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

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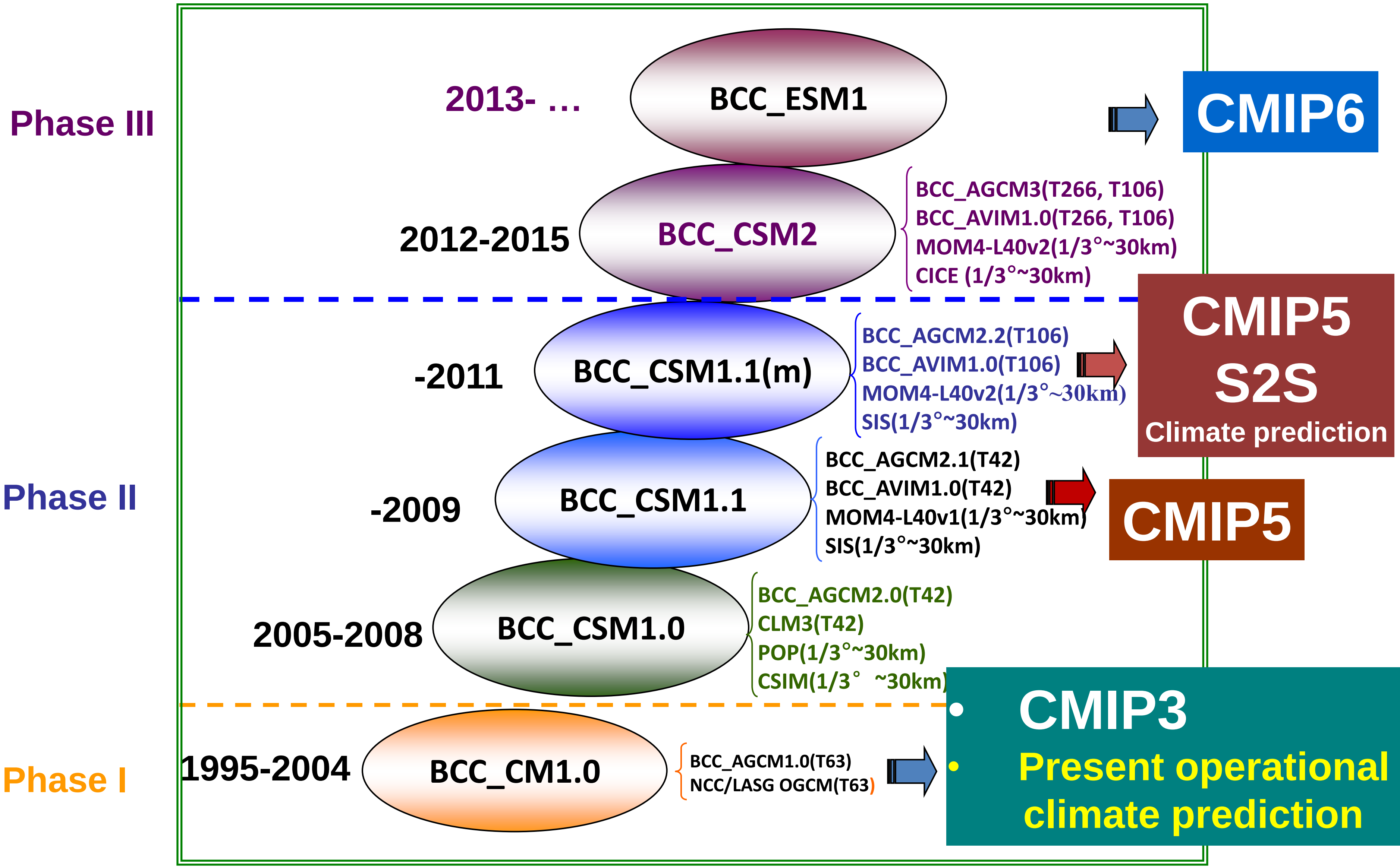
Contents

- 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

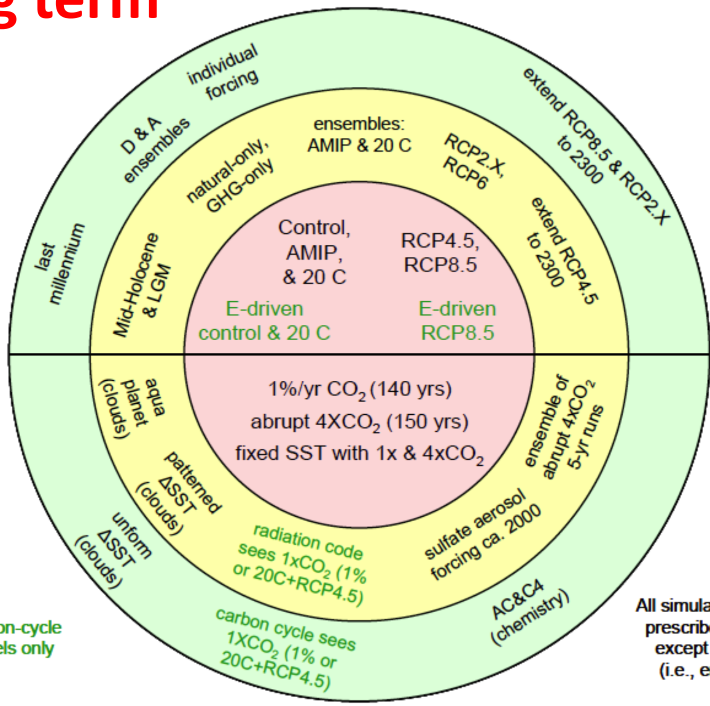
- To monitor and diagnose global atmospheric and oceanic conditions, as well as extreme climate events , especially in East Asia
- To issue global climate predictions and impact assessments at monthly, seasonal and inter-annual time scales, particularly over East Asia
- To provide climate services to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

Beijing Climate Center Climate System Model (BCC_CSM)



CMIP5 experiments

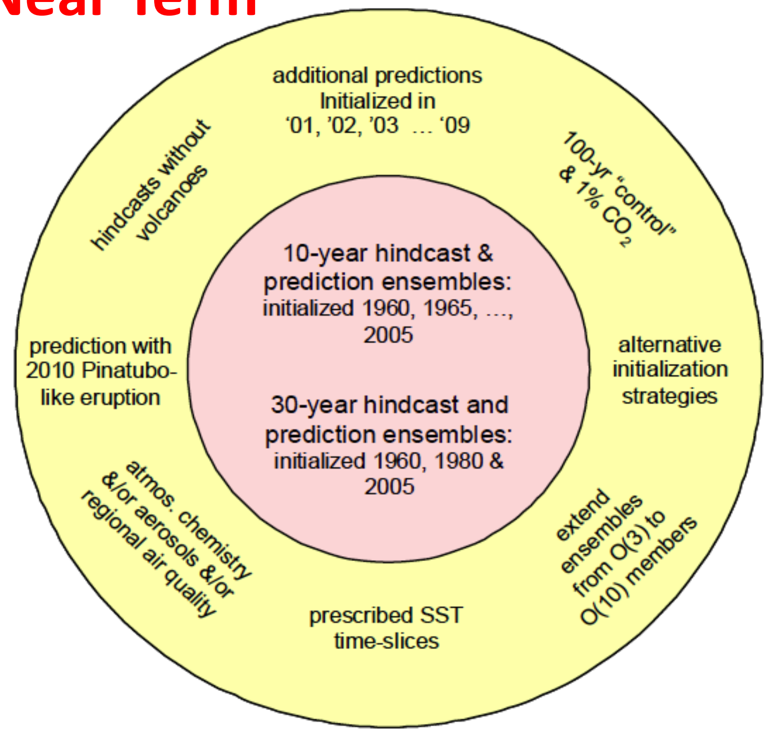
Long term



Coupled carbon-cycle climate models only

All simulations are forced by prescribed concentrations except those “E-driven” (i.e., emission-driven).

Near Term



- **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)

No.	Model	Count	No.	Model	Count	No.	Model	Count
1	IPSL-CM5A-LR	504	24	IPSL-CM5B-LR	234	47	GFDL-CM2.1	110
2	MPI-ESM-LR	486	25	FGOALS-g2	216	48	GISS-E2-H-CC	104
3	CanESM2	477	26	HadCM3	213	49	CanAM4	103
4	HadGEM2-ES	472	27	NorESM1-ME	209	50	CESM1-CAM5.1.FV2	101
5	MRI-CGCM3	468	28	FGOALS-s2	208	51	GISS-E2-R-CC	100
6	NorESM1-M	459	29	BNU-ESM	205	52	MRI-AGCM3.2S	95
7	CNRM-CM5	450	30	ACCESS1.3	182	53	MRI-AGCM3.2H	92
8	CCSM4	440	31	CESM1-CAM5	178	54	MPI-ESM-HR	87
9	MIROC5	428	32	CMCC-CM	174	55	GFDL-HIRAM-C180	86
10	CSIRO-Mk3.6.0	413	33	EC-EARTH	169	56	GFDL-HIRAM-C360	85
11	MIROC-ESM	409	34	MPI-ESM-P	169	57	FGOALS-gl	84
12	BCC-CSM1.1	389	35	BCC-CSM1.1-m	168	58	MIROC4m	84
13	GFDL-ESM2M	376	36	CESM-BGC	165	59	GISS-E2CS-R	81
14	INM-CM4	366	37	MIROC4h	158	60	CNRM-CM5-2	80
15	GISS-E2-R	356	38	FIO-ESM	140	61	GISS-E2CS-H	80
16	IPSL-CM5A-MR	347	39	HadGEM2-AO	140	62	HiGEM1.2	77
17	GFDL-ESM2G	344	40	CanCM4	135	63	HadCM3Q	76
18	HadGEM2-CC	337	41	CMCC-CMS	134	64	CFSv2-2011	75
19	GFDL-CM3	332	42	CMCC-CESM	130	65	GEOS-5	74
20	MIROC-ESM-CHEM	308	43	HadGEM2-A	120	66	CCSM4-RSMAS	73
21	MPI-ESM-MR	265	44	CESM1-WACCM	117	67	NICAM.09	73
22	GISS-E2-H	255	45	MRI-ESM1	113	68	BESM-OA2.3	69
23	ACCESS1.0	236	46	CESM1-FASTCHEM	112			

Updated by Oct 8, 2015

BCC Models for **CMIP5**

Model versions	Model components	Resolutions
BCC-CSM1.1	BCC-AGCM2.1 BCC-AVIM1 MOM4-L40v1 SIS	Atmos: T42L26, Top: 2.19 hPa Ocn: 1/3^o in 30S-30N and 1/3-1^o in 30-60 N/S, and 1^o in high latitudes
BCC-CSM1.1(m)	BCC-AGCM2.2 BCC-AVIM1 MOM4-L40v2 SIS	Atmos: T106L26, Top: 2.19 hPa Ocn: 1/3^o in 30S-30N and 1/3-1^o in 30-60N/S, and 1o in high latitudes

BCC Models for **CMIP6**

Model Versions	Model Components	Resolutions
BCC-ESM1-LR	BCC-AGCM3-Chem BCC-AVIM2 MOM4-HAMOCC CICE5	Atmos: T42L26, Top: 2.19 hPa Ocn: 1/3 ^{o} in 30S-30N and 1/3-1^o in 30-60 N/S, and 1^o in high latitudes
BCC-CSM2-MR	BCC-AGCM3-MR BCC-AVIM2 MOM4-HAMOCC CICE5	Atmos: T106L46, Top: 1.46 hPa Ocn: 1/3 ^{o} in 30S-30N and 1/3-1^o in 30-60 N/S, and 1^o in high latitudes
BCC-CSM2-HR	BCC-AGCM3-HR BCC-AVIM2 MOM4-HAMOCC CICE5	Atmos: T266L26, Top: 2.19 hPa Ocn: 1/3 ^{o} in 30S-30N and 1/3-1^o in 30-60 N/S, and 1^o in high latitudes

AGCM component

BCC_AGCM2 ---> CMIP5	BCC_AGCM3 --- > CMIP6
Originated from CAM3 **A component of BCC-CSM1.1, BCC-CSM1.1m** **Resolution: T42L26, T106L26** **Model Dynamic Core:** Wu T., R. Yu, F. Zhang, 2008: A modified dynamic framework for atmospheric spectral model and its application, **J.Atmos.Sci.,** 65. **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	**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

BCC_AVIM1 --> CMIP5	BCC_AVIM2 --> CMIP6
Originated from CLM3 A component of BCC-CSM1.1, BCC-CSM1.1m 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)	A component of BCC-CSM2, BCC-ESM1 Model physics: ➢ 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

MOM4_L40 => CMIP5	MOM5_HAMOCC=> CMIP6
Originated from MOM4 developed by GFDL **A component of BCC-CSM1.1, BCC-CSM1.1m** • Resolution: Tri-pole gridpoints 1º×1º, 1/3º meridionally in tropics,40 vertical layers • To couple with a carbon cycle module (from OCMIP2) with simple biogeochemical processes.	**A component of BCC-CSM2, BCC-ESM1** **Updated to MOM5** • Resolution: Same as MOM4_L40 • To couple with the MPI biogeochemical module (HAMOCC)

Sea ice model

SIS => CMIP5	CICE5 => CMIP6
Originated from GFDL **A component of BCC-CSM1.1, BCC-CSM1.1m** • Resolution: Same as Ocean model. 3 vertical layers, including 1 snow cover and 2 sea ice layers of equal thickness.	**Originated from the Los Alamos sea ice model version 5 (CICE5)** **A component of BCC-CSM2, BCC-ESM1** • Resolution: Same as MOM4_L40.

BCC Earth System Model (BCC-ESM)

BCC_CSM1 => CMIP5	BCC_ESM1 => CMIP6
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 Ref.: Wu T., et al., 2013: Global carbon budgets simulated by the Beijing climate center climate system model for the last century. *J. Geophys. Res. Atmos.*, 118.	1. Atmospheric model: BCC-AGCM-Chem1 2. Land CO2 cycle: BCC-AVIM2 3. Ocean: MOM5 coupled with HAMOCC (MPI ocean biogeochemical model)

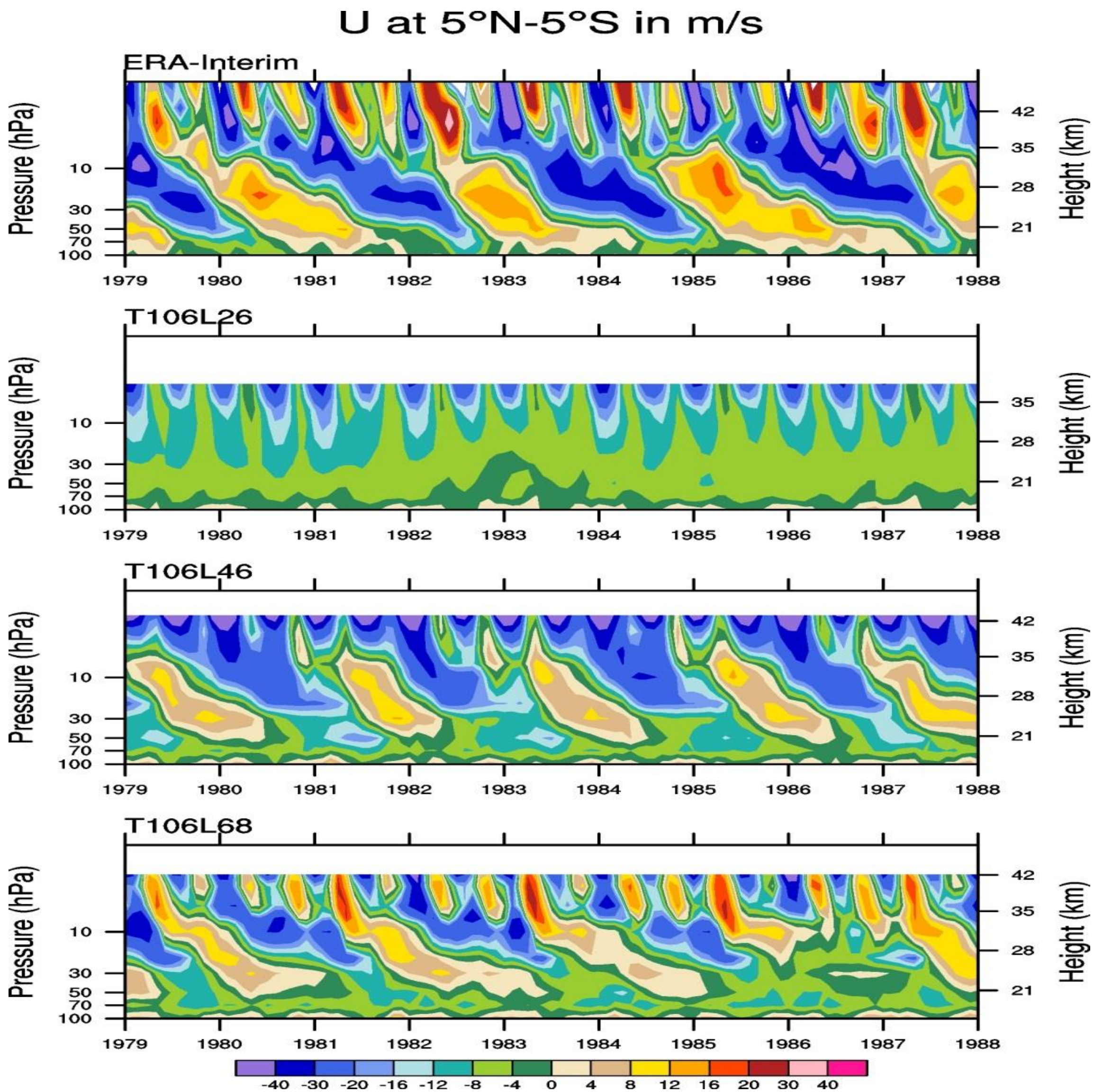
BCC-AGCM-Chem1: BCC Atmospheric General Circulation Chemistry model

OX	N2O	N	NO	NO2
NO3	HNO3	HO2NO2	N2O5	CH4
CH3O2	CH3OOH	CH2O	CO	OH
HO2	H2O2	C3H6	ISOP	PO2
CH3CHO	POOH	CH3CO3	CH3COOOH	PAN
ONIT	C2H6	C2H4	C4H10	MPAN
ISOPO2	MVK	MACR	MACRO2	MACROOH
MCO3	C2H5O2	C2H5OOH	C10H16	C3H8
C3H7O2	C3H7OOH	CH3COCH3	ROOH	CH3OH
C2H5OH	GLYALD	HYAC	EO2	EO
HYDRALD	RO2	CH3COCHO	Rn	Pb
ISOPNO3	ONITR	XO2	XOOH	ISOPOOH
H2	O3S	O3INERT	O3	O1D
O	**CO2**	**SO2**		
SO4	**DMS**	**OC1**	**OC2**	**CB1**
CB2	**SSLT01**	**SSLT02**	**SSLT03**	**SSLT04**
DST01	**DST02**	**DST03**	**DST04**	

82 chemistry tracers (66 in MOZART2 + CO2 + SO2 + 14 Aerosols)

MOZART2: Model version 2 for OZone And Related chemical Tracers

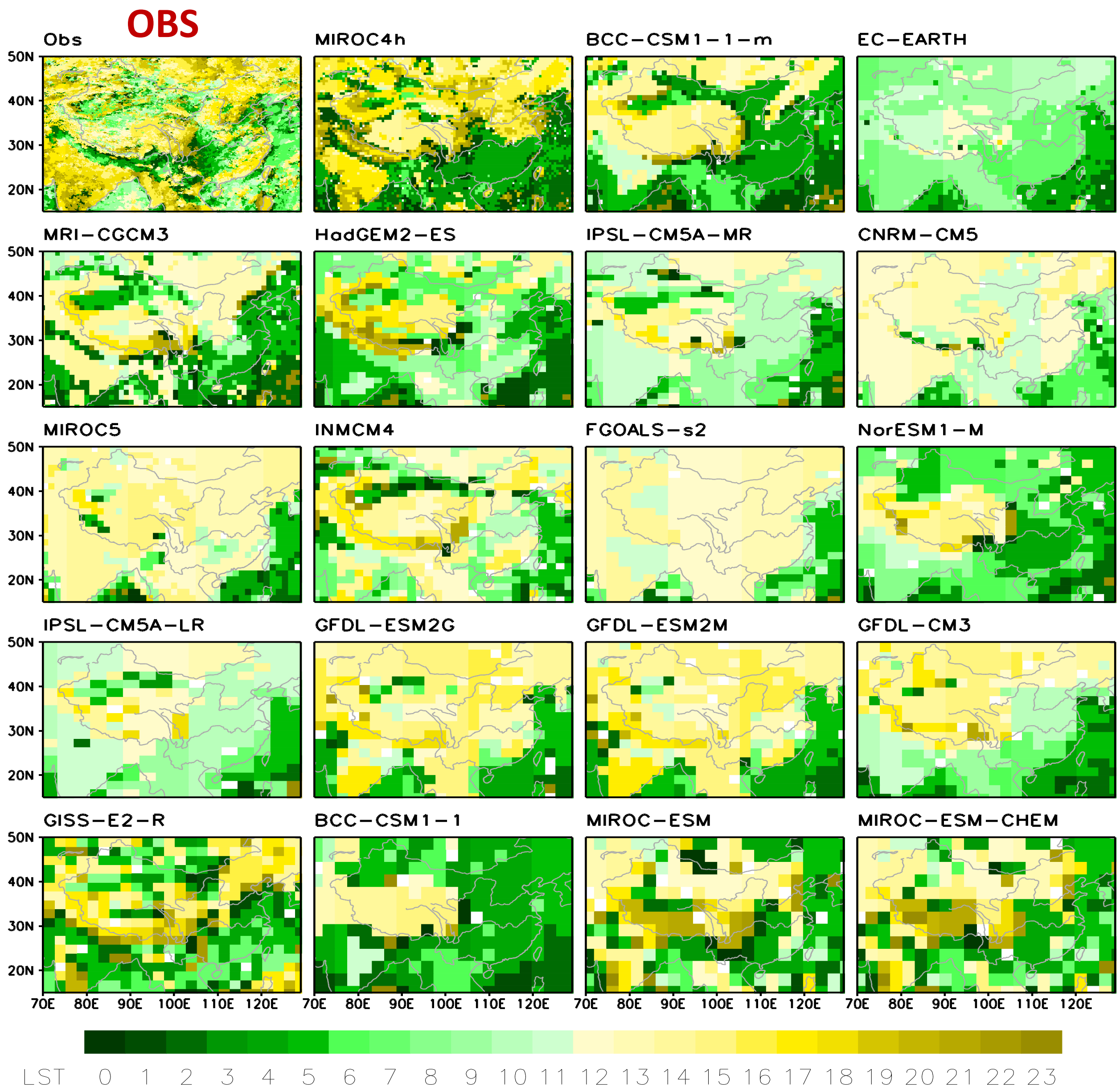
5S-5N zonal wind monthly means



OBS (ERA-Interim data)

BCC-AGCM simulations

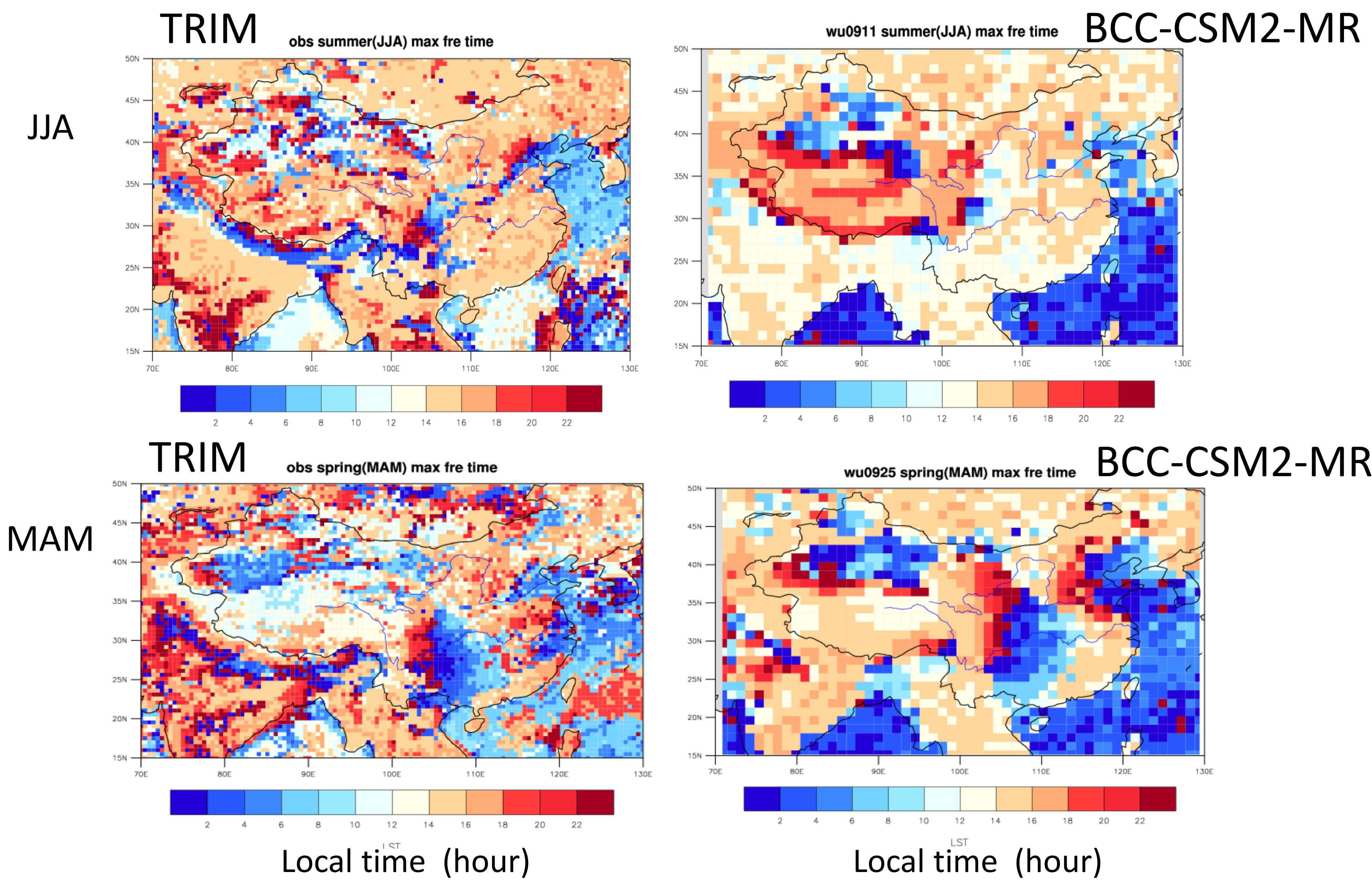
The local time of maximum frequency of diurnal rainfall



JJA

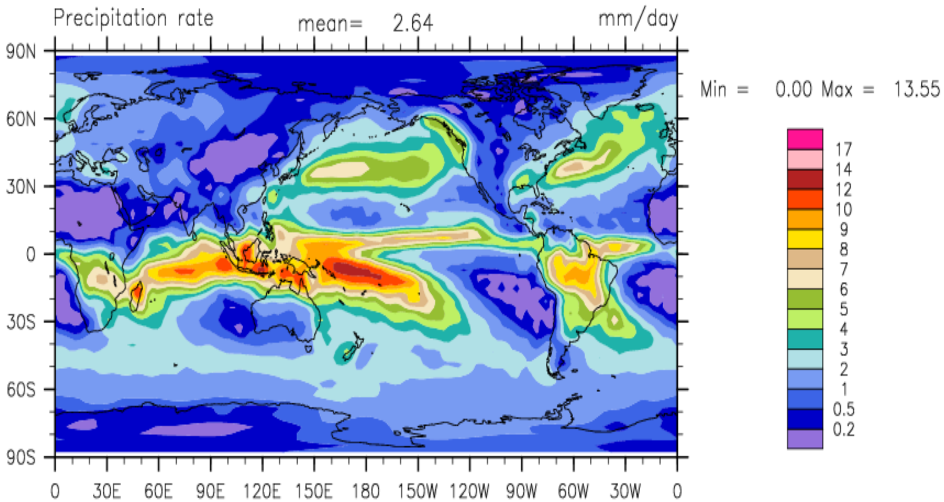
CMIP5 models

The local time of maximum frequency of diurnal rainfall

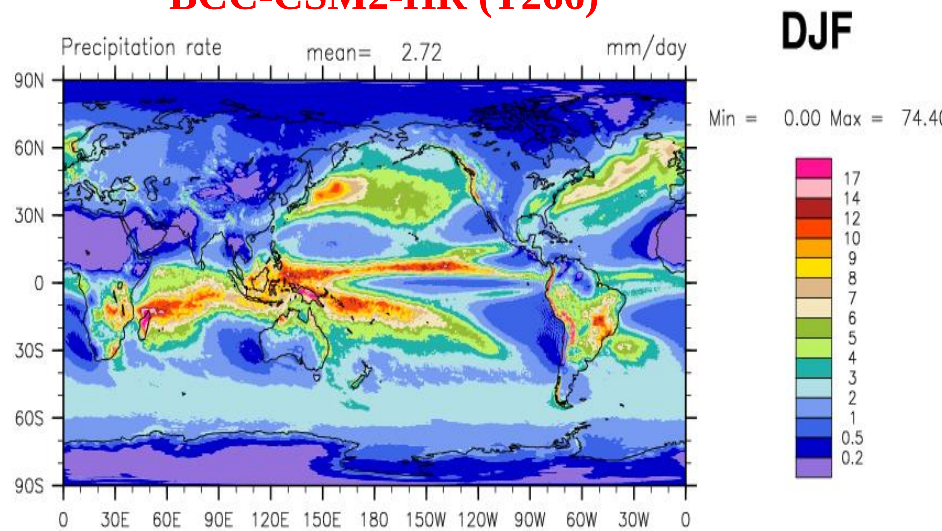


DJF mean precipitation

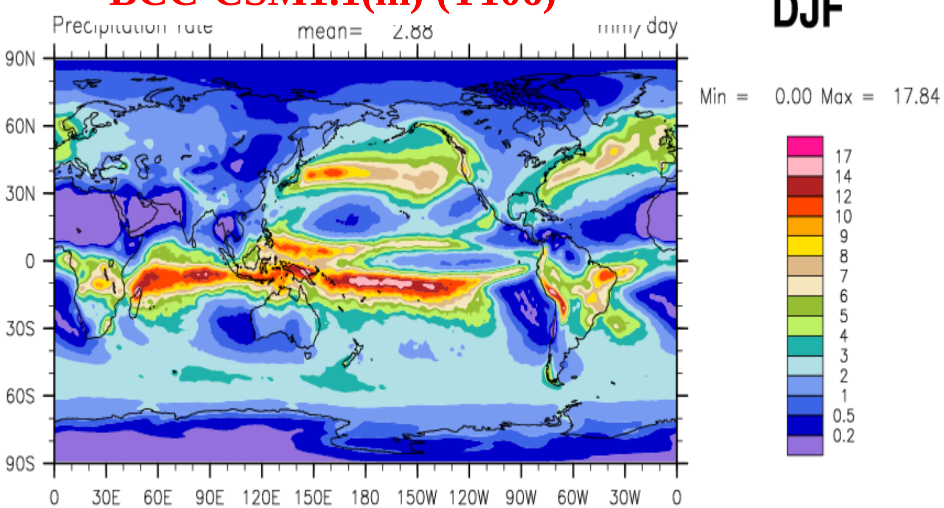
XIE-ARKIN



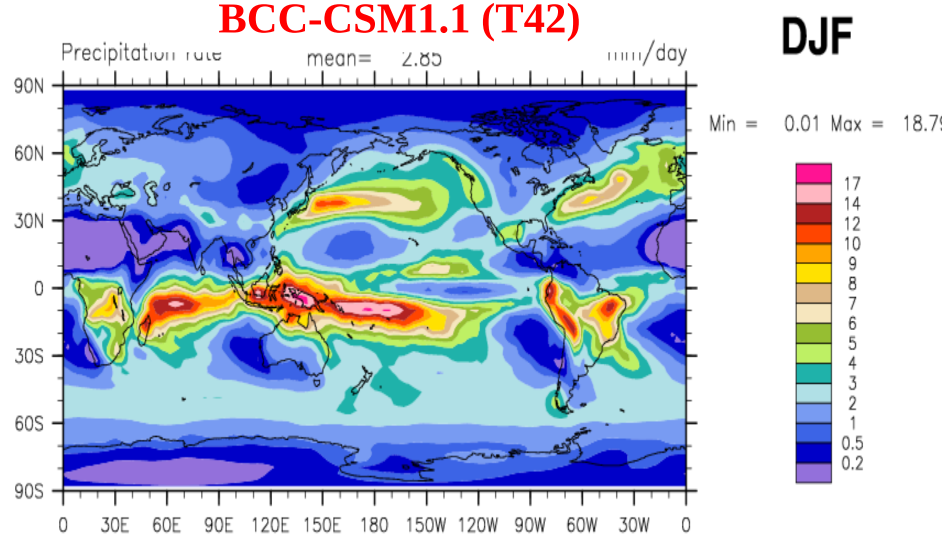
BCC-CSM2-HR (T266)



BCC-CSM1.1(m) (T106)

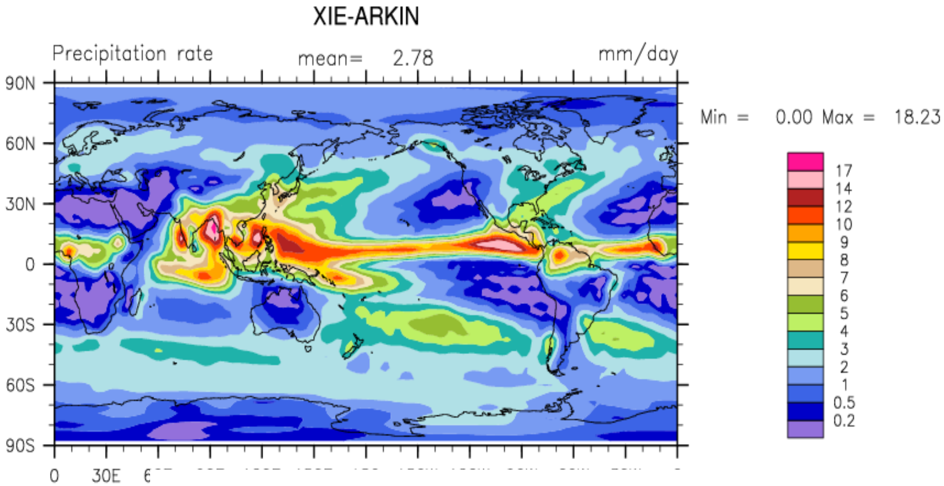


BCC-CSM1.1 (T42)

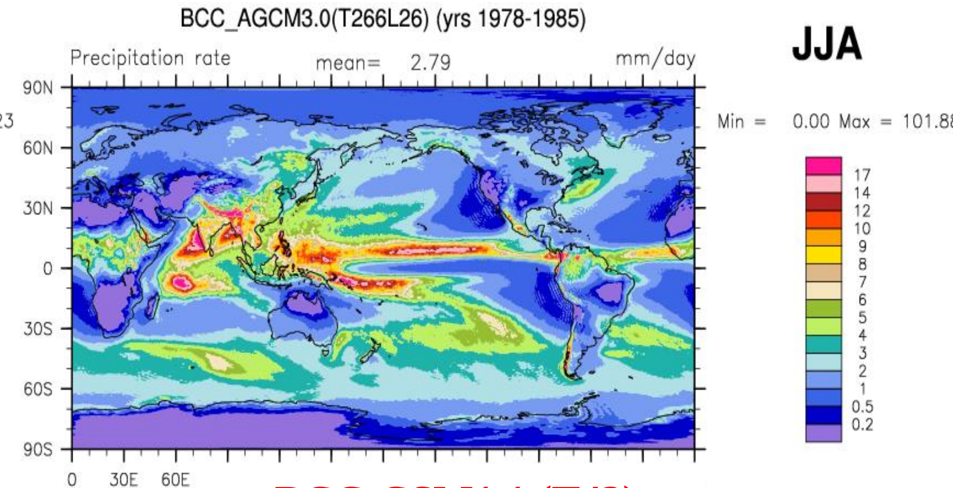


JJA mean precipitation

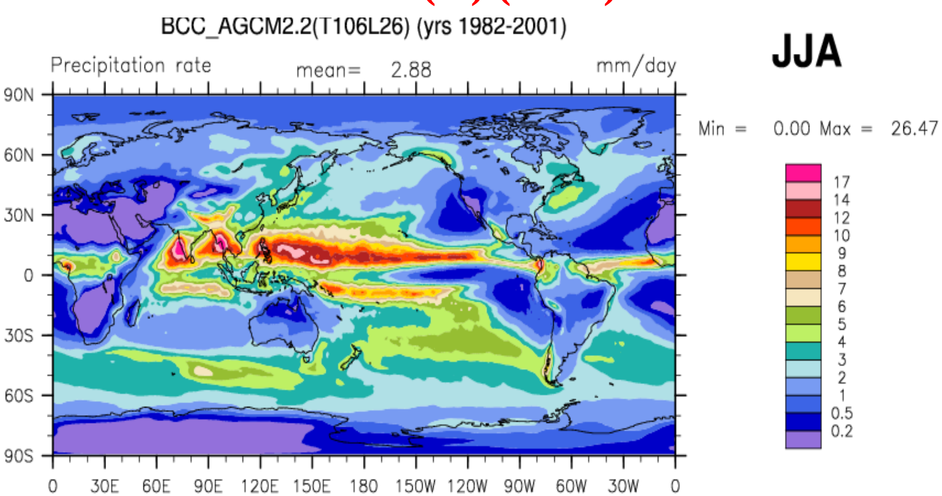
XIE-ARKIN



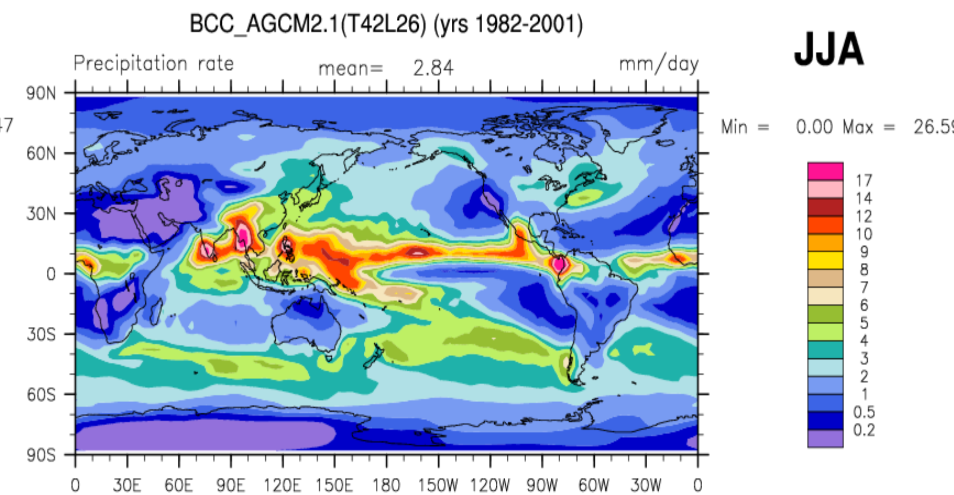
BCC-CSM2-HR (T266)



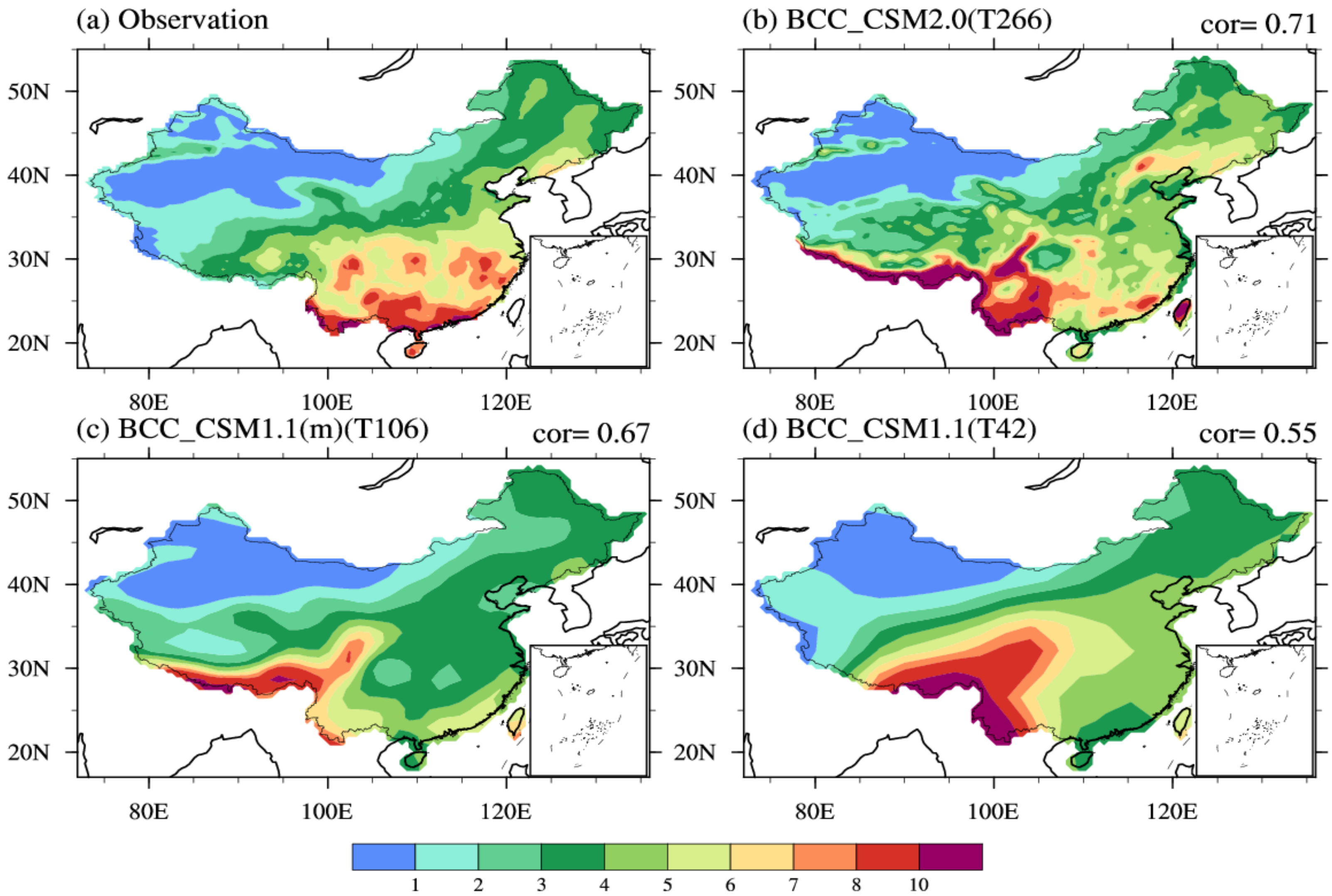
BCC-CSM1.1(m) (T106)



BCC-CSM1.1 (T42)

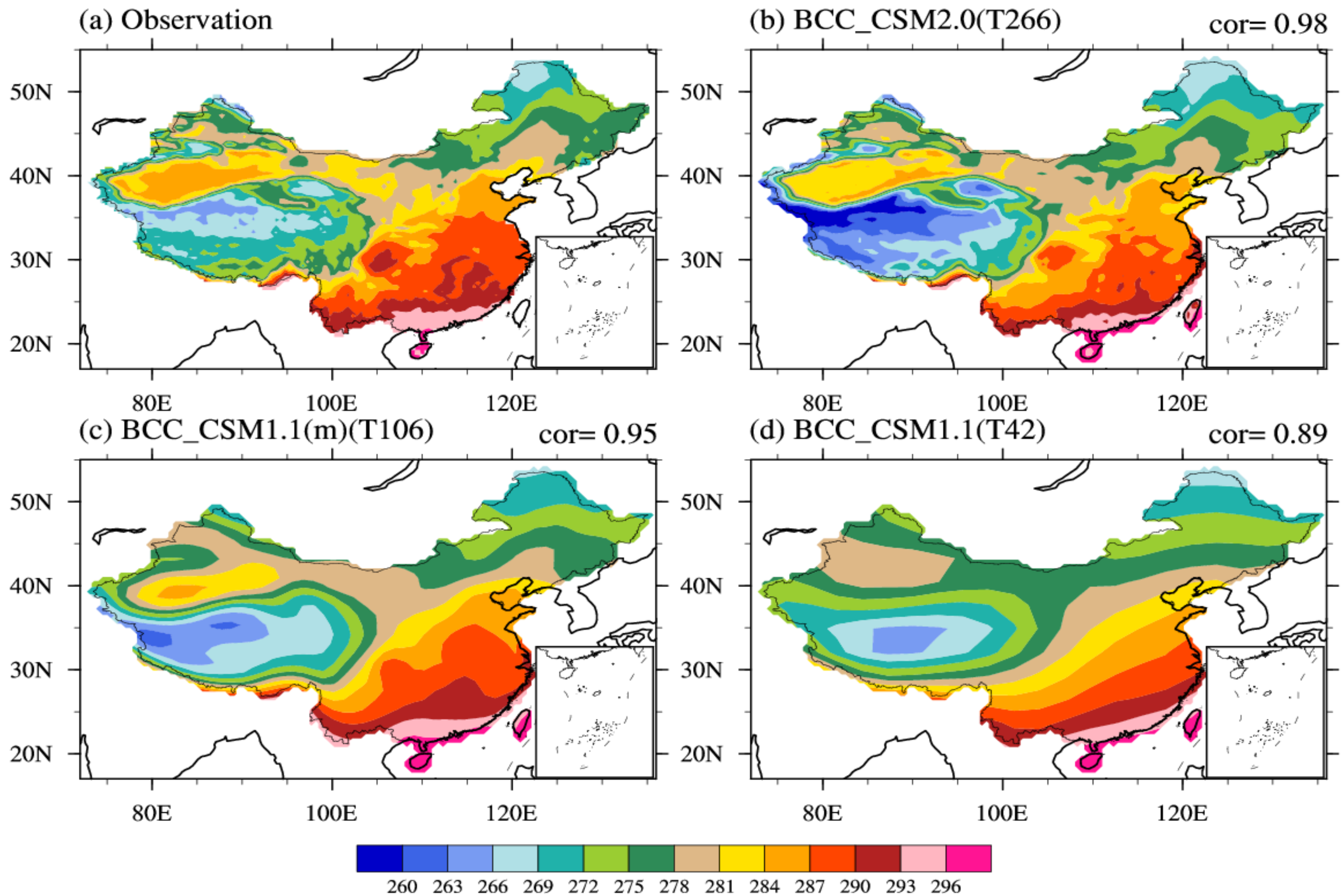


JJA Mean precipitation (mm/day)

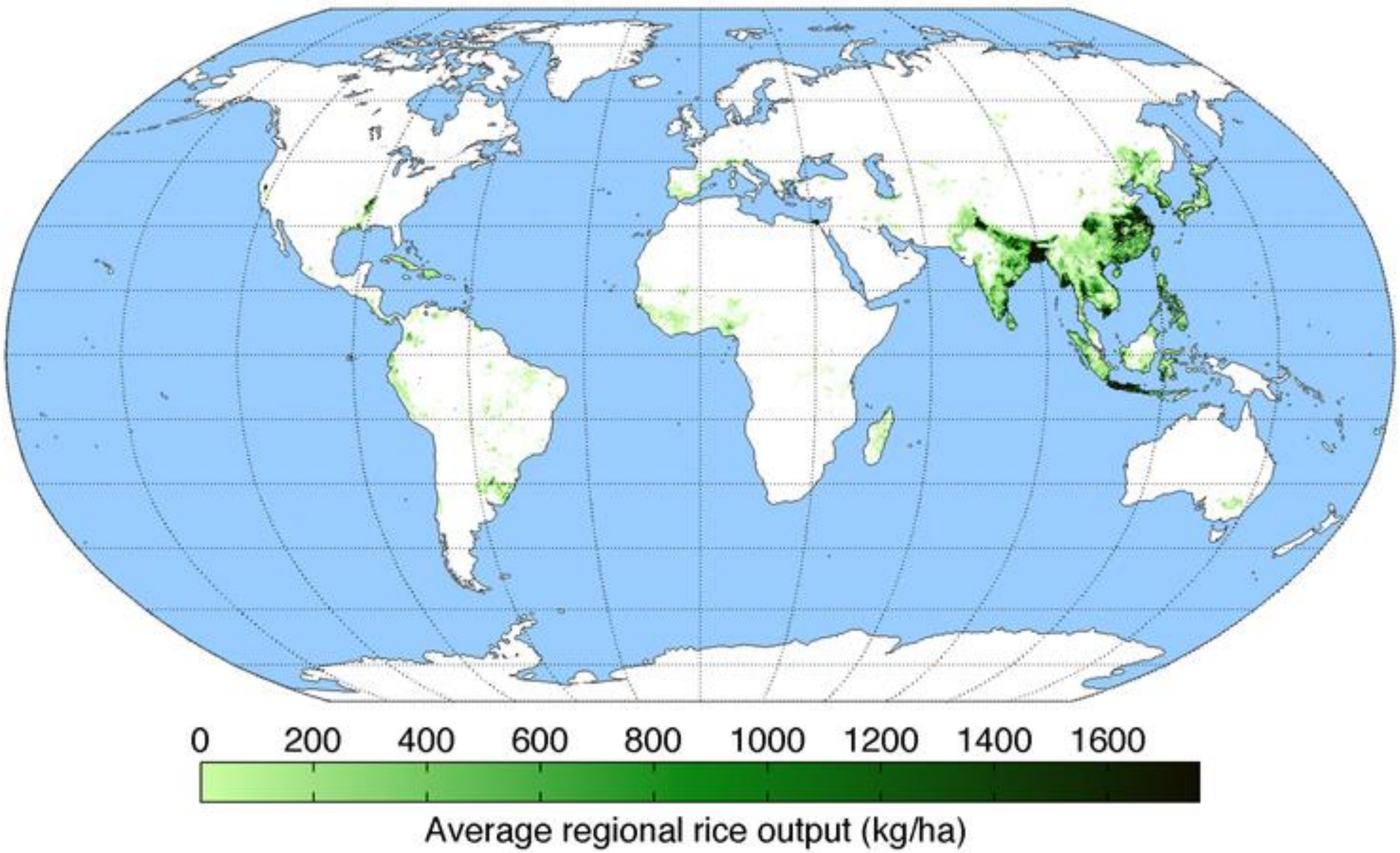


In high resolution model, the regional feature of precipitation is obviously improved

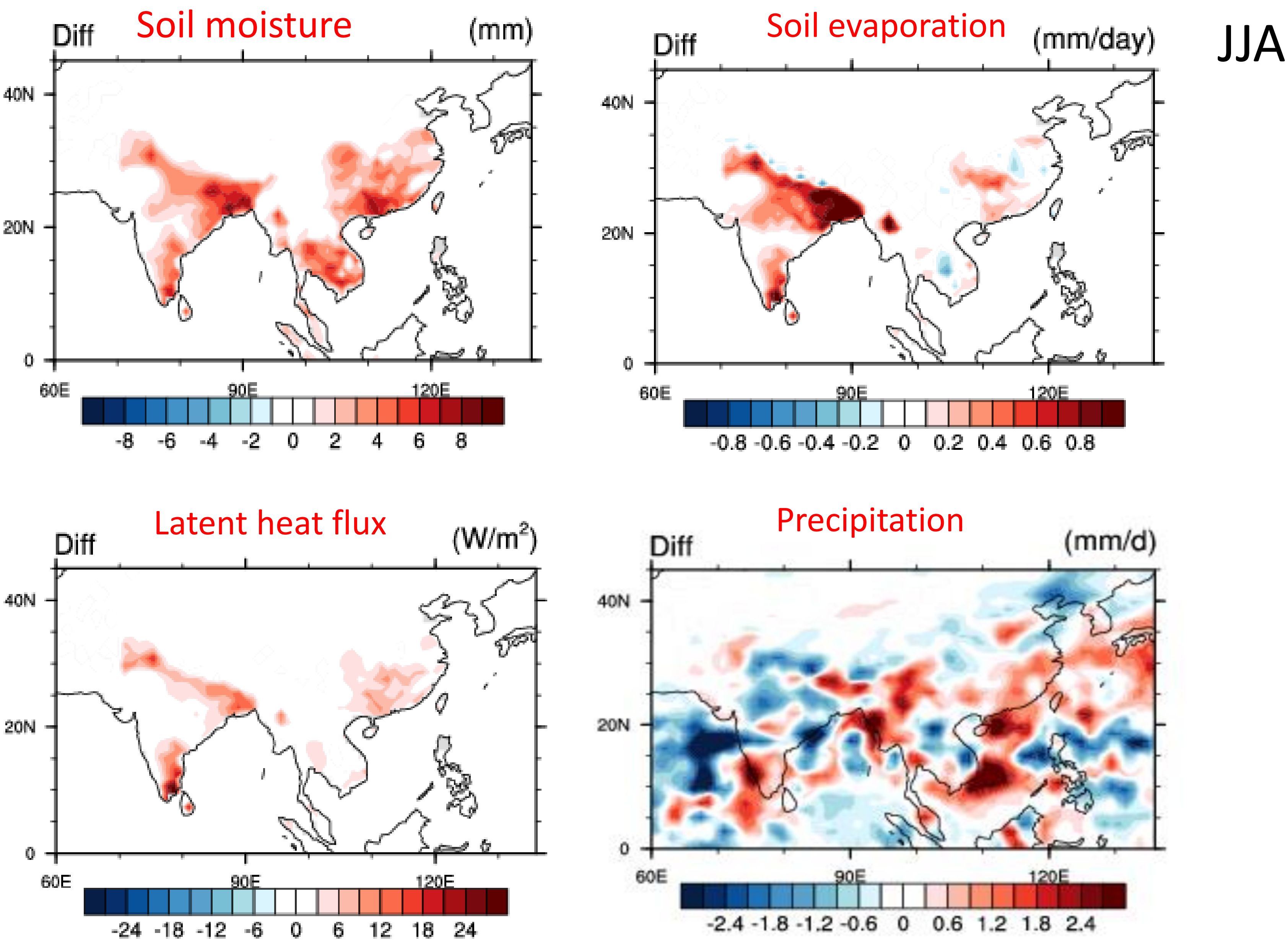
Annual mean temperature



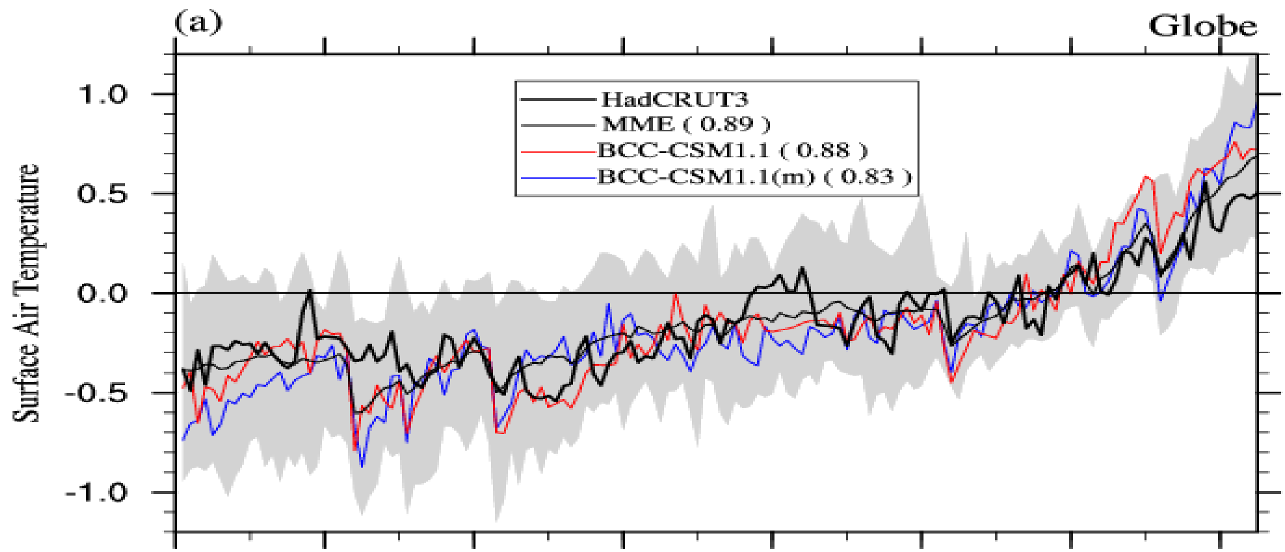
In high resolution model, the regional feature of air surface temperature is obviously improved


0
200
400
600
800
1000
1200
1400
1600
Average regional rice output (kg/ha)

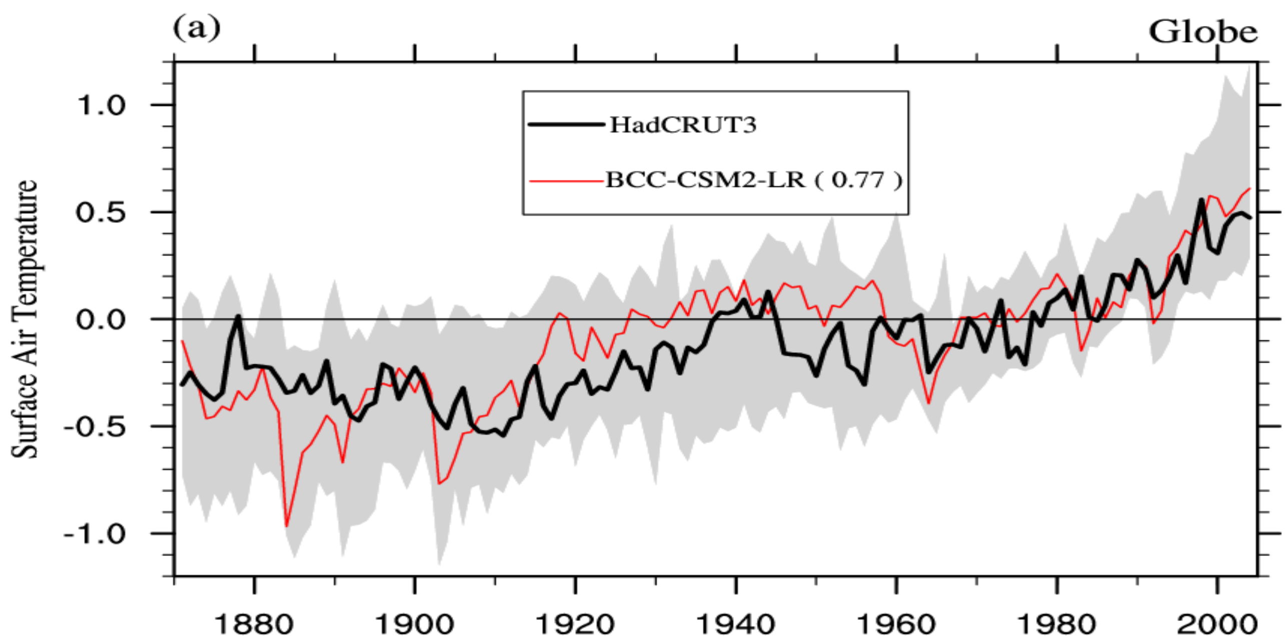
The impact of rice paddy water in BCC-AGCM2



Annual mean temperature anomalies from CMIP5
(relative to the climate mean: 1961-1990)



CMIP5 simulations



BCC-CSM2-LR
using prescribed aerosols

Wu Tongwen, Weiping Li, Jinjun Ji, et al., 2013: **Global carbon budgets simulated by the Beijing Climate Center Climate System Model for the last century**. ***J. Geophys. Res. Atmos***., 118, 4326–4347, doi:10.1002/jgrd.50320.

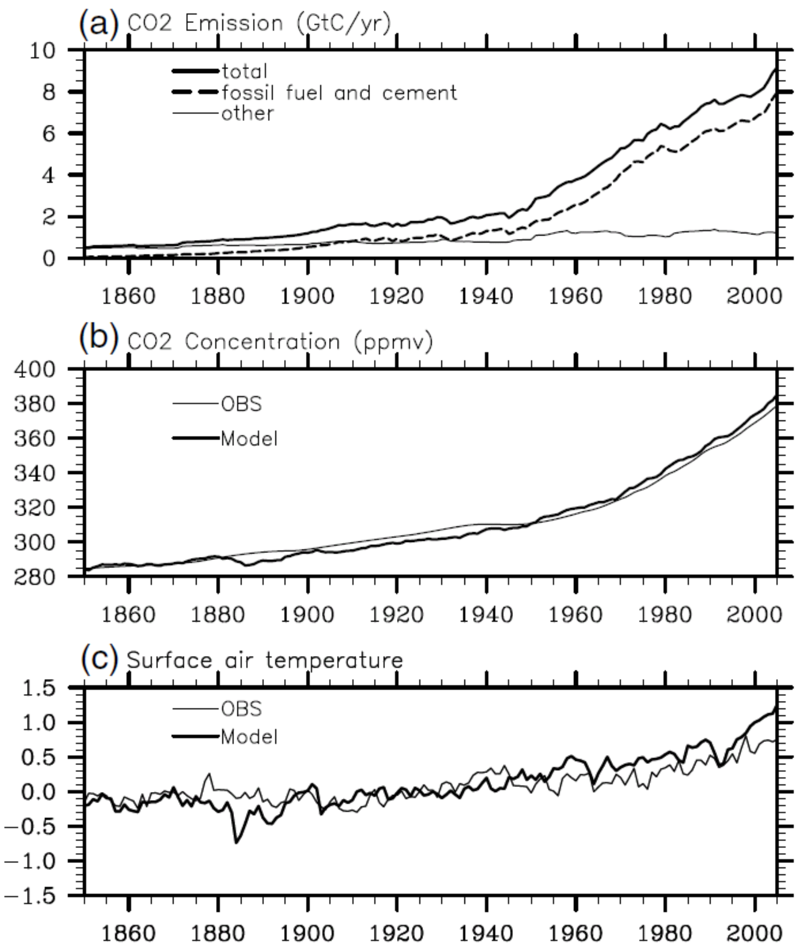


Figure 2. Time series of (a) the CMIP5-recommended global annual anthropogenic CO_2 emissions (thick solid line) due to fossil fuel combustion and cement production (dash line) and other anthropogenic activities (thin solid line), (b) the annual CO_2 concentration, and (c) the global mean surface air 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 CO_2 observation data set and the HadCRUT3 data set [*Brohan et al.*, 2006], respectively.

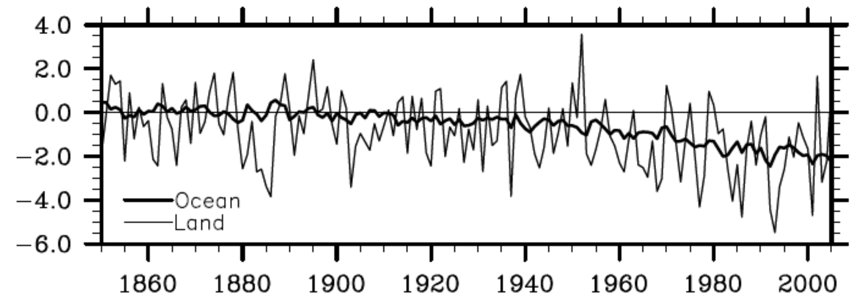
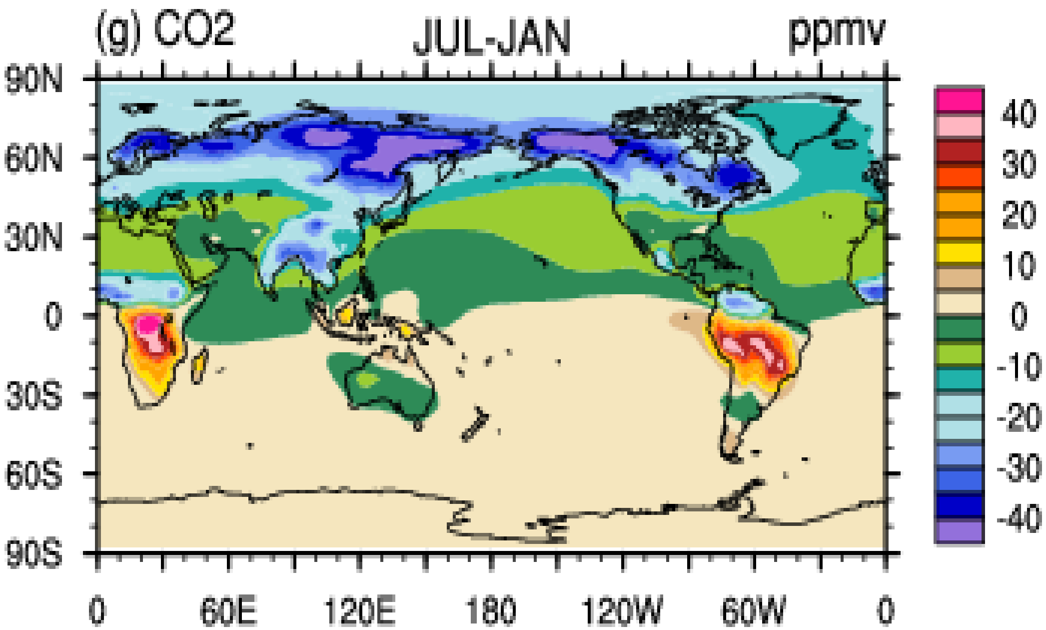


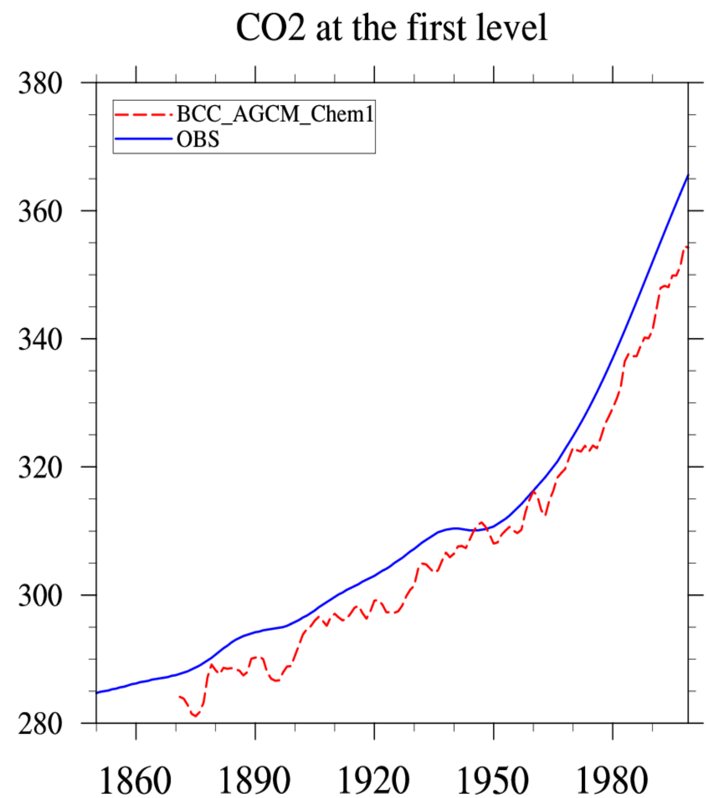
Figure 3. Time series of the simulated annual mean CO_2 flux averaged for the global ocean (thick line) and global land (thin line). The units are GtC yr^{-1}, accounted positive upward.

$$\frac{\partial CO_{2\,atm}(t)}{\partial t} = E_{fossil} + E_{landuse} + F_{land} + F_{ocean} \qquad (1)$$

where t is the time, E_{fossil} and $E_{landuse}$ are the CO_2 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

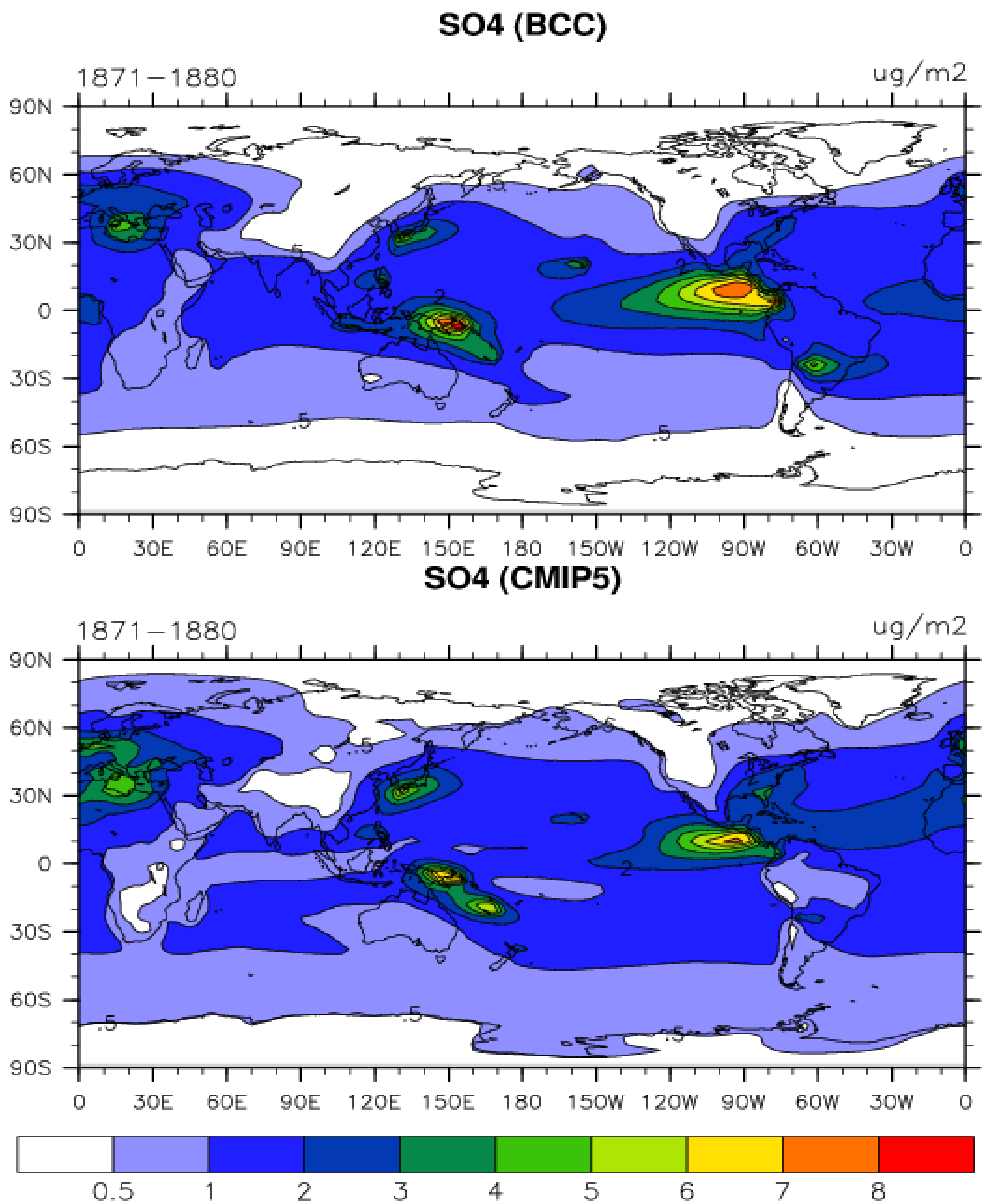




	CMIP5	BCC-ESM
SO4	**0.6472**	**0.6165**
OC1	0.0398	0.0420
OC2	0.2783	0.2877
OC	**0.3181**	**0.3297**
CB1	0.0098	0.0102
CB2	0.0426	0.0419
CB	**0.0524**	**0.0521**
SSLT01	0.5959	0.5965
SSLT02	4.9224	4.9066
SSLT03	5.6279	5.5974
SSLT04	0.6606	0.6637
SSLT	**11.8068**	**11.7642**
DST01	2.6121	2.7745
DST02	6.9424	7.2175
DST03	5.7097	5.7677
DST04	6.8172	6.8990
DST	**22.0814**	**22.6587**

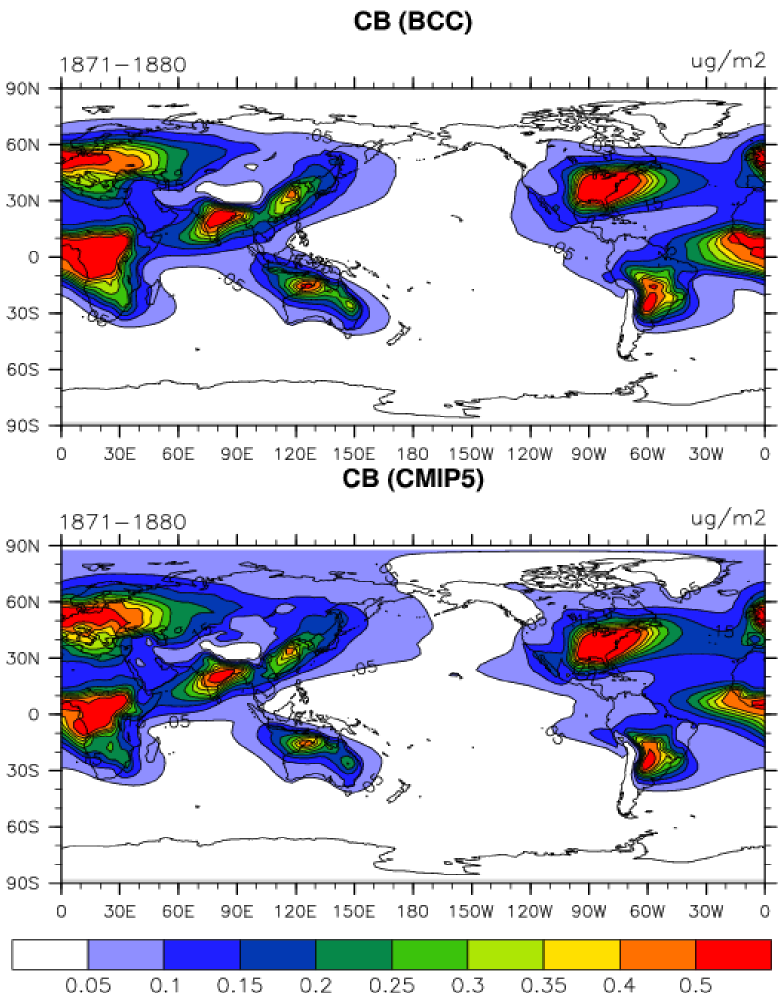
Global aerosol amount (Tg) in the atmosphere averaged for 1871 to 1880

Annual mean vertically integrated concentrations of sulfate

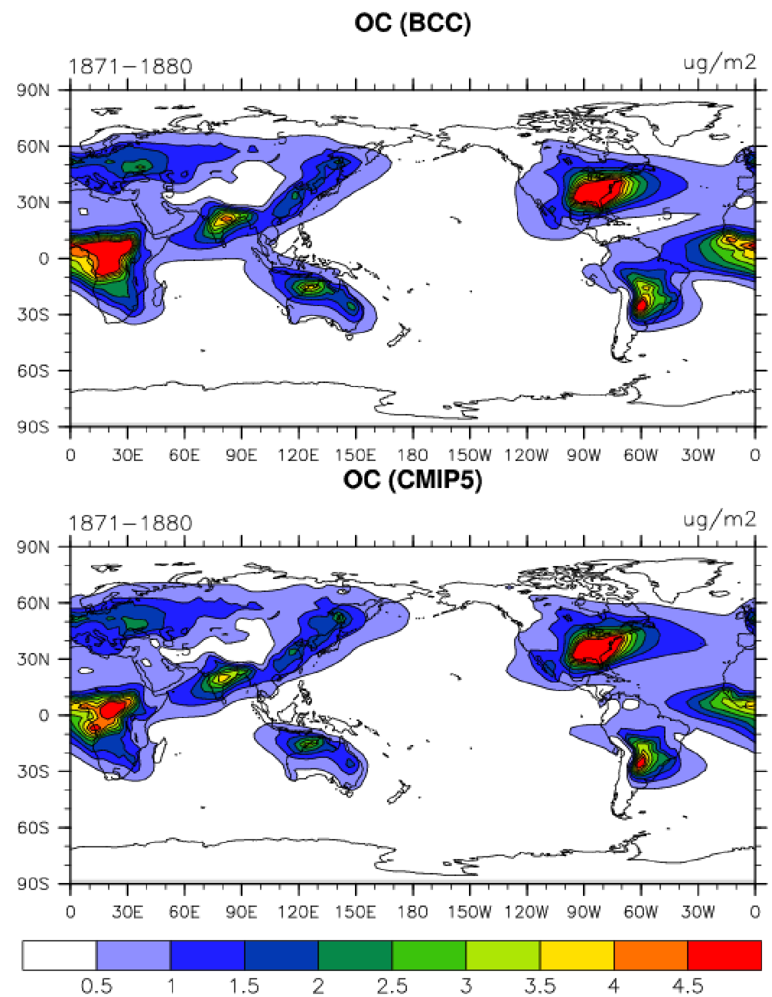


Annual mean vertically integrated concentrations of Black Carbon (CB) and Organic Carbon (OC)

Total: CB=CB1+CB2

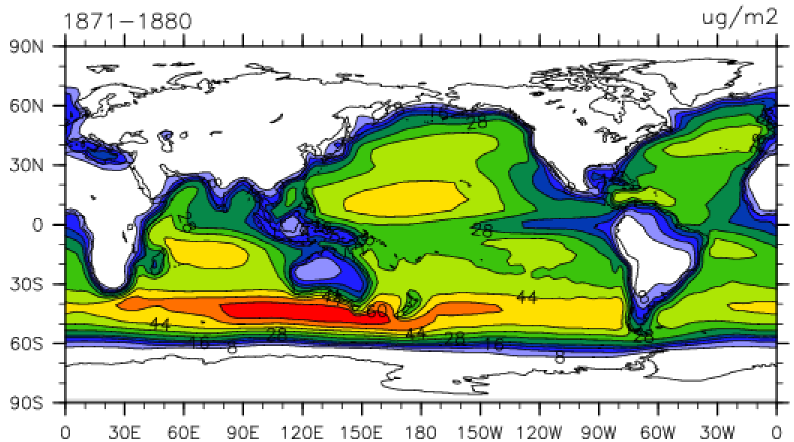


Total: OC=OC1+OC2

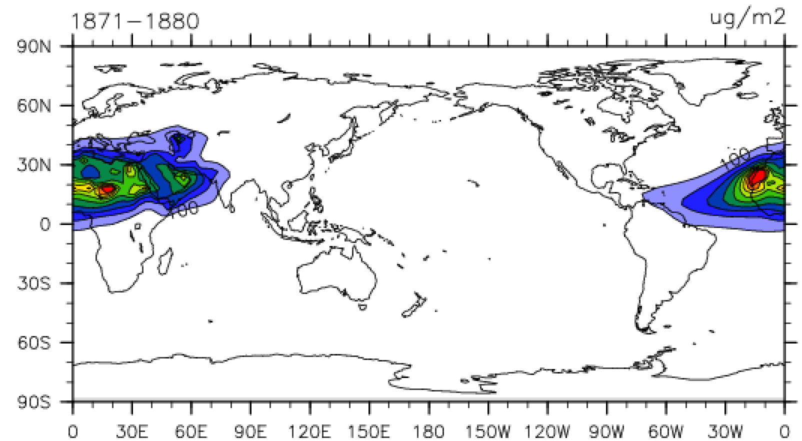


Annual mean vertically integrated concentrations of Sea Salt (SSLT) and Dust (DST)

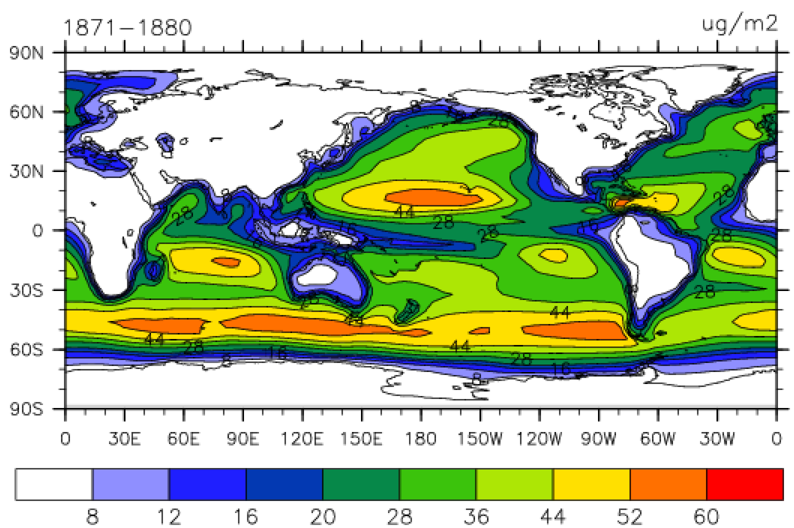
SSLT (BCC)



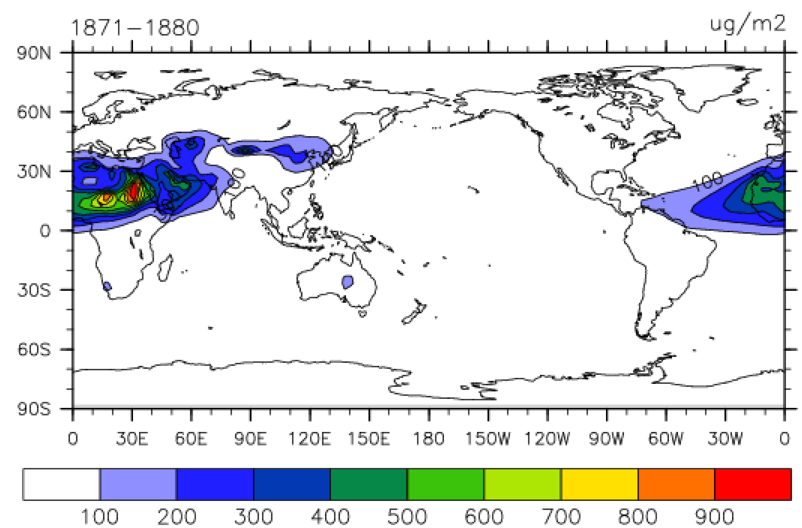
DST (BCC)



SSLT (CMIP5)



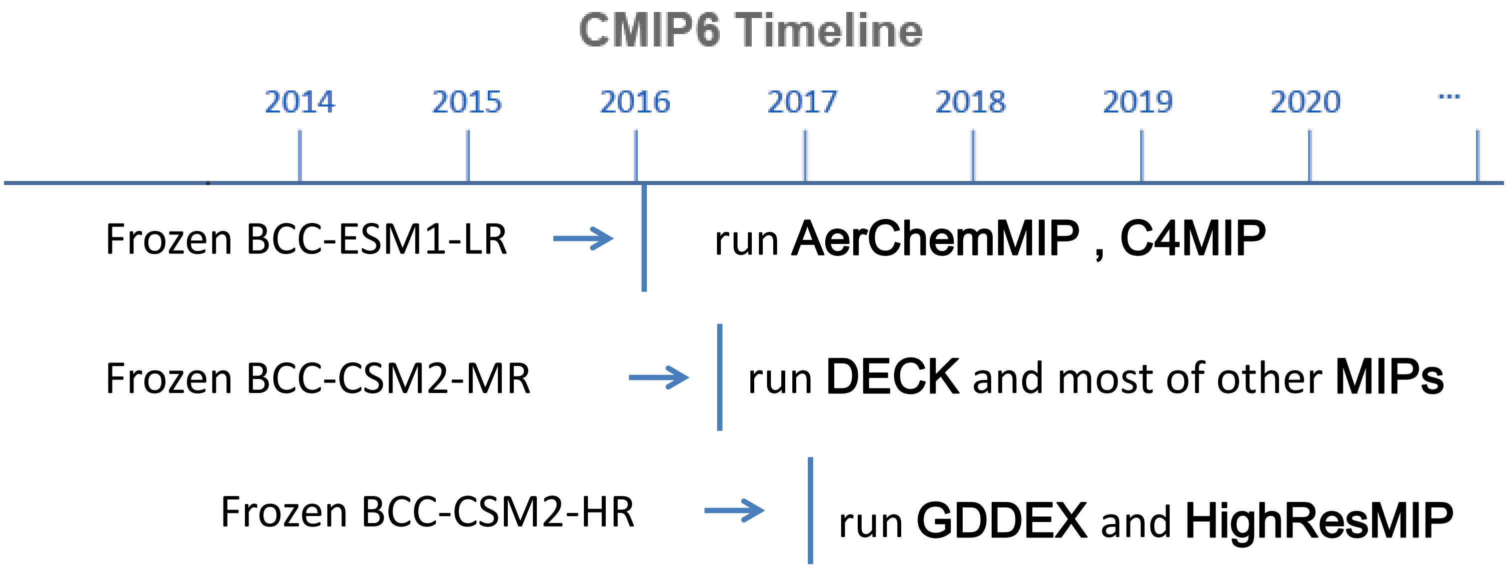
DST (CMIP5)



MIPs in CMIP6

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

	Short name of MIP	Long name of MIP	BCC China
1	AerChemMIP	Aerosols and Chemistry Model Intercomparison Project	√
2	C4MIP	Coupled Climate Carbon Cycle Model Intercomparison Project	√
3	CFMIP	Cloud Feedback Model Intercomparison Project	√
4	DAMIP	Detection and Attribution Model Intercomparison Project	√
5	DCPP	Decadal Climate Prediction Project	√
7	GDDEX	Global Dynamical Downscaling Experiment	√
9	GMMIP	Global Monsoons Model Intercomparison Project	√
10	HighResMIP	High Resolution Model Intercomparison Project	√
13	LS3MIP	Land Surface, Snow and Soil Moisture	√
14	LUMIP	Land-Use Model Intercomparison Project	√
16	OCMIP6	Ocean Carbon Cycle Model Intercomparison Project, Phase 6	√
19	RFMIP	Radiative Forcing Model Intercomparison Project	√
20	ScenarioMIP**	Scenario Model Intercomparison Project	√
6	FAFMIP	Flux-Anomaly-Forced Model Intercomparison Project	
8	GeoMIP	Geoengineering Model Intercomparison Project	
11	ISMIP6	Ice Sheet Model Intercomparison Project for CMIP6	
12	JCOMM*	Coordinated Ocean Wave Climate Project	
15	nonlinMIP	Non-linear Model Intercomparison Project	
17	PDRIP	Precipitation Driver and Response Model Intercomparison Project	
18	PMIP	Palaeoclimate Modelling Intercomparison Project	
21	SensMIP	Sensitivity Model Intercomparison Project	
22	VolMIP	Volcanic Forcings Model Intercomparison Project	



CMIP6 Timeline
2014
2015
2016
2017
2018
2019
2020
…
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^{st}, 6^{th}, 11^{th}, 16^{th}, 21th and 26^{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

In Dec. 2014:

The second generation of Beijing Climate Center Climate Prediction System (BCC-CPSv2)

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

BCC_CSM1.1(m)

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

Forecast： initialized on 1st of each month, 13-month integration

Ensemble forecast： 15 LAF members + 4 SV members

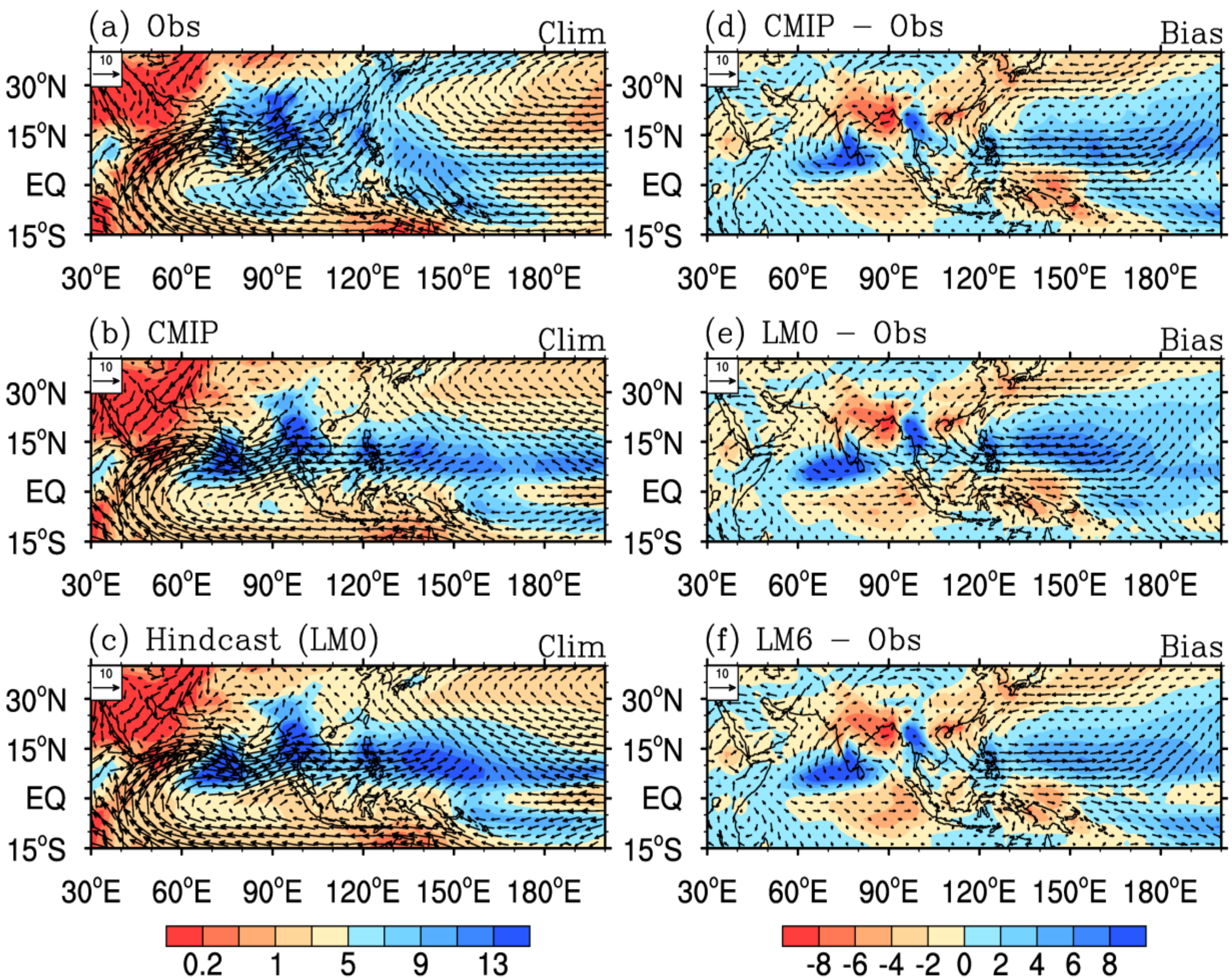
Hindcast period： 1991-2013

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）

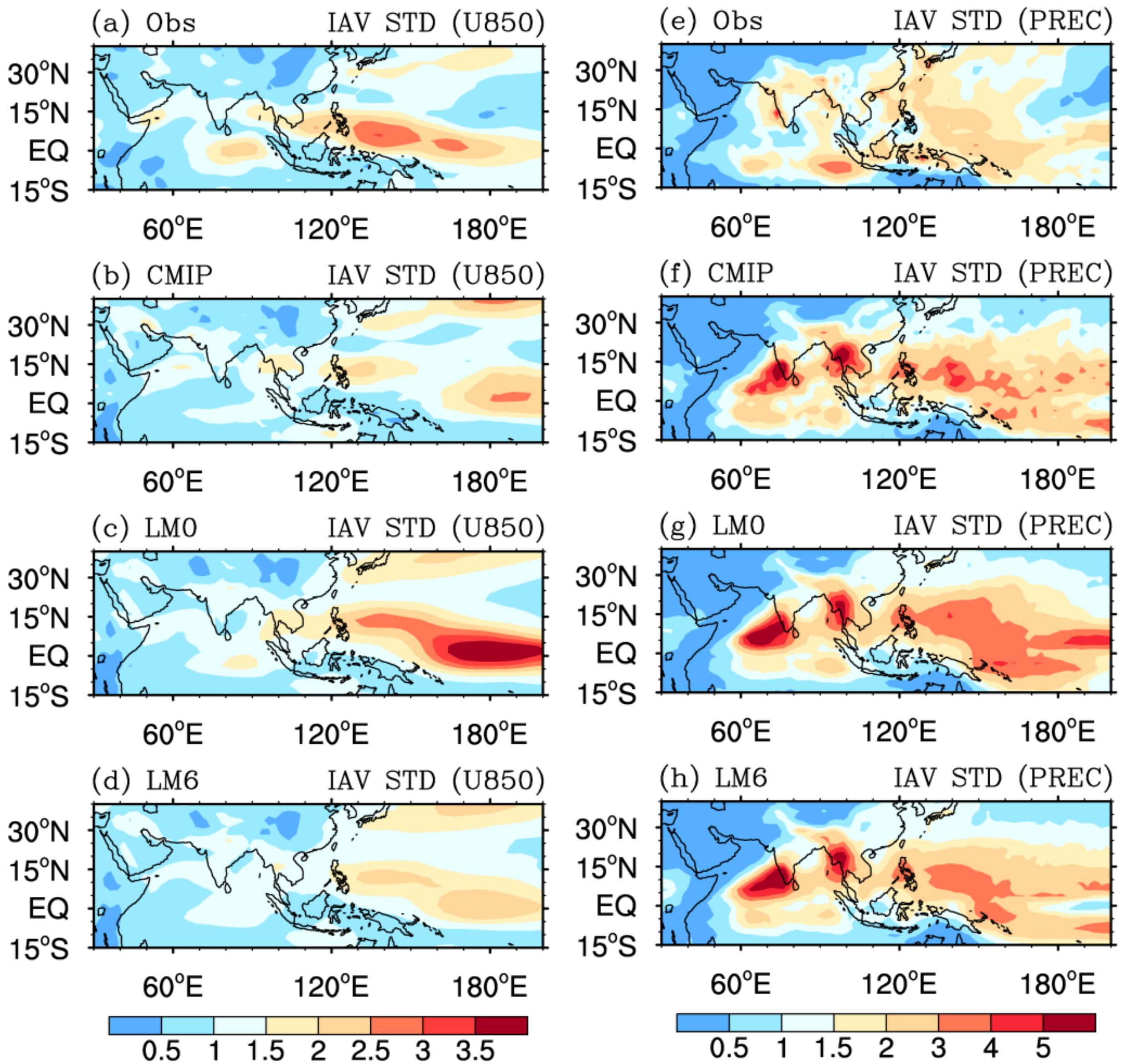


A quick formation and stable maintenance of prediction biases from beginning of forecast.

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

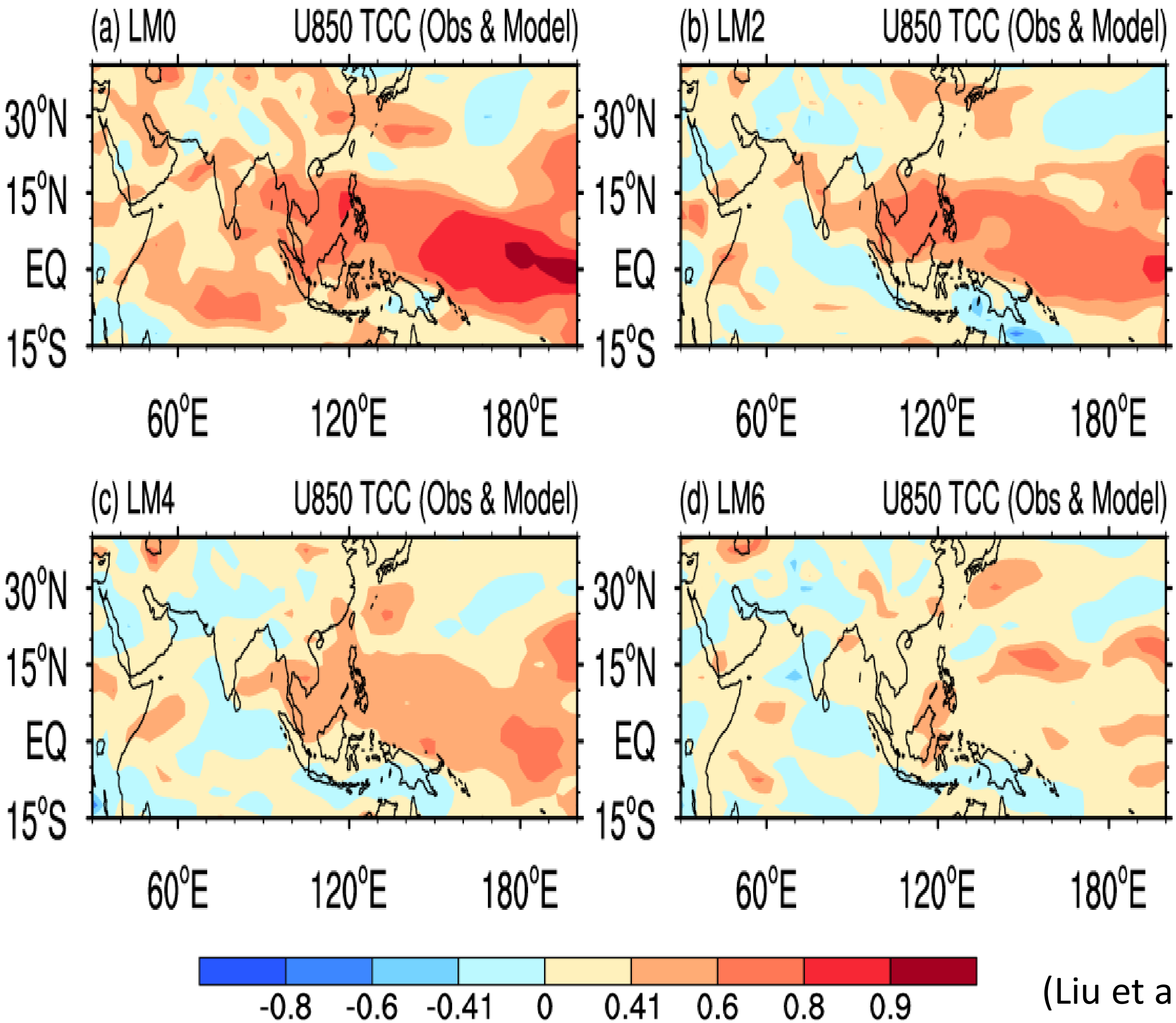


The seasonal forecasts may reproduce the similar pattern to observations. It is better than CMIP-type simulations.

(Liu et al., 2015: Adv. Atmos.Sci.)

Forecast skills in JJA-mean U850 at different lead time

（Data：1991-2013，ensemble mean）

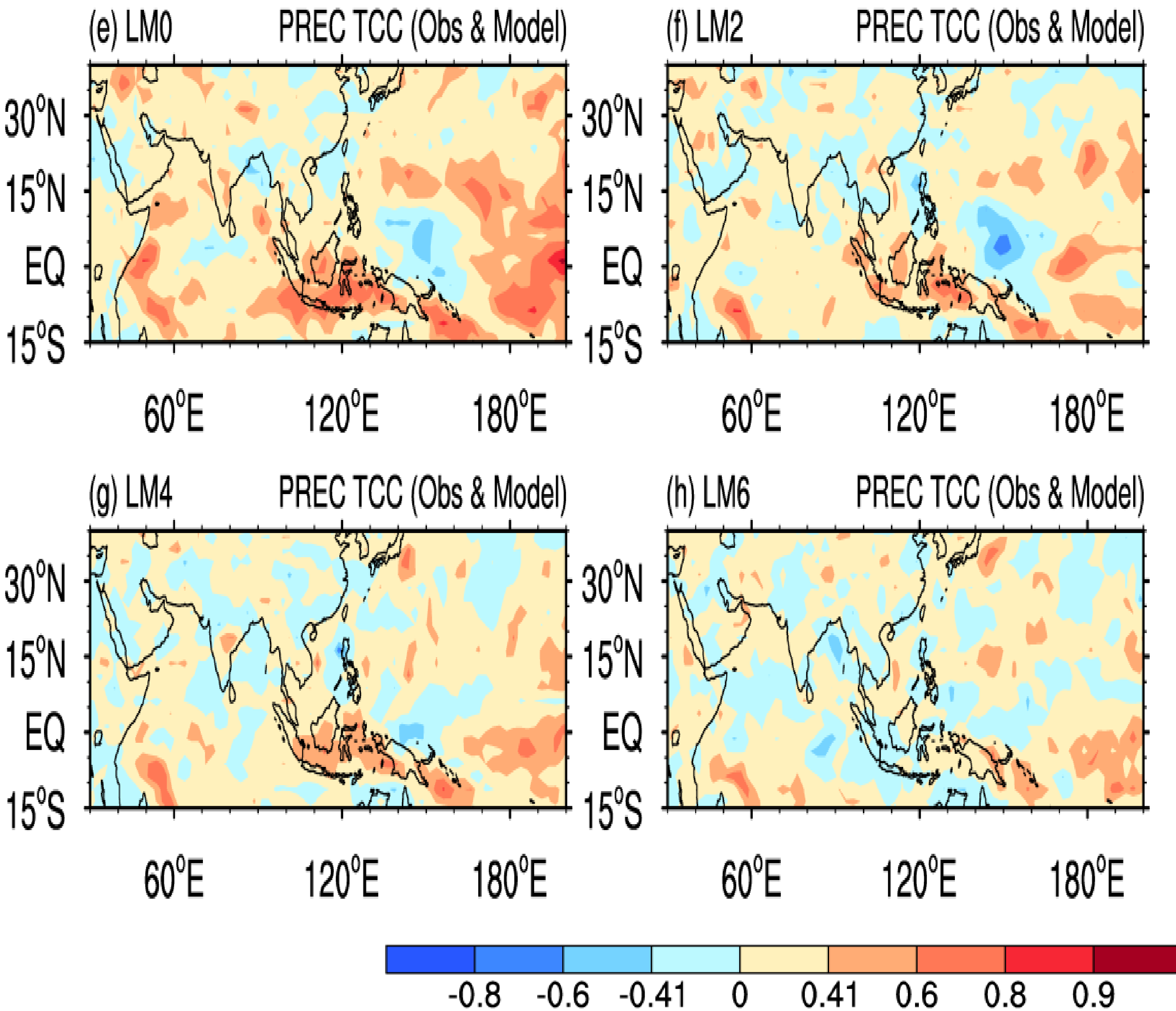


Significant TCCs are over most tropical Indian-Pacific oceans.

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

(Liu et al., 2015: Adv. Atmos.Sci.)

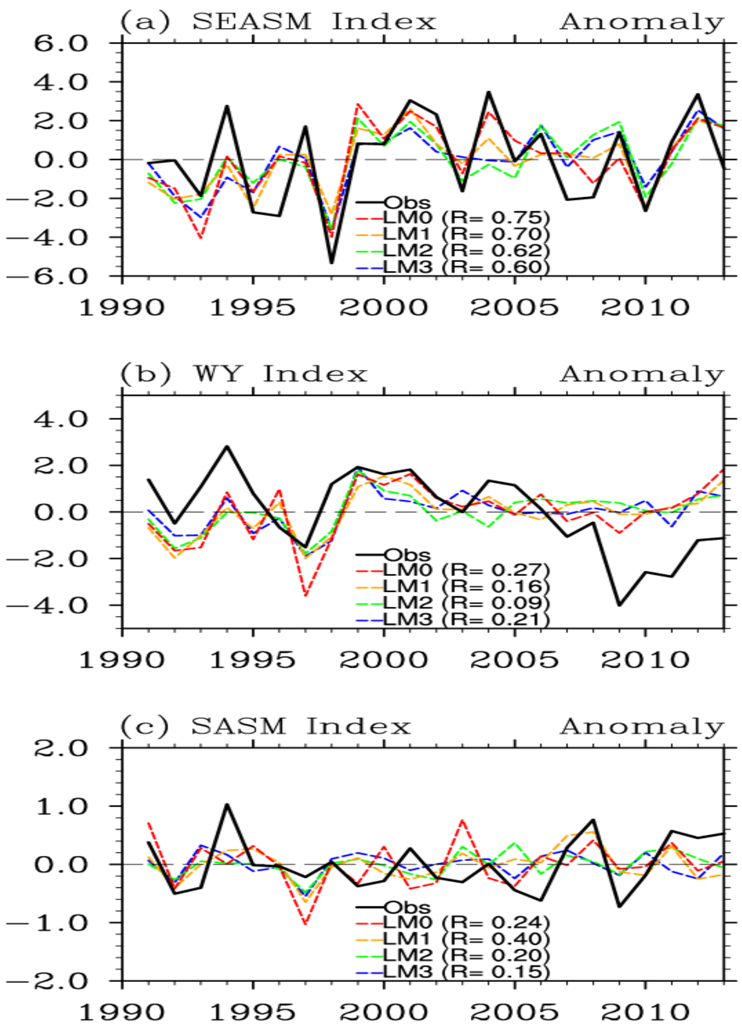
Forecast skills in JJA-mean PREC at different lead time



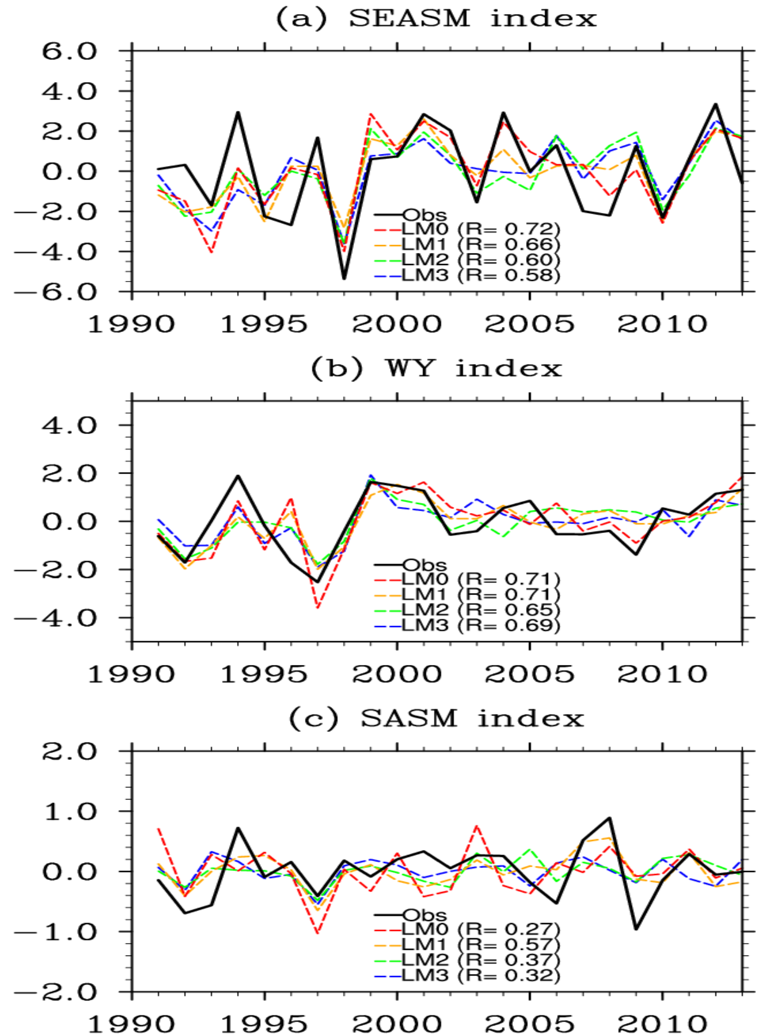
Less forecast skill for precipitation than 850 hPa wind. It drops quickly with lead time.

Interannual variations of SEASM, WY, and SASM indices

Validation data: NCEP-R2

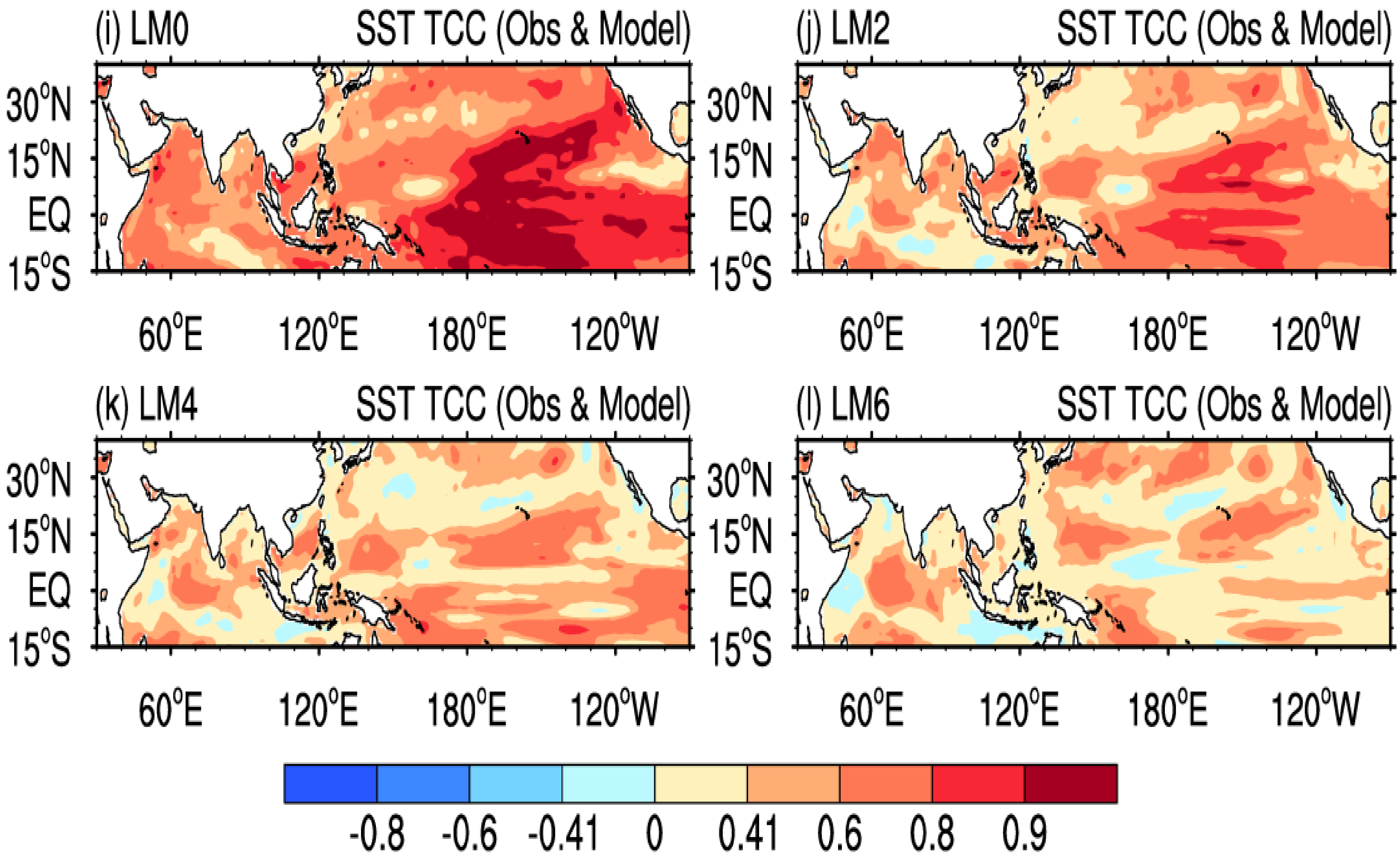


Validation data: ERA Interim

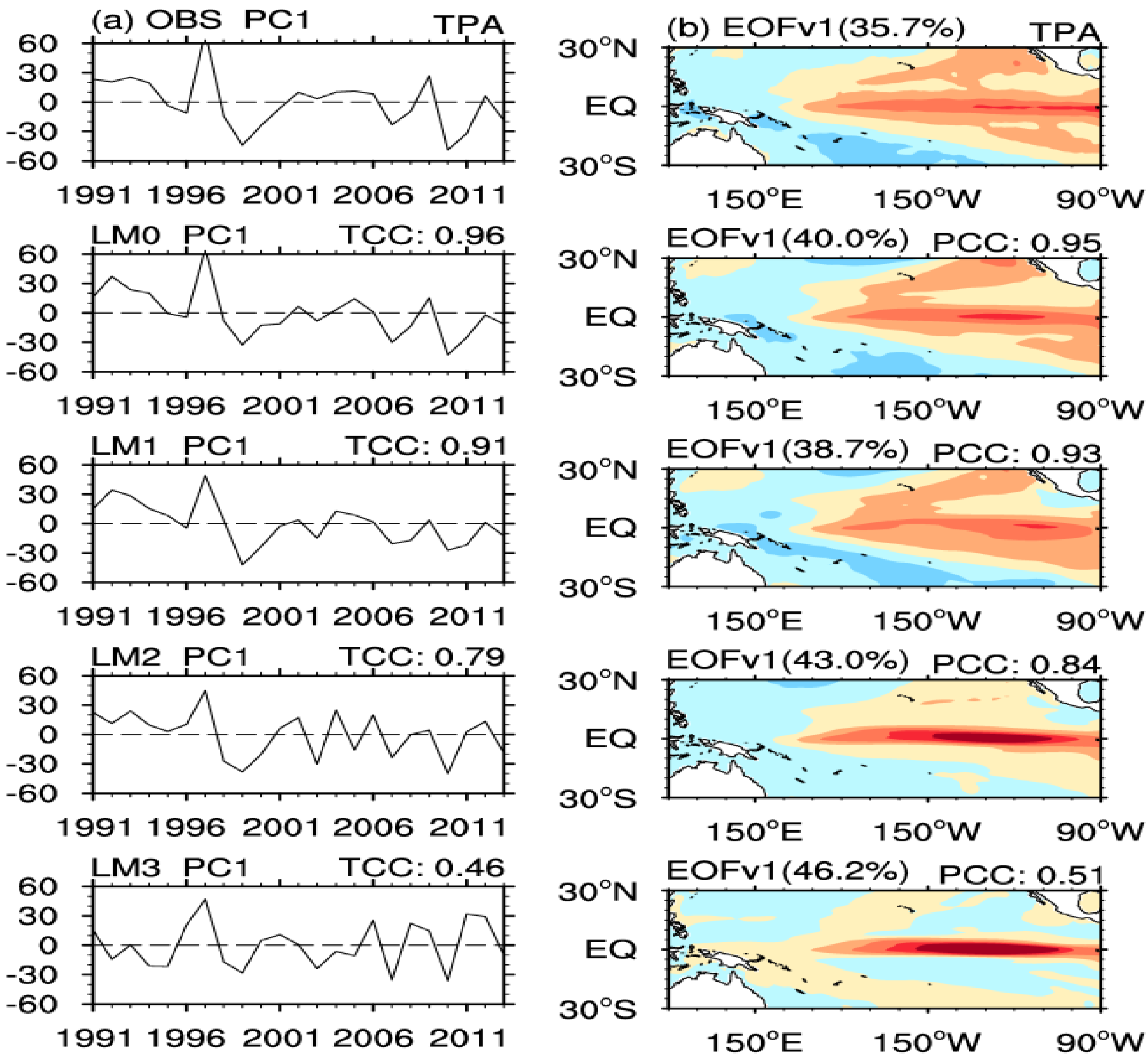


- SEASM: horizontal shear of 850-hPa zonal wind between 5–15N/90–130E and 22.5–32.5N/110–140E (Wang and Fan, 1999).
- WY: vertical shear of zonal winds between 850 and 200-hPa levels averaged over 0–20N/40–110E (Webster and Yang, 1992)
- SASM: vertical shear of meridional winds between 850 and 200-hPa levels averaged over 10–30N/70–110E (Goswami et al., 1999)

Forecast skills in JJA-mean SST at different lead time

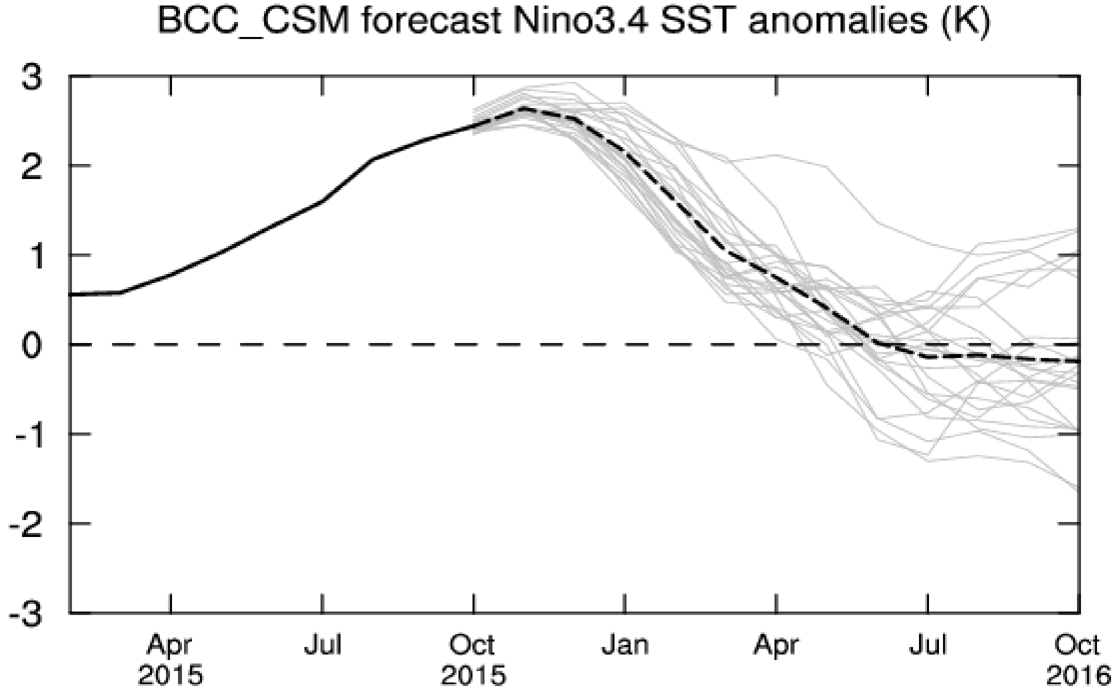


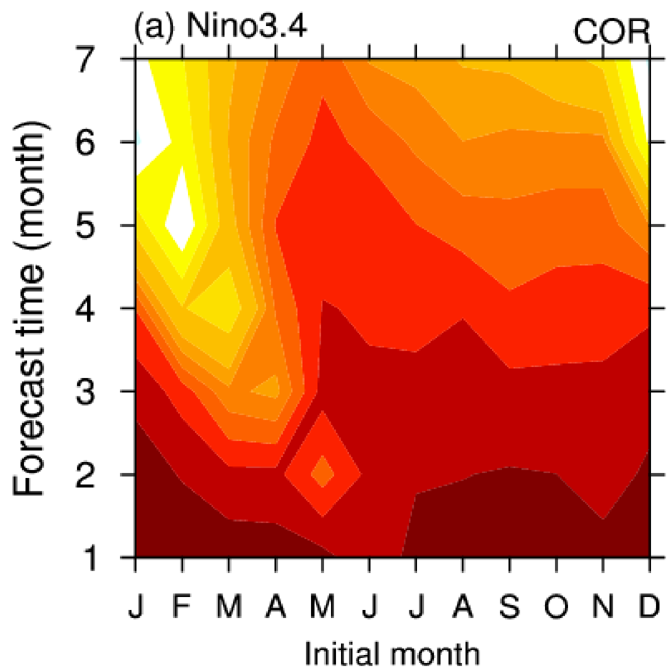
First principal components and spatial modes for EOF analysis of SSTs over the tropical Pacific.

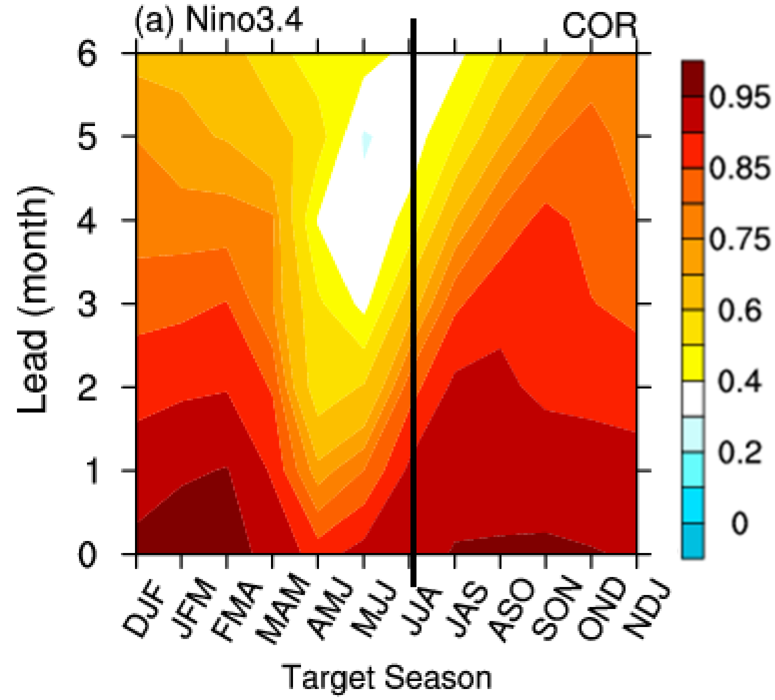


The extensive significant anomaly over the eastern Pacific is well captured by the 0- and 1-month lead forecasts, but its spatial range quickly reduces to a narrow band near the equator at the lead time of 2 and 3 months

Nino 3.4
SST forecast

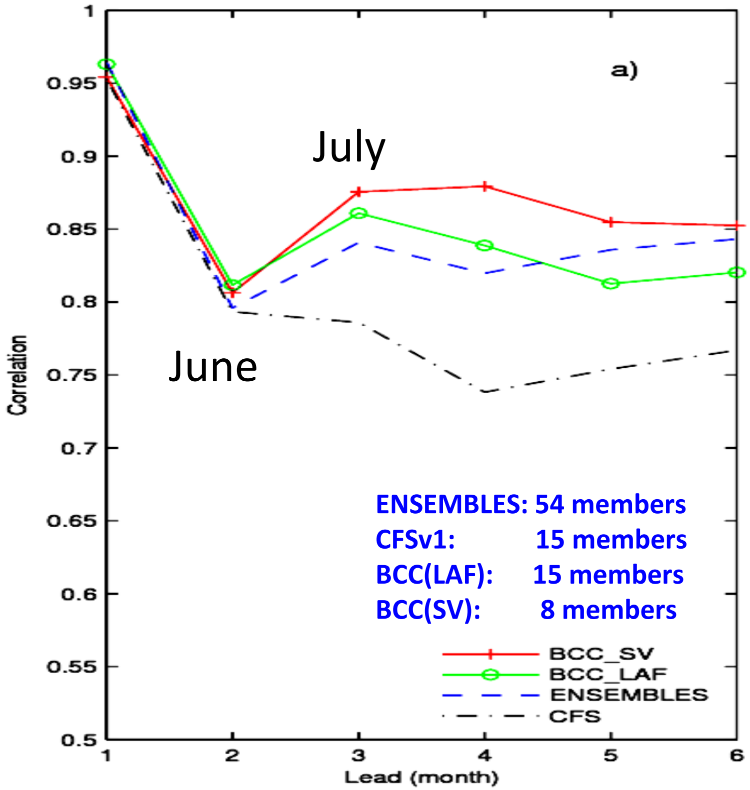




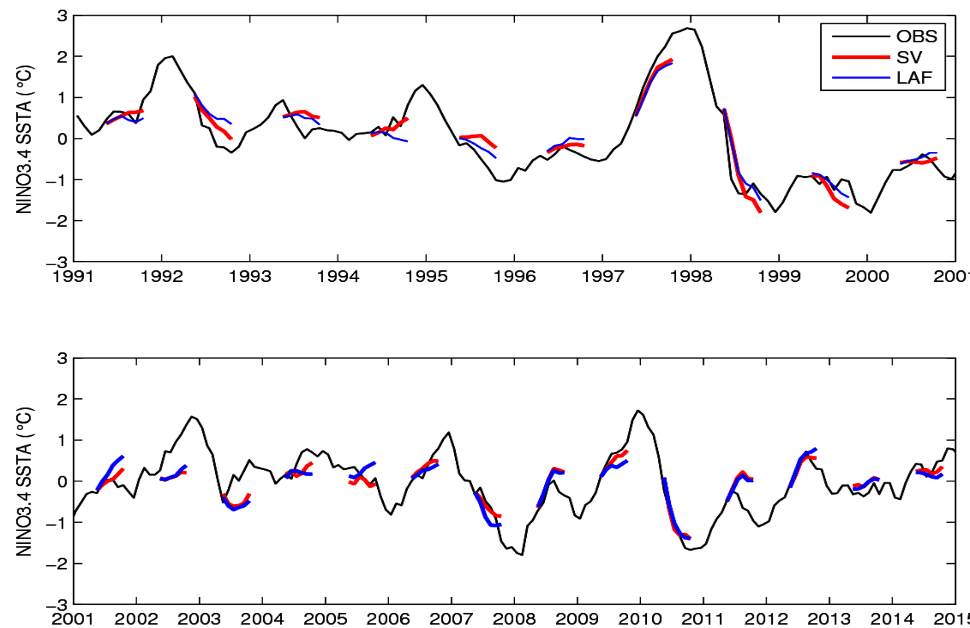


ENSO Hindcast Skills (1991-2005)

Starting date: May 01



BCC_CSM1.1m,1991-2014， May



ENSEMBLES

(9 member each model)

Models	Organizations
IFS/HOPE	ECMWF
ARPEGE/OPA	Météo-France
HadGEM2	Met Office，UK
ECHAM5/OPA8.2	INGV
ECHAM5/OM1	IfM Kiel
HadCM3 (perturbed parameter)	Met Office，UK

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Characteristics of S2S forecast systems

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

Fully-coupled Climate System Model

S2S

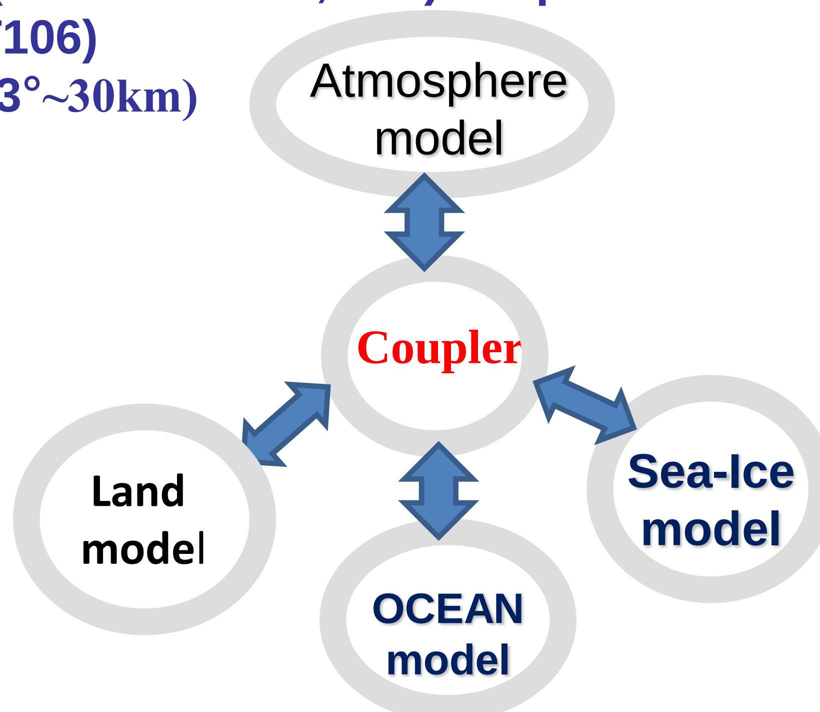
BCC_CSM2.0

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

BCC_CSM1.1(m)

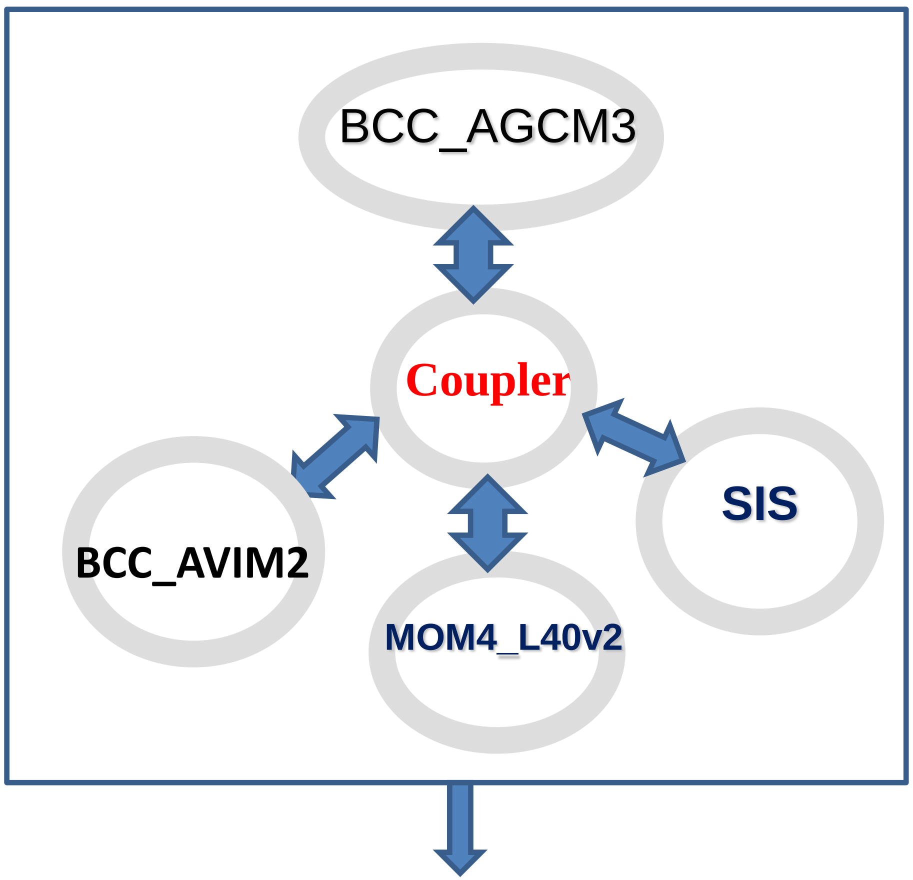
- BCC_AGCM2.2(T106 ~110 km, L26) Top: 2.19 hPa
- BCC_AVIM1.0(T106)
- MOM4-L40v2(1/3°~30km)
- SIS(1/3°~30km)

(Newly-developed operational model system)



The Coordinated Initialization System (CIS)

BCC_CSM2 (T106L40)

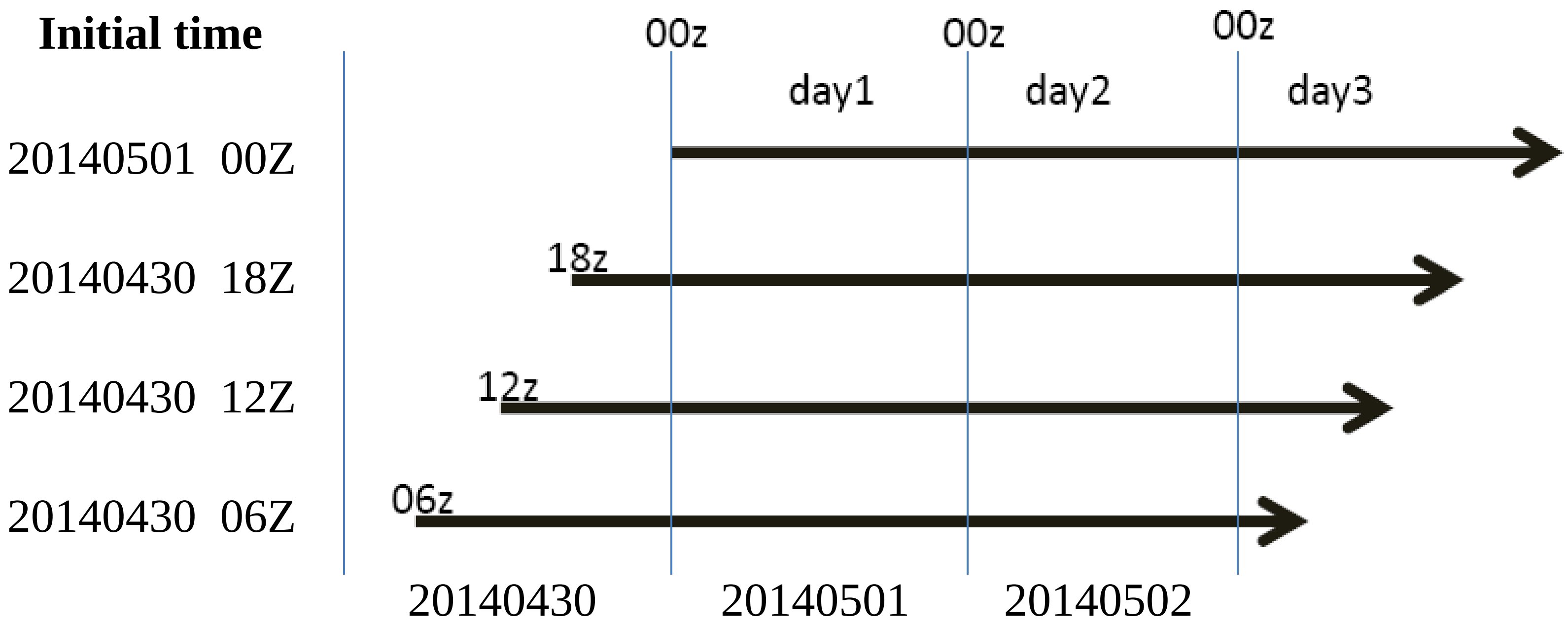


Observations or Reanalyse data
- atmospheric states
  - (e.g. CMA, NCEP, FNL)
- Land surface states
  - (e.g. BCC_MergP)
- Oceanic states
  - (e.g. BCC_GODASv2)
- ....

BCC Model initial data for S2S run

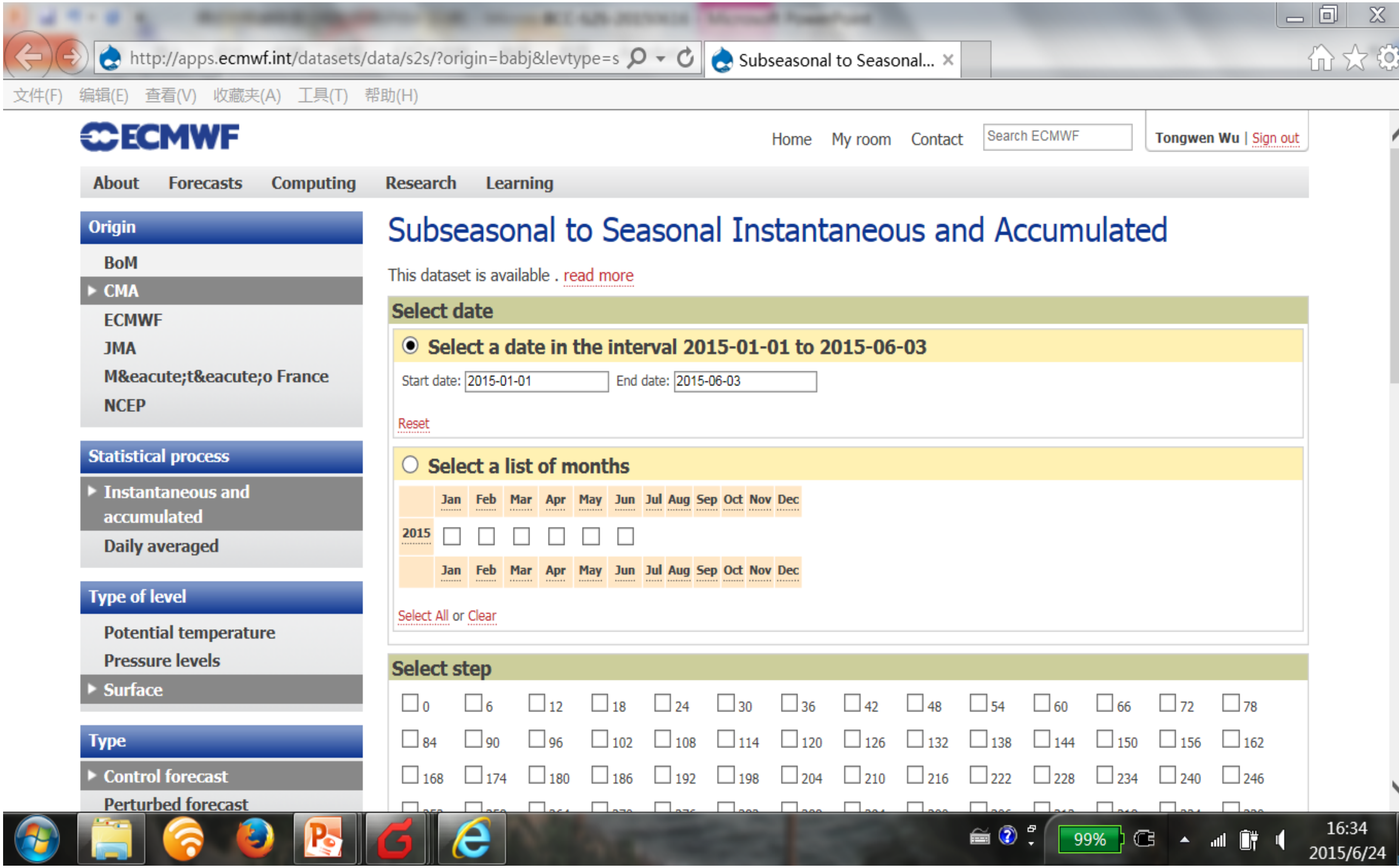
Configuration of S2S hindcast

e.g., the forecast initialized on 20140501



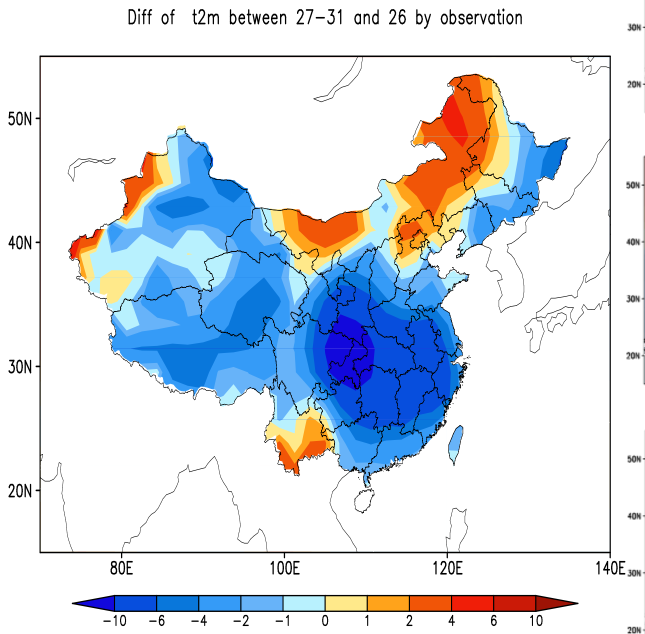
Daily rolling hindcasts, 60-day integrations (19940101-20140430)

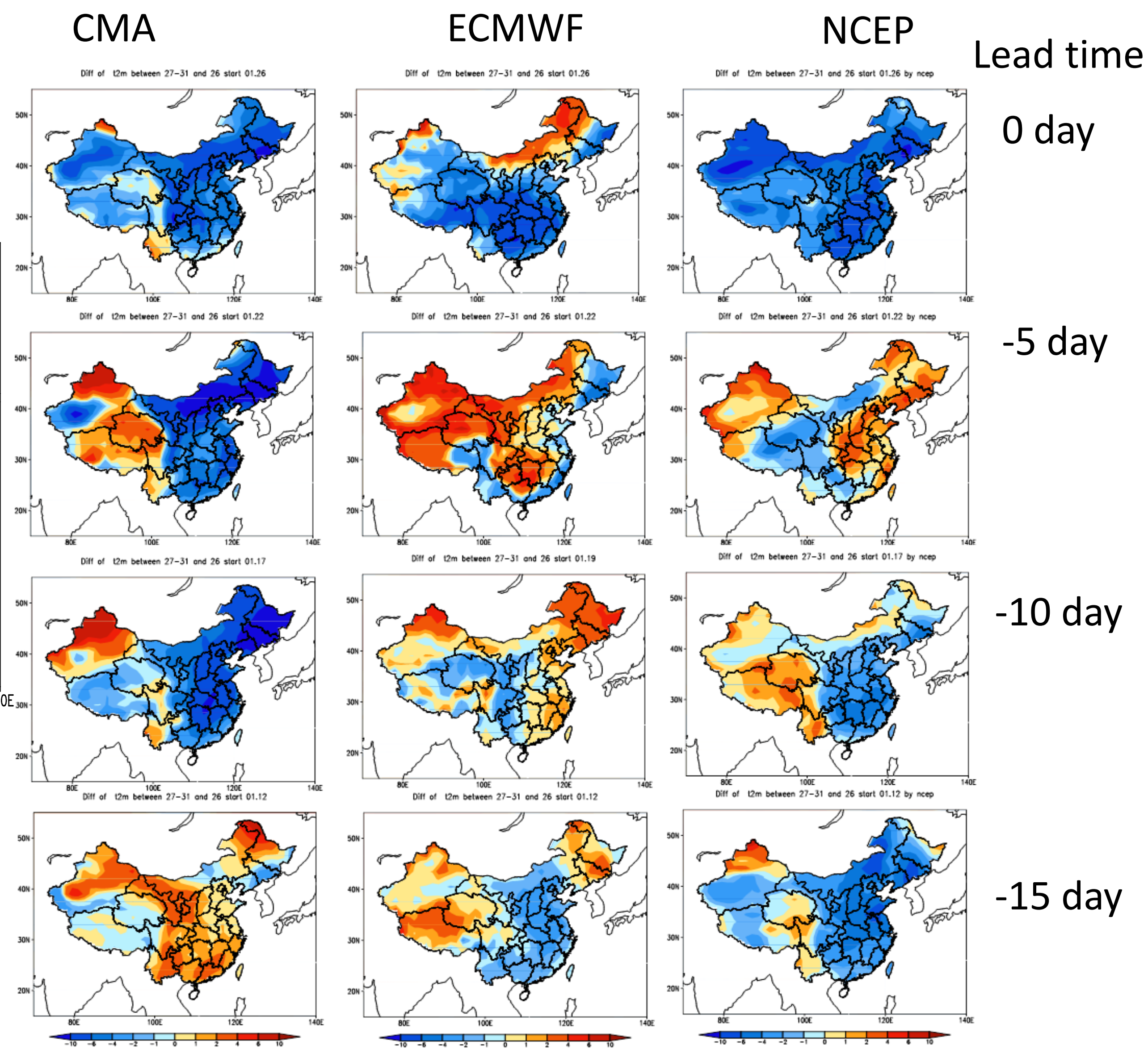
- 3 weeks behind real-time
- 20 years of CMA S2S hindcast data have been published on ECMWF website



Extreme event (27-31 Jan, 2015) of cold surge forecasts from the S2S Project

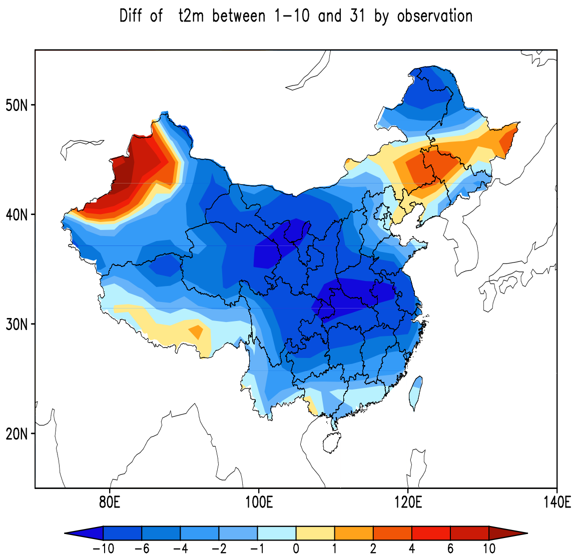
2m temperature difference between 27-31 Jan. and 26 Jan.





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

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



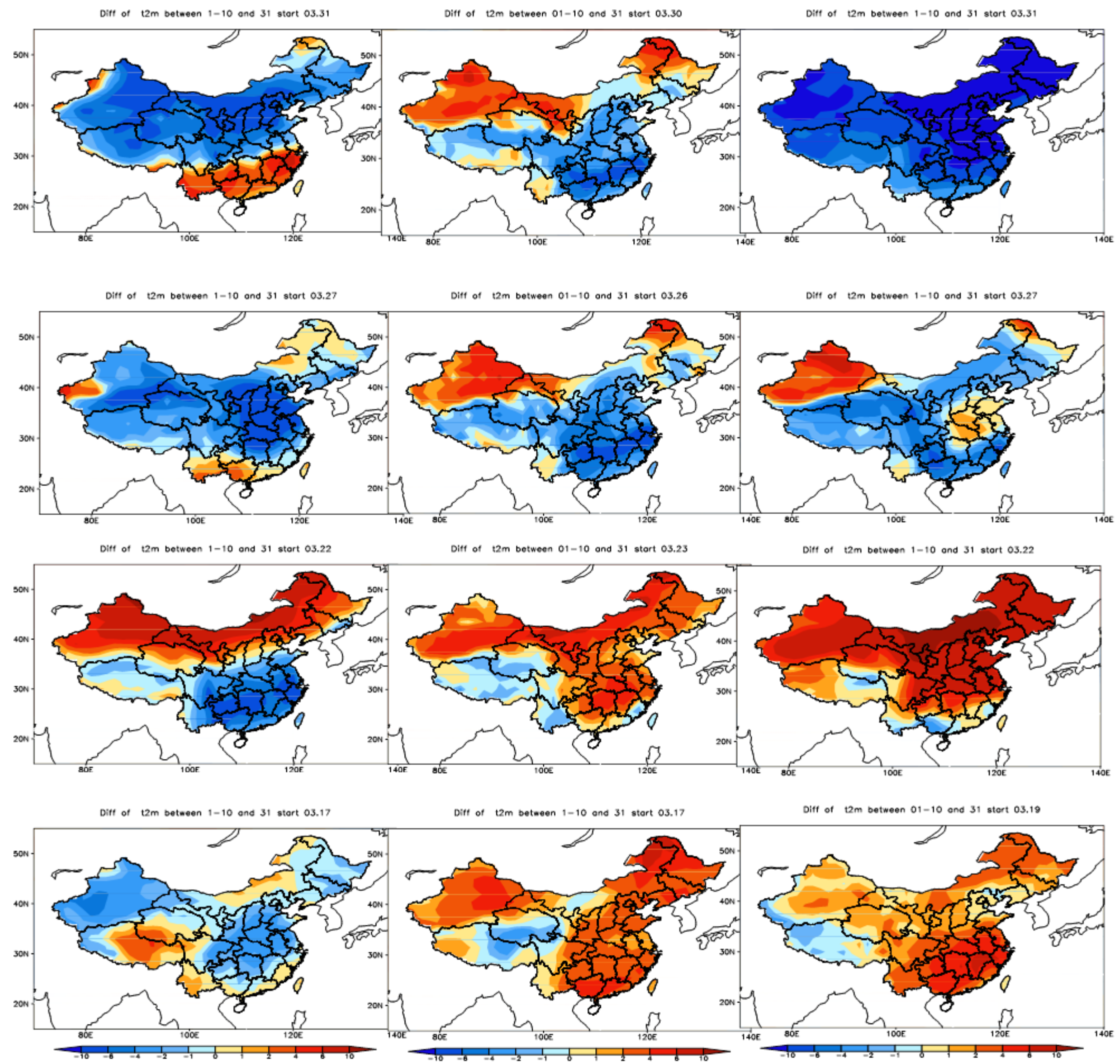
CMA | ECMWF | NCEP

0 day

-5 day

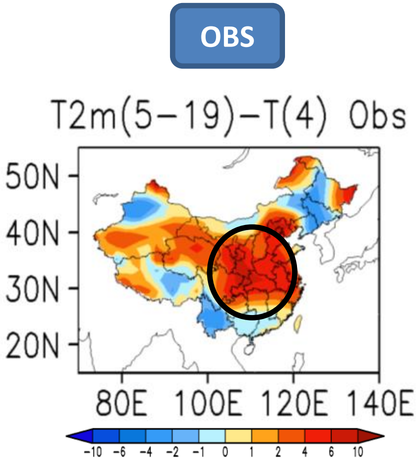
-10 day

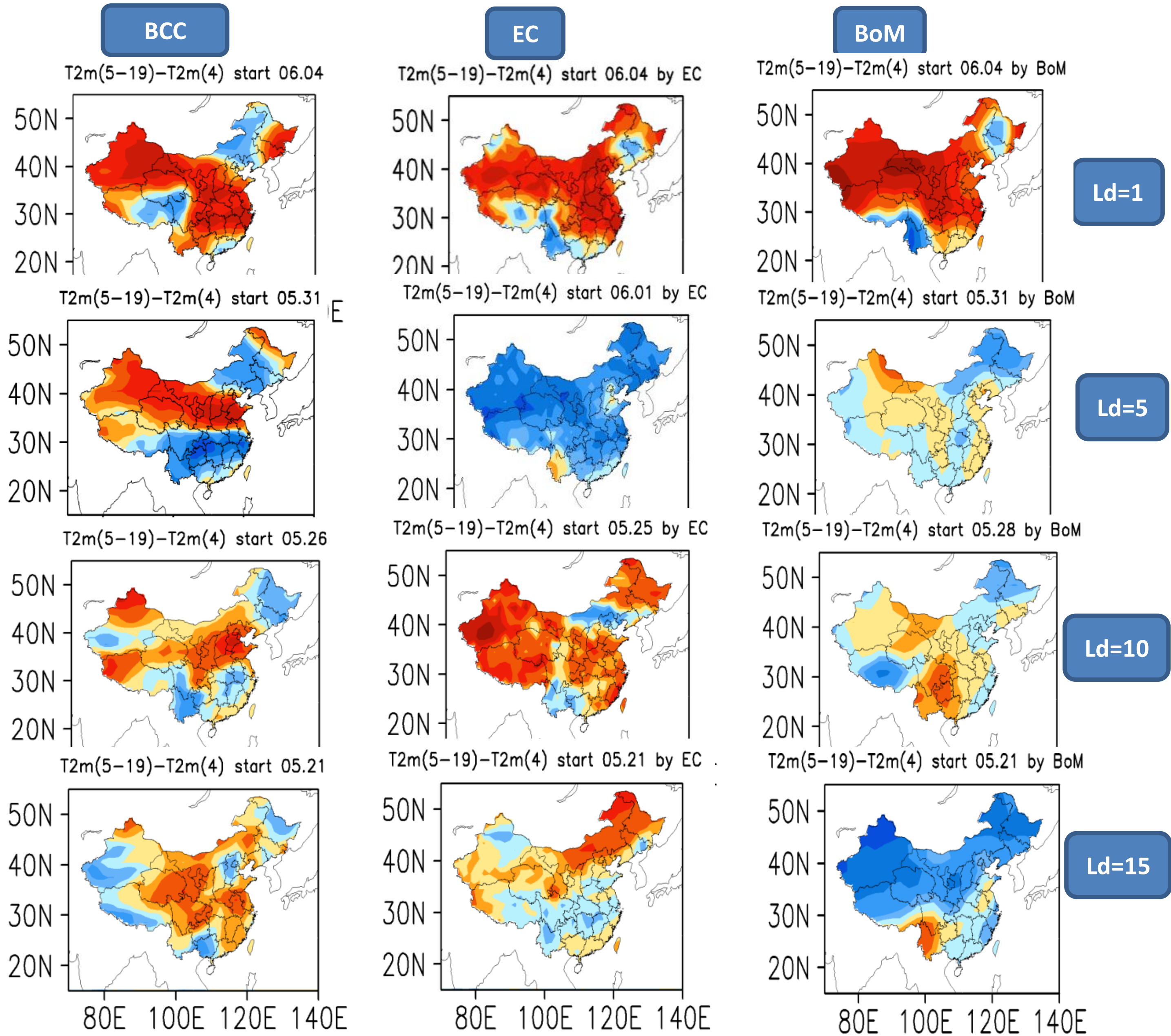
-15 day



Extreme event (5-19 June, 2015) of heat wave forecasts

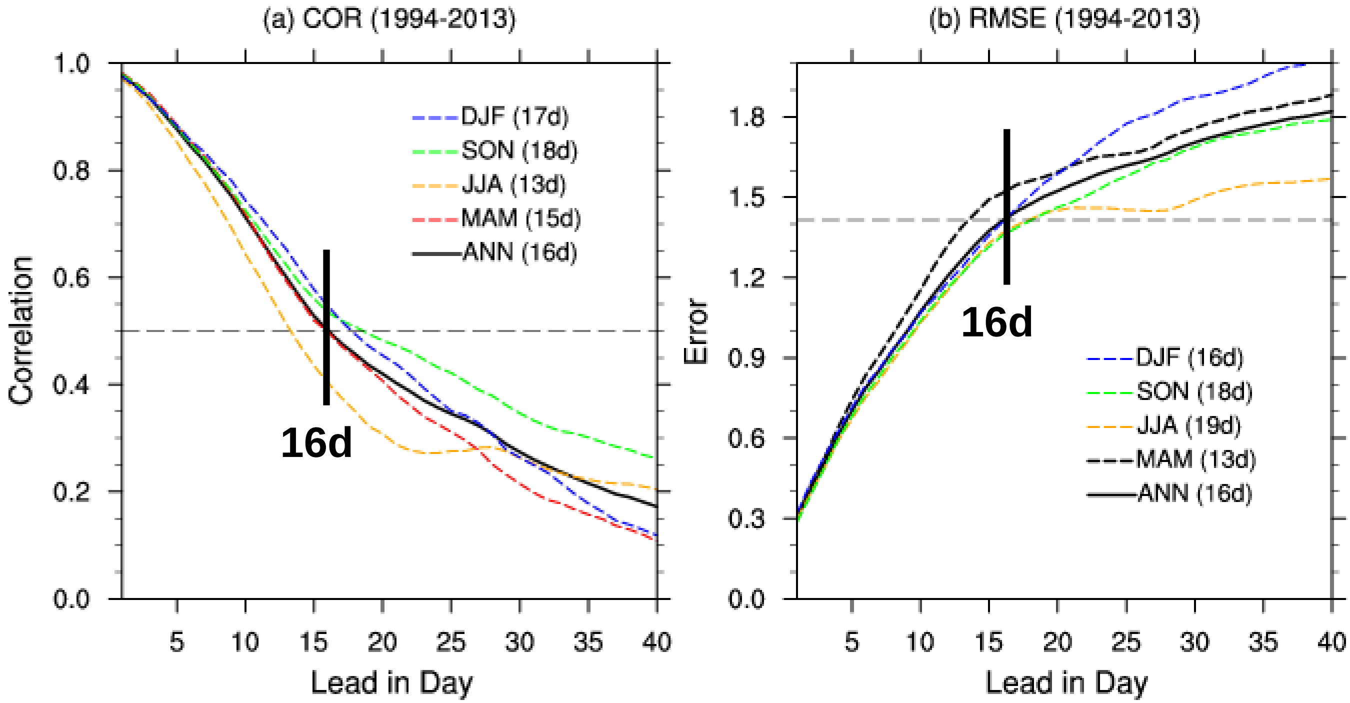
2m temperature difference between 5-19 June and 4 June.





MJO forecast verification

Overall MJO prediction skill in original S2S hindcasts



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

$$\mathrm{RMSE}(\tau) = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\{[a_{1i}(t) - b_{1i}(t)]^2 + [a_{2i}(t) - b_{2i}(t)]^2\}}$$

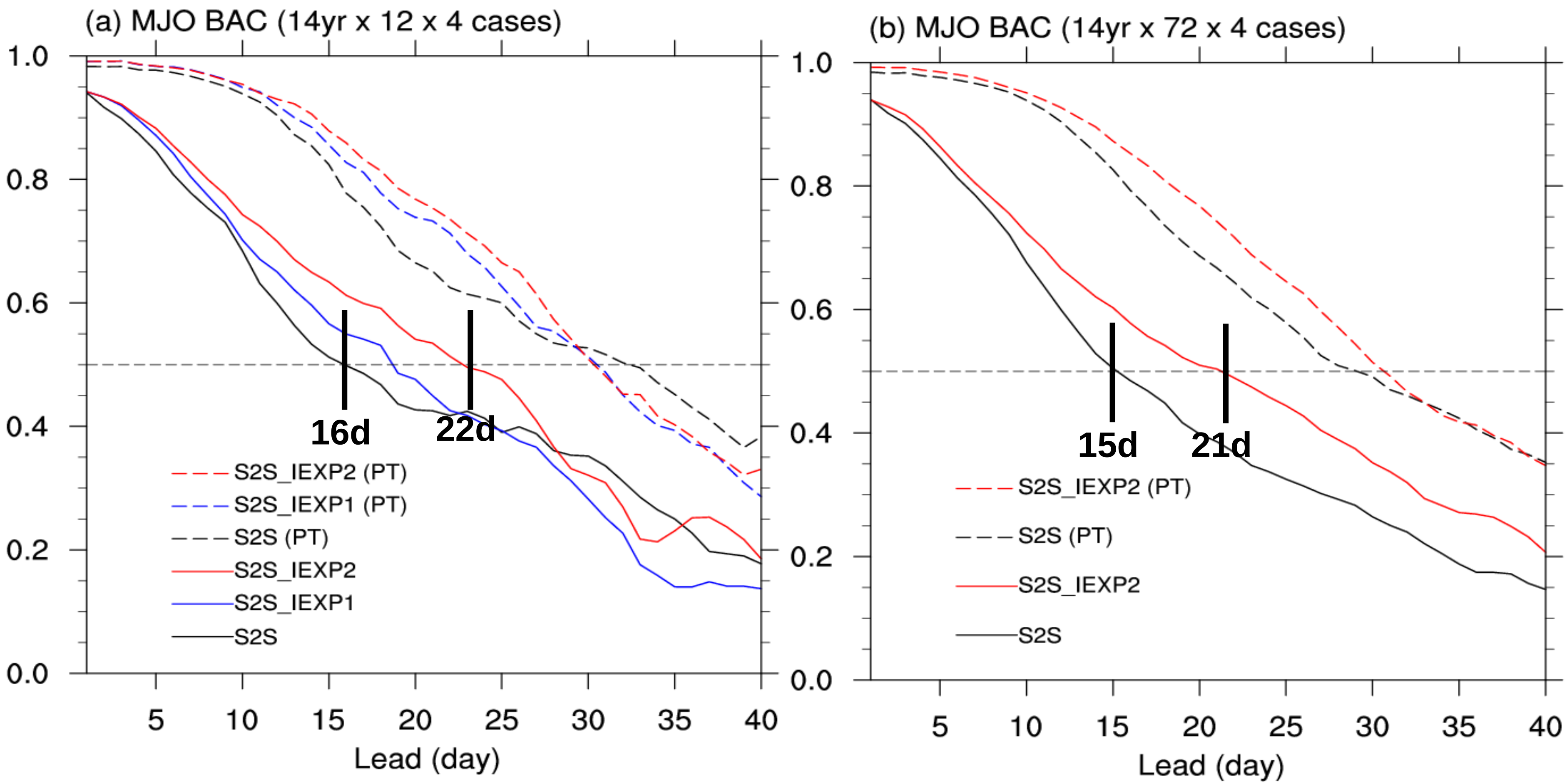
Different initialization schemes

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



Skill: 6-day increase !

Plan of BCC_CSM climate model development

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)

Phase 3 — 2012-2016 — BCC_CSM2

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

→ CMIP6

Phase 2

2005-2011 — BCC_CSM1.1(m)

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

→ CMIP5, S2S, Climate prediction

2005-2009 — BCC_CSM1.1

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

→ CMIP5

2005-2008 — BCC_CSM1.0

BCC_AGCM2.0(T42L26);CLM3(T42);
POP(1/3°~30km); CSIM(1/3° ~30km)

Phase 1 — 1995-2004 — BCC_CM1.0

BCC_AGCM1.0(T63)
NCC/LASG OGCM(T63)

→ CMIP3

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 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!