

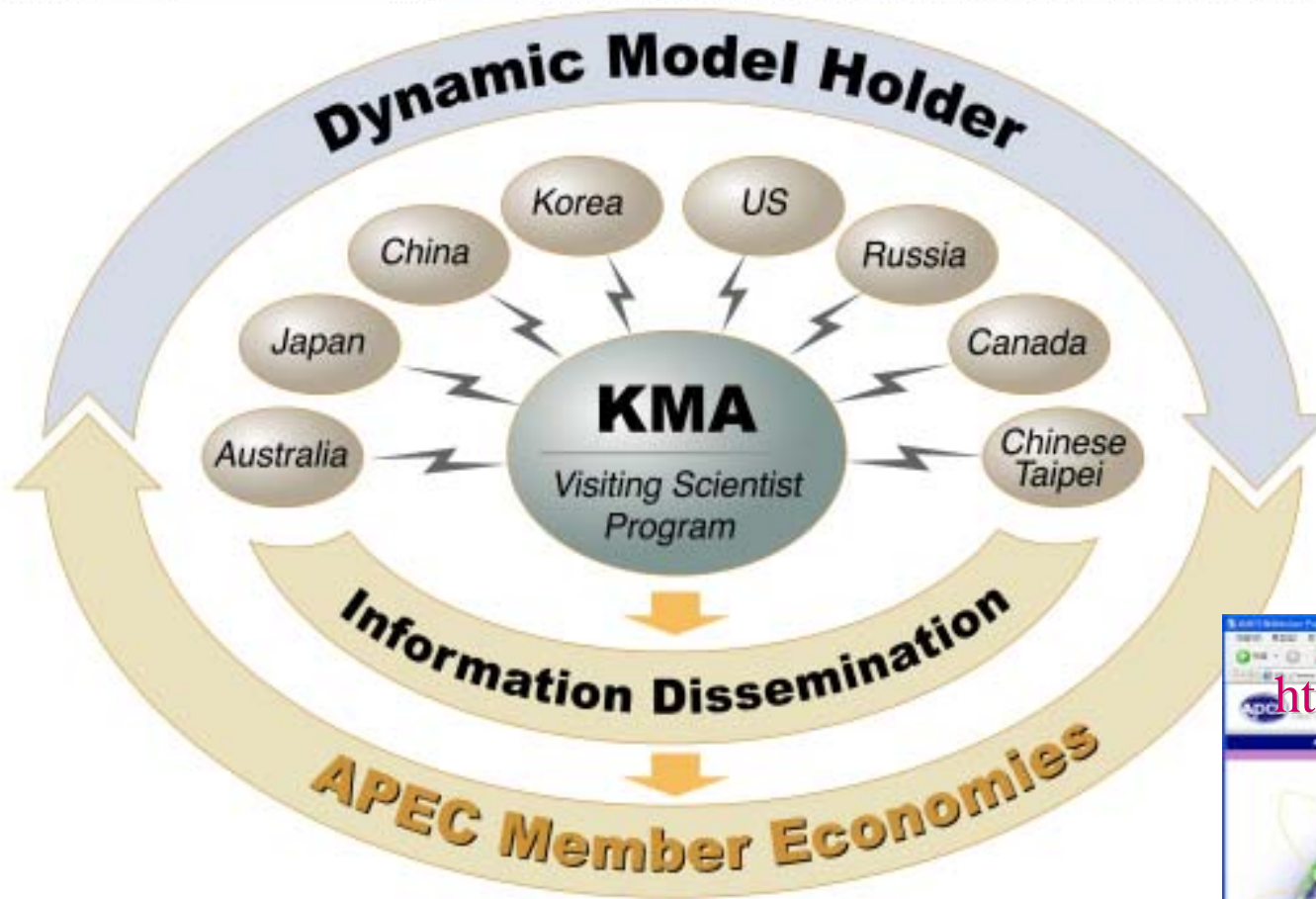
*APCN Working Group & Steering Committee Meeting
Nov. 9-12 2004 Busan, Korea*

APCN MME Seasonal Prediction System

W. T. Yun
APCN/CPD/KMA



APCN Multi-Model Ensemble Procedure



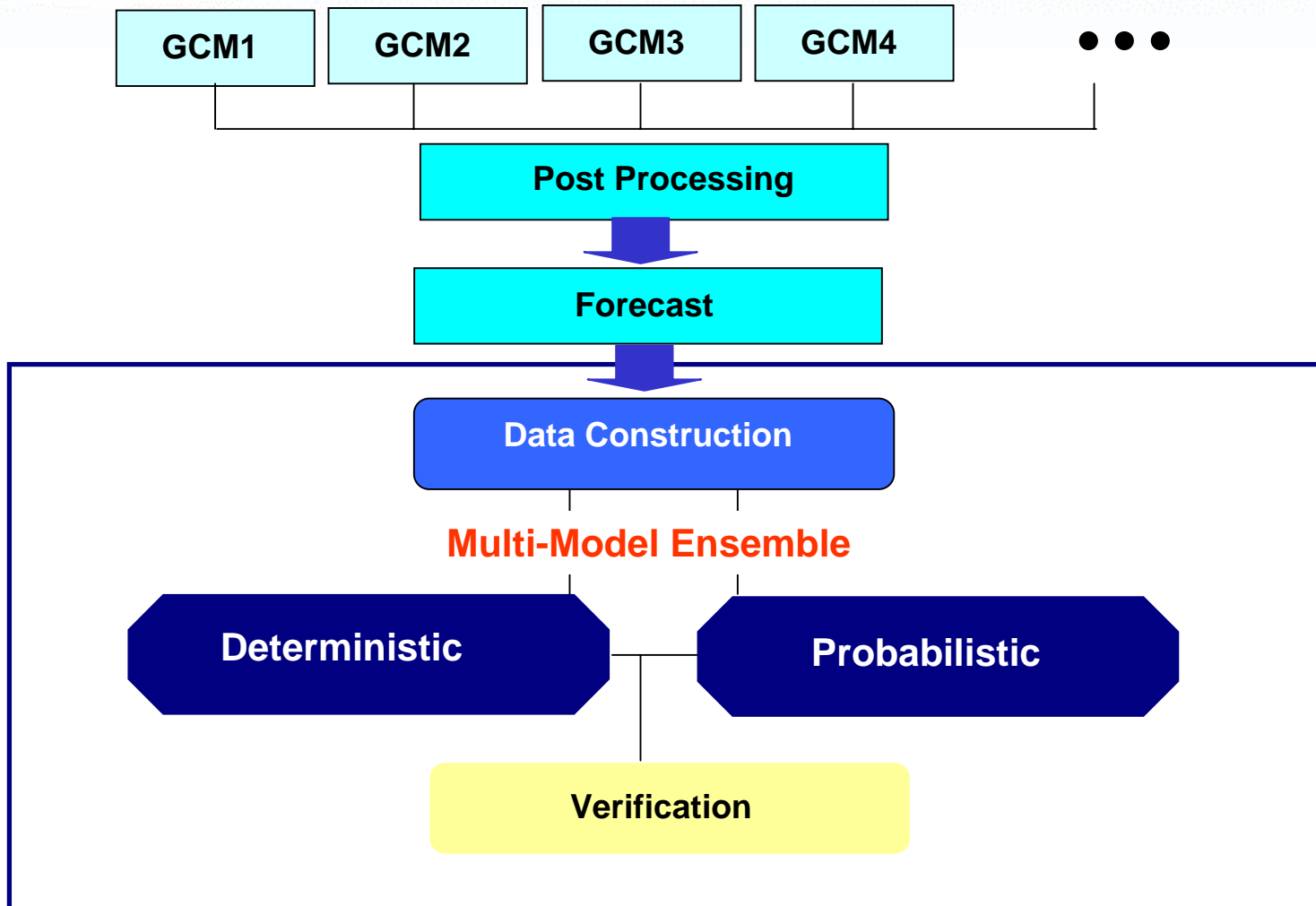
Variables and Frequency

Year	Frequency	Variables
2001	Once for JJA	Precipitation
2002 ~ 2003	Twice a year - for JJA - for DJF	Precipitation 850hPa Temperature 500hPa Geopotential Height
2004 ~	Four times a year - for MAM - for JJA - for SON - for DJF	Precipitation [mm/day] 850hPa Temperature [K] Surface(2m) air temperature [K] Sea Surface Temperature [K] Mean Sea Level Pressure [hPa] Outgoing Longwave Radiation [W/m ²] 500hPa geopotential height [m] 850hPa zonal and meridional velocity [m/sec] 200hPa zonal and meridional velocity [m/sec]

Participating Models

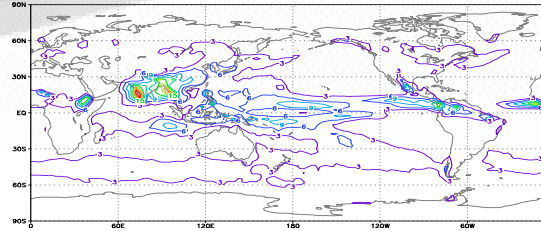
Member Economies	Acronym	Organization	Model Resolution
Australia	POAMA	Bureau of Meteorology Research Centre	T47L17
Canada	MSC	Meteorological Service of Canada	1.875 ° × 1.875 ° L50
China	NCC	National Climate Center/CMA	T63L16
	IAP	Institute of Atmospheric Physics	4 ° × 5 ° L2
Chinese Taipei	CWB	Central Weather Bureau	T42L18
Japan	JMA	Japan Meteorological Agency	T63L40
Korea	GDAPS/KMA	Korea Meteorological Administration	T106L21
	GCPS/KMA	Korea Meteorological Administration	T63L21
	METRI/KMA	Meteorological Research Institute	4 ° × 5 ° L17
Russia	MGO	Main Geophysical Observatory	T42L14
	HMC	Hydrometeorological Centre of Russia	1.125 ° × 1.40625 ° L28
USA	COLA	Center for Ocean-Land-Atmosphere Studies	T63L18
	IRI	International Research Institute for Climate Prediction	T42L18
	NCEP	NCEP Coupled Forecast System	T62L64
	NSIPP/NASA	National Aeronautics and Space Administration	2 ° × 2.5 ° L34

APCN MME Procedure

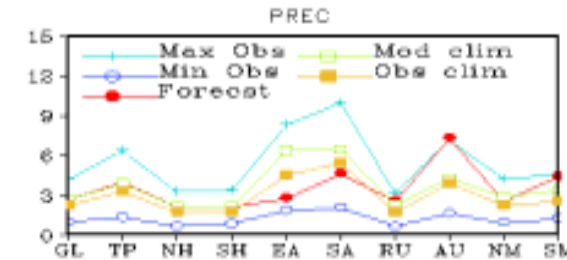


Quality Check

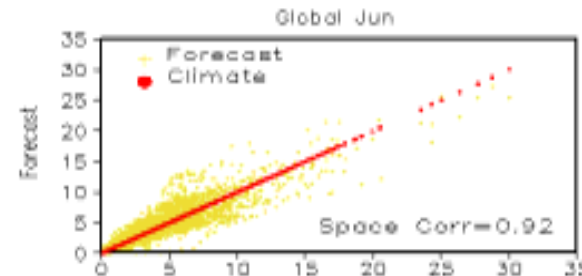
Eyeball Checking



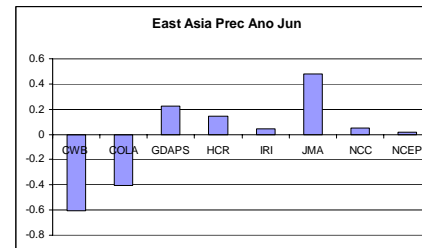
Extreme/Climate Fields Checking



Pattern Correlation Checking

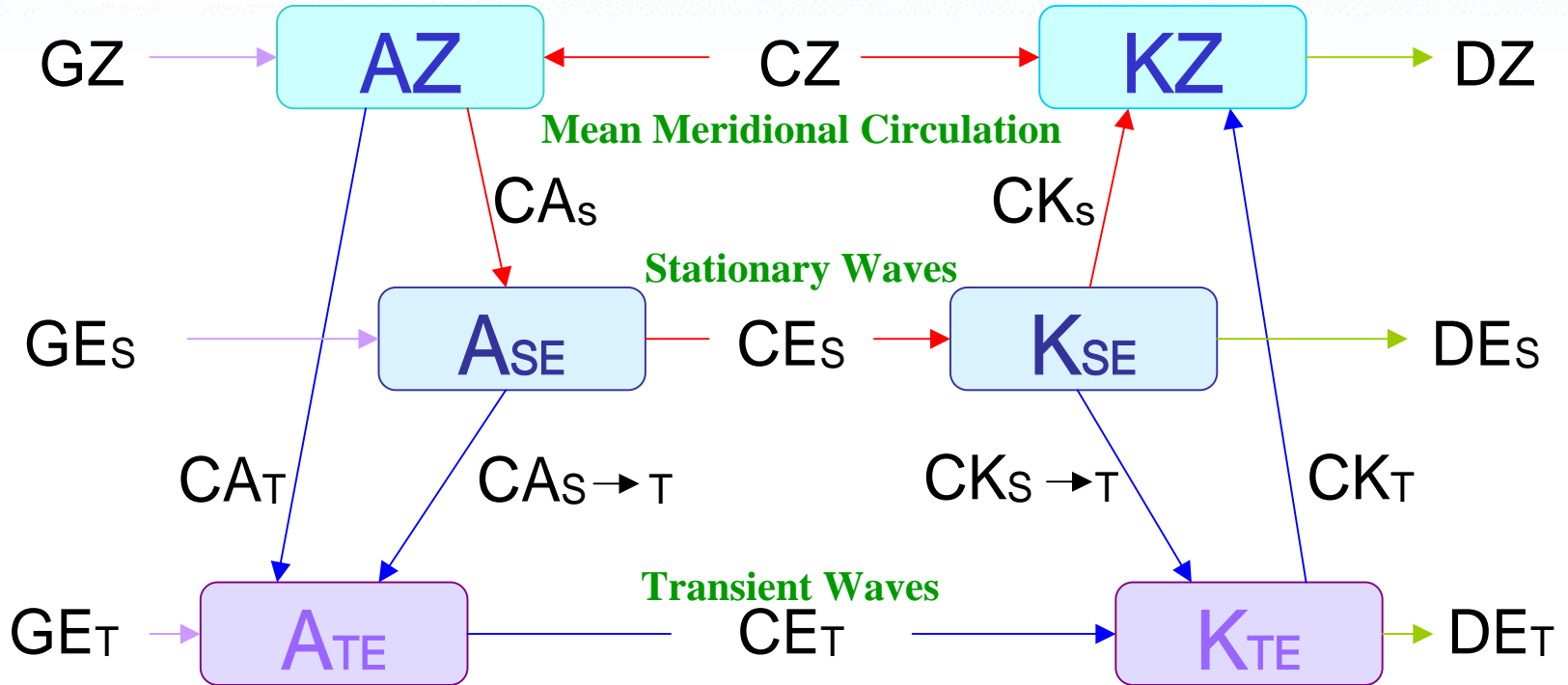


Comparison among the model Forecasts



Model Assessment

Mixed Space-Time Domain Energetics



AZ zonal available potential energy
AE eddy available potential energy
KZ zonal kinetic energy
KE eddy kinetic energy

CZ conversion $AZ \rightarrow KZ$
CE conversion $AE \rightarrow KE$
CA conversion $AZ \rightarrow AE$
CK conversion $KZ \rightarrow KE$

Kinetic Energy

(Mixed space-time domain energetics)

$$Kz = \frac{1}{2g} \left(\overline{[u]^2} + \overline{[v]^2} \right)$$

$$Kse = \frac{1}{2g} \left[\overline{(u')^2} + \overline{(v')^2} \right]$$

$$Kte = \frac{1}{2g} \left[\overline{u''^2} + \overline{v''^2} \right]$$

$$Total_K = Kz + Kse + Kte$$

$[u]$ zonal mean

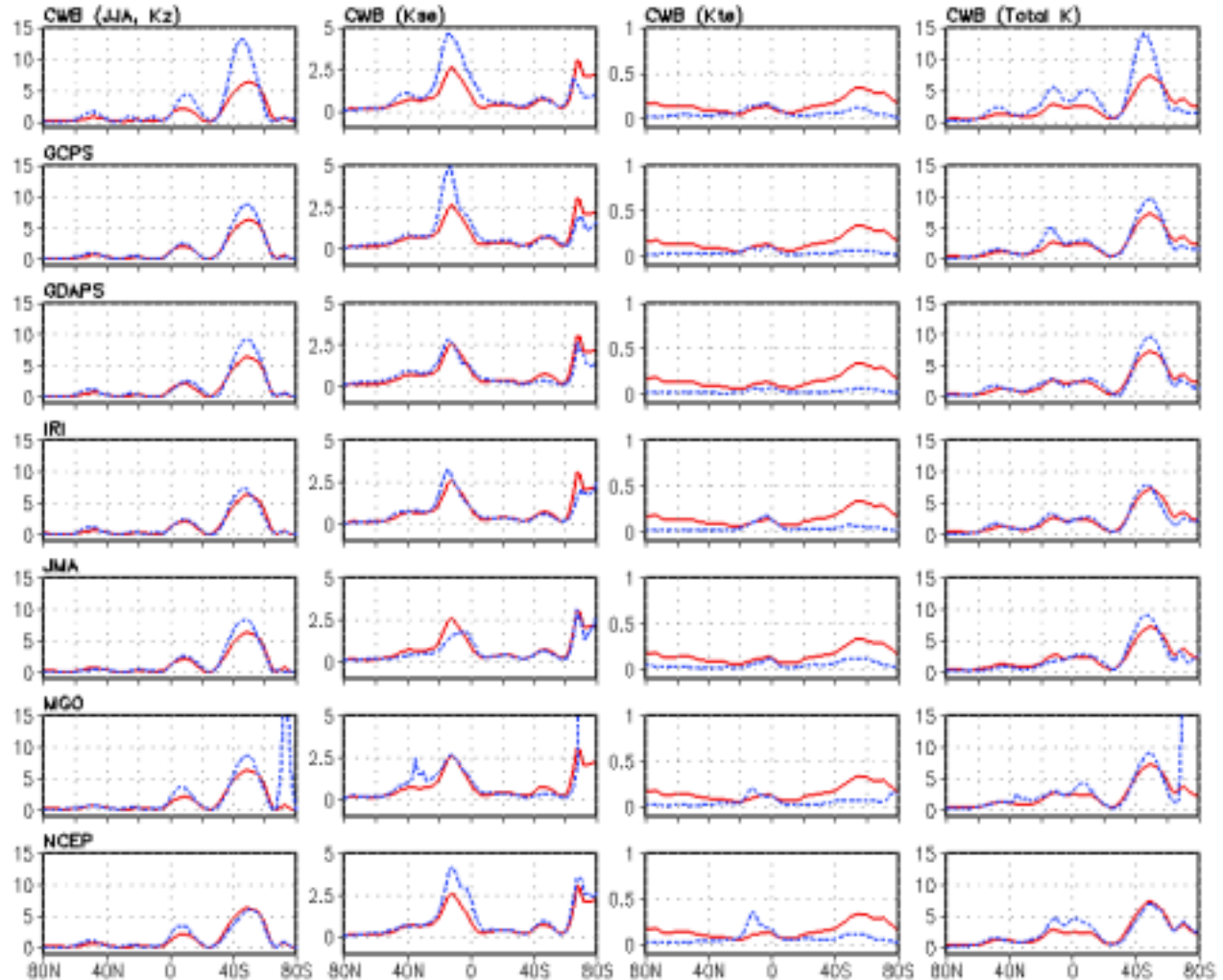
\bar{u} time average

$u' = u - [u]$

$u'' = u - \bar{u}$

Hindcast (1979-1999)

— Obs (21yr)
 Member Model



Kinetic Energy

(Mixed space-time domain energetics)

DJF 2004/05, 850hPa

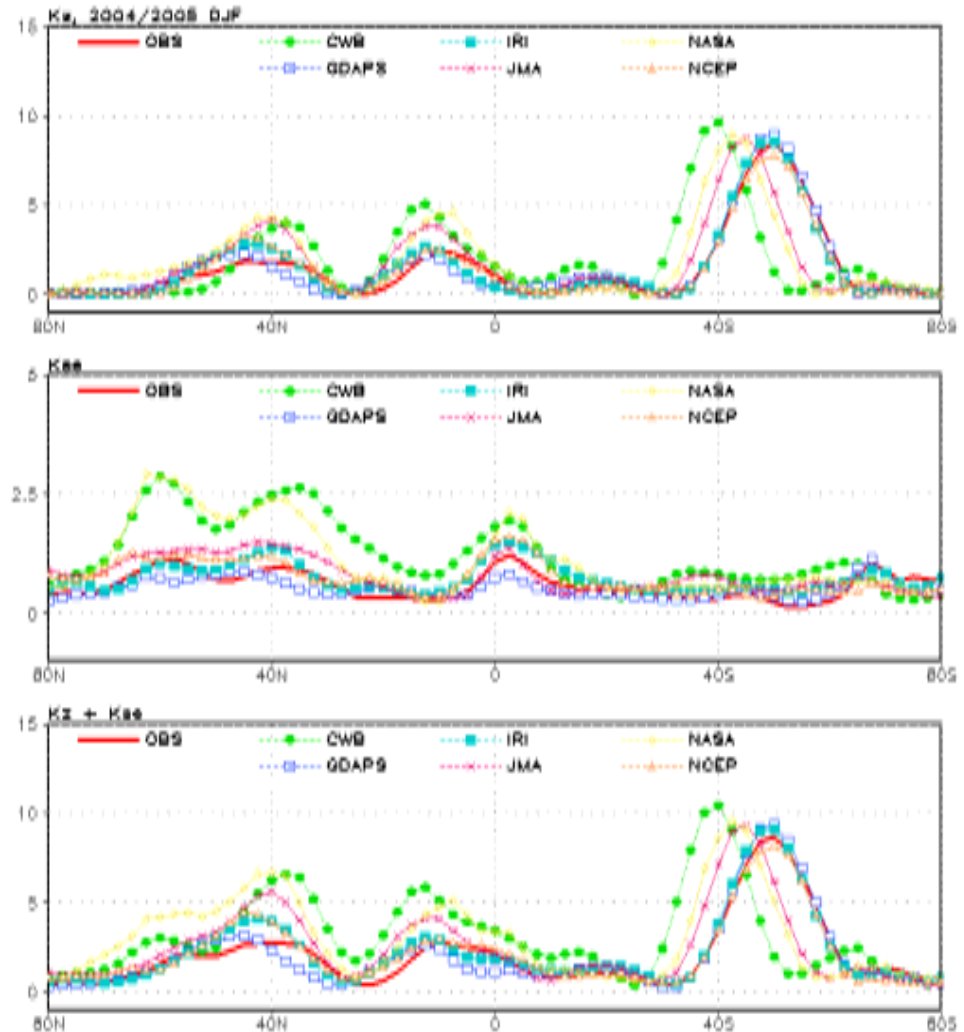
$$K_z = \frac{1}{2g} \left([\bar{u}]^2 + [\bar{v}]^2 \right)$$

$$K_{se} = \frac{1}{2g} \left[(\bar{u}')^2 + (\bar{v}')^2 \right]$$

$[u]$ zonal mean

\bar{u} time average

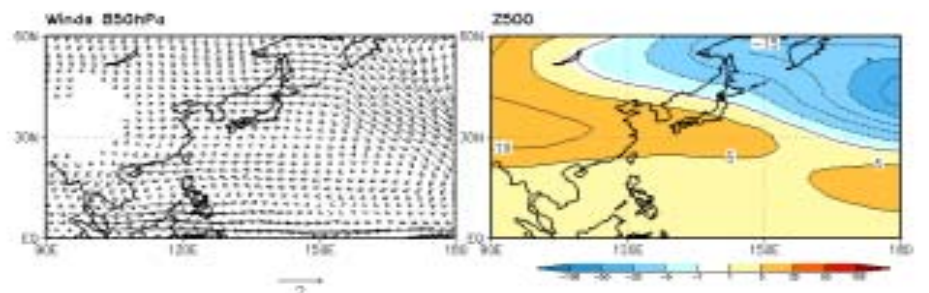
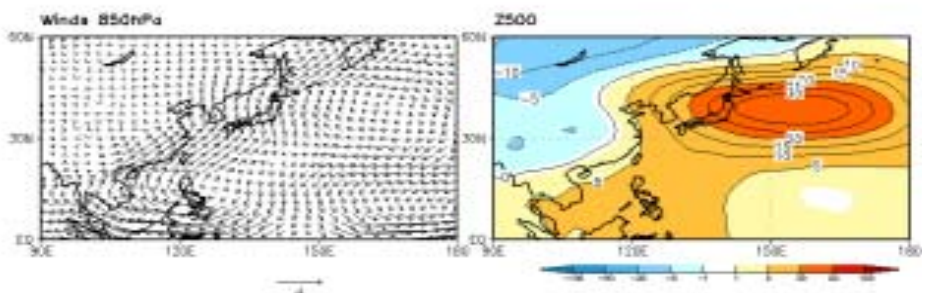
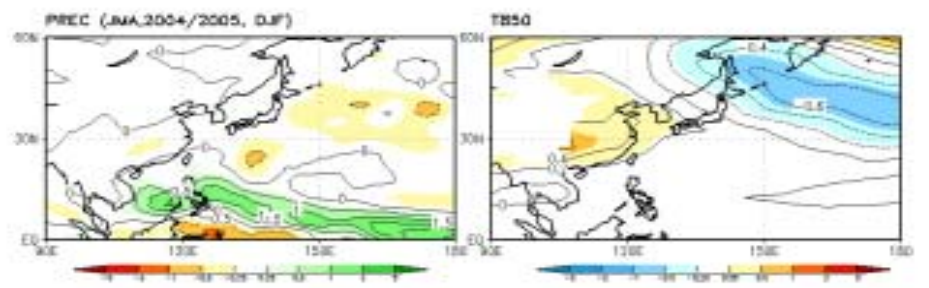
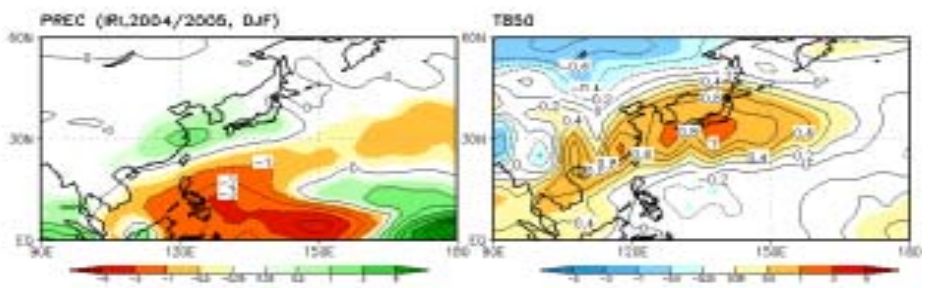
$$u' = u - [u]$$



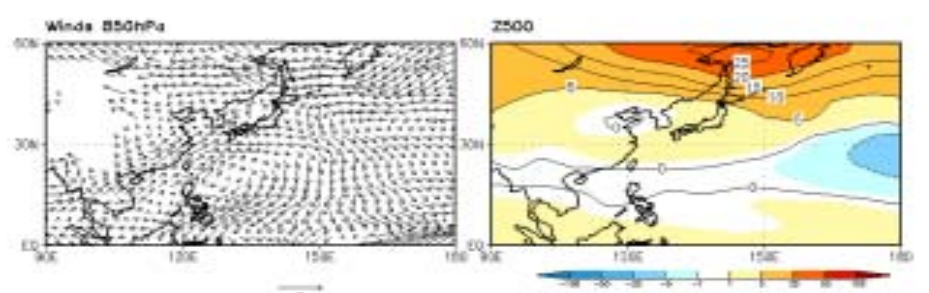
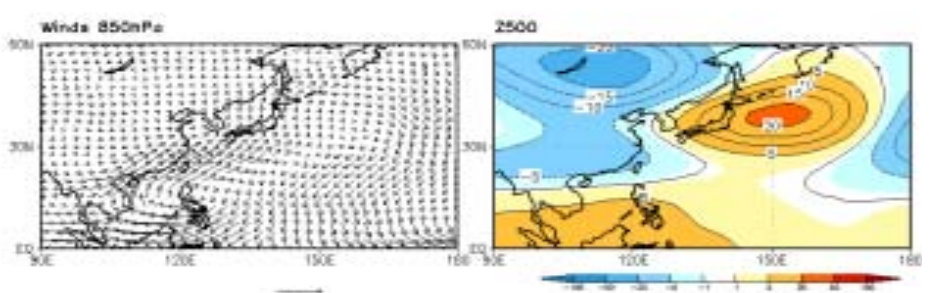
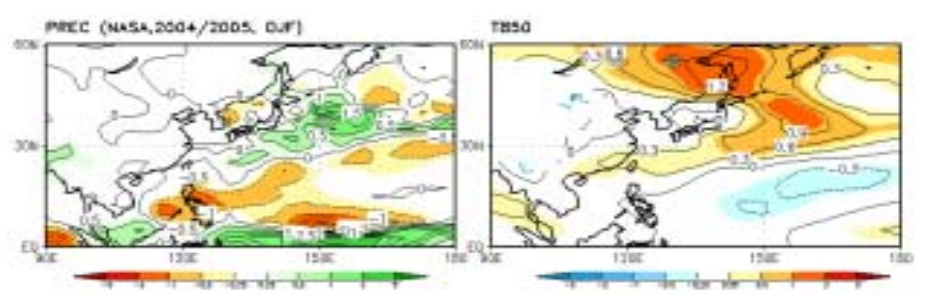
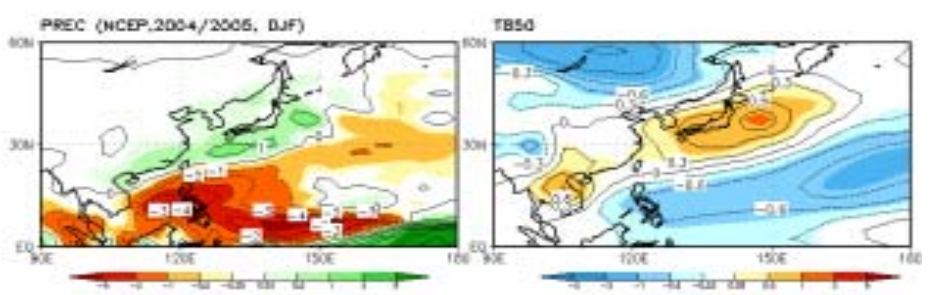
Uncertainty of Forecast

- **Errors in Initial Condition**
 - **Errors in Raw Observational Data**
 - **Errors in Objective Analysis Procedure**
 - **Sparse Observation over Ocean**

- **Errors in Forecast Model**
 - **Limitation in the Spatial Resolution**
 - **Errors in Physical Processes**



DJF 2004/05 (IRI, JMA, NCEP, NASA)



Internal- and External Variance

$$\sigma_{INR}^2 = \frac{1}{N(n-1)} \sum_{i=1}^N \sum_{j=1}^n (x_{ij} - \bar{x}_i)^2$$

$$\sigma_{SST}^2 = \sigma_{EN}^2 - \frac{1}{n} \sigma_{INR}^2$$

$$\sigma_{EN}^2 = \frac{1}{N-1} \sum_{i=1}^N (\bar{x}_i - \bar{x})^2$$

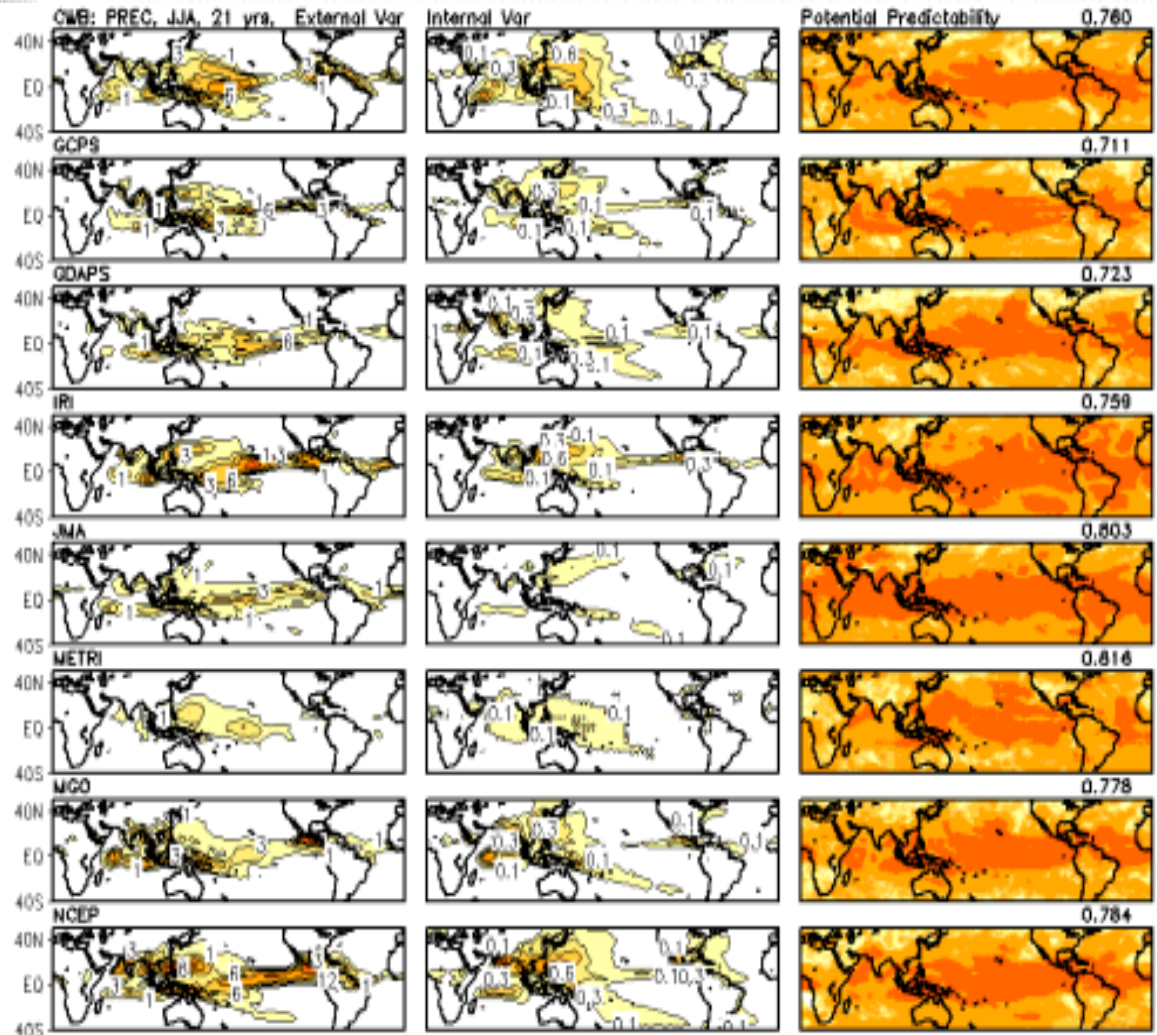
$$\bar{x} = 1/(Nn) \sum_{i=1}^N \sum_{j=1}^n x_{ij}$$

i : years

j : ensemble member

\bar{x}_i : ensemble Mean

\bar{x} : climatological Mean



APCN Deterministic MME Schemes



- **MME1 :**

Simple composite of individual forecast with equal weighting.
(special case of MME2)

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

- **MME2 :**

Weighted combination of individual forecasts. The weighting coefficient is obtained by regression based on SVD technique

W.T. Yun et al. (2003)

$$P = \sum_i a_i F_i'$$

- **MME3 :**

Simple composite of individual forecasts, which was corrected by statistical post process

I.S. Kang et al. (2004)

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

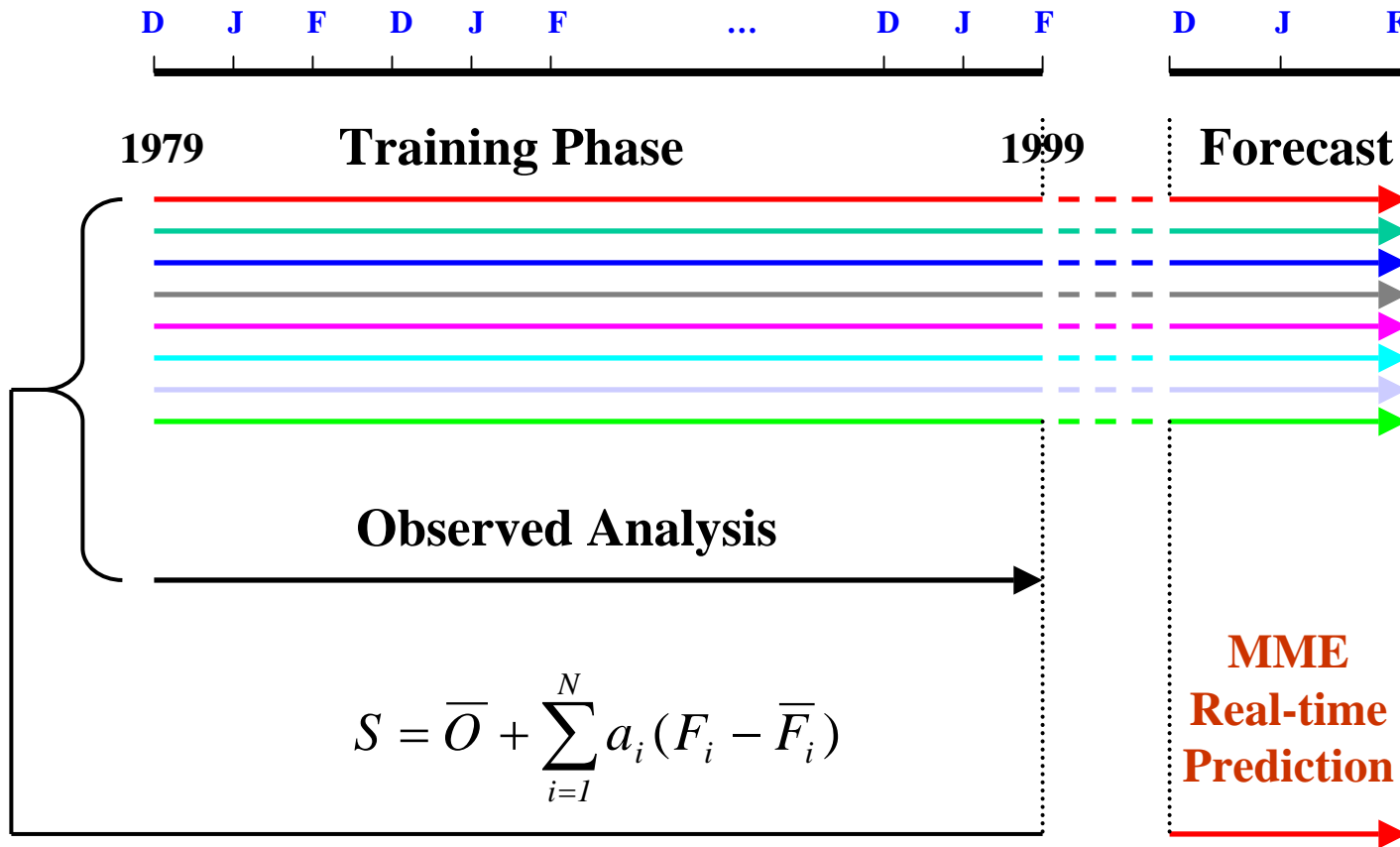
- **MME4 :**

weighted combination of statistical corrected multi model output

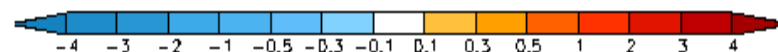
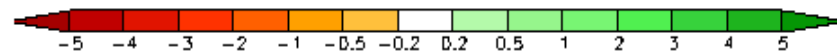
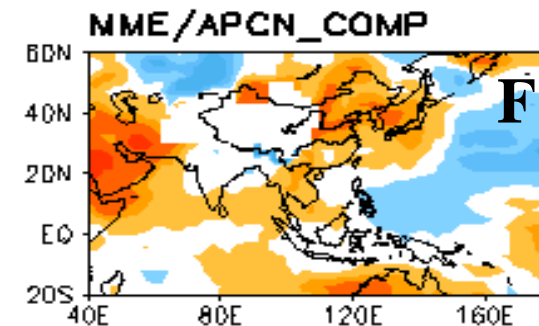
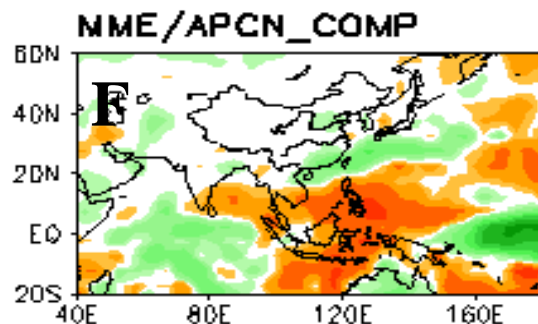
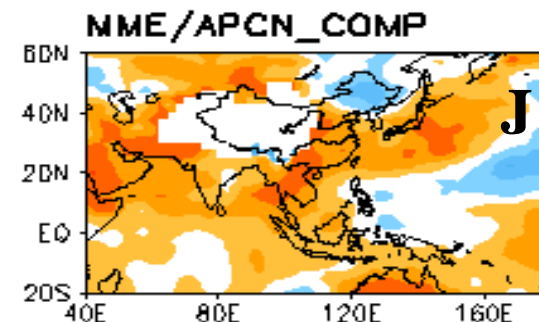
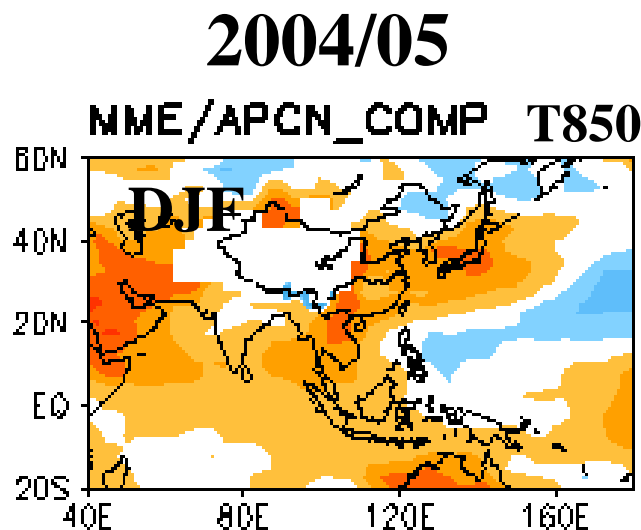
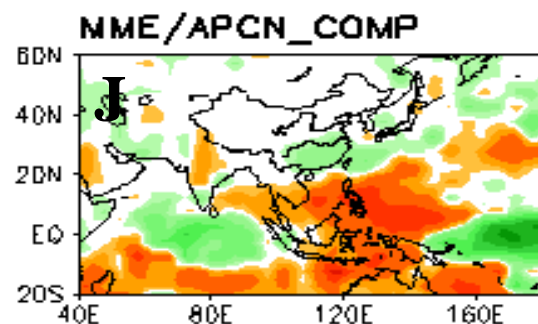
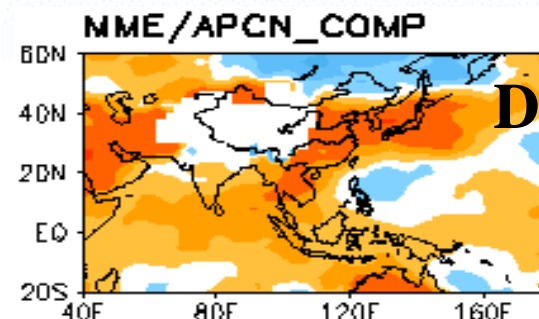
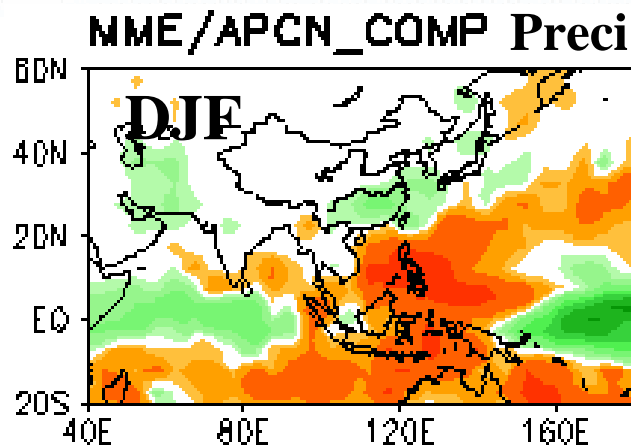
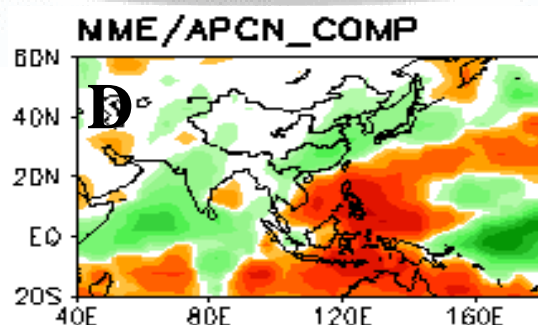
W.T. Yun et al. (2004)

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

APCN MME Prediction



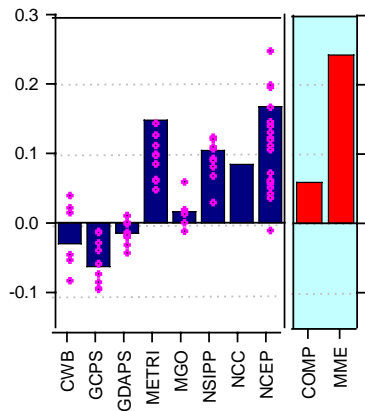
APCN MME-Comp Prediction Preci. & Temp.



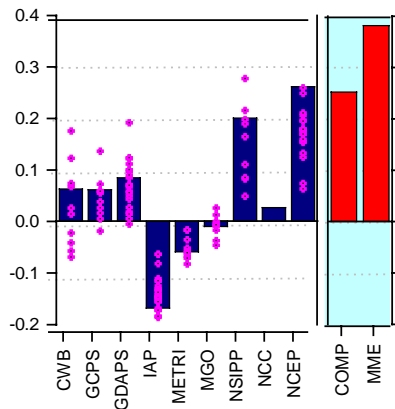
AC Skill Score of MME

2001-2004 JJA Forecast

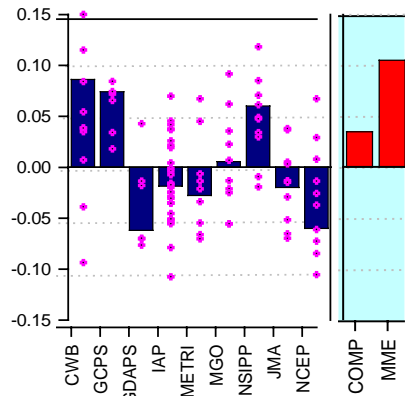
Precipitation 2001



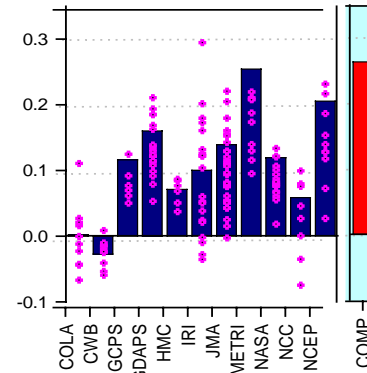
2002



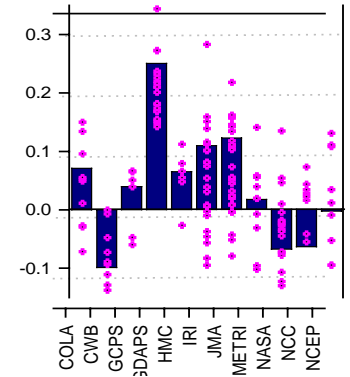
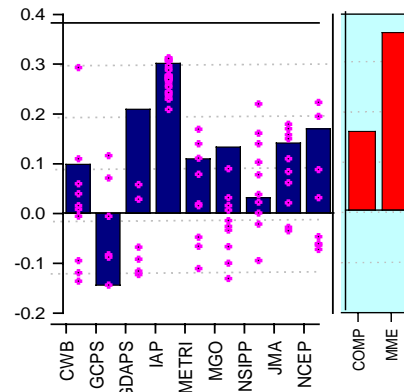
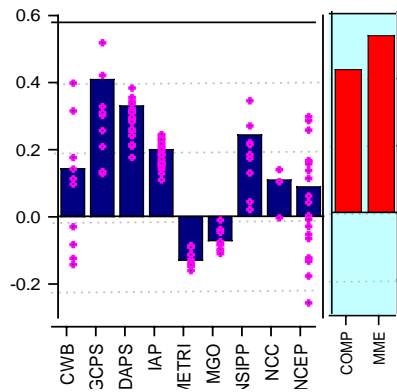
2003



2004



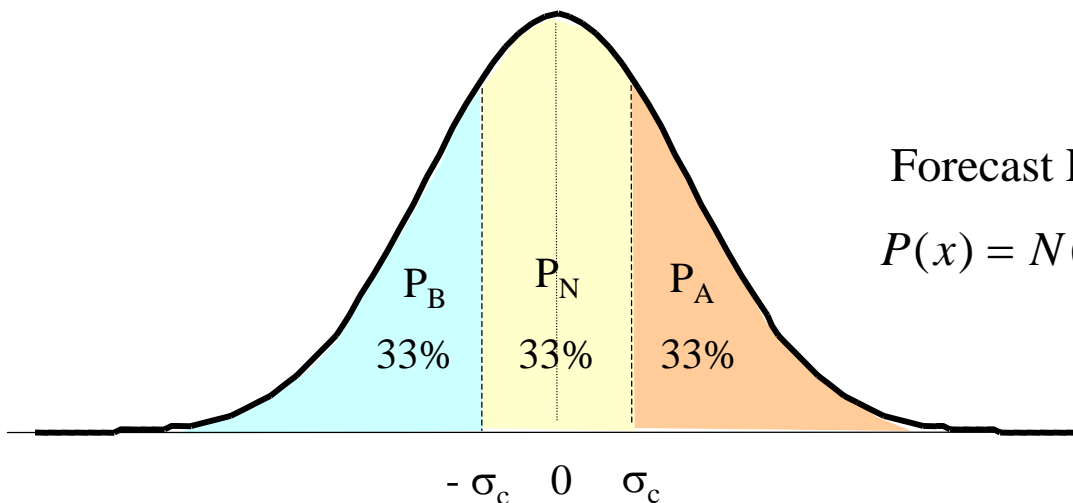
850hPa Temperature



APCN Probabilistic MME Schemes

Climatological PDF

$$P(x) = N(x, 0, \sigma_c) = \frac{1}{\sqrt{2\pi}\sigma_c} \exp\left(-\frac{x^2}{\sigma_c^2}\right)$$



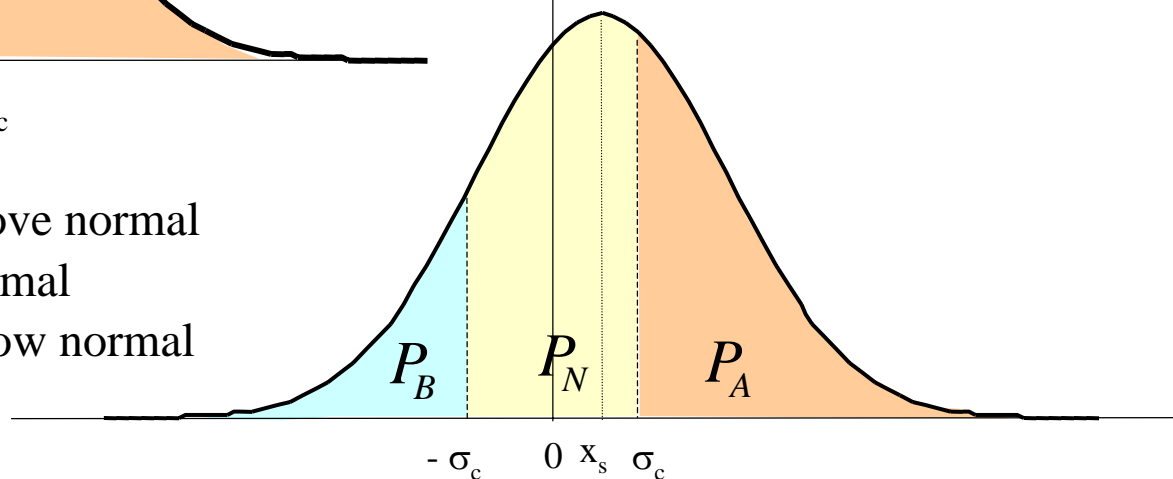
PA : probability of Above normal
 PN : probability of Normal
 PB : probability of Below normal

Probability of three categories

- ▣ Ranking (MMEP1)
- ▣ Normal distribution fitting (MMEP2)

Forecast PDF

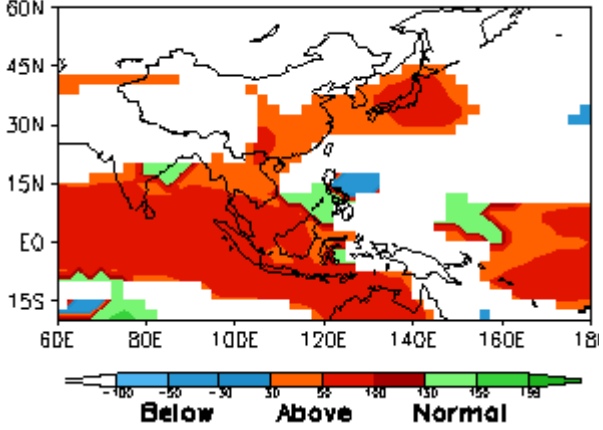
$$P(x) = N(x, x_s, \sigma_n) = \frac{1}{\sqrt{2\pi}\sigma_n} \exp\left(-\frac{(x - x_s)^2}{\sigma_n^2}\right)$$



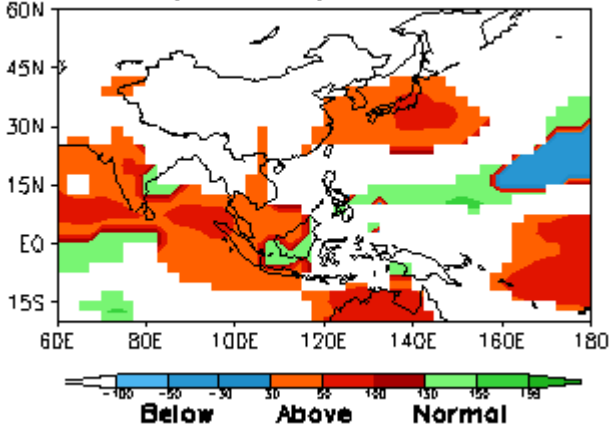
Probabilistic Forecast

T850 DJF 2004/05

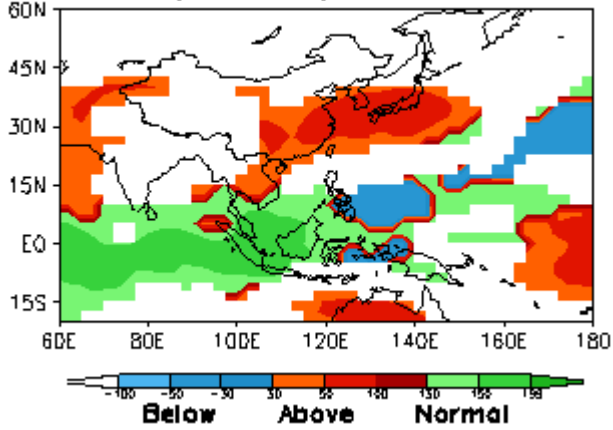
Pattern(DEC2004)



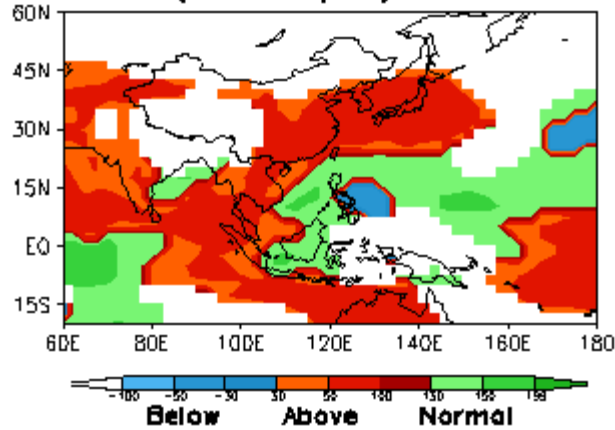
Pattern(JAN2005)



Pattern(FEB2005)

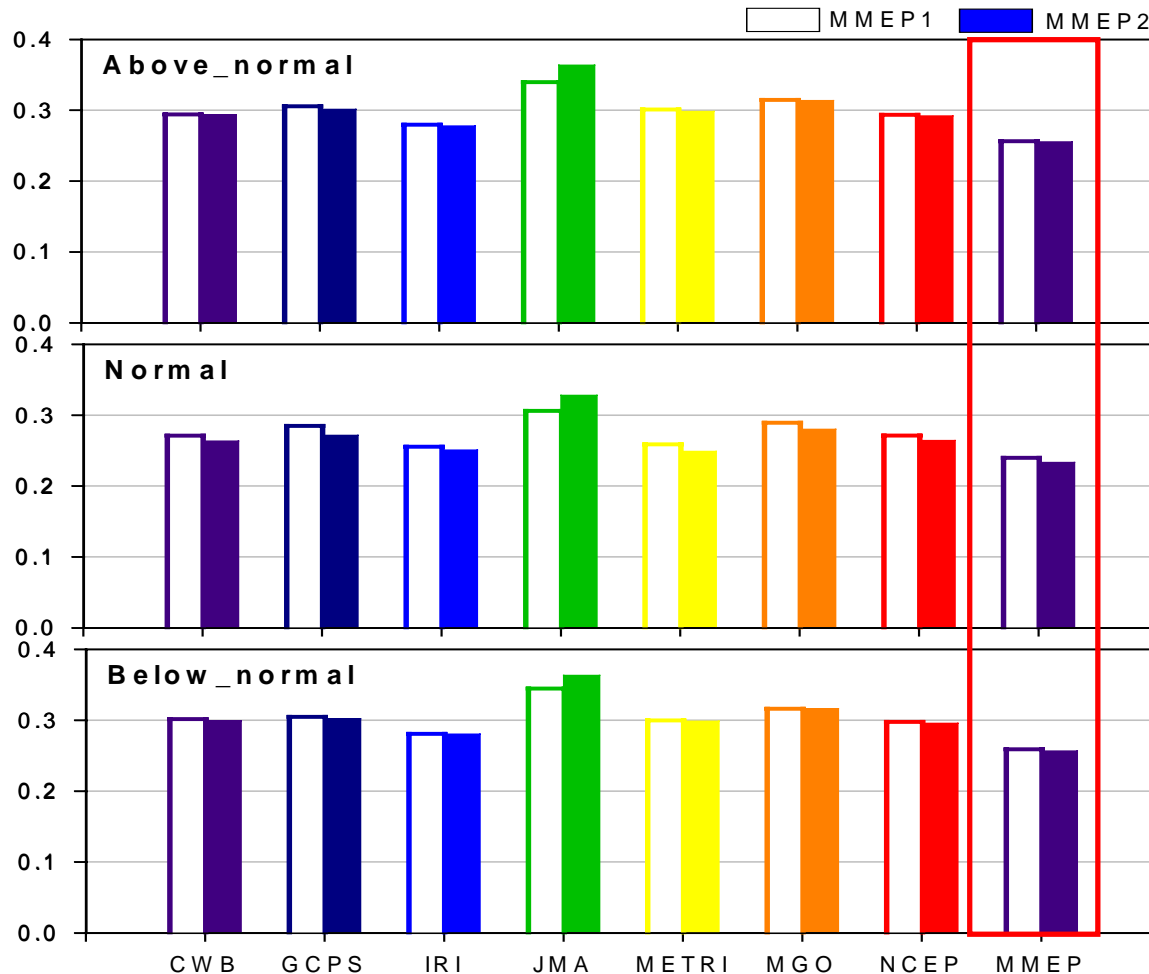


Pattern(DJF2004/05)



Results of Probabilistic MME Prediction

21-year(1979-1999) Averaged Brier Score for JJA mean T850



Lessons Learned

● **Training of the Models**

The design of weighting function is a key for the MME system. The weighting coefficient be derived using much larger samples, and the models participating in the MME be kept unchanged.

● **Boundary Forcing**

The SST prediction information must be incorporated in the MME seasonal prediction and the training of the models. The single model prediction is not able to provide us with reliable SST prediction information. One tier system is recommendable.

● **Daily Forecast Data**

It is desirable to archive daily time series data of key forecast variables, which provides useful information for various regions.

● **Data Exchange**

The standardized data format can help to reduce data processing.

Acknowledgments

- **S. Kar, V. Kryjov, W.-S. Lee, C. Zhu, H. Kang, A. Hovsepyan, H.-G. Jung, M.J. Yoon, Y.H. Byun (APCN, Korea)**
- **I.-S. Kang and many other colleagues at SNU**
- **C.-K. Park and many other colleagues at CPD/KMA**
- **Focal point of APEC Member Economies**