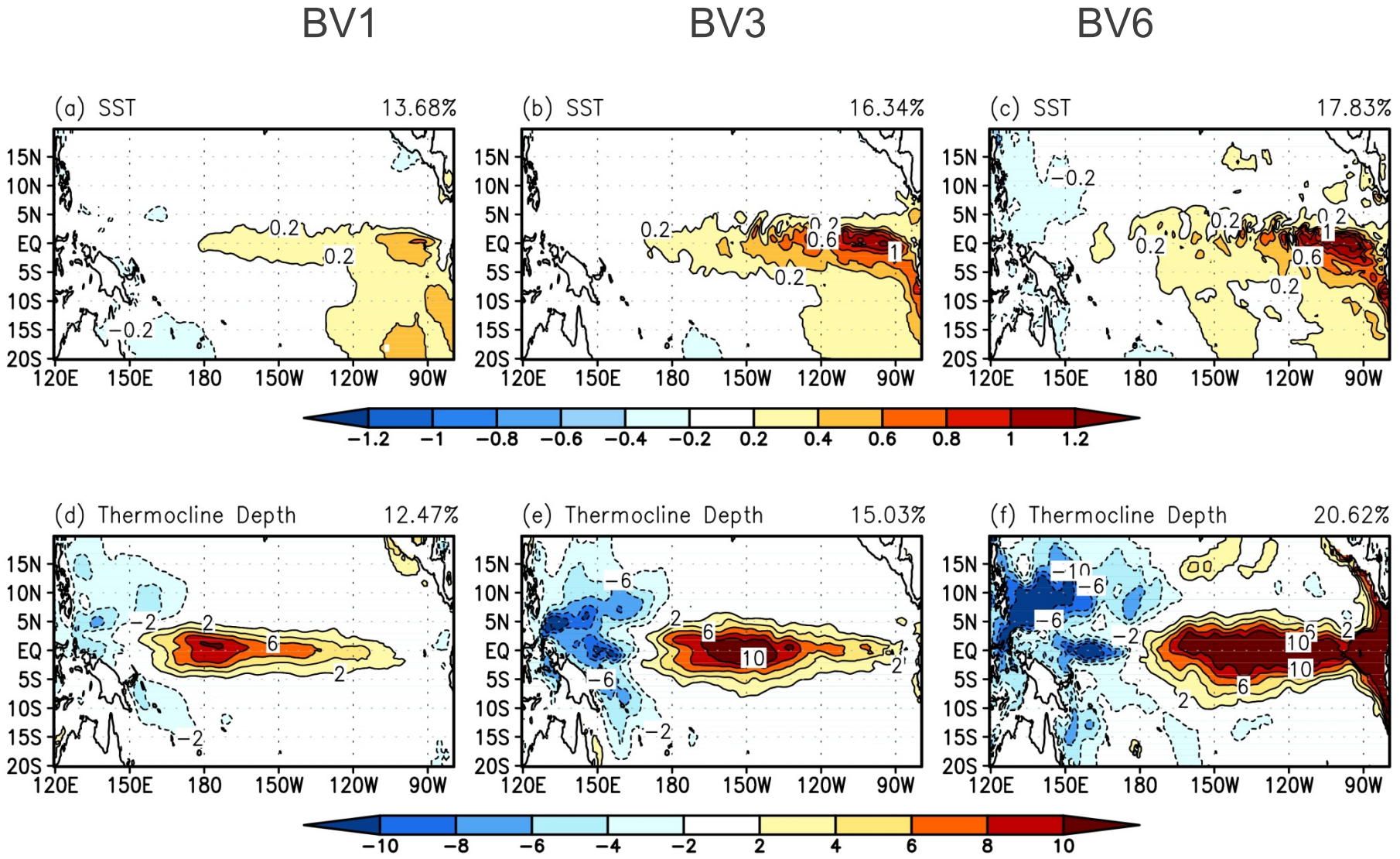
Perturbation method

- Lagged average forecast (LAF)
- Breeding Method
- Empirical Singular Vector

Seasonal Prediction - Initialization

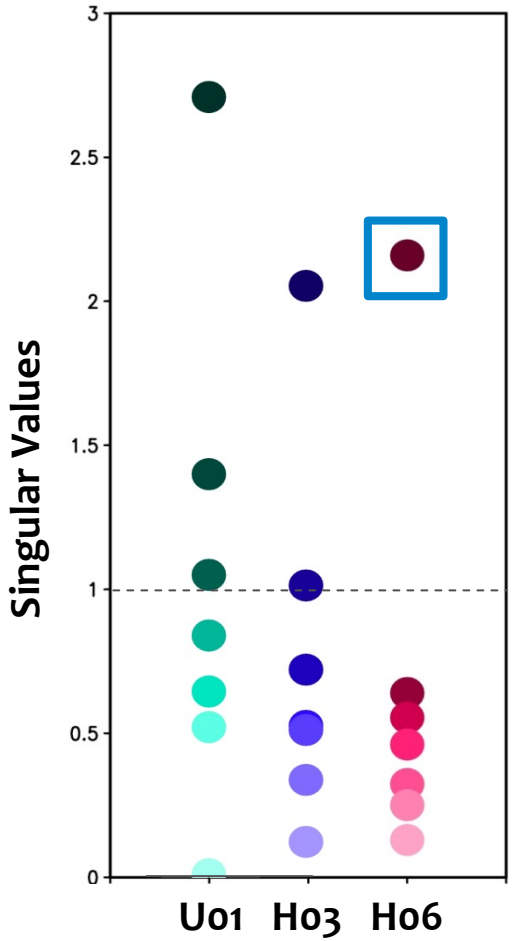


1st EOF Modes of BVs



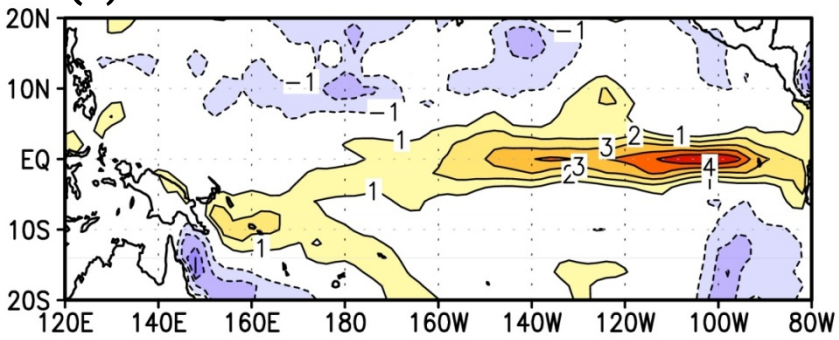
ESV

■ Singular Values

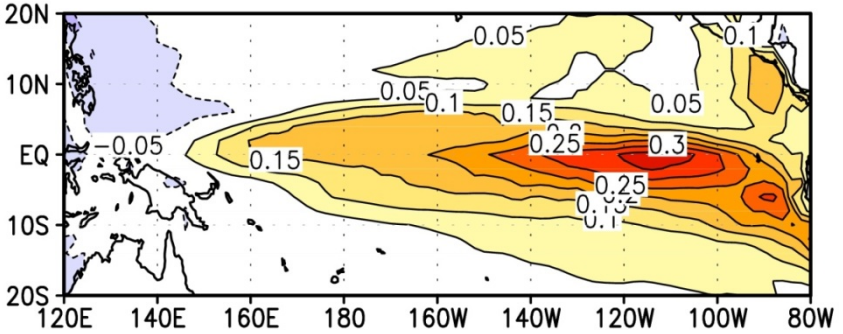


■ 1st Singular Mode (H) and Final Perturbation (SST) of ESV

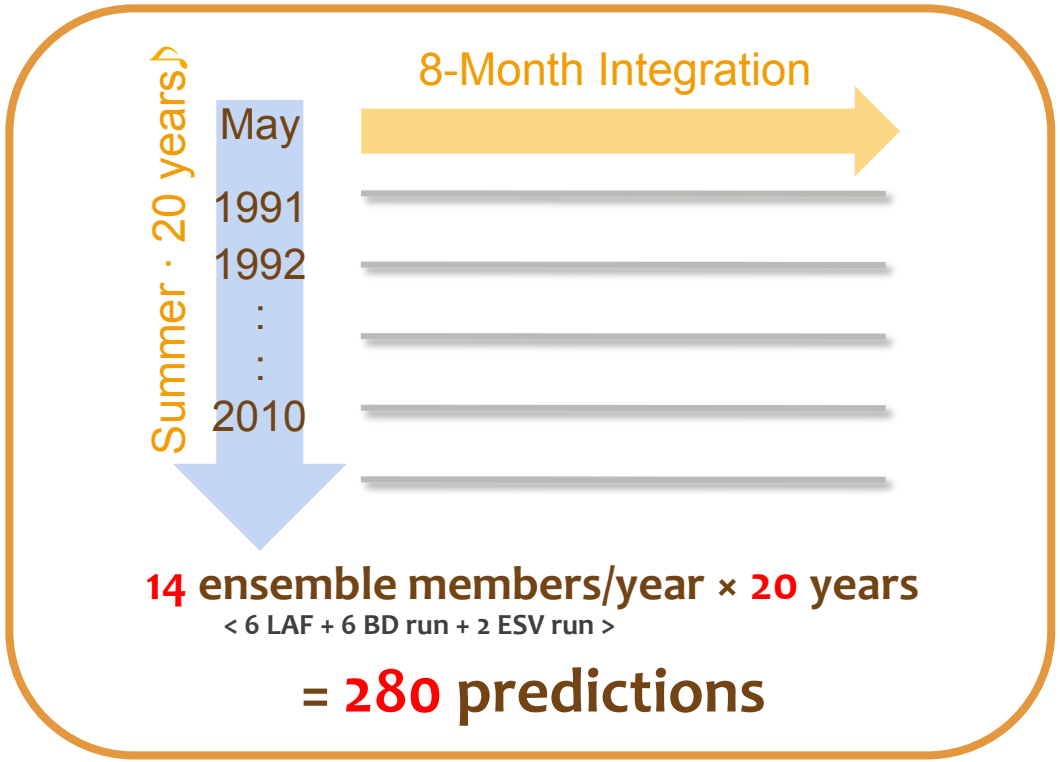
(a) initial H



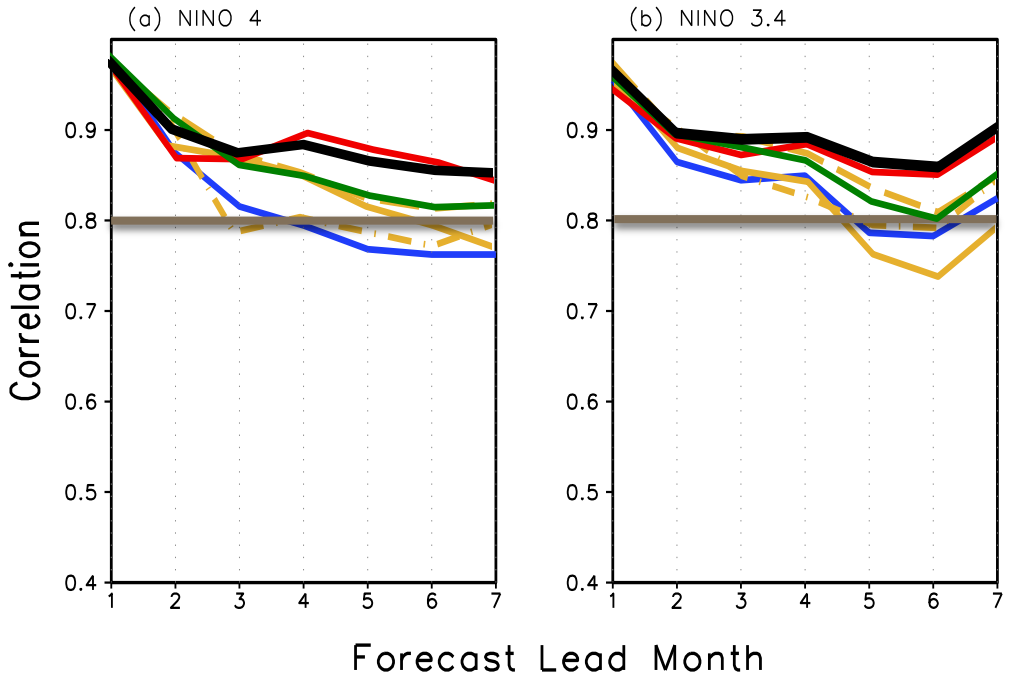
(b) final SST

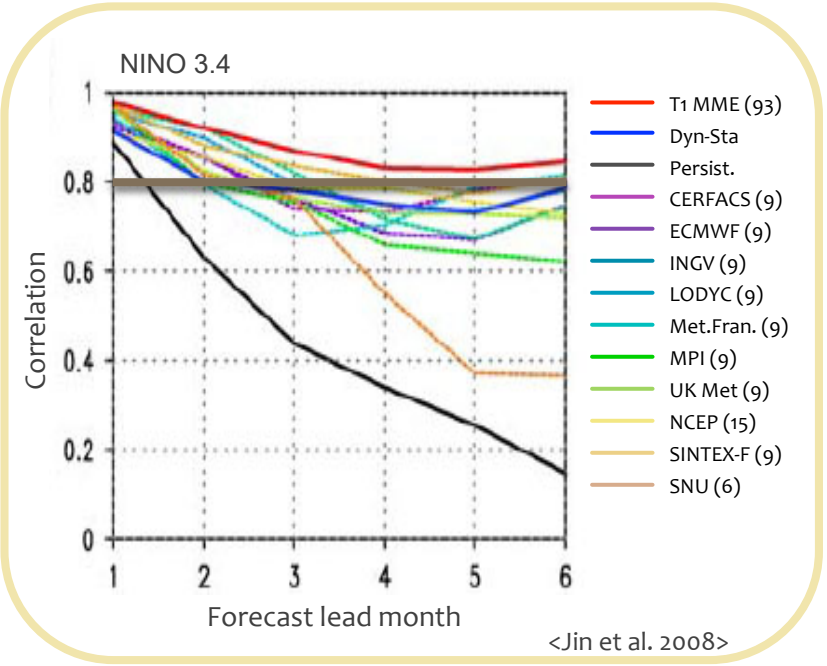


Seasonal Prediction - Outline



Seasonal Prediction - Results





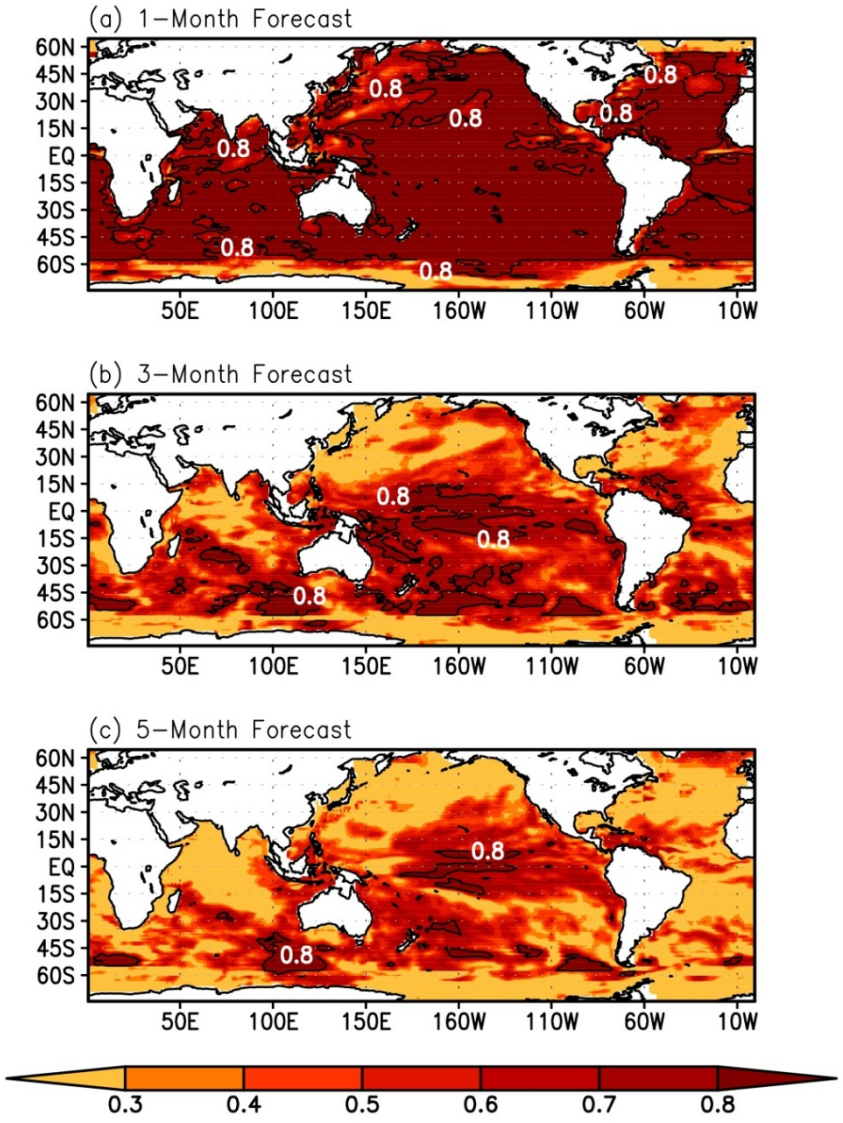
<Jin et al. 2008>

numbers in parenthesis refer to
the number of ensemble members

LAF (6 ensemble members with 1 day lag intervals)
BD1 month (breeding interval : 1 month)
BD3 months (breeding interval : 3 months)
BD6 months (breeding interval : 6 months)
ESV
BD1+3+6 months
BD3 months+ESV

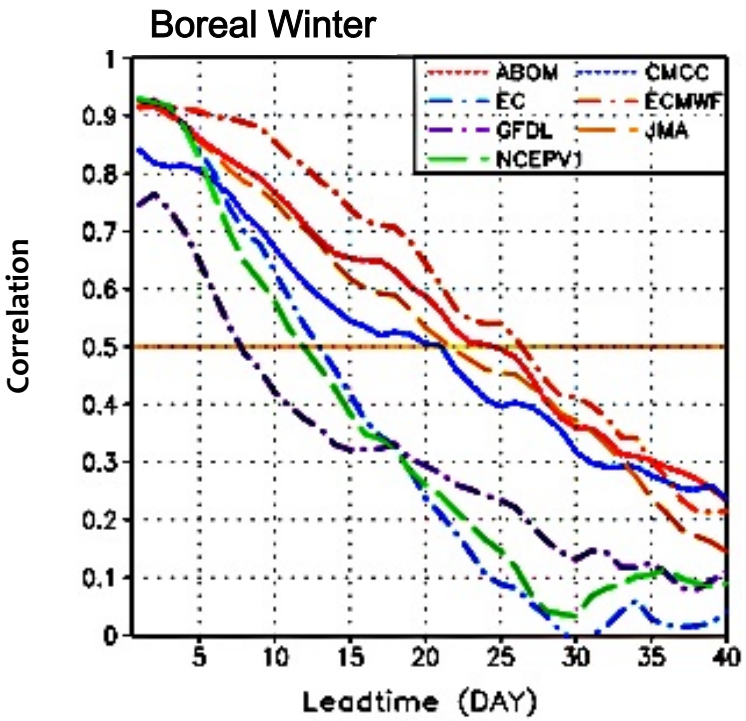
Spatial distribution of correlation skill

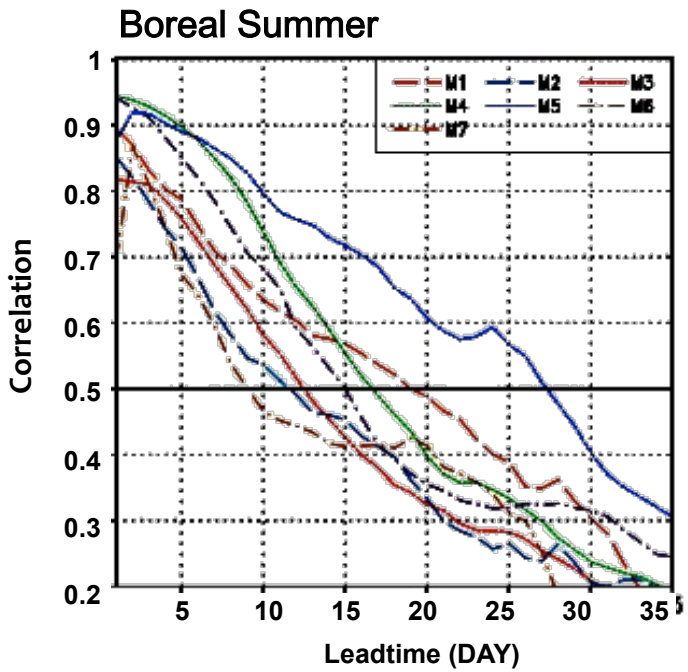
LAF+BD1+BD3+BD6



Intraseasonal MJO Prediction

RMM index

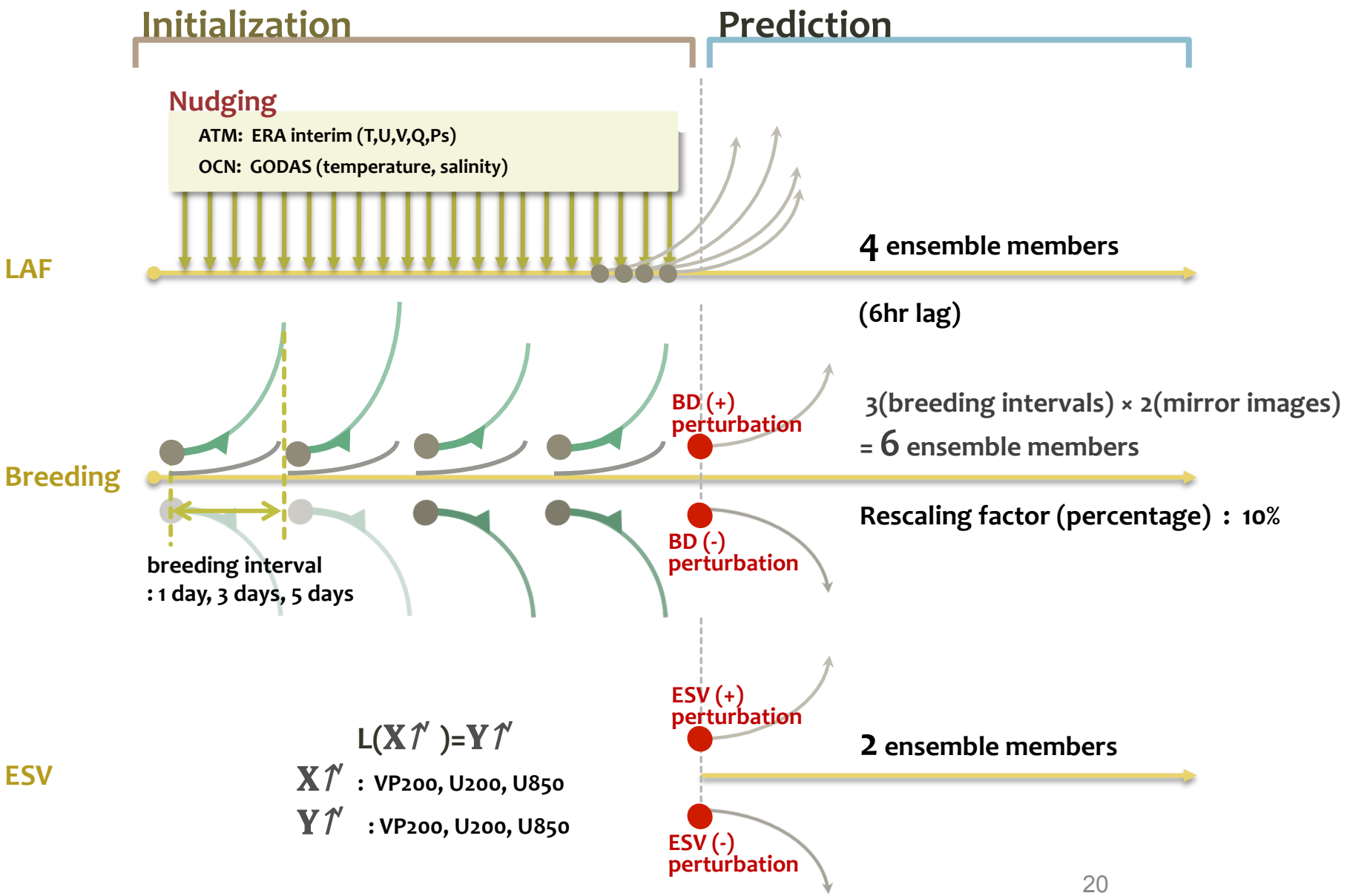




	ABOM	EC	GFDL	NCEP	CMCC	ECMWF	JMA
Ensemble number	10	10	10	5	5	15	6

Ref. CLIVAR/ISVHE
Intraseasonal Variability Hindcast Experiment

Intra-seasonal prediction



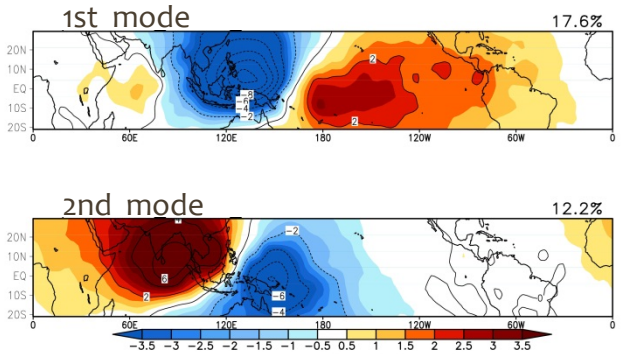
Breeding

■ Characteristics of Bred Vector (boreal summer)

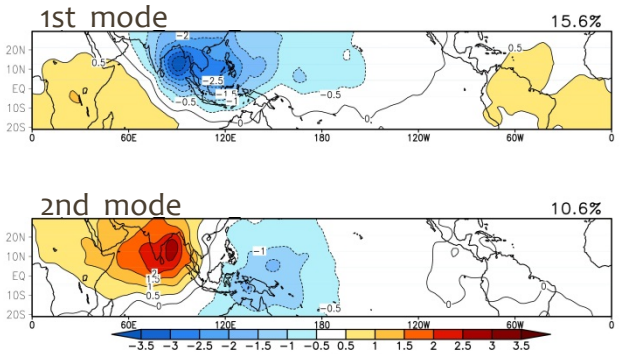
Unit : $\times 10^5$ (m^2/s)

EOF

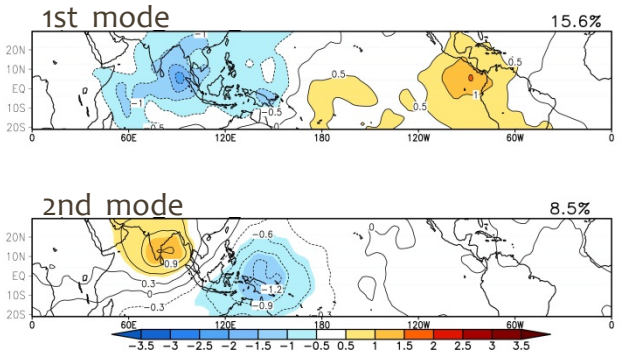
BV 1day



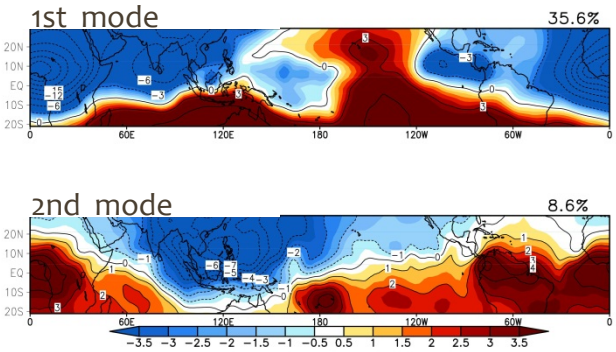
BV 3day



BV 5day



LAF case (6hr lag)



Ensemble prediction

■ Outline

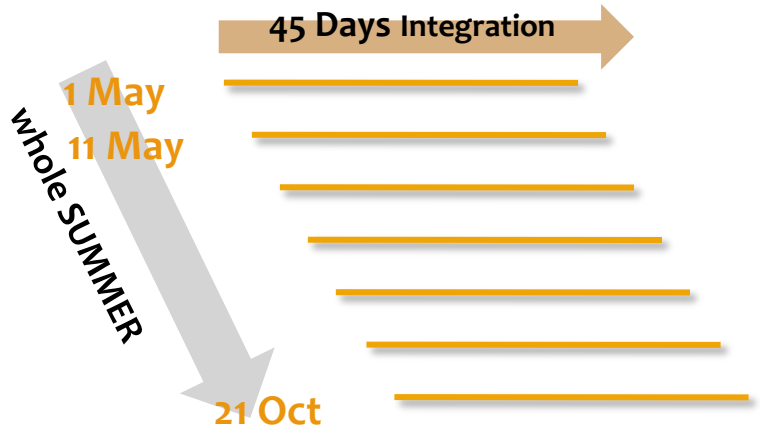
Total 360 cases per a season ➔ Include all MJO phase

Summer :

12 < LAF(4) + BD1day(2) + BD3day(2) + BD5day(2) + ESV(2)> /case

× 18 cases/year × 20 years

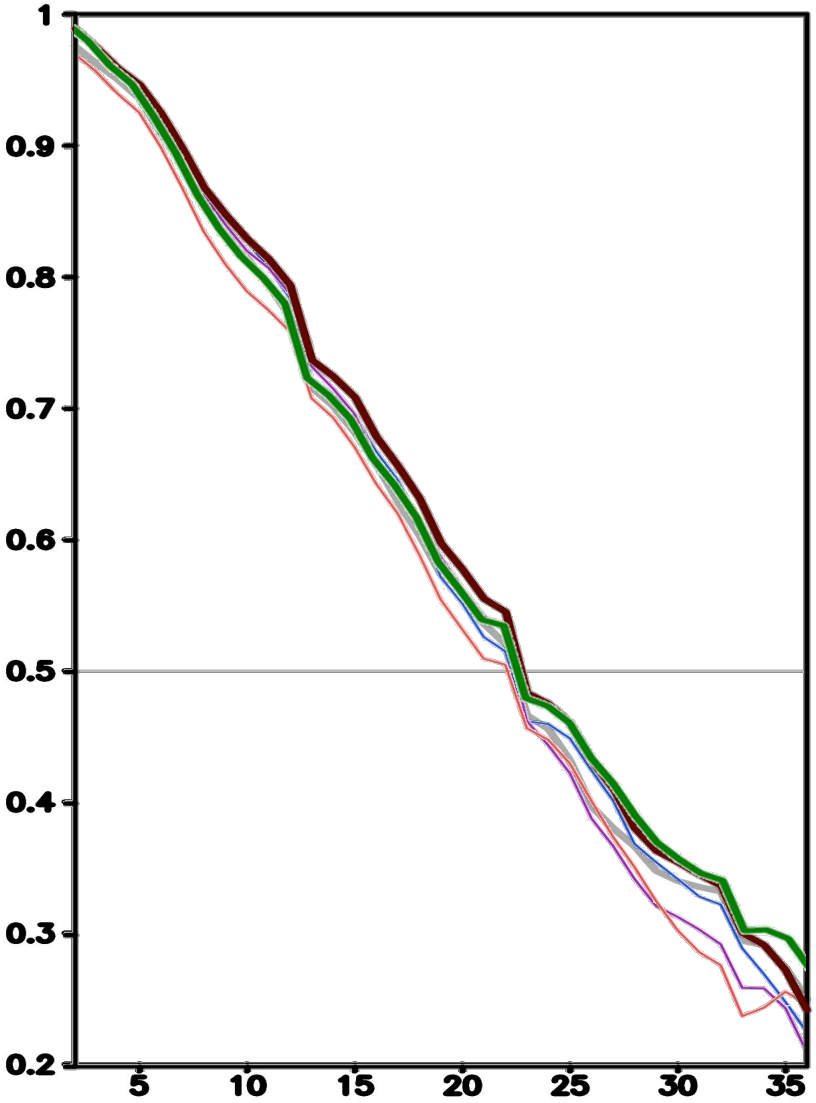
= 3600 predictions



Correlation skills

■ Correlation skill of Real-time Multivariate MJO (RMM) Index

* The parenthesis refers ensemble members



LAF [4]

BD1day [2]

BD1day+BD3day [4]

BD3day [2]

BD5day [2]

BD1day+BD3day+BD5day [6]

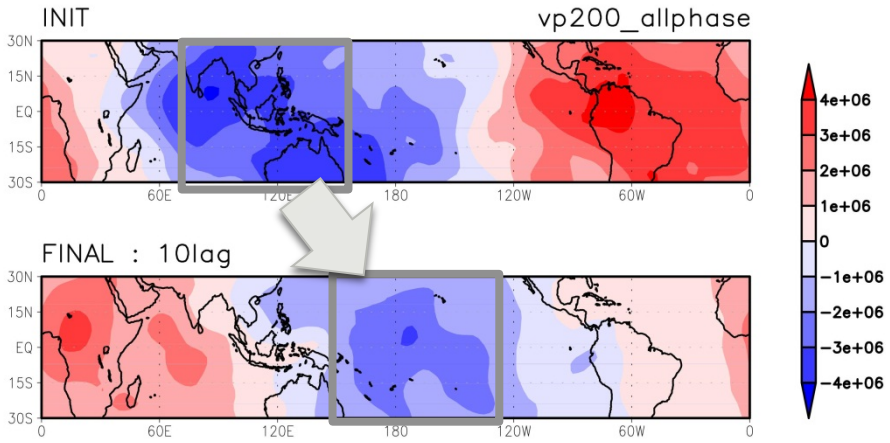
ESV (Empirical singular vector)

■ **Singular mode of ESV**

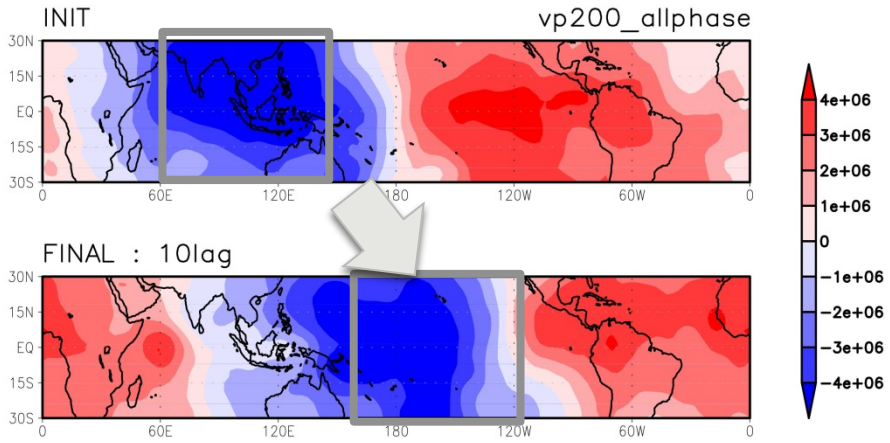
Empirical singular vectors

-Total (all phases)-

Observation



Model



Final VP200 anomaly is on the east of initial VP200 anomaly

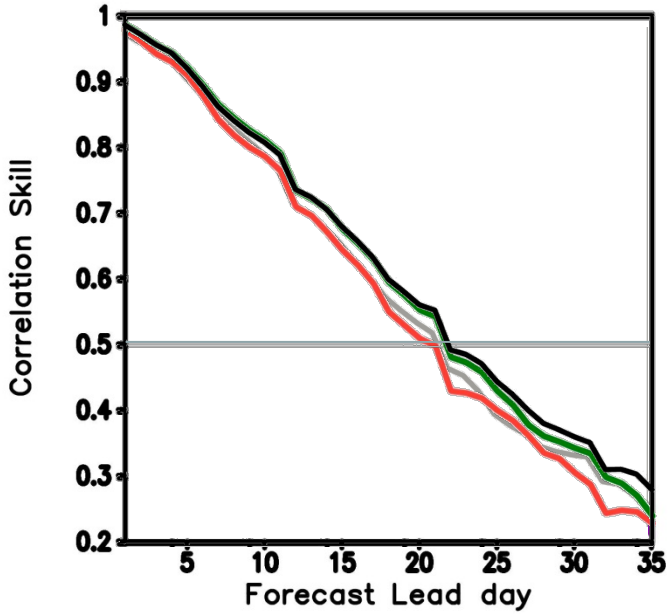
Eastward propagating mode

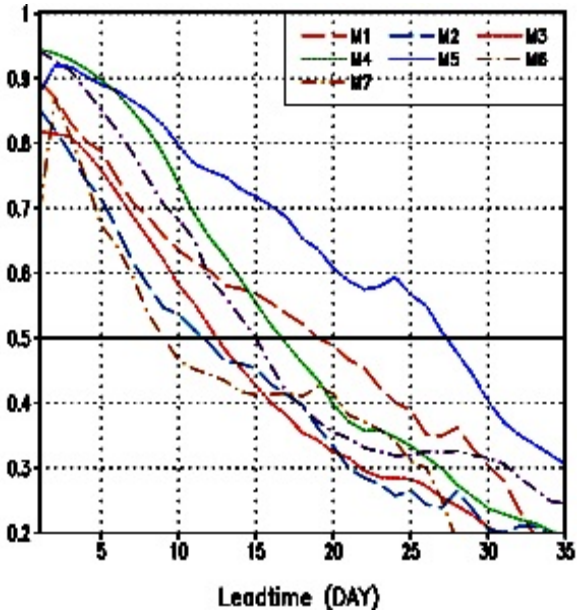
Ensemble

■ Correlation skill of Real-time Multivariate MJO Index

* The parenthesis refers ensemble members

Summer





LAF (4) : 4 ensemble members with 6 hours lag intervals

BDlag-BDlag-BDlag-BDlag(6)

ESV (2)

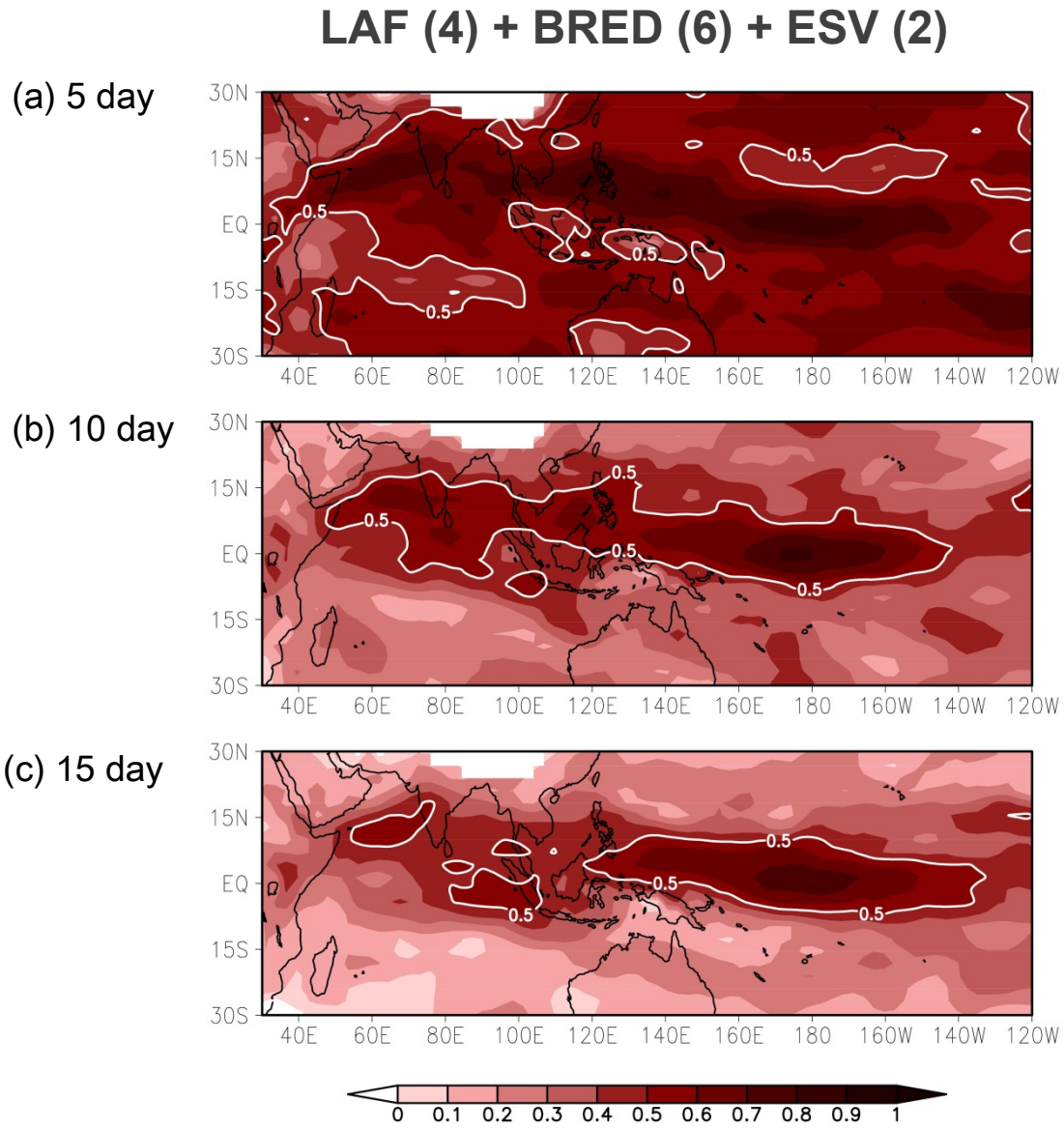
ALE (12)

Ensemble

■ Correlation Skill of U850 for lead times

* The parenthesis refers ensemble members

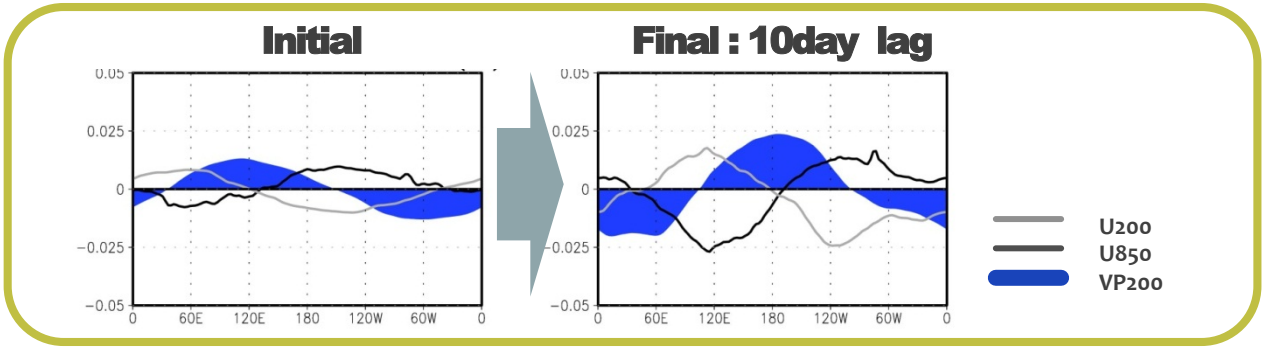
Summer



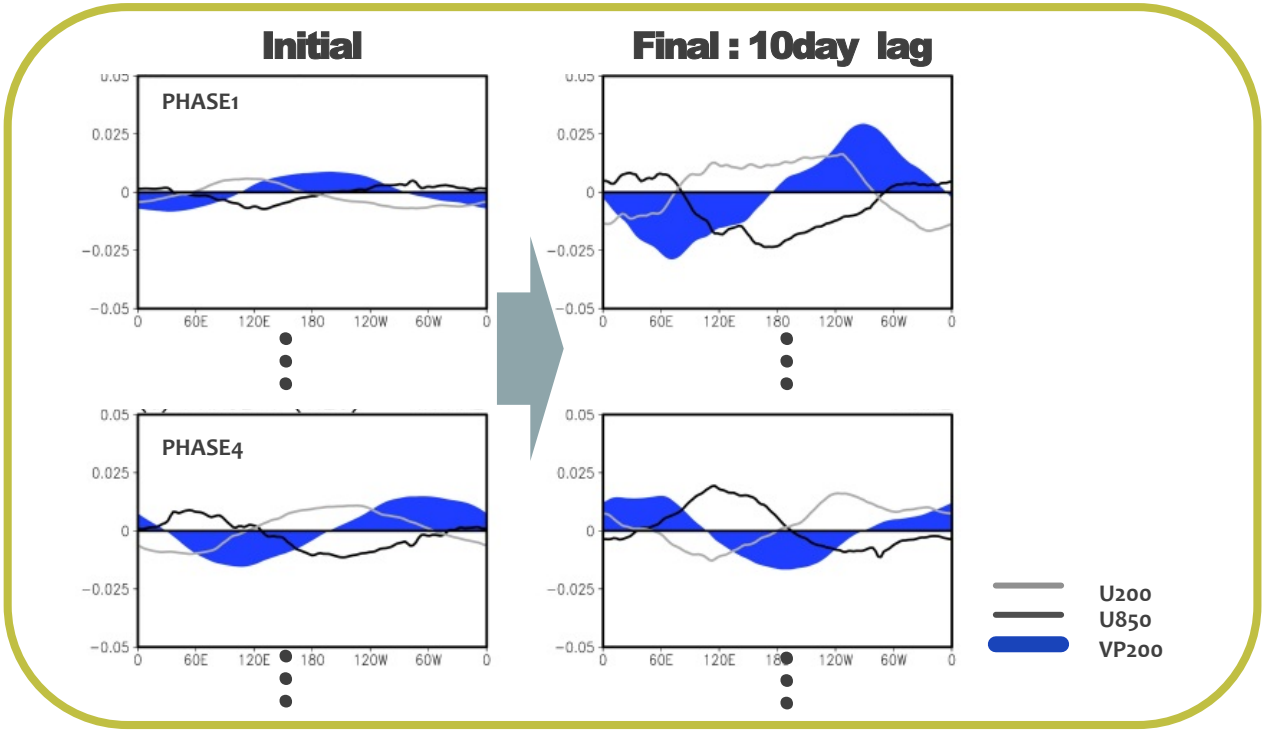
ESV

■ ESV phase dependency

ESV



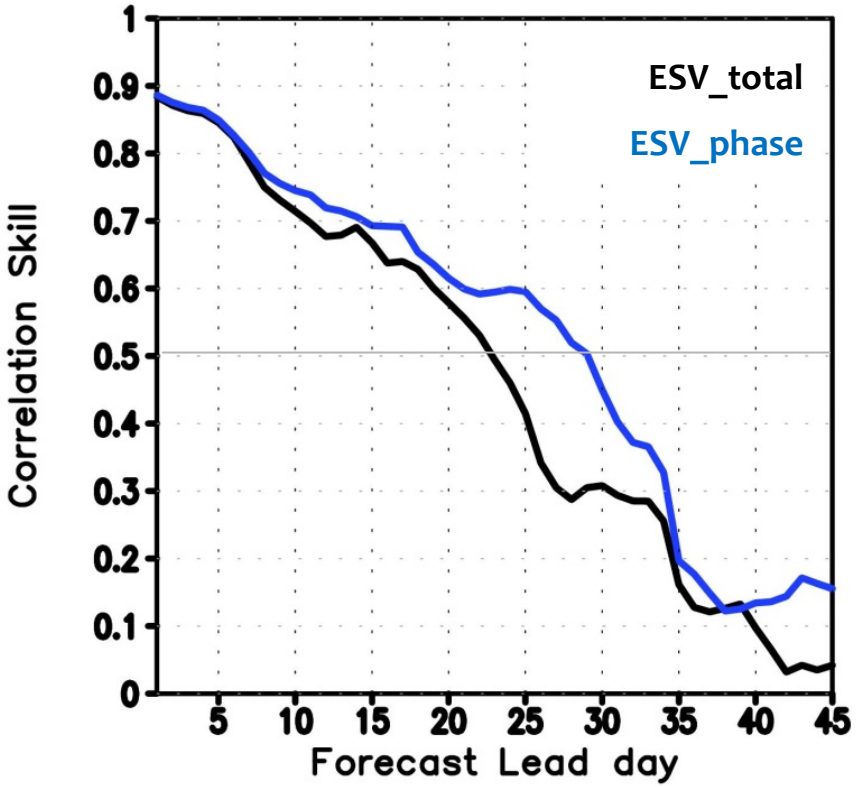
ESV
(considering phase)



ESV

■ ESV phase dependency

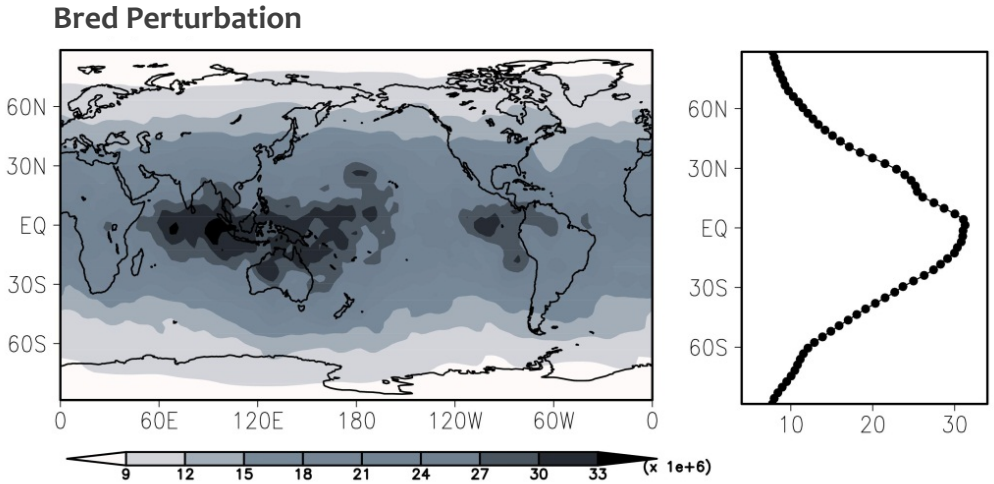
* Note : Every 1st day of month run for 20 year



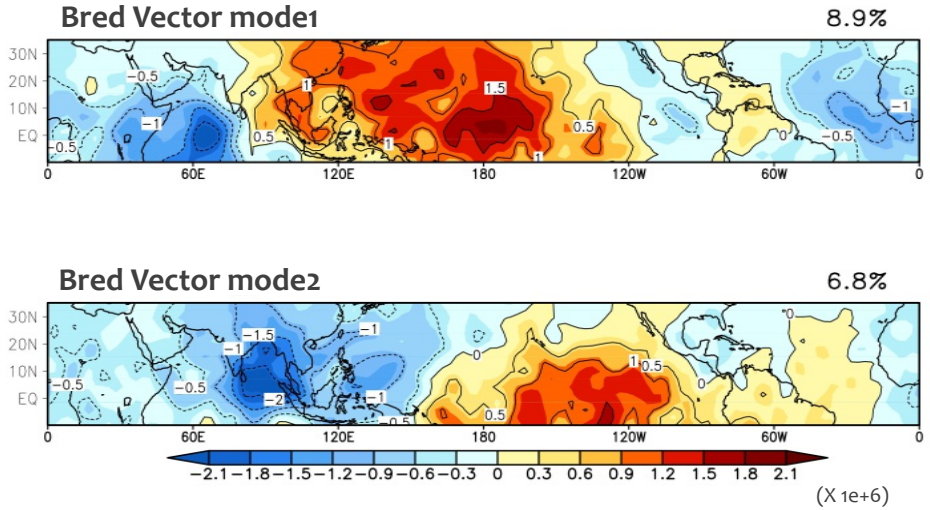
Characteristics of Bred perturbation (Winter)

■ STD of VP200 perturbation

- Breeding rescaling factor : 10%
- Breeding interval : 5 day



■ EOF modes of VP200 perturbation



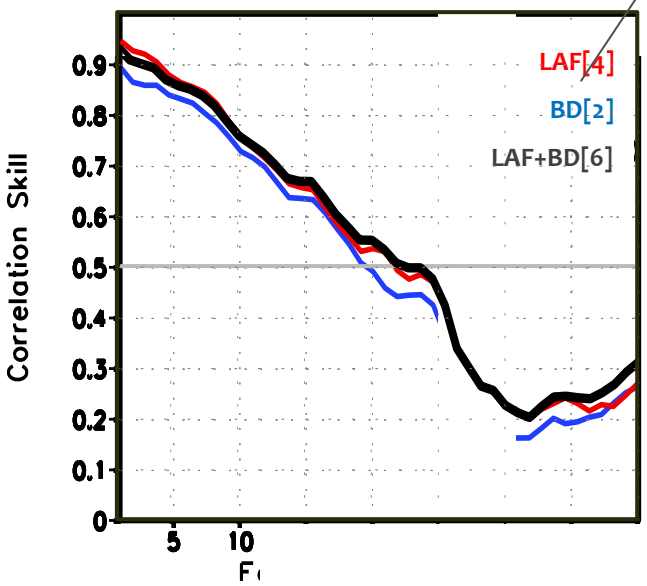
Intra-Seasonal Prediction – Results

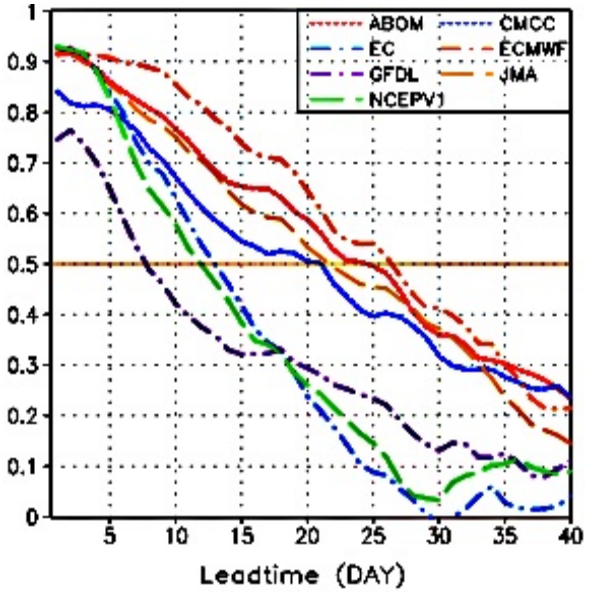
* The parenthesis refers ensemble members

Winter

LAF (4) + BD5day (2)

SNU CGCM





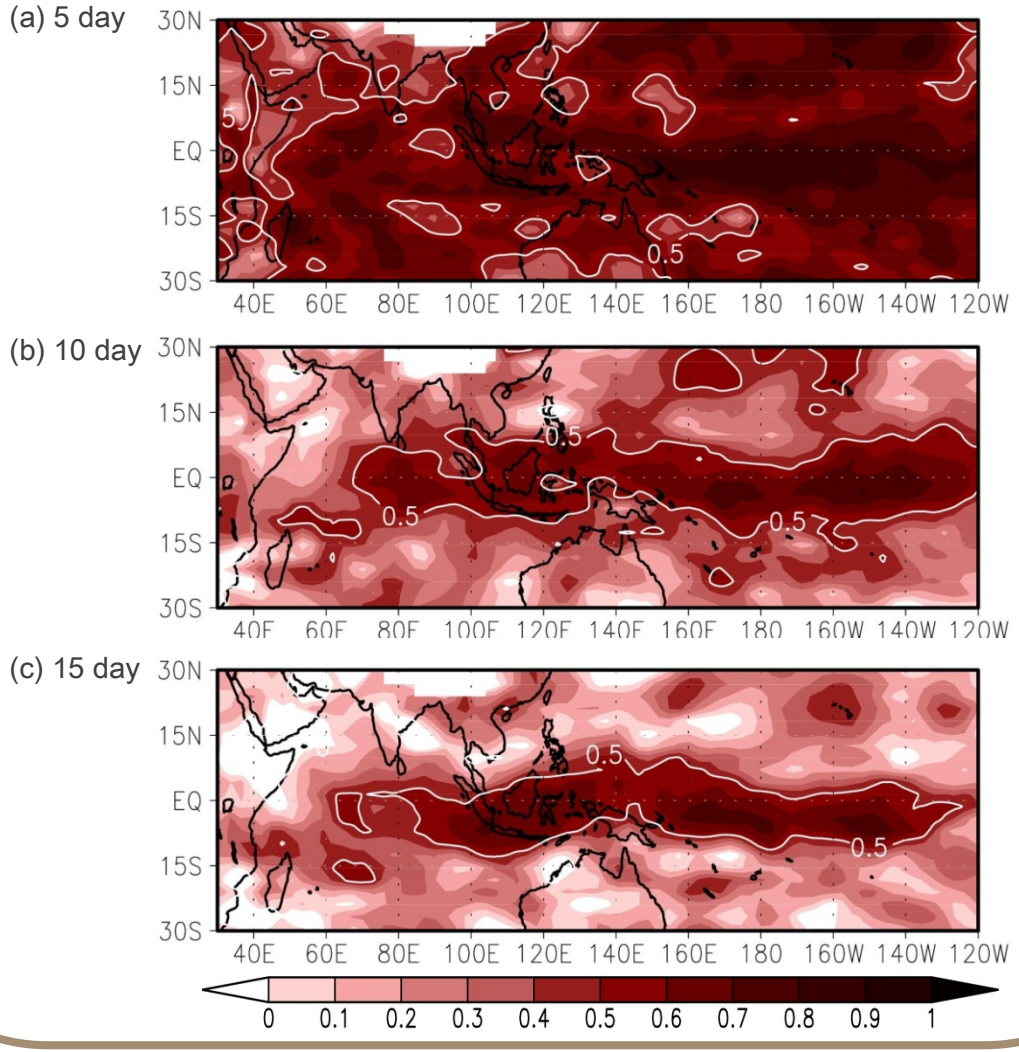
Intra-Seasonal Prediction - Results

* The parenthesis refers ensemble members

■ Correlation Skill of U850 for lead times

Winter

LAF (4) + BD5day (2)



Summary

SNU SI Prediction System

- Improved CGCM
- Multi-initialization methods

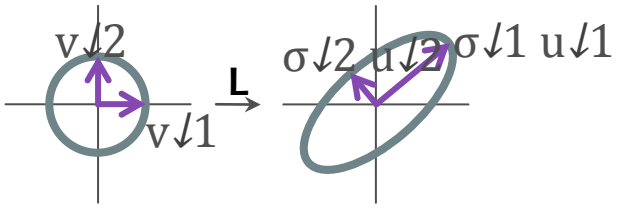
↓

- Ensemble ENSO prediction
- Ensemble MJO prediction

“ Good Predictions ”


Thank You

ESV (Empirical Singular Vector)



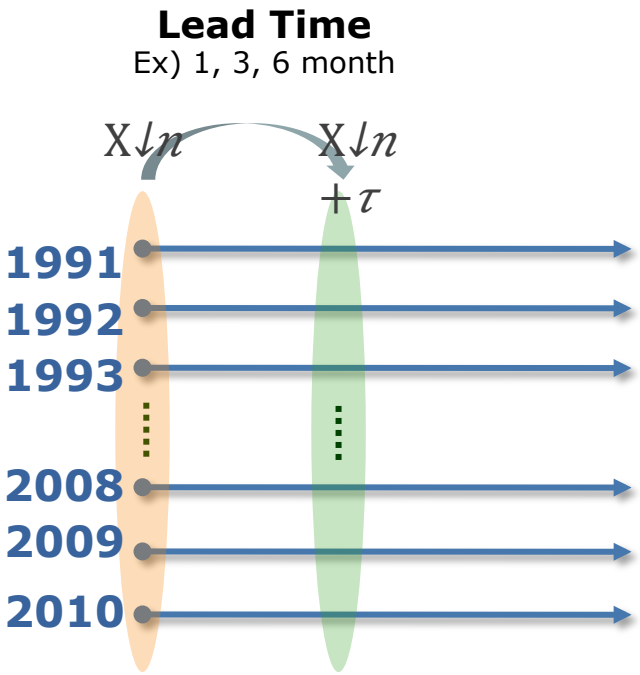
$L = U\Sigma V^T$

$Y_{\downarrow n} = X_{\downarrow n+\tau} \cong L(X_{\downarrow n}) = Y$

$L = YX^{\uparrow t}(XX^{\uparrow t})^{\uparrow -1}$

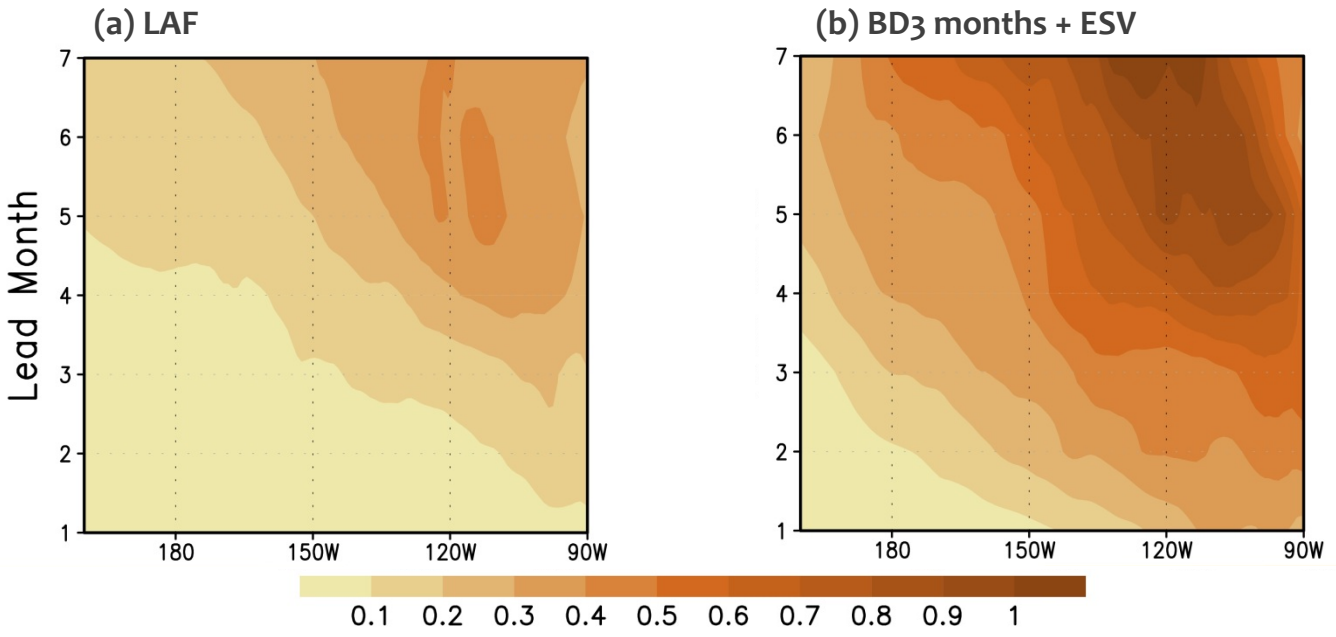
$U^{\uparrow t} Y = \Sigma V^{\uparrow t} X$

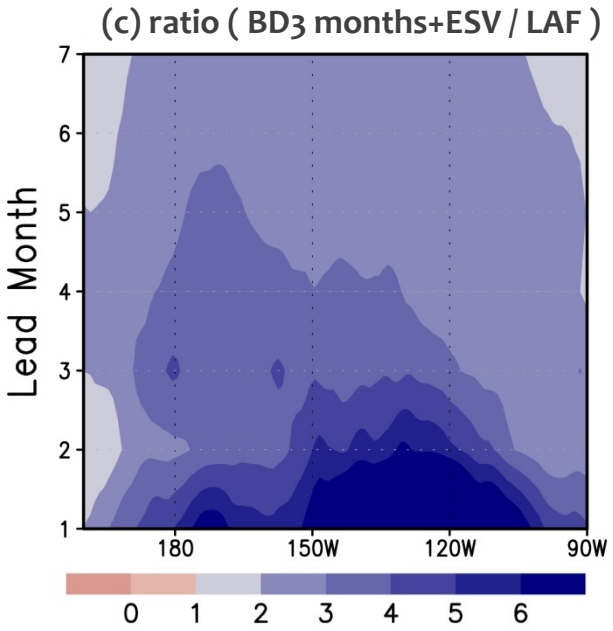
$u_{\downarrow i}{}^{\downarrow\uparrow t} Y = \sigma_{\downarrow i}\, v_{\downarrow i}{}^{\downarrow\uparrow i}$



Empirical singular Vectors achieve maximum perturbation growth rate without a linear model.

Ensemble Spread of Seasonal Prediction



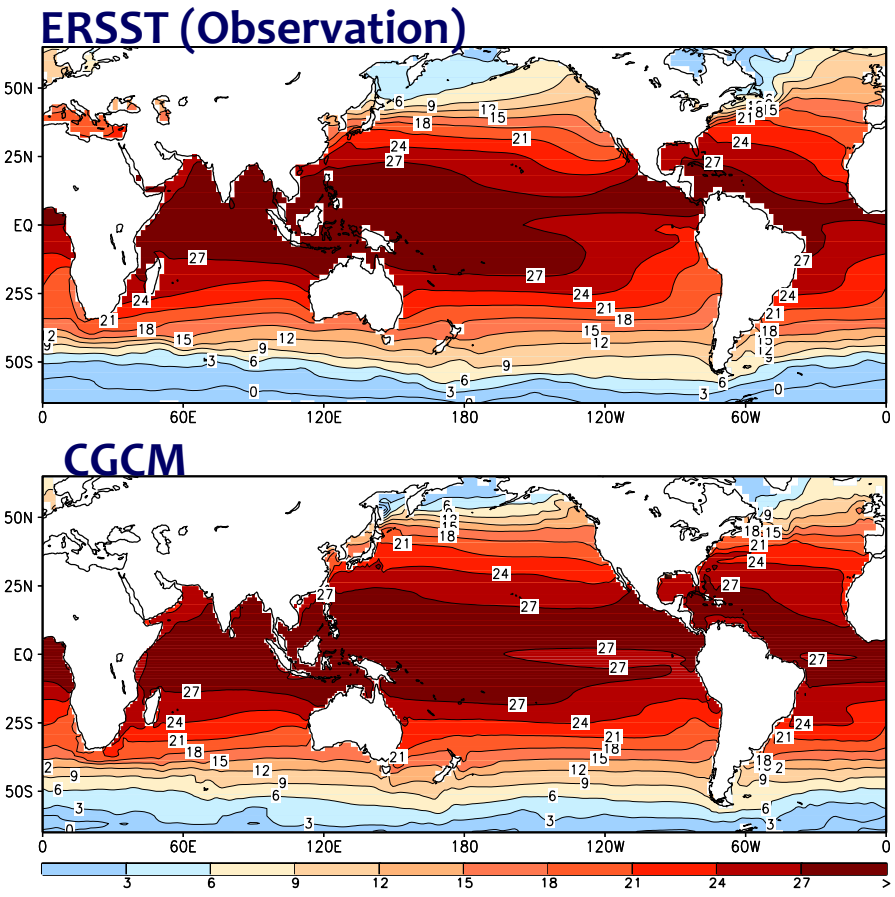


Ensemble Spread

The variance of SST perturbations (5˚S-5˚N averaged)

Improvement of SNU CGCM

Annual mean SST



Annual mean Precipitation