Beijing Climate Center Climate System Model (BCC-CSM) development and its operational applications for sub-seasonal to seasonal prediction

Tongwen WU (twwu@cma.gov.cn)
Beijing Climate Center (BCC), China Meteorological Administration

Contributed by: Xiangwen Liu, Weihua Jie, Weiping Li, Xiaoge Xin, Fang Zhang, Yanwu Zhang

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Contents

• Beijing Climate Center Climate System Model (BCC_CSM) development, and towards to CMIP6
• The present status of operational seasonal climate prediction in CMA
• Sub-seasonal to seasonal (S2S) prediction in CMA
Mission of Beijing Climate Center, CMA

- To monitor and diagnose global atmospheric and oceanic conditions, as well as extreme climate events, especially in East Asia
- To issue global climate predictions and impact assessments at monthly, seasonal and inter-annual time scales, particularly over East Asia
- To provide climate services to different users
- To do research on climate and climate change issues
Beijing Climate Center Climate System Model (BCC_CSM)

Phase I
- 1995-2004
  - BCC_CM1.0

Phase II
- 2005-2008
  - BCC_CSM1.0
  - BCC_CSM1.1
  - BCC_CSM1.1(m)

Phase III
- 2012-2015
  - BCC_CSM2
- 2013- ...
  - BCC_ESM1

CMIP6
- BCC_AGCM3(T266, T106)
- BCC_AVIM1.0(T266, T106)
- MOM4-L40v2(1/3°~30km)
- CICE (1/3°~30km)

CMIP5
- BCC_AGCM2.2(T106)
- BCC_AVIM1.0(T106)
- MOM4-L40v2(1/3°~30km)
- SIS(1/3°~30km)

CMIP5 S2S
- Climate prediction

CMIP3
- Present operational climate prediction

Phase I
- 1995-2004
  - BCC_CM1.0
  - BCC_AGCM1.0(T63)
  - NCC/LASG OGCM(T63)

Phase II
- 2005-2008
  - BCC_CSM1.0
  - BCC_CSM1.1
  - BCC_CSM1.1(m)

Phase III
- 2012-2015
  - BCC_CSM2
- 2013- ...
  - BCC_ESM1

CMIP6
- BCC_AGCM3(T266, T106)
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CMIP5
- BCC_AGCM2.2(T106)
- BCC_AVIM1.0(T106)
- MOM4-L40v2(1/3°~30km)
- SIS(1/3°~30km)

CMIP5 S2S
- Climate prediction

CMIP3
- Present operational climate prediction
• BCC_CSM1.1: performed almost all the experiments
• BCC_CSM1.1(m): Only the core experiments
### CMIP5 publications

http://cmip.llnl.gov/cmip5/publications/model

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Updated by Oct 8, 2015
# BCC Models for **CMIP5**

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<th>Resolutions</th>
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<tr>
<td>BCC-CSM1.1</td>
<td>BCC-AGCM2.1&lt;br&gt;BCC-AVIM1&lt;br&gt;MOM4-L40v1&lt;br&gt;SIS</td>
<td>Atmos: T42L26, Top: 2.19 hPa&lt;br&gt;Ocn: 1/3° in 30S-30N and 1/3-1° in 30-60 N/S, and 1° in high latitudes</td>
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<td>BCC-CSM1.1(m)</td>
<td>BCC-AGCM2.2&lt;br&gt;BCC-AVIM1&lt;br&gt;MOM4-L40v2&lt;br&gt;SIS</td>
<td>Atmos: T106L26, Top: 2.19 hPa&lt;br&gt;Ocn: 1/3° in 30S-30N and 1/3-1° in 30-60N/S, and 1° in high latitudes</td>
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# BCC Models for **CMIP6**

<table>
<thead>
<tr>
<th>Model Versions</th>
<th>Model Components</th>
<th>Resolutions</th>
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<tbody>
<tr>
<td>BCC-ESM1-LR</td>
<td>BCC-AGCM3-Chem&lt;br&gt;BCC-AVIM2&lt;br&gt;MOM4-HAMOCC&lt;br&gt;CICE5</td>
<td>Atmos: T42L26, Top: 2.19 hPa&lt;br&gt;Ocn: 1/3 ° in 30S-30N and 1/3-1° in 30-60 N/S, and 1° in high latitudes</td>
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<tr>
<td>BCC-CSM2-MR</td>
<td>BCC-AGCM3-MR&lt;br&gt;BCC-AVIM2&lt;br&gt;MOM4-HAMOCC&lt;br&gt;CICE5</td>
<td>Atmos: T106L46, Top: 1.46 hPa&lt;br&gt;Ocn: 1/3 ° in 30S-30N and 1/3-1° in 30-60 N/S, and 1° in high latitudes</td>
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<td>BCC-CSM2-HR</td>
<td>BCC-AGCM3-HR&lt;br&gt;BCC-AVIM2&lt;br&gt;MOM4-HAMOCC&lt;br&gt;CICE5</td>
<td>Atmos: T266L26, Top: 2.19 hPa&lt;br&gt;Ocn: 1/3 ° in 30S-30N and 1/3-1° in 30-60 N/S, and 1° in high latitudes</td>
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</tbody>
</table>
### BCC_AGCM2 --- > CMIP5

**Originated from CAM3**
**A component of BCC-CSM1.1, BCC-CSM1.1m**
**Resolution:** T42L26, T106L26

**Model Dynamic Core:**

**Model Physics**
- **Deep convection:** Wu T., 2012: A Mass-Flux Cumulus Parameterization Scheme for Large-scale Models: Description and Test with Observations, Clim. Dyn., 38
- **Dry Adiabatic adjust scheme**
- **Snow cover fraction parameterization** (Wu T. and Wu G., 2004)
- **A modified sensible and latent flux parameterization on the ocean-Atmosphere interface** (Wu et al. 2010: Climate Dynamics)
- **No indirect effects of aerosols**

**Land:** BCC_AVIM1

**Ref:** Wu et al. 2010: Climate Dynamics

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### BCC_AGCM3 --- > CMIP6

**A component of BCC-CSM2-MR, BCC-CSM2-HR**
**Resolution:** T106L46, T266L26

**Model Dynamic Core:**
- The spatially variant divergence damping scheme in higher resolution version (Whitehead et al., 2011)
- A Flux-Form Semi-Lagrangian (FFSL) transport scheme (Lin and Rood,1996)

**Model Physics:**
- A modified Wu’2012 deep convective scheme
- A gravity wave drag generated by orography, and convection (Beres et al., 2004)
- A new scheme to parameterize deep and shallow cumulus cloud amount
- A modified parameterization scheme for surface turbulent fluxes between air and ocean/sea ice
- **Indirect effects of aerosols.** The liquid cloud droplet number concentration is diagnosed using the aerosols mass or a prognostic scheme (MG2008) using two moments of liquid and ice clouds.
- A radiative transfer scheme (Zhang H., 2010)

**Land:** BCC_AVIM2
# Land surface model component

<table>
<thead>
<tr>
<th>BCC_AVIM1</th>
<th>--&gt; CMIP5</th>
<th>BCC_AVIM2</th>
<th>--&gt; CMIP6</th>
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</thead>
<tbody>
<tr>
<td>Originated from CLM3</td>
<td>A component of BCC-CSM1.1, BCC-CSM1.1m</td>
<td>A component of BCC-CSM2, BCC-ESM1</td>
<td></td>
</tr>
</tbody>
</table>

**Model physics:**
- Soil-Vegetation-Atmosphere Transfer module (same as NCAR CLM3)
- Multi-layer snow-soil scheme (same as NCAR CLM3)
- Snow Cover Fraction scheme (sub-grid topography)
- Vegetation growth module (Ji, 1998)
- Soil carbon decomposition module (Ji, 1995)
- Land use change module (variable crop planting area)

- Modified freeze-thaw scheme for soil water (below 0°C and dependent on soil & water) (Xia et al., 2011)
- Improved snow surface albedo scheme (Chen et al., 2014)
- Four-stream radiation transfer through vegetation canopy (Zhou et al., 2009)
- Vegetation Phenology similar to CTEM (Canadian Terrestrial Ecosystem Model) (Arora and Boer, 2005)
- Deep lake module (observed real depth)
- Wild fire module (Li et al., 2013)
- A scheme for rice paddy water
## OGCM model

<table>
<thead>
<tr>
<th>MOM4_L40 =&gt; CMIP5</th>
<th>MOM5_HAMOCC =&gt; CMIP6</th>
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<tbody>
<tr>
<td><strong>Originated from MOM4</strong> developed by GFDL</td>
<td><strong>A component of BCC-CSM2, BCC-ESM1</strong></td>
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<tr>
<td><strong>A component of BCC-CSM1.1, BCC-CSM1.1m</strong></td>
<td><strong>Updated to MOM5</strong></td>
</tr>
<tr>
<td>• Resolution: Tri-pole gridpoints $1^\circ \times 1^\circ$, $1/3^\circ$ meridionally in tropics, 40 vertical layers</td>
<td>• Resolution: Same as MOM4_L40</td>
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<tr>
<td>• To couple with a carbon cycle module (from OCMIP2) with simple biogeochemical processes.</td>
<td>• To couple with the MPI biogeochemical module (HAMOCC)</td>
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## Sea ice model

<table>
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<tr>
<th>SIS =&gt; CMIP5</th>
<th>CICE5 =&gt; CMIP6</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Originated from GFDL</strong></td>
<td><strong>Originated from the Los Alamos sea ice model version 5 (CICE5)</strong></td>
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<tr>
<td><strong>A component of BCC-CSM1.1, BCC-CSM1.1m</strong></td>
<td><strong>A component of BCC-CSM2, BCC-ESM1</strong></td>
</tr>
<tr>
<td>• Resolution: Same as Ocean model.</td>
<td>• Resolution: Same as MOM4_L40.</td>
</tr>
<tr>
<td>3 vertical layers, including 1 snow cover and 2 sea ice layers of equal thickness.</td>
<td></td>
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</table>
# BCC Earth System Model (BCC-ESM)

**BCC_CSM1 => CMIP5**

1. Atmospheric model: BCC-AGCM2.1 Only prognostic CO2. No chemistry and advected transfer
2. Land: BCC-AVIM1
3. Ocean: MOM4 coupled with OCMIP module


## BCC-AGCM-Chem1: BCC Atmospheric General Circulation Chemistry model

| OX | N2O | N | NO | NO2 | NO3 | HNO3 | HO2NO2 | N2O5 | CH4 | CH3O2 | CH3OOH | CH2O | CO | OH | H2O2 | C3H6 | ISOP | PO2 | CH3CHO | POOH | CH3CO3 | CH3COOOH | PAN | ONIT | C2H6 | C2H4 | C4H10 | MPAN | ISOPO2 | MKV | MACR | MACRO2 | MACROOH |
|----|-----|---|----|-----|-----|------|--------|------|-----|------|--------|------|----|----|-----|------|------|-----|-----|--------|------|--------|--------|-----|-----|-----|-----|------|------|-------|----|-----|--------|--------|

**BCC_ESM1 => CMIP6**

1. Atmospheric model: BCC-AGCM-Chem1
2. Land CO2 cycle: BCC-AVIM2
3. Ocean: MOM5 coupled with **HAMOCC** (MPI ocean biogeochemical model)

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**82 chemistry tracers**

(66 in MOZART2 + CO2 + SO2 + 14 Aerosols)

**MOZART2**: Model version 2 for OZone And Related chemical Tracers
5S-5N zonal wind monthly means

U at 5°N-5°S in m/s

OBS (ERA-Interim data)

BCC-AGCM simulations
The local time of maximum frequency of diurnal rainfall

JJA

CMIP5 models
The local time of maximum frequency of diurnal rainfall

**JJA**

**MAM**

**Local time (hour)**

**TRIM**

**BCC-CSM2-MR**

**obs summer (JJA) max fre time**

**wu0911 summer (JJA) max fre time**

**obs spring (MAM) max fre time**

**wu0925 spring (MAM) max fre time**
DJF mean precipitation

**XIE-ARKIN**

**BCC-CSM2-HR (T266)**

**BCC-CSM1.1(m) (T106)**

**BCC-CSM1.1 (T42)**
JJA mean precipitation

XIE-ARKIN

BCC-CSM1.1(m) (T106)

BCC-CSM2-HR (T266)

BCC-CSM1.1 (T42)
In high resolution model, the regional feature of precipitation is obviously improved.
In high resolution model, the regional feature of air surface temperature is obviously improved.
The impact of rice paddy water in BCC-AGCM2

- **Soil moisture**
- **Soil evaporation**
- **Latent heat flux**
- **Precipitation**
Annual mean temperature anomalies from CMIP5
(relative to the climate mean: 1961-1990)

CMIP5 simulations

BCC-CSM2-LR
using prescribed aerosols

**Figure 2.** Time series of (a) the CMIP5-recommended global annual anthropogenic CO₂ emissions (thick solid line) due to fossil fuel combustion and cement production (dash line) and other anthropogenic activities (thin solid line), (b) the annual CO₂ concentration, and (c) the global mean surface air temperature anomalies from the historical experiment (widen solid line) compared to observations (thin solid line). The units are (a) GtC yr⁻¹, (b) ppmv, and (c) K, respectively. The observation data in Figures 2b and 2c are the CMIP5-recommended global CO₂ observation data set and the HadCRUT3 data set [Brohan et al., 2006], respectively.

**Figure 3.** Time series of the simulated annual mean CO₂ flux averaged for the global ocean (thick line) and global land (thin line). The units are GtC yr⁻¹, accounted positive upward.

\[
\frac{\partial \text{CO}_2 \text{atm}(t)}{\partial t} = E_\text{fossil} + E_\text{landuse} + F_\text{land} + F_\text{ocean}
\]  

where \( t \) is the time, \( E_\text{fossil} \) and \( E_\text{landuse} \) are the CO₂ emissions due to fossil fuel consumption and cement manufacture, and land use change (including wood harvest), respectively. The
CO2 seasonal variation simulated by BCC-ESM1
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Global aerosol amount (Tg) in the atmosphere averaged for 1871 to 1880.
Annual mean vertically integrated concentrations of sulfate
Annual mean vertically integrated concentrations of Black Carbon (CB) and Organic Carbon (OC)

Total: CB=CB1+CB2

Total: OC=OC1+OC2
Annual mean vertically integrated concentrations of Sea Salt (SSLT) and Dust (DST)

SSLT (BCC) and SSLT (CMIP5) maps show the distribution of sea salt concentrations.

DST (BCC) and DST (CMIP5) maps display the distribution of dust concentrations.

The color bars indicate the concentration levels in ug/m².
MIPs in CMIP6

- **DECK** and **NUCLEUS 6**
- **13 MIPs** that BCC will contribute simulations to

<table>
<thead>
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<th>Short name of MIP</th>
<th>Long name of MIP</th>
<th>BCC China</th>
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<td>1 AerChemMIP</td>
<td>Aerosols and Chemistry Model Intercomparison Project</td>
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<tr>
<td>2 C4MIP</td>
<td>Coupled Climate Carbon Cycle Model Intercomparison Project</td>
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<tr>
<td>3 CFMIP</td>
<td>Cloud Feedback Model Intercomparison Project</td>
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<td>4 DAMIP</td>
<td>Detection and Attribution Model Intercomparison Project</td>
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<tr>
<td>5 DCPP</td>
<td>Decadal Climate Prediction Project</td>
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<td>7 GDDEX</td>
<td>Global Dynamical Downscaling Experiment</td>
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<td>9 GMMIP</td>
<td>Global Monsoons Model Intercomparison Project</td>
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<td>Land Surface, Snow and Soil Moisture</td>
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<td>19 RFMIP</td>
<td>Radiative Forcing Model Intercomparison Project</td>
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<td>6 FAFMIP</td>
<td>Flux-Anomaly-Forced Model Intercomparison Project</td>
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<tr>
<td>8 GeoMIP</td>
<td>Geoengineering Model Intercomparison Project</td>
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<td>11 ISMIP6</td>
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<td>12 JCOMM*</td>
<td>Coordinated Ocean Wave Climate Project</td>
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<td>15 nonlinMIP</td>
<td>Non-linear Model Intercomparison Project</td>
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<td>21 SensMIP</td>
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<td>22 VolMIP</td>
<td>Volcanic Forcings Model Intercomparison Project</td>
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</table>
Frozen BCC-ESM1-LR → run AerChemMIP, C4MIP

Frozen BCC-CSM2-MR → run DECK and most of other MIPs

Frozen BCC-CSM2-HR → run GDDEX and HighResMIP
Contents

• Beijing Climate Center Climate System Model (BCC_CSM) development, and towards to CMIP6
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• Sub-seasonal to seasonal (S2S) prediction in CMA
In Dec. 2005:

The first generation of Beijing Climate Center Climate Prediction System (BCC-CPSv1)

| A month forecast (0-45 days) | • BCC_AGCM1.0 (T63L16)  
| | • 6 times a month. The starting dates are the 1\textsuperscript{st}, 6\textsuperscript{th}, 11\textsuperscript{th}, 16\textsuperscript{th}, 21\textsuperscript{th} and 26\textsuperscript{th} of each month.  
| | • integrated for 45 days forced by persisted SST anomalies (persistence of the previous weekly SST anomalies).  
| | • Atmospheric initial states: weather forecast model (T639) in NMC/CMA  
| | • 40 ensemble members. Half of them are generated with lagged-average-forecast (LAF) method, the other half with singular-vector-decomposition (SVD) method.  
| | • Re-Forecasts: 1982-now |

| Seasonal Forecast (0-11 months) | • BCC_CM1 (T63L16 in Atmosphere; T63L30 in ocean)  
| | • Once a month  
| | • Integrated for 11 months.  
| | • 48 ensemble members (6 oceans and 8 atmospheres).  
| | Atmospheric initial states: NCEP reanalyses  
| | Oceanic initial states: BCC_GODASv1  
| | • Re-Forecasts: 1982-now |
### A month forecast (0-45 days)

- **BCC AGCM2.2 (T106L26)**
- **Daily four times forecast.** The starting times are every 6-hour interval.
- Integrate 45 days forced by persisted SST anomalies (persistence of the previous weekly SST anomalies).
- Initial data: NMC/CMA T639 assimilation \((u, v, ps, T)\) and NOAA OiSST (fixed the SST anomalies)
- 13 ensemble members.
- The operational run stated on Dec. 1, 2013.
- Re-Forecasts: 1991-2012

### Seasonal Forecast (0-11 months)

- The fully coupled climate model **BCC CSM1.1m (T106L26)**
- Forecast on the first day of every month
- Integrate 11 months.
- 19 ensemble members of 15 lagged-average-forecast and 4 singular-vector (SV) method
- Initial data:
  - Atmosphere: NCEP reanalyses for hindcast, and NMC/CMA T639 assimilation for real-time prediction;
  - Ocean: NCEP-GODAS oceanic data for hindcast, and BCC-GODASv2 for real-time prediction
- The quasi operational run stated on Jan. 1, 2014.
- Re-Forecasts: 1991-2012

### S2S Forecast (0-60 days)

- **BCC-CSM1.2 (T106L40)**
- Once a day
- Control forecast + 3 perturbed ensemble members
- The operational run stated on Jan. 1, 2015.
Seasonal prediction skills and biases

Forecast: initialized on 1\textsuperscript{st} of each month, 13-month integration

Ensemble forecast: 15 LAF members + 4 SV members

Hindcast period: 1991-2013

Data preprocess: 0-month lead (LM0); 1-month lead (LM1) …… 6-month lead (LM6)
Hindcasted climatologies of JJA-mean U850 and PREC

Obs, CMIP, 0-month lead (LM0), 6-month lead (LM6)

A quick formation and stable maintenance of prediction biases from beginning of forecast.

Compared to the long-term CMIP simulation, resemble distributions of biases are found.

(Liu et al., 2015: Adv. Atmos. Sci.)
Interannual standard deviations of JJA-mean U850 and PREC

The seasonal forecasts may reproduce the similar pattern to observations. It is better than CMIP-type simulations.

(Liu et al., 2015: Adv. Atmos.Sci.)
Forecast skills in JJA-mean U850 at different lead time

(Data: 1991-2013, ensemble mean)

Forecast becomes unskillful over most regions beyond 4-month lead.

Significant TCCs are over most tropical Indian-Pacific oceans.

(Liu et al., 2015: Adv. Atmos.Sci.)
Forecast skills in JJA-mean PREC at different lead time

Less forecast skill for precipitation than 850 hPa wind. It drops quickly with lead time.
Interannual variations of SEASM, WY, and SASM indices

Validation data: NCEP-R2

Validation data: ERA Interim

- WY: vertical shear of zonal winds between 850 and 200-hPa levels averaged over 0–20N/40–110E (Webster and Yang, 1992)
- SASM: vertical shear of meridional winds between 850 and 200-hPa levels averaged over 10–30N/70–110E (Goswami et al., 1999)

![Graphs showing interannual variations of SEASM, WY, and SASM indices with validation data from NCEP-R2 and ERA Interim.](image-url)
Forecast skills in JJA-mean SST at different lead time
First principal components and spatial modes for EOF analysis of SSTs over the tropical Pacific.

The extensive significant anomaly over the eastern Pacific is well captured by the 0- and 1-month lead forecasts, but its spatial range quickly reduces to a narrow band near the equator at the lead time of 2 and 3 months.
Nino 3.4 SST forecast

Starting date: May 01

ENSEMBLES:
- 54 members
- CFSv1: 15 members
- BCC(LAF): 15 members
- BCC(SV): 8 members

Models

<table>
<thead>
<tr>
<th>Models</th>
<th>Organizations</th>
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<td>IFS/HOPE</td>
<td>ECMWF</td>
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<td>ARPEGE/OPA</td>
<td>Météo-France</td>
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<tr>
<td>HadGEM2</td>
<td>Met Office, UK</td>
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<tr>
<td>ECHAM5/OPA8.2</td>
<td>INGV</td>
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<tr>
<td>ECHAM5/OM1</td>
<td>IfM Kiel</td>
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<td>HadCM3 (perturbed parameter)</td>
<td>Met Office, UK</td>
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### Characteristics of S2S forecast systems

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<th>Time-range</th>
<th>Resolution</th>
<th>Top Level</th>
<th>Freq.</th>
<th>Ens. Size</th>
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<tbody>
<tr>
<td>ECMWF</td>
<td>D 0-32</td>
<td>T639/319L62</td>
<td>~0.5 hPa</td>
<td>2/week</td>
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<td>UKMO</td>
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<td>N96L85</td>
<td>~0.25 hPa</td>
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<td>NCEP</td>
<td>D 0-60</td>
<td>N126L64</td>
<td>~0.2 hPa</td>
<td>daily</td>
<td>4</td>
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<tr>
<td>EC</td>
<td>D 0-35</td>
<td>0.6×0.6L40</td>
<td>~2 hPa</td>
<td>weekly</td>
<td>4</td>
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<tr>
<td>CAWCR</td>
<td>D 0-120</td>
<td>T47L17</td>
<td>~10 hPa</td>
<td>weekly</td>
<td>33</td>
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<tr>
<td>JMA</td>
<td>D 0-34</td>
<td>T159L60</td>
<td>~0.1 hPa</td>
<td>weekly</td>
<td>5</td>
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<tr>
<td>KMA</td>
<td>D 0-30</td>
<td>T106L21</td>
<td>~10 hPa</td>
<td>3/month</td>
<td>20</td>
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<tr>
<td>Meteo-France</td>
<td>D 0-60</td>
<td>T127L31</td>
<td>?</td>
<td>monthly</td>
<td>51</td>
</tr>
<tr>
<td>CMA</td>
<td>D 0-60</td>
<td>T106L40</td>
<td>1.65 hPa</td>
<td>daily</td>
<td>4</td>
</tr>
</tbody>
</table>
S2S

Fully-coupled Climate System Model

BCC_CSM2.0

BCC_CSM1.1(m)

BCC_AGCM3 (T106, L40)  Top: 0.31 hPa
BCC_AVIM2.0 (T106)
MOM4-L40v2 (1/3° ~30km)
SIS(1/3° ~30 km)

BCC_AGCM2.2(T106 ~110 km, L26)  Top: 2.19 hPa
BCC_AVIM1.0(T106)
MOM4-L40v2(1/3°~30km)
SIS(1/3°~30km)

Atmosphere model

Coupler

Land model

Sea-Ice model

OCEAN model

( Newly-developed operational model system)
The Coordinated Initialization System (CIS)

BCC_CSM2 (T106L40)

BCC_AGCM3

Coupler

BCC_AVIM2

SIS

MOM4_L40v2

Observations or Reanalyse data
atmospheric states
(e.g. CMA, NCEP, FNL)
Land surface states
(e.g. BCC_MergP)
Oceanic states
(e.g. BCC_GODASv2)
....

BCC Model initial data for S2S run
Configuration of S2S hindcast

e.g., the forecast initialized on 20140501

Daily rolling hindcasts, 60-day integrations (19940101-20140430)
- 3 weeks behind real-time
- 20 years of CMA S2S hindcast data have been published on ECMWF website
Extreme event (27-31 Jan, 2015) of cold surge forecasts from the S2S Project

2m temperature difference between 27-31 Jan. and 26 Jan.

CMA    ECMWF    NCEP

Lead time

0 day
-5 day
-10 day
-15 day
Extreme event (1-10 April, 2015) of cold surge forecasts from the S2S Project

2m temperature difference between 1-10 April and 31 March.

Diff of 2m between 1-10 and 31 by observation

CMA
ECMWF
NCEP

0 day
-5 day
-10 day
-15 day
Extreme event (5-19 June, 2015) of heat wave forecasts

2m temperature difference between 5-19 June and 4 June.
MJO forecast verification

Overall MJO prediction skill in original S2S hindcasts

\[
\text{COR}(\tau) = \frac{\sum_{i=1}^{N} \left[ a_{1i}(t)b_{1i}(t) + a_{2i}(t)b_{2i}(t) \right]}{\sqrt{\sum_{i=1}^{N} [a_{1i}(t) + a_{2i}(t)]} \sqrt{\sum_{i=1}^{N} [b_{1i}(t) + b_{2i}(t)]}}
\]

\[
\text{RMSE}(\tau) = \sqrt{\frac{1}{N} \sum_{i=1}^{N} \left[ [a_{1i}(t) - b_{1i}(t)]^2 + [a_{2i}(t) - b_{2i}(t)]^2 \right]}
\]
Different initialization schemes

**S2S**: ocean initials (BCC_GODAS) + atmosphere initials (NCEP R1)

**S2S_IEXP1**: ocean initials (BCC_GODAS) + atmosphere initials (NCEP FNL)

**S2S_IEXP2**: ocean initials (BCC_GODAS + OISST) + atmosphere initials (NCEP FNL)
MJO prediction skill and potential predictability in original S2S experiments and improved experiments

(a) MJO BAC (14yr x 12 x 4 cases)

(b) MJO BAC (14yr x 72 x 4 cases)

Skill: 6-day increase!
Plan of BCC_CSM climate model development

Phase 1
1995-2004
BCC_CM1.0
BCC_AGCM1.0(T63)
NCC/LASG OGCM(T63)

Phase 2
2005-2008
BCC_CSM1.0
BCC_AGCM2.0(T42L26); CLM3(T42); POP(1/3°~30km); CSIM(1/3°~30km)

2005-2009
BCC_CSM1.1
BCC_AGCM2.1(T42L26); BCC_AVIM1.0(T42)
MOM4-L40v1(1/3°~30km); SIS(1/3°~30km)

2005-2011
BCC_CSM1.1(m)
BCC_AGCM2.2(T106L26); BCC_AVIM1.0(T106)
MOM4-L40v2(1/3°~30km); SIS(1/3°~30km)

Phase 3
2012-2016
BCC_CSM2
BCC_AGCM3(T266L26); BCC_AVIM1.0(T266)
MOM4-L40v2(1/3°~30km); SIS(1/3°~30km)

Phase 4
2017-2020
BCC_CSM3
BCC_AGCM: T266—>T382(576X1152,~0.313°)
L26—L46—L70 (0.01hPa)
BCC_AVIM: T266—>T382
MOM5-L50 (1/4°~25km)
CICE5 (1/4°~25km)

CMIP5
S2S
CMIP6
Climate prediction
Summary

• Test versions of BCC-CSM2 and BCC-ESM1 for CMIP6 have been set up. The basic model climates are reasonable. With contrast to BCC CMIP5 model, some features such as QBO in stratosphere and diurnal cycle of precipitation are evidently improved. The high-resolution model version shows better performances in reproducing regional climate features in China than lower resolution versions.

• Biases of monthly to seasonal forecast closely related to the model biases of CMIP-type experiment. There are relatively higher forecast skills in atmospheric circulation and SST anomalies than precipitation.

• There are a large amount of S2S data to provide users to do research on MJO, extreme events, and etc. Using the released CMA S2S re-forecast data, the present version of BCC S2S model has low MJO forecast skill (~16 days). Further experiments using BCC model show that oceanic initial states largely impact on the MJO forecast skill.
Thanks for your attention!