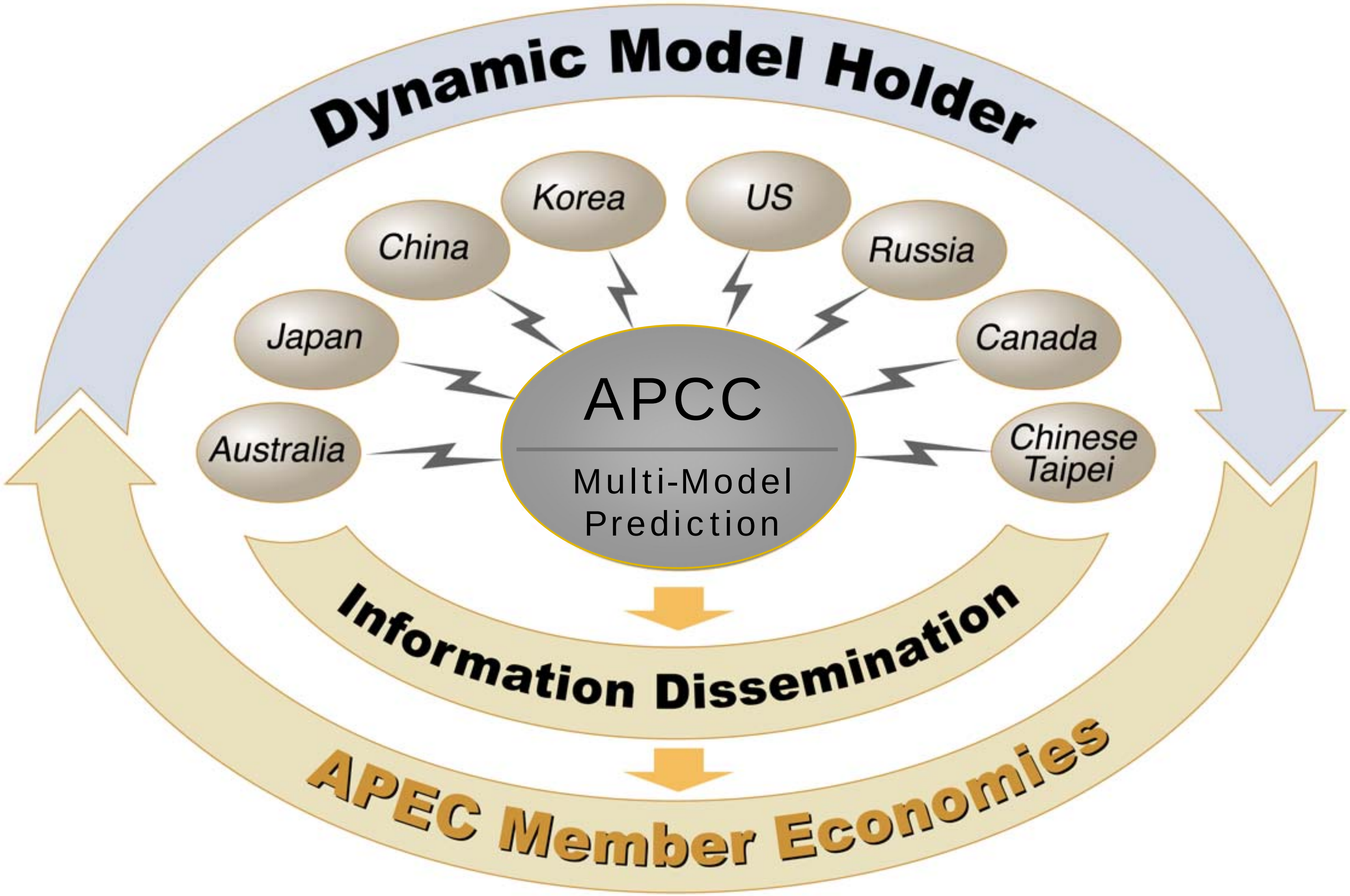
APCC/CliPAS multi-model ensemble seasonal prediction

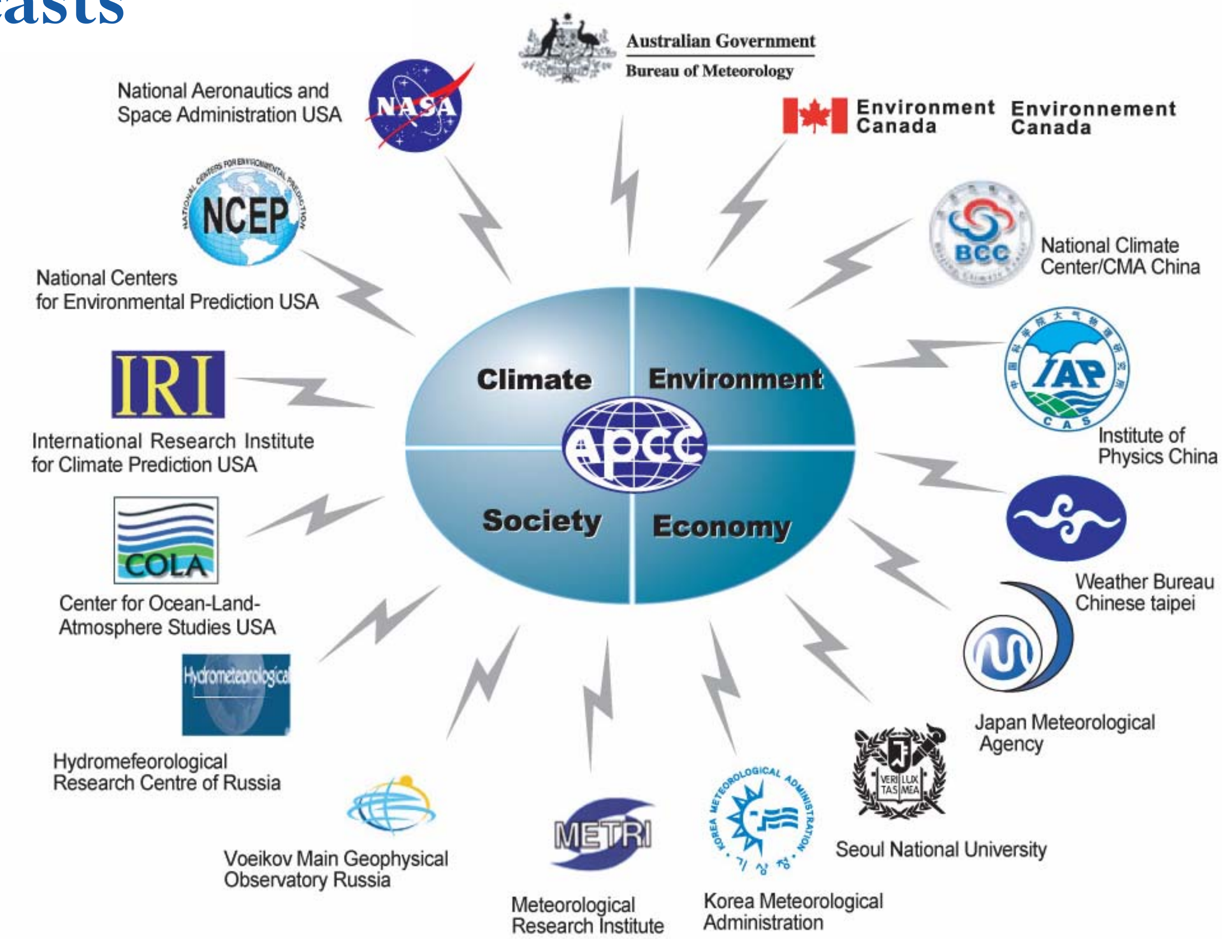
In-Sik Kang
Seoul National University

APCC Multi-Model Ensemble System



APEC Climate Center - APCC

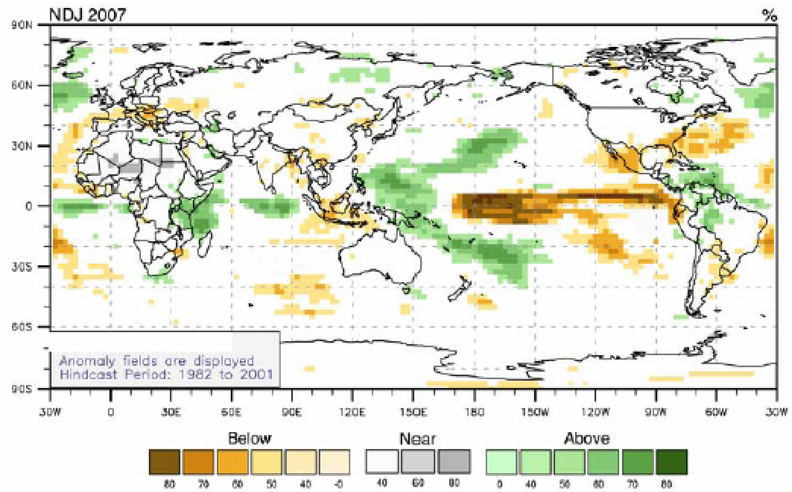
Operational centers or institutions sending their seasonal forecasts



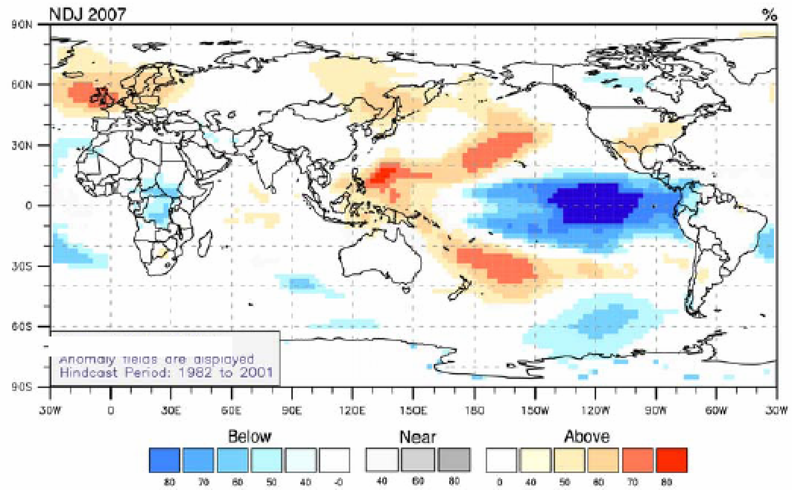
APCC Monthly MME 3-Month Prediction outlook for NDJ

Probabilistic

Multi-Model Probabilistic MME for Precipitation

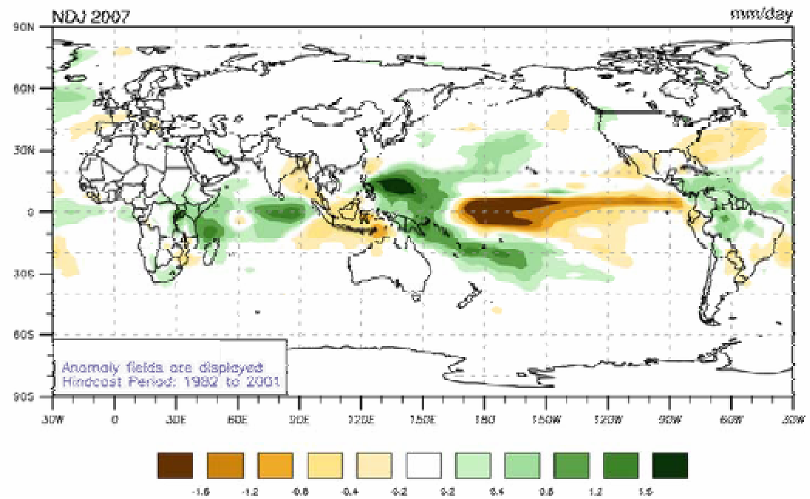


Multi-Model Probabilistic MME for Air temperature at 850mb

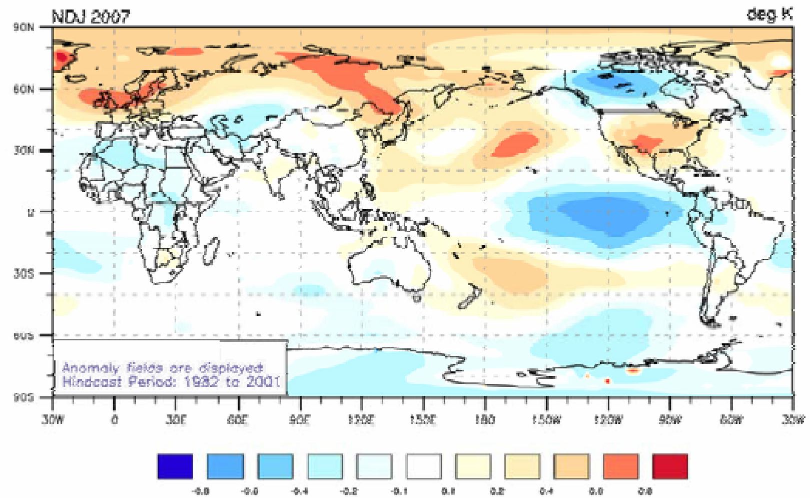


Deterministic

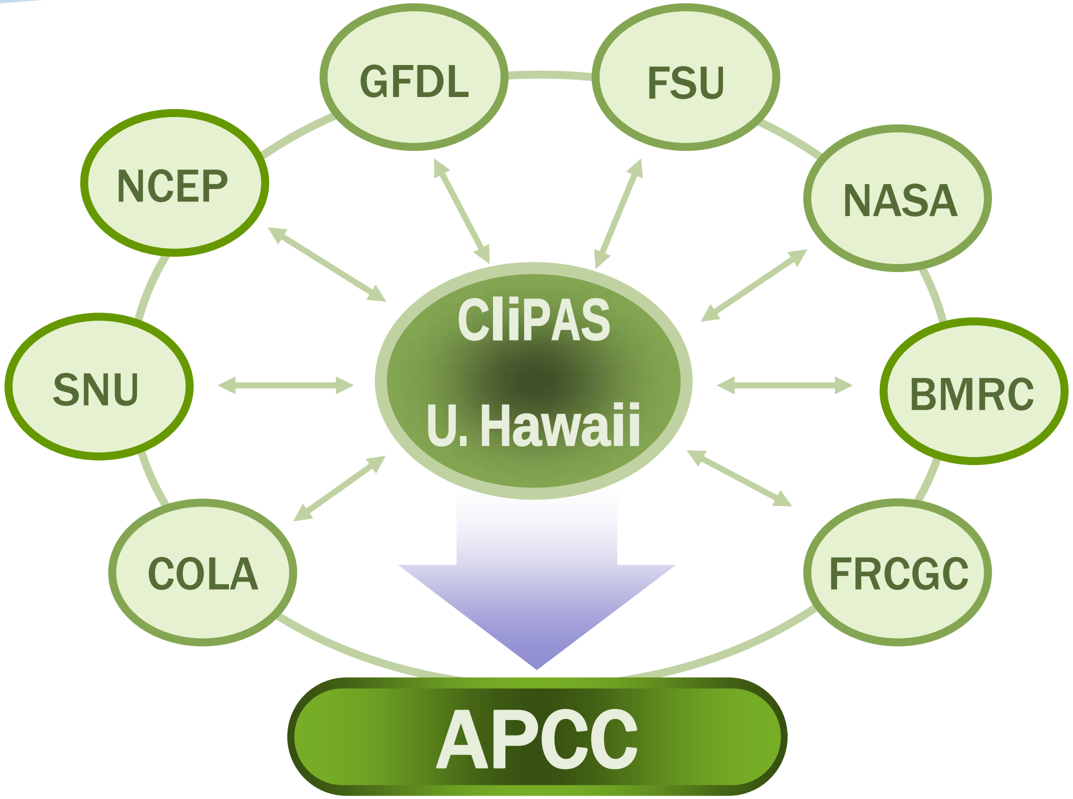
Multi-Model Deterministic MME for Precipitation



Multi-Model Deterministic MME for Air temperature at 850mb



CliPAS Climate Prediction and Its Application to Society



➔ CliPAS supports APCC as a research component

1. Multi-model ensemble prediction
2. Dynamic subseasonal (intraseasonal) prediction
3. High-resolution modeling

1. Current Skill of MME system

- Tier-1 vs. Tier-2
- CliPAS vs. DEMETER

The Current Status of HFP Production

Two-Tier systems

Statistical-Dynamical SST prediction (SNU) → AGCM

FSU *79-04, 2 seasons*	**GFDL** *79-04, 2 seasons*
SNU/KMA *79-02, 4 seasons*	**CAM2 (UH)** *79-03, 4 seasons*
ECHAM(UH) *79-03, 2 seasons*	**IAP** *79-04, 4 seasons*
***NCEP** *81-04, 4 seasons*	

One-Tier systems

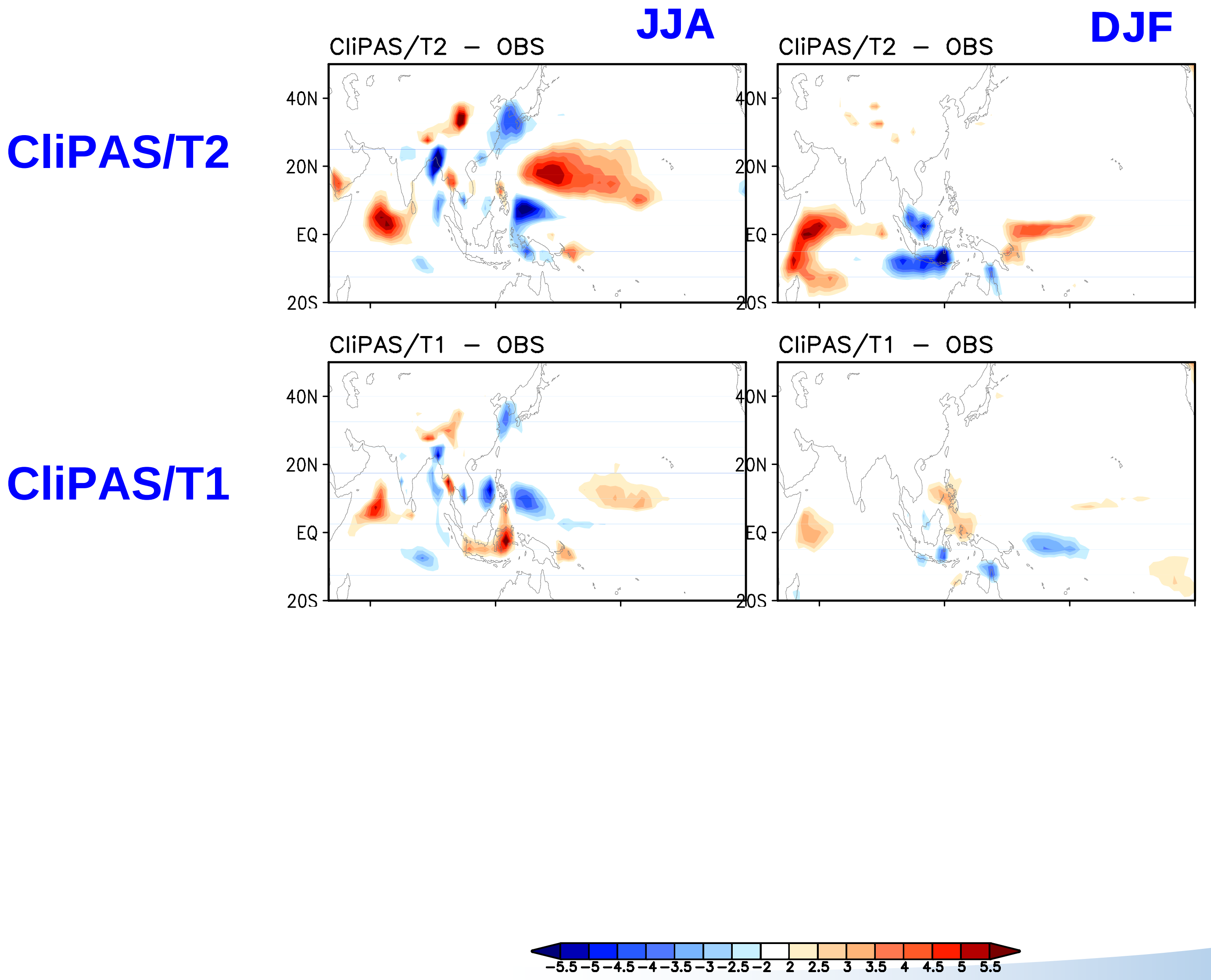
CGCM

NASA *80-04, 2 seasons*	**CFS (NCEP)** *81-04, 4 seasons*
SNU *80-02, 4 seasons*	**SINTEX-F** *82-04, 4 seasons*
UH Hybrid *82-03, 2 seasons*	**GFDL** *79-05, 4 seasons*
POAMA(BMRC) *80-02, 4 seasons*	

*** NCEP two-tier prediction was forced by CFS SST prediction**

One-Tier vs Two-Tier / Climatology

Climatological Bias of Precipitation



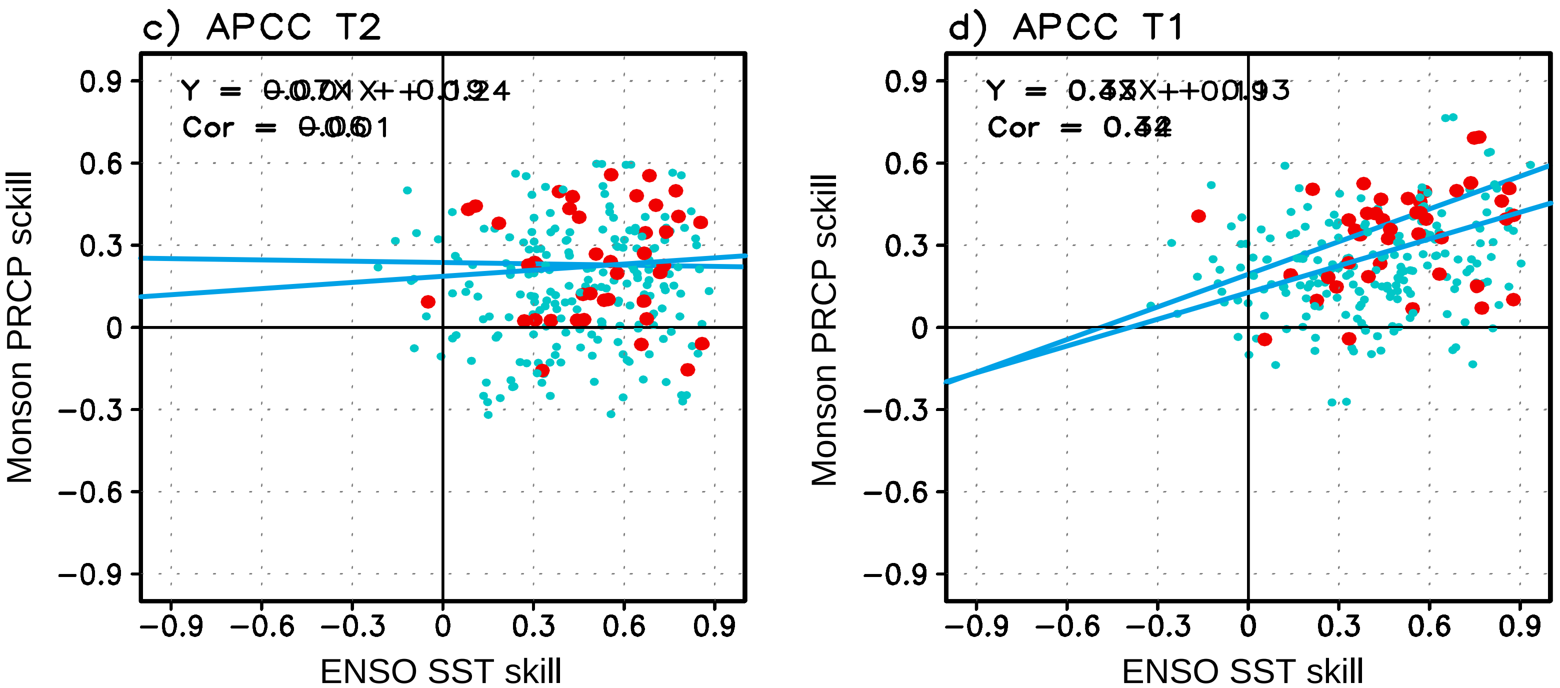
One-Tier vs Two-Tier MME Prediction

Inherent Problem of two-tier system in monsoon prediction : Kitoh and Arakawa 1999, Wang et al. 2004, Wang et al. 2005, Wu and Kirtman 2005, Kumar et al. 2005, Nanjundiah et al. 2005

ENSO SST skill vs. Monsoon Precipitation skill

Local SST skill vs. Monsoon Precipitation skill

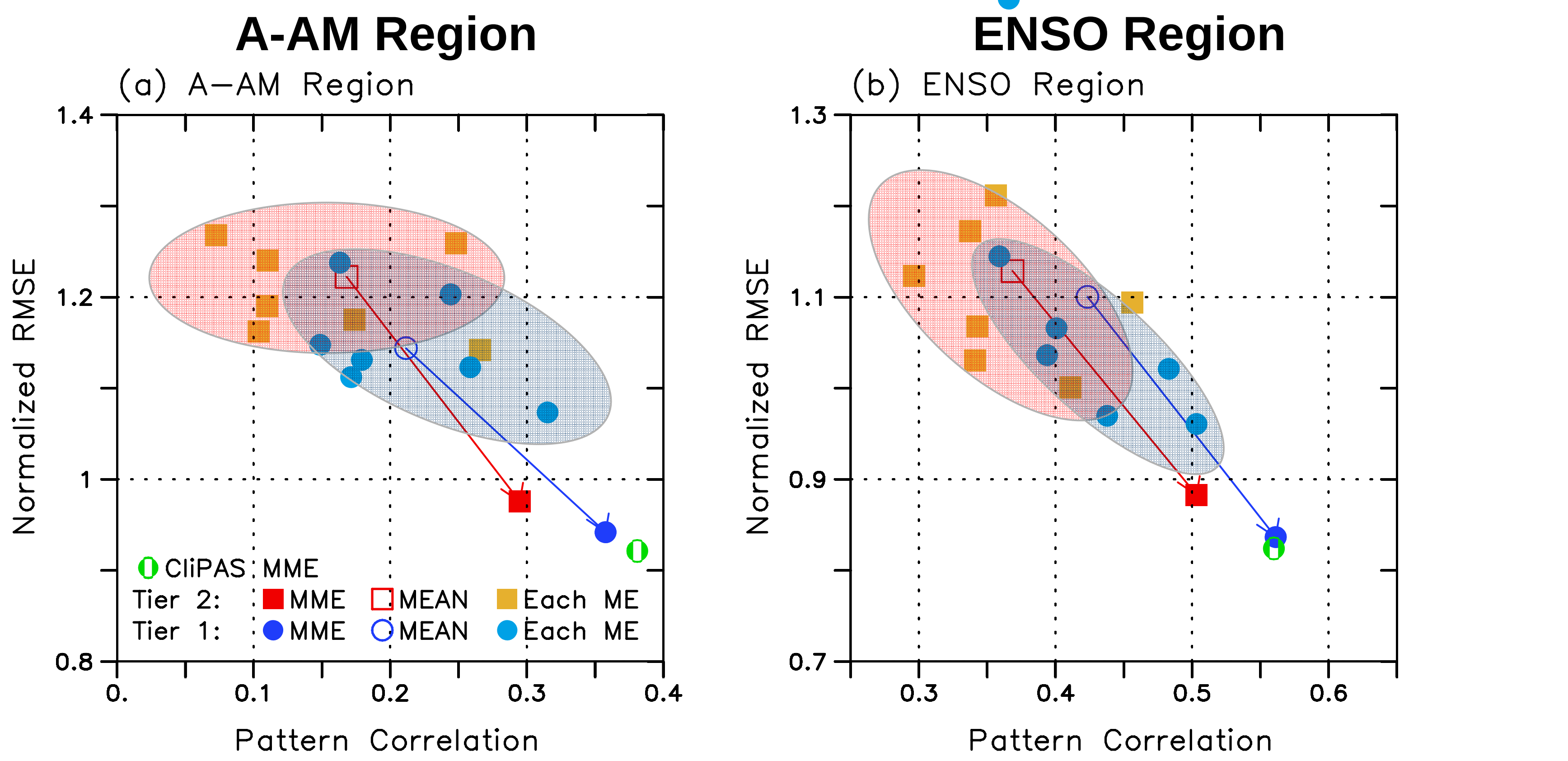
Two-Tier MME | One-Tier MME



Improved ENSO teleconnection

Increased feedback of local surface SST

One-Tier vs Two-Tier MME Prediction

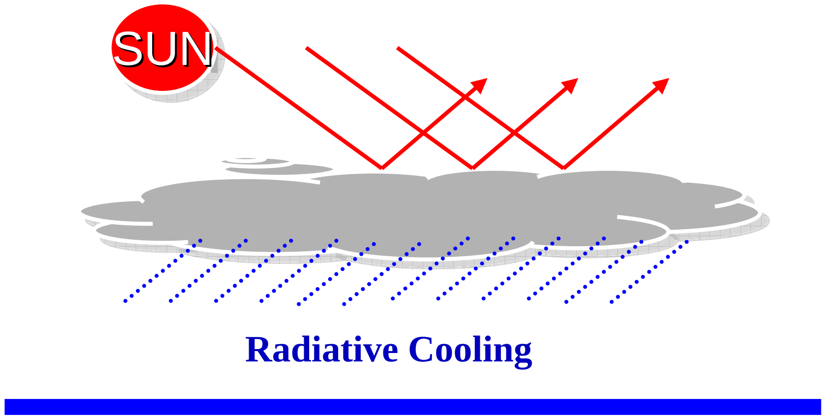


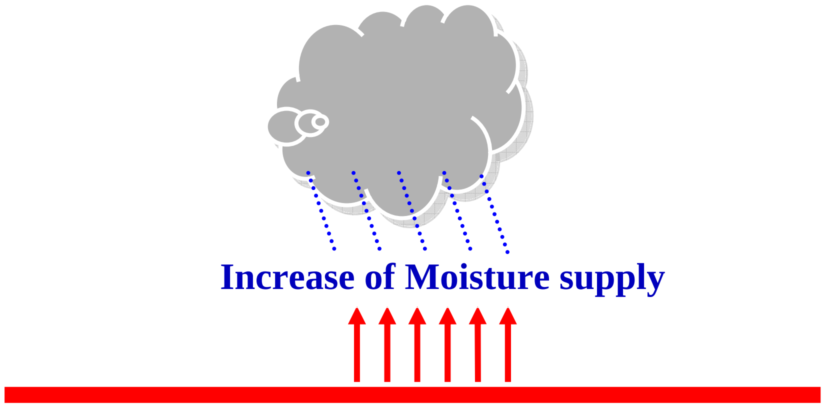
It is documented that **the prediction skill of tier-1 systems is better than the tier-2 seasonal prediction system** in boreal summer over both A-AM and ENSO regions in terms of pattern correlation skill and normalized RMS error.

One-Tier vs Two-Tier MME Prediction

Air-sea interaction in the tropical Pacific

Radiation flux > Ocean Dynamics	Radiation flux < Ocean Dynamics





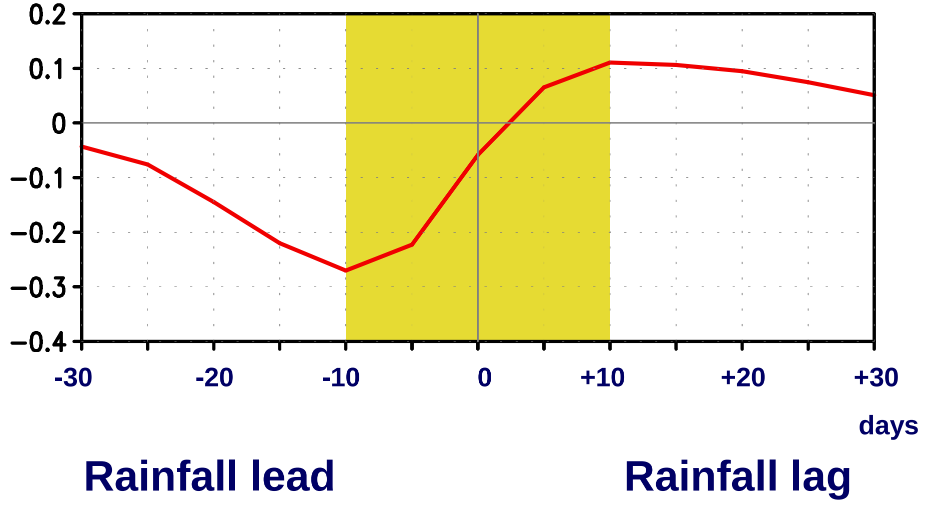
Where radiative flux control the SST

1. Radiative flux would lead the SST anomalies
2. Temporal correlation between PRCP & SST can be a negative sign

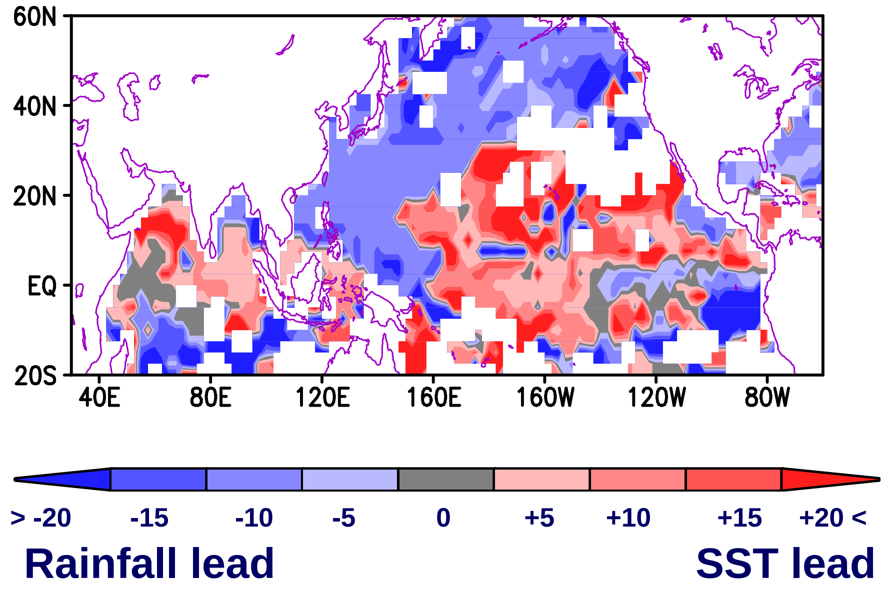
Air-Sea Interaction

Lag correlation between SST and rainfall (82-99, JJA)

Western North Pacific (5-30N, 110-150E)



Lead-lag pentad number

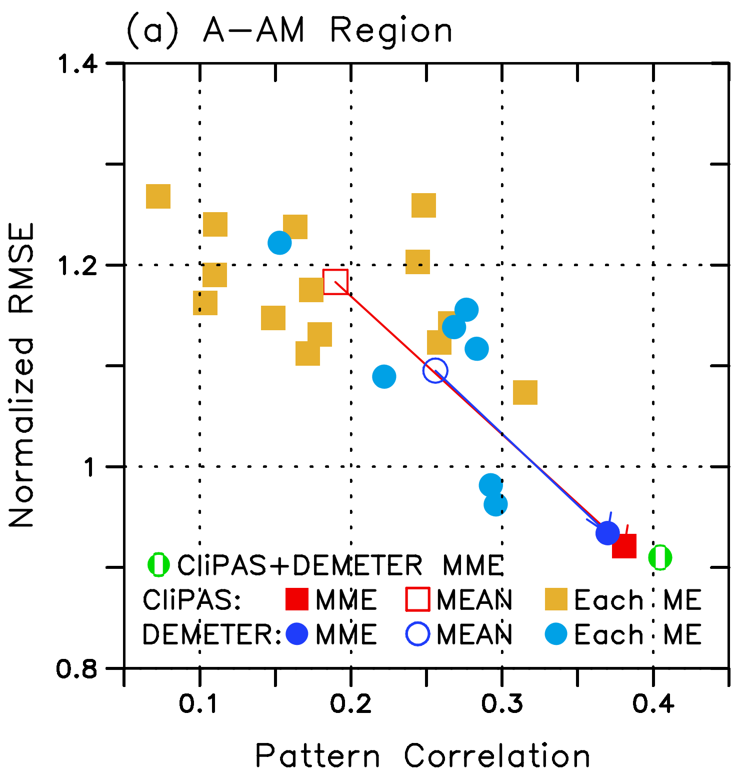


Shaded - more than 95% significance level

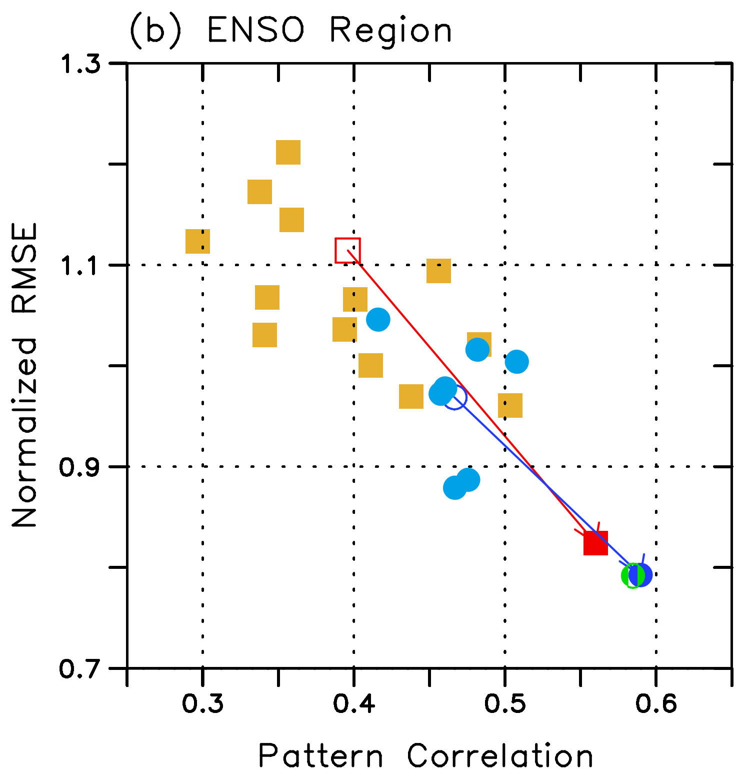
→ Atmosphere forces the ocean where the correlation coefficients between rainfall and SST show negative.

CliPAS vs DEMETER MME Prediction

A-AM Region



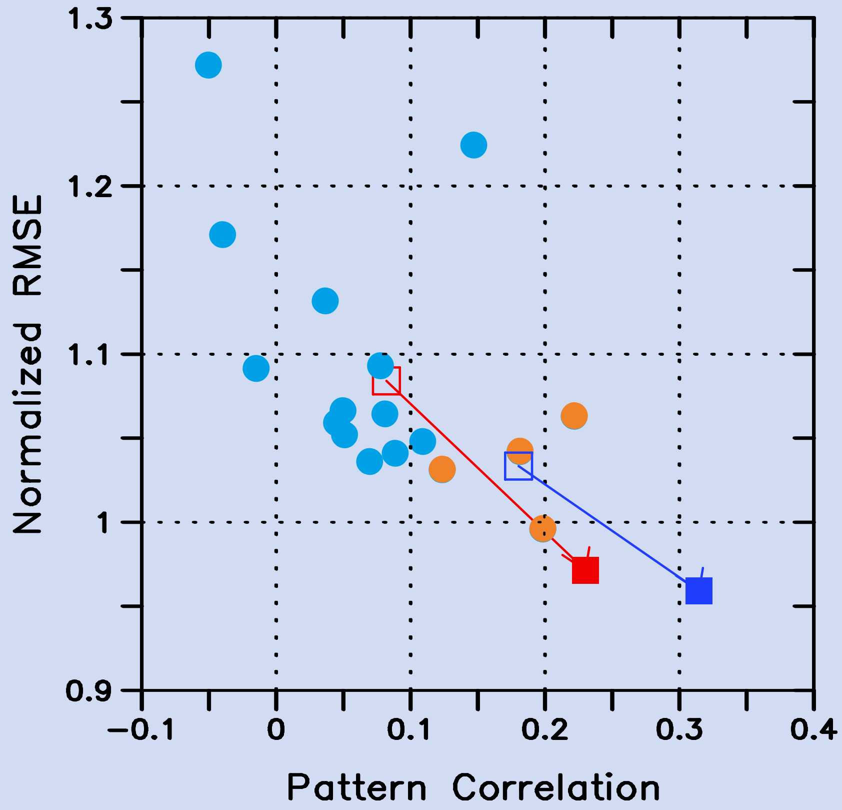
ENSO Region



Multi-Model Ensemble (MME)

Optimal Selection of a Subgroup of Models

Example: East Asian Domain [105-145E, 20-45N]
The best MME skill is obtained using 4 models.



MME Techniques

MME1

$$P = \frac{1}{M}\sum_i F_i$$

- Simple composite
- Equal weighting

MME2

$$P = \sum_i a_i F_i$$

- Super ensemble
- Weighted ensemble using SVD

MME3

$$P = \frac{1}{M}\sum_i \hat{F}_i$$

- Corrected Ensemble
- Simple Composite after Applying SPPM

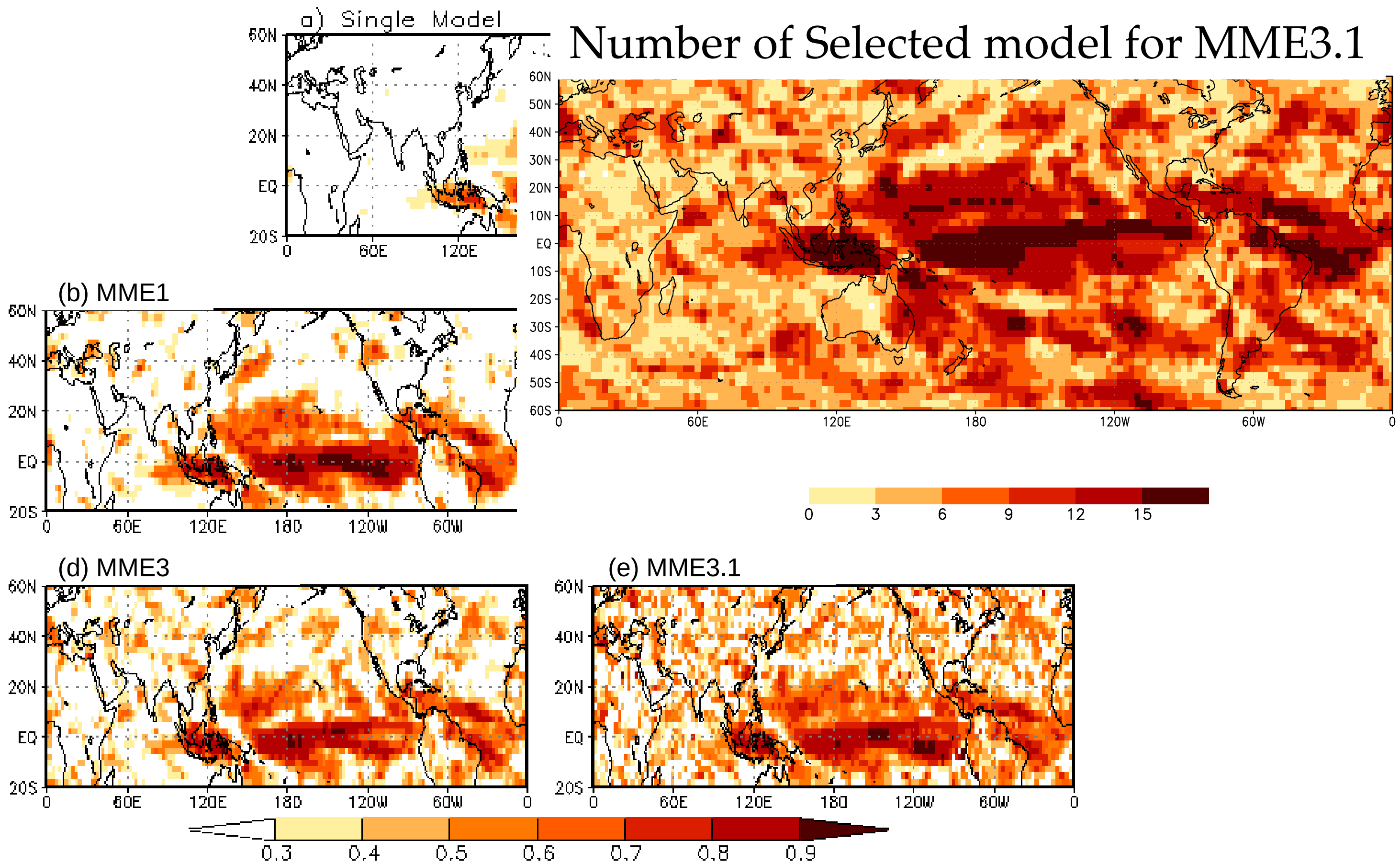
MME3.1

$$P = \frac{1}{M}\sum_i \hat{F}_i$$

- Corrected Ensemble
- Simple composite after Applying SPPM with criterion

Optimal MME Technique

Correlation Skill of MMEs using 15 models



2. High resolution modeling

Tropical cyclone and MJO

High resolution modeling - Tropical Cyclone

CLIVAR project

Leaded by Siegfried D. Schubert (NASA/GSFC) & In-Sik Kang (SNU)
Endorsed by CLIVAR/AA Monsoon Panel

Tropical cyclone activity simulation project		
Participant institutes	**Subject**	**Requirement**
NASA/GSFC NCEP FRCGC BMRC ECMWF	2004/2005 on tropical cyclone	ee resolution or better

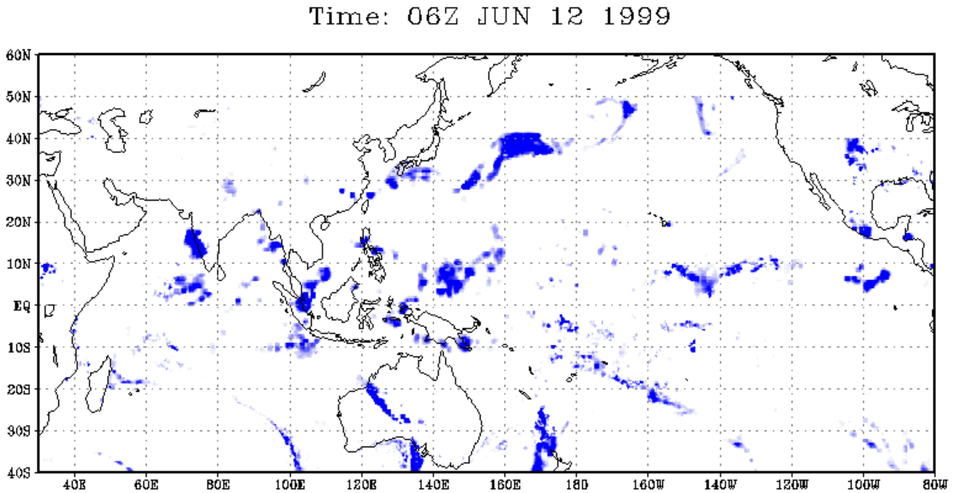
20km resolution model simulation (6 ensembles)

SST	Period	Some Interesting Events
1999	May 15- Nov 30	La Nina conditions
1997	May15 – Nov 30	El Nino conditions

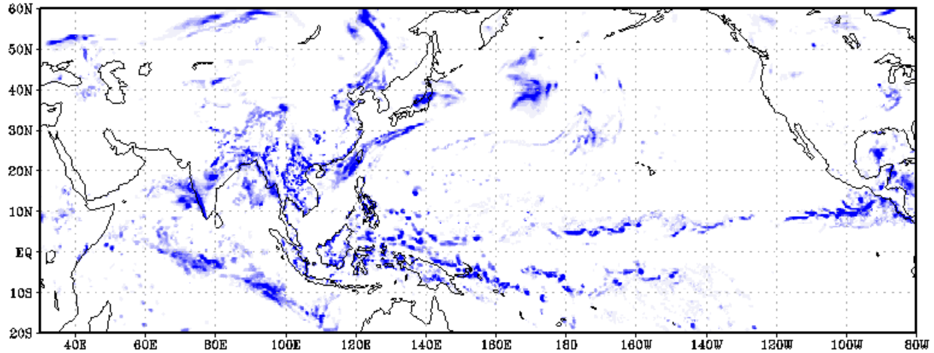
High resolution modeling

June 1999 – 20km resolution

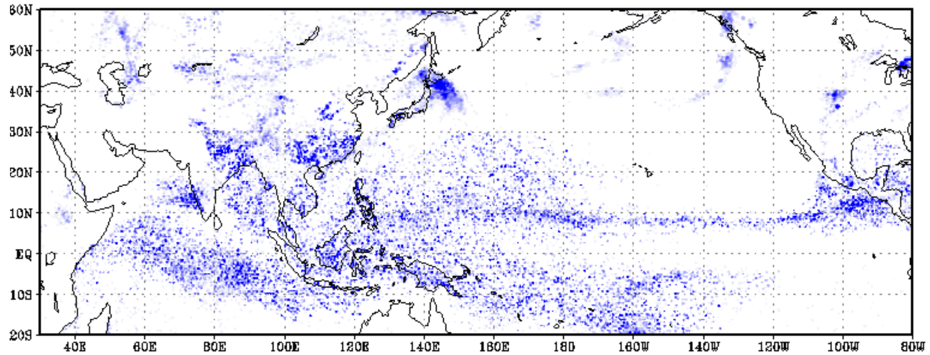
Satellite observation



High resolution Finite volume GCM

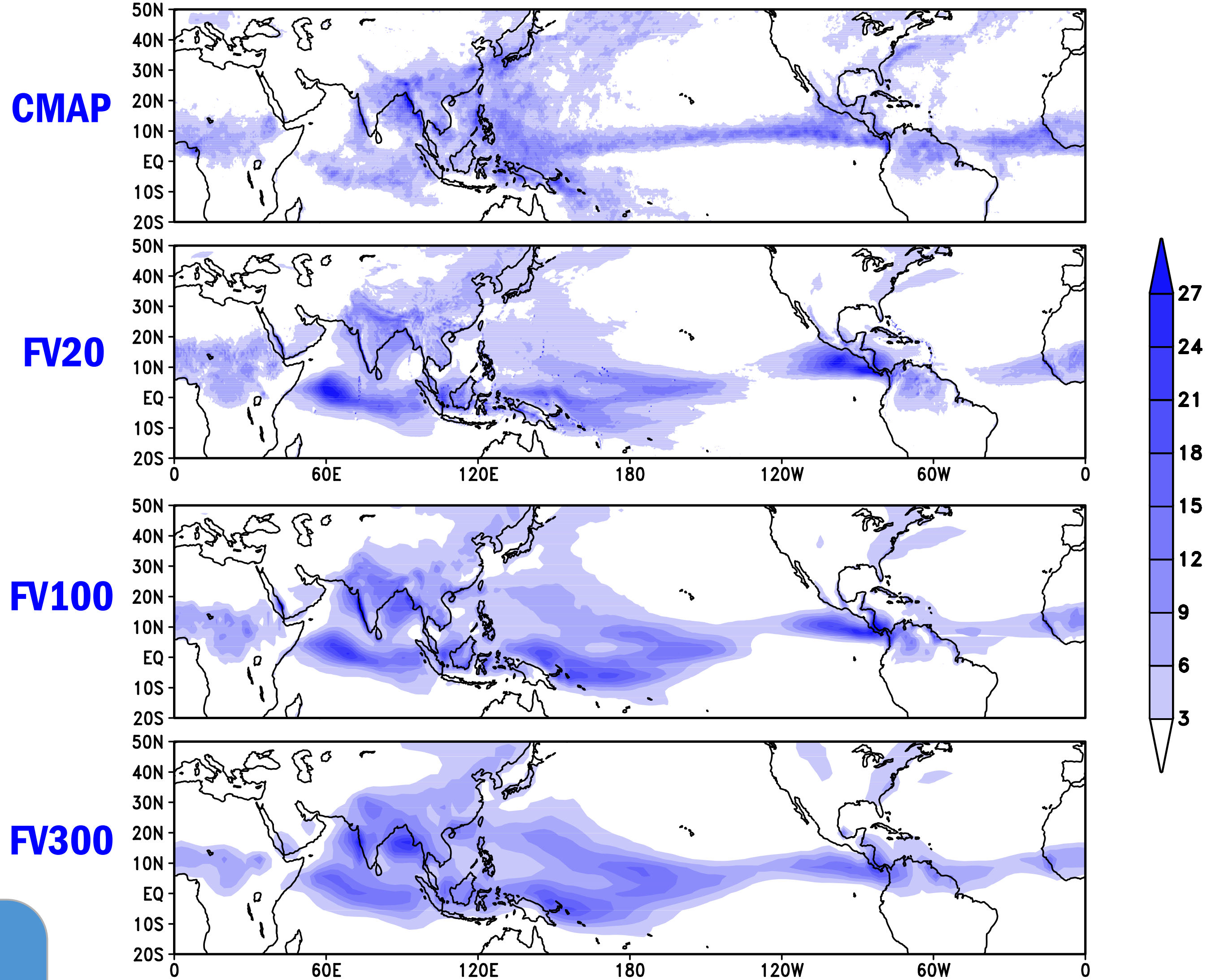


High resolution spectral GCM



Comparison between observation, finite volume and spectral AGCM

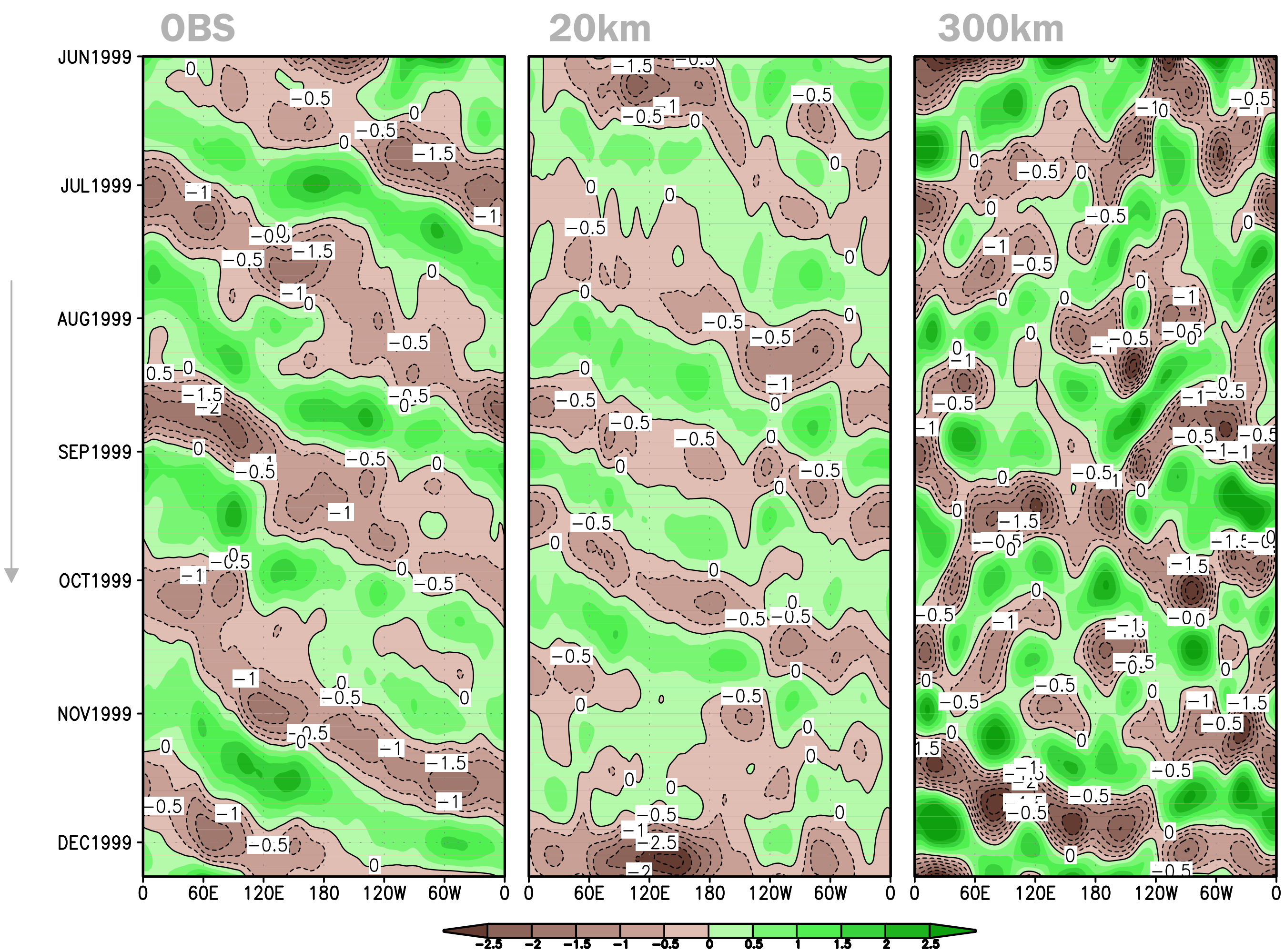
High resolution modeling



Climatology
Precipitation

MJO Propagation

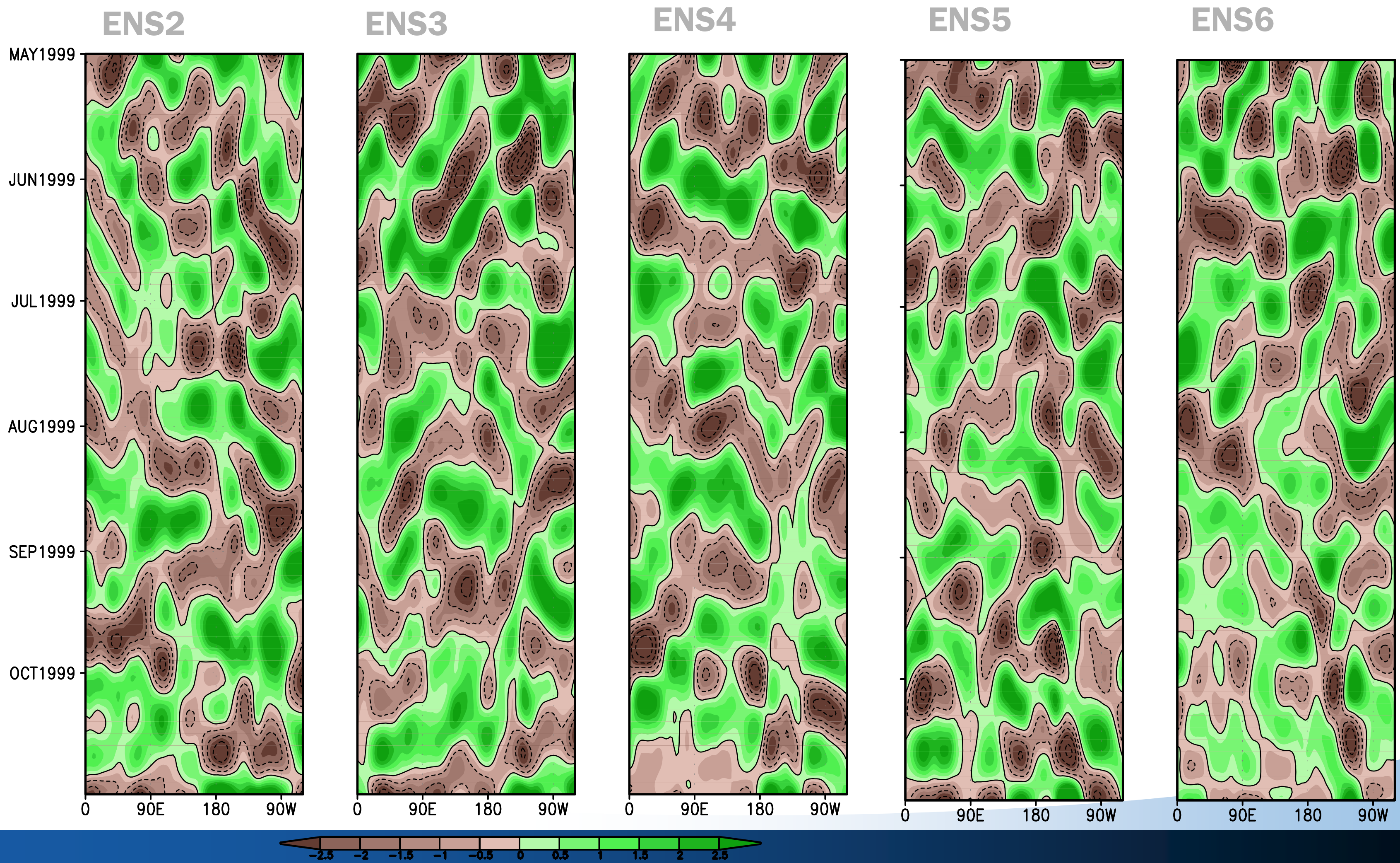
- 200hPa velocity potential (1999) **The FIRST Ensemble case**



MJO Propagation

- 200hPa velocity potential (1999)

ENSEMBLES in 20km High resolution !



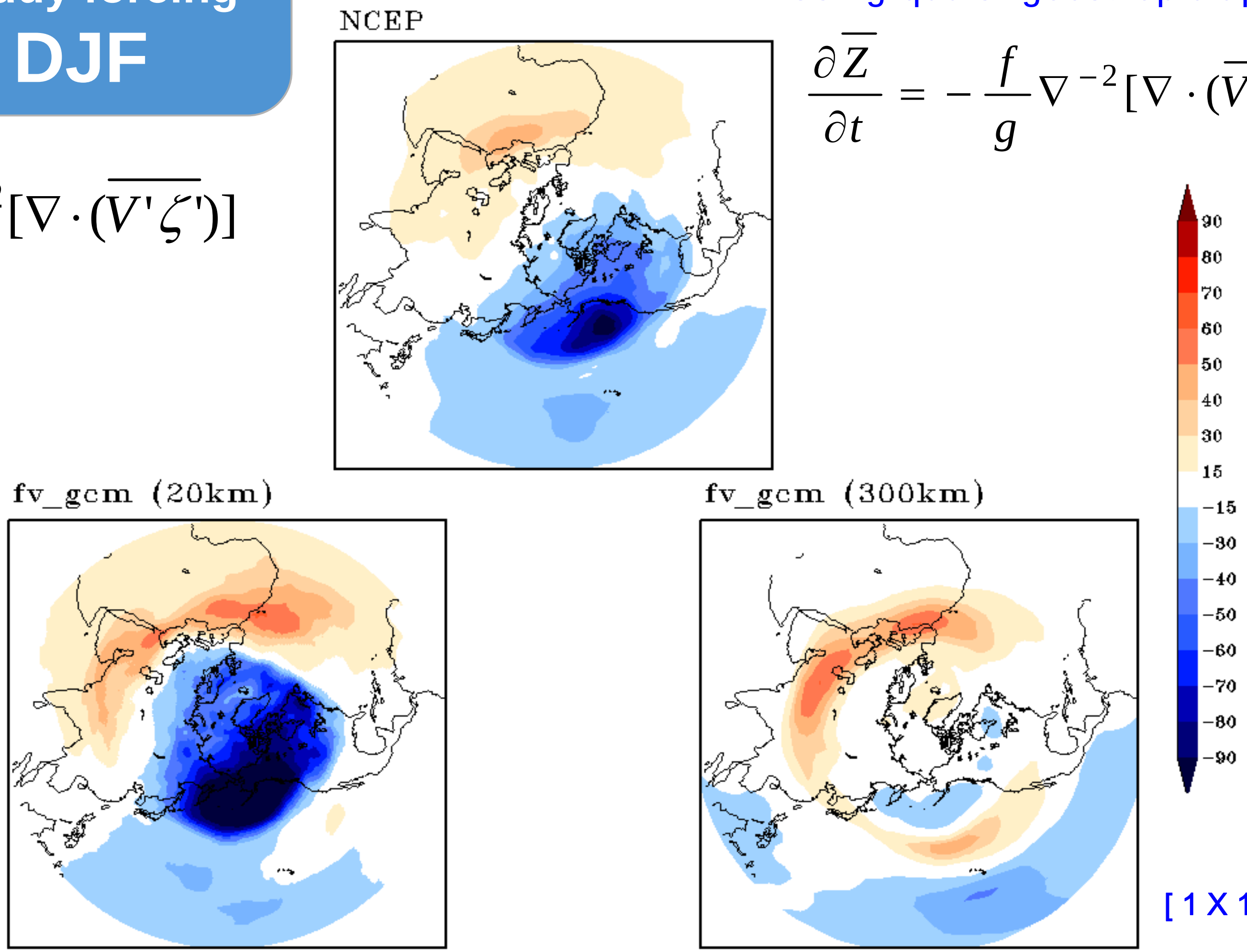
High resolution modeling

Transient eddy forcing
1997 DJF

$$\frac{\partial \overline{\psi}}{\partial t} \propto -\nabla^{-2}[\nabla \cdot (\overline{V'\zeta'})]$$

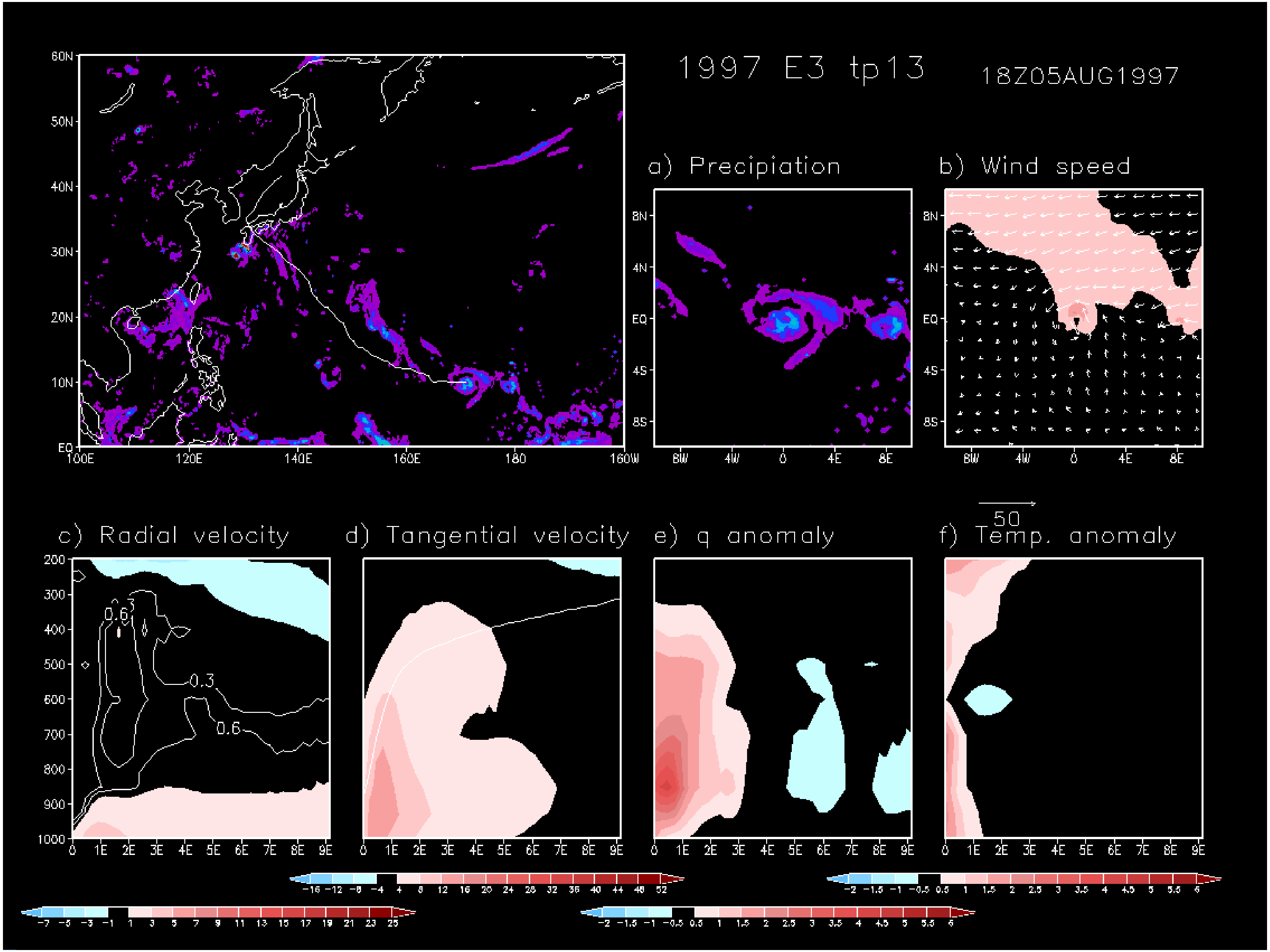
Using quaisi-geostropic approximation,

$$\frac{\partial \overline{Z}}{\partial t} = -\frac{f}{g}\nabla^{-2}[\nabla \cdot (\overline{V'\zeta'})]$$



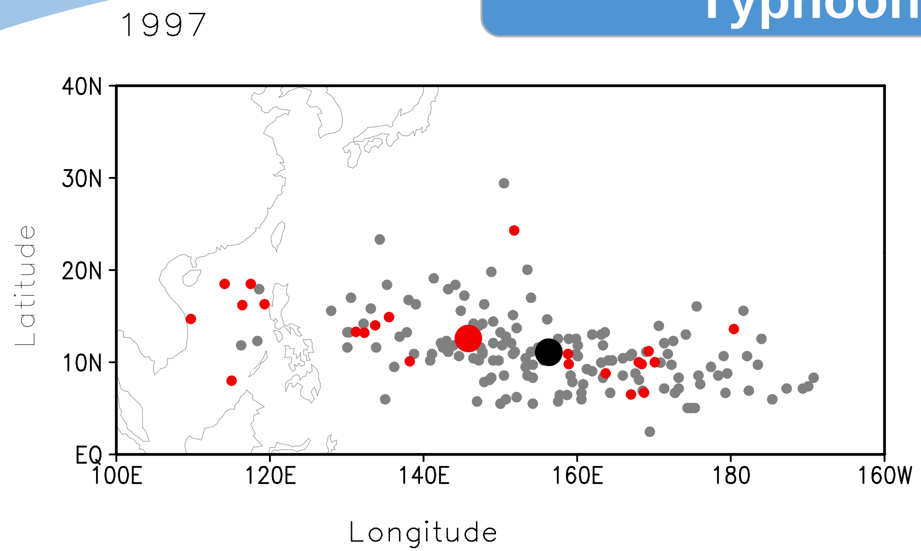
[1 X 10^{-5} m s^{-1}]

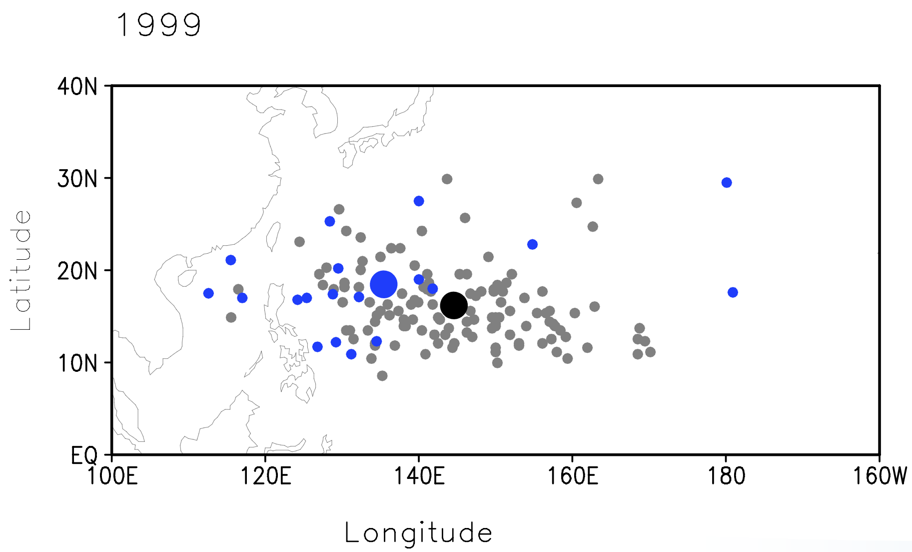
Using 2~8 day filtered 200hPa u-wind(u') / v-wind (v')


1997 E3 tp13
18Z05AUG1997
a) Precipiation
b) Wind speed
50
c) Radial velocity
d) Tangential velocity
e) q anomaly
f) Temp. anomaly

High resolution modeling - Tropical Cyclone

Typhoon Genesis





Mean Longitude		
Year	OBS	Model
1997	145.82	156.3
1999	135.41	144.55
Diff.(1997-1999)	10.41	11.75

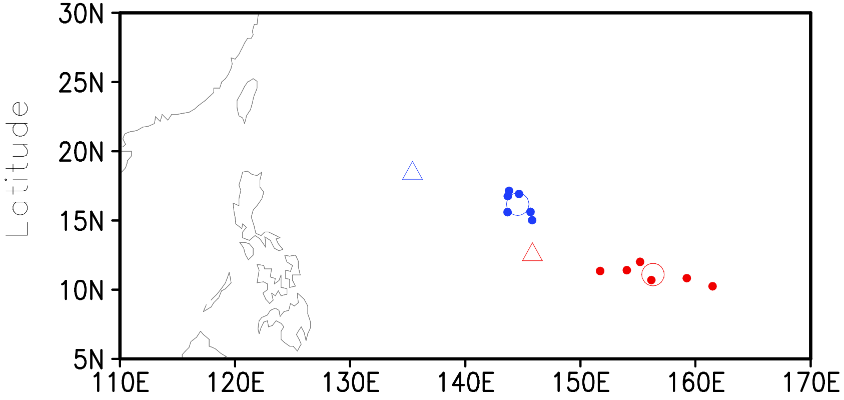
Mean Latitude		
Year	OBS	Model
1997	12.57	11.08
1999	18.46	16.17
Diff.(1997-1999)	-5.89	-5.09

All of typhoons simulated by 6 ensembles
1997 Observation (Tokyo-Typhoon center)
1999 Observation (Tokyo-Typhoon center)

Mean Location of Typhoon Genesis

Typhoon Genesis

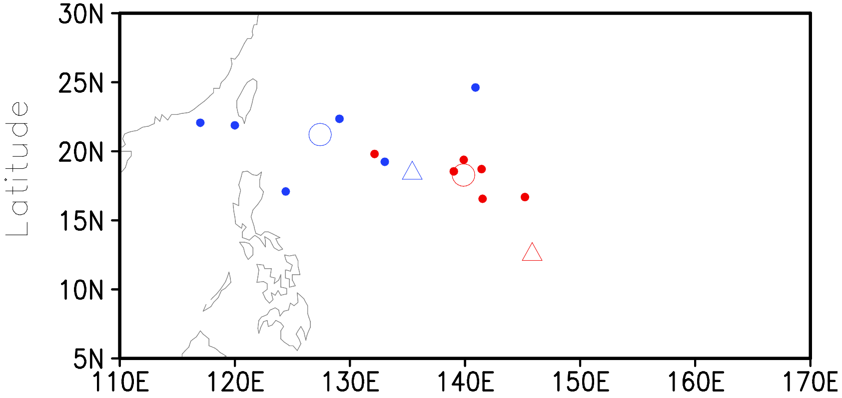
20km



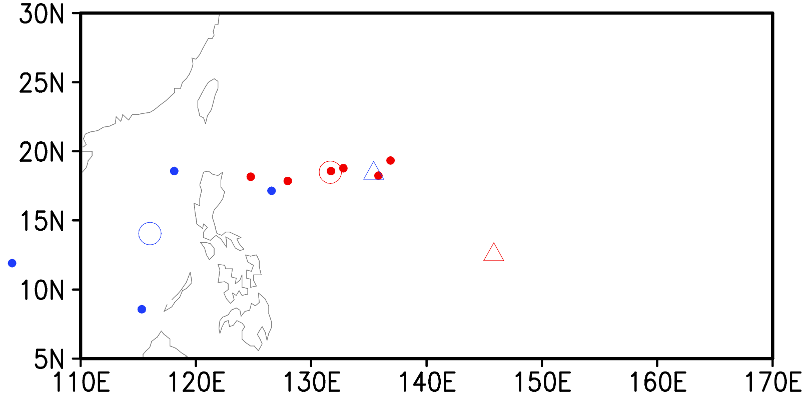
1997
- Each ensemble
- 6-Member Ensemble mean
- Observation (Tokyo-Typhoon center)

1999
- Each ensemble
- Ensemble mean
- Observation (Tokyo-Typhoon center)

100km

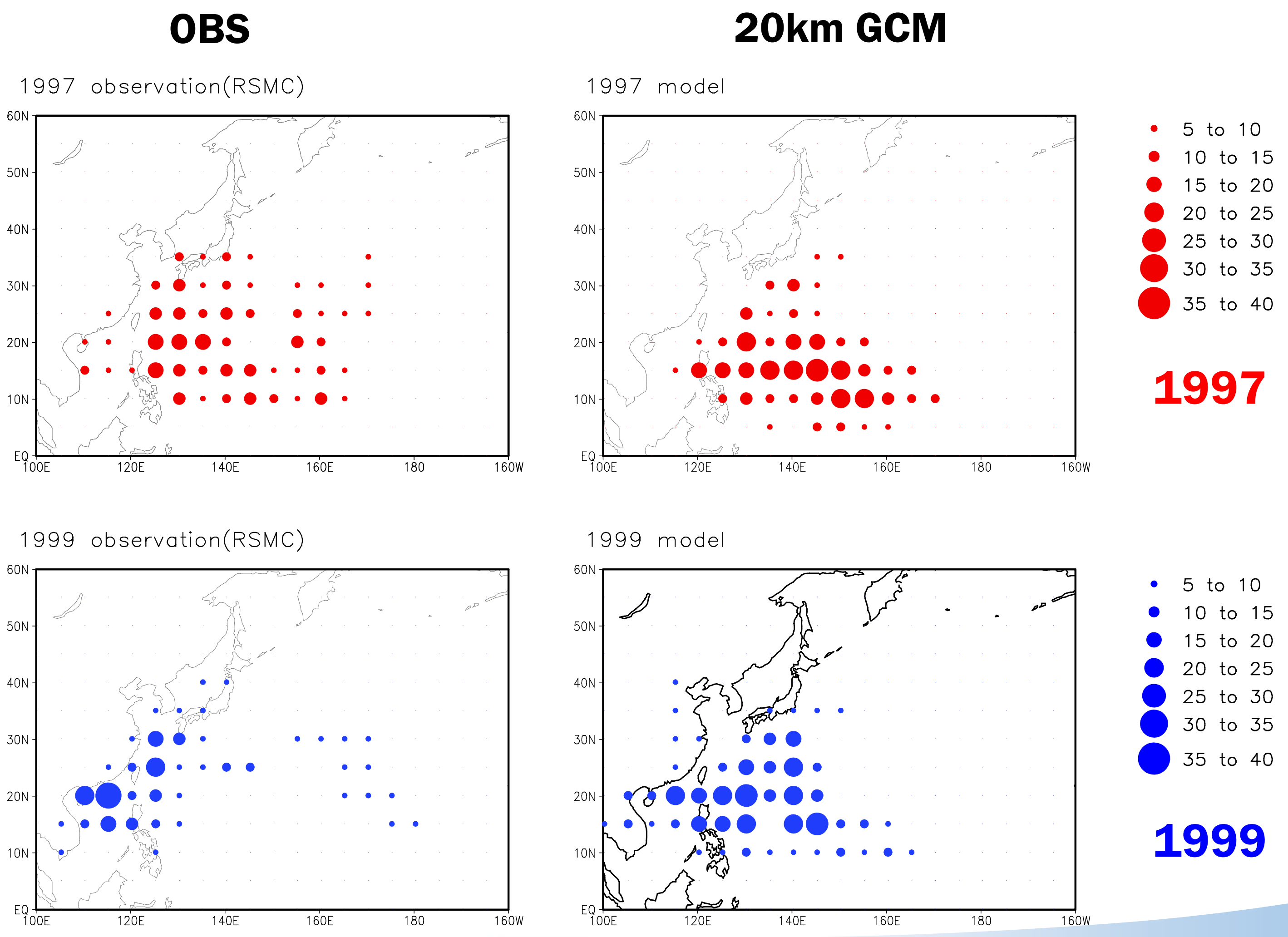


300km



High resolution modeling - Tropical Cyclone

Typhoon Passage Frequency

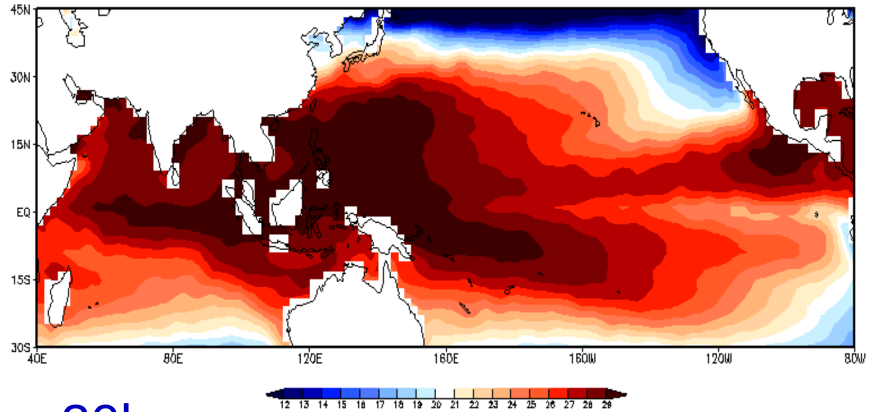


High resolution modeling - coupled model

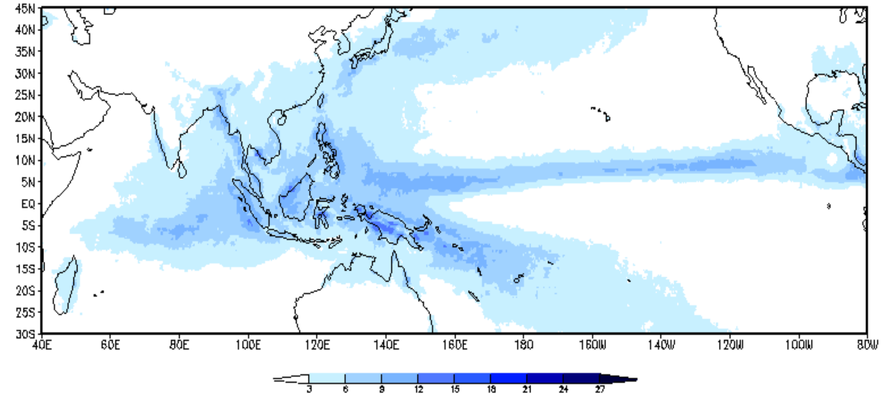
SST

PRCP

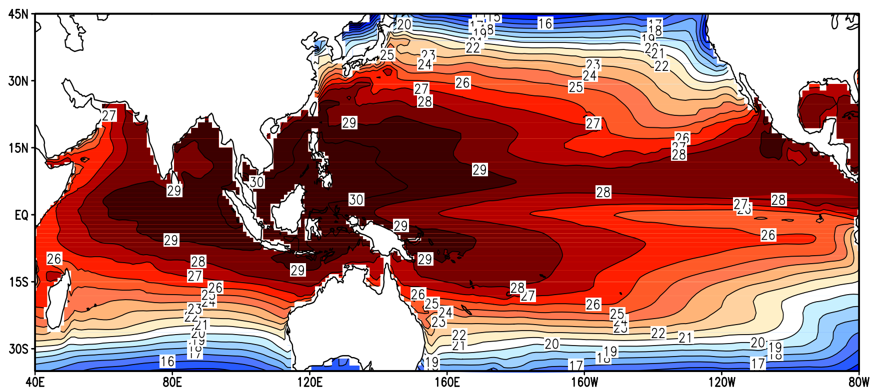
ERSST



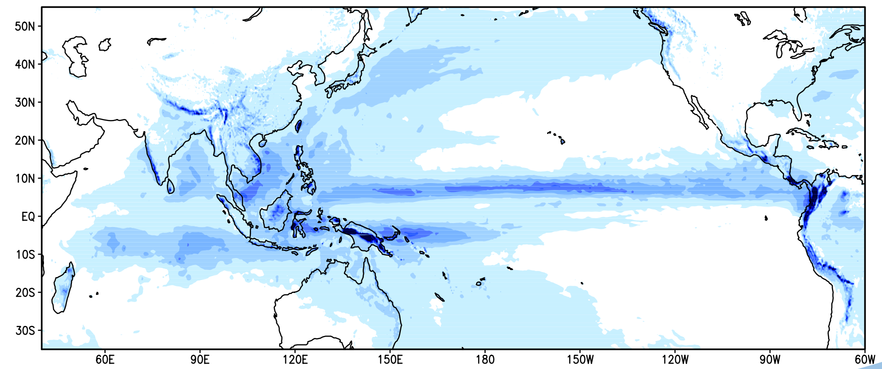
TRMM



30km



30km



Thank you!

Model Descriptions of CliPAS System

APCC/CliPAS Tier-1 Models

Institute	AGCM	Resolution	OGCM	Resolution	Ensemble Member	Reference
BMRC	BAM3d 3.0d	T47L17	ACOM2	0.5-1.5° latx 2° lon L25	10	Zhong et al., 2005
FRCGC	ECHAM4	T106 L19	OPA 8.2	2° cos(lat)x2° lon L31	9	Luo *et al.* (2005)
GFDL	AM2.1	2°latx2.5°lon L24	MOM4	1/3°latx1°lon L50	10	Delworth et al. (2006)
NASA	NSIPP1	2° latx2.5° lon L34	Poseidon V4	1/3° lat x 5/8° lon L27	3	Vintzileos *et al.* (2005)
NCEP	GFS	T62 L64	MOM3	1/3° lat x 1° lon L40	15	Saha *et al.* (2005)
SNU	SNU	T42 L21	MOM2.2	1/3° lat x 1° lon L32	6	Kug *et al.* (2005)
UH	ECHAM4	T31 L19	UH Ocean	1° lat x 2° lon L2	10	Fu and Wang (2001)

APCC/CliPAS Tier-2 Models

Institute	AGCM	Resolution	Ensemble Member	SST BC	Reference
FSU	FSUGCM	T63 L27	10	SNU SST forecast	Cocke, S. and T.E. LaRow (2000)
GFDL	AM2	2° lat x 2.5° lon L24	10	SNU SST forecast	Anderson *et al.* (2004)
IAP	LASG	2.8° lat x 2.8° lon L26	6	SNU SST forecast	Wang et al. (2004)
NCEP	GFS	T62 L64	15	CFS SST forecast	Kanamitsu et al. (2002)
SNU/KMA	GCPS	T63 L21	6	SNU SST forecast	Kang *et al.* (2004)
UH	CAM2	T42 L26	10	SNU SST forecast	Liu *et al.* (2005)
UH	ECHAM4	T31 L19	10	SNU SST forecast	Roeckner *et al.* (1996)

MME3.1 Procedure

1. Applying statistical correction using SPPM to individual models

First Step: Prior prediction selection

-Select qualified predictor grid based on correlation for training period of cross validation

- Gather split predictors and regard as a predictor pattern

Second Step: Pattern Projection

- Construct covariance pattern between observation and reconstructed model pattern
- Obtain prediction by projecting model pattern on the covariance pattern

$$X_P(t) = \sigma_Y \sum_{i,j} \frac{COV(i,j) \bullet X(i,j,t)}{\sigma_X^2(i,j)}$$

Third Step: Optimal choice of prediction

- Judge whether the predictand is predictable at each grid point using double cross-validation with the threshold correlation of 0.3. If the prediction skill of double cross validation with the selected predictor pattern is not exceed the threshold value, we give up prediction at the grid point.

2. Simple multi-model composite using available predictions