Present day bias and future change signal of temperature over China in a series of multi-GCM driven RCM simulations

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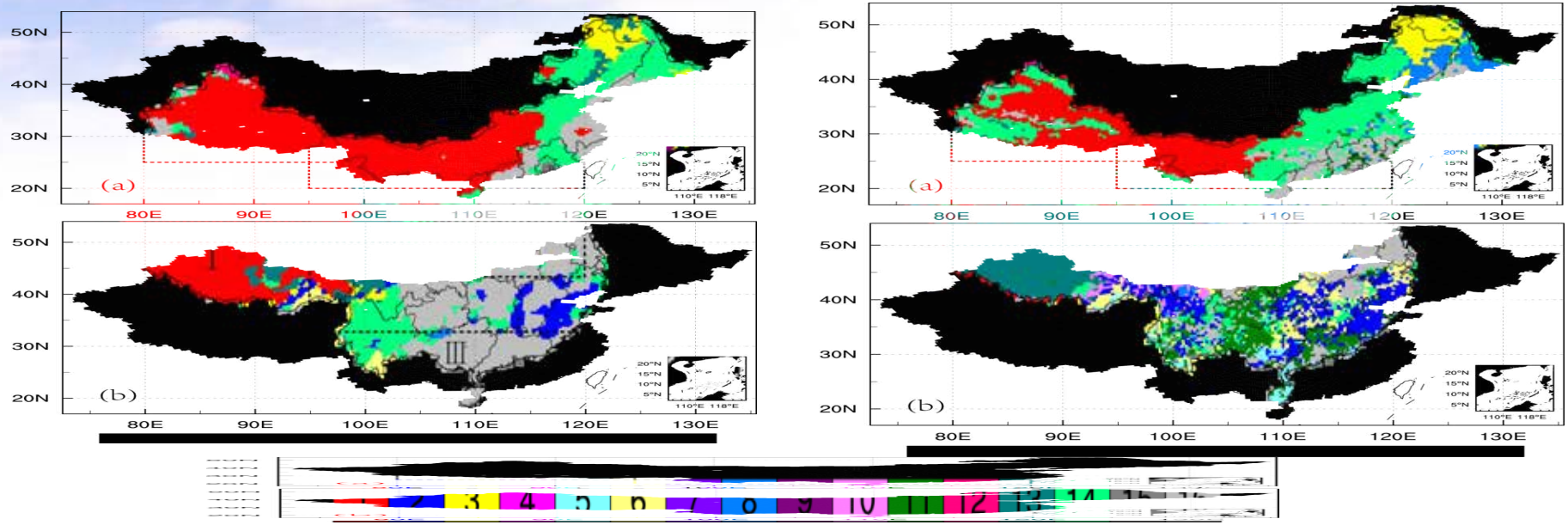
Motivation:

- How do GCM biases affect climate change signal in the regional scale?
- How do driving GCM affect biases of nested RCM?
- Correlation between the GCM and RCM signals?
- The added value?
- Start from temperature

Model set up

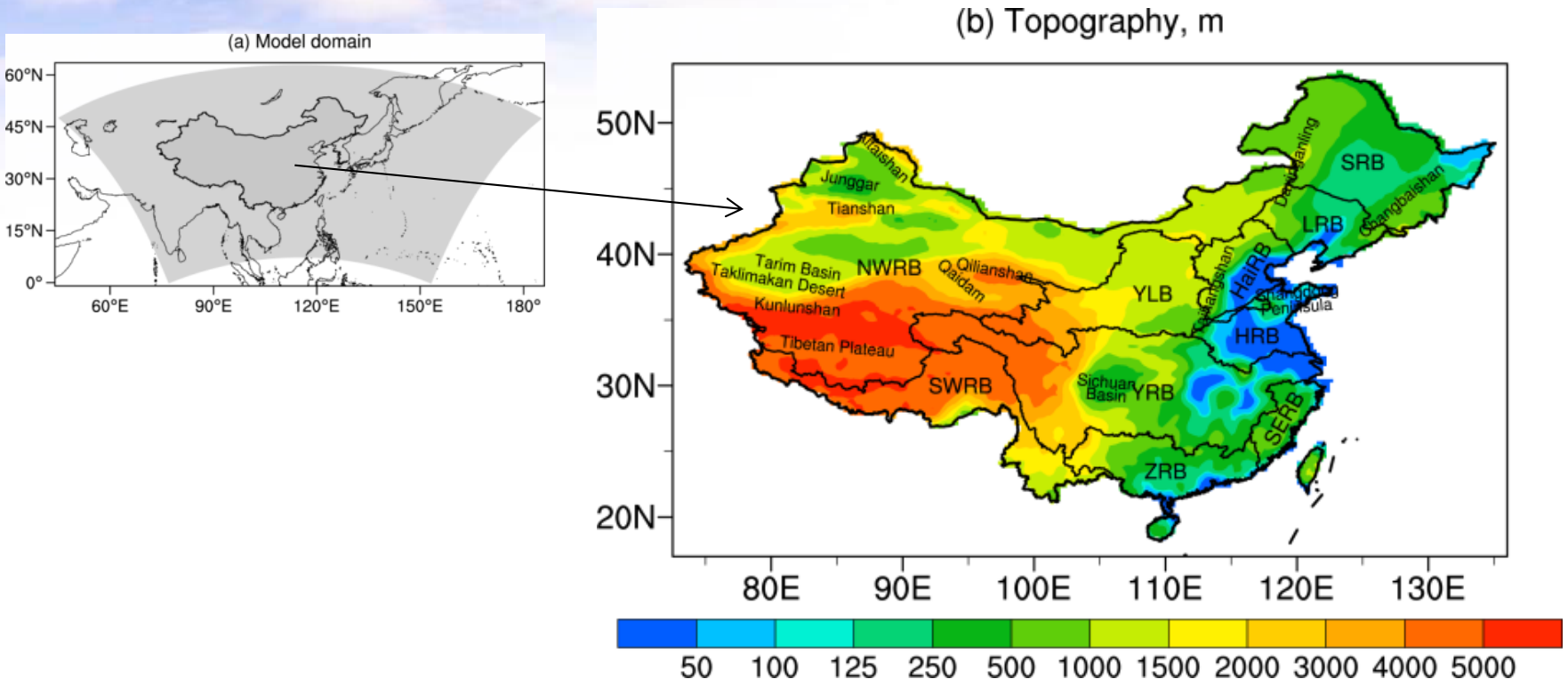
- Domain: CORDEX-EA (phase II), 25km resolution
- Version: RegCM4.4
- CLM land surface process + Emanuel convection
- Updated vegetation cover over China
- Updated surface emissivity
  - ✓ For bare soil and snow in CLM: 0.96 and 0.97 to 0.80 and 0.92 following observation literatures
  - ✓ Reduced effectively the cold bias in DJF



The distribution of land cover in China from CLM (a) and the updated (b)

1 bare ground, **2** temperate needleleaf evergreen tree, **3** boreal needleleaf evergreen tree, **4** boreal needleleaf deciduous tree, **5** tropical broadleaf evergreen tree, **6** temperate broadleaf evergreen tree, **7** tropical broadleaf deciduous tree; **8** temperate broadleaf deciduous tree, **9** boreal broadleaf deciduous tree, **10** temperate broadleaf evergreen shrub, **11** temperate broadleaf deciduous shrub, **12** boreal broadleaf deciduous shrub, **13** C_3 arctic grass, **14** C_3 grass, **15** C_4 grass, **16** crop

(Han et al., 2015)

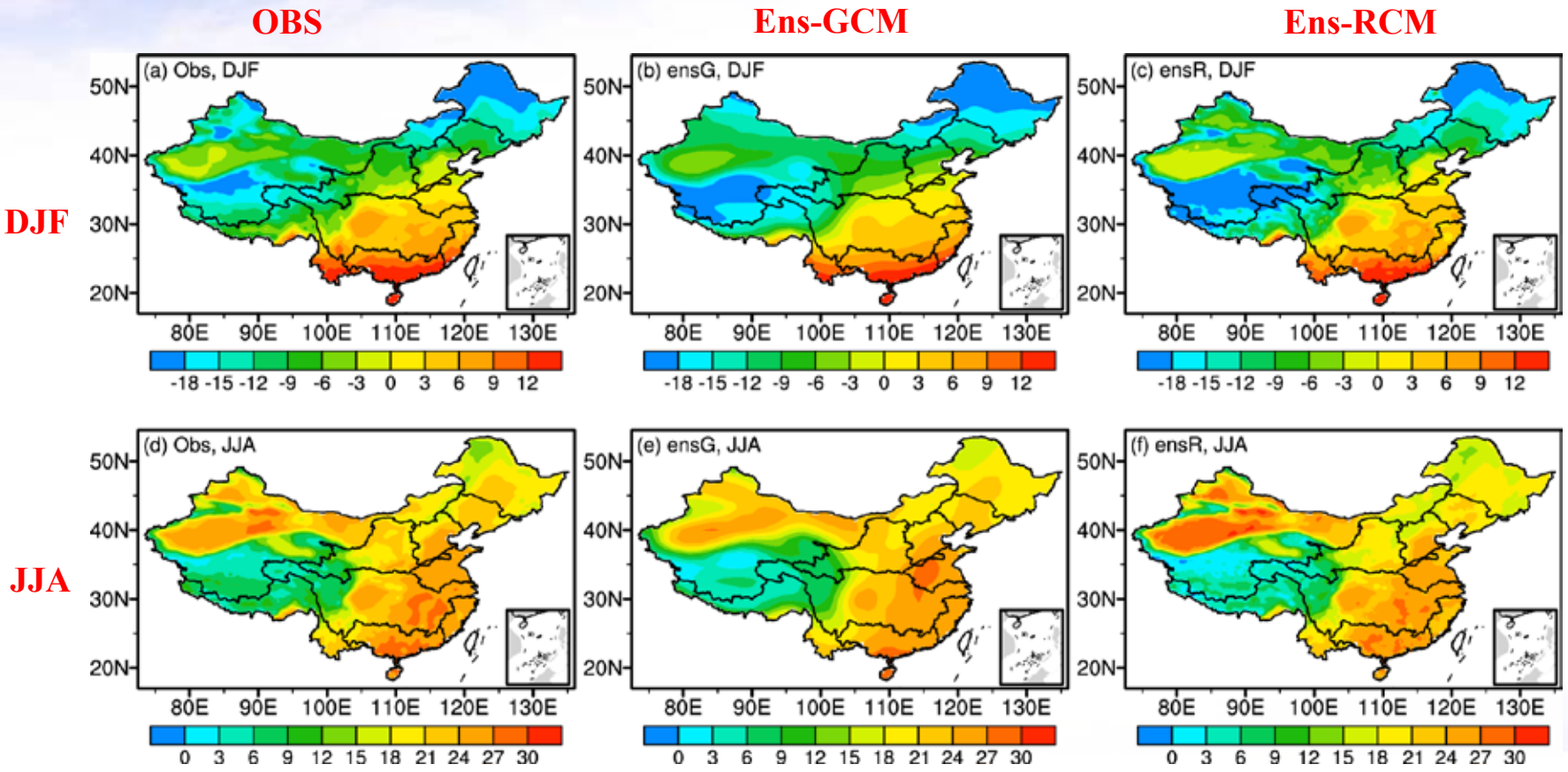


Model domain, topography and the 10 major river basins over China

Multi-GCM driven RegCM4 simulations over the domain

RCM	GCM	Period	Experiments	Abb.
RegCM4	ERA-Interim	1990-2010	Evaluation	
	EC-EARTH	1971-2099	Hist.,RCP 4.5, 8.5	EdR
	MPI-ESM-MR	1971-2099	Hist.,RCP2.6, 4.5, 8.5	MdR
	HadGEM2-ES	1971-2099	Hist.,RCP2.6, 4.5, 8.5	HdR
	CSIRO-Mk3.6	1971-2099	Hist.,RCP 4.5, 8.5	CdR
	NorESM	1971-2099	Hist.,RCP2.6, 4.5, 8.5	NdR

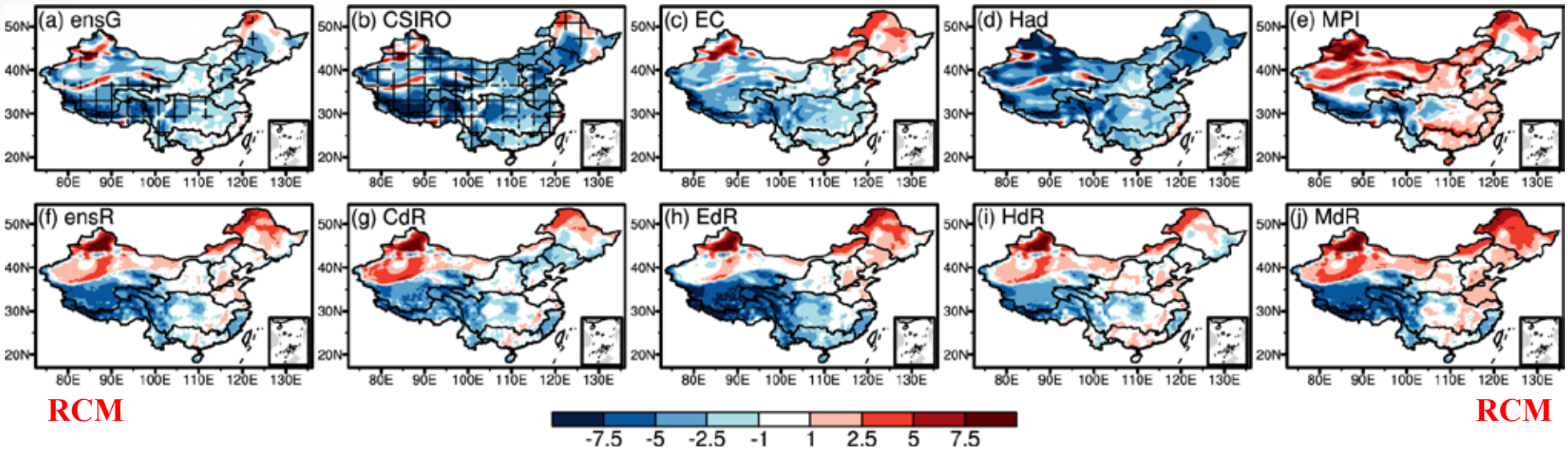
Present day simulation of climatology



Biases of the GCM and RCM in DJF

GCM

GCM



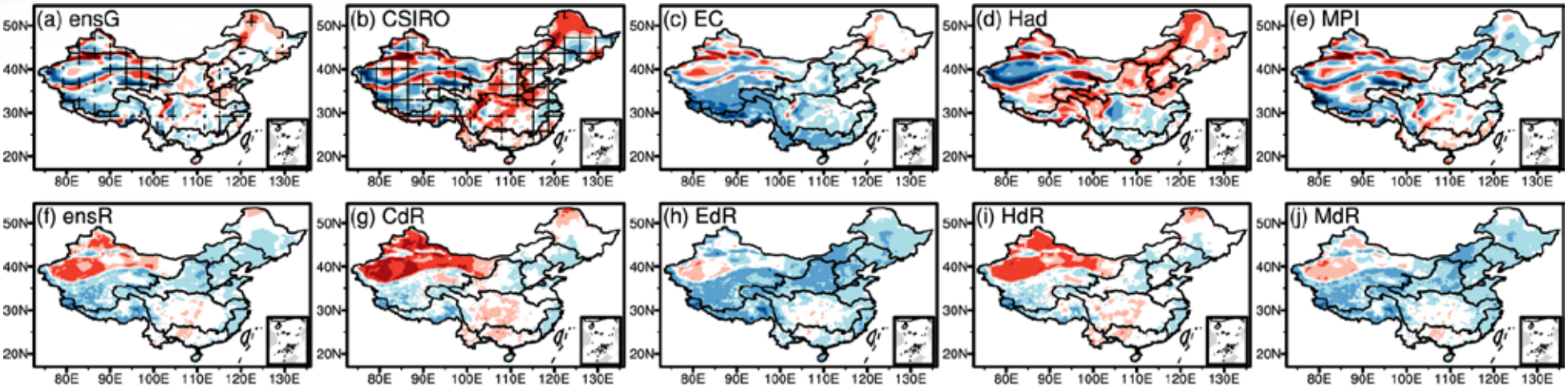
RCM

RCM

Cross area in (a) and (b) show model agreements

Biases of the GCM and RCM in JJA

GCM GCM

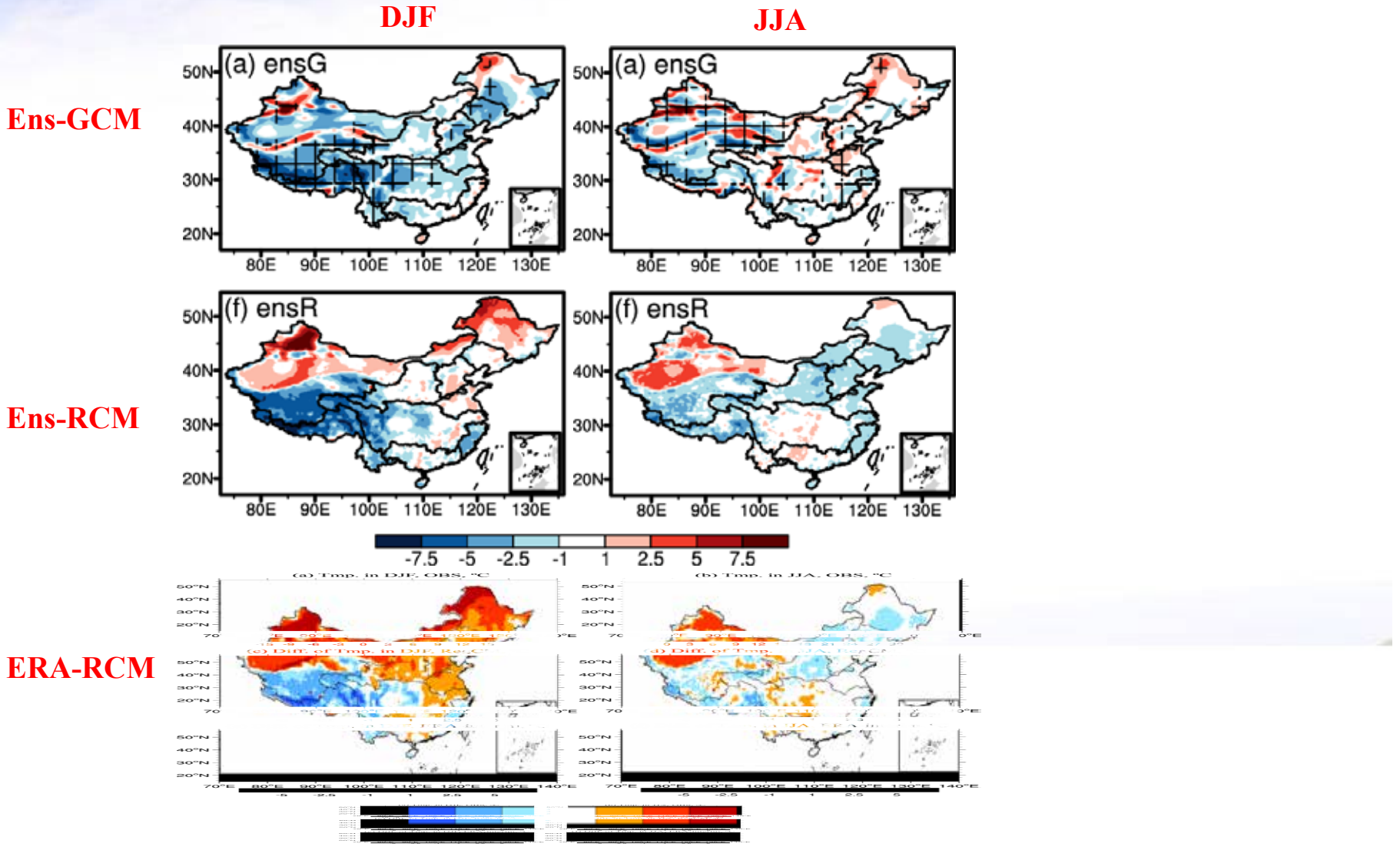


RCM RCM

-7.5 -5 -2.5 -1 1 2.5 5 7.5

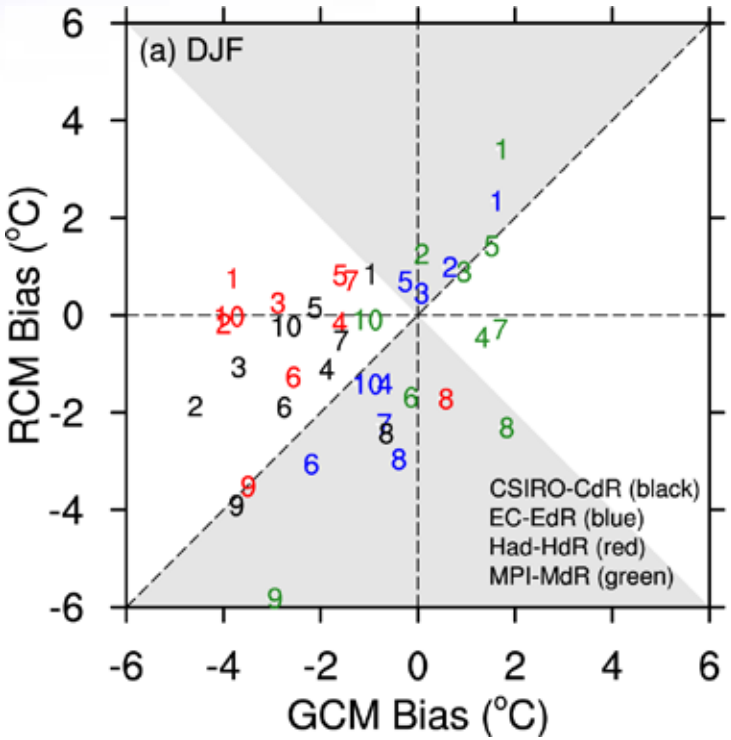
Cross area in (a) and (b) show model agreements

Biases of ens-GCM and ens-RCM in DJF and JJA

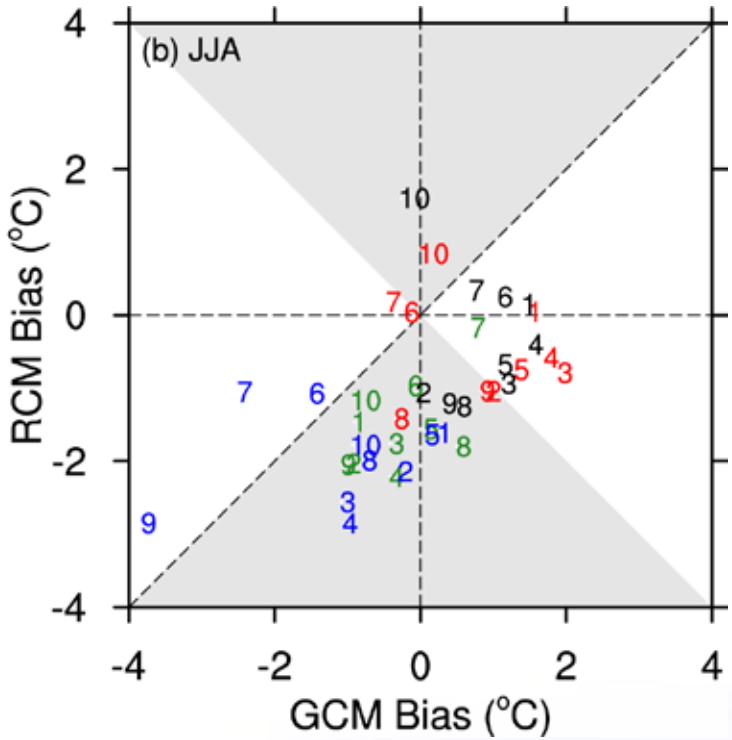


The correlation between GCM and RCM biases over different basins

DJF



JJA



Correlation coefficient of the biases between GCM and RCM in DJF

	CSIRO	EC	Had	MPI	CdR	EdR	HdR	MdR
CSIRO	-	0.59*	0.61*	0.77*	0.31*	0.31*	0.34*	0.33*
EC	0.59*	-	0.39*	0.74*	0.51*	0.68*	0.62*	0.65*
Had	0.61*	0.39*	-	0.44*	-0.11	-0.06	-0.03	-0.05
MPI	0.77*	0.74*	0.44*	-	0.53*	0.57*	0.59*	0.60*
CdR	0.31*	0.51*	-0.11	0.53*	-	*0.89**	*0.93**	*0.92**
EdR	0.31*	0.68*	-0.06	0.57*	*0.89**	-	0.92*	0.99*
HdR	0.34*	0.62*	-0.03	0.59*	*0.93**	*0.92**	-	0.93*
MdR	0.33*	0.65*	-0.05	0.60*	*0.92**	*0.99**	*0.93**	-

Over whole China in the present day, * indicate significant at 95% confidence level

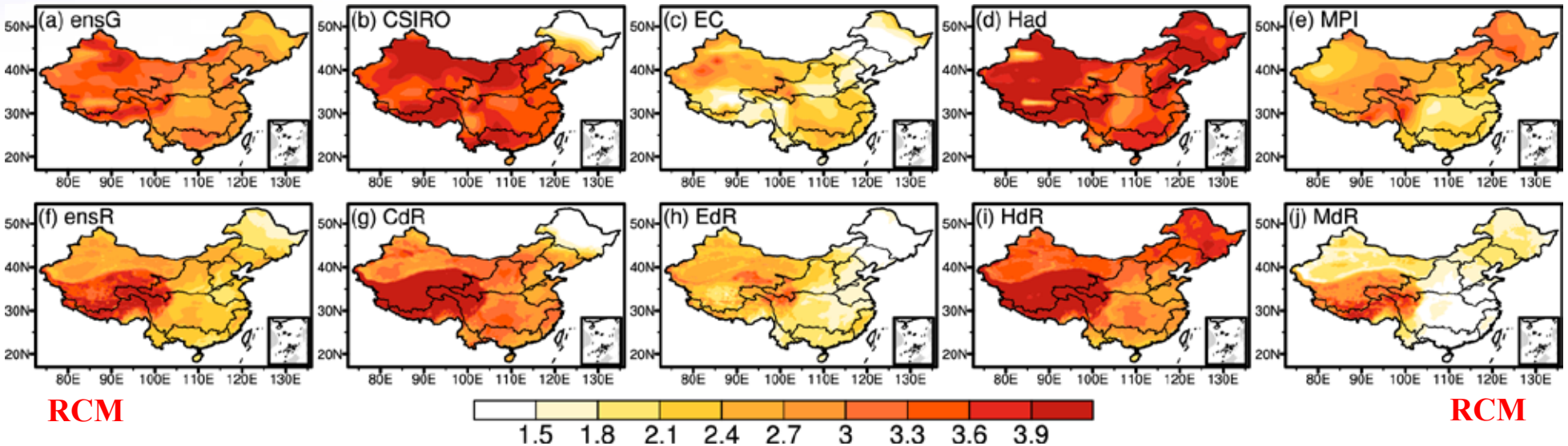
Correlation coefficient of the biases between GCM and RCM in JJA

	CSIRO	EC	Had	MPI	CdR	EdR	HdR	MdR
CSIRO	-	0.63*	0.70*	0.83*	-0.14	-0.06	-0.07	-0.05
EC	0.63*	-	0.49*	0.66*	0.17	0.18*	0.20*	0.14
Had	0.70*	0.49*	-	0.68*	-0.44*	-0.42*	-0.34*	-0.41*
MPI	0.83*	0.66*	0.68*	-	-0.09	-0.03	-0.03	-0.00
CdR	-0.14	0.17	-0.44*	-0.09	-	0.79*	0.95*	0.84*
EdR	-0.06	0.18*	-0.42*	-0.03	*0.79**	-	*0.85**	0.96*
HdR	-0.07	0.20*	-0.34*	-0.03	*0.95**	*0.85**	-	0.91*
MdR	-0.05	0.14	-0.41*	-0.00	*0.84**	*0.96**	*0.91**	-

Over whole China in the present day, * indicate significant at 95% confidence level

Future changes of the GCM and RCM in DJF

GCM



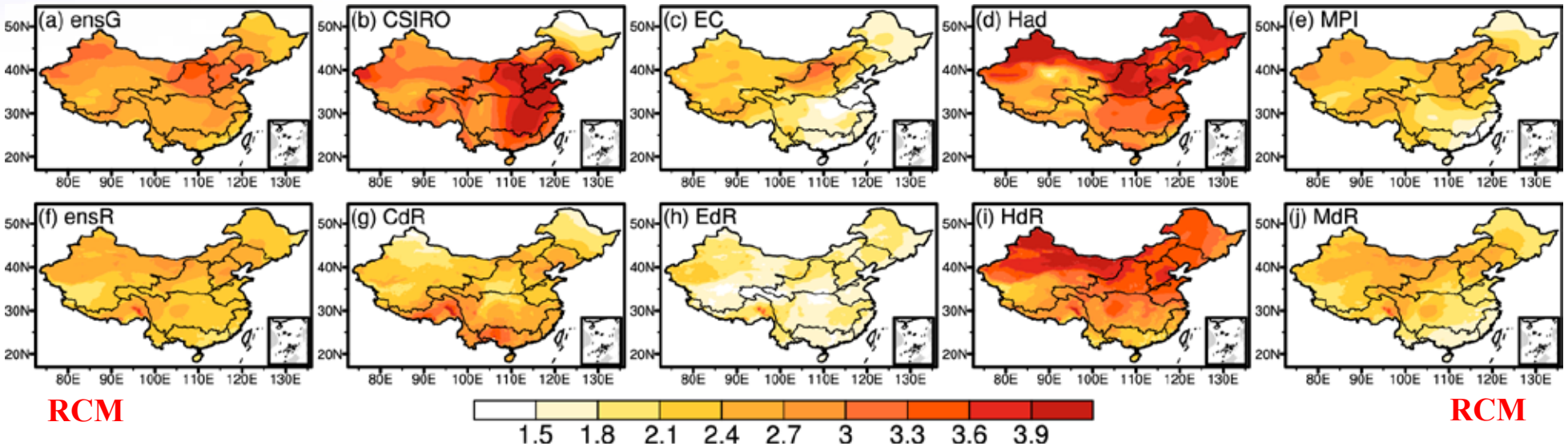
GCM

RCM

RCM

Future changes of the GCM and RCM in JJA

GCM

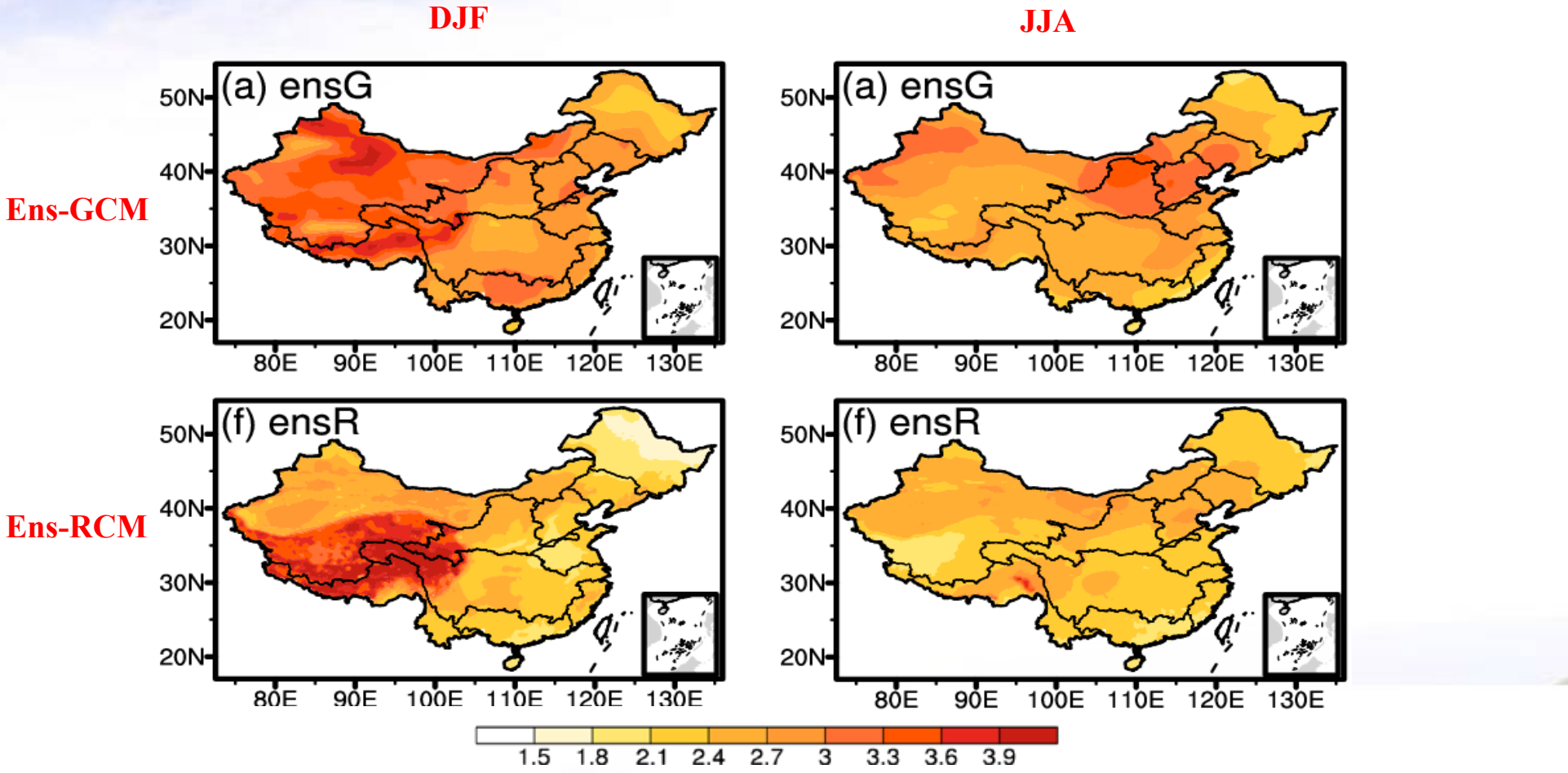


GCM

RCM

RCM

Future changes of ens-GCM and ens-RCM in DJF and JJA



Correlation coefficient of the signal between GCM and RCM in DJF

	CSIRO	EC	Had	MPI	CdR	EdR	HdR	MdR
CSIRO	–	0.26*	0.12	-0.21*	0.64*	0.61*	-0.01	0.18*
EC	**0.26***	–	0.24*	0.05	0.42*	0.60*	0.35*	0.33*
Had	**0.12**	**0.24***	–	0.50*	0.23*	0.21*	0.43*	0.51*
MPI	**-0.21***	**0.05**	**0.50***	–	0.12	0.04	0.70*	0.63*
CdR	**0.64***	0.42*	0.23*	0.12	–	0.74*	0.57*	0.71*
EdR	0.61*	**0.60***	0.21*	0.04	***0.74****	–	0.48*	0.53*
HdR	-0.01	0.35*	**0.43***	0.70*	***0.57****	***0.48****	–	0.90*
MdR	0.18*	0.33*	0.51*	**0.63***	***0.71****	***0.53****	***0.90****	–

Over whole China in the end of the century

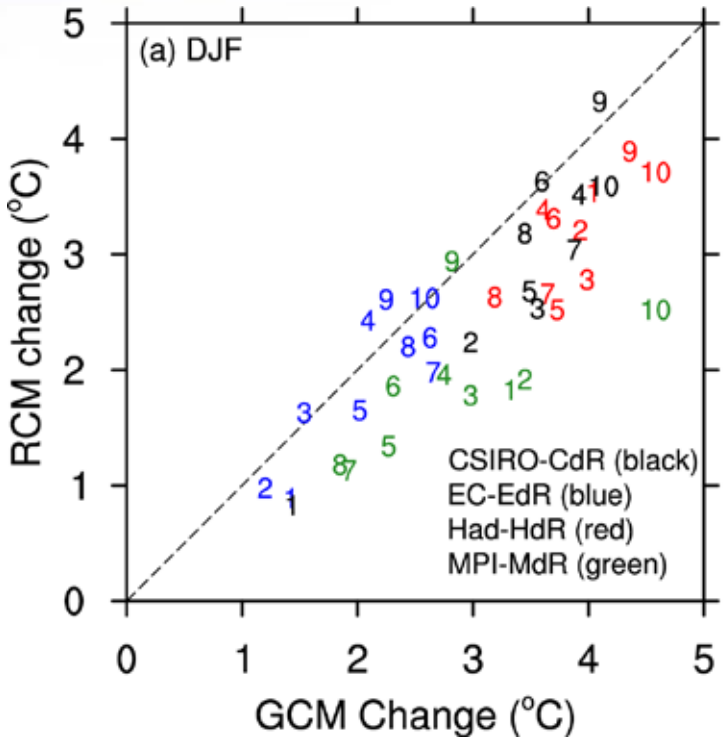
Correlation coefficient of the signal between GCM and RCM in JJA

	CSIRO	EC	Had	MPI	CdR	EdR	HdR	MdR
CSIRO	–	-0.09	-0.10	0.29*	0.37*	-0.02	0.01	0.05
EC	**-0.09**	–	-0.33*	0.40*	0.13	0.25*	-0.05	0.26*
Had	**-0.10**	**-0.33***	–	0.15	-0.53*	0.26*	0.65*	0.15
MPI	**0.29***	**0.40***	**0.15**	–	-0.04	0.26*	0.51*	0.67*
CdR	**0.37***	0.13	-0.53*	-0.04	–	0.08	-0.46*	-0.10
EdR	-0.02	**0.25***	0.26*	0.26*	***0.08***	–	0.36*	0.34*
HdR	0.01	-0.05	**0.65***	0.51*	***-0.46****	***0.36****	–	0.69*
MdR	0.05	0.26*	0.15*	**0.67***	***-0.10***	***0.34****	***0.69****	–

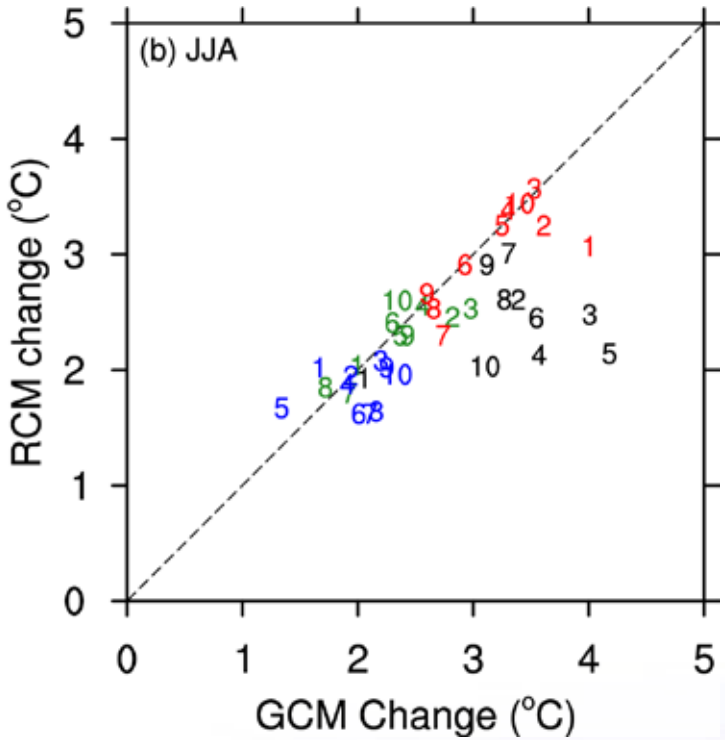
Over whole China in the end of the century

The correlation between GCM and RCM changes over different basins

DJF



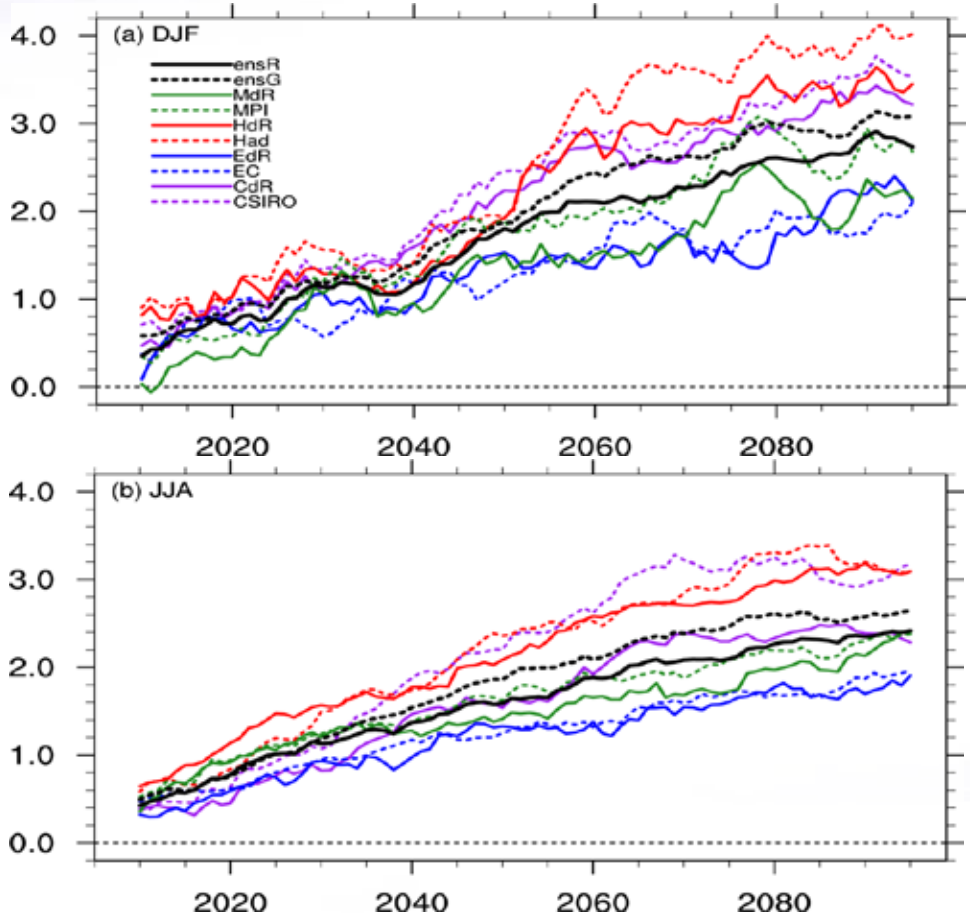
JJA



Temporal evolution over the 21st century in DJF and JJA

DJF

JJA



Summary

- For present day, the added value is more on the spatial details in RCM. The bias patterns show some correlation between RCM and driving GCM in DJF but not in JJA.
- For change signals, dominant forcings from GCM are evident both for magnitude and large scale distribution in the regional scale, as well as the inter-annual changes: decided more by their climate sensitivities
- RCM provides with more spatial detail of the changes in sub-regional scale. Reduced warming is projected by the RCM, more significant in DJF.
- In general no clear relationships are found between the model bias and change signal, both for GCM and RCM.

Future work:

- Bias and signal of precipitation: more dramatic
- Changes in tropical cyclones (typhoon) in western Pacific
- Bias correction and data distribution for impact studies
- Mechanisms and more analysis
- Improvements of the model over East Asia
- ……


谢 谢 !
THANK YOU!

CORs of temperature change between different pair of model simulations in DJF/JJA over the 10 major river basins in the end of the 21st century.

	CSIRO-CdR	EC-EdR	Had-HdR	MPI-MdR	NoSP
1-SRB	0.88*/0.86*	0.47*/0.05	0.08/0.42*	0.45*/0.82*	3/3
2-LRB	0.70*/0.82*	0.44*/0.28*	-0.05/0.68*	0.01/0.91*	2/4
3-HaiRB	0.67*/0.04	-0.06/0.54*	-0.29*/0.29*	0.67*/0.83*	2/2
4-YLB	-0.38*/-0.14	0.81*/-0.61*	0.45*/0.73*	0.90*/-0.27*	3/1
5-HRB	-0.56*/-0.70*	0.33*/0.46*	0.23*/0.29*	0.86*/0.83*	3/3
6-YRB	0.37*/-0.16	0.74*/0.12	0.78*/0.25*	0.90*/0.58*	4/2
7-ZRB	0.70*/-0.13	0.31*/0.60*	0.27*/0.55*	-0.16/0.79*	3/3
8-SERB	0.31*/-0.54*	0.90*/0.42*	0.81*/0.83*	-0.14/0.58*	3/4
9-SWRB	0.48*/0.13	0.24*/-0.16	0.75*/-0.03	0.74*/0.49*	4/1
10-NWRB	-0.39*/0.52*	0.45*/0.25*	0.02/0.71*	0.44*/0.24*	2/4
NoSP	7/5	9/6	6/9	7/9	–

CORs of temperature change between ensG and ensR in DJF/JJA over China and the 10 major river basins for early, mid, and end of the 21st century.

	2016-2035 DJF/JJA	2046-2065 DJF/JJA	2080-2099 DJF/JJA	NoSP
CN	0.66*/0.56*	0.53*/0.56*	0.68*/0.55*	3/3
1-SRB	0.26*/0.24*	0.33*/0.50*	0.63*/0.51*	3/3
2-LRB	-0.15/0.81*	0.06/0.81*	-0.16/0.91*	0/3
3-HaiRB	0.47*/0.04	0.33*/0.24*	-0.23*/0.35*	2/2
4-YLB	0.78*/0.51*	0.87*/-0.49*	0.83*/0.10	3/2
5-HRB	0.80*/0.53*	0.39*/-0.42*	0.02/0.40*	2/2
6-YRB	0.90*/0.45*	0.88*/-0.38*	0.86*/-0.34*	3/1
7-ZRB	0.06/0.15	0.55*/0.62*	0.56*/0.68*	2/2
8-SERB	0.50*/0.37*	0.85*/0.11	0.80*/0.68*	3/2
9-SWRB	0.77*/0.33*	0.66*/0.18*	0.77*/0.24*	3/3
10-NWRB	0.32*/0.30*	0.13/0.67*	0.11/0.64*	1/3
NoSP	8/8	8/4	6/8	–

Biases of each pair of the GCM-RCM over the 10 major river in DJF and JJA during 1986-2005. The blue circles/asterisks indicate the biases of GCMs/RCMs, respectively.