New developments of climate predictions in CMA: BCC-CPSv3 and CMME-ENSO

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(1) The 3rd generation of Beijing Climate Center Climate Prediction System (BCC-CPSv3)

In CMA, during the past 25 years, the three generations of climate prediction system have been established for operational use.

BCC-CPSv1

1995-2004

- Seasonal Prediction — BCC-CM1
- Monthly Extended Range Forecast (DERF1) — BCC-AGCM1 (T63)

BCC-CPSv2

2005-2015

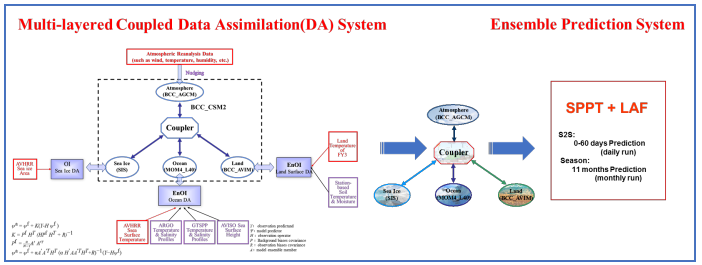
- S2S Prediction — BCC-CSM1.2
  - BCC-AGCM2.3(T106L40)
  - BCC-AVIM1(T106)
  - MOM4-L40(1/3°~30km)
  - SIS(1/3°~30km)
- Seasonal Prediction — BCC-CSM1.1m
  - BCC-AGCM2.2(T106L26)
  - BCC-AVIM1(T106)
  - MOM4-L40(1/3°~30km)
  - SIS(1/3°~30km)
- Monthly Extended Range Forecast (DERF2) — BCC-AGCM2 (T106L26)

BCC-CPSv3

2016-2020

- Subseasonal to Seasonal and Interannual Prediction — BCC-CSM2
  - BCC-AGCM3(T266, T106)
  - BCC-AVIM2(T266, T106)
  - MOM4-L40v2(1/3°~30km)
  - SIS (1/3°~30km)

Res (45km, L56)

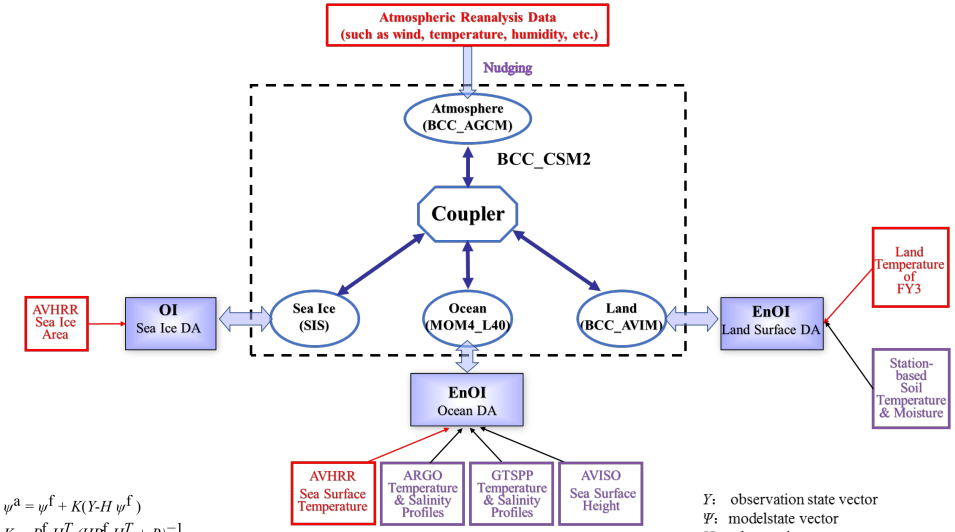


(Wu et al. 2021 GMD)

Beijing Climate Center Climate Prediction System --BCC-CPSv3

- Based on BCC-CSM2-HR (T266, L56), an integrated Climate Prediction System (BCC-CPSv3) cover multiple timescales (including sub-seasonal, seasonal and interannual) was established at the end of 2020.

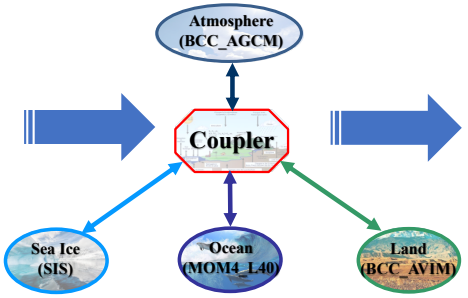
Multi-layered Coupled Data Assimilation(DA) System



$$\psi^a = \psi^f + K(Y - H\psi^f)$$
$$K = P^f H^T (HP^f H^T + R)^{-1}$$
$$P^f = \frac{\alpha}{N-1} A' A'^T$$
$$\psi^a = \psi^f + \alpha A' A'^T H^T (\alpha H' A A'^T H^T + R)^{-1} (Y - H\psi^f)$$

Y: observation state vector
Ψ: modelstate vector
H: observation operator
P: Background biases covariance
R: observation biases covariance
A: model ensemble member

Ensemble Prediction System



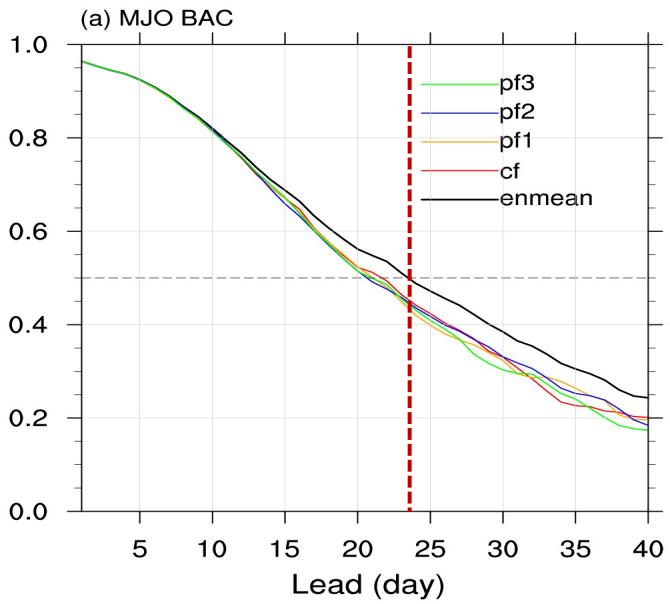
SPPT + LAF

S2S:
0-60 days Prediction
(daily run)
Season:
11 months Prediction
(monthly run)

SPPT : the Stochastically Perturbed Parameterization Tendency
LAF : the Time-Lagged Average Forecast

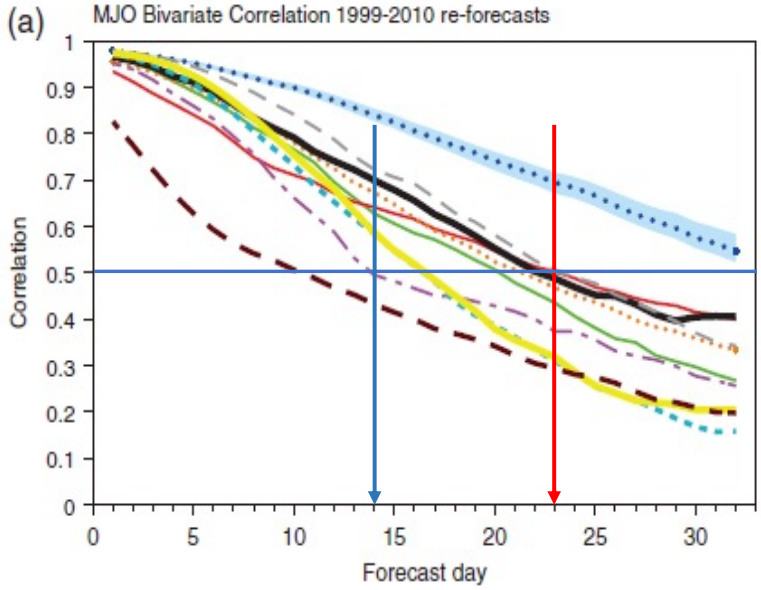
BCC_CPSv3 prediction performance --- MJO

MJO prediction skill



The bivariate anomaly correlation skill of MJO for S2S experiment conducted from November to June during 2005–2019.

- **The MJO prediction skill is 23 days.**

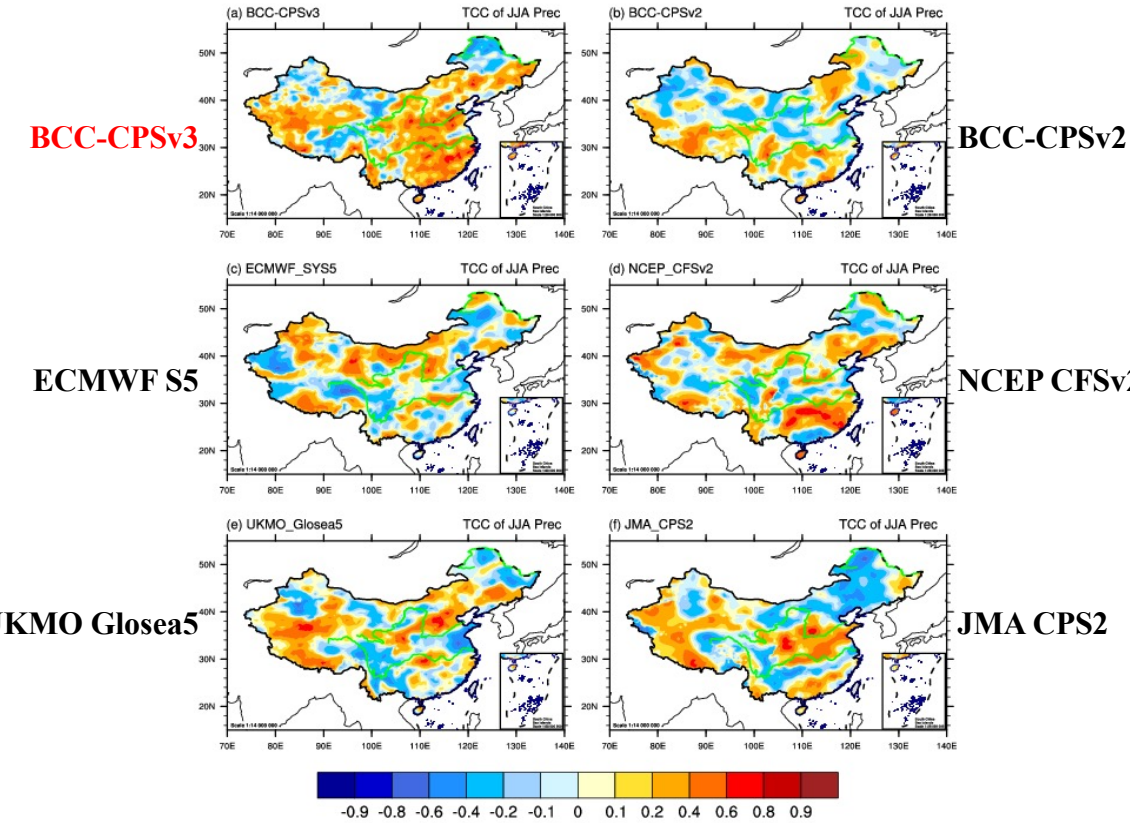


The bivariate anomaly correlation skill of MJO based on 1999-2010 re-forecasts.

F. Vitart. 2017

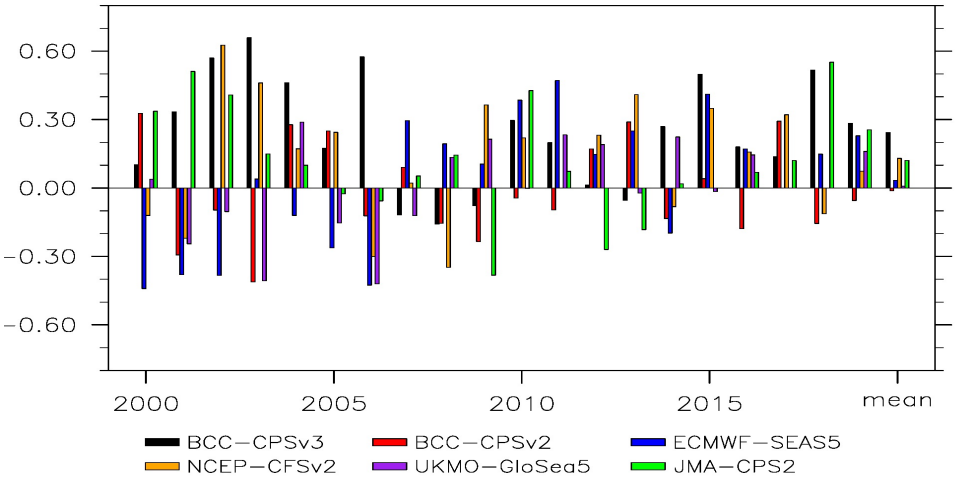
BCC_CPSv3 prediction performance -- Summer Rainfall over China

TCC skill



TCC skill for summer (JJA) precipitation over China for the period 2000–2019 (**initiated in March**) .

PCC skill



PCC skill for summer (JJA) rainfall over China (105-122E, 20-45N).

- **Prediction skill of China rainfall forecast in the flooding season has been improved much in the BCC-CPSv3, comparable to other international model systems.**

BCC_CPSv3 → S2S Prediction project Phase II

Beijing Climate Center (BCC) Climate Prediction System version 2 for S2S is based on lagged average forecasting (LAF) method using a fully-coupled BCC Climate System Model BCC-CSM2-HR. The S2S Forecasts are running on fixed date (3-day interval during 1 Jan to 31 Dec) and end with a 60-day integration. Each forecast consists of 4 LAF ensemble members, which are initialized at 00 UTC of the first forecast day and 18, 12 and 06 UTC of the previous day, respectively.

Overview of the model changes

Model version	Implementation date in S2S	Time range	Resolution	Ens. Size	Frequency	Re-forecasts	Rfc period	Rfc frequency	Rfc size	Ocean resolution	Active Sea Ice	Remarks
BCC-CPS-S2Sv2	**11/11/2019**	d 0-60	**T266 L56**	3+1	**2/week** (Mon, Thu)	**on the fly**	**past 15 years**	**2/week** (Mon, Thu)	3+1	**0.25°**	No	**additional ocean parameters added since** 2019-11-11
BCC-CPS-S2Sv1	**01/01/2015**	d 0-60	T106 L40	3+1	daily	fixed	1994-2014 (model version date 01/05/2014)	daily	3+1	1°	No	

Wu T, etal., 2021: BCC-CSM2-HR: A High-Resolution Version of the Beijing Climate Center Climate System Model. GMD, Geosci. Model Dev., 14, 2977–3006, doi.10.5194/gmd-14-2977-2021

(2) Develop the China Multi-Model Ensemble (CMME) - ENSO prediction

CMME-ENSO family

Fully coupled GCMs (CGCMS)
- BCC CSM1.1m
- CAMS CSM
- FGOALS_f2_1.3
- FGOALS_s2
- FIO CPS2.0
- FU CGCM
- IAP CIESM
- NUIST CFS1.0
- NZC_PCCSM4

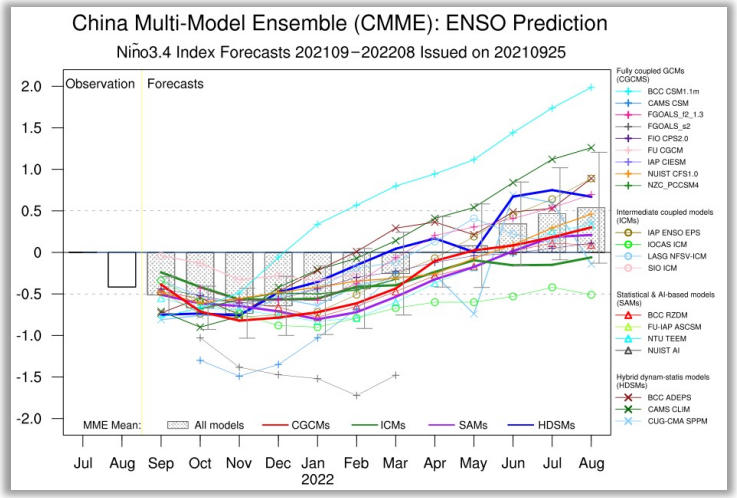
Intermediate coupled models (ICMs)
- IAP ENSO EPS
- IOCAS ICM
- LASG NFSV-ICM
- SIO ICM

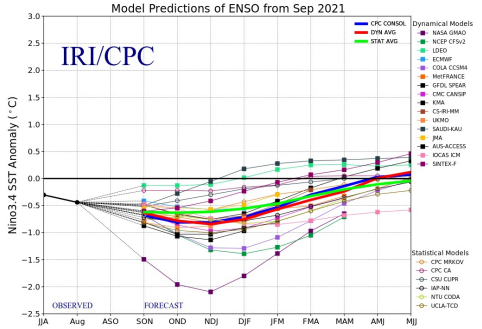
Statistical & AI-based models (SAMs)
- BCC RZDM
- FU-IAP ASCSM
- NTU TEEM
- NUIST AI

Hybrid dynam-statis models (HDSMs)
- BCC ADEPS
- CAMS CLIM
- CUG-CMA SPPM

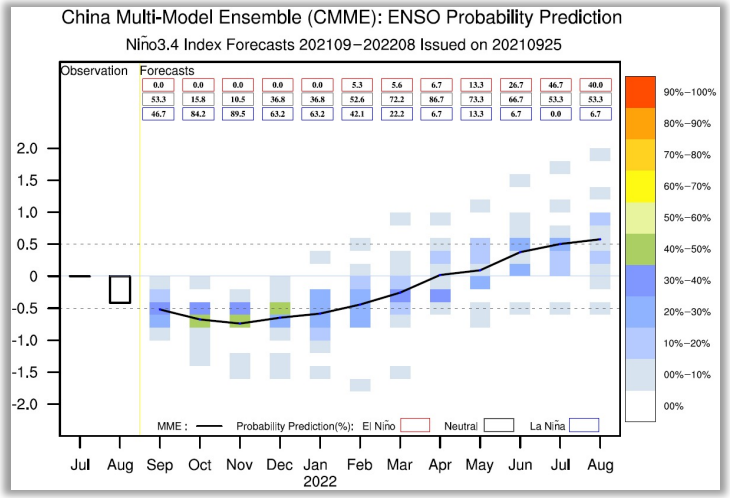
https://cmdp.ncc-cma.net/pred/cn_cmme.php?Elem=CMME-ENSO

Deterministic prediction product

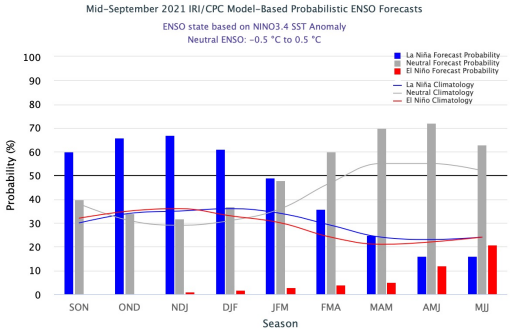




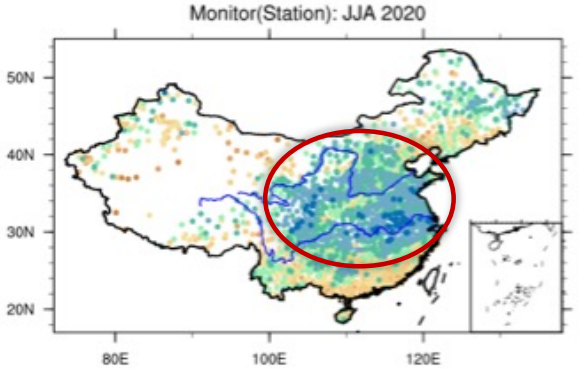
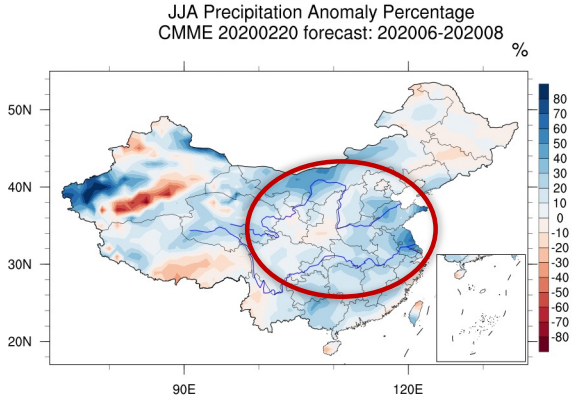
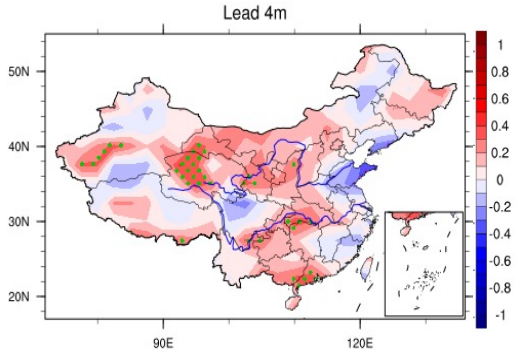
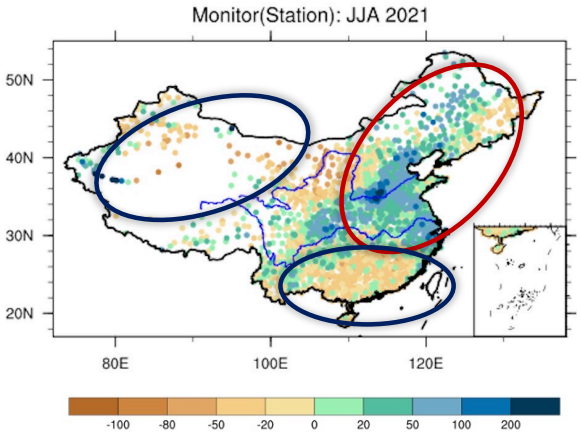
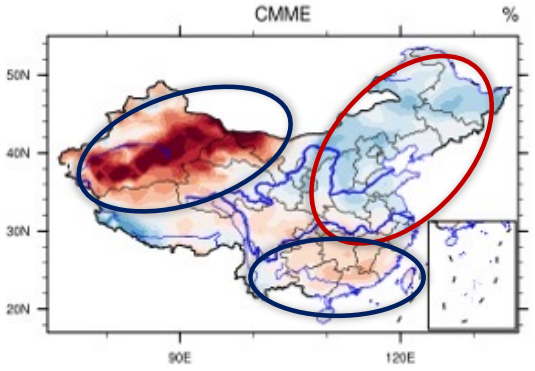
Probabilistic prediction product



Issue products monthly



CMMEv1.0 → real-time predictions of summer rainfall in China

	Observations (Departure percentage, %)	Predictions	Reforecast skills
2020JJA ACC 0.2			
2021JJA ACC 0.3			

Lead month = 4
Issued in mid March

To be addressed

- ✓ More dynamic models
- ✓ Effective MME methods
- ✓ Verification statistics

Summary

- The new generation of Beijing Climate Center Climate Prediction System version 3 (BCC-CPSv3) has been put into the operational use in CMA since Dec 2020, which shows superior performance compared to previous versions.
- BCC-CPSv3 provides renewed reforecast dataset and route real-time products under the S2S project phase II.
- For China multi-model ensemble (CMME), an ENSO ensemble prediction has been newly established with 20 dynamic/statistic models and monthly issued.
- CMME-mean shows exciting skills for real-time predicting the flooding-season rainfall over China.