BCC climate prediction model system: developments and applications

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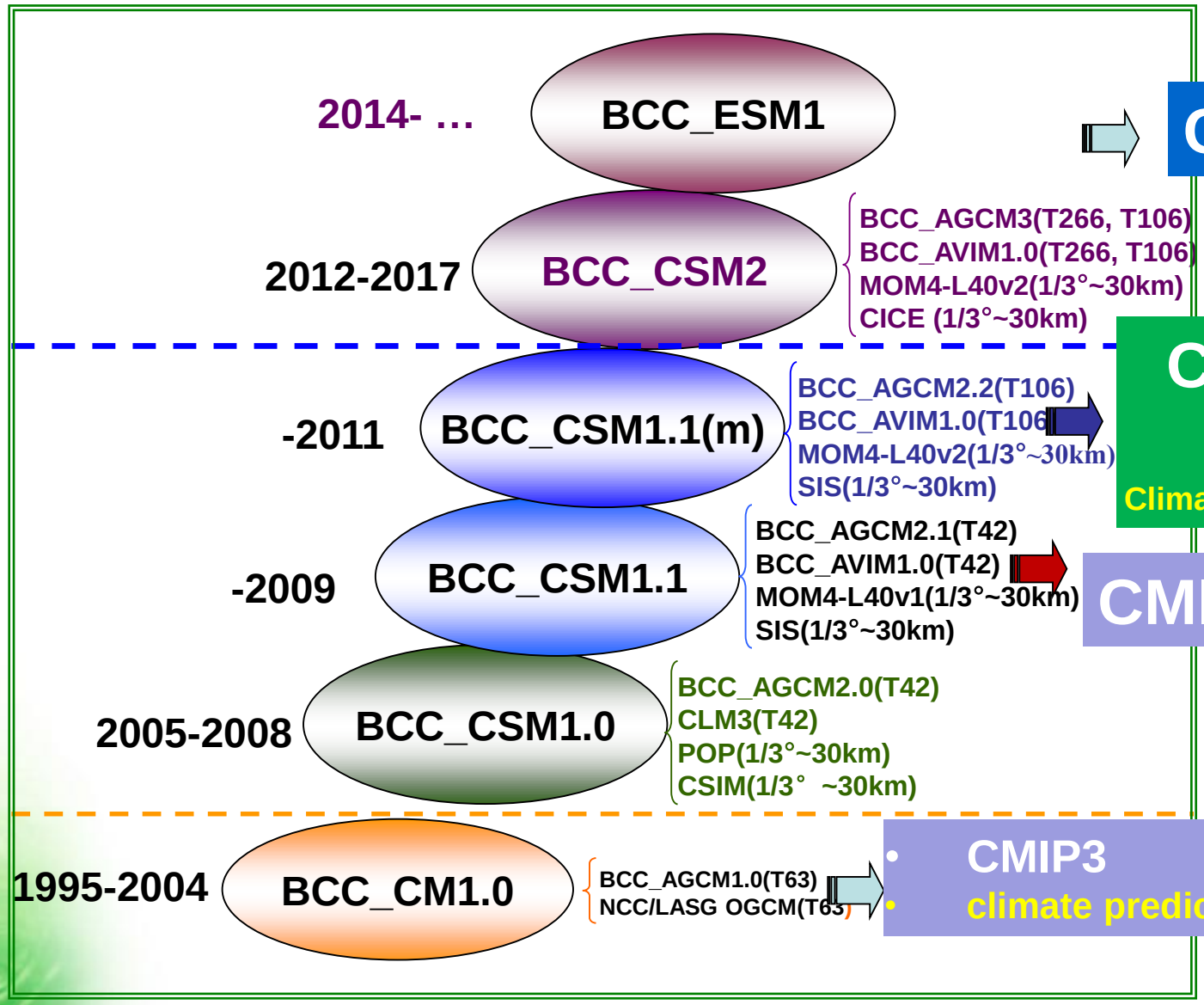
2017-11-09

Outline

- The present status of Beijing Climate Center Climate Prediction System
- Performance of the Seasonal Ensemble Prediction System in BCC
- WWRP/WCRP sub-seasonal to seasonal prediction project (S2S) activity in BCC

Part I:

Beijing Climate Center Climate System Model (BCC_CSM)



http://forecast.bcccsm.ncc-cma.net/htm/

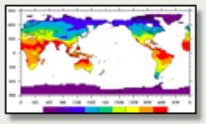
Beijing Climate Center
Climate System Model

GO

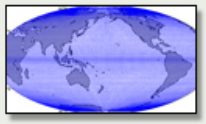
Home | Models | Projects | Prediction | Publications | Announcement | Code Release | Staffs

Climate System Model
- BCC_CSM 1.1(m)
- BCC_CSM 1.1
- BCC_CSM 1.0
- BCC_CM 1.0

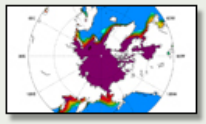
Atmospheric Model
- BCC_AGCM 2.2
- BCC_AGCM 2.1
- BCC_AGCM 2.0
- BCC_AGCM 1.0



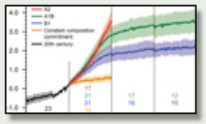
Land Model
- BCC_AVIM 1.1
- BCC_AVIM 1.0



Ocean Model
- MOM4_L40
- T63L30 OGCM



Sea Ice Model
- SIS

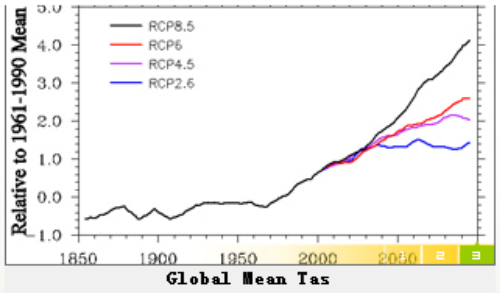


Projects
- CMIP5
- AMIP
- Data Download

About BCC Model More >

Climate System Modeling Division (CSMD) is a part of Beijing Climate Center, China Meteorological Administration. It was established in June 2001. Its previous name is Climate Dynamics Division. In October 2004, it was reconstructed and renamed to Climate System Modeling Division. The main function of CSMD is to improve the current operational Dynamic Climate Model Prediction System (DCMPS), to develop the climate system model (BCC-CSM) and finally use it to serve ...

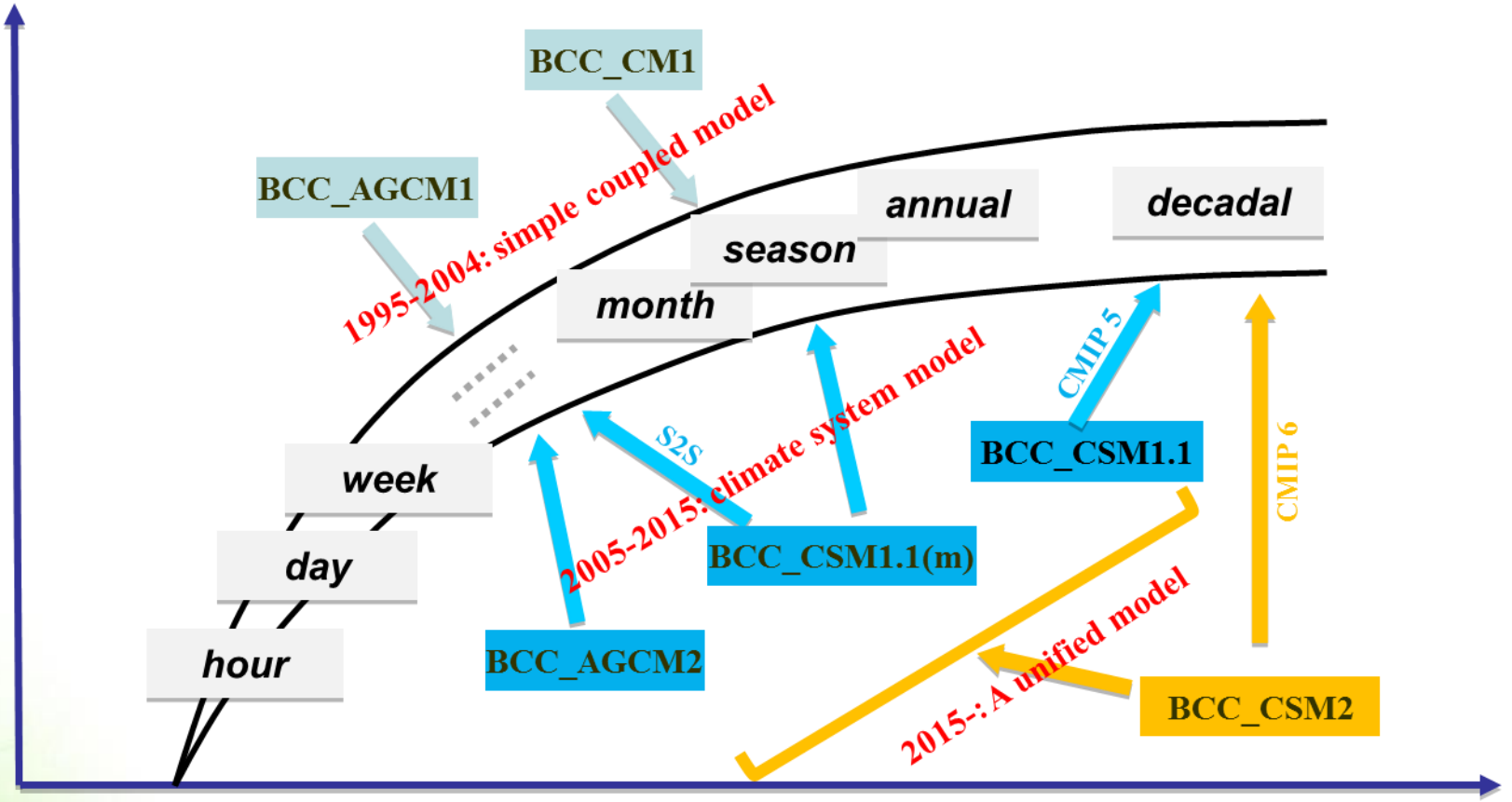
Prediction



Announcement More >

Friendship Links

Beijing Climate Center Climate Prediction System (BCC-CPS)



Generation 1	DERF1 based on BCC_AGCM1、Seasonal forecast system based on BCC_CM1
Generation 2	DERF2 based on BCC_AGCM2、 Seasonal forecast system based on BCC_CSM1.1m、S2S forecast system based on BCC_CSM1.2
Next	A seamless forecast based on BCC_CSM2

Part II:

Performance of the Seasonal Ensemble Prediction System in BCC

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 months** integration

Ensemble forecast: 15 lagged-average-forecast (LAF) and

9 singular-vector (SV) method

Initial data: NCEP-R1 reanalysis + NCEP_GODAS

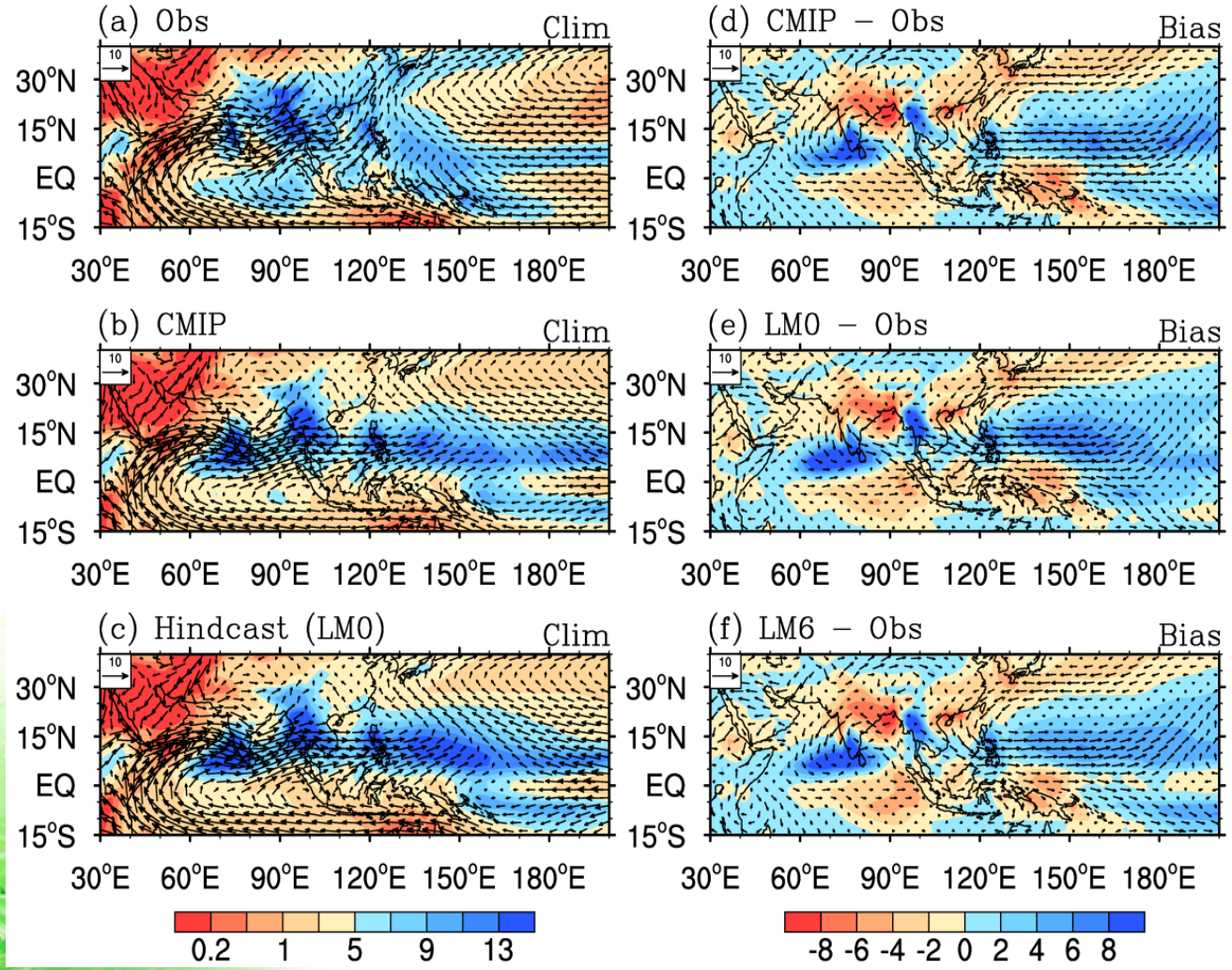
Hindcast period: 1991-2013

Data preprocess: 0-month lead (LM0) ; 1-month lead (LM1) ……

6-month lead (LM6)

Hindcasted climatologies of JJA-mean UV850 and PREC

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



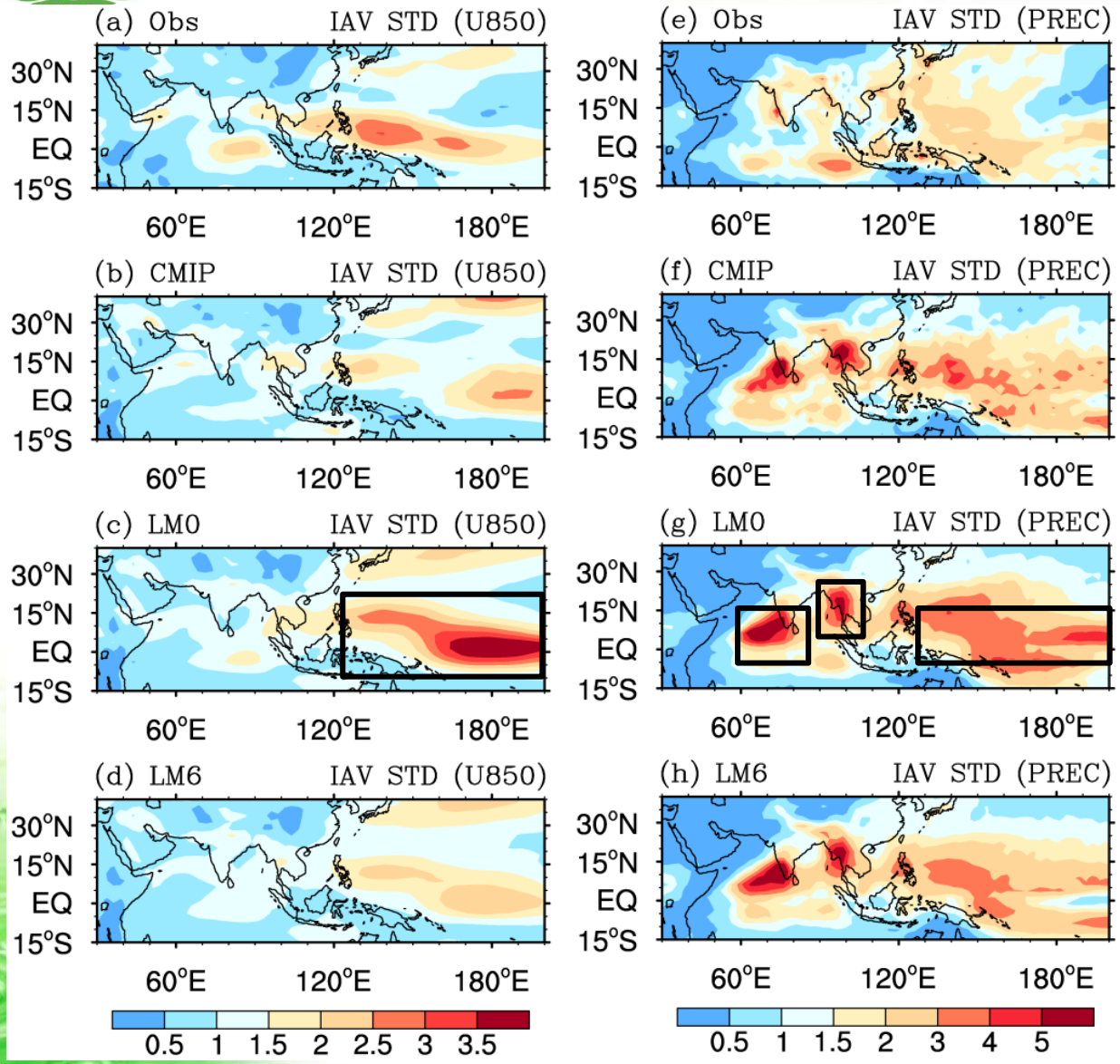
Wet biases over the Indian subcontinent, the western Indo-China Peninsula, and the tropical NWP.

Dry biases over the Bay of Bengal and the South China Sea and the cyclonic wind bias over NWP.

The biases show little increase from 0 to 6 months of lead.

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

Interannual standard deviations of JJA-mean U850 and PREC



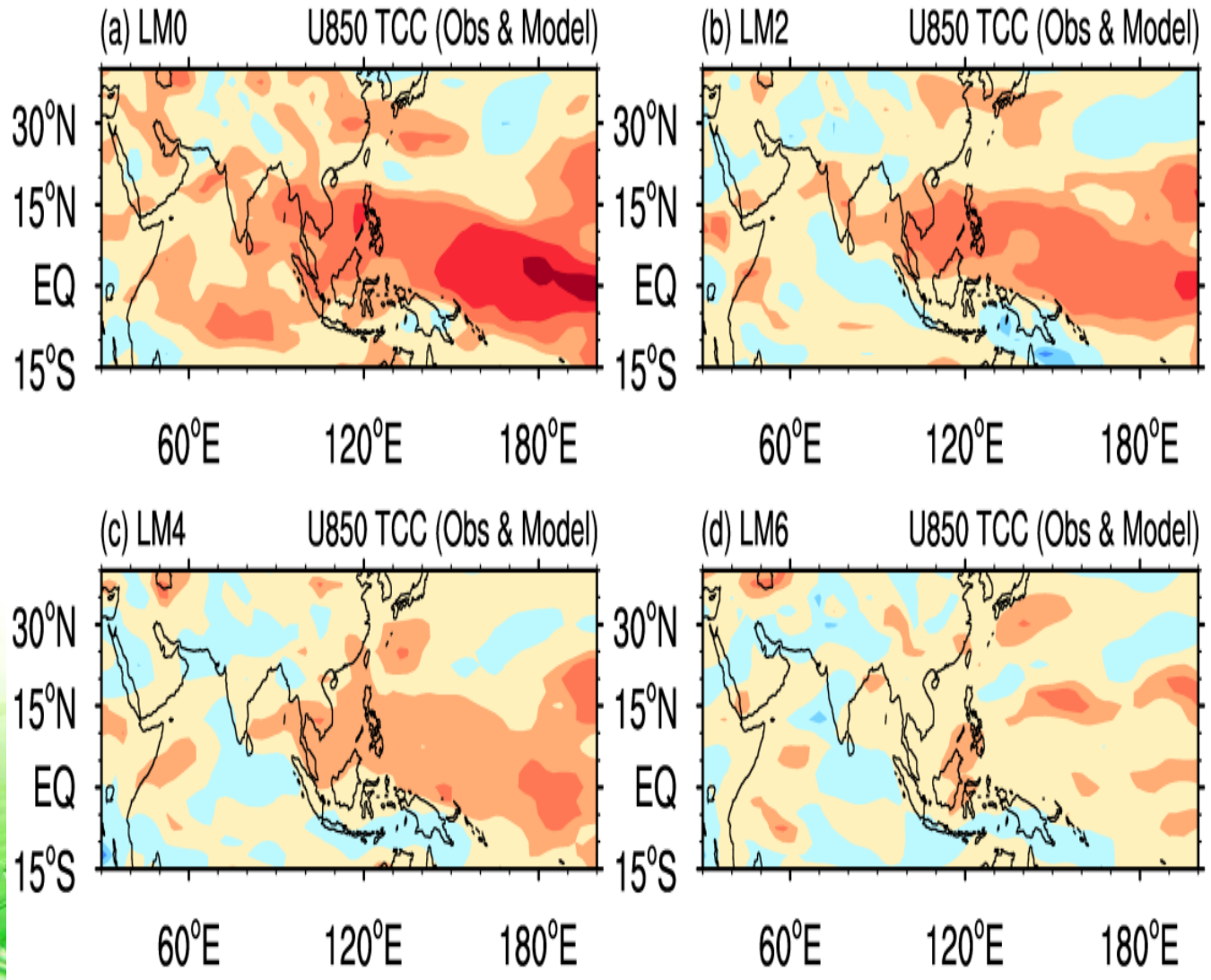
Strong interannual variability of U850 over the western tropical Pacific, with a maximum center near the Philippine Sea.

Remarkable overestimated the interannual variance of PRECIP over the SE Arabian Sea, western Indo-China Peninsula, and the western tropical Pacific.

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

Forecast skills in JJA-mean U850 at different lead time

（Data：1991-2013， ensemble mean）

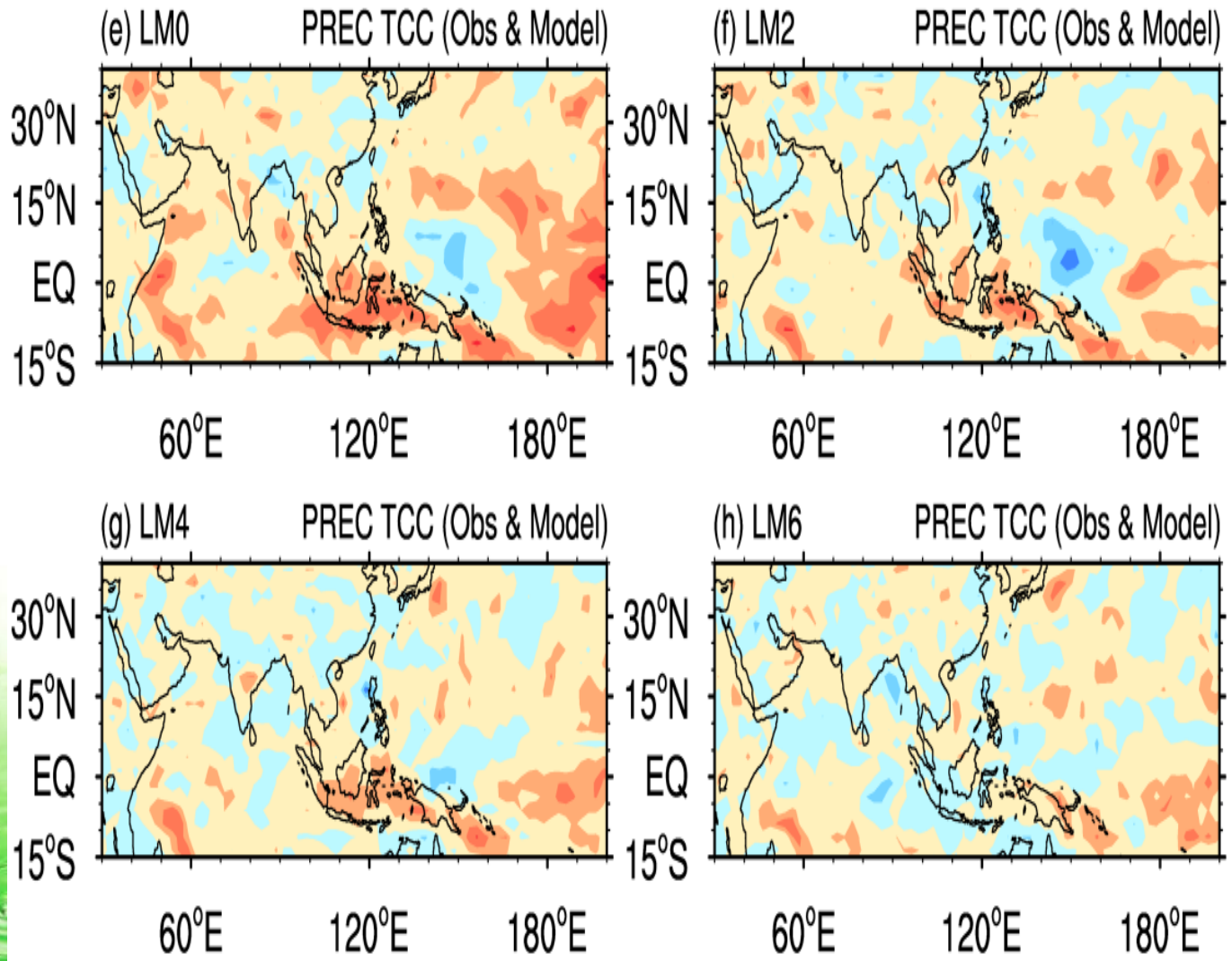


TCC: Temporal Corre. Coef.

Significant TCCs are over most tropical Indian-Pacific oceans.

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

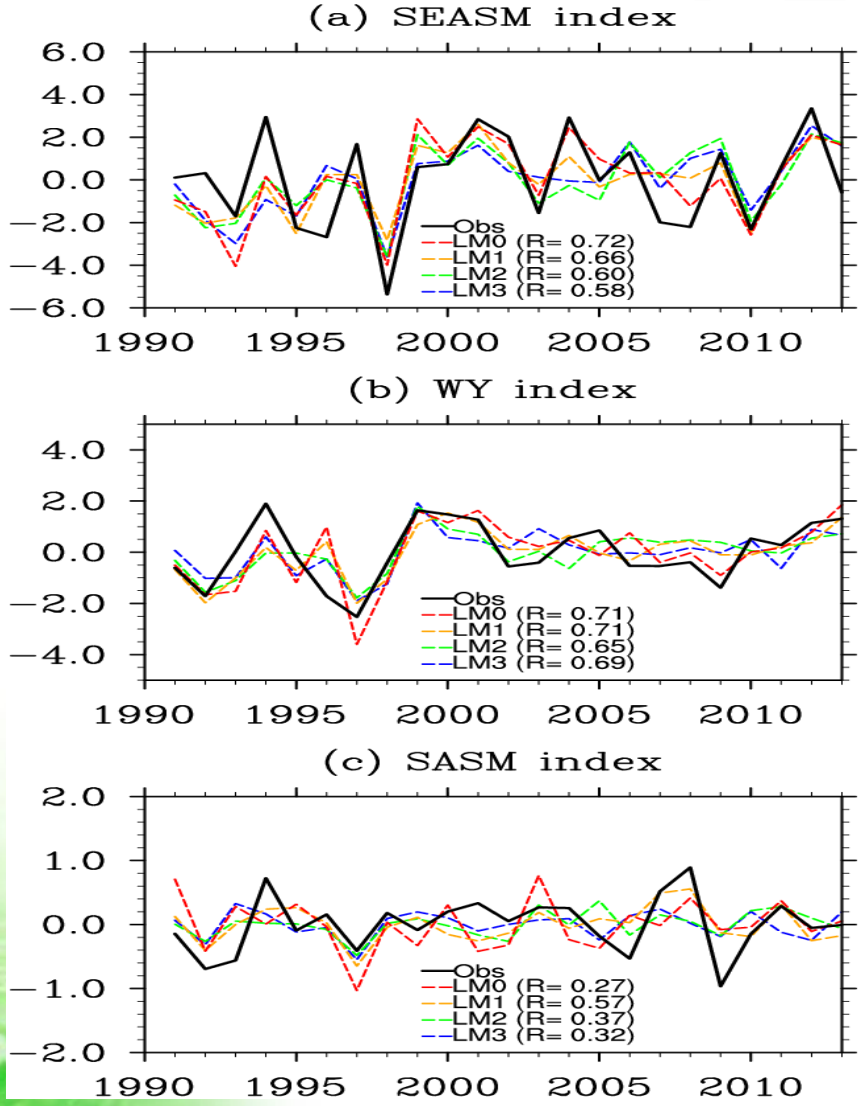
Forecast skills in JJA-mean PREC at different lead time



Less forecast skill for precipitation.

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

Interannual variations of summer monsoon indices

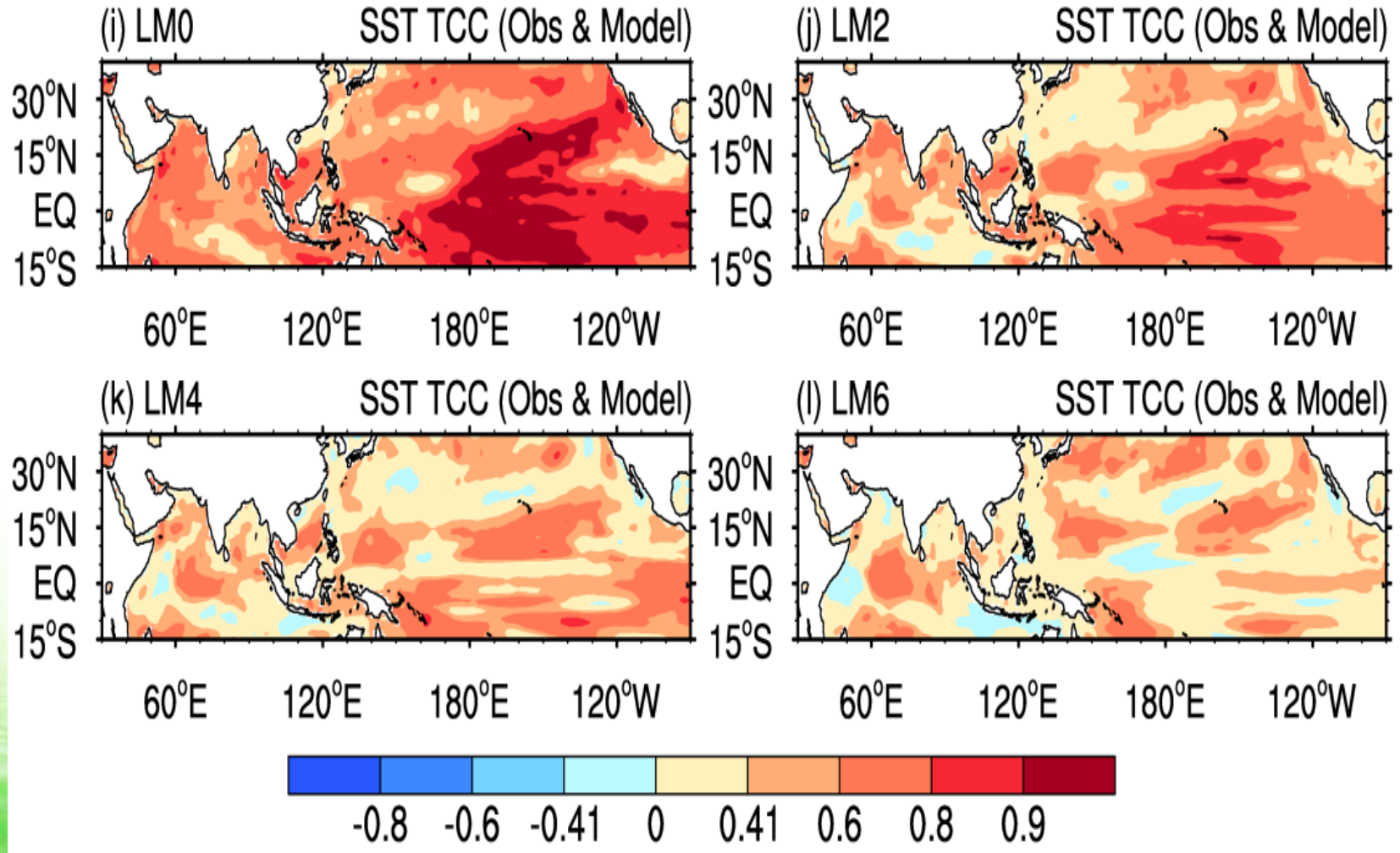


- SEASM: horizontal shear of 850-hPa zonal wind between 5–15N/90–130E and 22.5–32.5N/110–140E (Wang and Fan, 1999).
- WY: vertical shear of zonal winds between 850 and 200-hPa levels averaged over 0–20N/40–110E (Webster and Yang, 1992)
- SASM: vertical shear of meridional winds between 850 and 200-hPa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

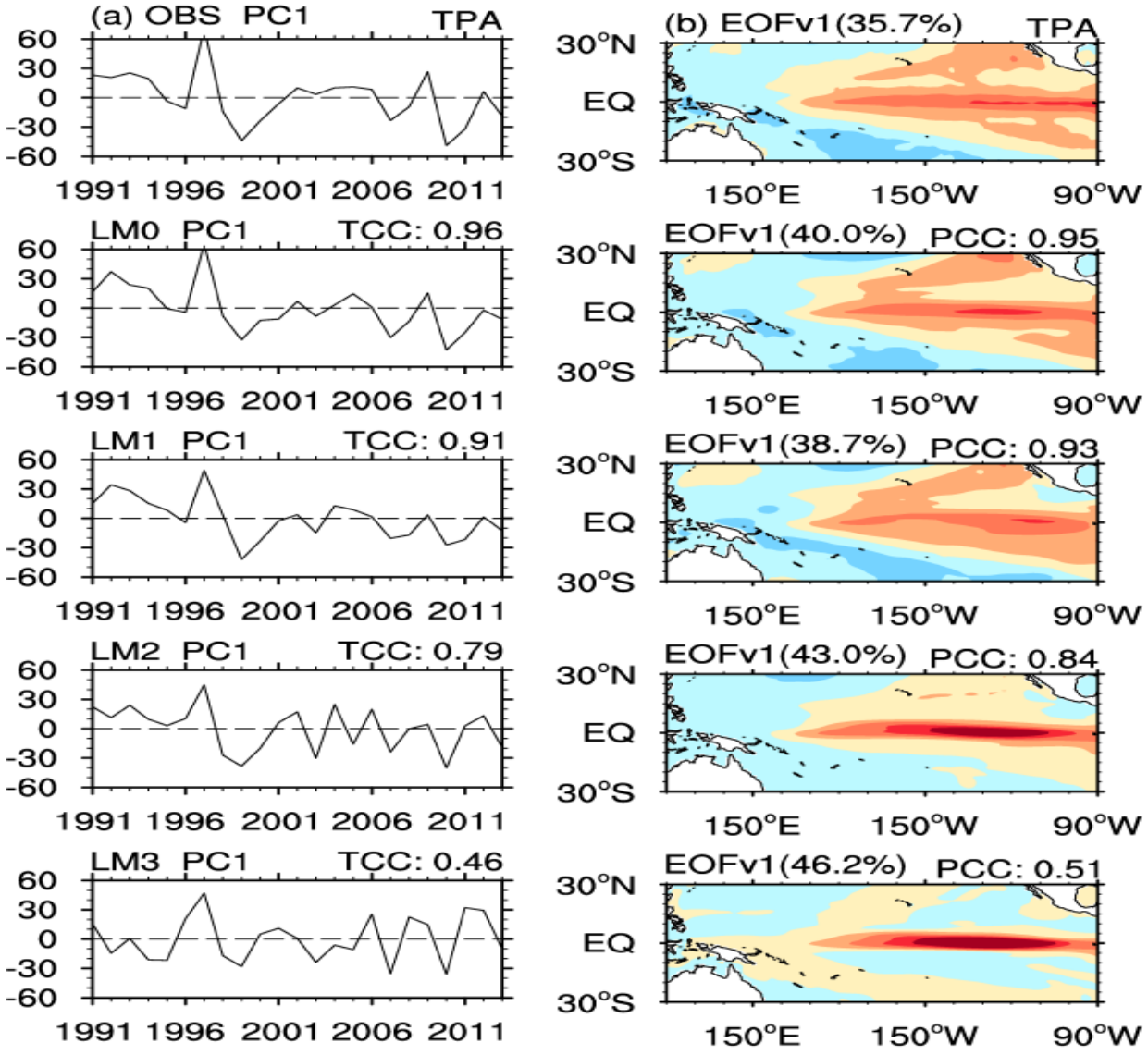
The ensemble predictions capture the observed interannual variability of the SEASM and WY index. The SASM index is unsuccessfully forecasted.

Validation data: ERA Interim

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 the spatial range quickly reduces to a narrow band near the equator at the lead time of 2 and 3 months

Forecast skills of Nino3.4 index and monsoon indices (LD-1month)

JJA forecast (lead=1mon)	Nino 3.4	Webster-Yang index	ISM	WNPSM	SEASM	SASM	Data length	Ref.
BCC_CSM	0.91	0.71	0.27	0.64	0.66	0.57	1991-2013	Liu, Wu, etal. (2015)
NCEP CFSv2	0.83	0.74	0.27	0.57	0.62	0.39	1982-2009	Kim et al. (2012)
ECMWF S4	0.87	0.78	0.29	0.77			1982-2009	Kim et al. (2012)

Liu X., Wu T., et al. Performance of the seasonal forecasting of the Asian summer monsoon by BCC_CSM1.1(m). 2015, Adv. Atmos. Sci.

Kim et al. Asian summer monsoon prediction in ECMWF System 4 and NCEP CFSv2 retrospective seasonal forecasts. 2012, Clim. Dyn.

Part III：

Sub-seasonal to seasonal prediction project (S2S) activity in CMA

5-year project, started in Nov 2013.

The Subseasonal to Seasonal Prediction (S2S) Project is a proposed WWRP/THORPEX/ WCRP joint research project.

The main goal of the S2S project is to improve forecast skill and understanding on the subseasonal to seasonal timescale, and promote its uptake by operational centres and exploitation by the applications community. Specific attention will be paid to the risk of extreme weather, including tropical cyclones, droughts, floods, heat waves and the waxing and waning of monsoon precipitation.

Sub-seasonal to Seasonal prediction (S2S) project provides a good opportunity to evaluate models from different operational centers and further improve their numerical forecast skills on the S2S timescales.

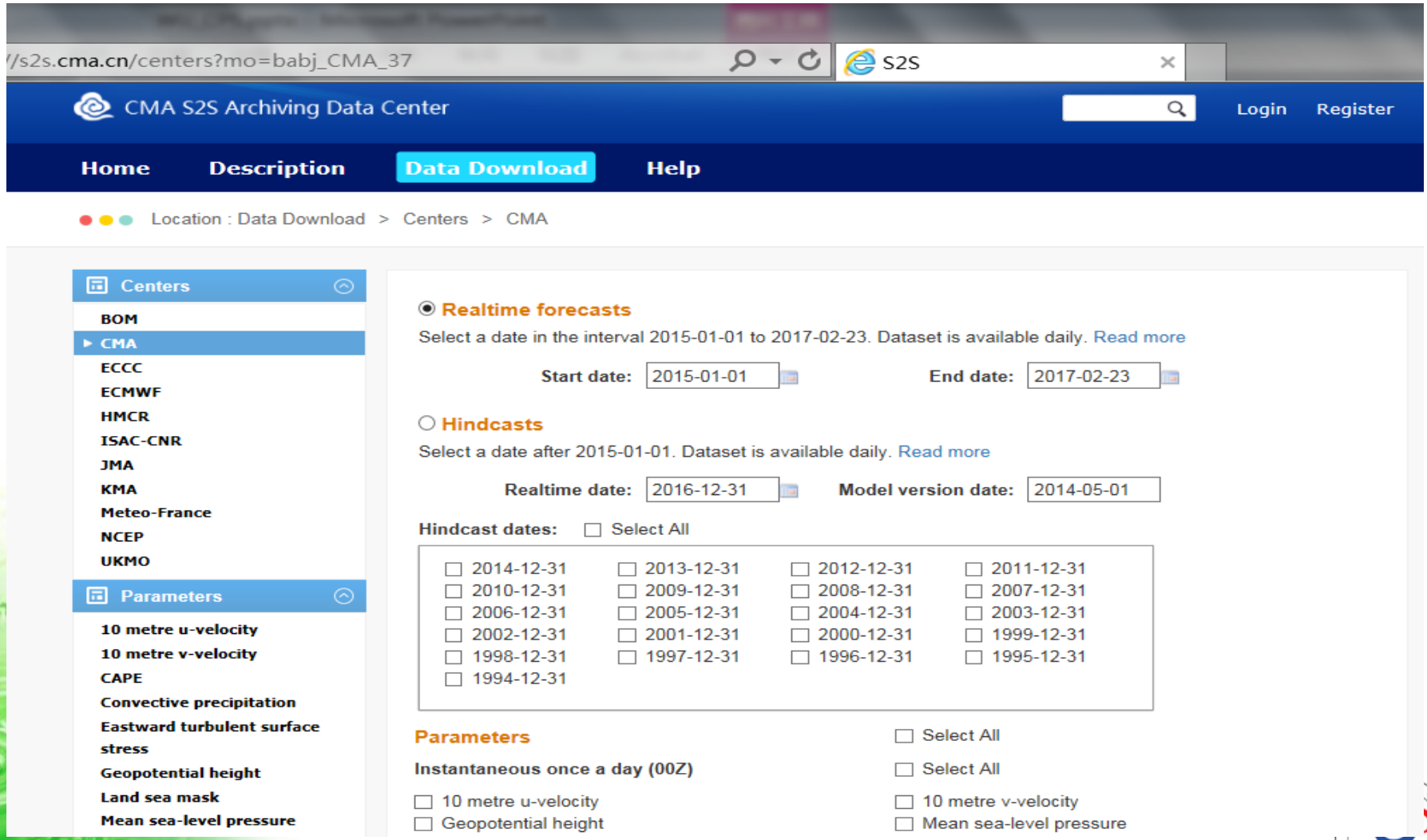
6 Topics: MJO, Monsoons, Extremes, Teleconnections, Verification ,Africa

S2S partners

	Time-range	Resol.	Ens. Size	Freq.	Hcsts	Hcst length	Hcst Freq	Hcst Size
ECMWF	D 0-46	T639/319L91	51	2/week	On the fly	Past 20y	2/weekly	11
UKMO	D 0-60	N216L85	4	daily	On the fly	1996-2009	4/month	3
NCEP	D 0-44	N126L64	4	4/daily	Fix	1999-2010	4/daily	1
EC	D 0-32	0.6x0.6L40	21	weekly	On the fly	1995-2014	weekly	4
CAWCR	D 0-60	T47L17	33	weekly	Fix	1981-2013	6/month	33
JMA	D 0-34	T319L60	25	2/weekly	Fix	1981-2010	3/month	5
KMA	D 0-60	N216L85	4	daily	On the fly	1996-2009	4/month	3
CMA	D 0-45	T106L40	4	daily	Fix	1886-2014	daily	4
CNRM	D 0-32	T255L91	51	Weekly	Fix	1993-2014	2/monthly	15
CNR-ISAC	D 0-32	0.75x0.56 L54	40	weekly	Fix	1981-2010	6/month	1
HMCR	D 0-63	1.1x1.4 L28	20	weekly	Fix	1981-2010	weekly	10

CMA S2S database

http://s2s.cma.cn



Subseasonal to Seasonal (S2S) Prediction by BCC_CSM1.2

BCC_CSM1.2

BCC_AGCM2.2(T106 ~110 km, L40,Top: 0.5 hPa
BCC_AVIM1.0(T106)
MOM4-L40v2(1/3°~30km)
SIS(1/3°~30km)

- **Atmospheric initials: NCEP reanalysis 1**

  Ocean initials: BCC Global Ocean Data Assimilation System

  (BCC_GODAS2.0)

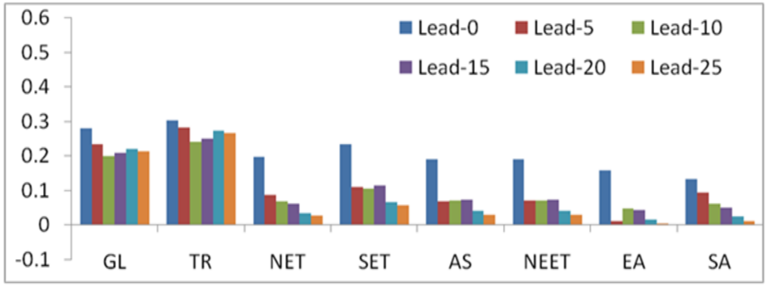
- **Time-lagged Average Forecasting (LAF) method**
- **1 control forecast + 3 perturbed ensemble members**

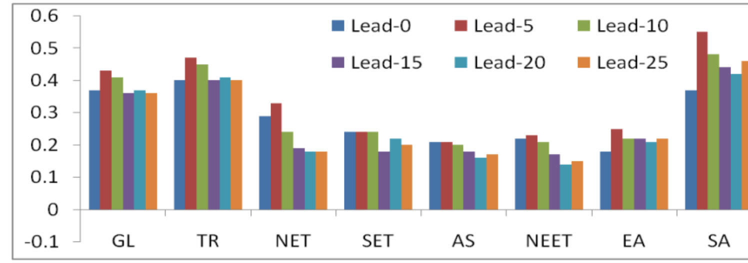
  (Initialized at 00 UTC of the first forecast day and 18, 12 and 06 UTC of the previous day)
- **60-day forecast integrations**
- **Daily rolling forecasts from 1994/01/01-2014/04/30**

ACC skills of monthly prediction

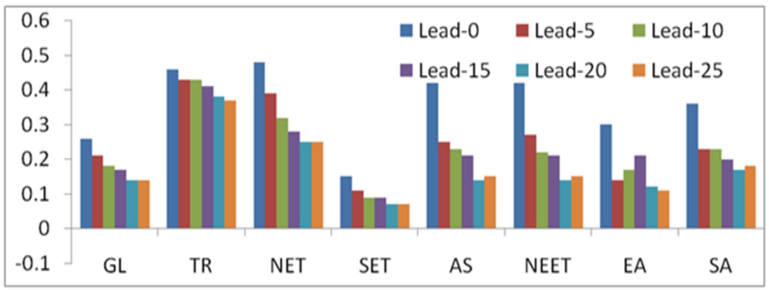
(JJA) (DJF)

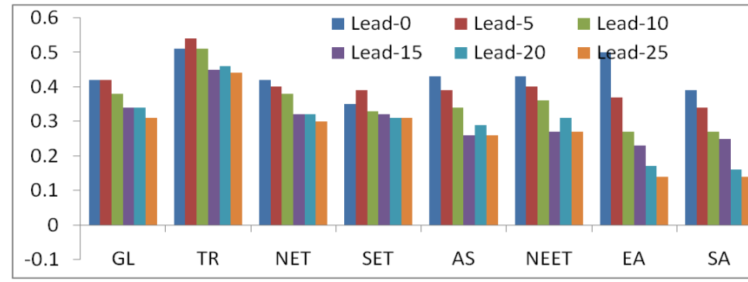
Precip



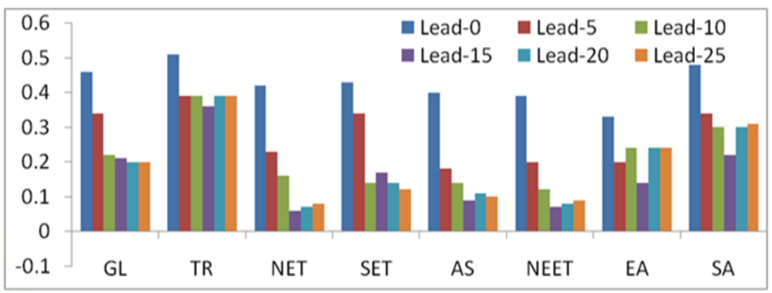


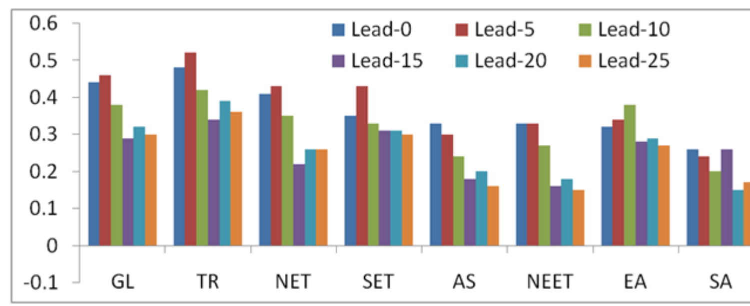
T2m





U850



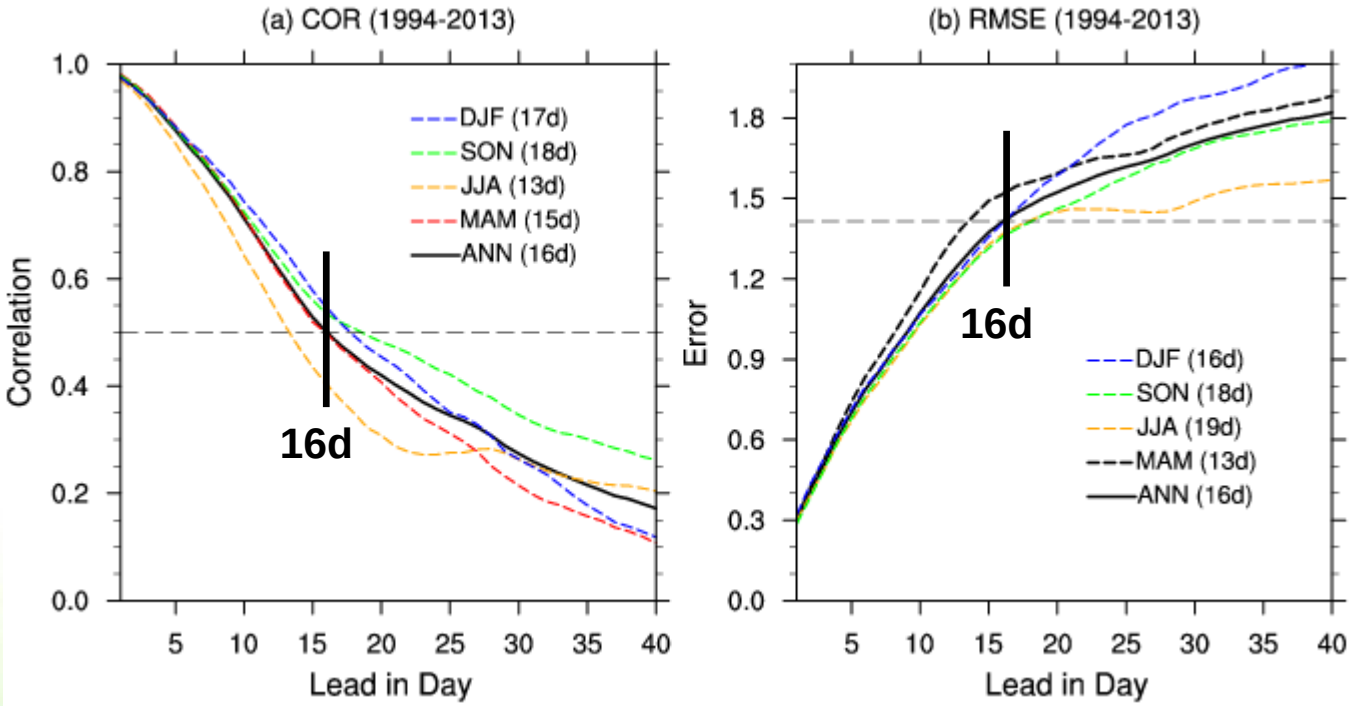


Anomaly correlation coefficients (ACC) between observations and the ensemble mean predictions with different lead days for precipitations ,air surface temperature and 850-hPa zonal wind over the sub-regions.

GL	0°-360°E，90°S-90°N
TR	0°-360°E，20°S-20°N
NET	0°-360°E，20°N-90°N
SET	0°-360°E，20°S-90°S
AS	30°-180°E，20°N-90°N
NEET	0°-180°E，20°N-90°N
EA	90°-150°E，20°N-50°N

MJO forecast verification

Overall MJO prediction skill in S2S hindcasts



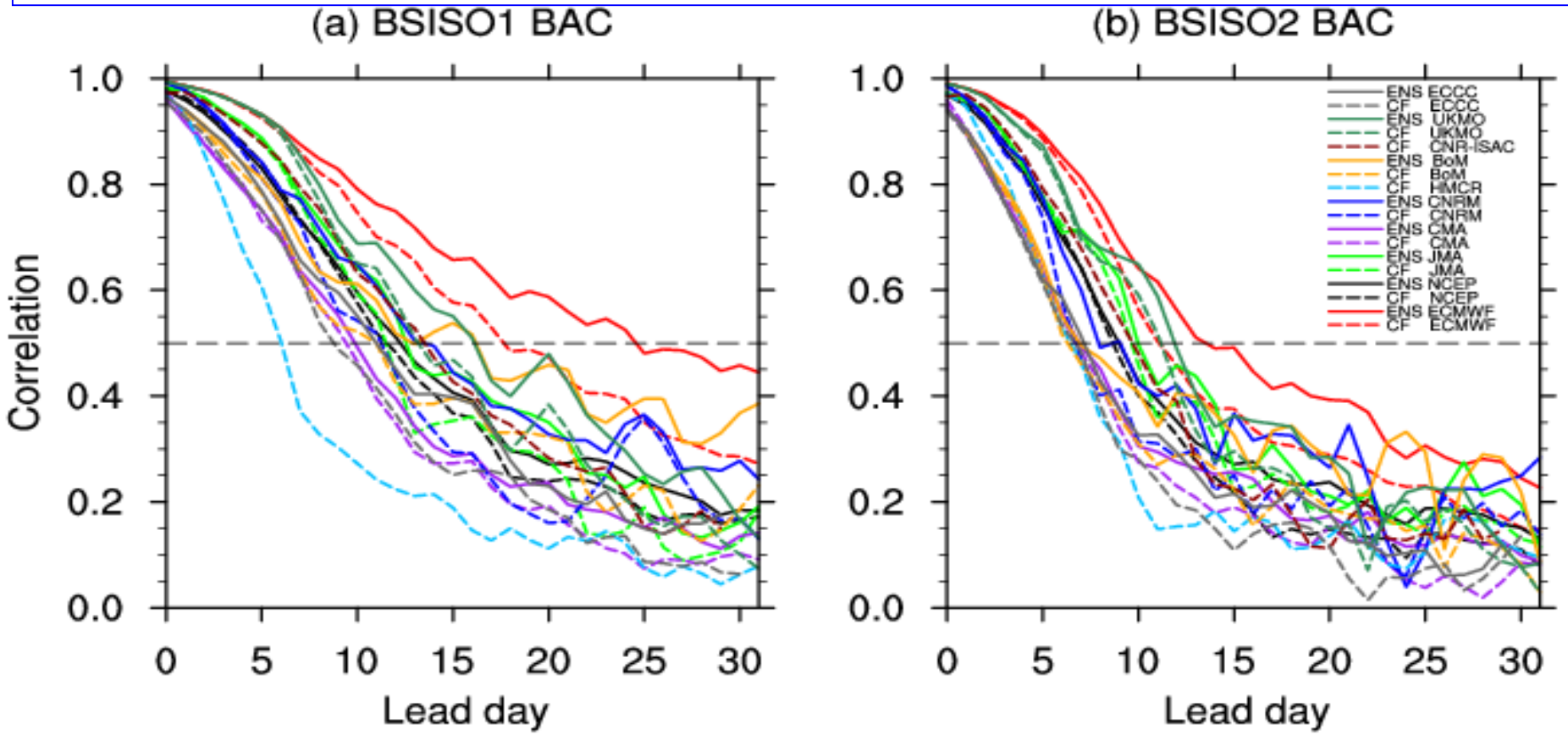
$$\mathrm{COR}(\tau) = \frac{\sum_{i=1}^{N} [a_{1i}(t)b_{1i}(t) + a_{2i}(t)b_{2i}(t)]}{\sqrt{\sum_{i=1}^{N} [a_{1i}^2(t) + a_{2i}^2(t)]}\sqrt{\sum_{i=1}^{N} [b_{1i}^2(t) + b_{2i}^2(t)]}}$$

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

(Liu X., et al., 2016)

Boreal Summer Intraseasonal Oscillation (BSISO) Index (May to October during 1999-2010)

BSISO1 Index defined based on EOF1 and EOF2 of U850/OLR is associated with MJO
BSISO2 Index defined based on EOF3 and EOF4 of U850/OLR is related to Asian Monsoon

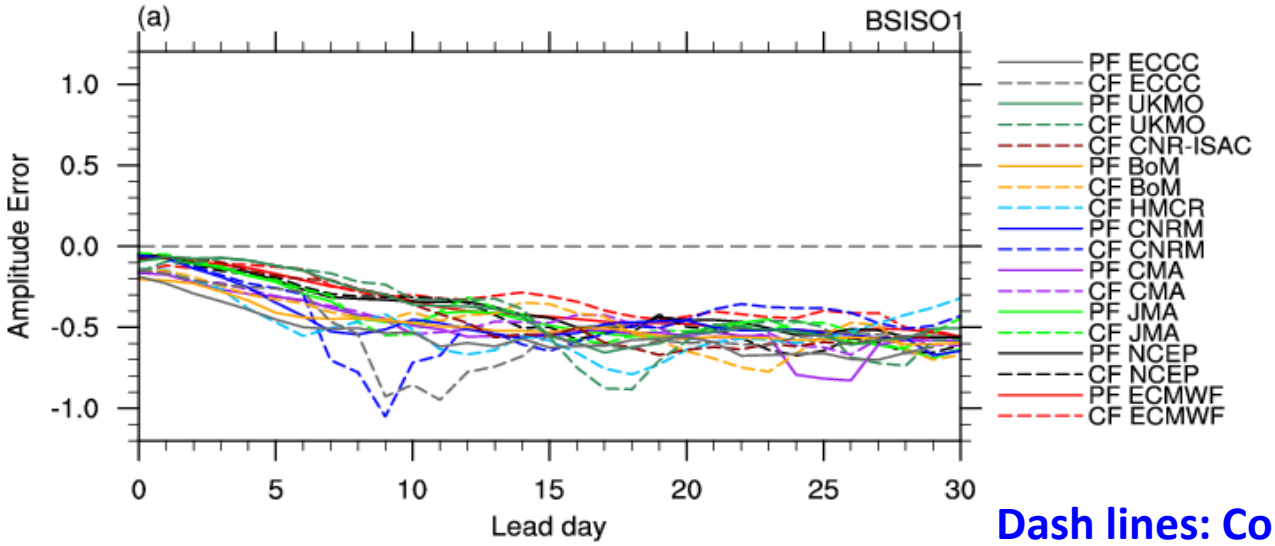


a. BSISO1 index shows **the prediction skill** is in range of 6 and 24.5 days
b. BSISO2 index shows the **prediction skill** is between 6.5 and 14 days
c. BCC model (purple lines) is 10 and 7.5 days, respectively

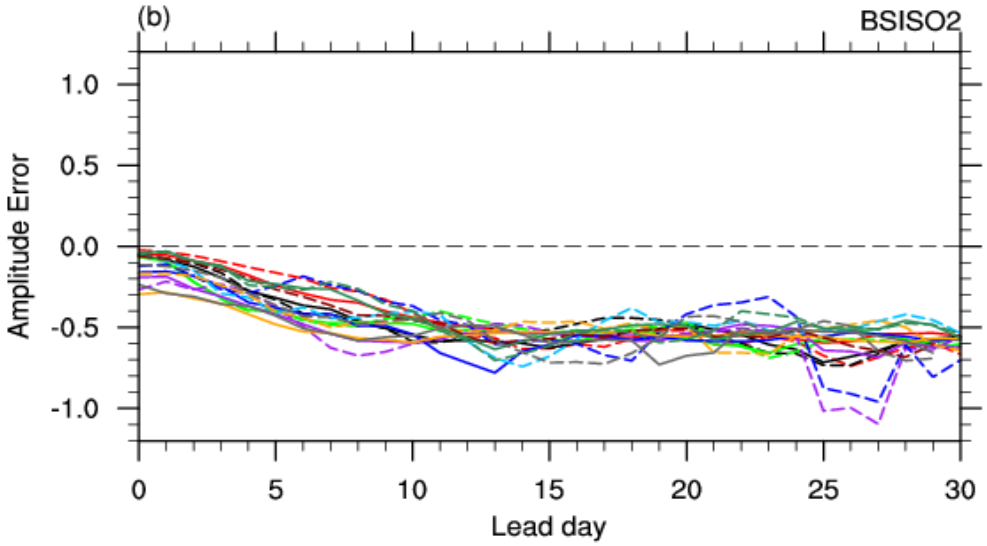
Jie et al.,2017

Amplitude errors of BSISO index

BSISO1



BSISO2

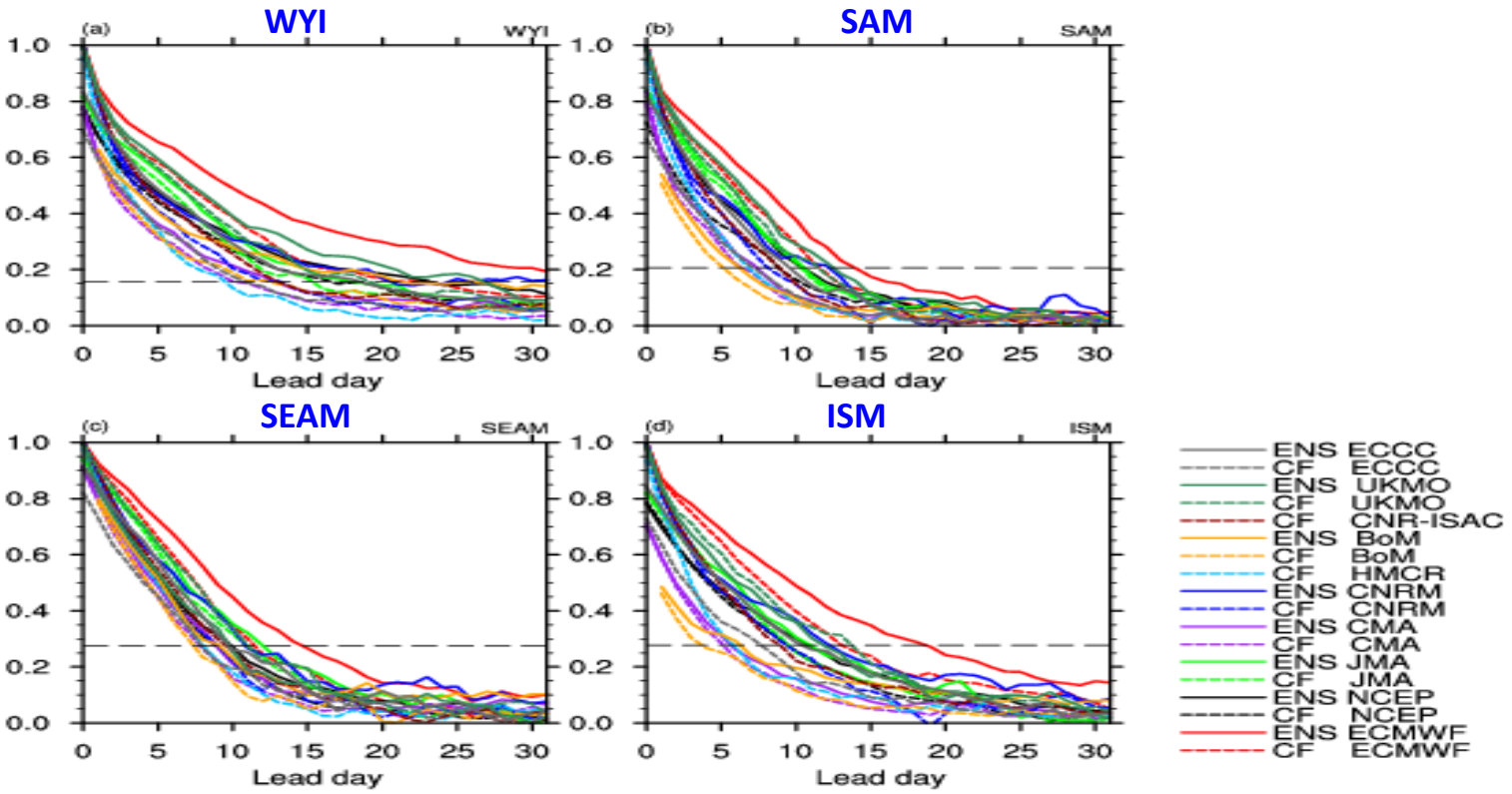


Dash lines: Control Forecasts
Solid lines: Perturb Forecasts

$$\frac{A_{model} - A_{obs}}{A_{model}}$$

Amplitude of BSISO is underestimated, and it becomes serious when lead time increases. The ECMWF, UKMO models show better performances in the first two weeks. Purple line is for BCC model.

Asian monsoon Indices



	Index	Definition
Atmospheric Circulation	WY	$U_{850} - U_{200}$ (0°–20°N, 40°–110°E)
	SAM	$V_{850} - V_{200}$ (10°–30°N, 70°–110°E)
	SEAM	U_{850} (5°–15°N, 90°–130°E) – U_{850} (22.5°–32.5°N, 110°–140°E)
	ISM	U_{850} (5°–15°N, 40°–80°E) – U_{850} (20°–30°N, 70°–90°E)

Conclusion:

WYI: 9 – 30 days (13d)

SAM: 5.5 – 14 days (8d)

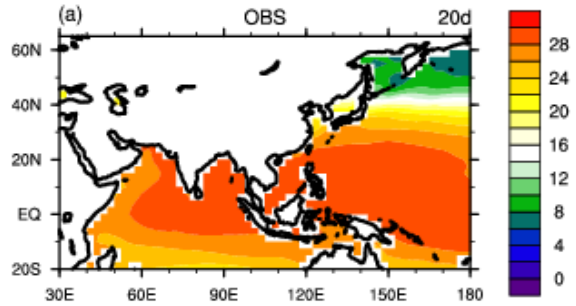
SEAM: 7 – 14 days (10d)

ISM: 5 – 19 days (5.5d)

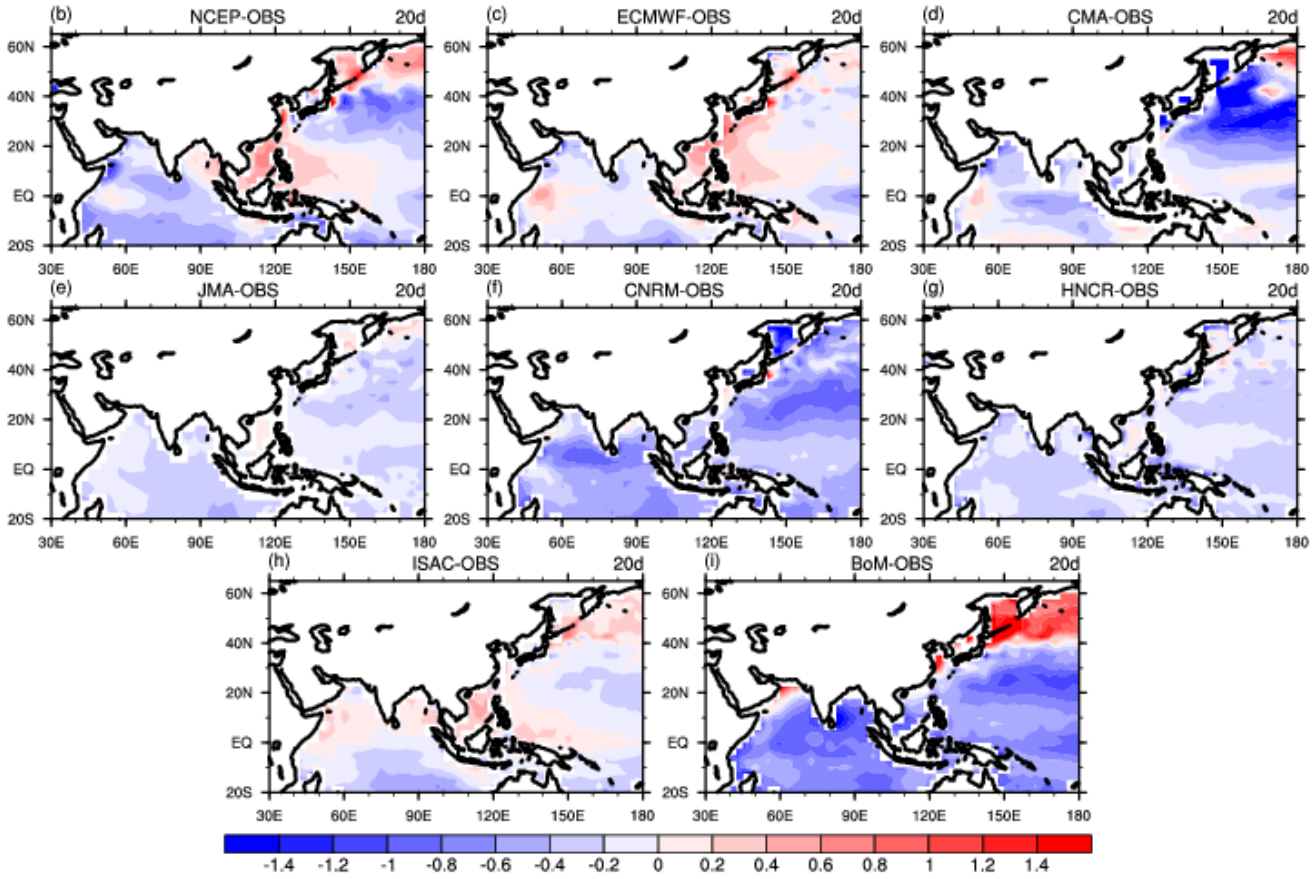
(purple lines for BCC)

Forecast bias of SST averaged from May to October during 1999-2010

OBS



Lead time: Day 10



➢ Improved experiments

Different initialization schemes

S2S_HST: ocean initials (BCC_GODAS)+atmosphere initials (NCEP R1)

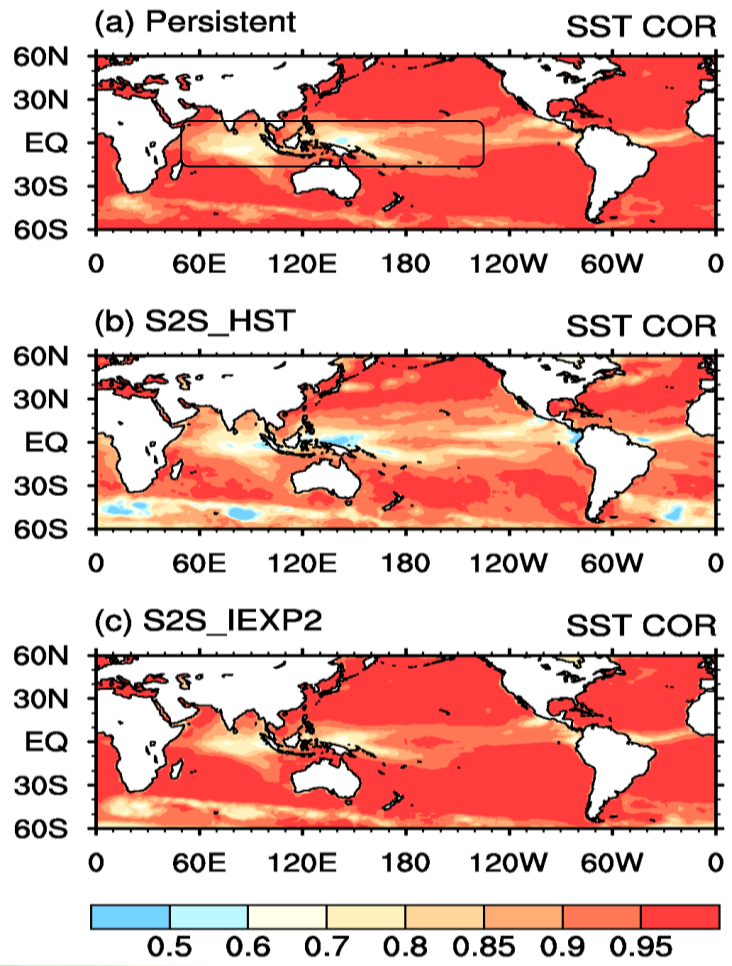
S2S_IEXP1: ocean initials (BCC_GODAS) + atmosphere initials (NCEP FNL)

S2S_IEXP2: ocean initials (BCC_GODAS + OISST) + atmosphere initials (NCEP FNL) (OISST gradually linearly transits to the BCC_GODAS from sea surface to subsurface of 30m)

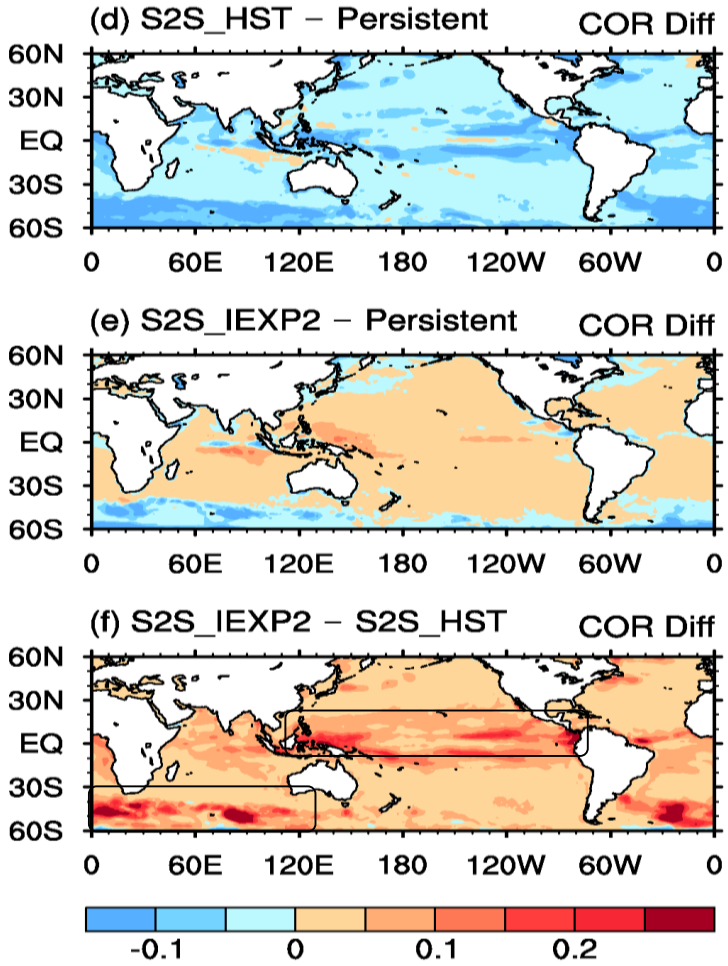
Hindcasts: Conducted on 1st , 6th, 11th, 16th, 21st, and 26th of each month during 2000-2013

Improvement of SST forecast

TCC of SST

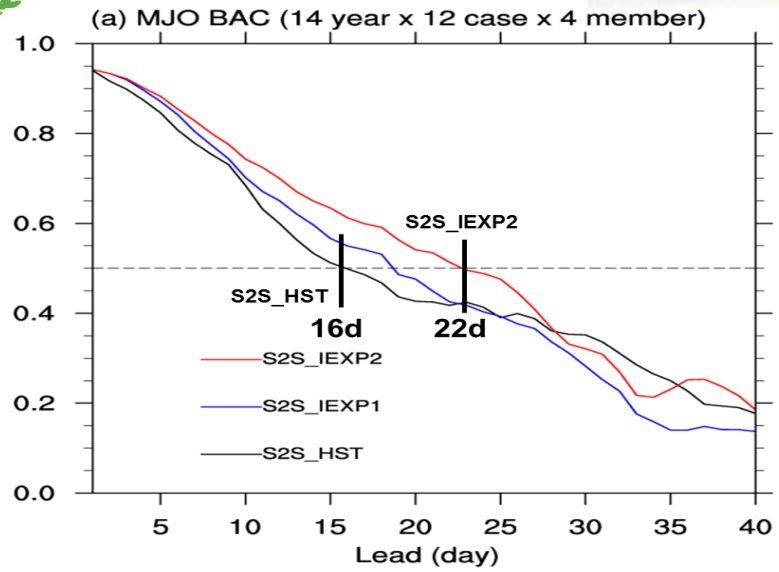


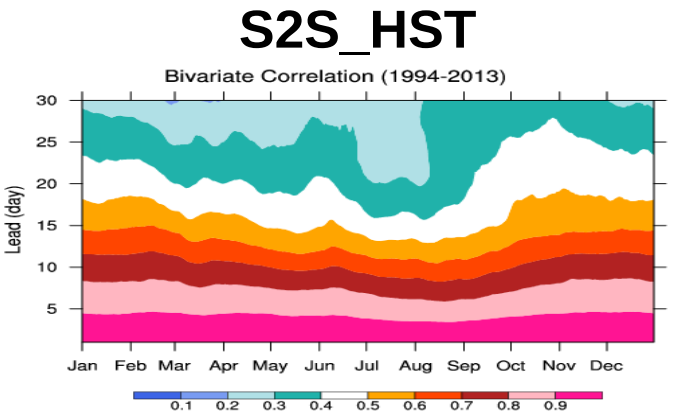
differences of SST forecast skill

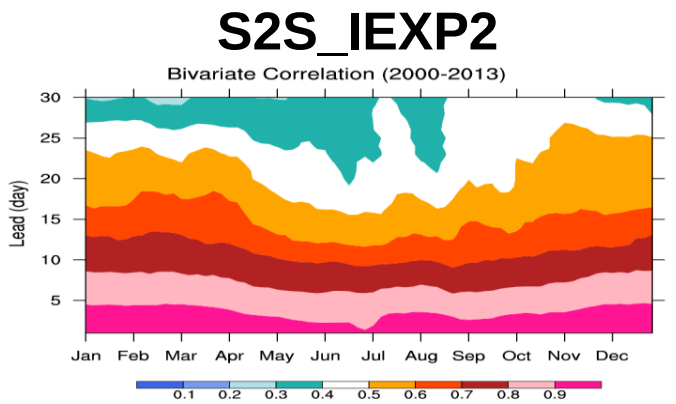


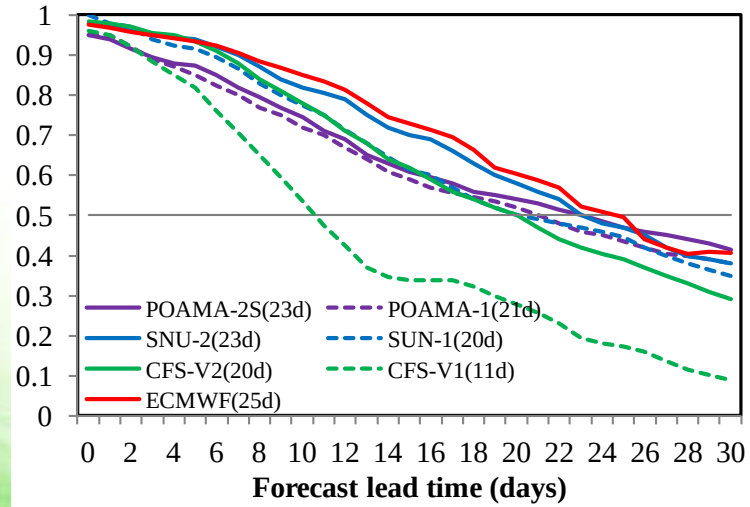
IEXP2 increased skills in most tropical and subtropical regions compared to the persistent forecasts.

MJO prediction skill in BCC_CSM1.2





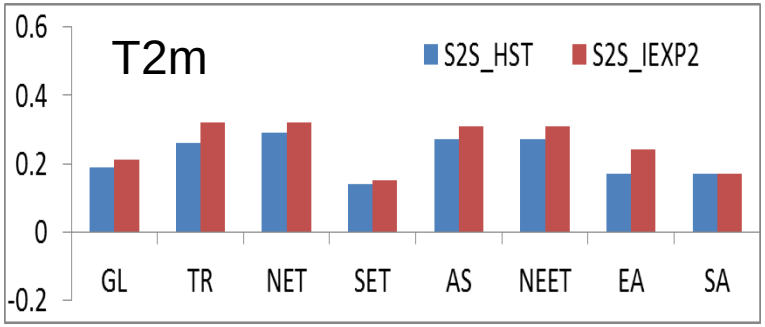


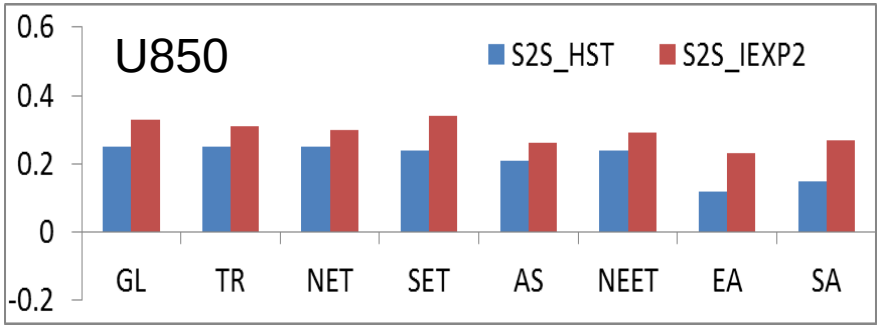


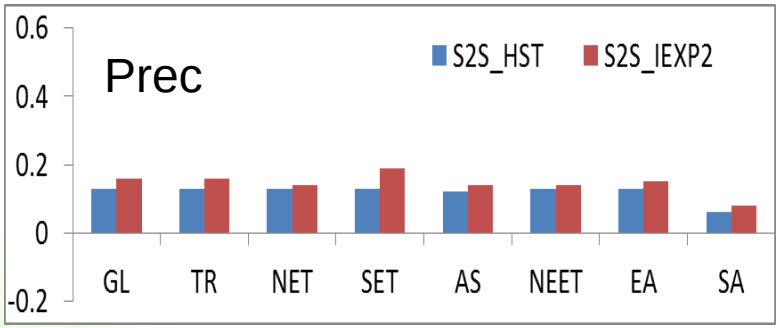
Further experiments using BCC model show that oceanic initial states largely impact on the East Asian summer monsoon and MJO forecast skill.

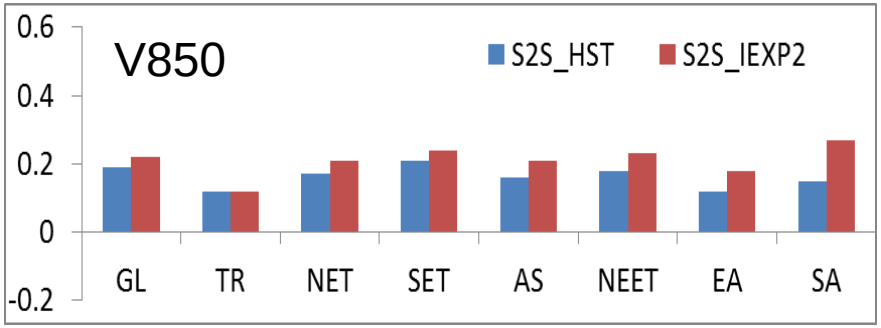
(Liu, et al. 2016)

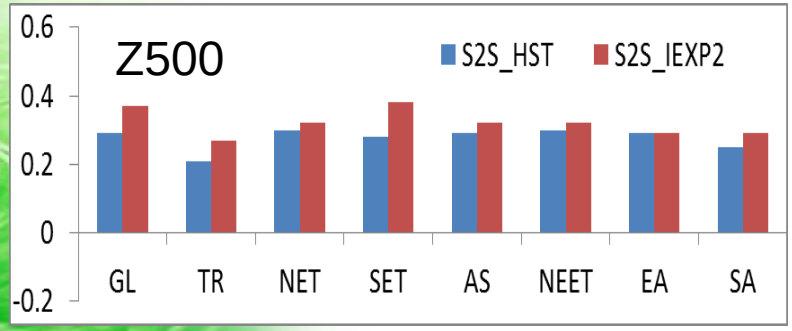
Improvement of monthly forecasts skill (July)









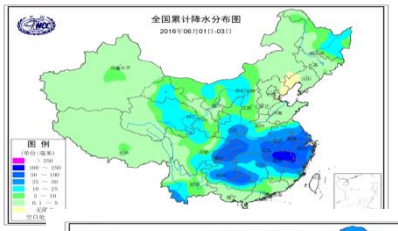


➢ Extreme events

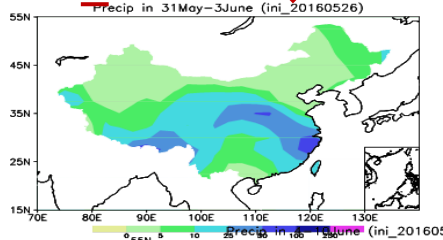
Real-time predictions in 2016

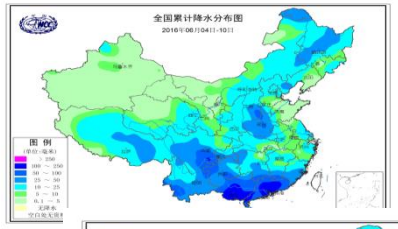
——6 heavy rainfall processes in southern China in June

OBS | **FST-BCC_CSM1.2(Lead-5day)**



5.31-6.3





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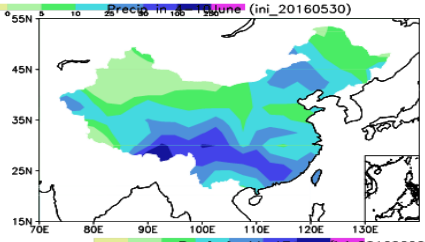
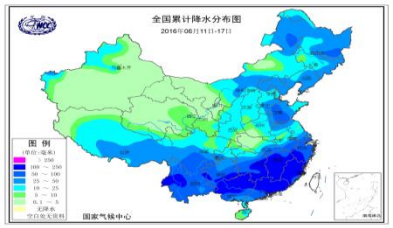
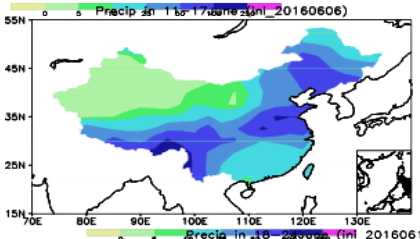
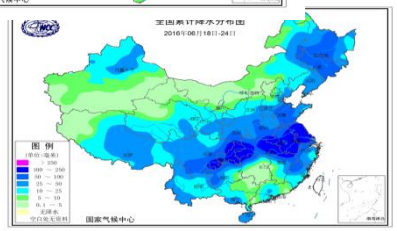




6.11-17





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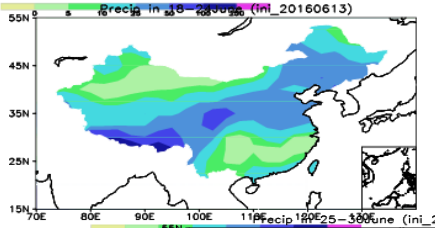

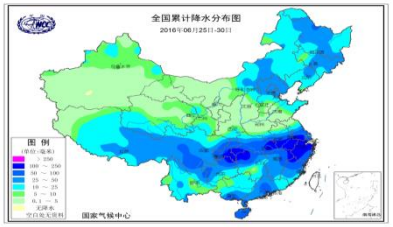

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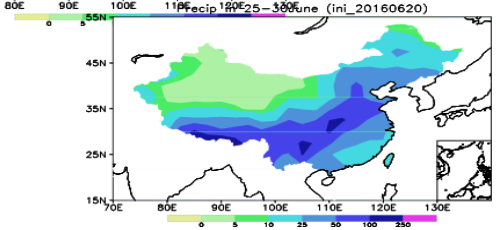
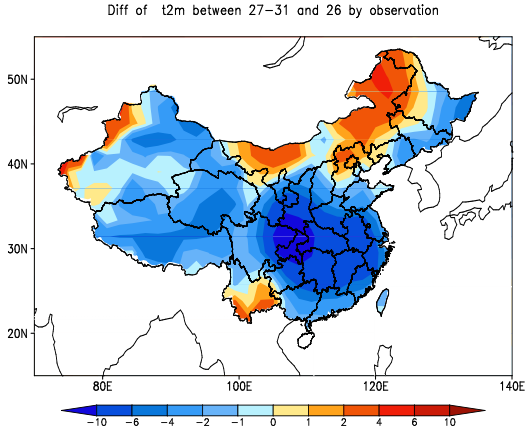
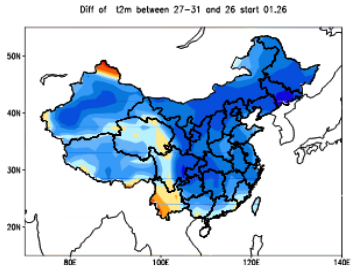
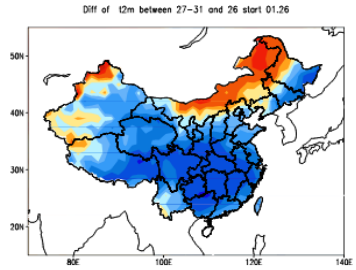
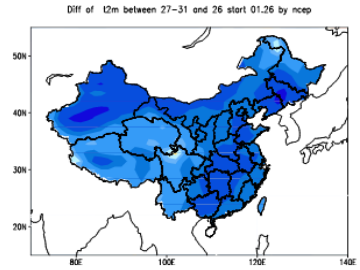
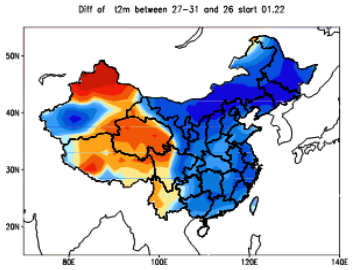
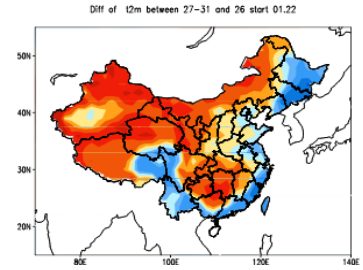
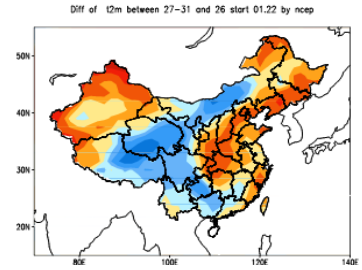
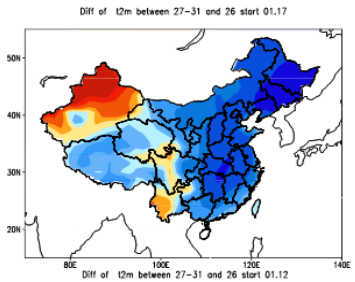
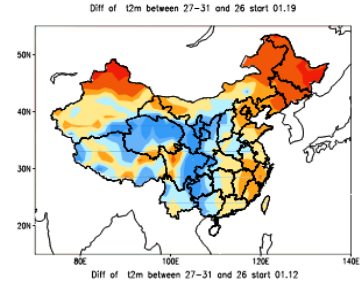
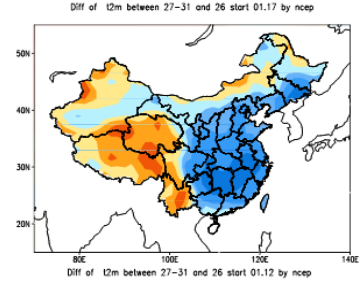
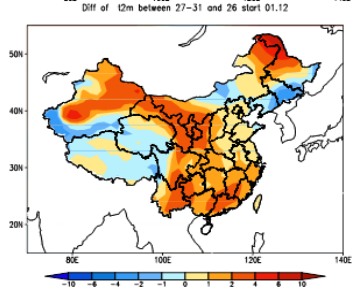
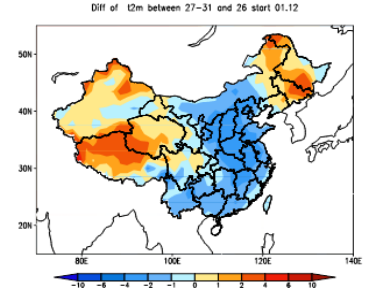
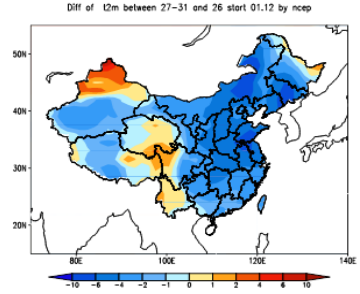


Extreme event (27-31 Jan, 2015) of cold surge forecasts

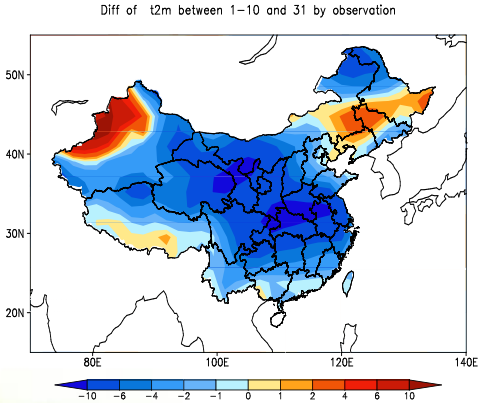
T2m difference between 27-31 Jan. and 26 Jan.

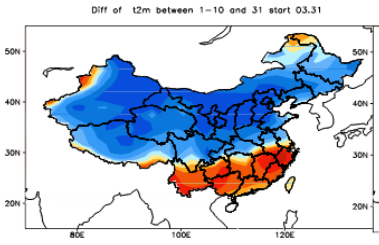
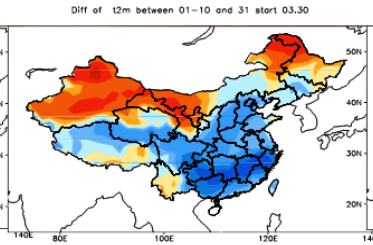
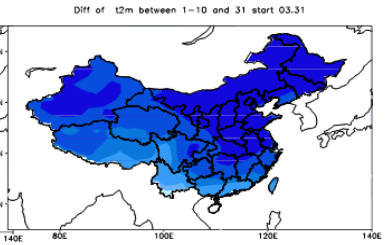
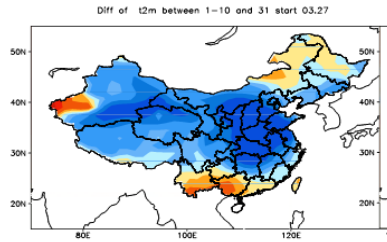
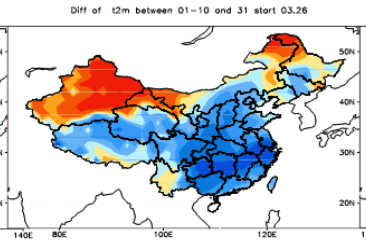
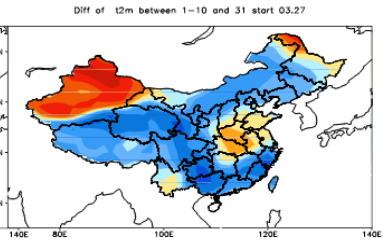
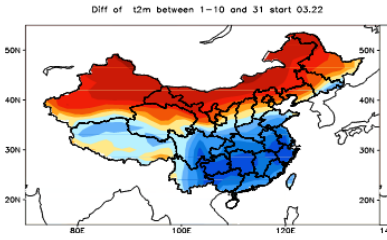
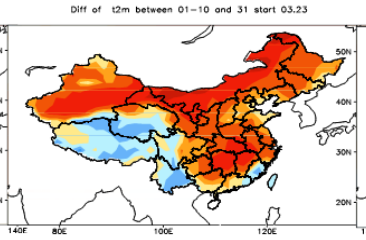
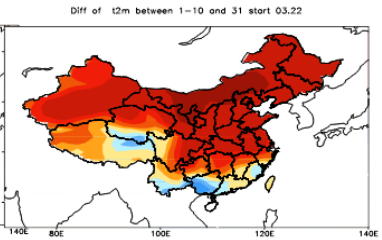
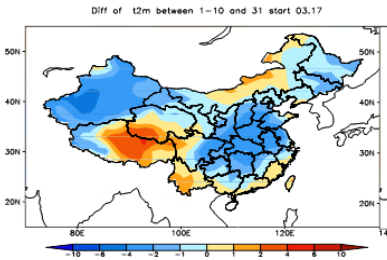
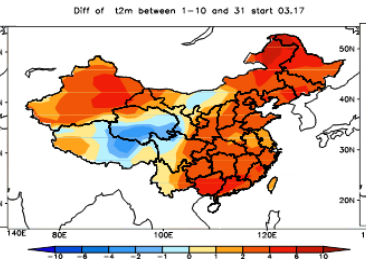
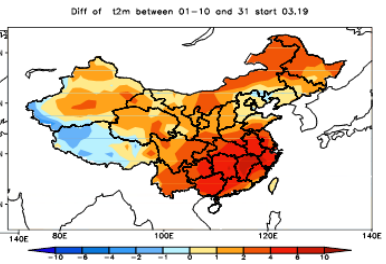


CMA	ECMWF	NCEP	Lead time
			LD-0 day
			LD-5 day
			LD-10 day
			LD-15 day

Extreme event (1-10 April, 2015) of cold surge forecasts

T2m difference between 1-10 April and 31 March.

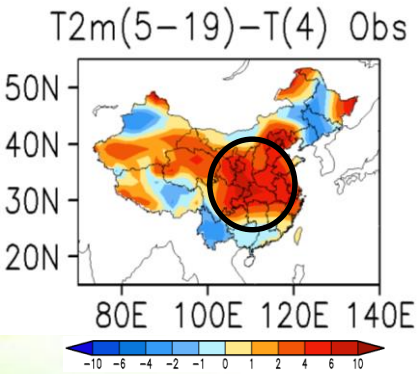


CMA	ECMWF	NCEP	Lead time
			LD-0 day
			LD-5 day
			LD-10 day
			LD-15 day

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

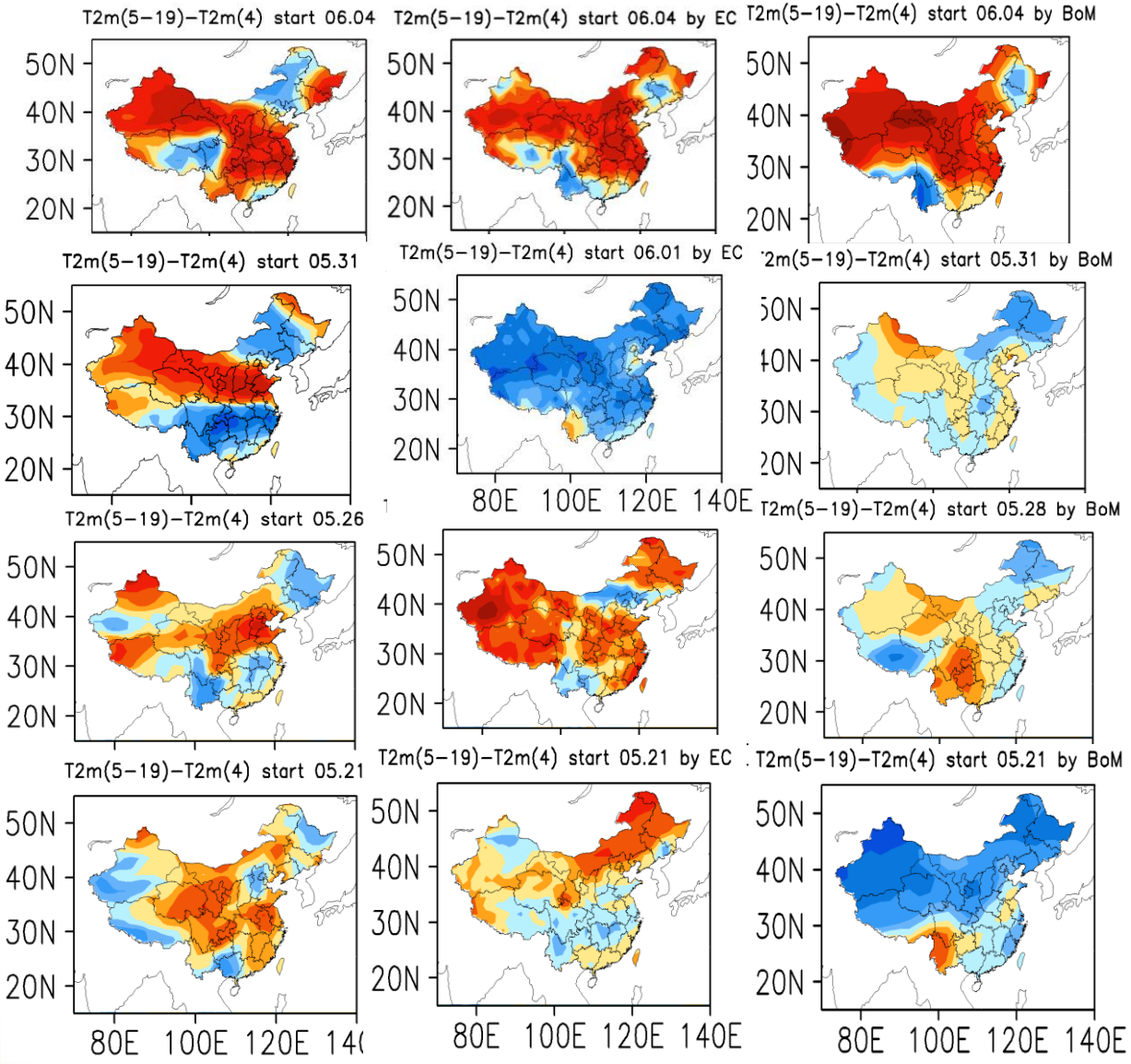
T2m difference between 5-19 June and 4 June.

OBS



BCC | ECMWF | BoM

Lead time



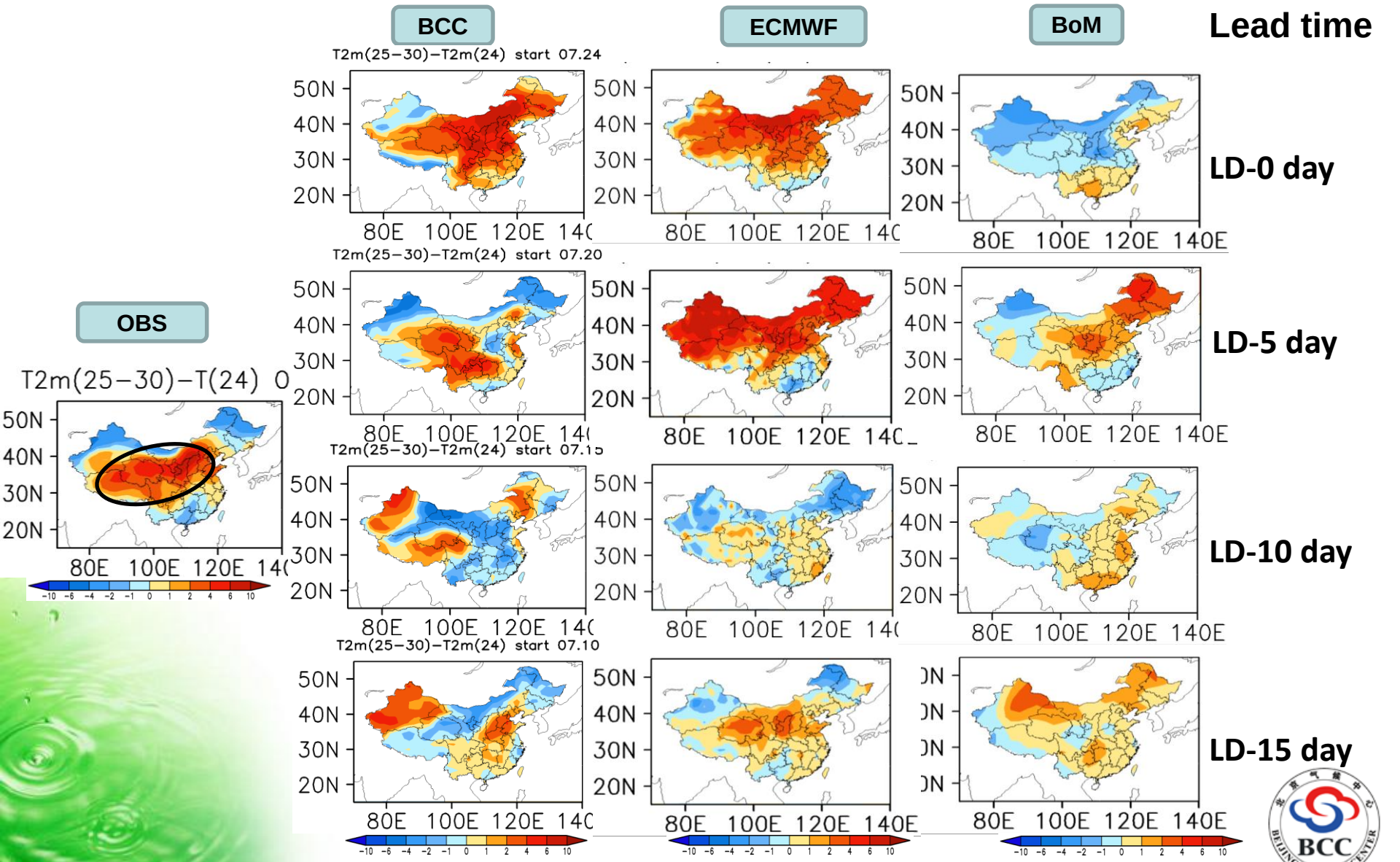
LD-0 day

LD-5 day

LD-10 day

LD-15 day

Extreme event (25-30 July, 2015) of heat wave forecasts



Discussions

- Biases of monthly to seasonal forecast closely related to the model biases of CMIP-type experiments.
- Reasonable skill is found in the model's forecasting of certain aspects of monsoon climatology and spatiotemporal variability. Significant forecast errors over the tropical western North Pacific and the eastern equatorial Indian Ocean are also found.
- Oceanic initial states largely impact on the MJO and summer monsoon forecast skill.

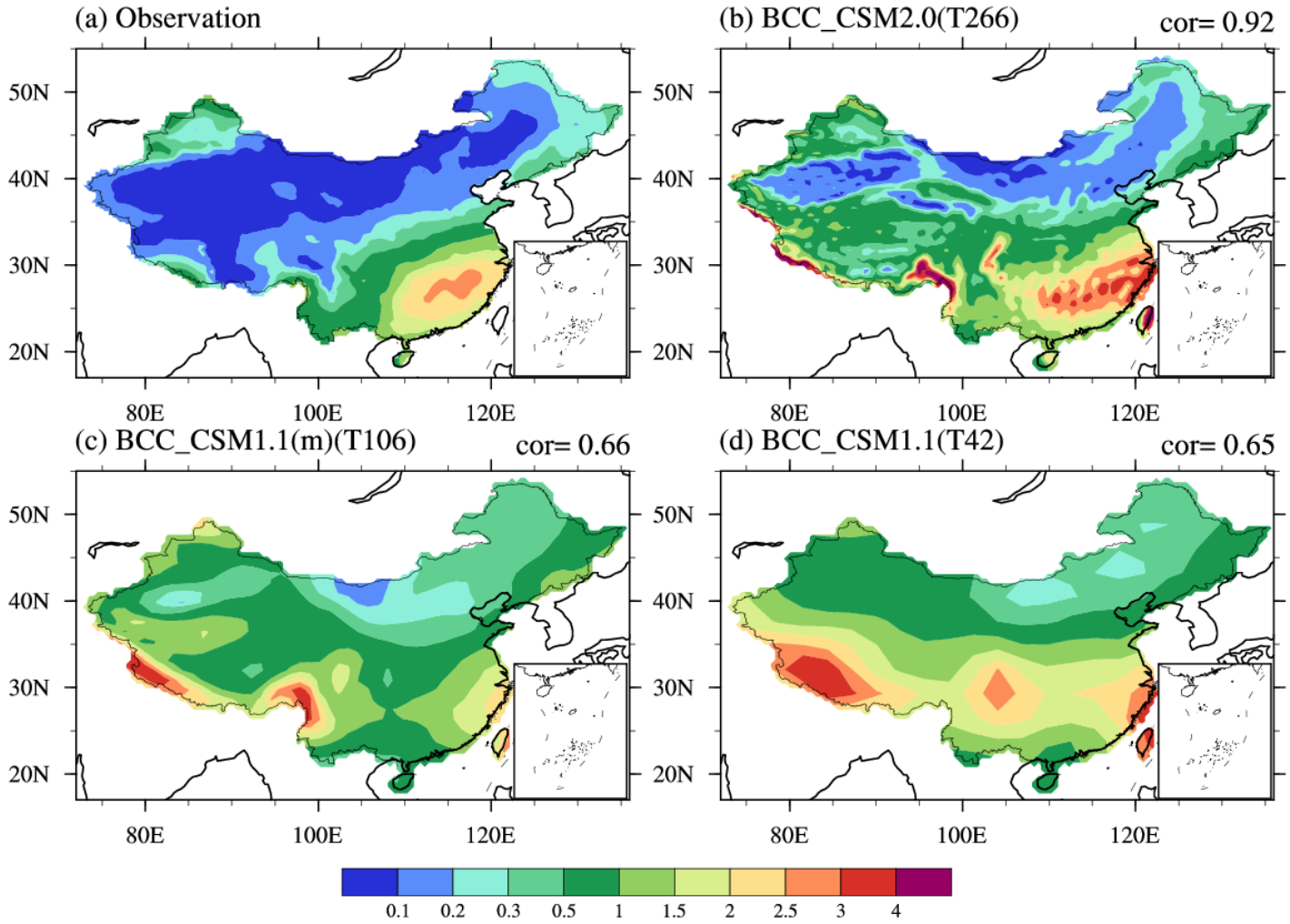
➢ Future

- Model development
  - ✓ **Higher resolution** (vertical and horizontal)
  - ✓ physical processes and parameterization schemes

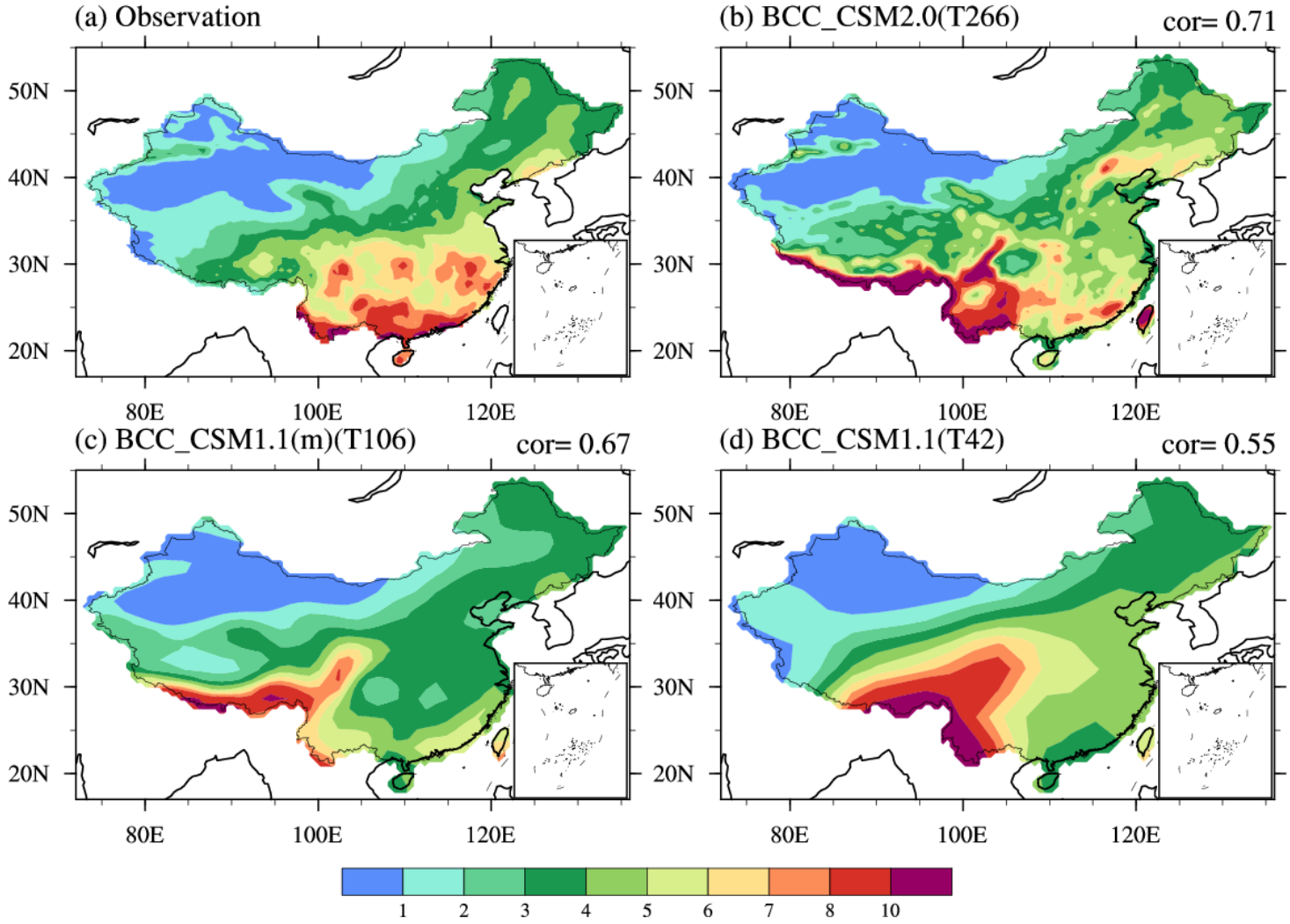
BCC_AGCM: T266—>T382(576X1152,~0.313˚)
L26—L56—L70 (0.01hPa)
BCC_AVIM: T266—>T382
MOM5-L50 (1/4°~25km)
CICE5 (1/4°~25km)

- To improve the **initial condition** by developing a coupled assimilation system.
  - ✓ Atmospheric initialization
  - ✓ Ocean data assimilation system
  - ✓ Land surface assimilation system
- To develop S2S seamless forecast system based on high-resolution BCC_CSM

DJF Mean precipitation (mm/day)



JJA Mean precipitation (mm/day)

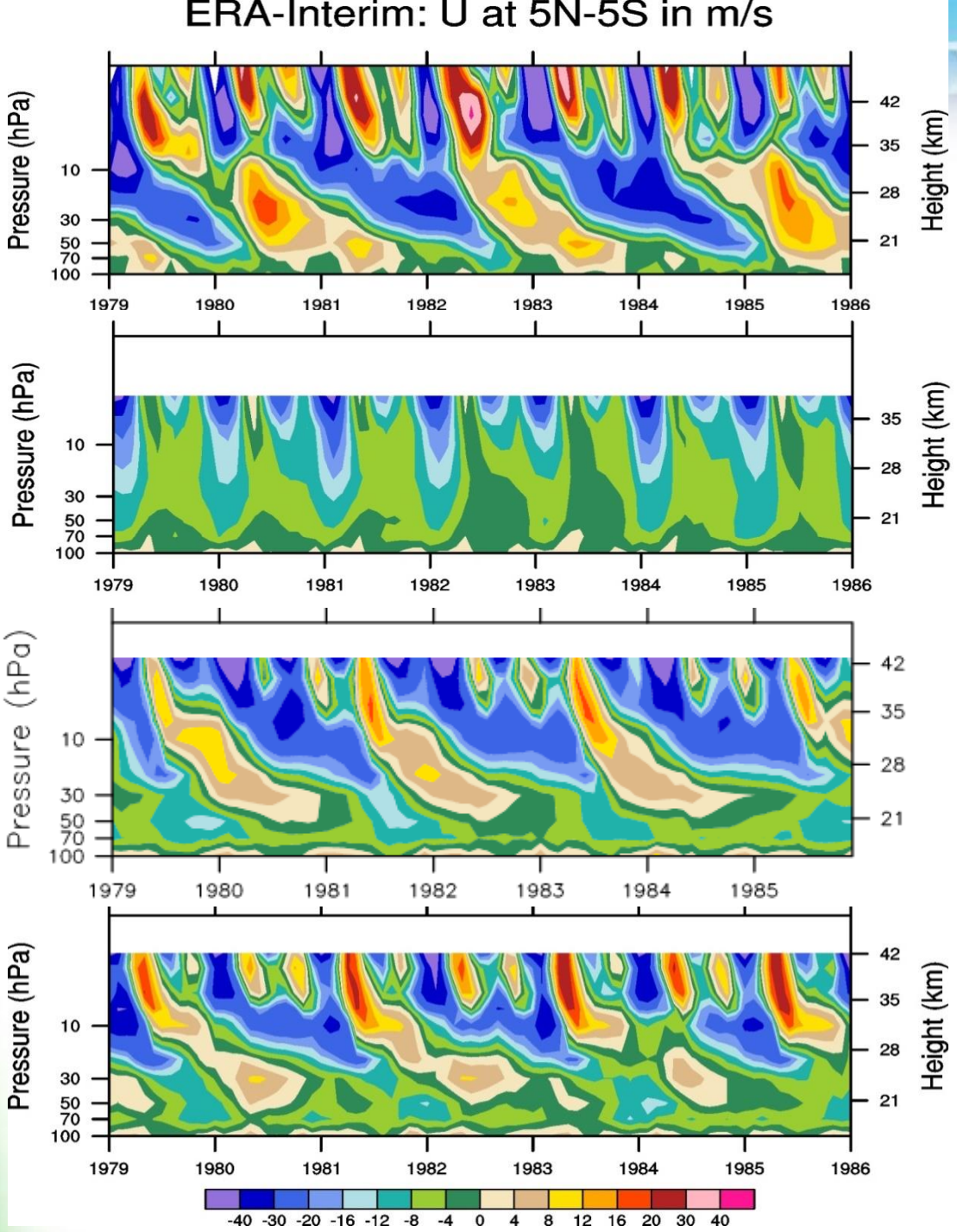


OBS

L26

L50

L68




Thanks
for your attention!