国际气候与环境科学中心
International Center for Climate and Environment Sciences

Seasonal predictability of summer precipitation over the Huaihe river basin with multiple APCC models

Zhaohui Lin[1] Tang Wei[1] Luo Lifeng[2]

[1] ICCES, Institute of Atmospheric Physics, CAS
[2]Department of Geography, Michigan State University

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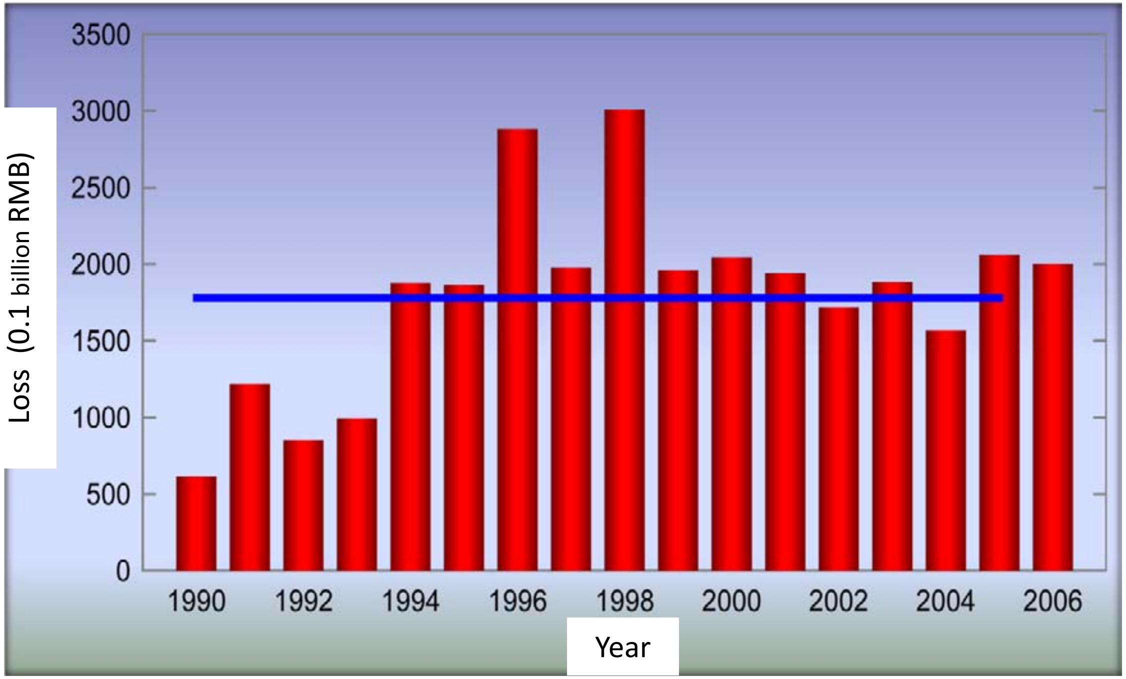
1. Introduction

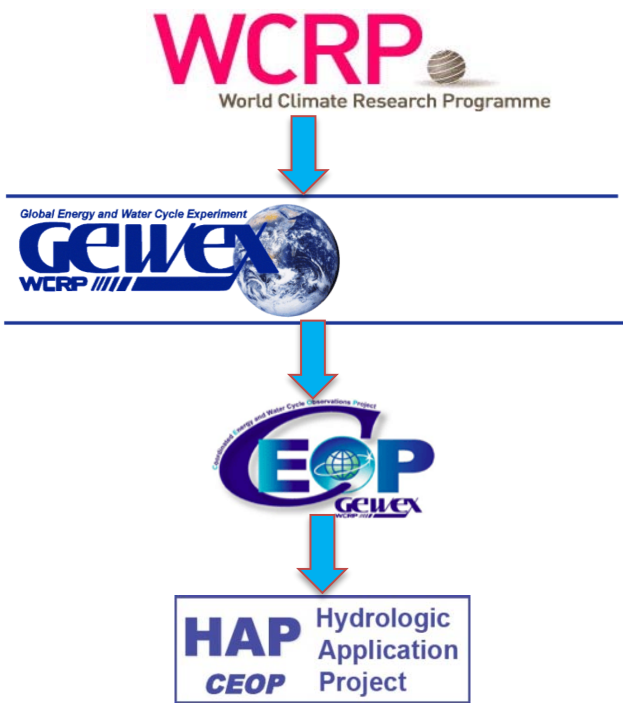
- flood and drought disasters in China



The economic loss caused by meteorological disasters between 1990 and 2006, with the annual average of 177.9 billion RMB.

1. Introduction

- Seasonal predictions of hydrologic variables, such as streamflow, have great economic value in sectors such as water resource management, reservoir operation, hydropower plants, and agriculture

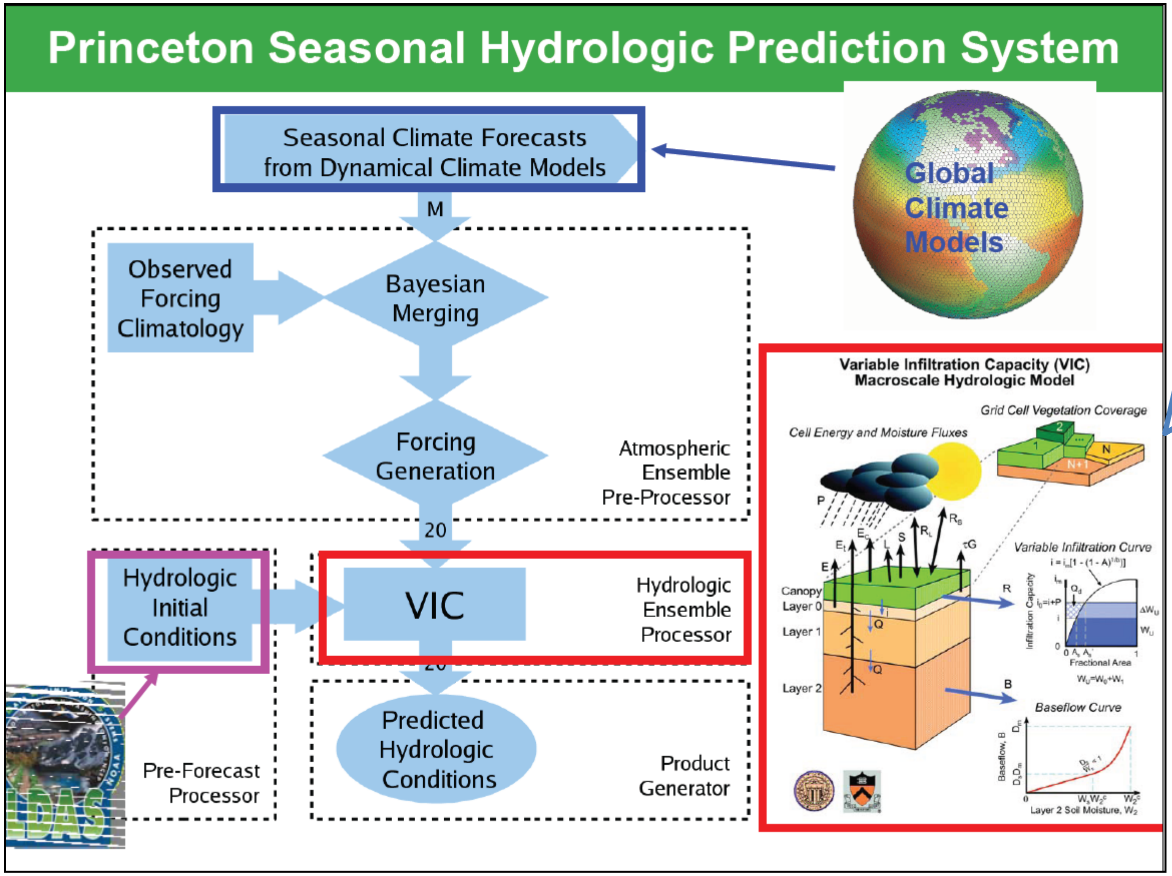


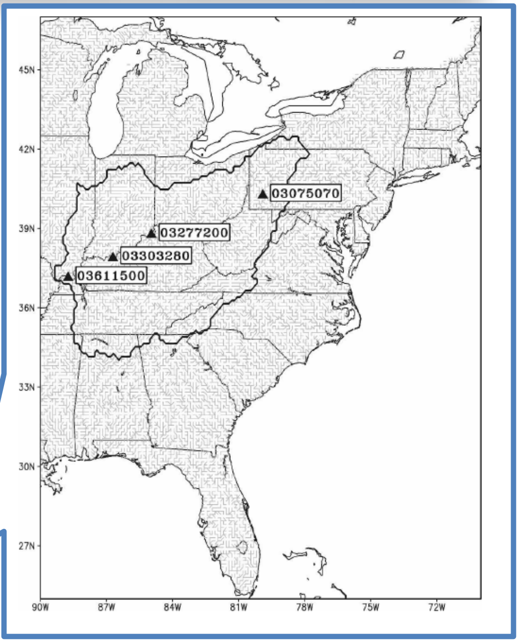
HAP Focus on

- **<u>Seasonal hydrologic forecasting</u>**
- Water cycle and drought monitoring
- Climate change projections and adaptation

1.Introduction

International Research Activities



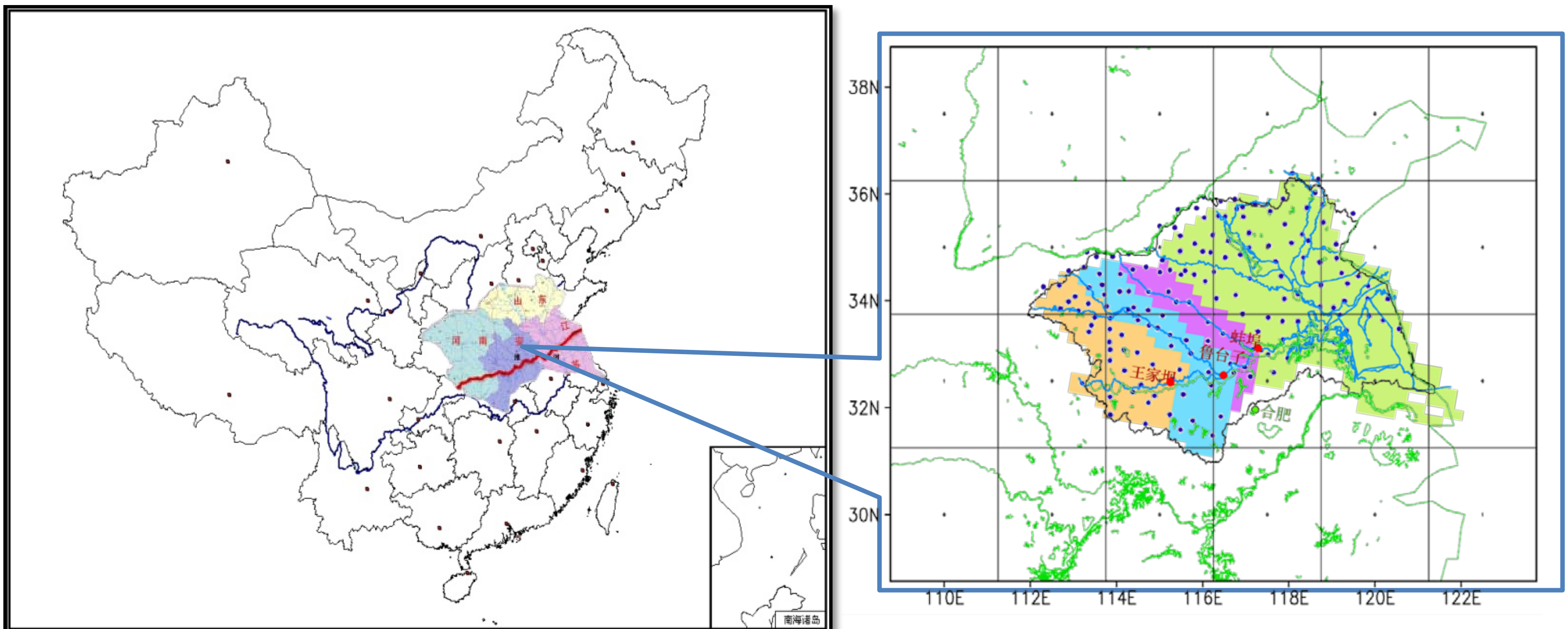


Eric F. Wood， Lifeng Luo,
Princeton University

Study Basin

Huaihe River Basin:

basin-averaged annual precipitation—888 mm



Severe floods occurred frequently since 2000

Model & Data

Data/Model	Institute	Ens	Period	Resolution	Exp Type	SST
NCEP (CFS)	NCEP/NWS/ NOAA(USA)	15	1981-2006	T62,L64	CMIP	**Predicted**
CWB spectral	CWB (CHN. Taipei)	10	1981-2005	T42,L18	SMIP2/HFP	**Predicted**
GCPS (GCPS)	SNU(Korea)	12	1979-2009	T63,L21	SMIP2/HFP	**Predicted**
GDAPS_F (GDAPS)	CPD/KMA(Korea)	20	1979-2009	T106,L21	SMIP2/HFP	**Predicted**
JMA (JMA-CGCM)	JMA (Japan)	5	1979-2008	TL95,L40	SMIP2/HFP	**Predicted**
IRI (ECHAM4.5)	IRI(USA)	24	1980-2005	T42,L19	AMIP	**Observed**
MGO (MGO AM2)	MGO (Russia)	6	1979-2004	T42,L14	SMIP2	**Observed**
HMC (SL-AV)	HCR (Russia)	10	1981-2003	1.125*1.40625, L28	SMIP2/HFP	**Persistent**
MSC_GM2 (CCCma GCM2)	MSC (Can.)	10	1979-2003	T32, L10	SMIP2/HFP	**Persistent**
MSC_GM3 (CCCma GCM3)	MSC (Can.)	10	1979-2003	T63, L32	SMIP2/HFP	**Persistent**

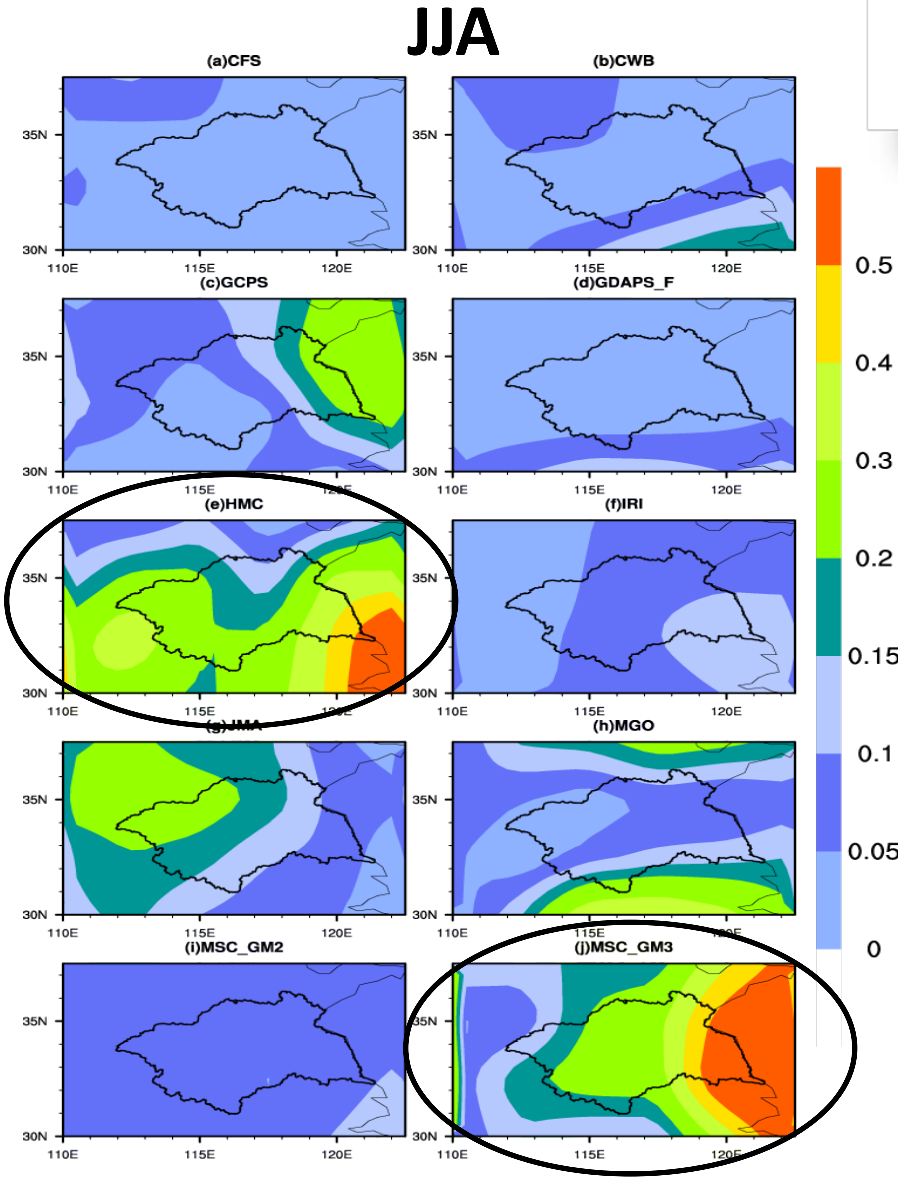
10 models from APCC Multi-model prediction system

Model & Data

Model/Obs	Period	Temporal Res.	Horizontal Res.	Variable	Reference
Models	1981-2003	monthly	$2.5^o*2.5^o$	P(mm/d)	
CMAP	1979-2009	monthly	$2.5^o*2.5^o$	P(mm/d)	Xie and Arkin, 1997

Model and observation data used in this study

Potential Predictability



$$\sigma_{INR}^2 = \frac{1}{Y(M-1)} \sum_{i=1}^{Y} \sum_{j=1}^{M} (X_{ij} - \overline{X_i})^2$$

$$\sigma_{SST}^2 = \sigma_E^2 - \frac{1}{M}\sigma_{INR}^2$$

$$= \frac{1}{Y-1}\sum_{i=1}^{Y}(\overline{X_i} - \overline{\overline{X}})^2 - \frac{1}{M}\frac{1}{Y(M-1)}\sum_{i=1}^{Y}\sum_{j=1}^{M}(X_{ij} - \overline{X_i})^2$$

$$r = \frac{\sigma_{SST}^2}{\sigma_{INR}^2}$$

$$R = \frac{r}{1+r}$$

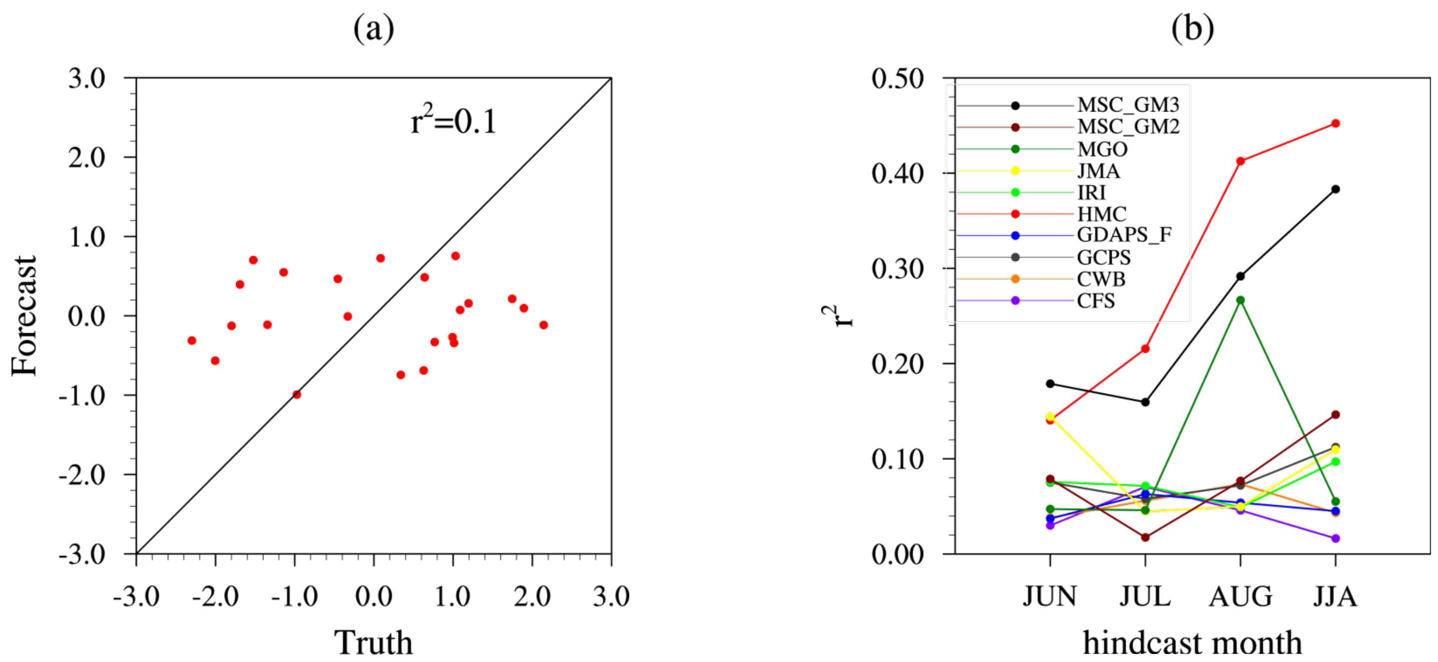
- R=0, without predictability
- 0<R<0.5, low predictability
- R>0.5, high predictability

ANOVA(Rowell and Folland et al. ,1995)

The spatial distributions of predictability (R) for the hindcasted summer mean precipitation over the Huaihe region from 1981-2003.

Potential Predictability

Method by Koster et al. (2004)



(a) Scatter plot for the idealized predictability analysis, showing the degree to which the model can "predict itself" on regional averaged scale. The x axis represents the "truth" and the y axis represents the "forecast". 23 points are from the 23 years (1981-2003). The solid line is the 1:1 line;
(b) the idealized predictability of 10 models with different lead time, each model is lined with colors, as marked in the top left corner of the panel.

Model Categories

How to make a distinction between the 10 models?
Different boundary SST forcing data

(a) persist_sst

- **HMC、**
- **MSC_GM2、**
- **MSC_GM3**

(b) obs_sst

- **IRI、**
- **MGO**

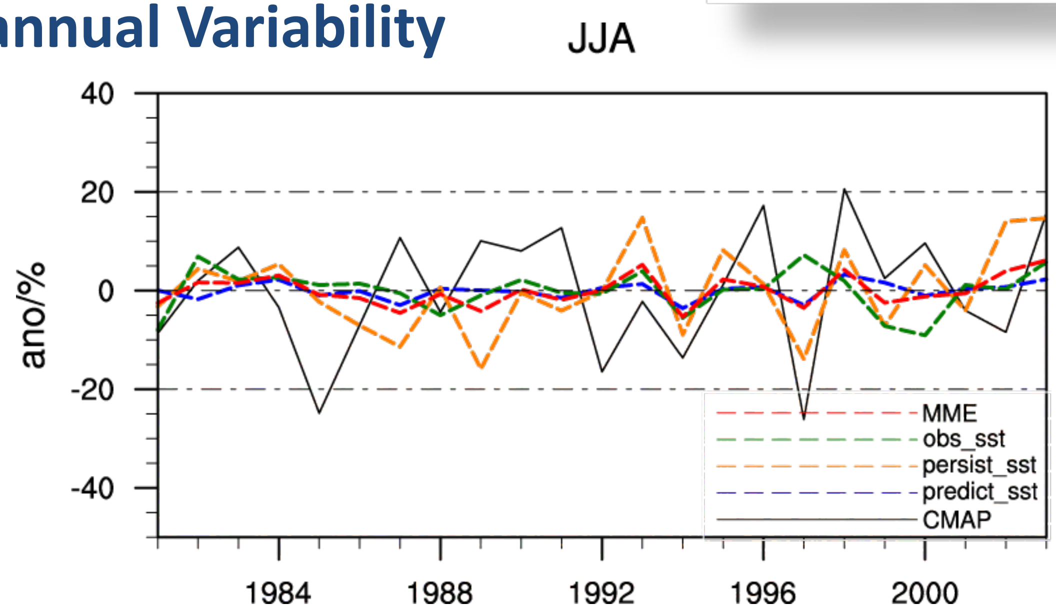
(c) predict_sst

- **CFS、**
- **CWB、**
- **GCPS、**
- **GDAPS_F、**
- **JMA**

(d) MME—10 models

MME Predictive skill

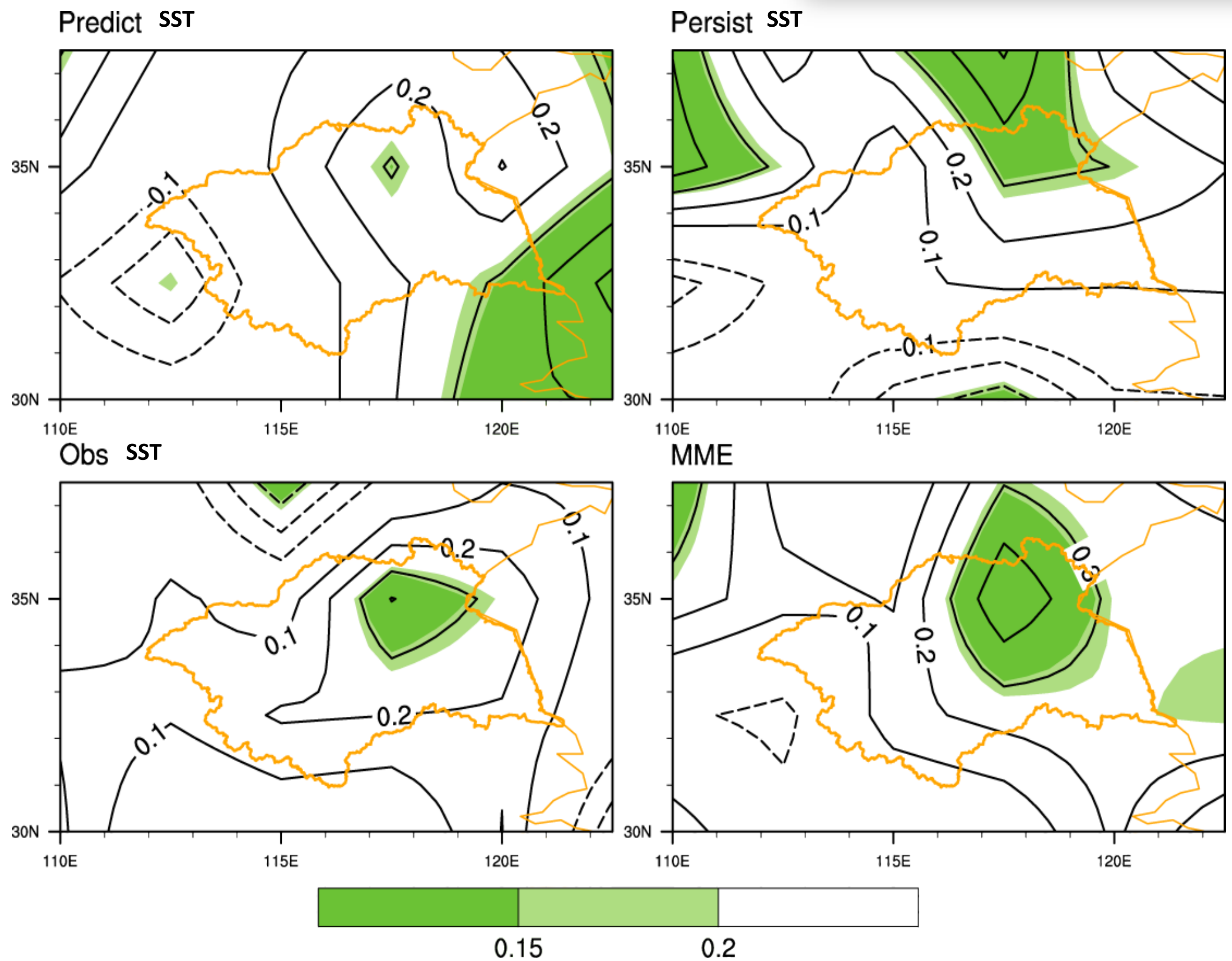
Interannual Variability



ACC/RMSE	JUN	JUL	AUG	JJA
PREDICT_SST	0.26/0.21	0.2/0.19	0.36/0.18	0.38/0.12
Total MME	0.17/0.22	0.22/0.19	0.3/0.18	0.28/0.12
PERSIST_SST	0.12/0.23	0.14/0.2	0.06/0.2	0.25/0.13
OBS_SST	-0.1/0.24	0.150.2	0.3/0.2	-0.01/0.13

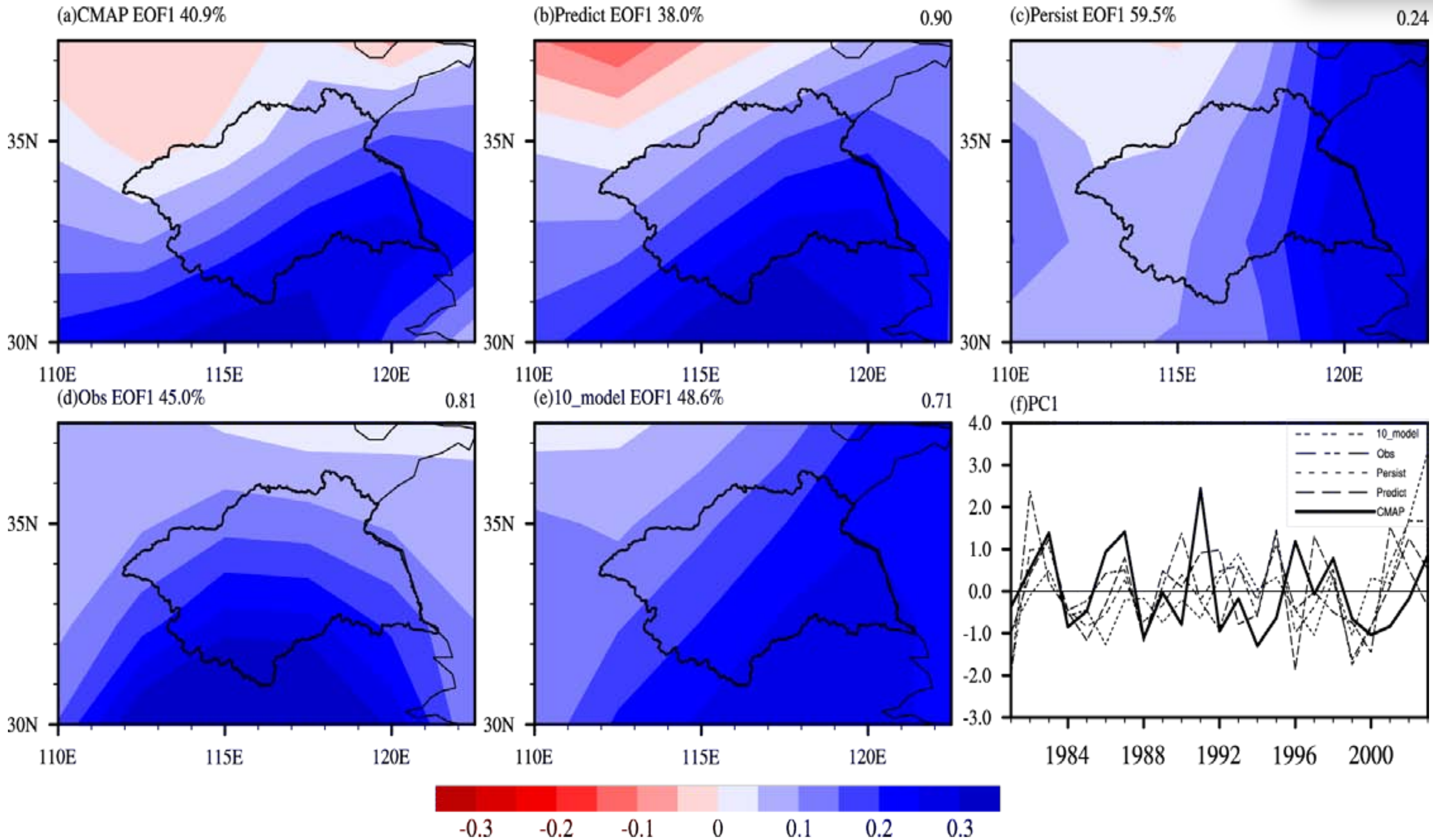
Skill decrease

MME Predictive skill



Spatial distribution of temporal correlation between the observed and hindcasted July precipitation over the Huaihe River region

MME skill

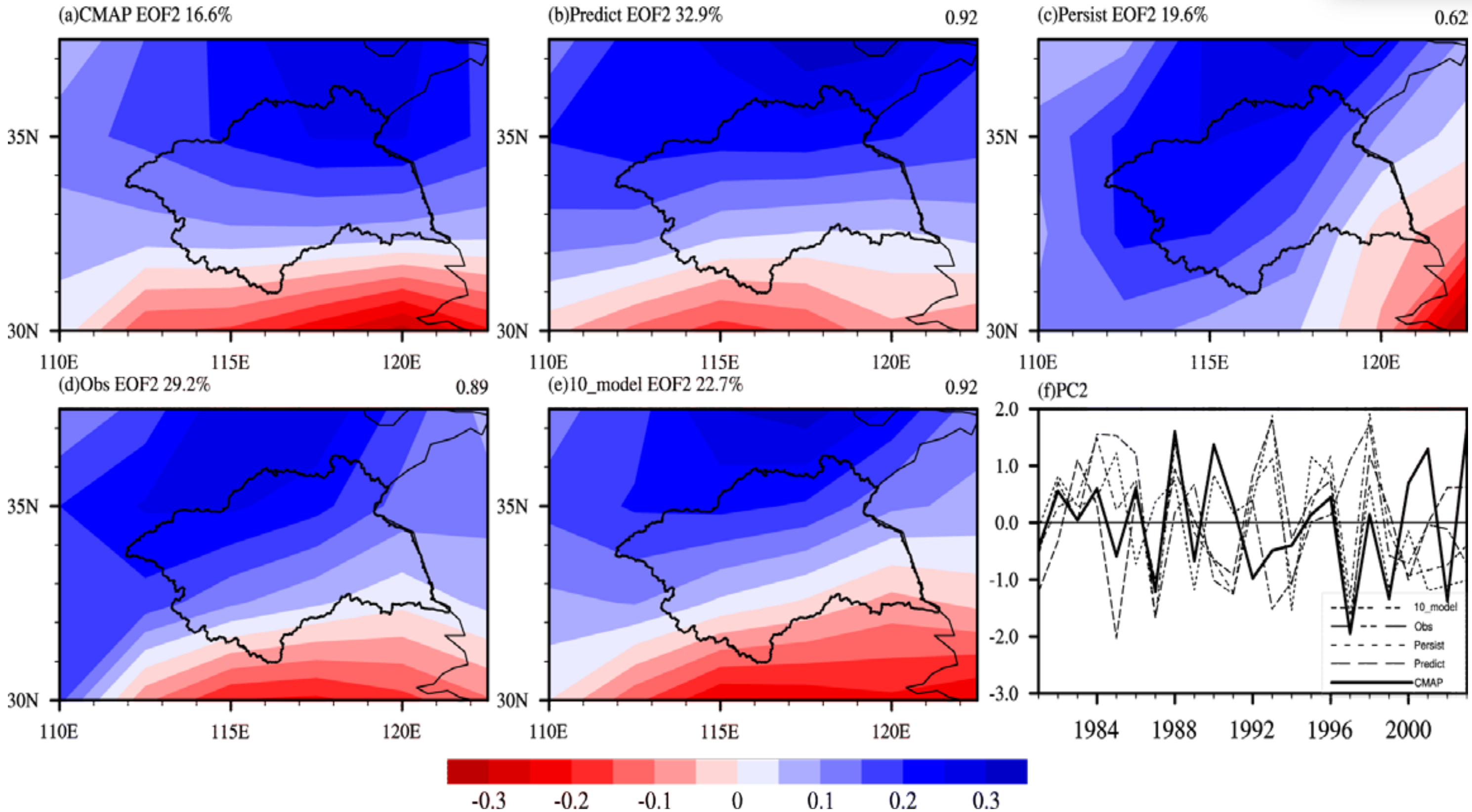


MMEs	TCC
PREDICT_SST	0.3
PERSIST_SST	0.04
OBS_SST	0.14
MME	0.21

First EOF modes of July mean precipitation for observation and 4 MMEs

The predict_SST MME is the best to reproduce the first eigenvector of the observation among the 10 models, while the persist_SST MME makes the poorest performance.

MME skill



MMEs	TCC
PREDICT_SST	0.25
PERSIST_SST	0.24
OBS_SST	0.02
MME	0.28

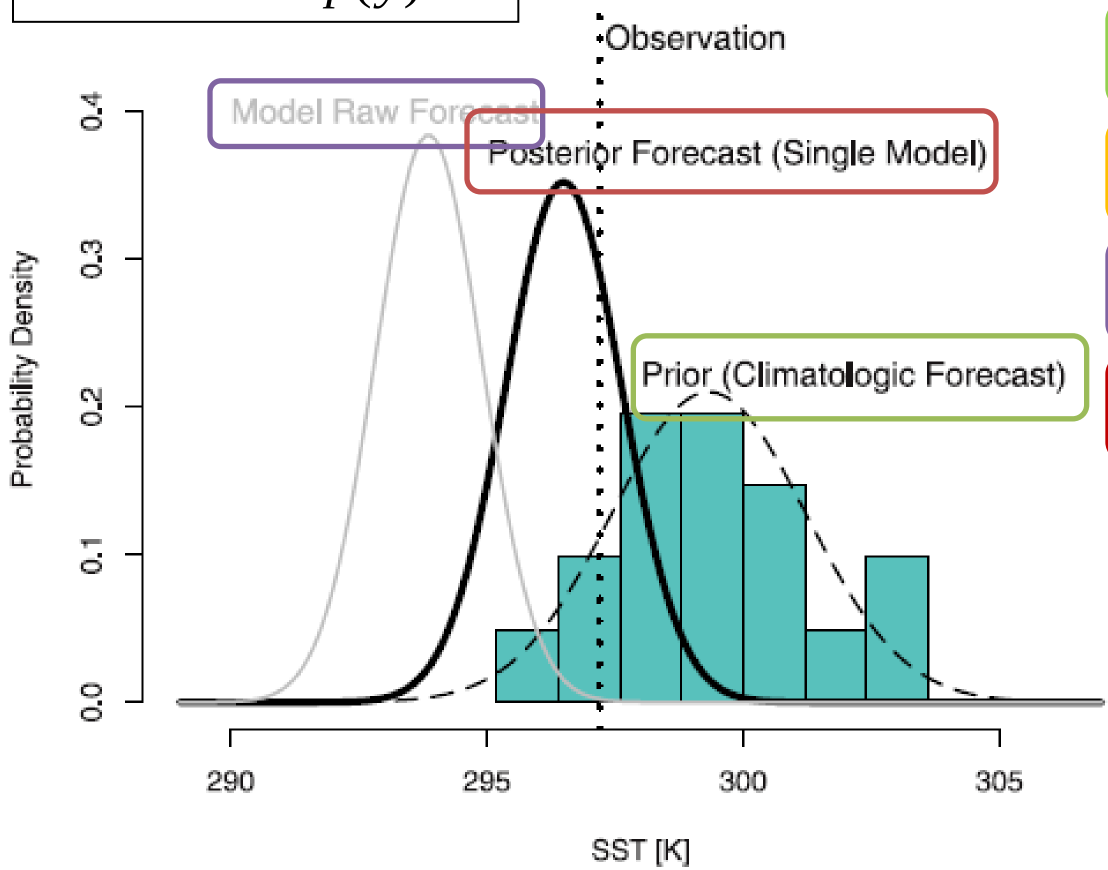
Second EOF modes of July mean precipitation for observation and 4 MMEs

The second eightvector of the July precipitation in the Huaihe region are better reproduced by the 10 models than the first.

The time series in 1987, 1988 and 1997 of PC2 are fitted quite well to the observation.

Bayesian Merging

$$p(\theta | y) = \frac{p(\theta)\, p(y | \theta)}{p(y)}$$



Prior (Clim Fcst): $p(\theta)$

Likelihood Function: $p(y|\theta)$

Model Raw Fcst: $p(y)$

Posterior Fcst: $p(\theta|y)$

(Luo, 2007)

Schematic map for the Bayesian Merging methodology, with solid gray for raw forecast, dash black for Prior distribution and solid black for posterior

Multimodel Bayesian Merging

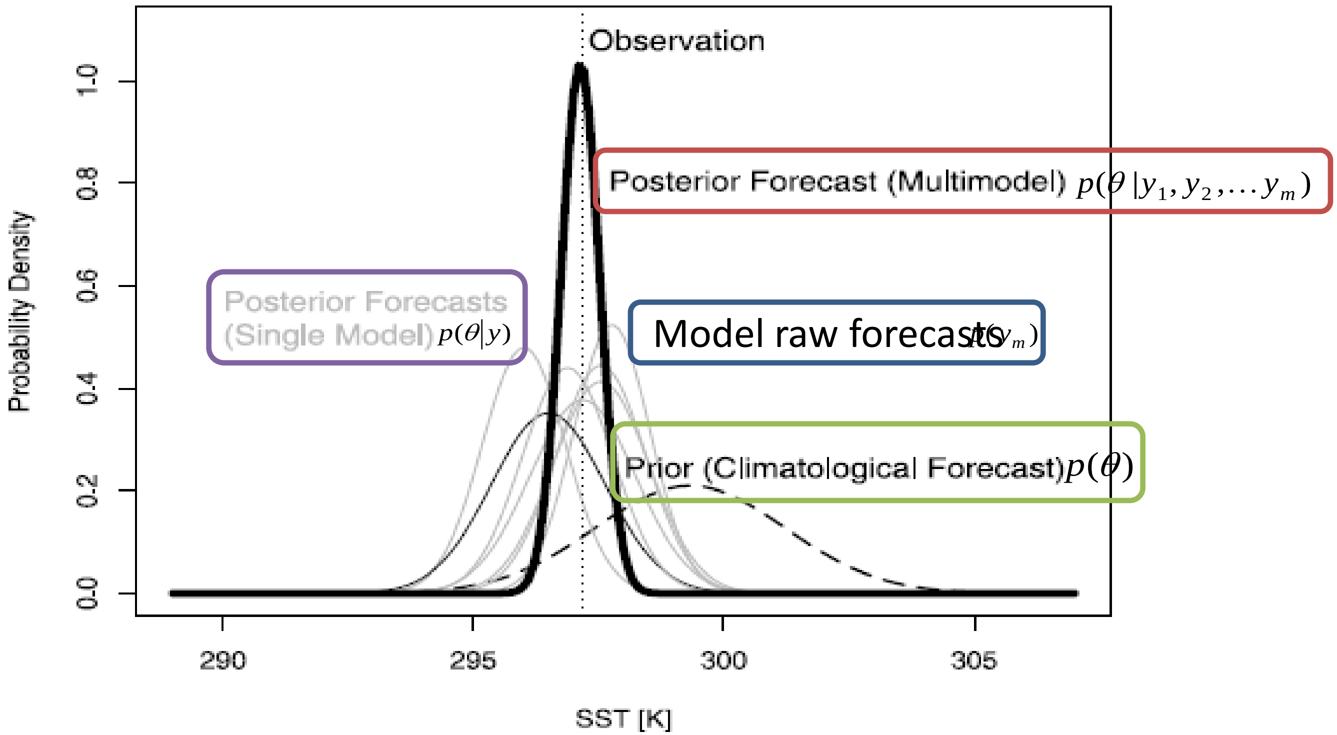
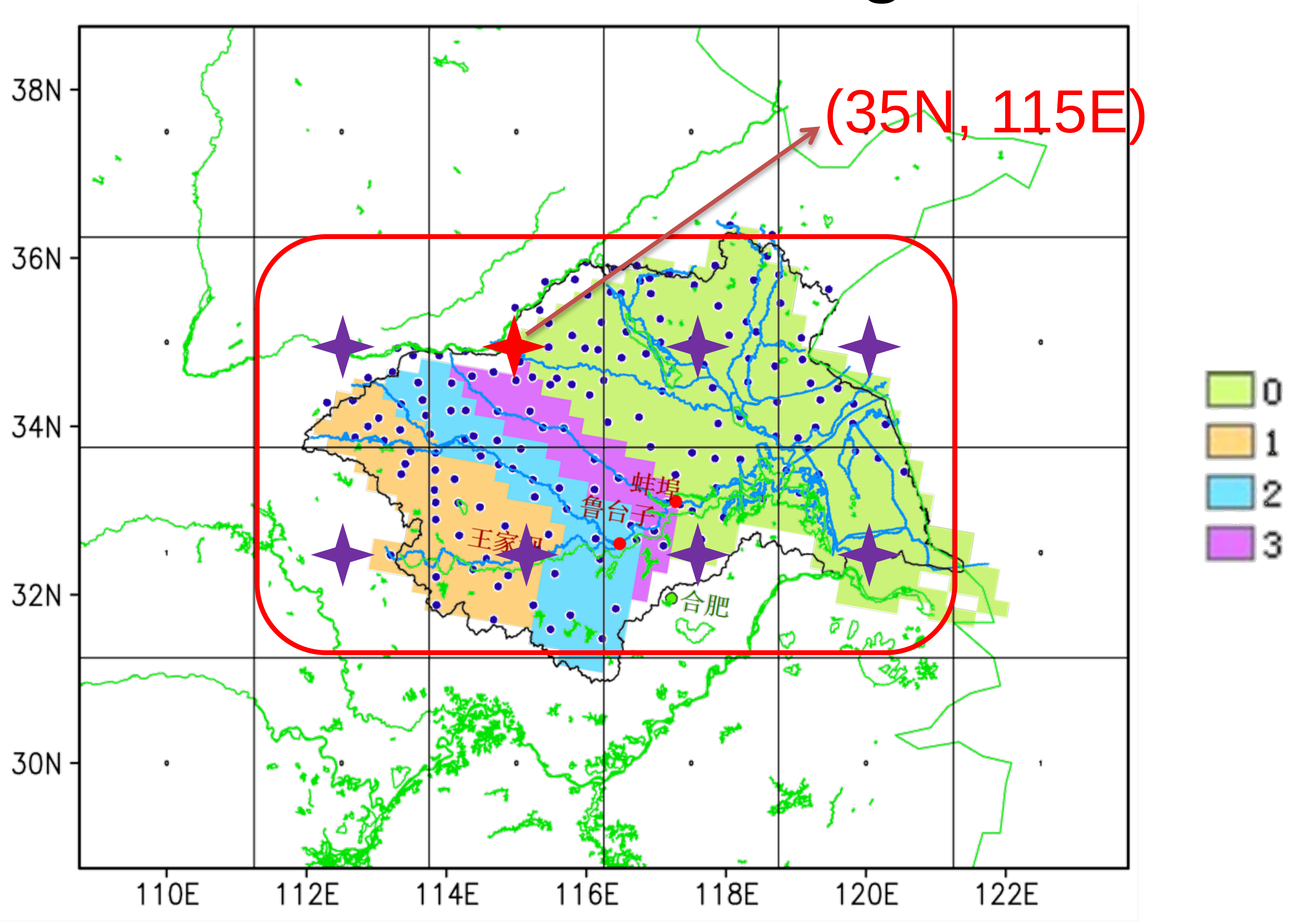
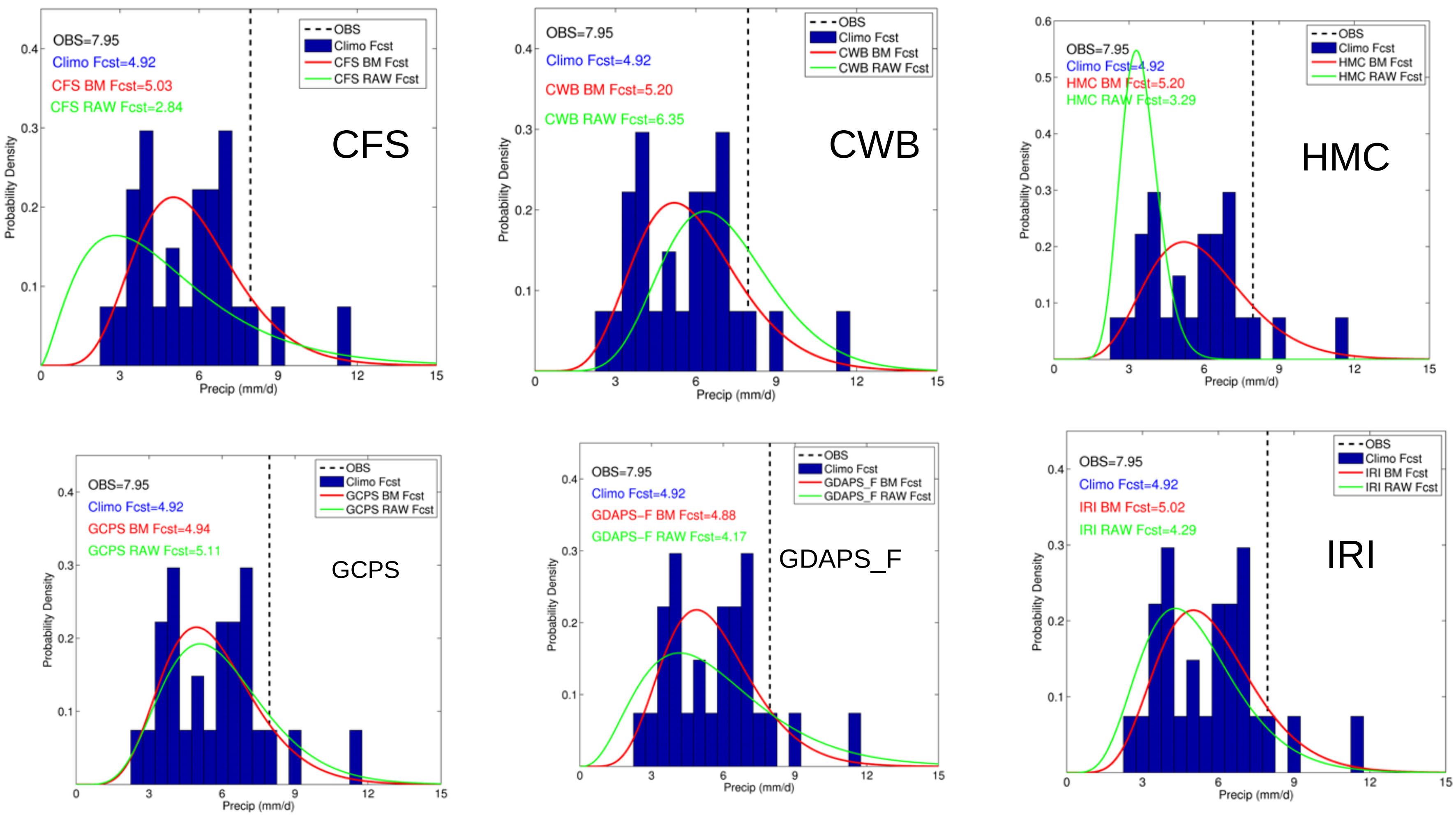


Fig 9. Posterior distribution updated with all seven models forecast (solid black) for the forecast of December 1998 monthly mean SST over selected grid.

BM Method for each grid

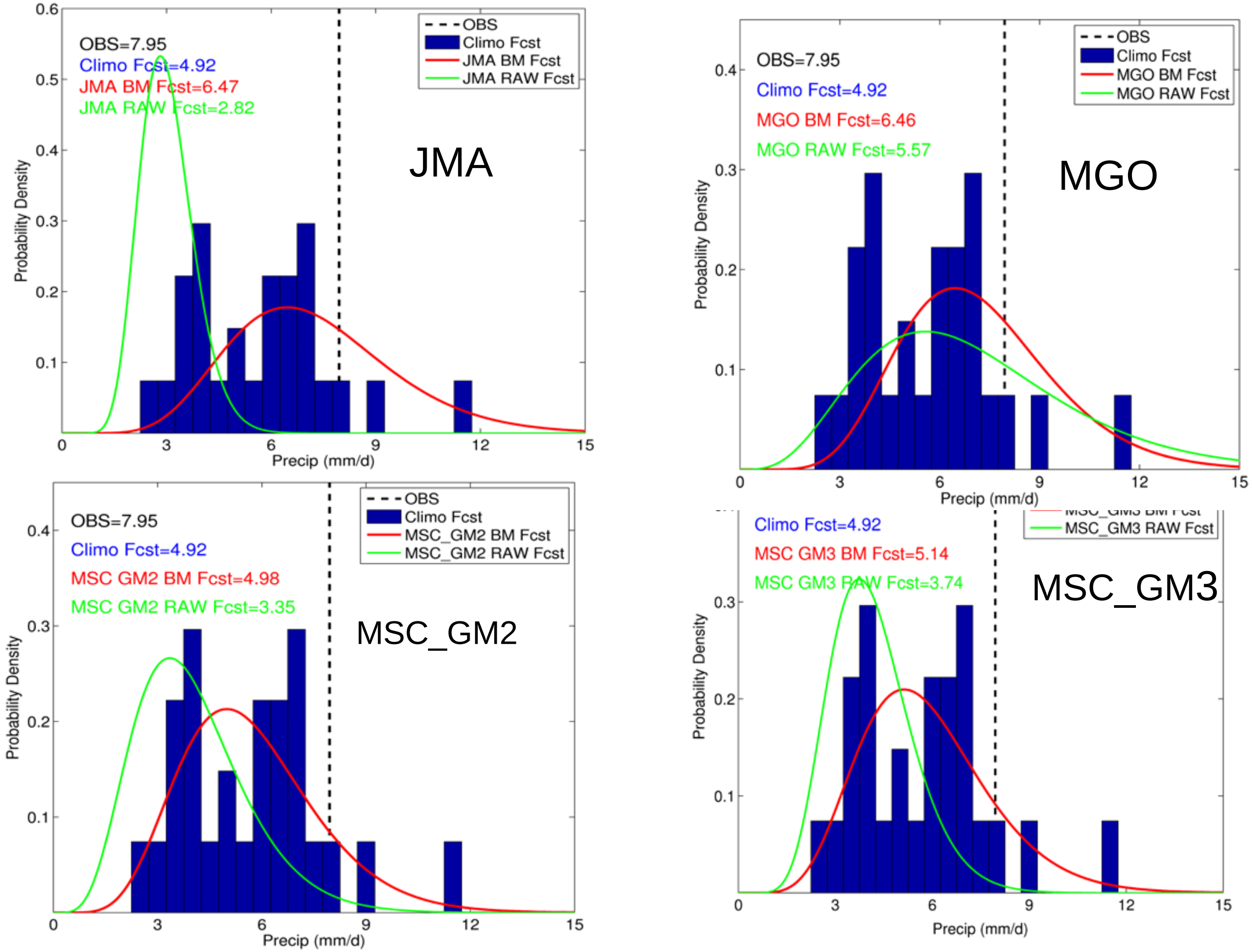


BM of July 1989 on (35N, 115E)

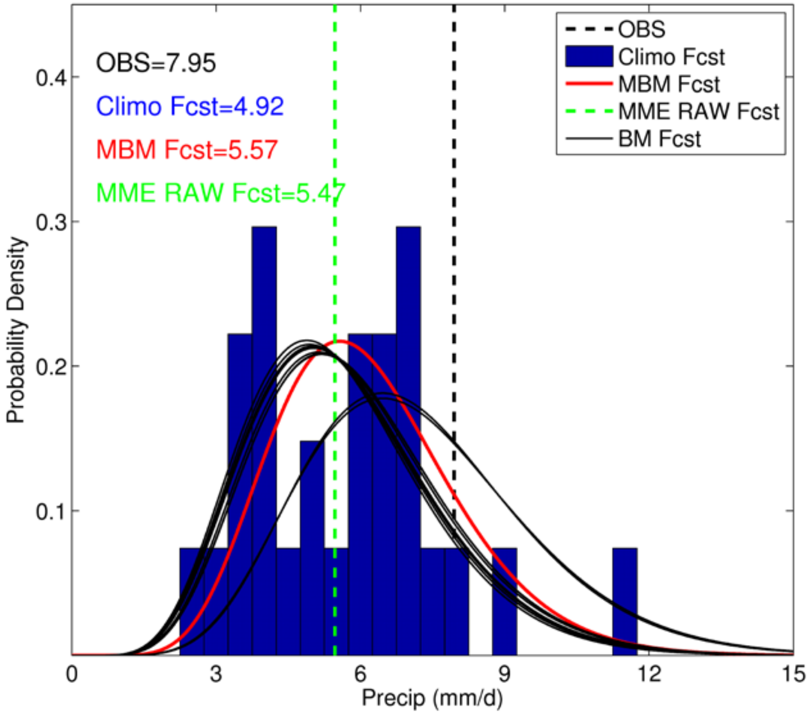


The red line is the pdf of single model BM posterior forecast, green line is the pdf of model raw forecast with ensembles, Blue bar is the frequency distribution of climatology

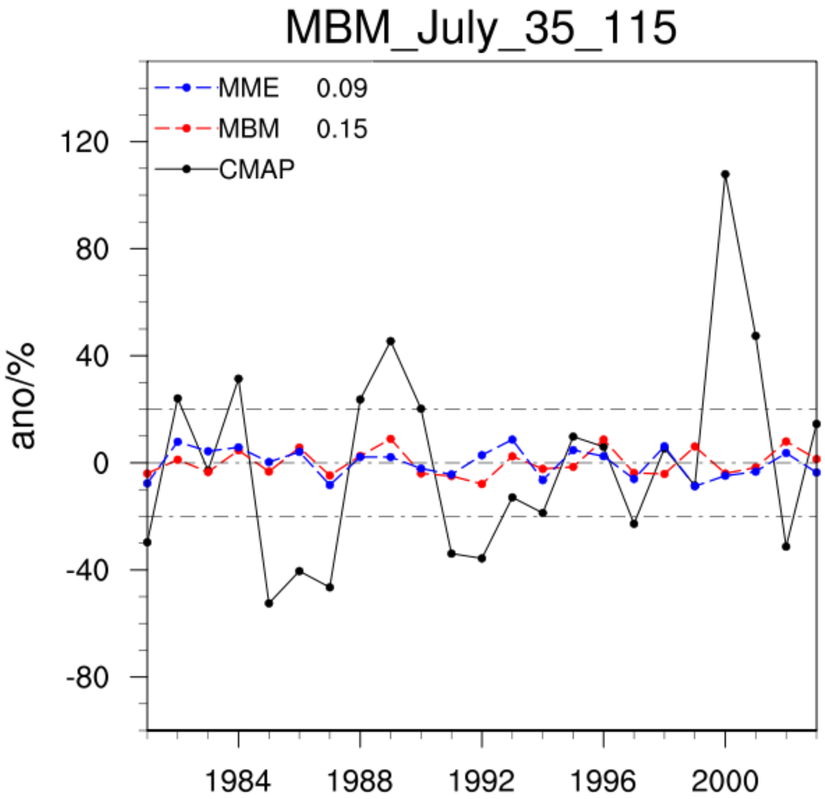
BM of July 1989 on (35N, 115E)



MBM of July 1989 on (35N, 115E)



10 models



Percentage rainfall anomalies for CMAP, MME and MBM respectively

Precipitation Fcst of July 1989 on (35N, 115E)

Models	OBS(mm/d)	Climatology	Model Raw Fcst	Model BM Fcst
CFS	7.95	4.92	2.84	**5.03**
CWB	7.95	4.92	**6.53**	5.2
GCPS	7.95	4.92	**5.11**	4.94
GDAPS_F	7.95	**4.92**	4.17	4.88
JMA	7.95	4.92	2.82	**6.47**
IRI	7.95	4.92	4.29	**5.02**
MGO	7.95	4.92	5.57	**6.46**
HMC	7.95	4.92	3.29	**5.2**
MSC_GM2	7.95	4.92	3.35	**4.98**
MSC_GM3	7.95	4.92	3.74	**5.14**
10_models	7.95	4.92	5.47	**5.57**

Summary

- The seasonal predictability of summer rainfall over Huaihe basin by 10 APCC climate models has been evaluated, it’s found that, although the potential predictability from 10 APCC models is relatively low, the Multi Model Ensemble (MME) method can increase the model predictability. However, the efficiency for MME differ from different MME Groups, with the highest prediction skill for Predict_SST MME.

- Further EOF analysis shows that, The first dominant EOF mode has been quite well captured by the “Predict_SST” MME, with TCC about 0.3; for the second eigenvector, it has been well reproduced by the 10 models than the first mode, and the PCCs are all about 0.9

Summary

- Bayesian Merging approach shows its potential to increase the seasonal rainfall prediction in Huaihe River Basin, and this method can also offer an effective way to statistically downscale information form large scale to smaller scale, that are suitable for hydrological applications.

- Will the blended EOF-Bayesian Merging method further increase the model prediction skill?