New developments of climate predictions in CMA:

BCC-CPSv3 and CMME-ENSO

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

(Wu et al. 2021 GMD)
Based on BCC-CSM2-HR (T266, L56), an integrated Climate Prediction System (BCC-CPSv3) covering multiple timescales (including sub-seasonal, seasonal, and interannual) was established at the end of 2020.

Multi-layered Coupled Data Assimilation (DA) System

Ensemble Prediction System

\[ \phi^p = \phi^0 + K(\hat{y} - H\hat{p}^0) \\
K = P^0H^T(HP^0H^T + R)^{-1} \\
P^0 = E^0 \tilde{E}^0 \\
\phi^m = \phi^0 + a_tA^T(\hat{u}^T\hat{u} + R)\{\hat{y} - H\hat{p}^0\} \]

\(K\): observation error vector  
\(P\): model error vector  
\(H\): observation operator  
\(P\): model error covariance  
\(R\): observation error covariance  
\(A\): model ensemble member

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
The MJO prediction skill is 23 days.

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

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

F. Vitart. 2017
TCC skill for summer (JJA) precipitation over China for the period 2000–2019 (initiated in March).

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.
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

<table>
<thead>
<tr>
<th>Model version</th>
<th>Implementation date in S2S</th>
<th>Time range</th>
<th>Resolution</th>
<th>Ens. Size</th>
<th>Frequency</th>
<th>Re-forecasts</th>
<th>Rfc period</th>
<th>Rfc frequency</th>
<th>Rfc size</th>
<th>Ocean resolution</th>
<th>Active Sea Ice</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCC-CPSv2</td>
<td>11/11/2019</td>
<td>d 0–60</td>
<td>T266 L56</td>
<td>3+1</td>
<td>2/week</td>
<td>on the fly</td>
<td>past 15 years</td>
<td>2/week (Mon, Thu)</td>
<td>3+1</td>
<td>0.25°</td>
<td>No</td>
<td>additional ocean parameters added since 2019-11-11</td>
</tr>
<tr>
<td>BCC-CPSv1</td>
<td>01/01/2015</td>
<td>d 0–60</td>
<td>T106 L40</td>
<td>3+1</td>
<td>daily</td>
<td>fixed</td>
<td>1994–2014 (model version date 01/01/2014)</td>
<td>daily</td>
<td>3+1</td>
<td>1°</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

Wu T, et al., 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

**Deterministic prediction product**

China Multi-Model Ensemble (CMME): ENSO Prediction

**Probabilistic prediction product**

China Multi-Model Ensemble (CMME): ENSO Probability Prediction

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https://cmdp.ncc-cma.net/pred/cn_cmme.php?Elem=CMME-ENSO
CMMEv1.0 → real-time predictions of summer rainfall in China

To be addressed
- More dynamic models
- Effective MME methods
- Verification statistics

Lead month = 4
Issued in mid March
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.