Development of Multi-model Ensemble technique and its application

Daisuke Nohara

APEC Climate Center (APCC), Busan, Korea

2007/2/21 JMA

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    2. statistical downscaling
4. Summary

Asia Pacific Economy Cooperation (APEC)

To meet the Bogor Goals of free and open trade and investment in the Asia-Pacific region

- **Trade and Investment Liberalisation**
- **Business Facilitation**
- **Economic and Technical Cooperation**

History

1998	Oct.	Proposed APCN : 3rd APEC S&T Ministers' Meeting
1999	Aug.	Approved APCN : 17th APEC ISTWG Meeting
		...
2003	Jan.	Established at the Korea Meteorological Administration
2004	Mar.	Proposed the establishment of APCC : 4th APEC S&T Minister's Meeting
	Sep.	Supported the establishment of APCC : 27th APEC ISTWG Meeting
2005	Mar.	Endorsed the establishment of APCC : 1st APEC Senior Official's Meeting
	Nov.	Welcomed the establishment of APCC : 17th APEC Ministerial Meeting
		Opening Ceremony : 13th APEC Economic Leader's Meeting

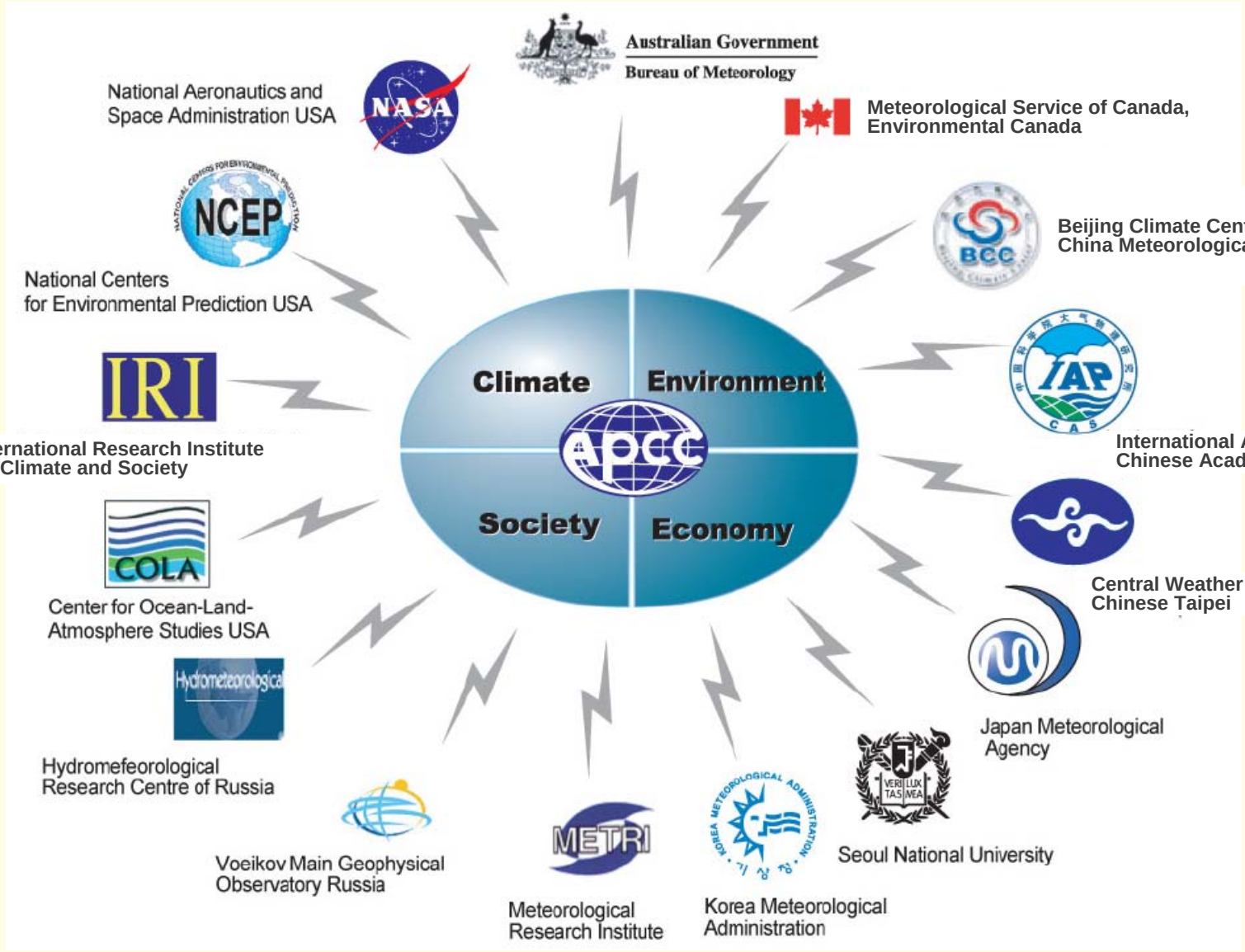
Goals of APCC

- Facilitating the share of high-cost climate data and information
- Capacity building in prediction and sustainable social and economic applications of climate information
- Accelerating and extending socio-economic innovation

Functions of APCC

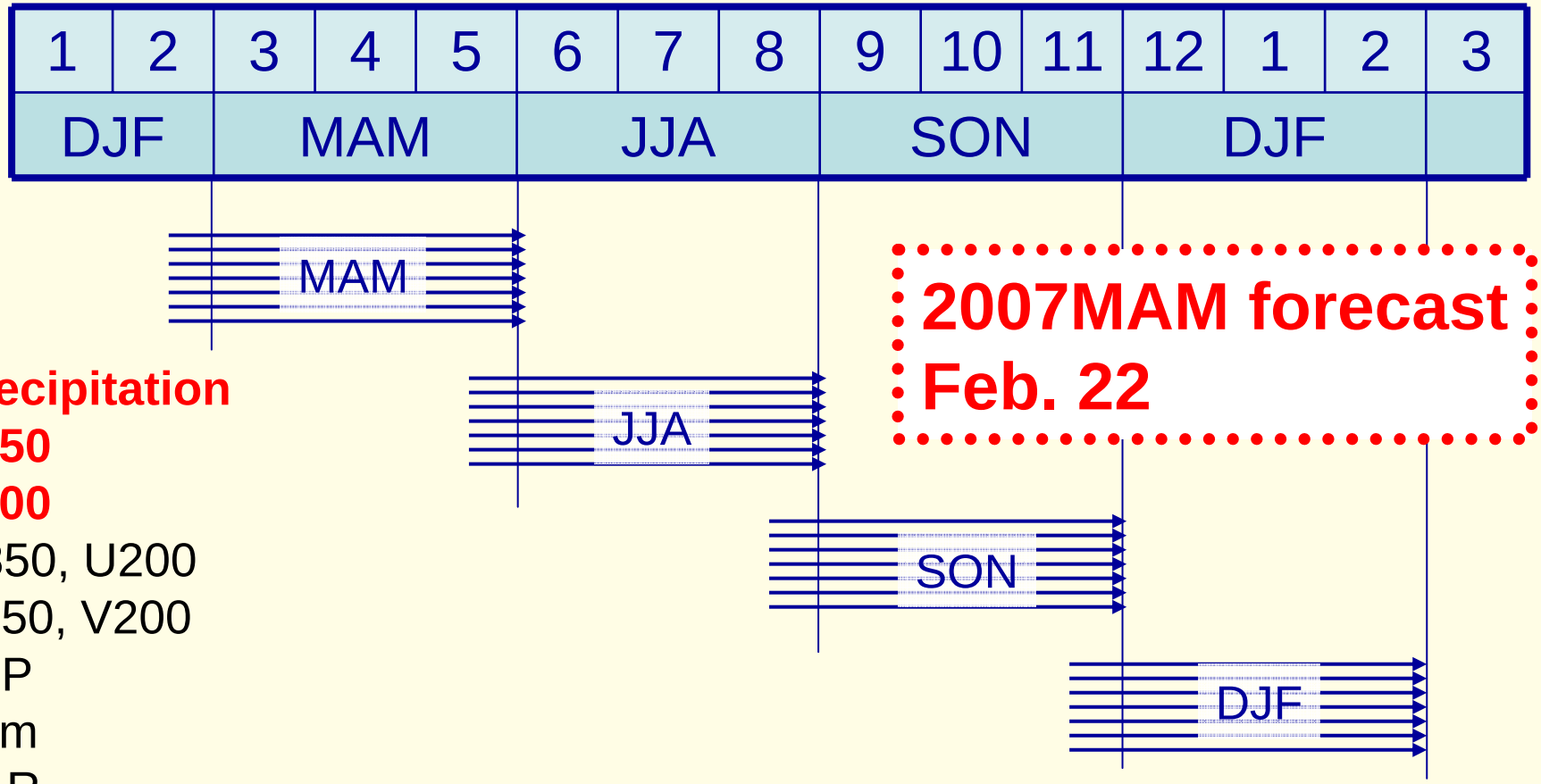
- Developing a value-added reliable climate prediction system
- Acting as a center for climate data and related information
- Coordinating research toward the development of an APEC integrated climate-environment-socio-economic system model

Multi-Institutional cooperation



Seasonal forecast based on Multi-Model Ensemble (MME)

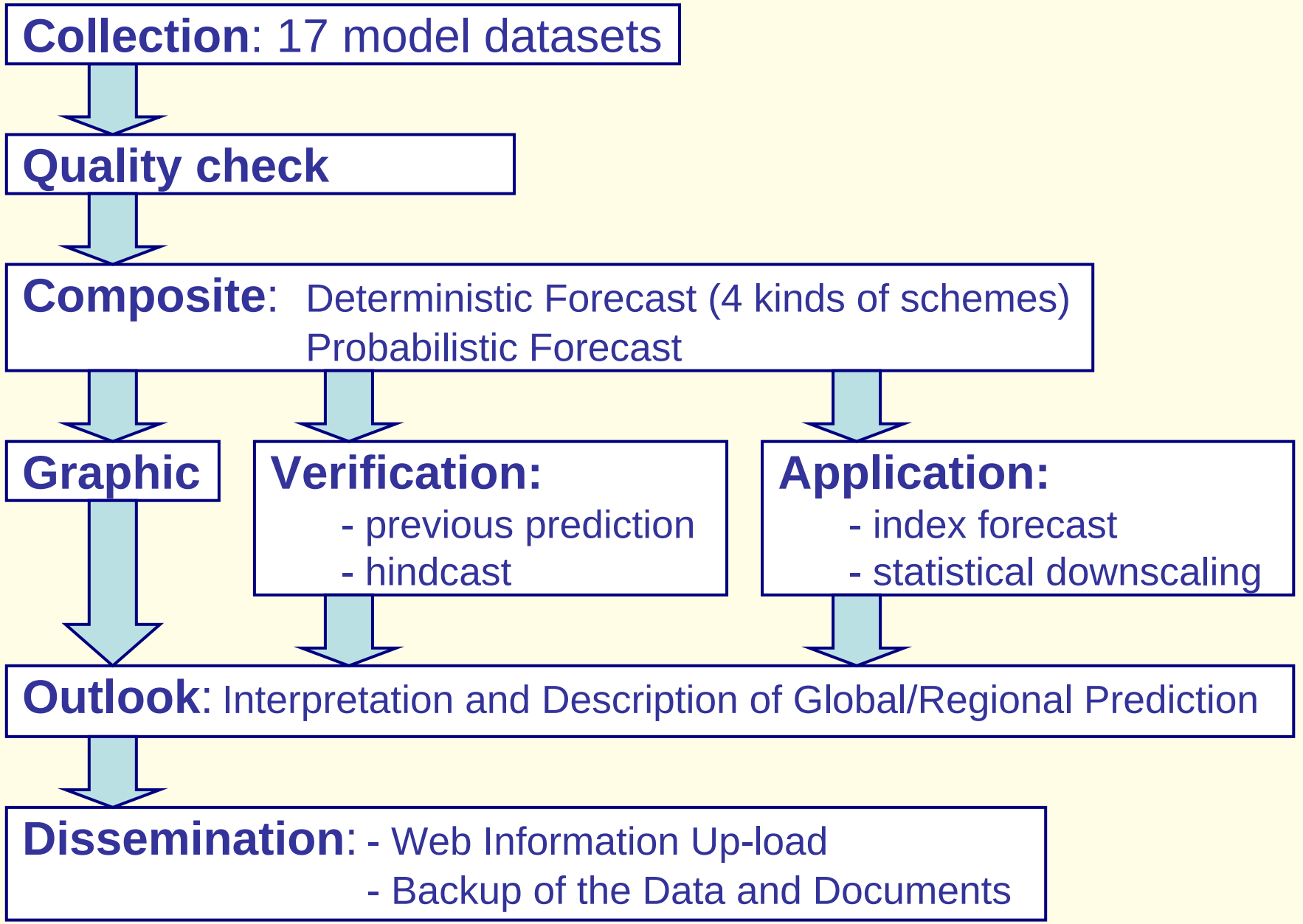
Schedule of APCC seasonal forecast



Precipitation
T850
Z500
U850, U200
V850, V200
SLP
T2m
OLR

APCC provides 3 month forecast in each season.

Procedure of seasonal forecast



APCC 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/SNU	Seoul National University	T63L21
	METRI/KMA	Meteorological Research Institute	4 ° × 5 ° L17
Russia	MGO	Main Geophysical Observatory	T42L14
	HMC	Hydrometeorological Centre of Russia	1.12 ° × 1.4 ° L28
USA	IRI	International Research Institute	T42L19
	COLA	Center for Ocean-Land-Atmosphere Studies	T63L18
	NCEP	NCEP Coupled Forecast System	T62L64
	NSIPP/NASA	National Aeronautics and Space Administration	2 ° × 2.5 ° L34

APCC Deterministic MME Schemes

1. SCM: **Simple composite of individual forecast with equal weighting.**

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

2. CPP – Coupled Pattern Projection Method :

Simple composite of individual forecasts, after correction by statistical downscaling using CPPM

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

3. MRG – Multiple Regression:

Optimally weighted composite of individual forecasts. The weighting coefficient is obtained by SVD based regression.

$$P = \sum_i a_i F_i'$$

4. SSE – Synthetic Multi-Model Super Ensemble:

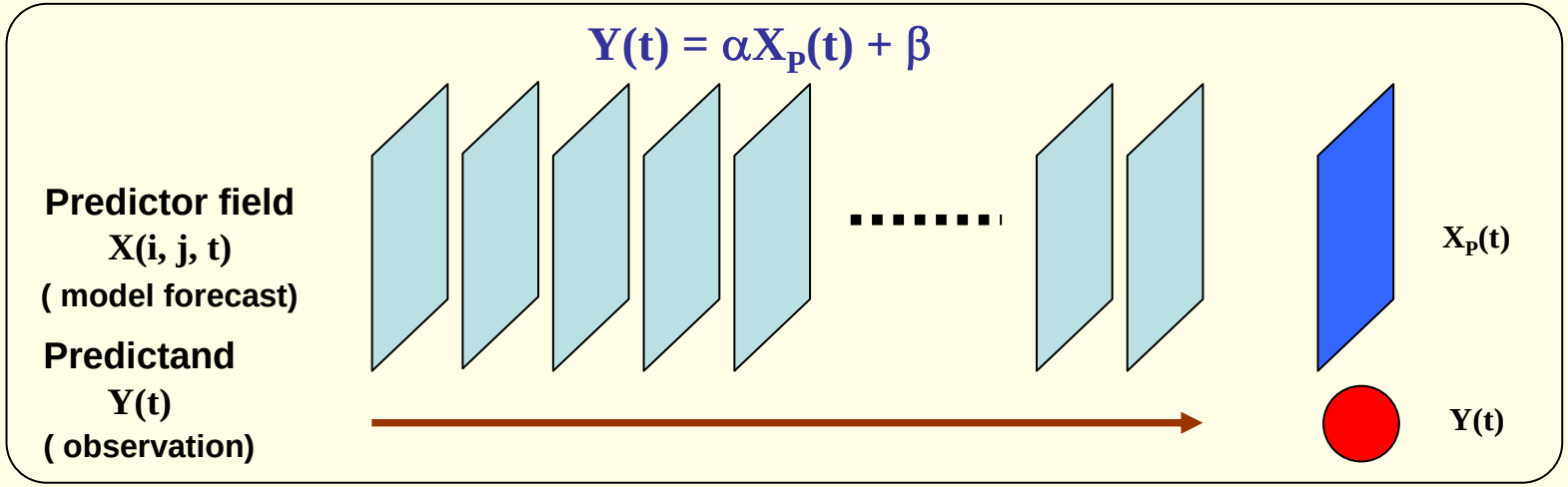
$$P = \frac{1}{M}\sum_i \alpha_i \hat{F}_i'$$

Weighted combination of statistically corrected multi model output

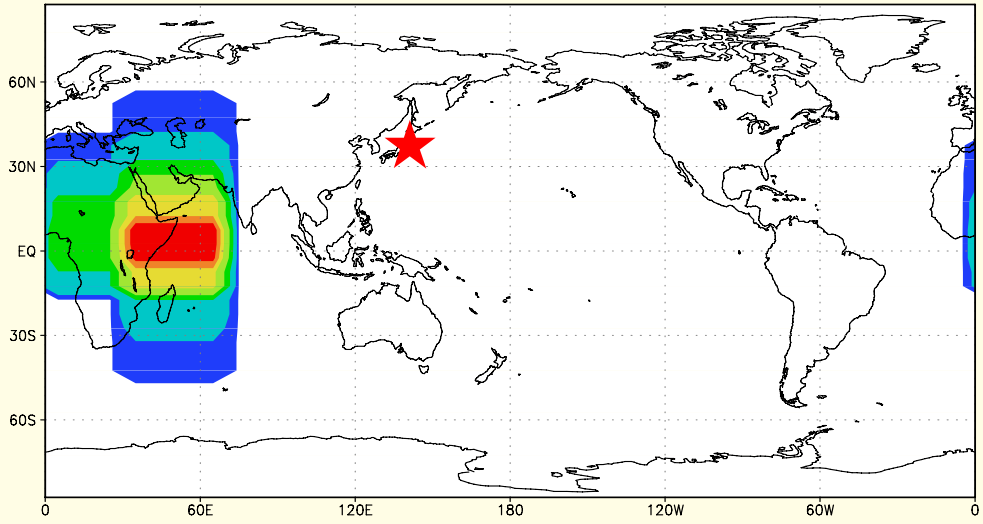
APCC Deterministic MME Schemes

2. CPP – Coupled Pattern Projection Method :

Simple composite of individual forecasts, after correction by statistical downscaling using CPPM



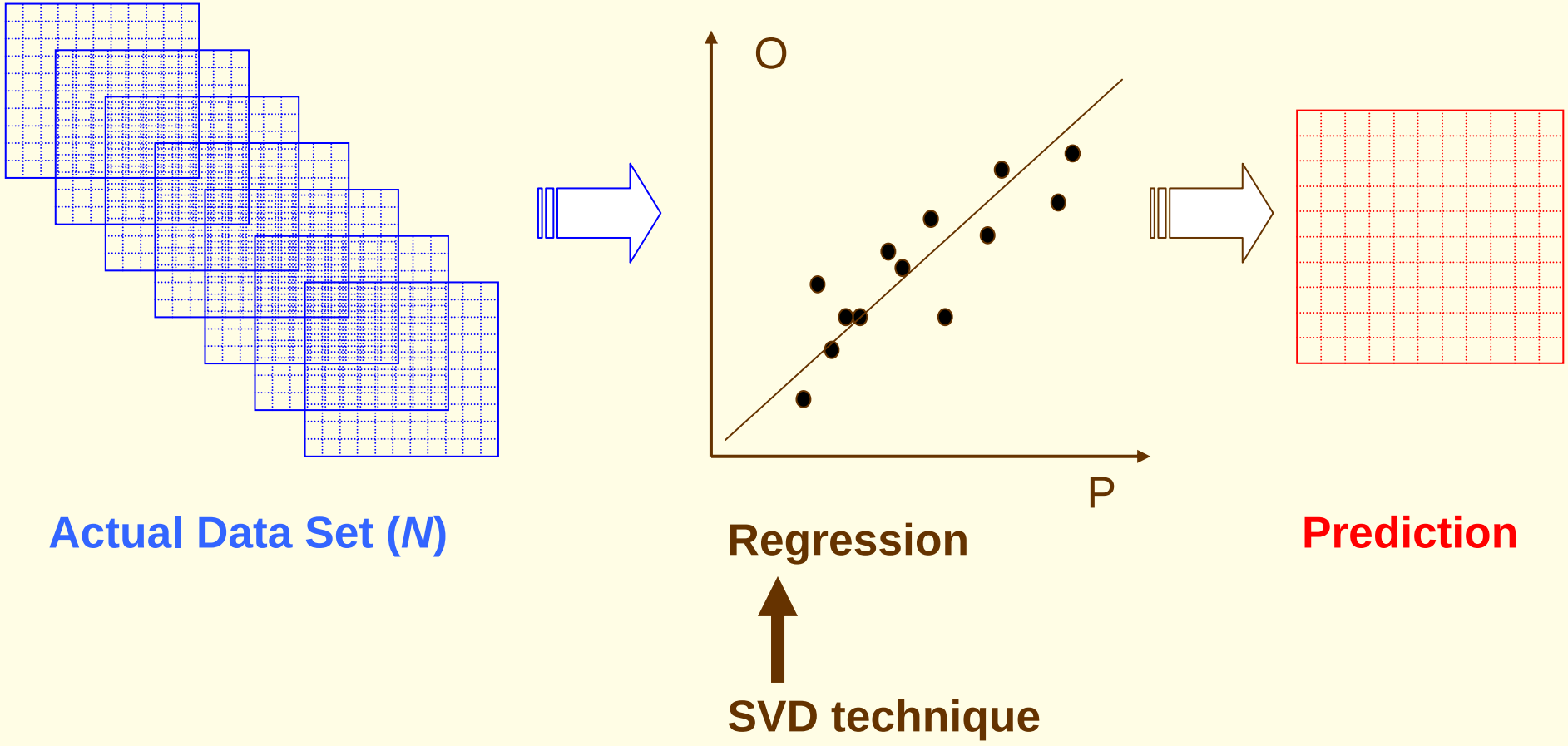
1. **determination of spatial pattern which is related to the target region.**
2. **calculation of regression coefficient in training period.**
3. **composition of all models**



APCC Deterministic MME Schemes

3. MRG – Multiple Regression:

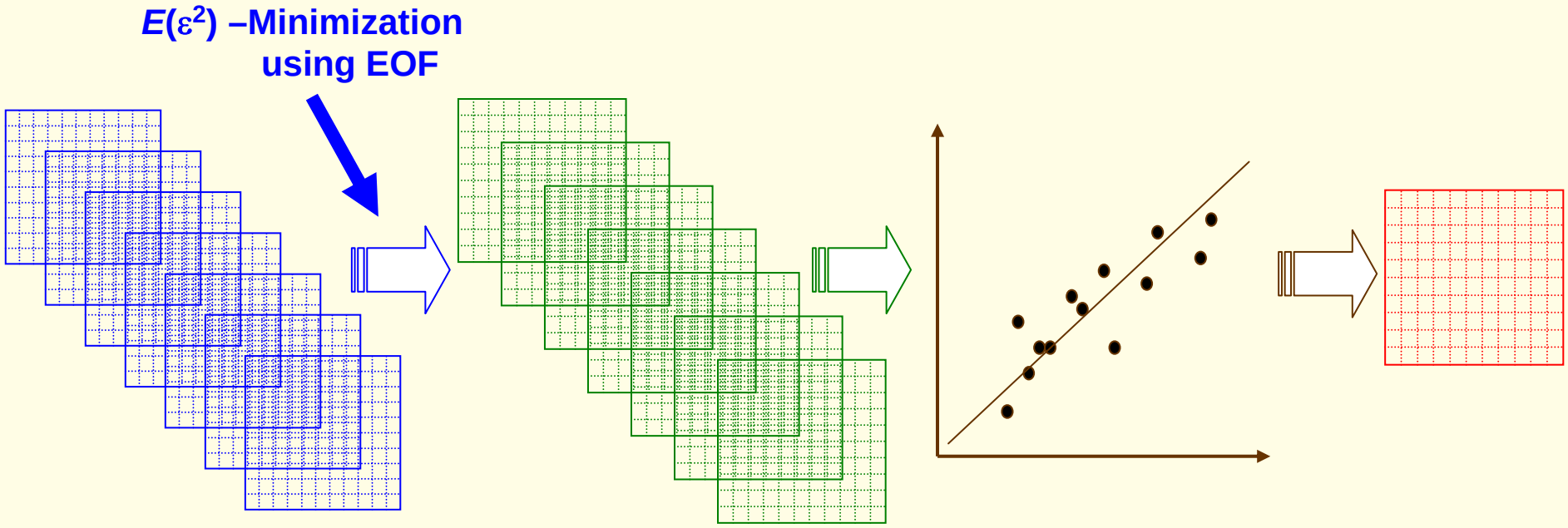
Optimally weighted composite of individual forecasts. The weighting coefficient is obtained by SVD based regression.



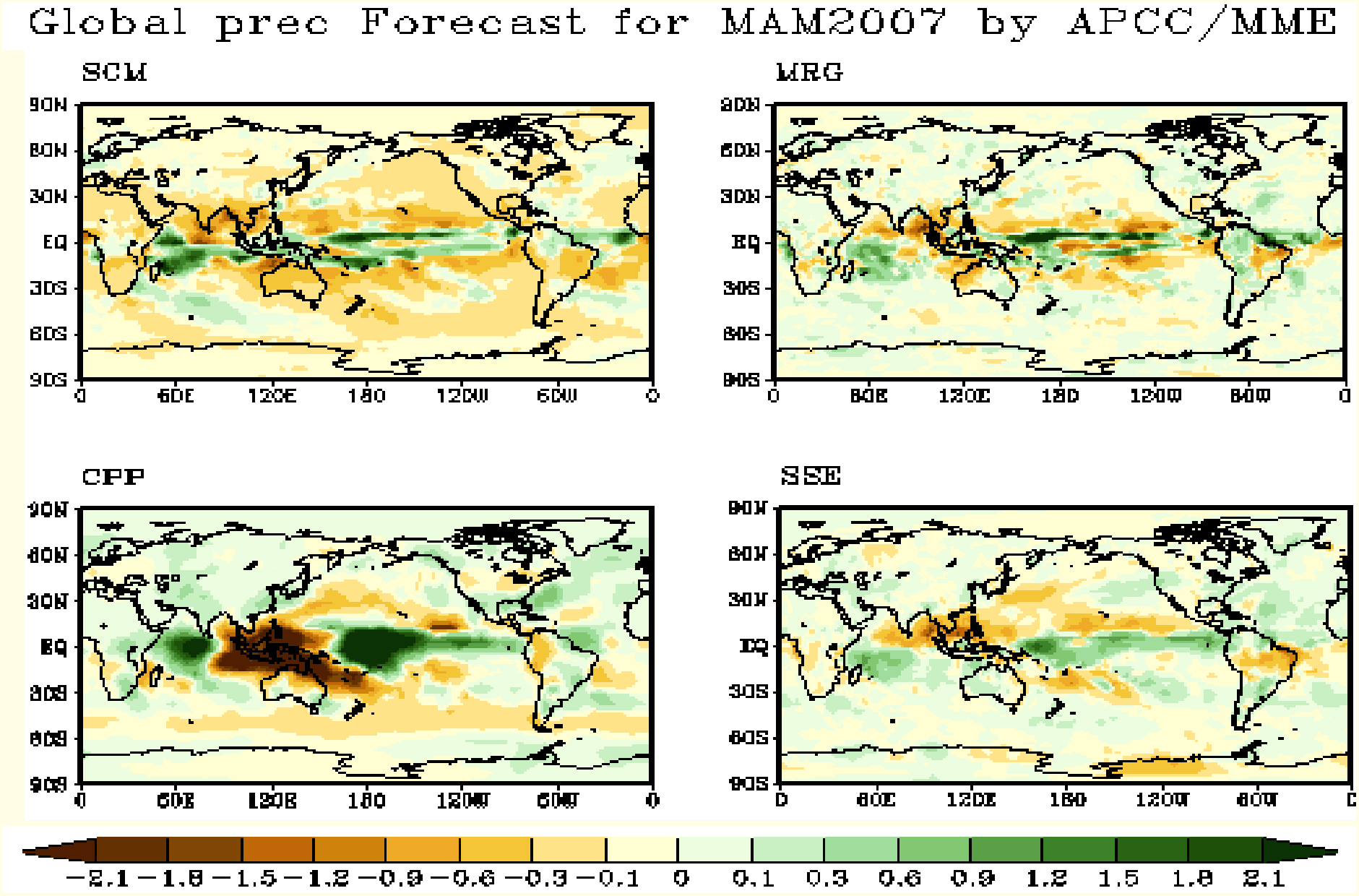
APCC Deterministic MME Schemes

4. SSE – Synthetic Multi-Model Super Ensemble:

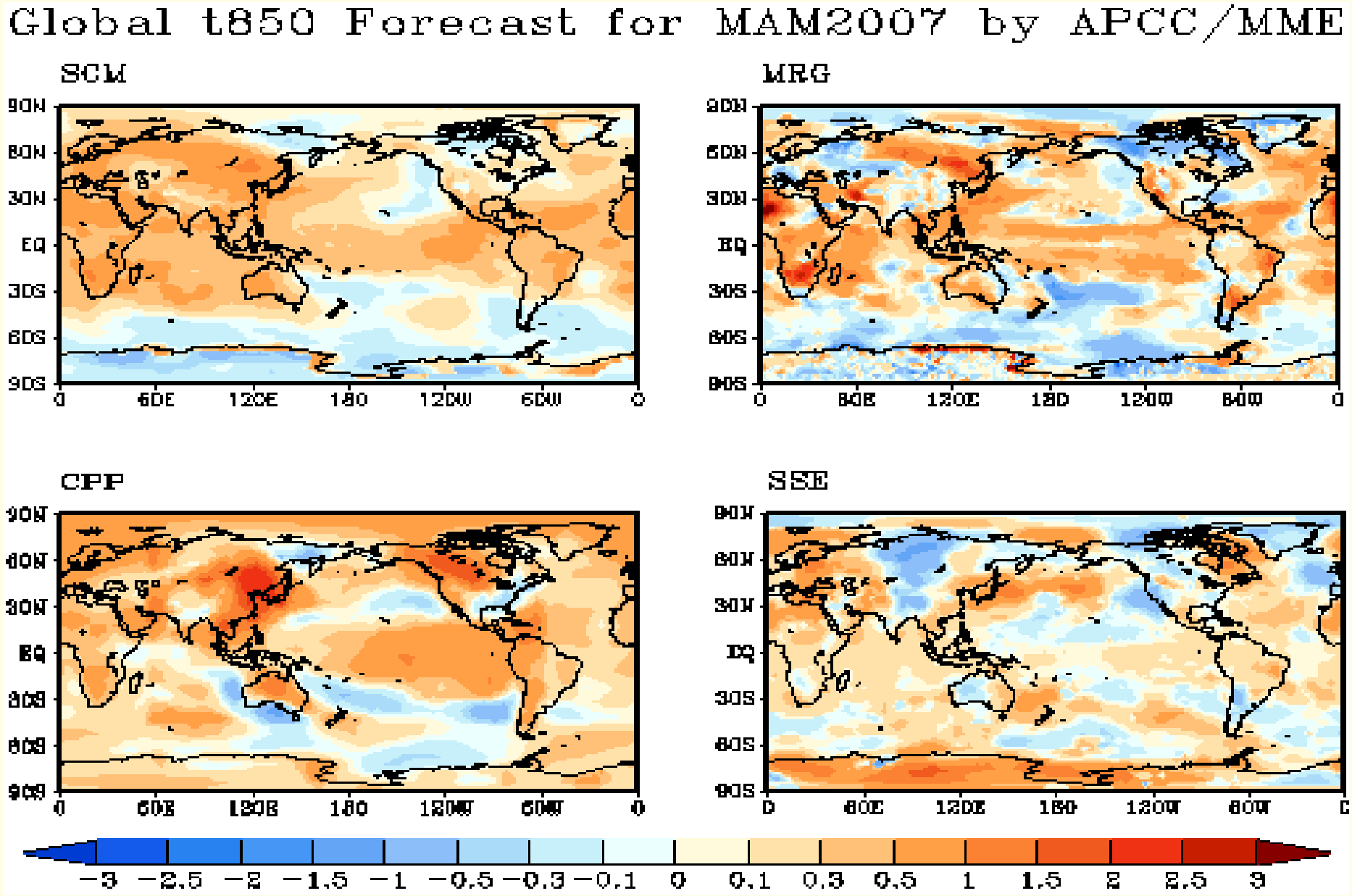
Weighted combination of statistically corrected multi model output



APCC Deterministic MME Forecast

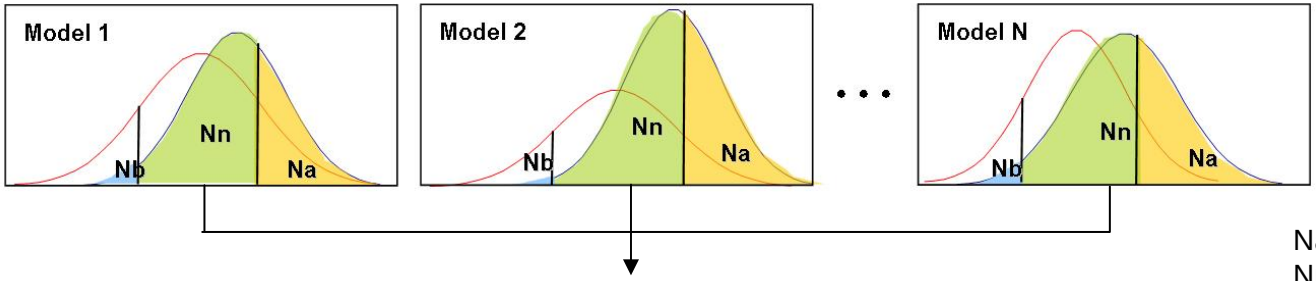


APCC Deterministic MME Forecast

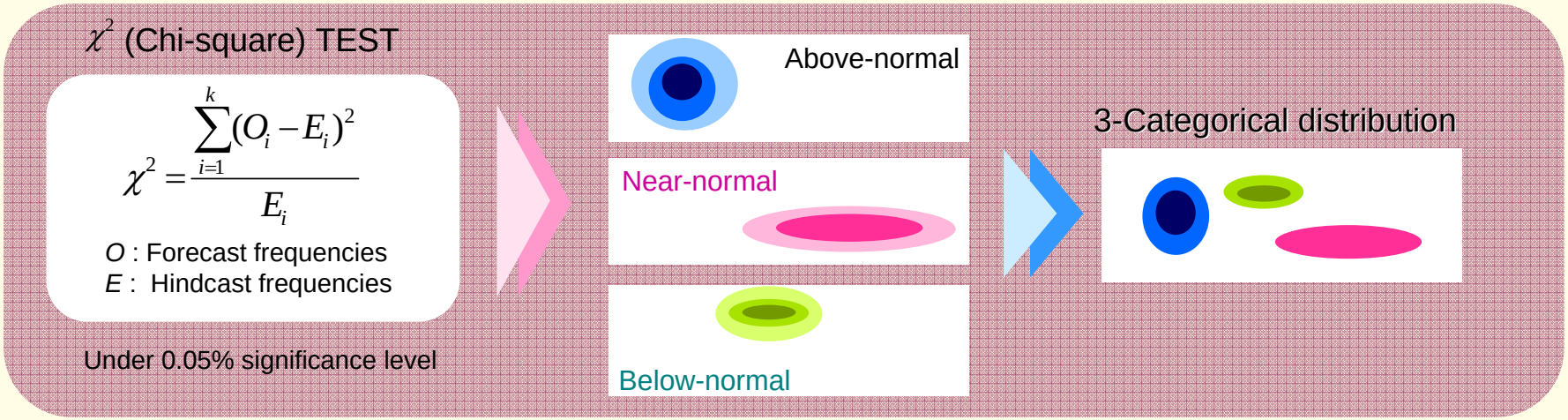


APCC Probabilistic MME Schemes

- **Combine different models**

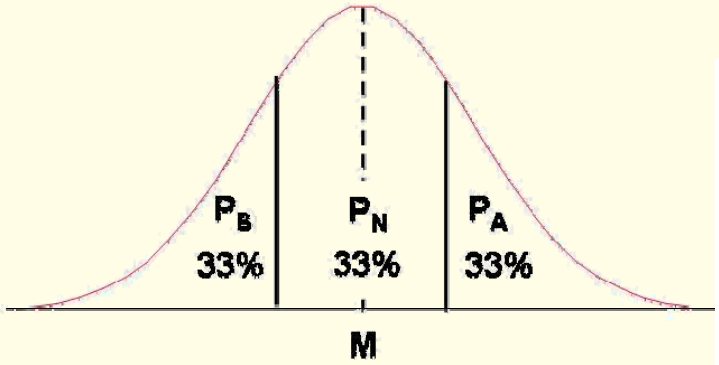


- **Merged 3-category distribution**

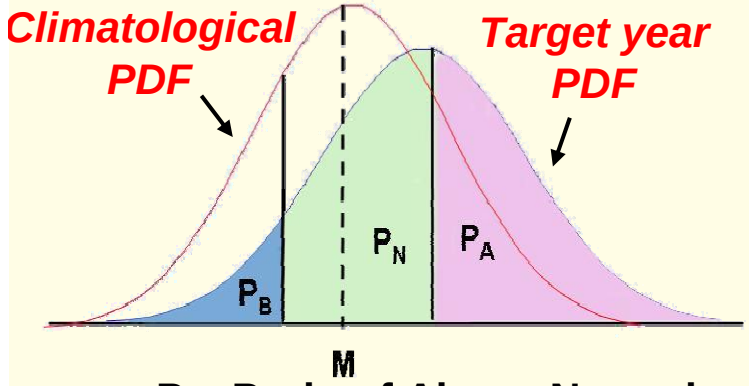


APCC Probabilistic MME Schemes

- **Normal fitting method**



- **Probabilistic forecast**

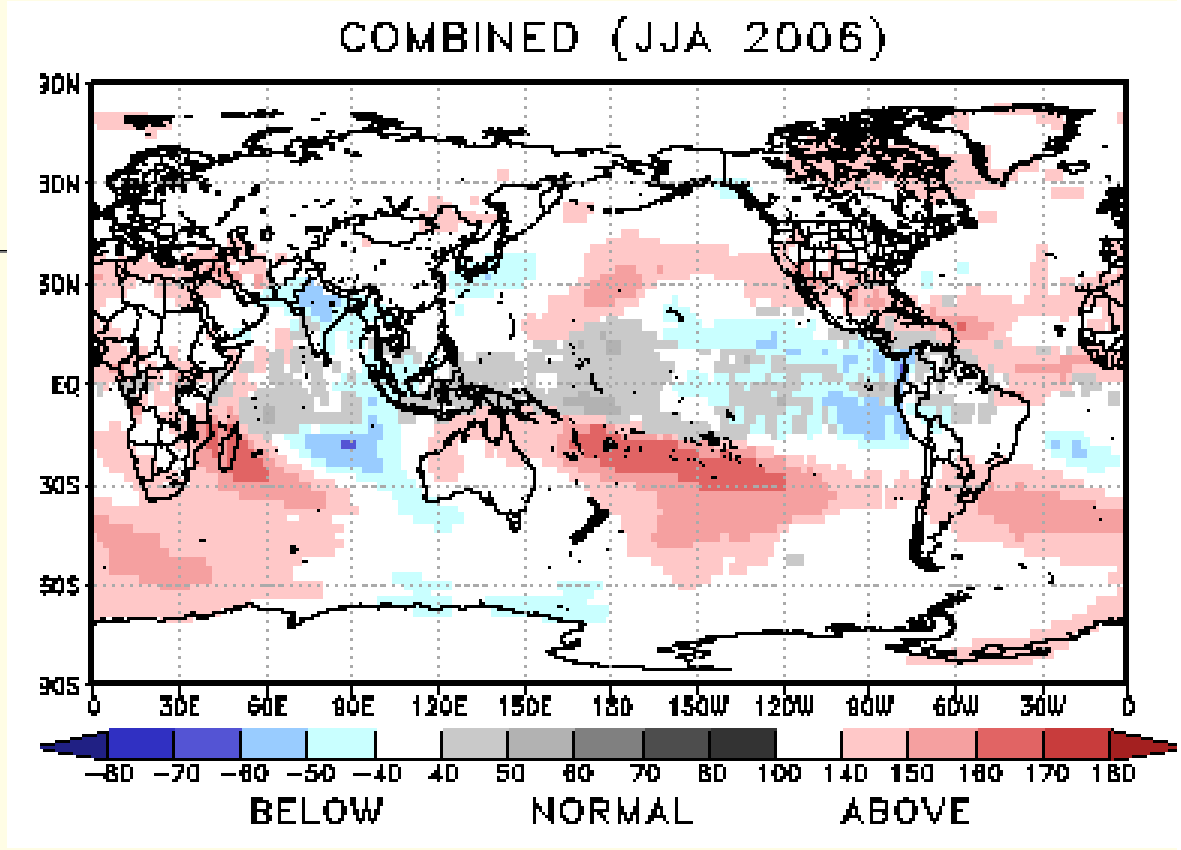


P_A: Prob. of Above-Normal

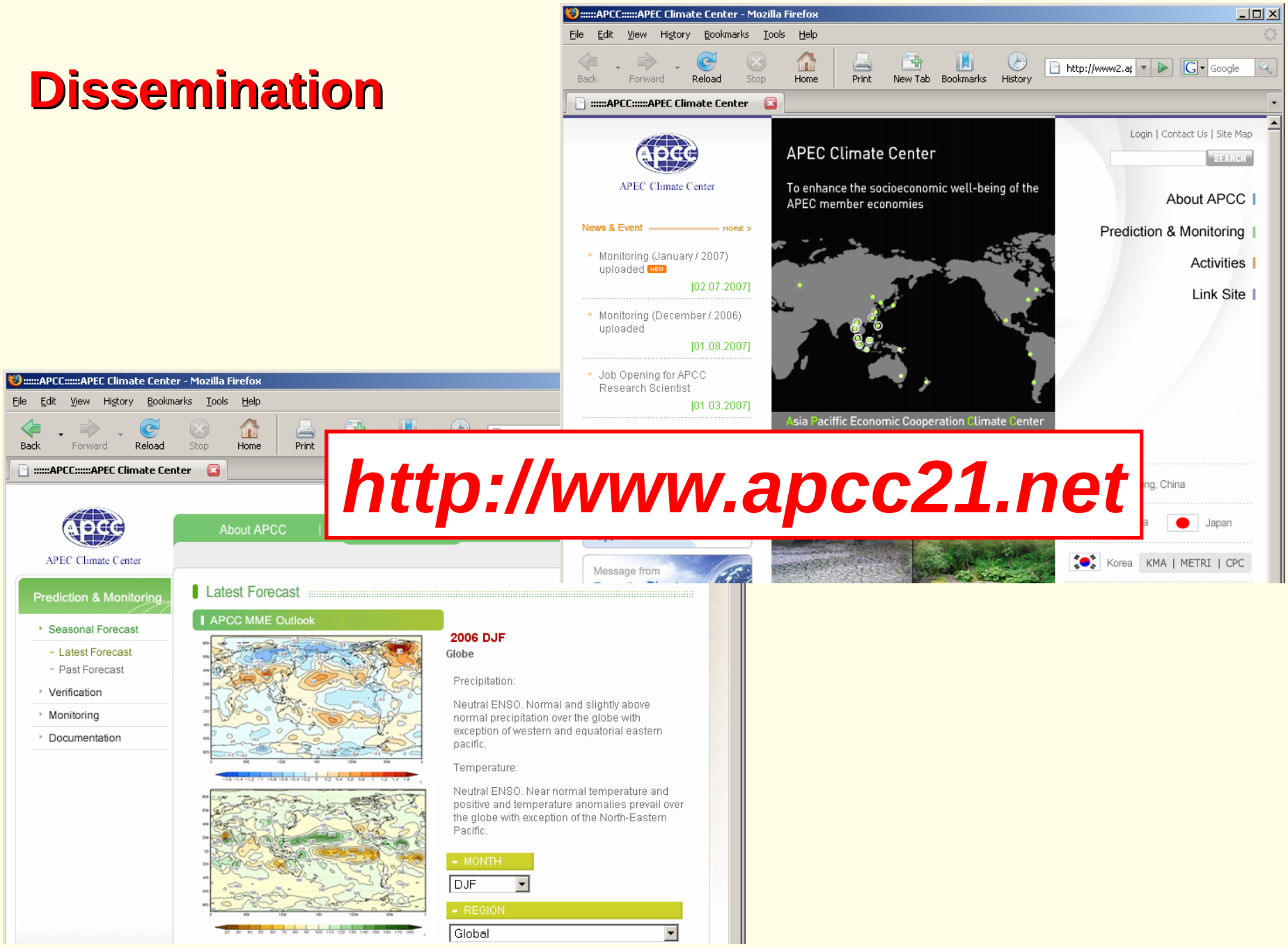
P_N: Prob. of Near-Normal

P_B: Prob. of Below-Normal

APCC Multi-Model Probabilistic Forecast
Temperature at 850 hPa (2006JJA)



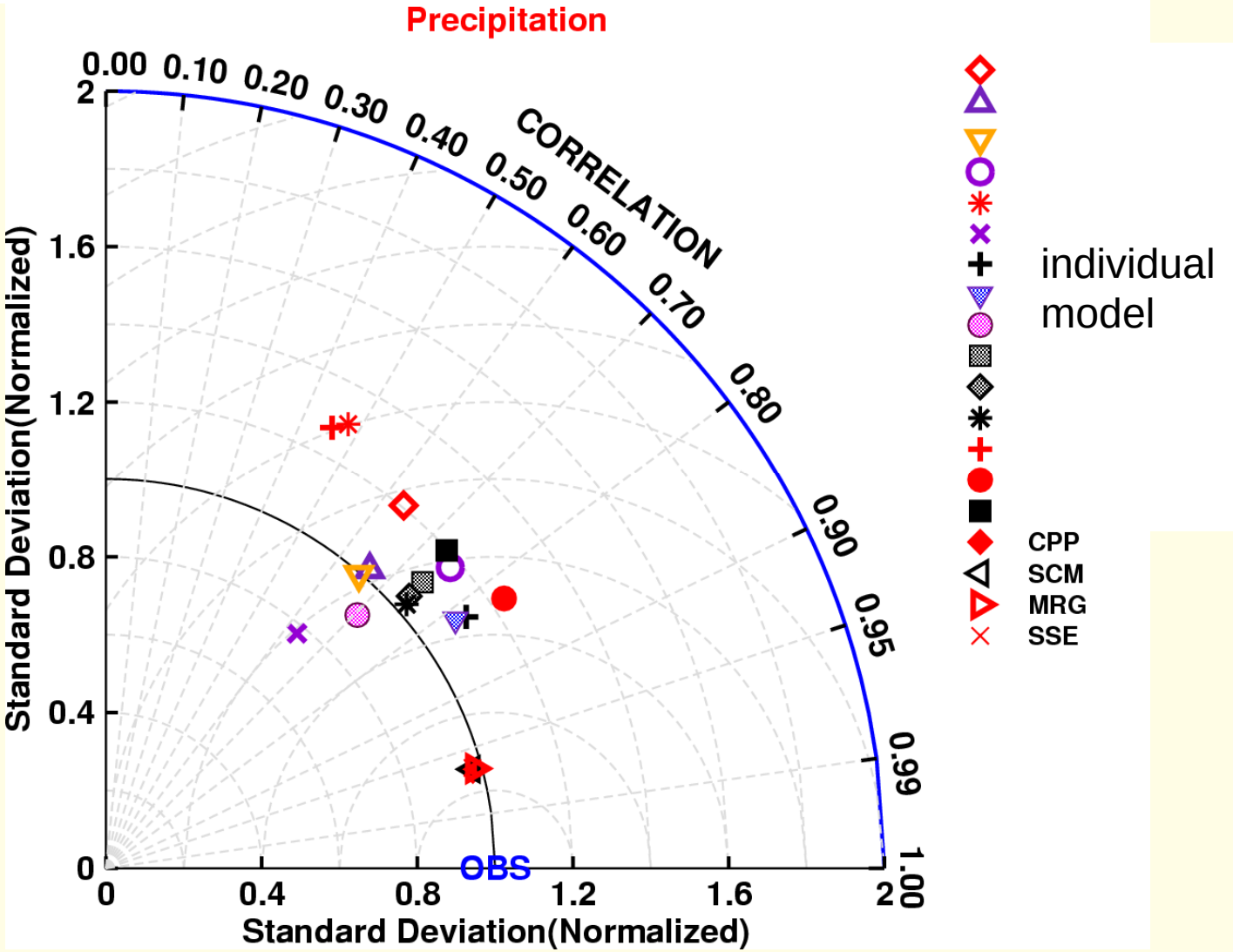
Dissemination



Verification for Seasonal Forecast

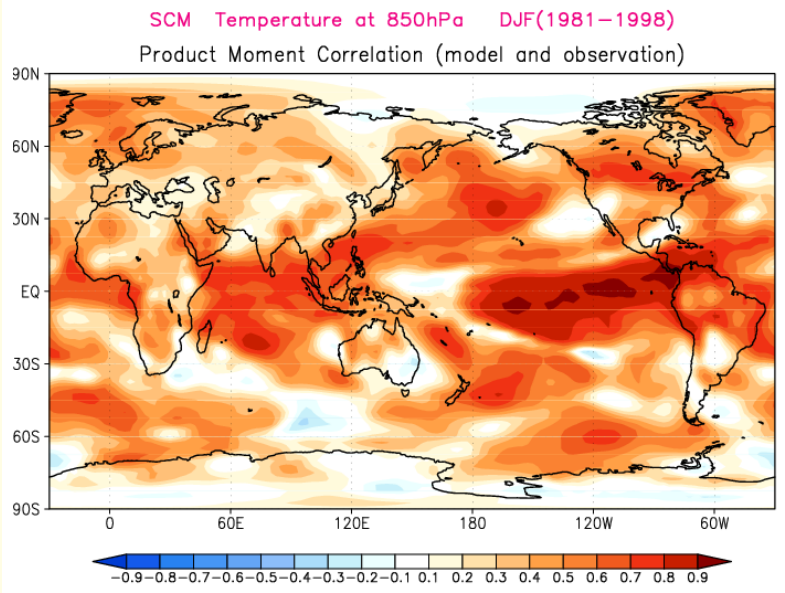
Verification of Deterministic MME (model performance)

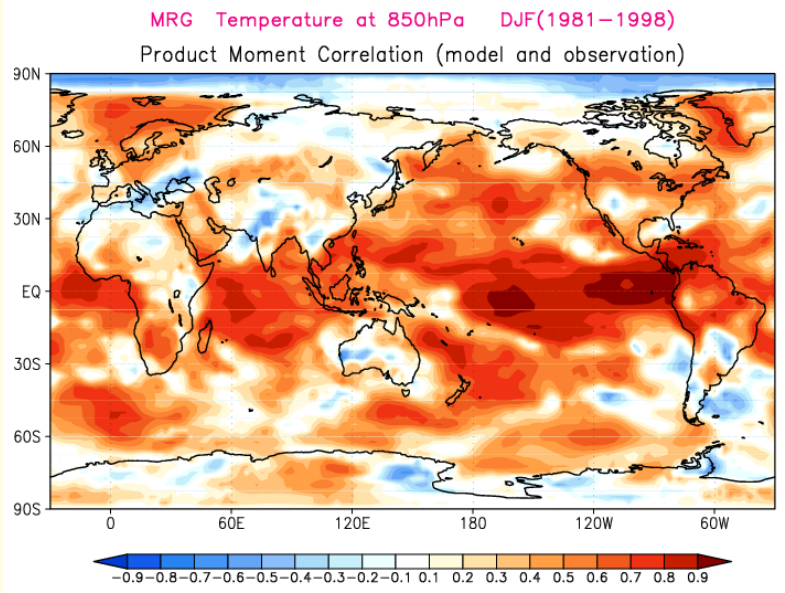
Taylor Diagram : 1983~2003, JJA Hindcast

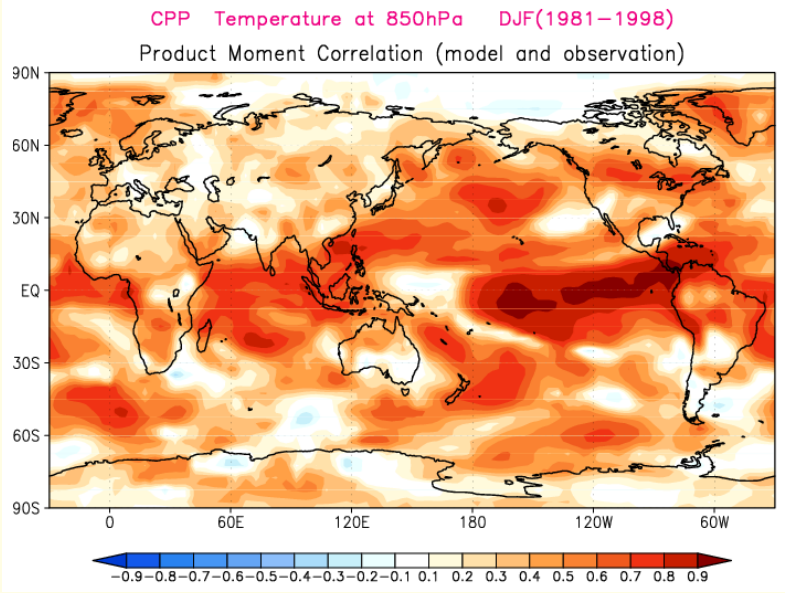


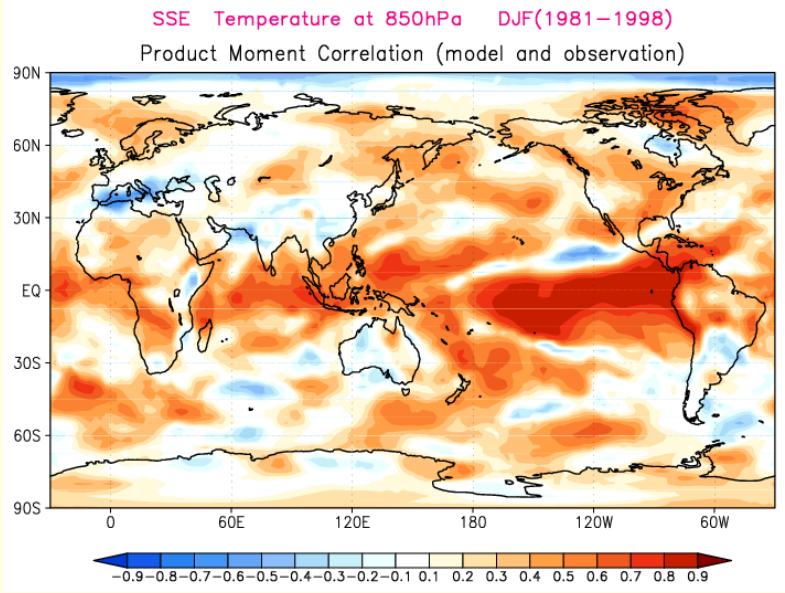
Verification of Deterministic MME

(spatial distribution of MSSS)

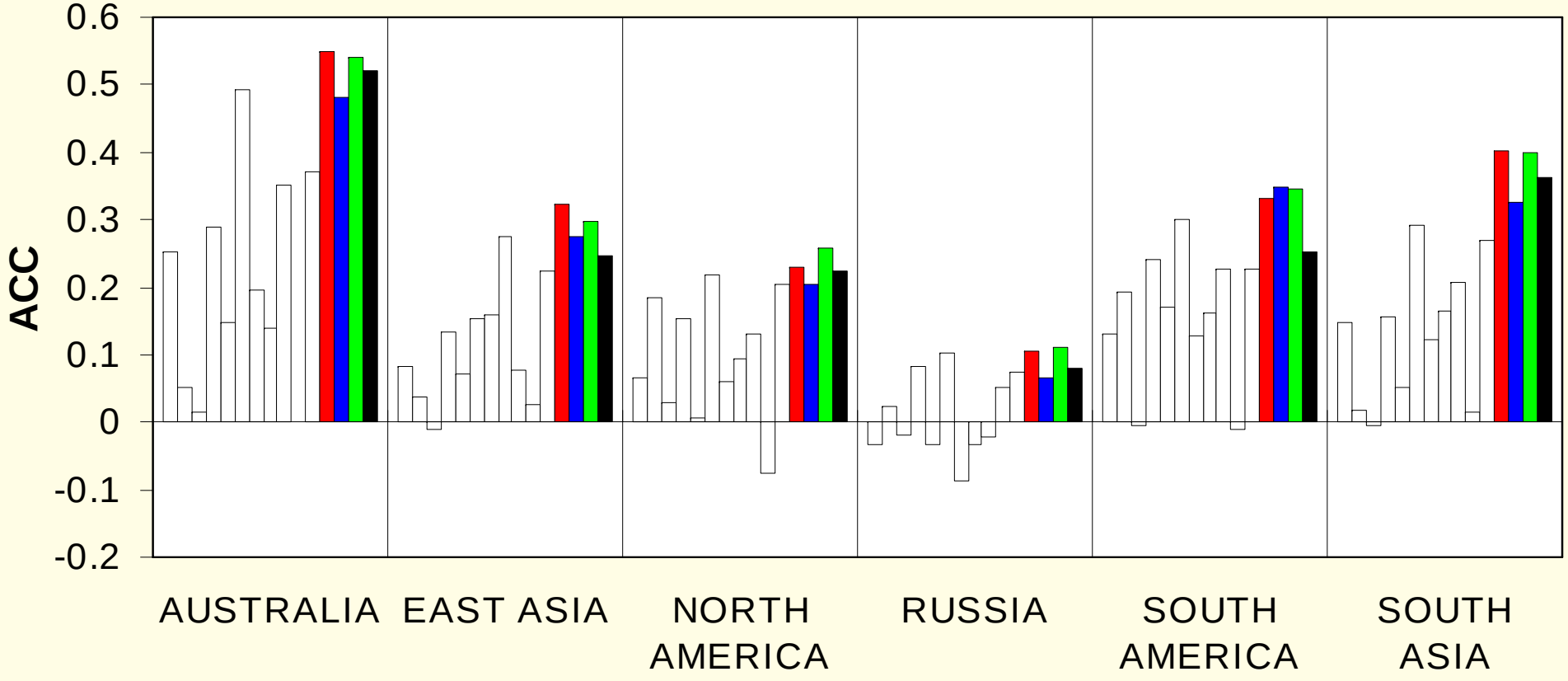




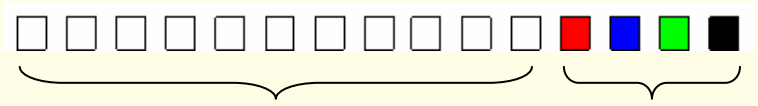




Verification of Deterministic MME (regionality)

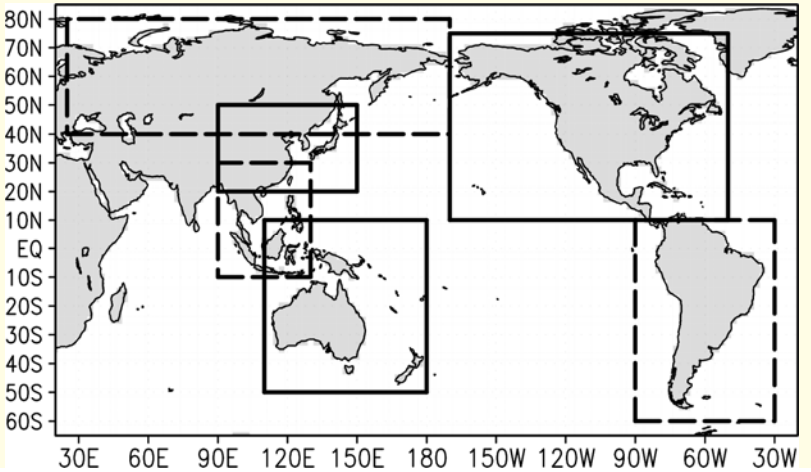


Anomaly Correlation Coefficient for hindcast in each region (precipitation, JJA, 1983-2003)

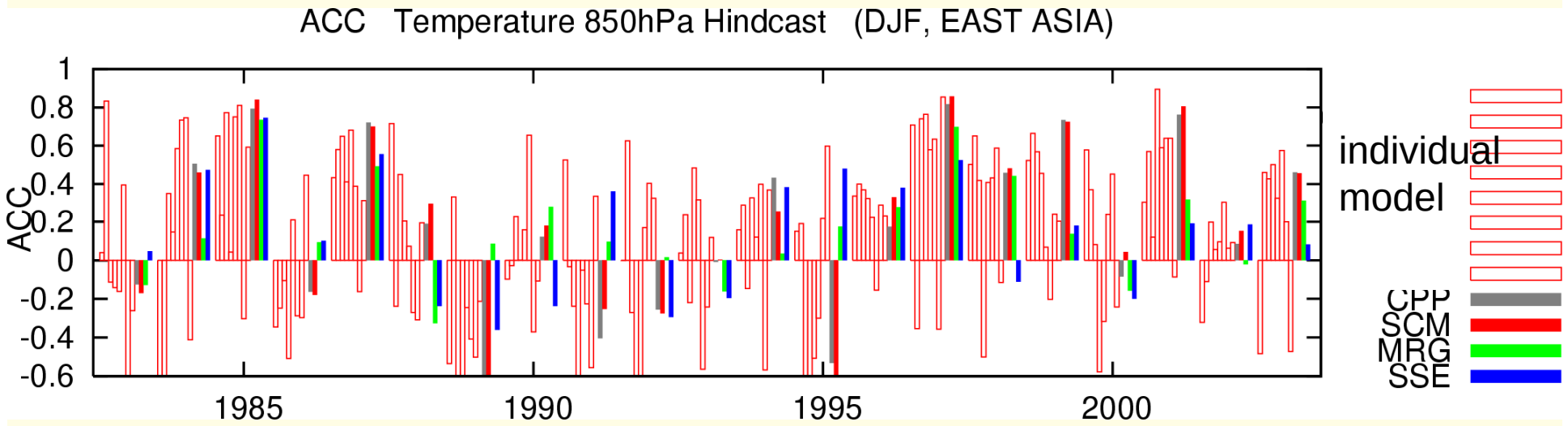


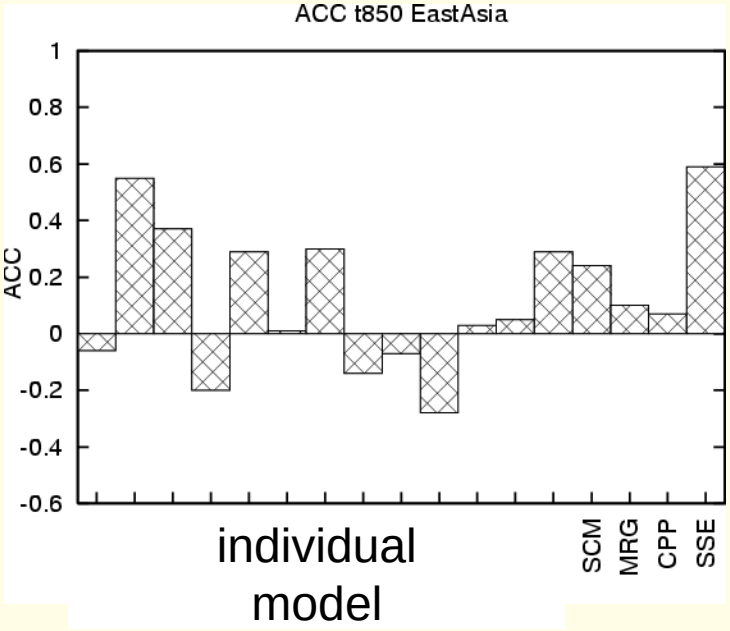
individual model

multi-model ensemble schemes

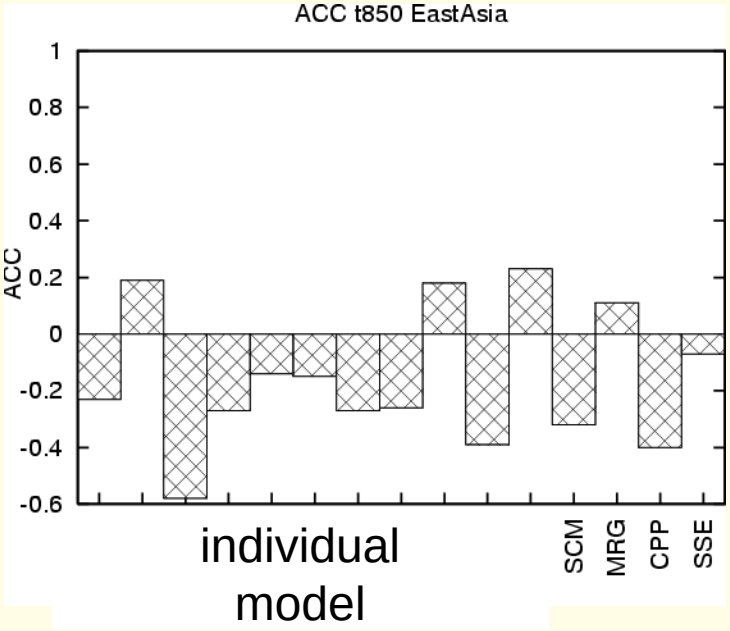


Verification of Deterministic MME (ACC skill score)





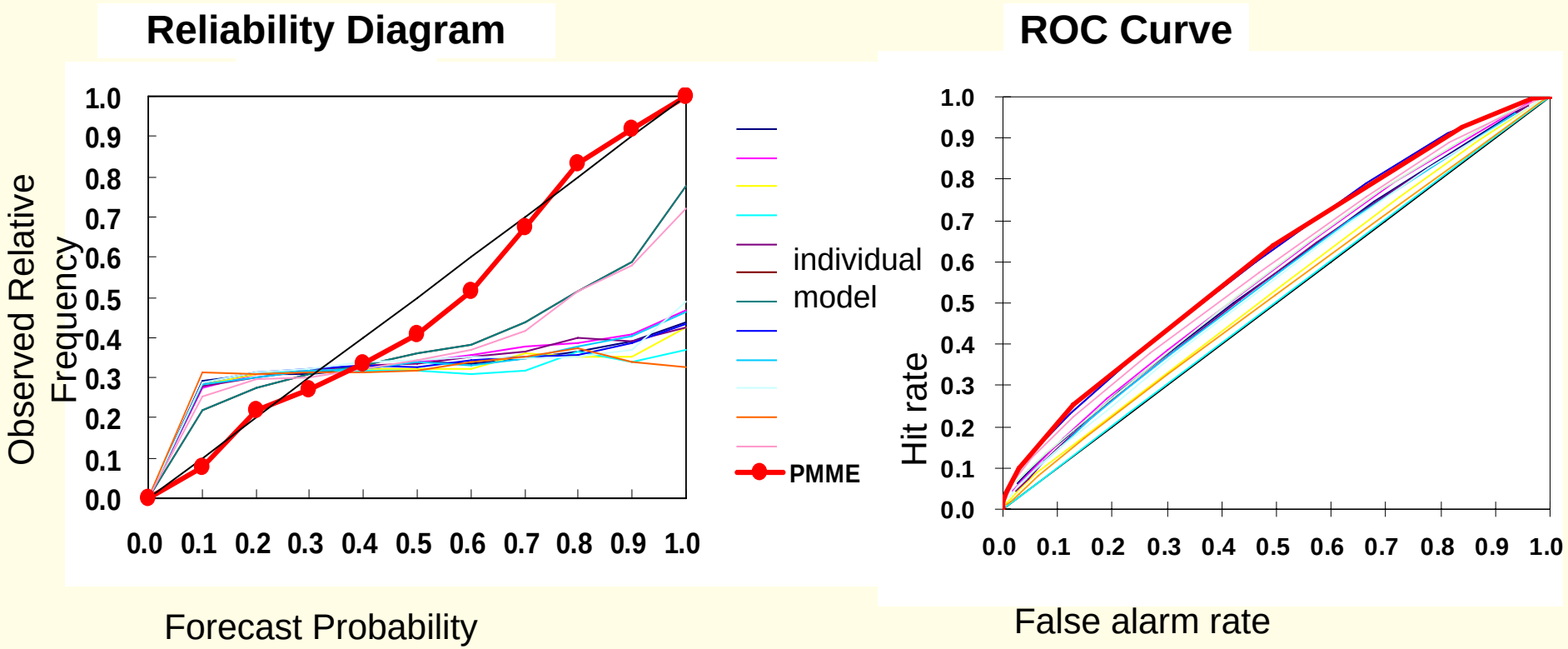
2004DJF forecast



2005DJF forecast

Verification of Probabilistic MME

Globe, Above-Normal, Precipitation

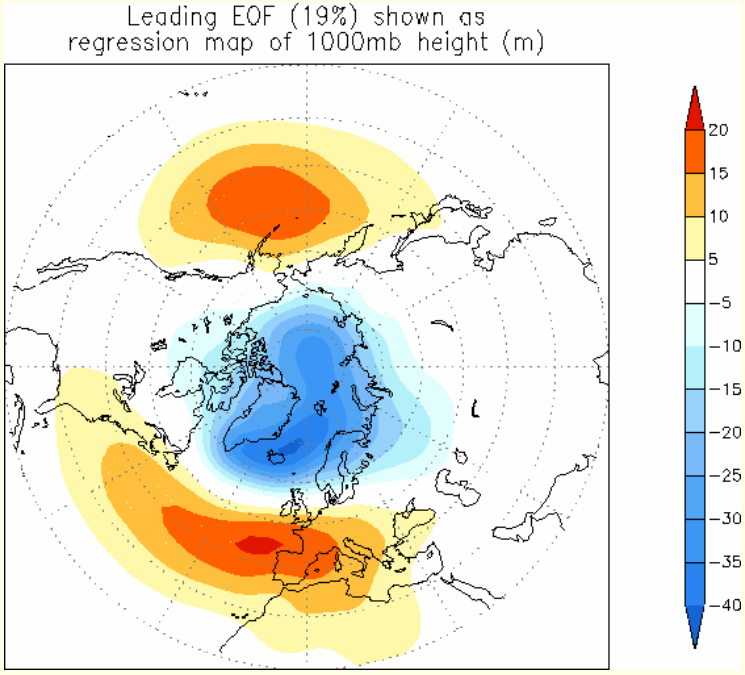


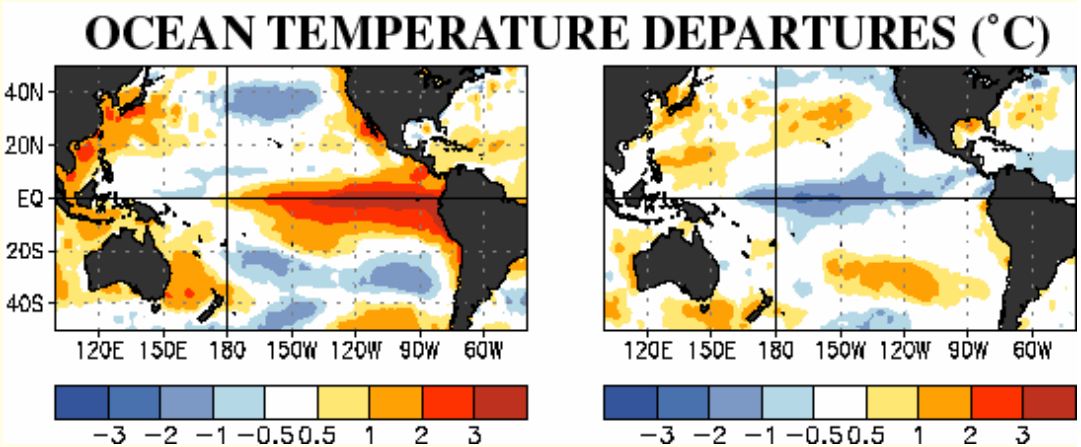
Forecast skill of probabilistic multi-model ensemble is better than that of individual model.

Application using APCC prediction

Application using APCC prediction

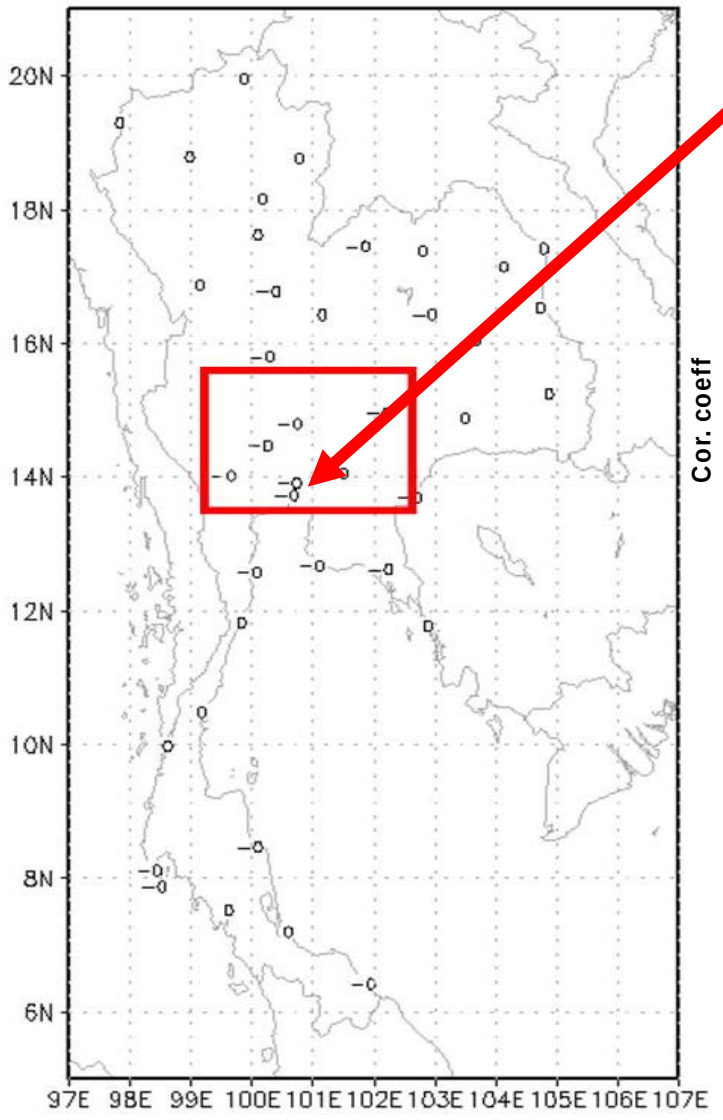
- Statistical downscaling using MME prediction
  - Thailand, Philippine, China
- Index forecast
  - El Nino, PNA, AO, NAO, Monsoon



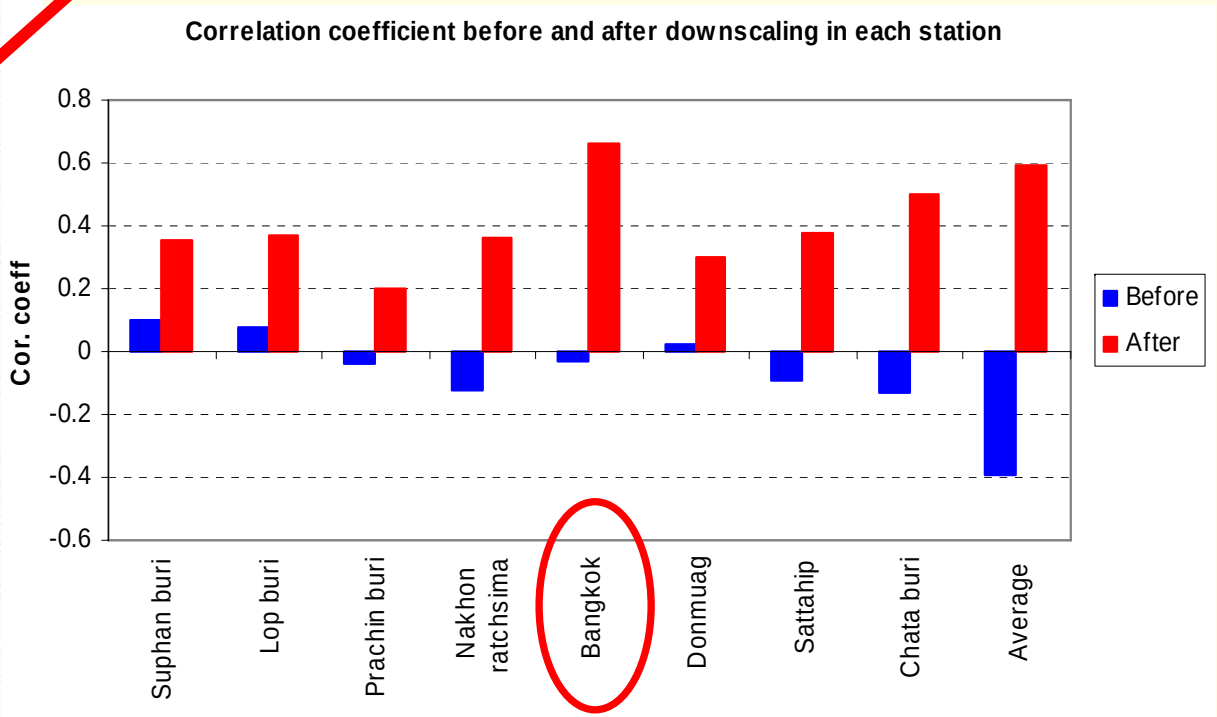


(figures: from NWS CPC, http://www.cpc.ncep.noaa.gov/)

APCC Downscaling MME Forecast for precipitation in Thailand



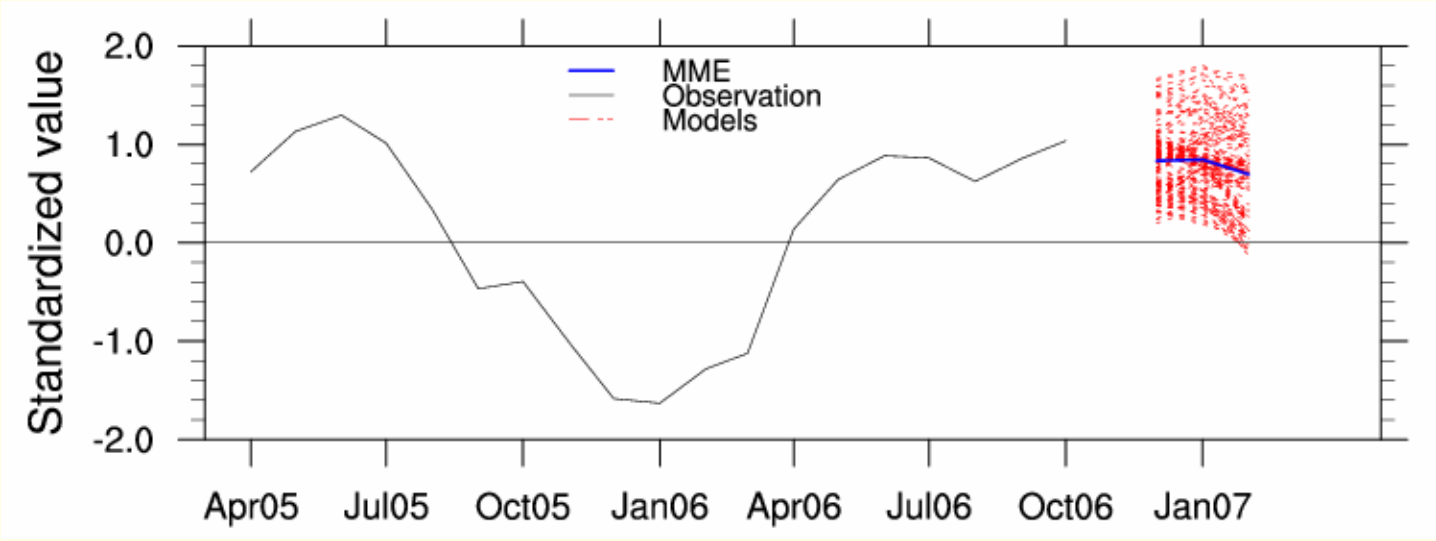
Bangkok



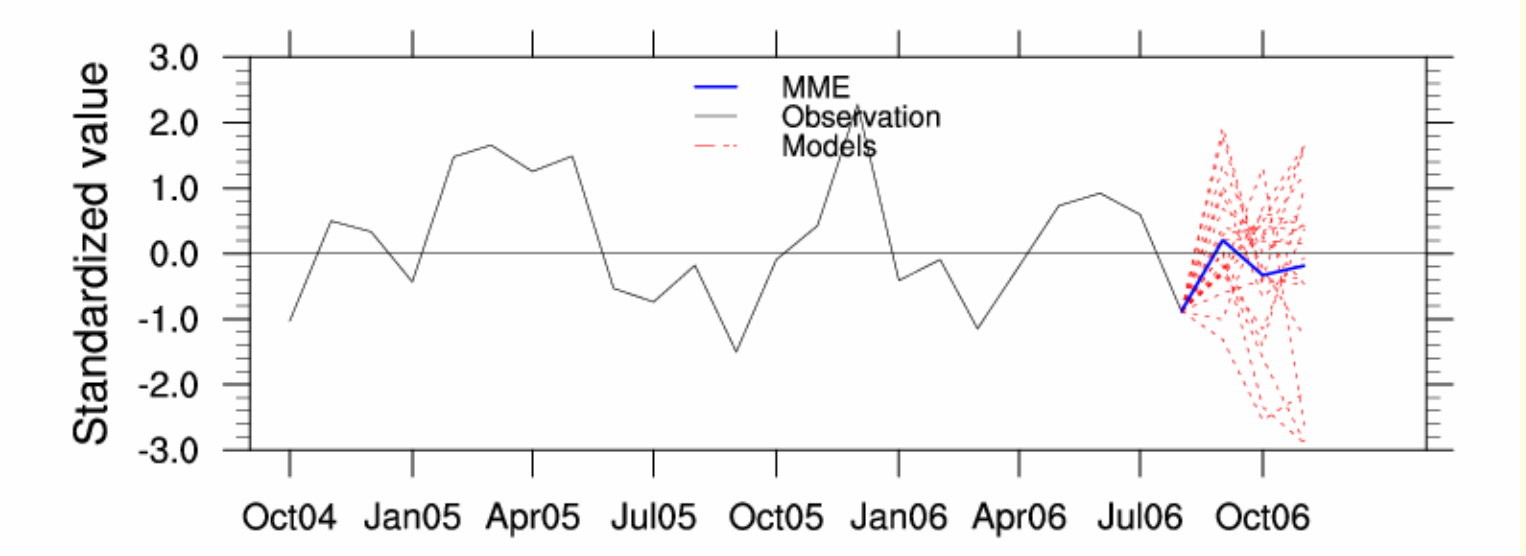
Precipitation at Bangkok relates to sea level pressure over the western Pacific.

Index Forecast using MME

DJF 2006/07 Nino3 Forecast



SON 2006 PNA Forecast



Index Monitoring

Atmospheric Teleconnection Indices

Index	Updated	Latest monthly value	*Latest 3-mo mean value	*Latest 3-mo tendency	Latest 1-yr mean value	Latest 1-yr tendency
AO	Oct 2006	-1.047	▪	⇔	▪	⇔
PNA	Oct 2006	-0.205	▪	⇔	▪	⇔
NAO	Oct 2006	-1.310	▼	⇔	▼	⇔

Monsoon Indices

Index	Updated	Latest monthly value	Latest 3-mo mean value	Latest 3-mo tendency	Latest 1-yr mean value	Latest 1-yr tendency
MHI	Oct 2006	0.194	▪	⇔	▼	⇔
IMI	Oct 2006	-1.394	▪	↓	▲	⇔
WYI	Oct 2006	-1.908	▼	↓	▪	⇔
WNPMI	Oct 2006	1.905	▲	⇔	▪	⇔
EASMI	Oct 2006	-2.210	▼	↓	▪	⇔
RM2	Oct 2006	-0.005	▪	⇔	▪	⇔
AUSMI	Oct 2006	-1.228	▼	↓	▪	⇔

Surface Ocean Indices

Index	Updated	Latest monthly value	Latest 3-mo mean value	Latest 3-mo tendency	Latest 1-yr mean value	Latest 1-yr tendency
NINO	Oct 2006	-1.047	▲	⇔	▪	⇔
NINO3.4	Oct 2006	-0.205	▲	⇔	▪	⇔
DMI	Oct 2006	-1.310	▲	↑	▲	↑

*** Value** : mean over the period indicated to lastest values (x)

- ▲ strongly positive (1 < x)
- ▲ weakly positive (0.3 < x < 1)
- ▪ neutral (-0.3 < x < 0.3)
- ▼ weakly negative (-1 < x < 0.3)
- ▼ strongly negative (x <-1)

*** Tendency** : rate of change over the period indicated to lastest values (dx/dt)

- ↑ strongly positive (1 < dx/dt)
- ↑ weakly positive (0.3 < dx/dt < 1)
- ⇔ neutral (-0.3 < dt/dt < 0.3)
- ↓ weakly negative (-1 < dx/dt < 0.3)
- ↓ strongly negative (dx/dt <-1)

Summary

- APCC is established in 2005 Nov in Busan Korea supported by APEC countries in order to reduce economic loss by climate.
- APCC provides 4 kinds of deterministic forecast and one probabilistic forecast. After the verification, we choose the best deterministic forecast.
- Forecast skill of deterministic MME schemes is better than that of individual model.
- Forecast skill over the land is worse than over the ocean.
- APCC has been developing statistical downscaling. The downscaling can improve forecast skill.
- APCC has been developing index forecast.

Thank you

APEC Climate Center

http://www.apcc21.net