APCC/CliPAS multi-model ensemble seasonal prediction

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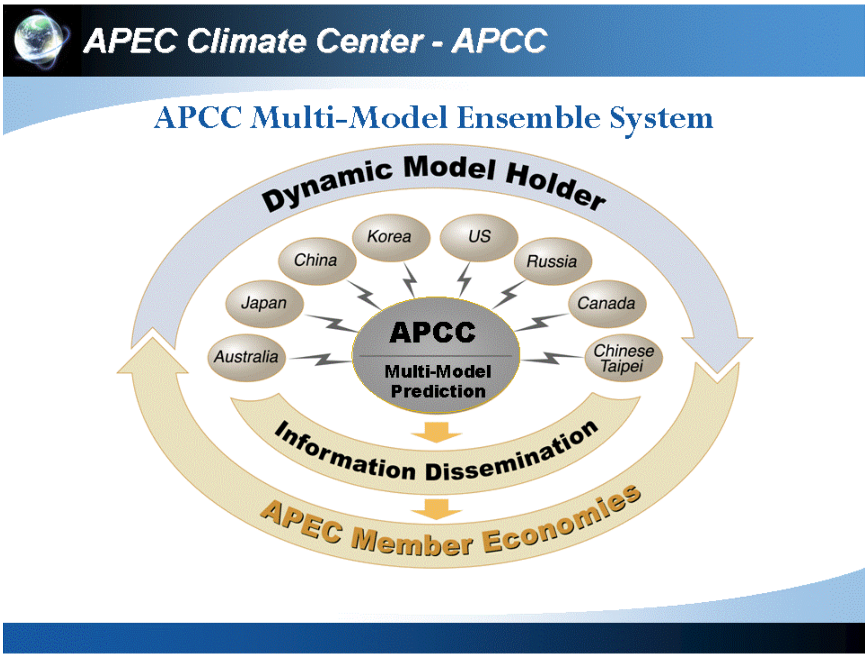
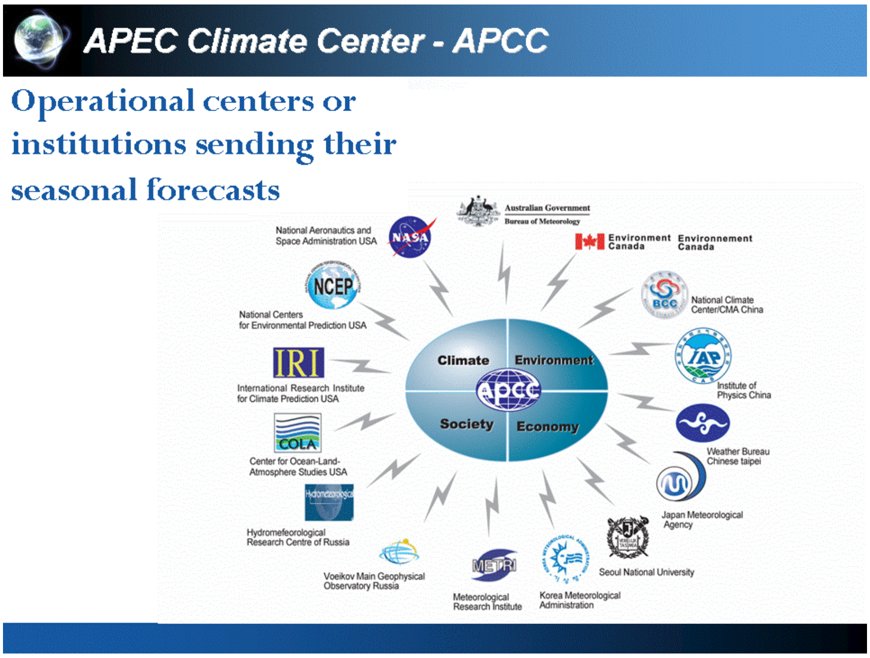
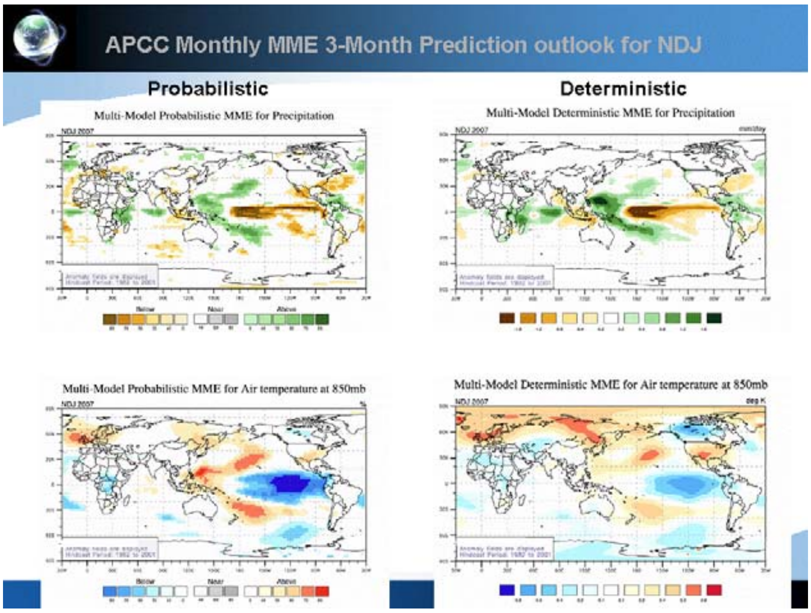
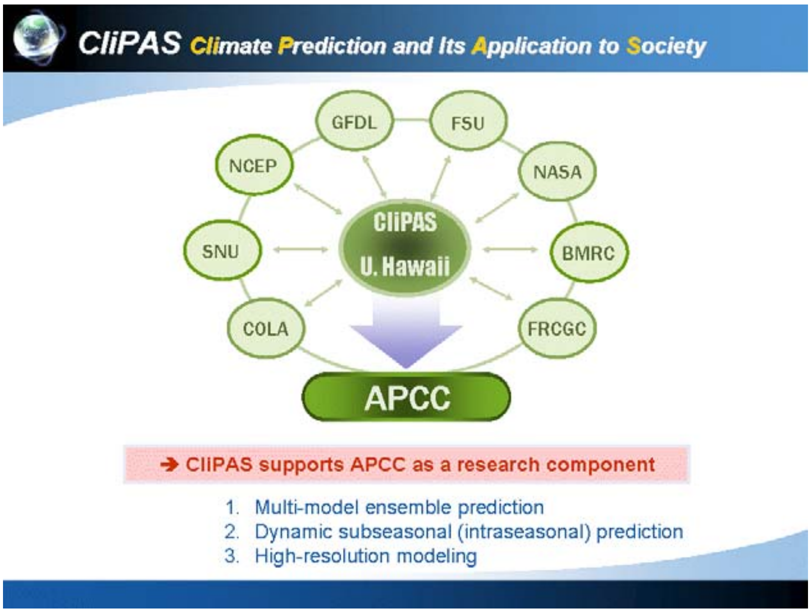
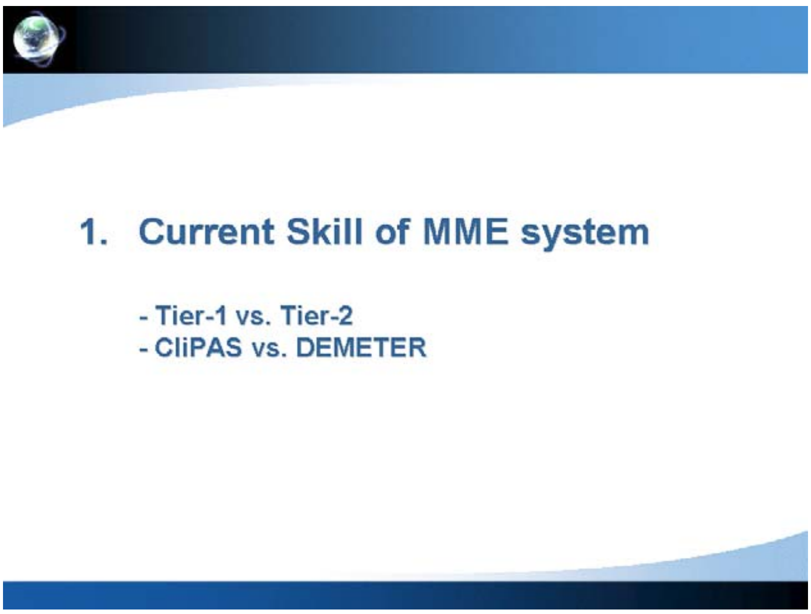
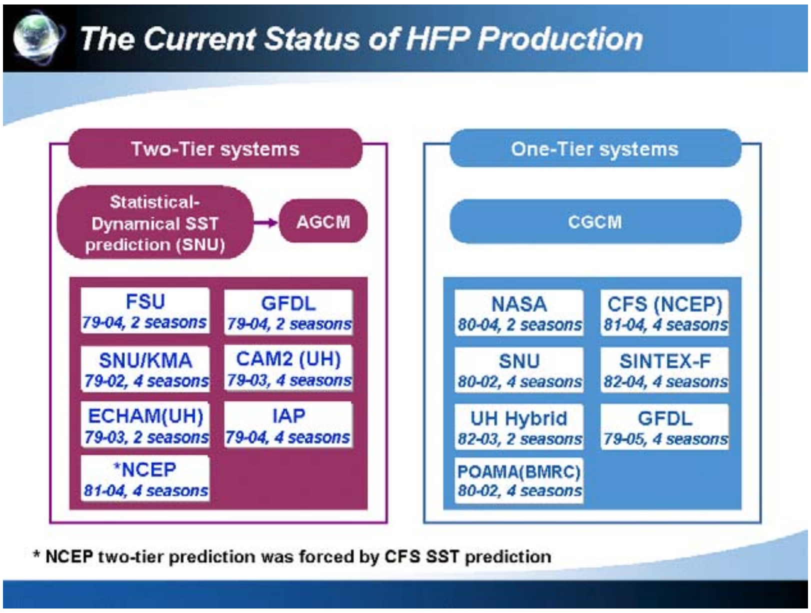


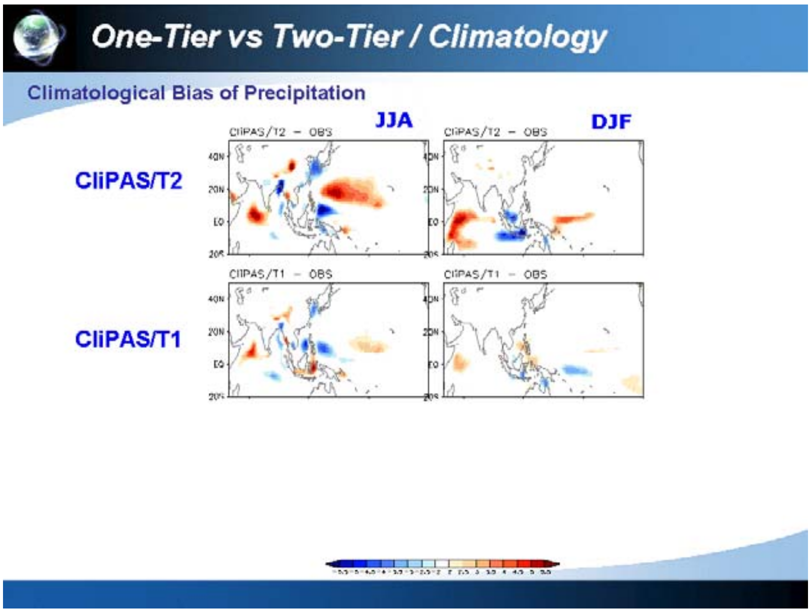


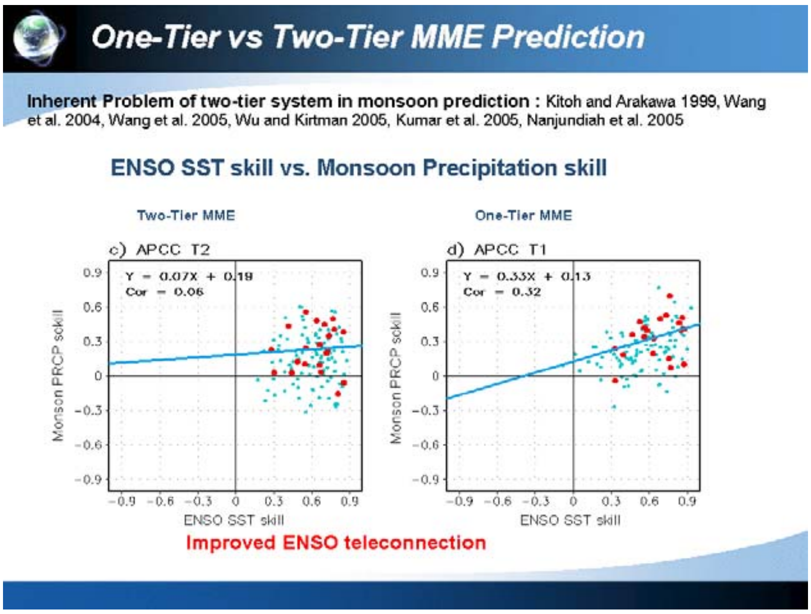

APCC Monthly MME 3-Month Prediction outlook for NDJ
Probabilistic
Deterministic
Multi-Model Probabilistic MME for Precipitation
Multi-Model Deterministic MME for Precipitation
Multi-Model Probabilistic MME for Air temperature at 850mb
Multi-Model Deterministic MME for Air temperature at 850mb

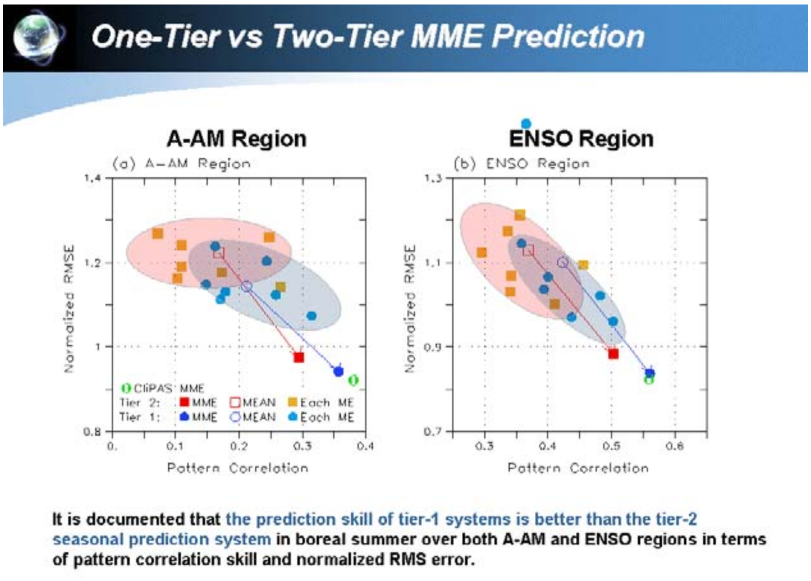

CliPAS Climate Prediction and Its Application to Society
GFDL
FSU
NCEP
NASA
SNU
CliPAS
U. Hawaii
BMRC
COLA
FRCGC
APCC
➔ CliPAS supports APCC as a research component
1. Multi-model ensemble prediction
2. Dynamic subseasonal (intraseasonal) prediction
3. High-resolution modeling

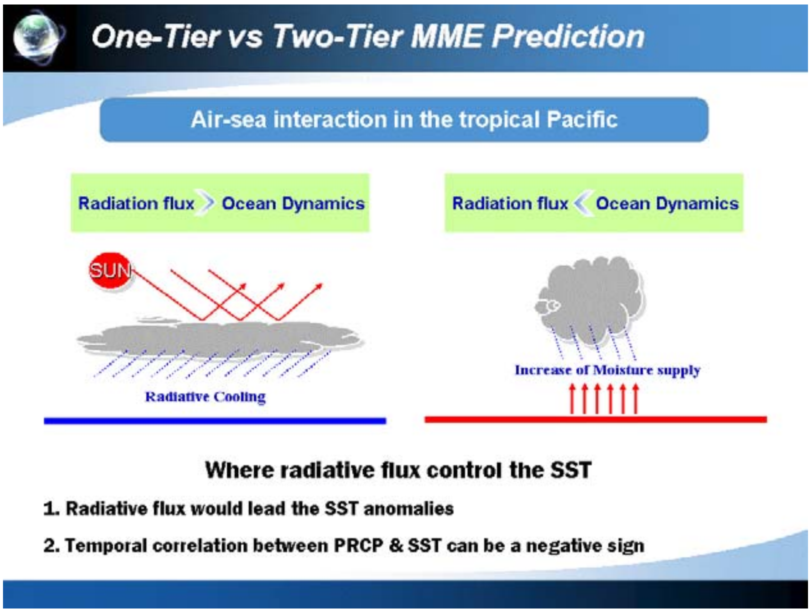

1. Current Skill of MME system
- Tier-1 vs. Tier-2
- CliPAS vs. DEMETER

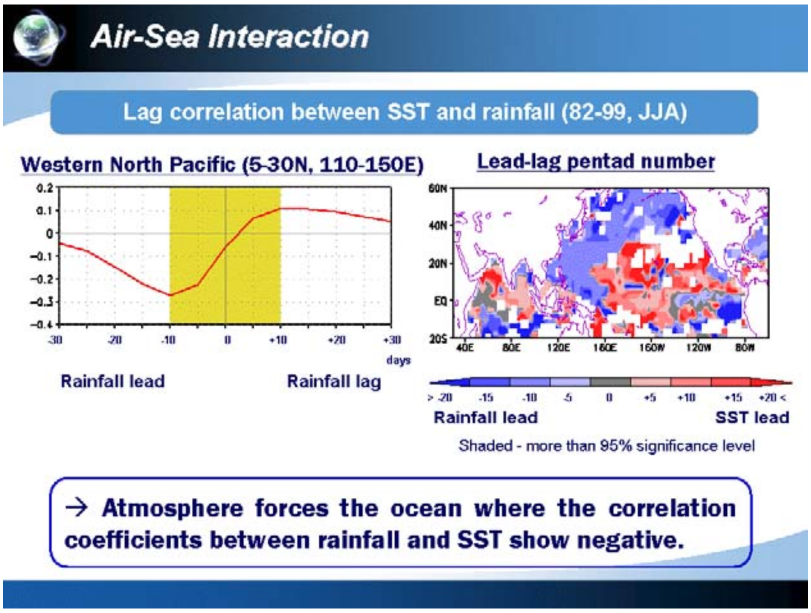

The Current Status of HFP Production
Two-Tier systems
Statistical-Dynamical SST prediction (SNU)
AGCM
FSU 79-04, 2 seasons
GFDL 79-04, 2 seasons
SNU/KMA 79-02, 4 seasons
CAM2 (UH) 79-03, 4 seasons
ECHAM(UH) 79-03, 2 seasons
IAP 79-04, 4 seasons
*NCEP 81-04, 4 seasons
One-Tier systems
CGCM
NASA 80-04, 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

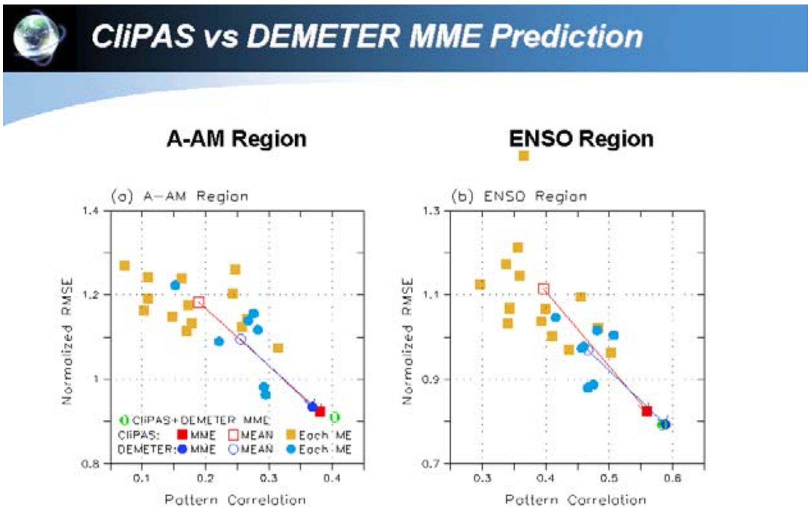

One-Tier vs Two-Tier / Climatology
Climatological Bias of Precipitation
JJA
DJF
CliPAS/T2
CliPAS/T1

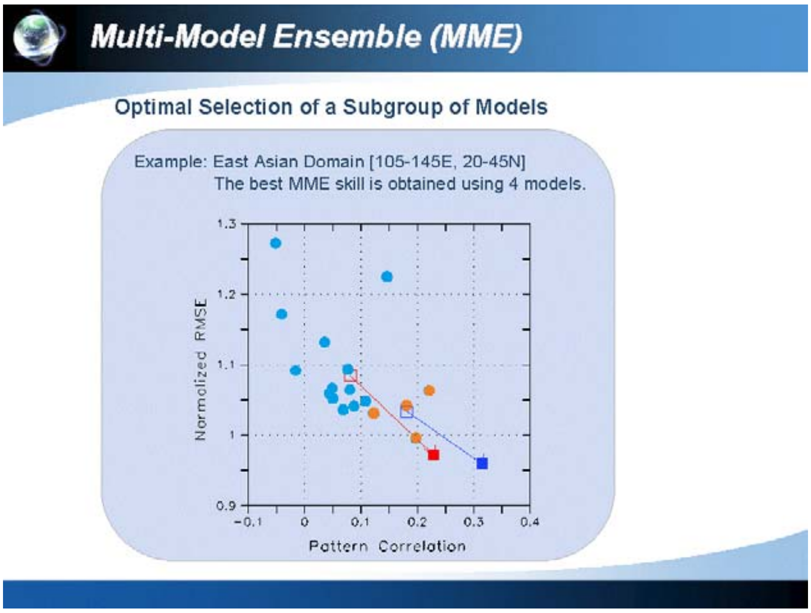

One-Tier vs Two-Tier MME Prediction
Inherent Problem of two-tier system in monsoon prediction : Kitoh and Arakawa 1999, Wang et al. 2004, Wang et al. 2005, Wu and Kirtman 2005, Kumar et al. 2005, Nanjundiah et al. 2005
ENSO SST skill vs. Monsoon Precipitation skill
Two-Tier MME
One-Tier MME
c) APCC T2
d) APCC T1
Y = 0.07X + 0.19
Cor = 0.06
Y = 0.33X + 0.13
Cor = 0.32
Monson PRCP skill
ENSO SST skill
Improved ENSO teleconnection

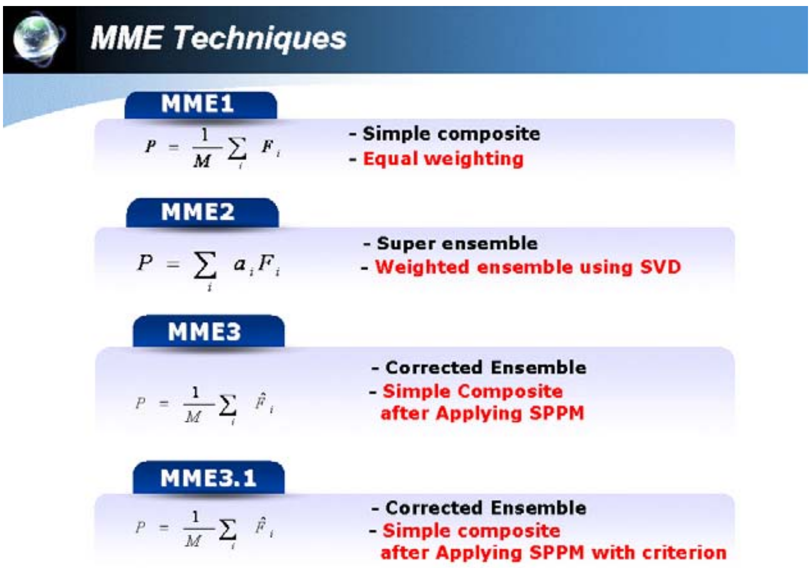

One-Tier vs Two-Tier MME Prediction
A-AM Region
(a) A-AM Region
ENSO Region
(b) ENSO Region
Normalized RMSE
Pattern Correlation
CliPAS MME
Tier 2: MME MEAN Each ME
Tier 1: MME MEAN Each ME
It is documented that the prediction skill of tier-1 systems is better than the tier-2 seasonal prediction system 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
SUN
Radiative Cooling
Increase of Moisture supply
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
days
Rainfall lead
Rainfall lag
Rainfall lead
SST lead
Shaded - more than 95% significance level
→ Atmosphere forces the ocean where the correlation coefficients between rainfall and SST show negative.

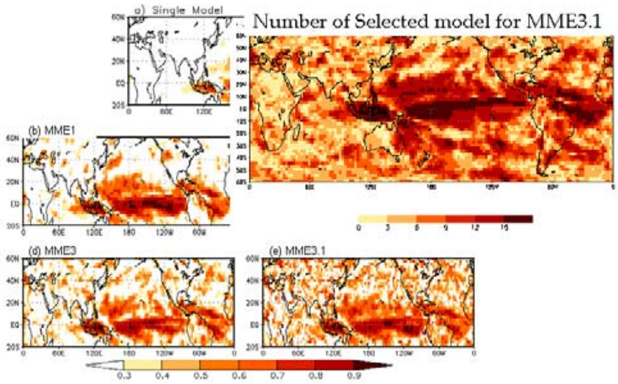

CliPAS vs DEMETER MME Prediction
A-AM Region
ENSO Region
(a) A–AM Region
(b) ENSO Region
Normalized RMSE
Pattern Correlation
CliPAS+DEMETER MME
CliPAS: MME MEAN Each ME
DEMETER: MME MEAN Each ME


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.
Normalized RMSE
Pattern Correlation


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

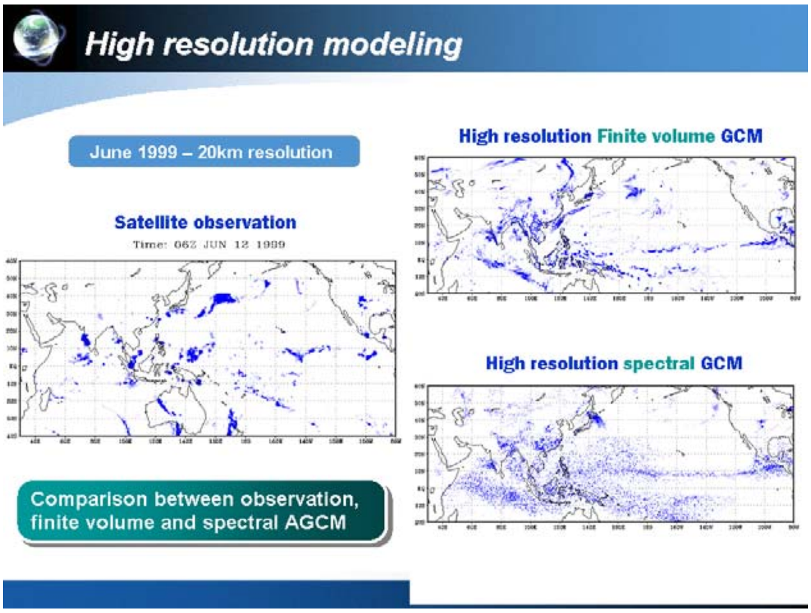
Leaded by Siegfried D. Schubert (NASA/GSFC) & In-Sik Kang (SNU)
Endorsed by CLIVAR/AA Monsoon Panel

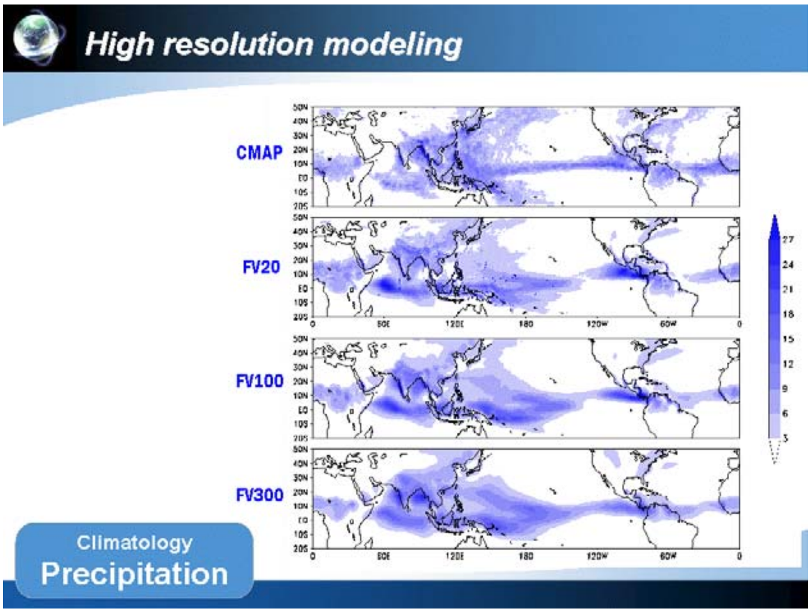
Tropical cyclone activity simulation project

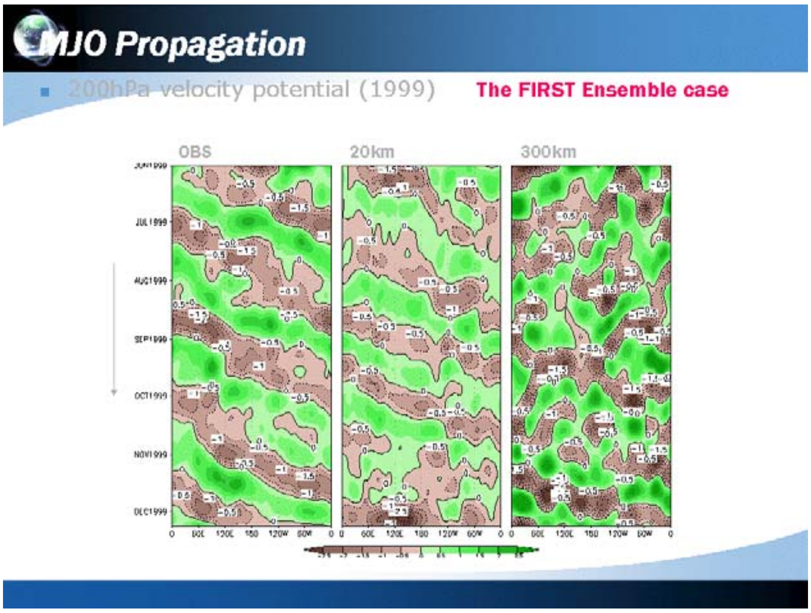
Participant institutes	Subject	Requirement
NASA/GSFC NCEP FRCGC BMRC ECMWF	2004/2005 on tropical cyclone	...ee resolution or better

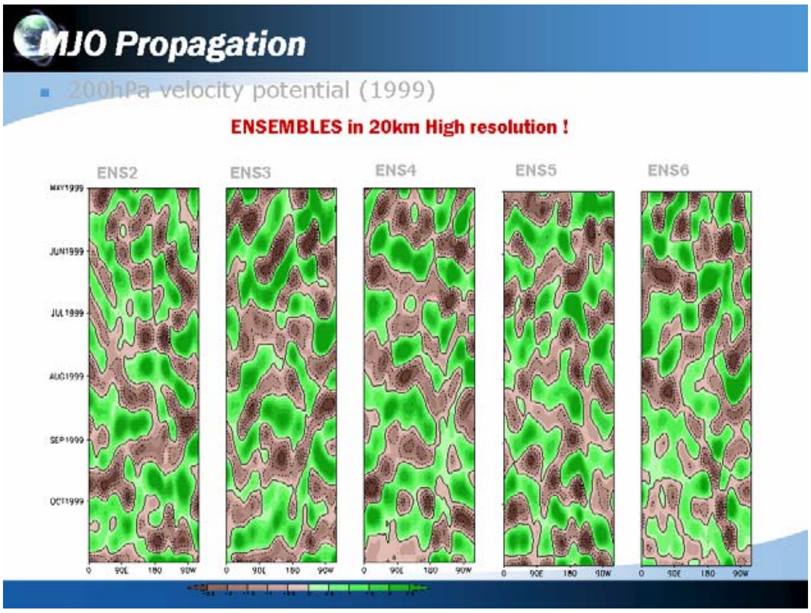
20km resolution model simulation (6 ensembles)

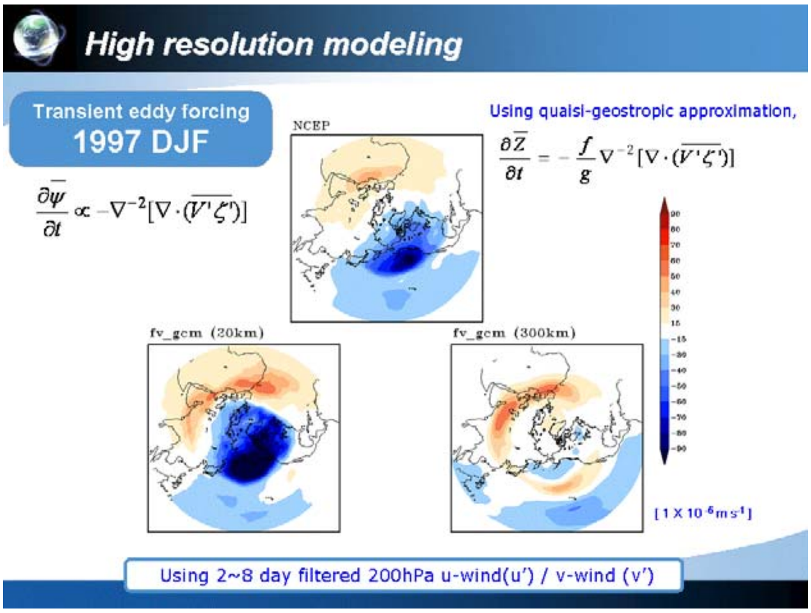
SST	Period	Some Interesting Events
1999	May 15- Nov 30	La Nina conditions
1997	May15 – Nov 30	El Nino conditions

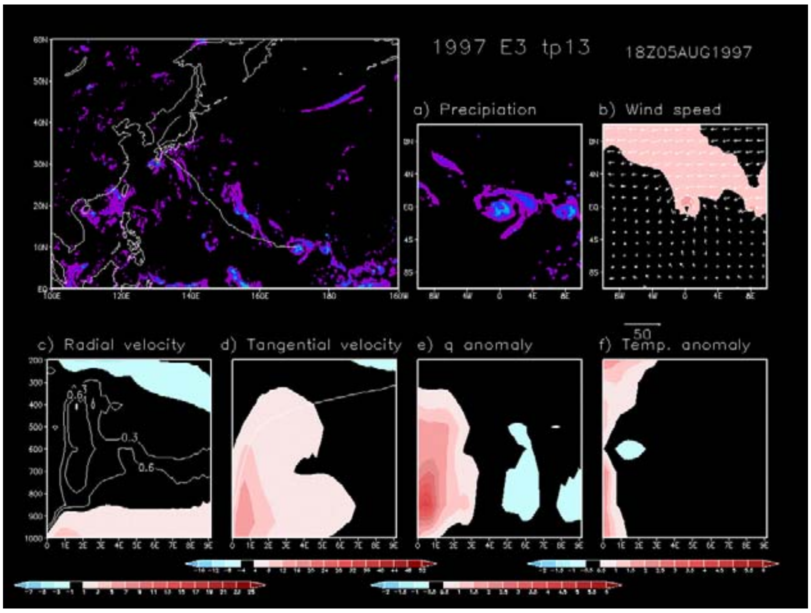

High resolution modeling
June 1999 – 20km resolution
Satellite observation
Time: 06Z JUN 12 1999
High resolution Finite volume GCM
High resolution spectral GCM
Comparison between observation, finite volume and spectral AGCM

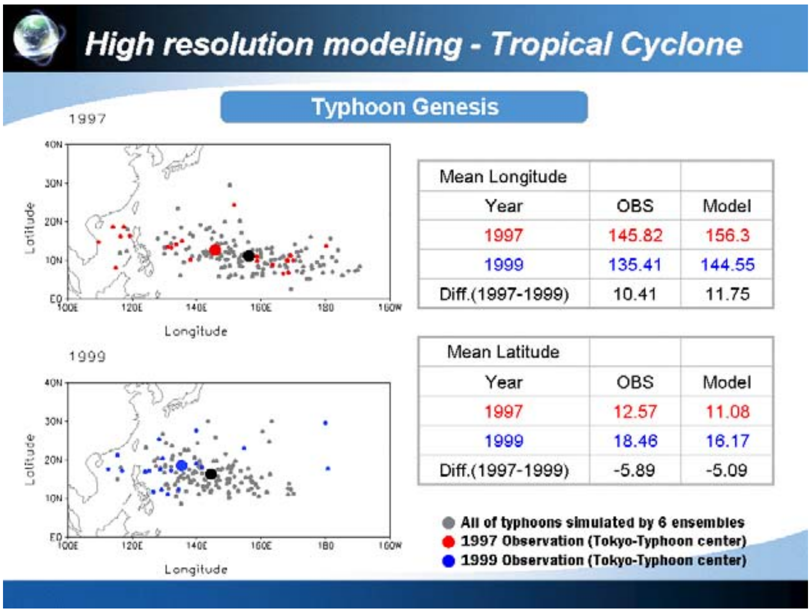

High resolution modeling
CMAP
FV20
FV100
FV300
Climatology
Precipitation

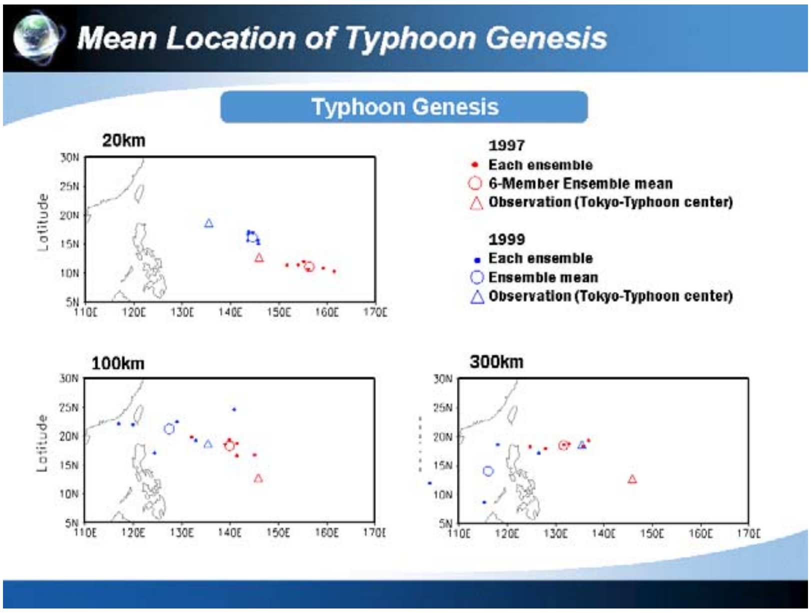

MJO Propagation
200hPa velocity potential (1999)
The FIRST Ensemble case
OBS
20km
300km

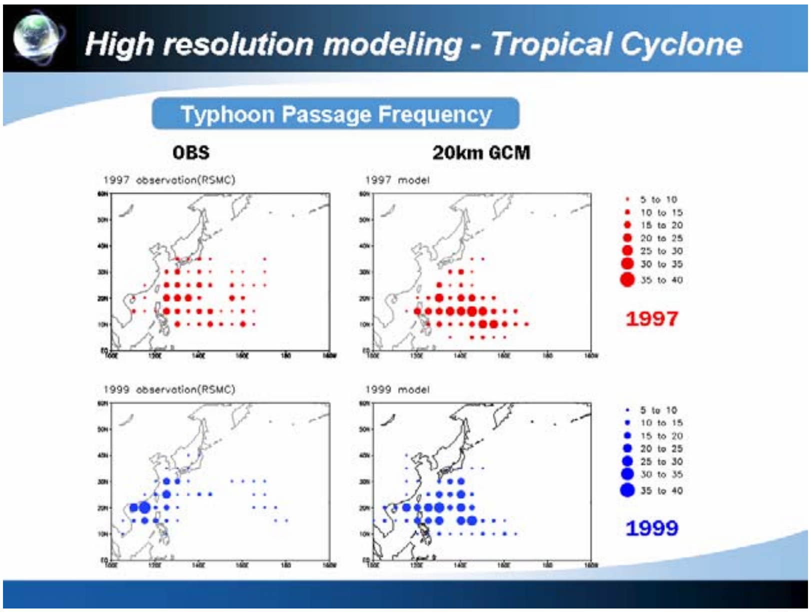

MJO Propagation
200hPa velocity potential (1999)
ENSEMBLES in 20km High resolution !
ENS2
ENS3
ENS4
ENS5
ENS6


High resolution modeling
Transient eddy forcing
1997 DJF
Using quaisi-geostropic approximation,
NCEP
fv_gcm (20km)
fv_gcm (300km)
Using 2~8 day filtered 200hPa u-wind(u') / v-wind (v')


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


High resolution modeling - Tropical Cyclone
Typhoon Genesis
1997
Latitude
Longitude
1999
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)

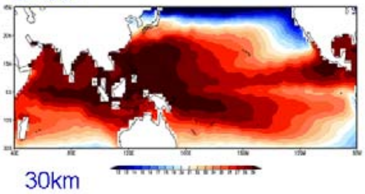

Mean Location of Typhoon Genesis
Typhoon Genesis
20km
100km
300km
Latitude
1997
Each ensemble
6-Member Ensemble mean
Observation (Tokyo-Typhoon center)
1999
Each ensemble
Ensemble mean
Observation (Tokyo-Typhoon center)


High resolution modeling - Tropical Cyclone
Typhoon Passage Frequency
OBS
20km GCM
1997 observation(RSMC)
1997 model
1999 observation(RSMC)
1999 model
5 to 10
10 to 15
15 to 20
20 to 25
25 to 30
30 to 35
35 to 40
1997
1999

High resolution modeling - coupled model

SST

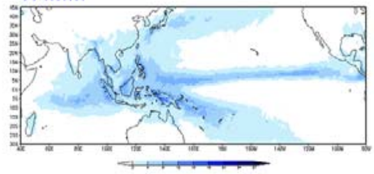
ERSST



30km

PRCP

TRMM



30km

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

$$X_p(t) = \sigma_Y \sum_{ij} \frac{COV(i,j) \cdot X(i,j,t)}{\sigma_X^2(i,j)}$$

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