Bias correction of temperature and precipitation over China for RCM simulations using the QM and QDM methods

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Tackling Challenges in Water Resource in a Changing Climate

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Background

- Systematic biases of climate model simulations relative to observations widely exist due to various reasons.
- Very difficult / even not possible to use model outputs directly in impact assessment studies, e.g. as forcings for hydrological and agricultural models: bias correction has been widely used.
- Most commonly used: QM, quantile mapping, effectively removes model biases.
- QM may artificially distort the climate change signals and corrupt future model-projected trends.
- QDM: quantile delta mapping, based on the quantile delta change and detrended quantile mapping method, preserves the changes in quantiles.

1. Model, data, and simulations

- ✓ **21st century climate change simulations by RegCM4 driven by multi-GCMs**

  GCM：CSIRO-Mk3-6-0, EC-EARTH, HadGEM2-ES, MPI-ESM-MR, and NorESM1-M

  RegCM4：CORDEX-EA region, grid spacing 25 km

  CdR，EdR，HdR，MdR，NdR，ensR

- ✓ **Observation:**

  CN05.1，0.25º×0.25º, based on 2400 station observations

- ✓ **Domain: CORDEX-EA**
- ✓ **Period:**

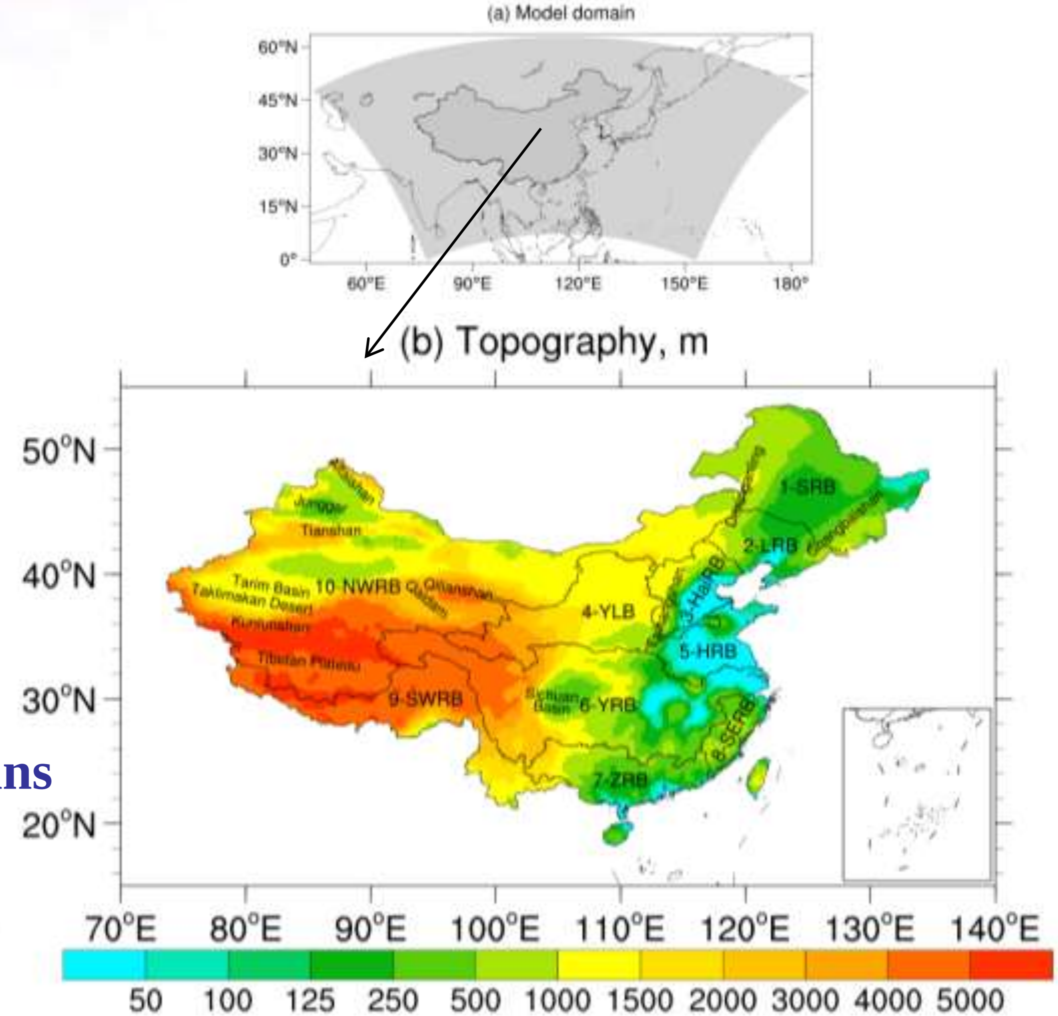
  Calibration: 1981-2000

  Validation: 2001-2015

  Future changes: 2079-2098

  Reference: 1986-2005

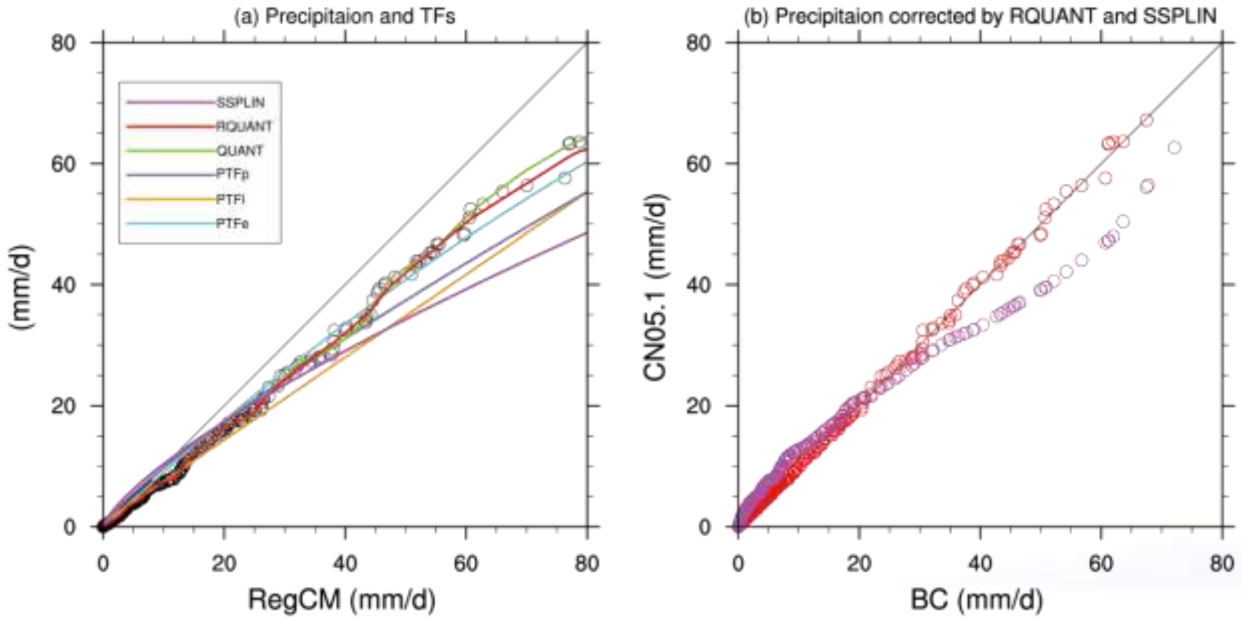
  DJF and JJA
- ✓ **Sub-regions: 10 river basins over China**



2. Method

➢ **QM（quantile-mapping, RQUANT）**

$$F_{m,c}(x_{m,c}) = F_{o,c}(x_{o,c}), \qquad x_{bc} = F_{o,c}^{-1}[F_{m,p}(x_{m,p})]$$



Transfer functions and simulated/bias corrected precipitation at a grid in JJA (mm/d）

➢ QDM (quantile delta mapping)

Detrended by quantiles firstly, bias corrected by QM, then projected changes added/multiplied back for the final results.

$$\varepsilon(\mathrm{t}) = F_{m,p}^{(t)}\left[x_{m,p}(t)\right]$$

$$\Delta(\mathrm{t}) = \frac{F_{m,p}^{(t)-1}[\varepsilon(\mathrm{t})]}{F_{m,c}^{-1}[\varepsilon(\mathrm{t})]} = \frac{x_{m,p}(t)}{F_{m,c}^{-1}\{F_{m,p}^{(t)}\left[x_{m,p}(t)\right]\}}$$

$$\Delta(\mathrm{t}) = F_{m,p}^{(t)-1}[\varepsilon(\mathrm{t})] - F_{m,c}^{-1}[\varepsilon(\mathrm{t})] = x_{m,p}(t) - F_{m,c}^{-1}\{F_{m,p}^{(t)}\left[x_{m,p}(t)\right]\}$$

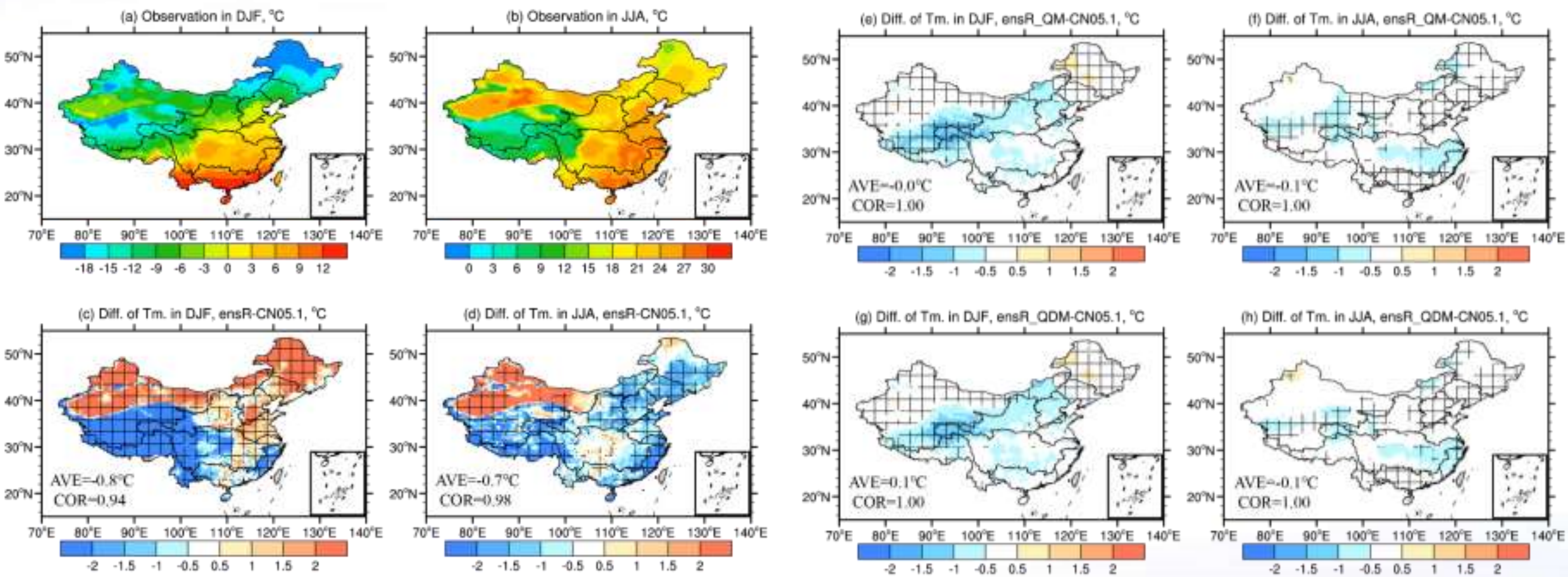
$$\hat{x}(\mathrm{t}) = F_{o,c}^{-1}[\varepsilon(\mathrm{t})],$$

Precipitation: $x_{bc}(\mathrm{t}) = \hat{x}(\mathrm{t})\Delta(\mathrm{t})$

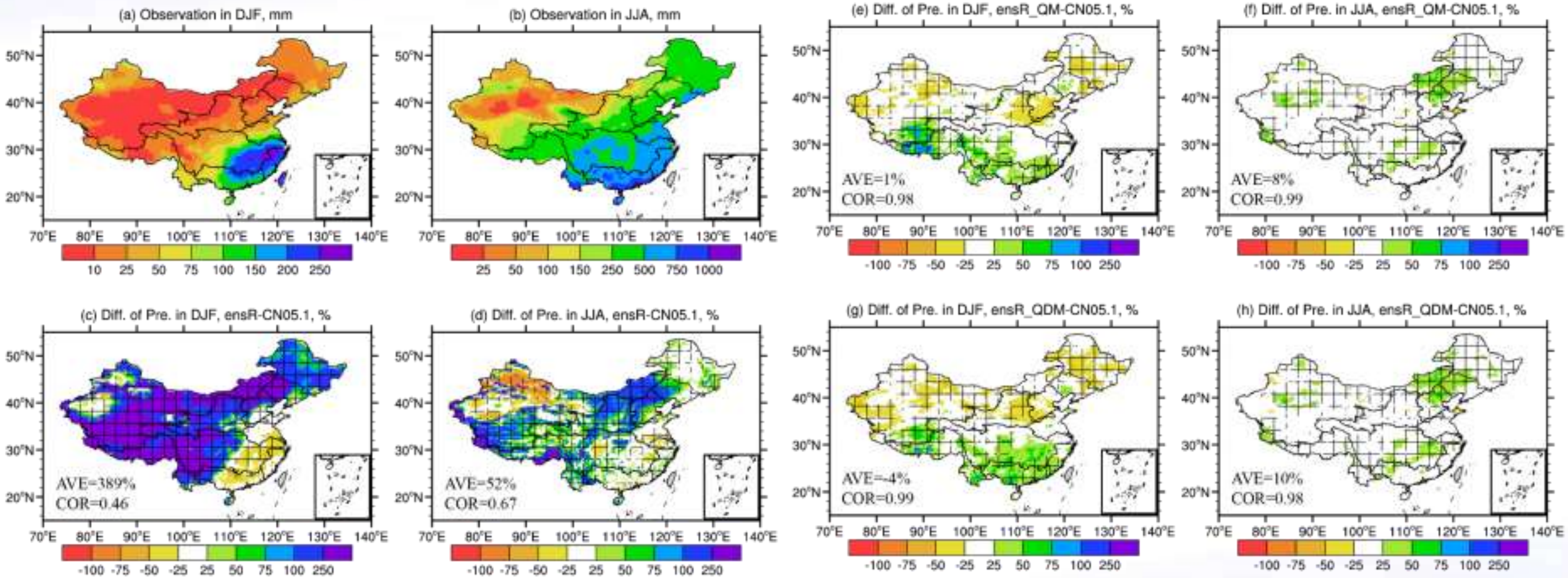
Temperature: $x_{bc}(\mathrm{t}) = \hat{x}(\mathrm{t}) + \Delta(\mathrm{t})$

3. Results for present day

✓ Surface air temperature



✓ Precipitation

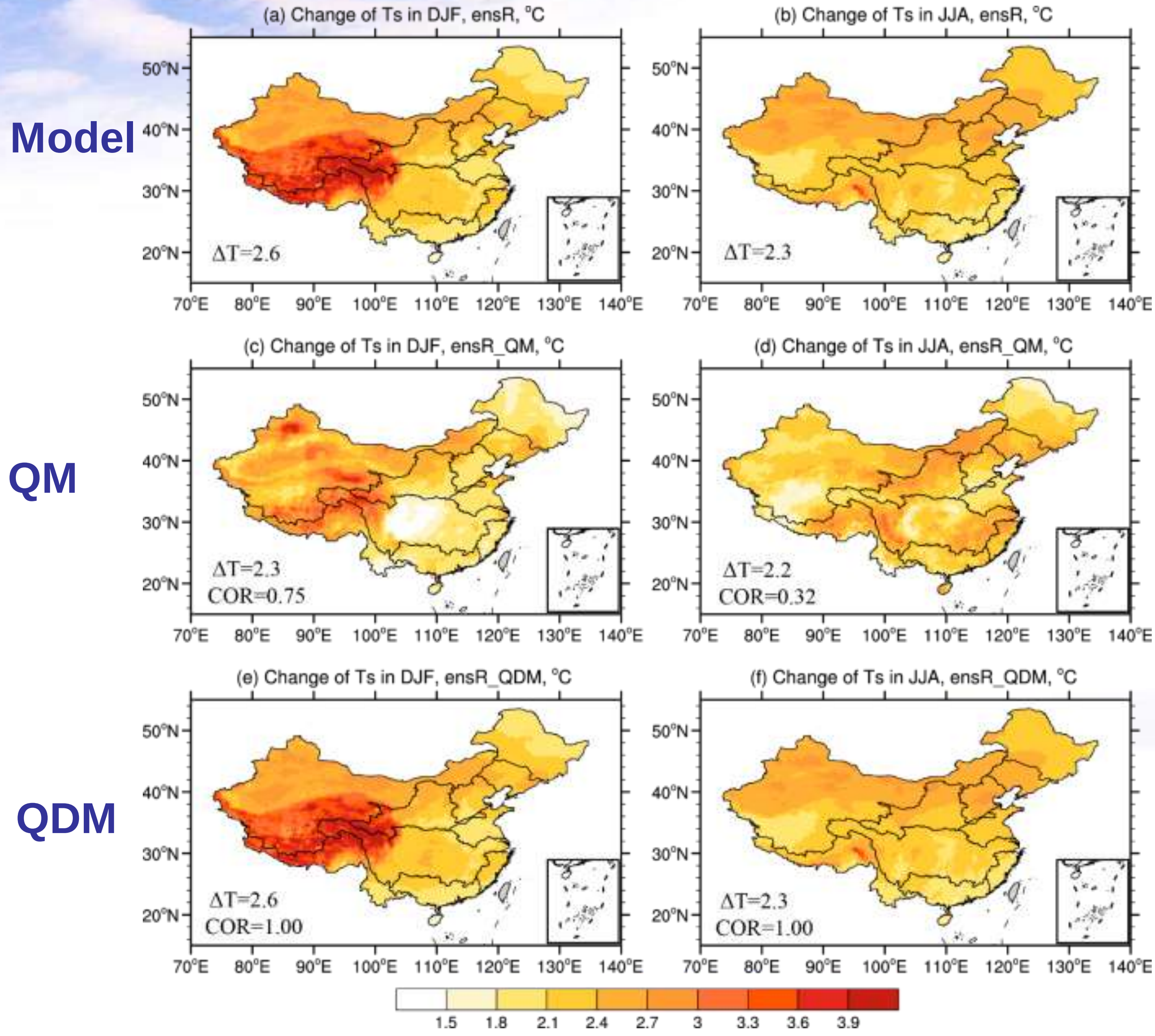


Biases of temperature (°C) and precipitation (units: %) for ensR and the spatial CORs between ensR and observations

	T (°C)		P (%)	
	DJF	JJA	DJF	JJA
1-SRB	2.6 / 0.93	-0.7 / 0.97	210 / 0.75	11 / 0.77
2-LRB	0.8 / 0.95	-1.4 / 0.97	375 / 0.89	33 / 0.70
3-HaiRB	0.5 / 0.99	-1.4 / 0.99	225 / *-0.11*	67 / *-0.08*
4-YLB	-0.7 / 0.97	-1.5 / 0.99	236 / 0.60	84 / 0.61
5-HRB	1.0 / 0.95	-1.1 / 0.94	23 / 0.94	-5 / *0.09*
6-YRB	-2.0 / 0.98	-0.6 / 0.99	320 / 0.29	29 / 0.38
7-ZRB	-0.4 / 0.95	-0.2 / 0.92	38 / *-0.22*	9 / *0.07*
8-SERB	-2.3 / 0.89	-1.8 / 0.87	-12 / *0.39*	17 / 0.58
9-SWRB	-5.3 / 0.99	-1.9 / 0.98	795 / 0.37	157 / *0.28*
10-NWRB	-0.3 / 0.81	-0.1 / 0.99	545 / 0.55	55 / 0.73
CN	-0.8 / 0.94	-0.7 / 0.98	389 / 0.46	52 / 0.67

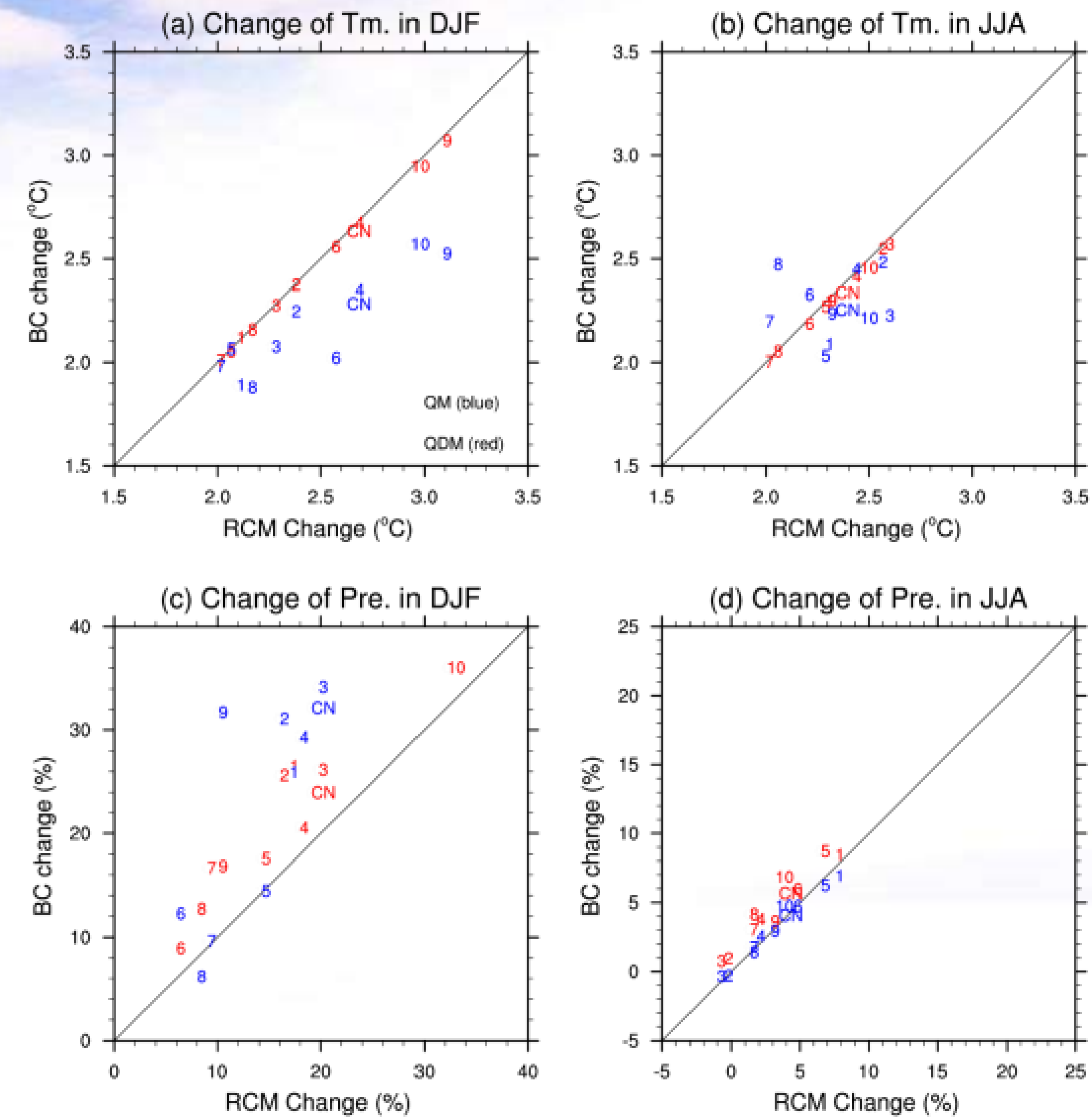
4. Future changes

Temperature



Temperature

Precipitation



Differences and CORs of temperature changes (units: ºC) at the end of 21st century between ensR_QM and ensR in DJF and JJA.

	T (°C)			
	Differences		CORs	
	DJF	JJA	DJF	JJA
1-SRB	-0.2	-0.2	0.82	0.37
2-LRB	-0.1	-0.1	0.39	*-0.07*
3-HaiRB	-0.2	-0.4	0.61	*0.27*
4-YLB	-0.3	0.0	0.79	0.72
5-HRB	0.0	-0.2	0.71	*-0.10*
6-YRB	-0.5	0.1	0.79	*0.16*
7-ZRB	-0.0	0.2	*0.14*	*-0.22*
8-SERB	-0.3	0.4	*-0.17*	0.64
9-SWRB	-0.6	-0.1	0.86	0.58
10-NWRB	-0.4	-0.2	0.41	0.52
CN	-0.3	-0.1	0.75	0.32

DJF

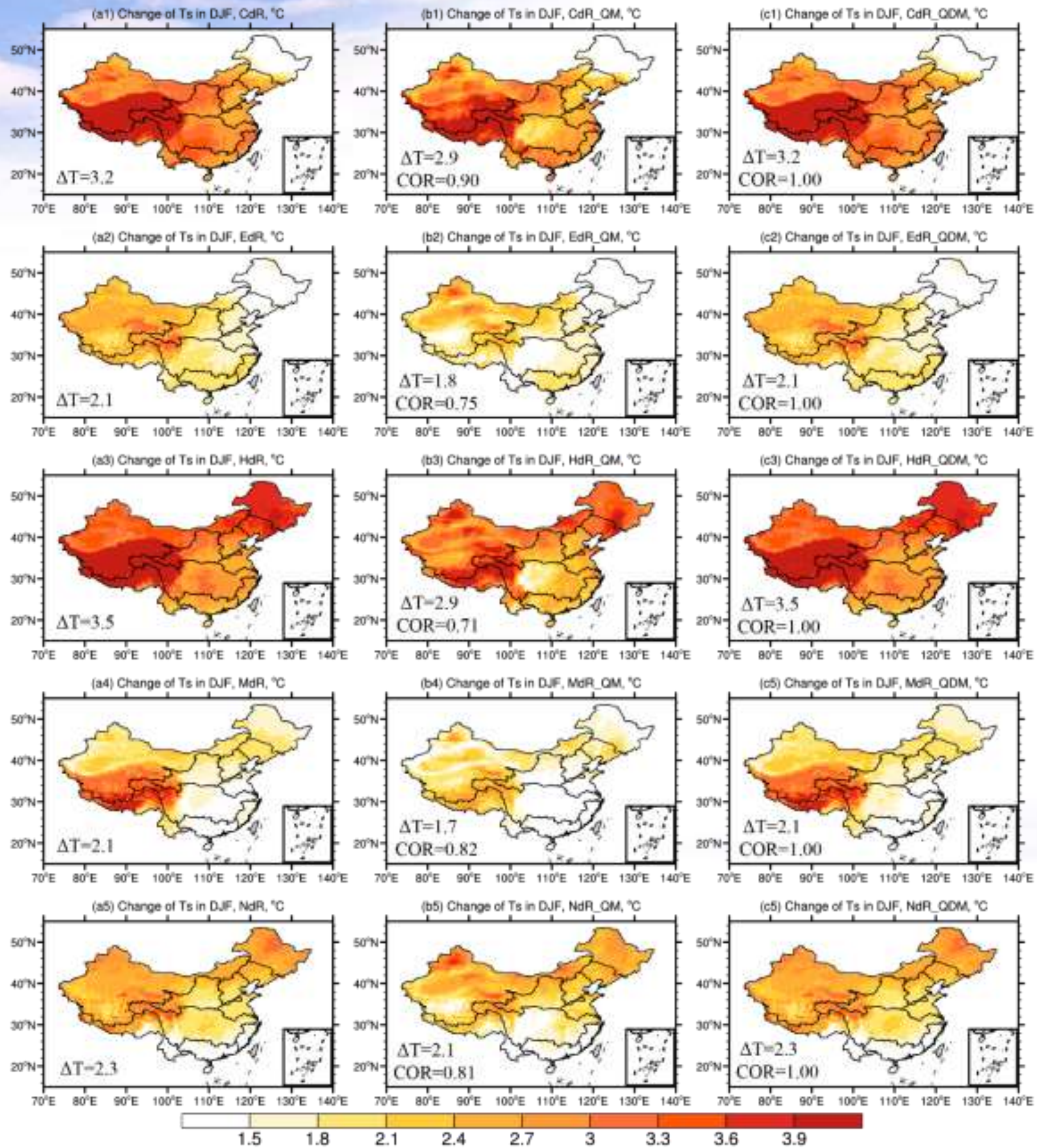
CdR

EdR

HdR

MdR

NdR



JJA

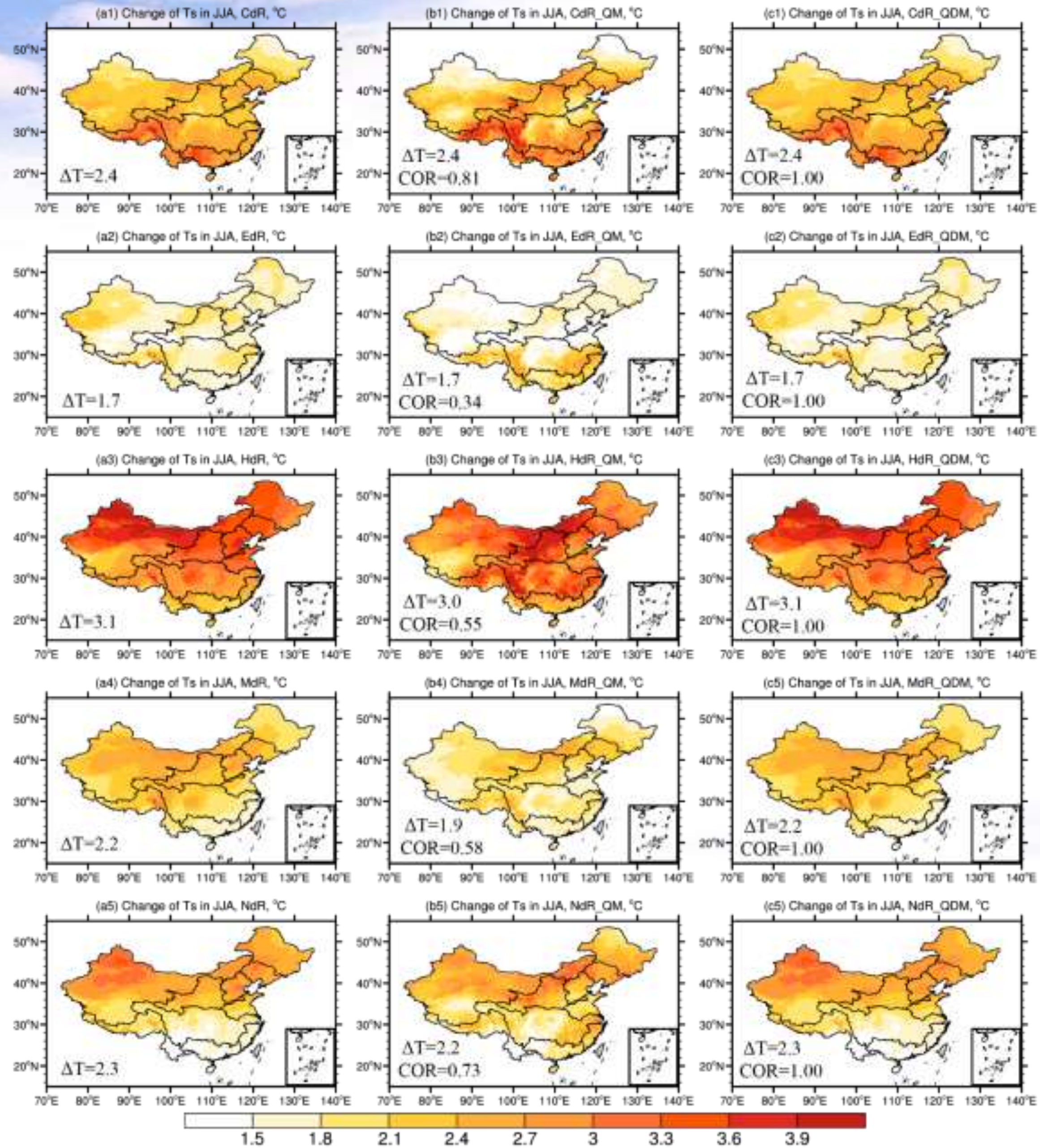
CdR

EdR

HdR

MdR

NdR

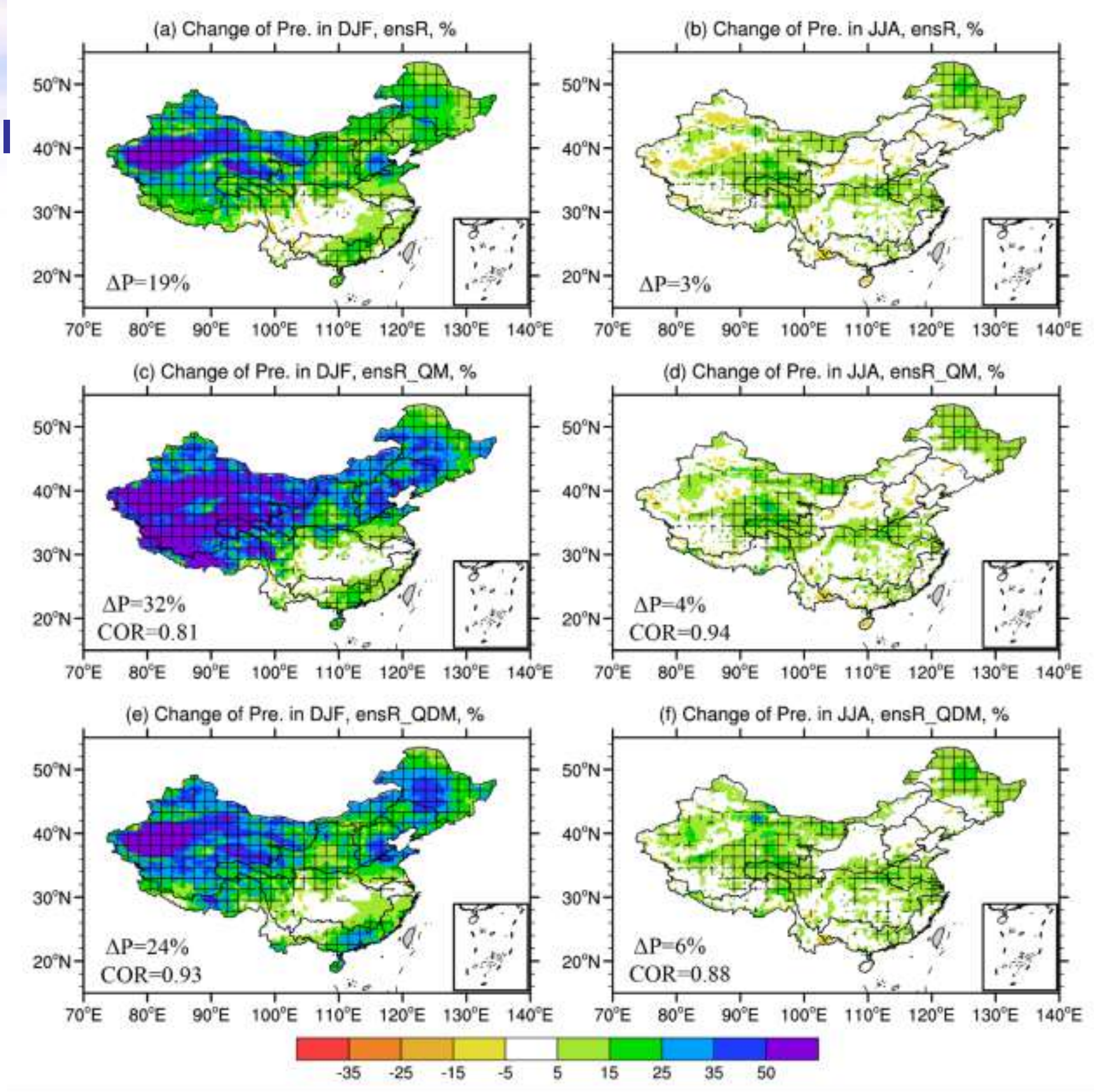


Precipitation

Model

QM

QDM



Differences and CORs of temperature changes (units: %) at the end of 21st century between ensR_QM and ensR in DJF and JJA.

	P (%)			
	Differences		CORs	
	DJF	JJA	DJF	JJA
1-SRB	9 / 9	-1 / 1	0.83 / 0.85	0.97 / 0.98
2-LRB	15 / 10	0 / 1	0.62 / 0.70	0.92 / 0.96
3-HaiRB	14 / 6	1 / 2	0.51 / 0.89	0.95 / 0.95
4-YLB	11 / 3	1 / 2	0.72 / 0.78	0.98 / 0.97
5-HRB	0 / 3	0 / 2	0.93 / 0.93	0.96 / 0.92
6-YRB	6 / 3	0 / 1	0.73 / 0.91	0.95 / 0.96
7-ZRB	1 / 8	0 / 2	0.89 / 0.85	0.97 / 0.94
8-SERB	-2 / 5	0 / 3	0.73 / 0.56	0.94 / 0.92
9-SWRB	22 / 7	0 / 1	0.68 / 0.78	0.94 / 0.98
10-NWRB	20 / 4	2 / 4	0.70 / 0.92	0.93 / 0.80
CN	13 / 5	1 / 3	0.81 / 0.93	0.94 / 0.88

DJF

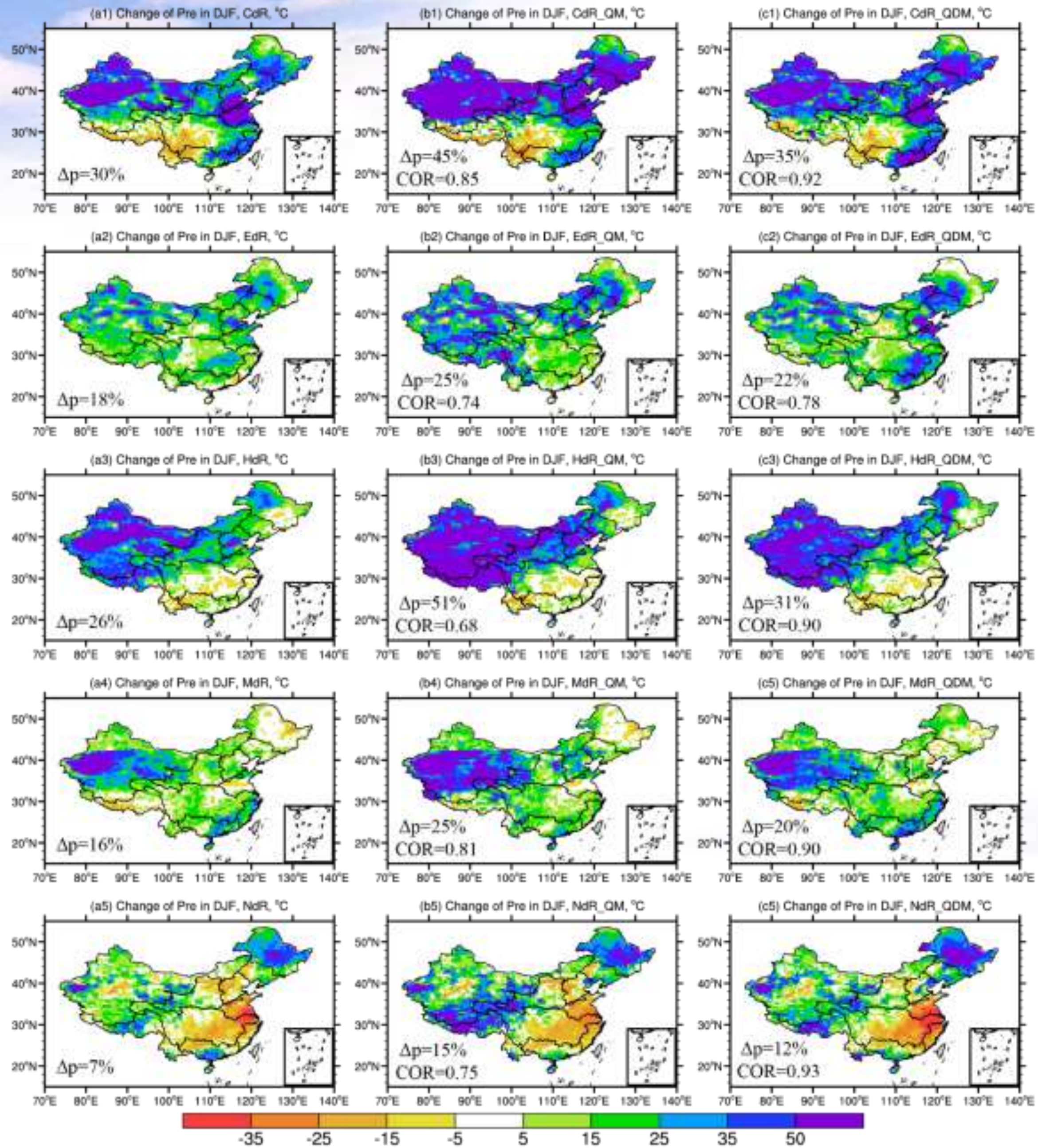
CdR

EdR

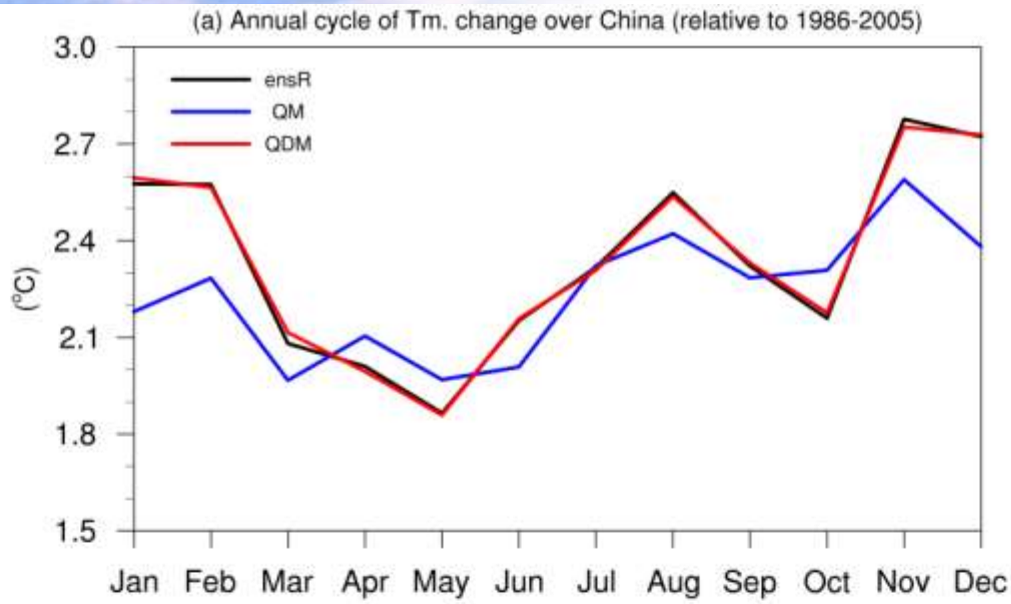
HdR

MdR

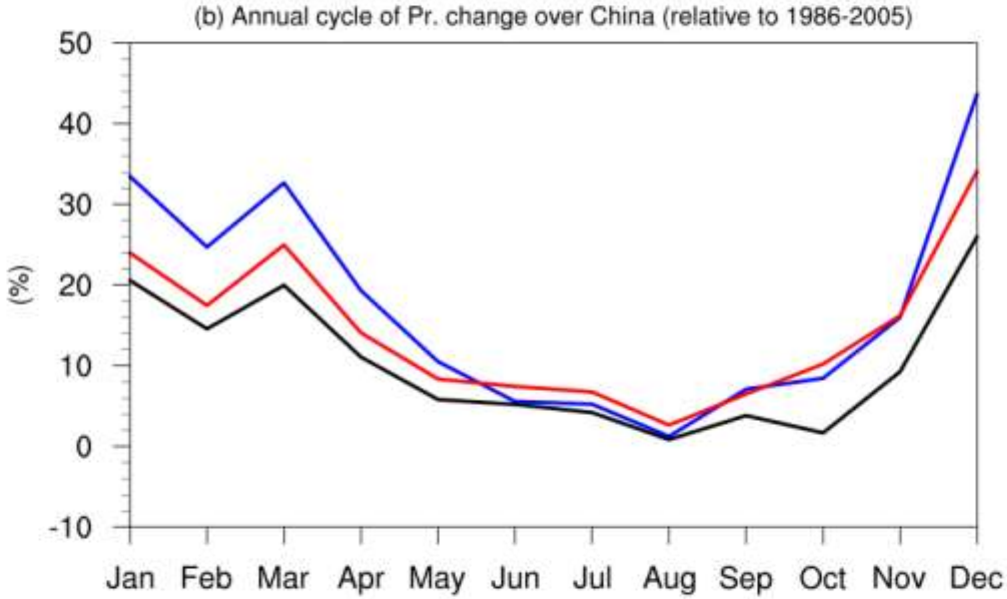
NdR



Temperature



Precipitation



5. Conclusions and discussions

- **Bias of RegCM4 in DJF: a warm bias in the high latitudes of northern China and a cold bias over the Tibetan Plateau, underestimate of precipitation in the Southeast and an overestimate in the dry north.**
- **Bias of RegCM4 in JJA, a warm bias over the deserts of the Northwest and a cold bias prevails elsewhere, while the precipitation climatology better simulated than in DJF.**
- **The biases are effectively removed by both the QM and QDM.**
- **QDM preserves very closely the temperature change signal of ensR, but substantial distortions for QM (lower warming and modifications in the patterns) of change.**
- **The patterns of precipitation change are in general preserved by both QM and QDM, but tend to amplify the increases, more pronounced in DJF and by QM.**
- **Bias correction does not aim to improve model skill.**


Thank you !