



基于人工神经网络技术发展中国地区
统计降尺度气候预估数据

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指导老师：闻新宇
2021年6月10日

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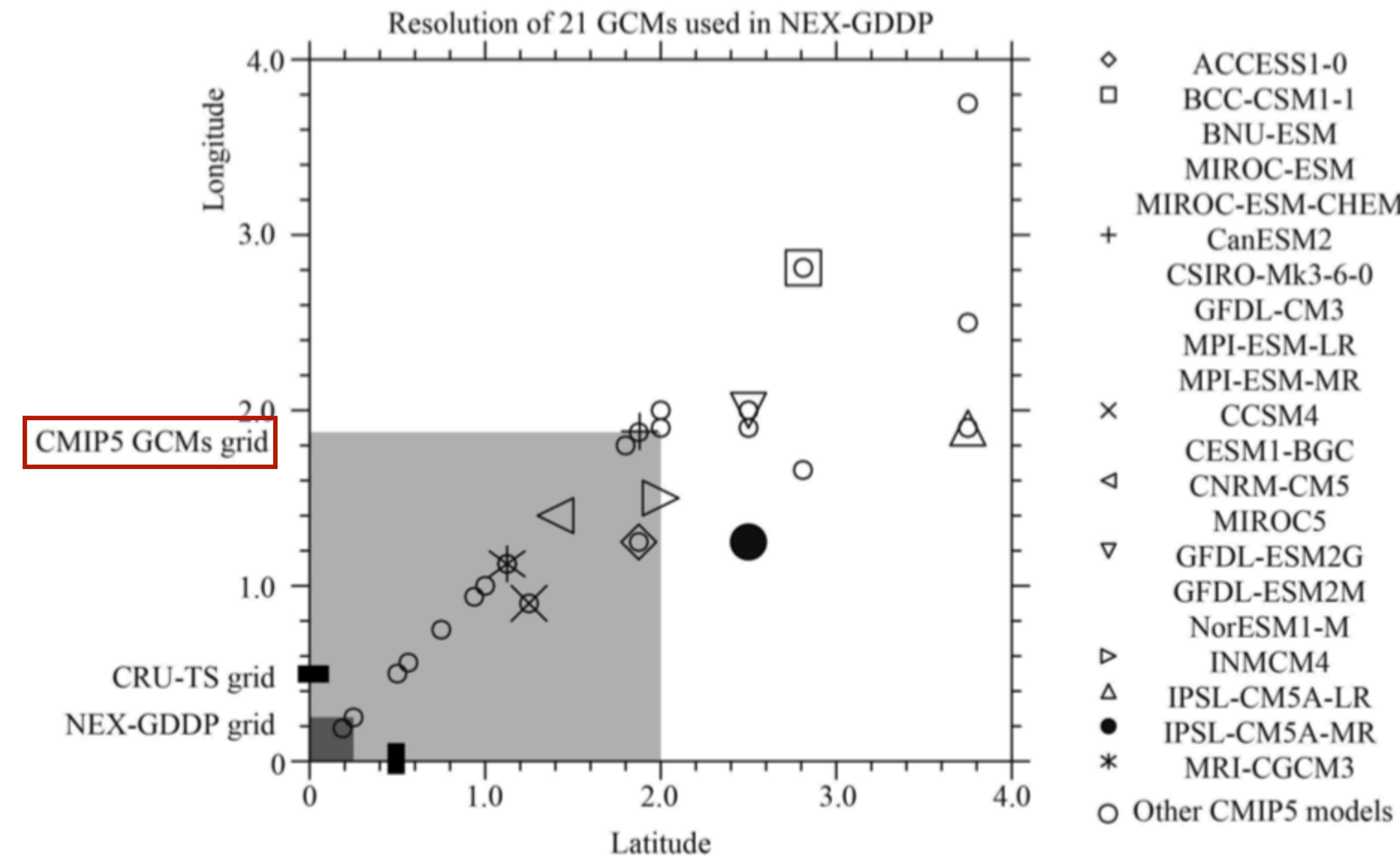
Part 01

研究背景和研究意义



研究背景和研究意义

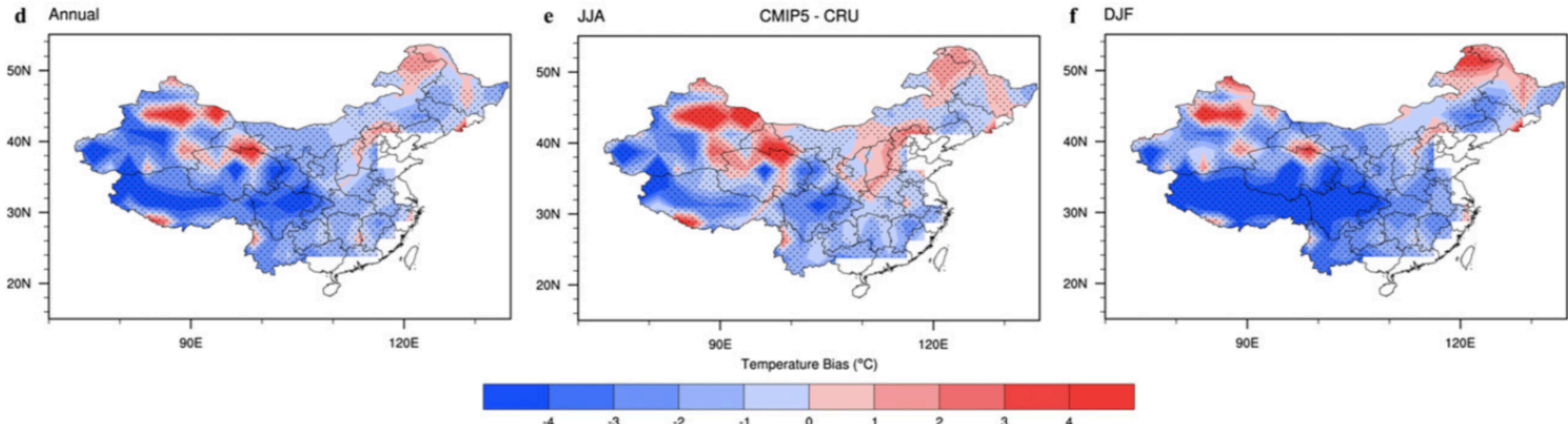
GCMs分辨率粗糙





研究背景和研究意义

GCMs存在系统性偏差（空间）

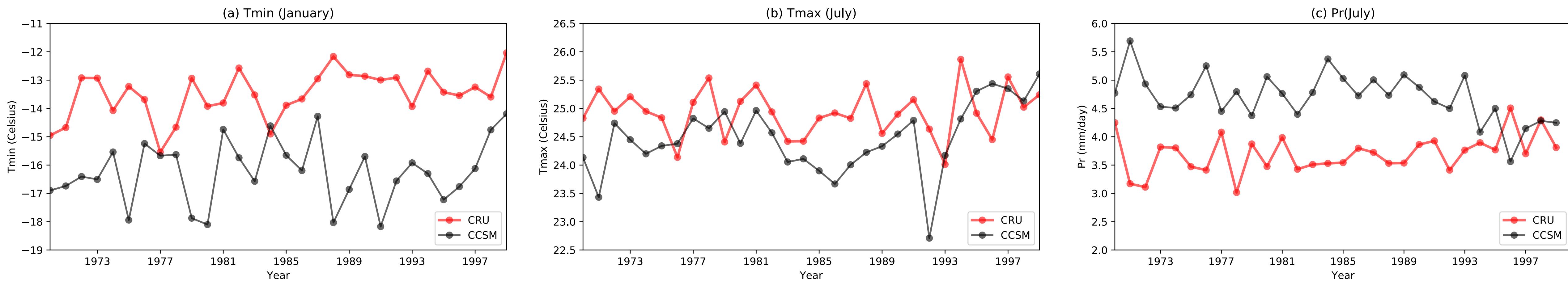


CMIP5温度偏差



研究背景和研究意义

GCMs存在系统性偏差（时间）



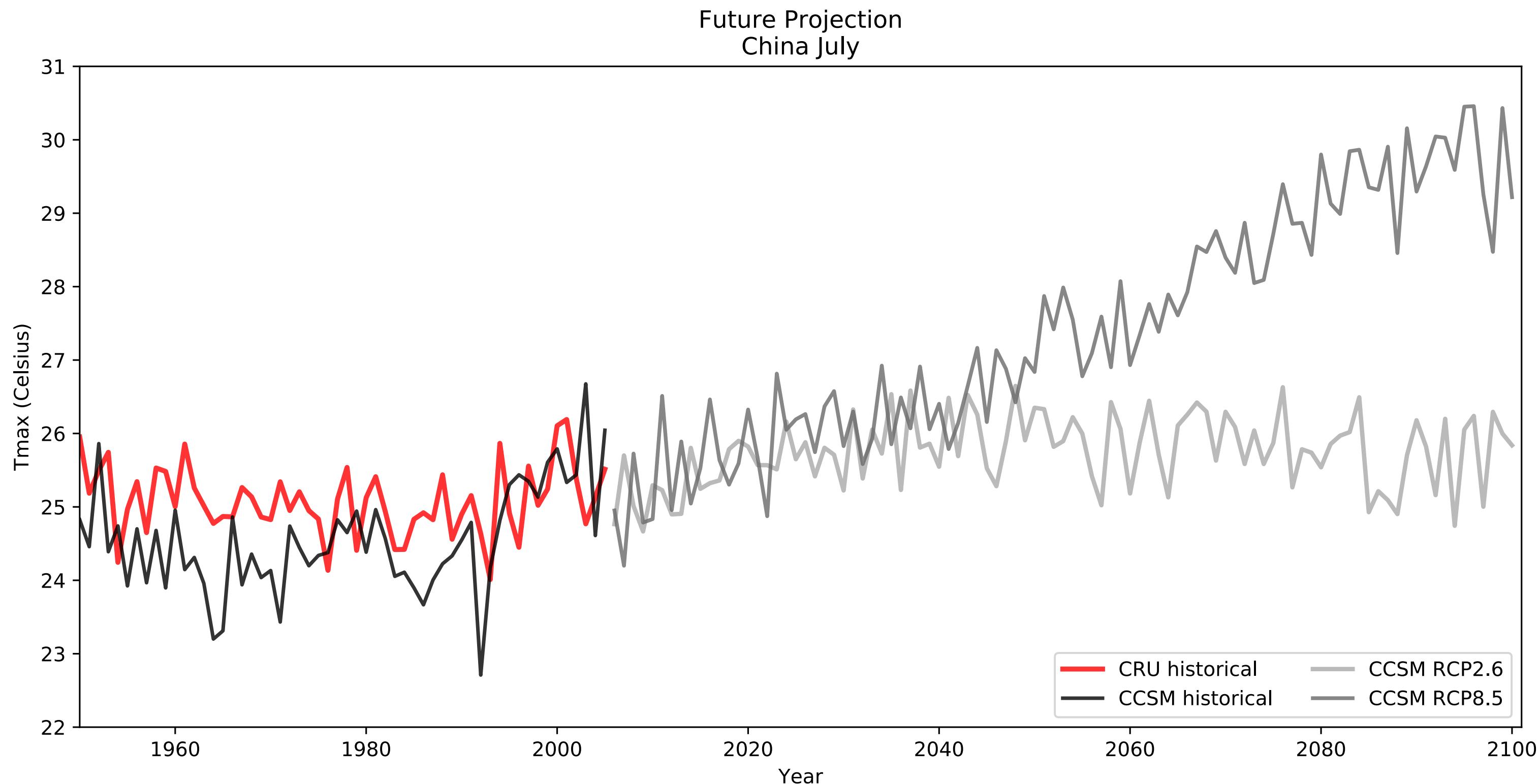
	CRU	CCSM4
Mean	-13.50	-16.23
StdDev	0.82	1.11
RMSE	N/A	3.10

	CRU	CCSM4
Mean	24.93	24.47
StdDev	0.42	0.61
RMSE	N/A	0.79

	CRU	CCSM4
Mean	3.70	4.70
StdDev	0.33	0.42
RMSE	N/A	1.20



研究背景和研究意义



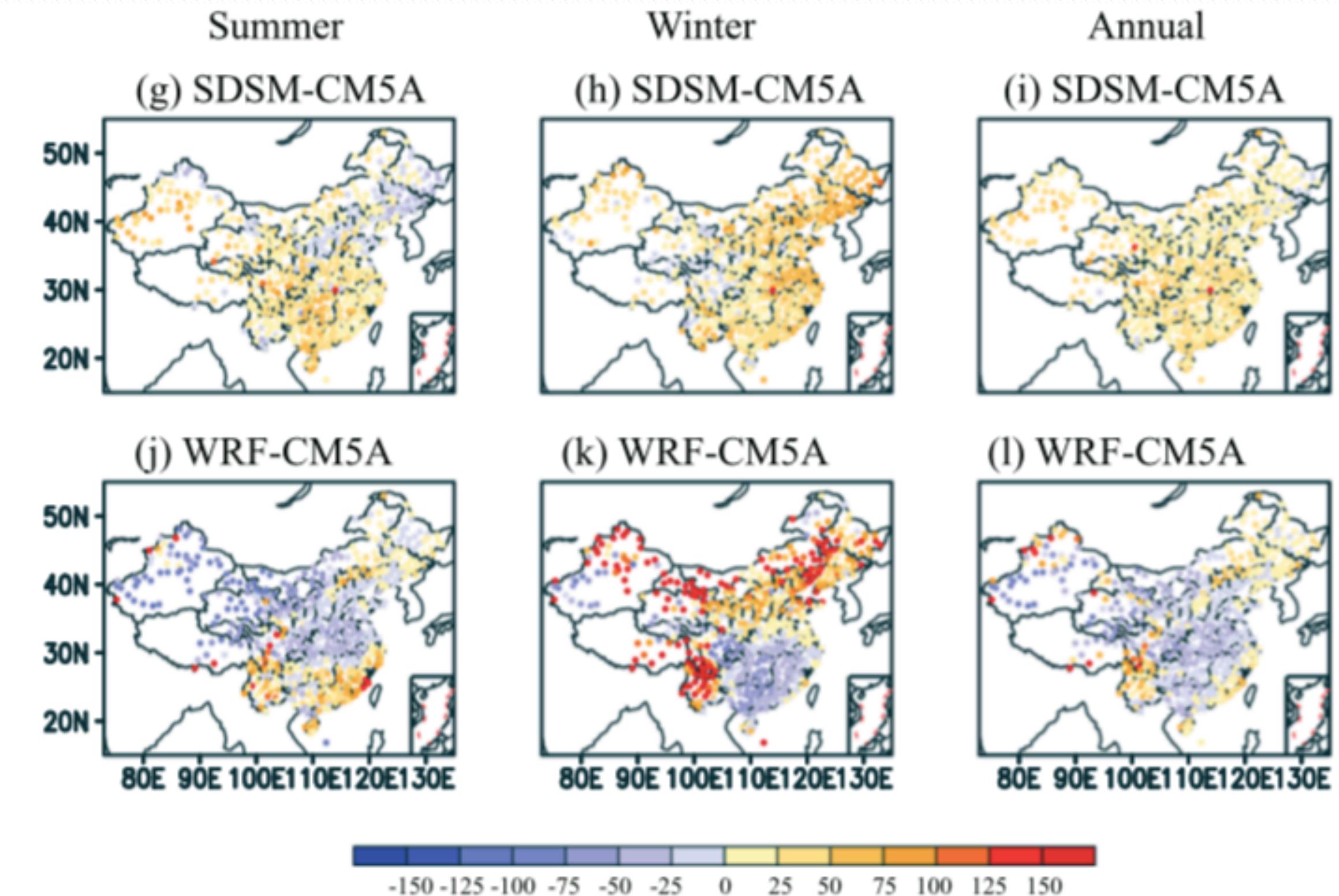
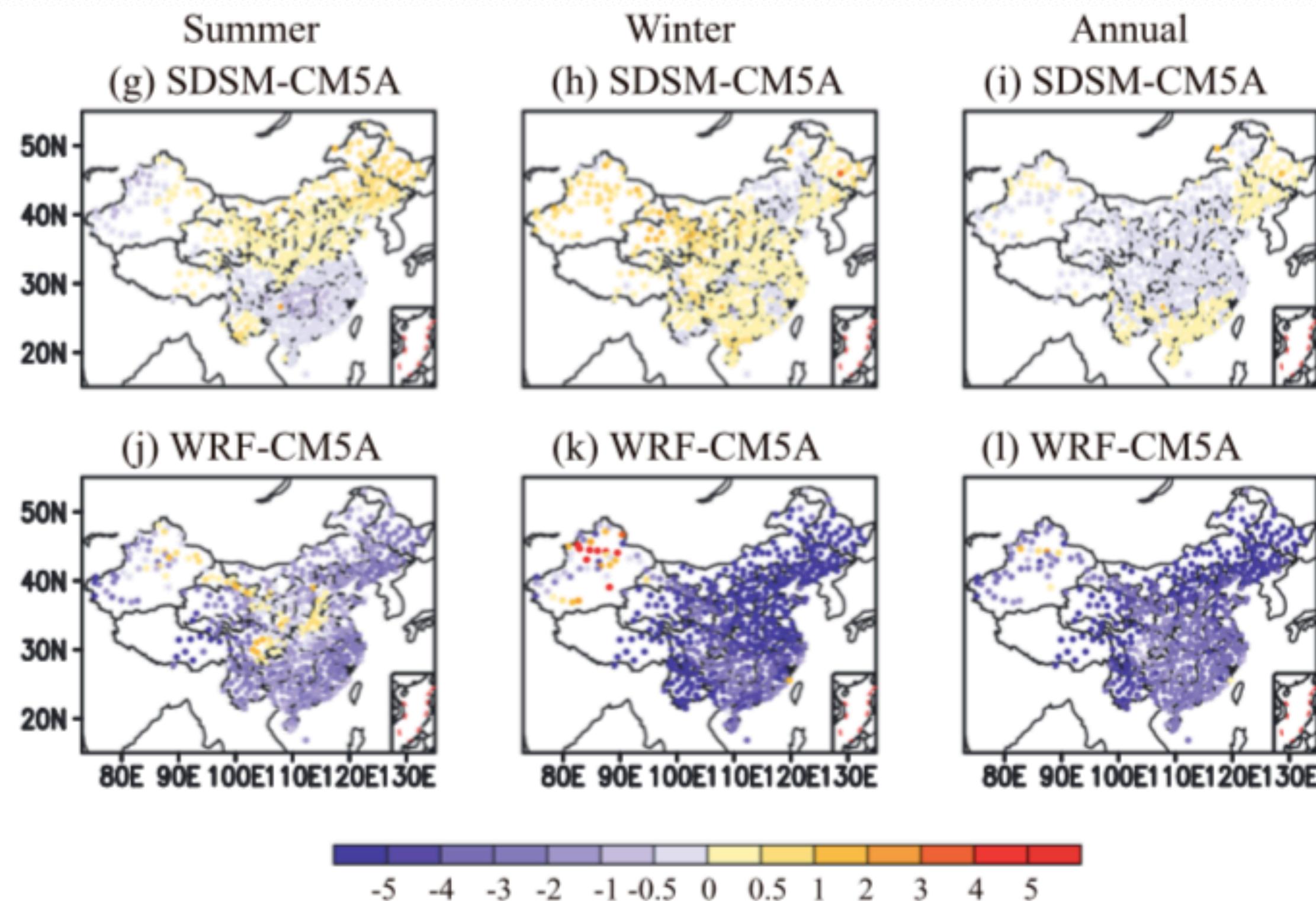
降尺度 (Downscaling):
动力降尺度
统计降尺度
线性回归
人工神经网络
.....

科学问题：如何结合两种数据得到对未来更准确的气候变化预估数据？



研究背景和研究意义

统计降尺度 vs. 动力降尺度



统计降尺度方法相较于动力降尺度略胜一筹



研究背景和研究意义

人工神经网络 vs. 多元线性回归

Fig. 3 Architecture of the neural network model used in this study

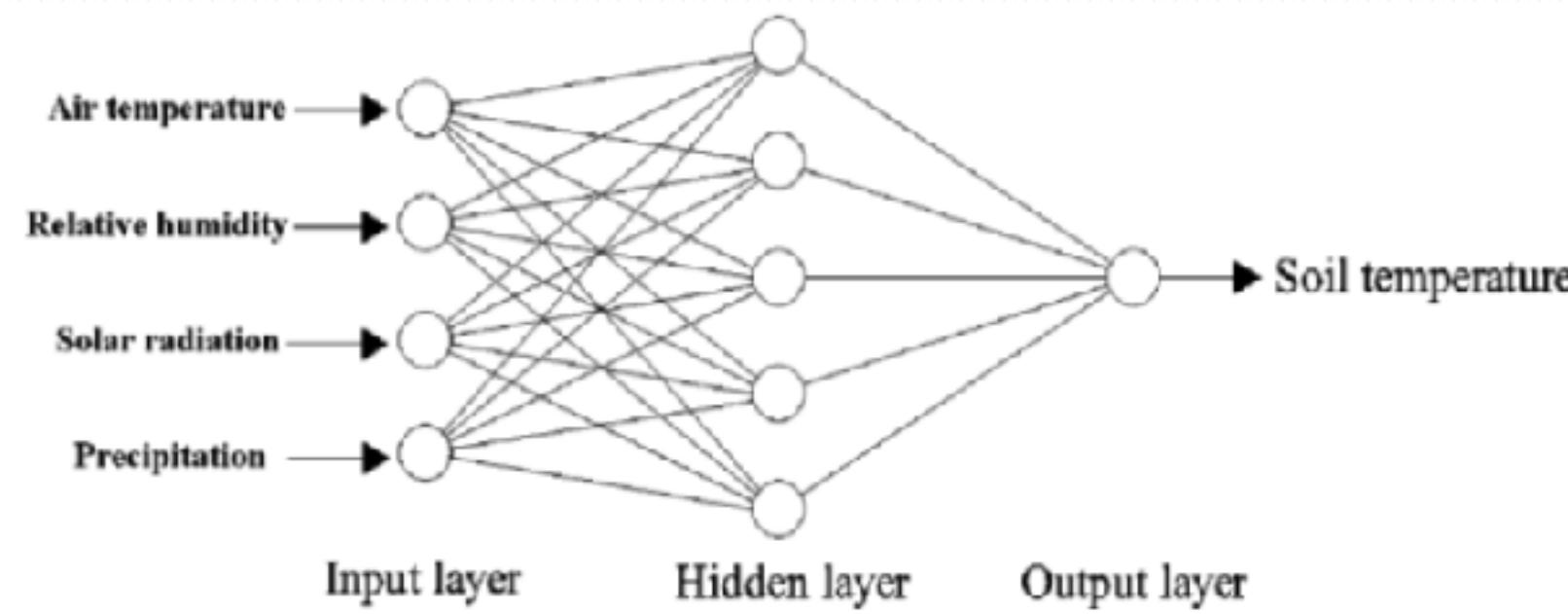
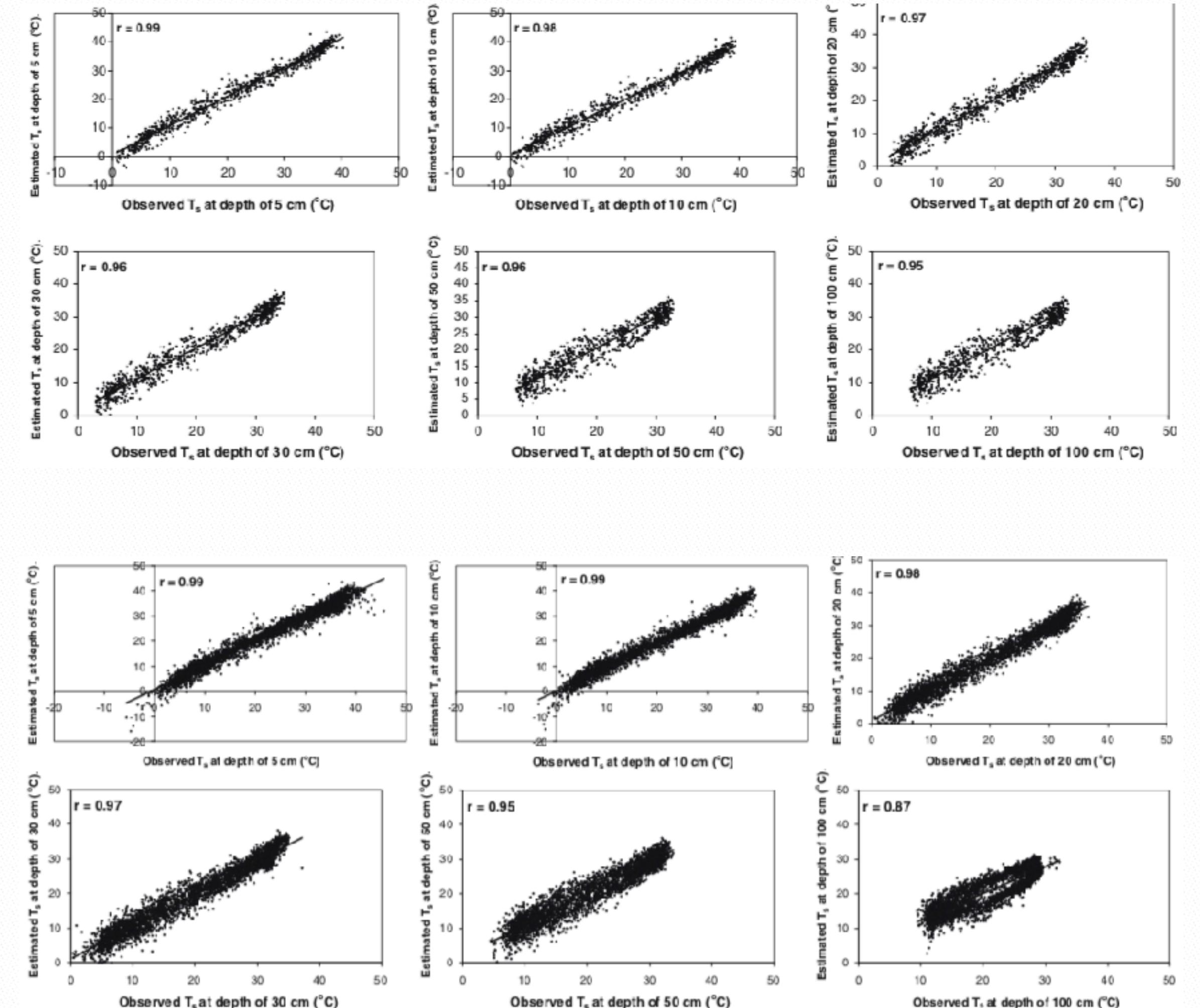


Table 5 Statistical performance evaluation criteria of MLR for all depths

Soil depth (cm)	r	RMSE	MAE	Equation
5	0.99	1.474	1.062	$T_{S-5} = 1.233T_a - 0.411RH + 0.004R_S - 0.143P + 0.585$
10	0.99	1.532	1.918	$T_{S-10} = 1.194T_a - 0.167RH + 0.017R_S - 0.109P + 0.526$
20	0.98	1.634	2.106	$T_{S-20} = 1.087T_a + 1.472RH + 0.001R_S - 0.088P + 0.896$
30	0.97	1.830	2.114	$T_{S-30} = 1.052T_a + 2.505RH - 0.006R_S - 0.118P + 1.332$
50	0.95	2.110	2.382	$T_{S-50} = 0.916T_a + 4.038RH - 0.009R_S - 0.176P + 3.734$
100	0.87	2.446	2.752	$T_{S-100} = 0.661T_a + 5.977RH + 7.17 \times 10^{-5}R_S - 0.244P + 7.288$

* RMSE and MAE are in °C



人工神经网络方法相较于多元线性回归略胜一筹



研究背景和研究意义

总结：

- 统计降尺度方法
- 人工神经网络方法
- 中国地区
- 气候预估数据



Part 02

数据和方法



数据和方法

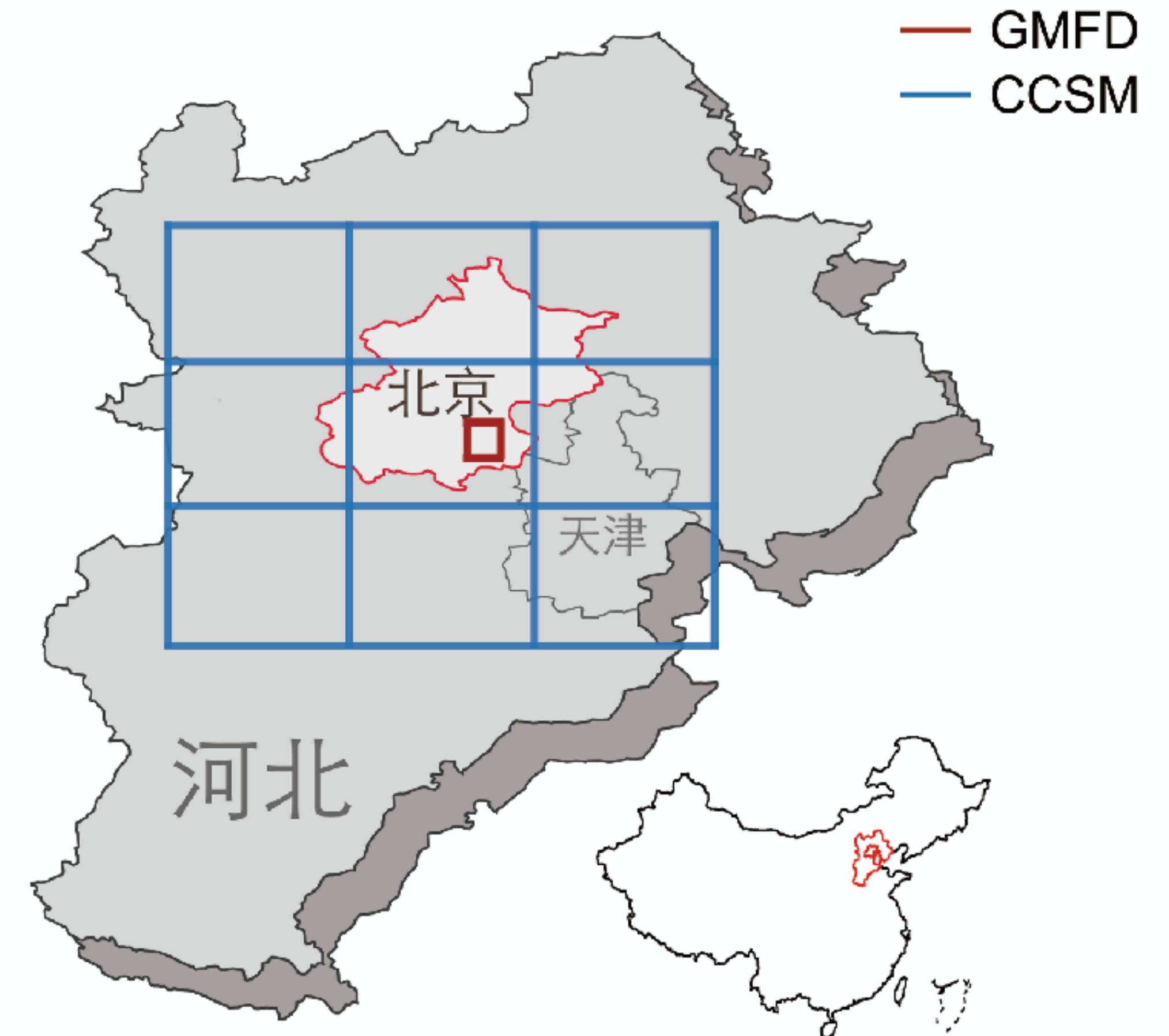
研究范围：中国地区

数据：

模式数据：CCSM4 ($1^\circ \times 1.25^\circ$)

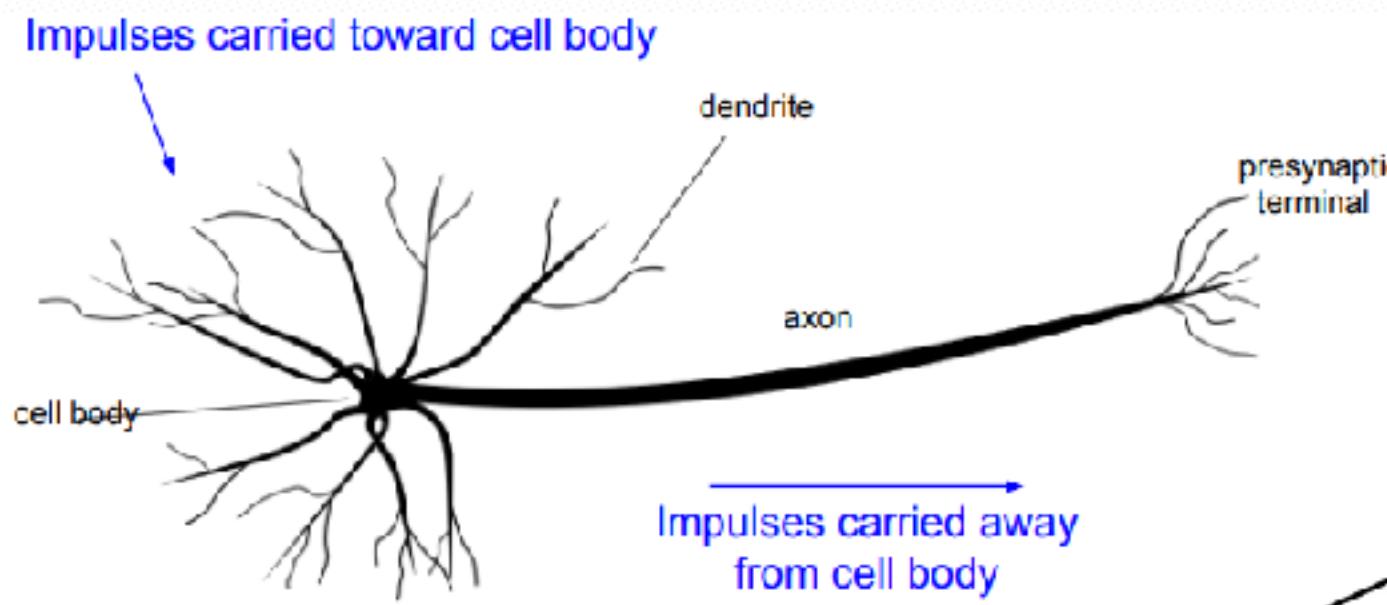
观测数据：GMFD ($0.25^\circ \times 0.25^\circ$),
CRU ($0.5^\circ \times 0.5^\circ$)

研究变量：日最低温(Tmin, Jan),
日最高温(Tmax, July),
日降水量(Pr, July)

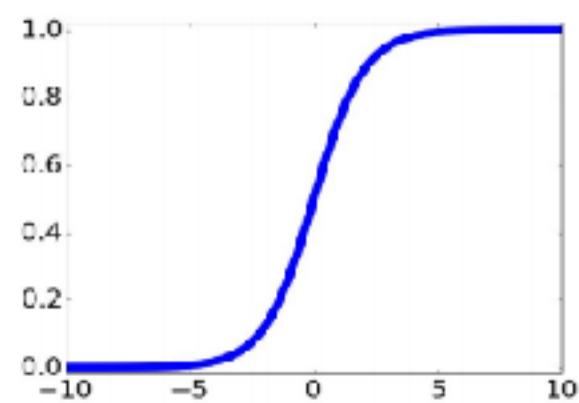




数据和方法

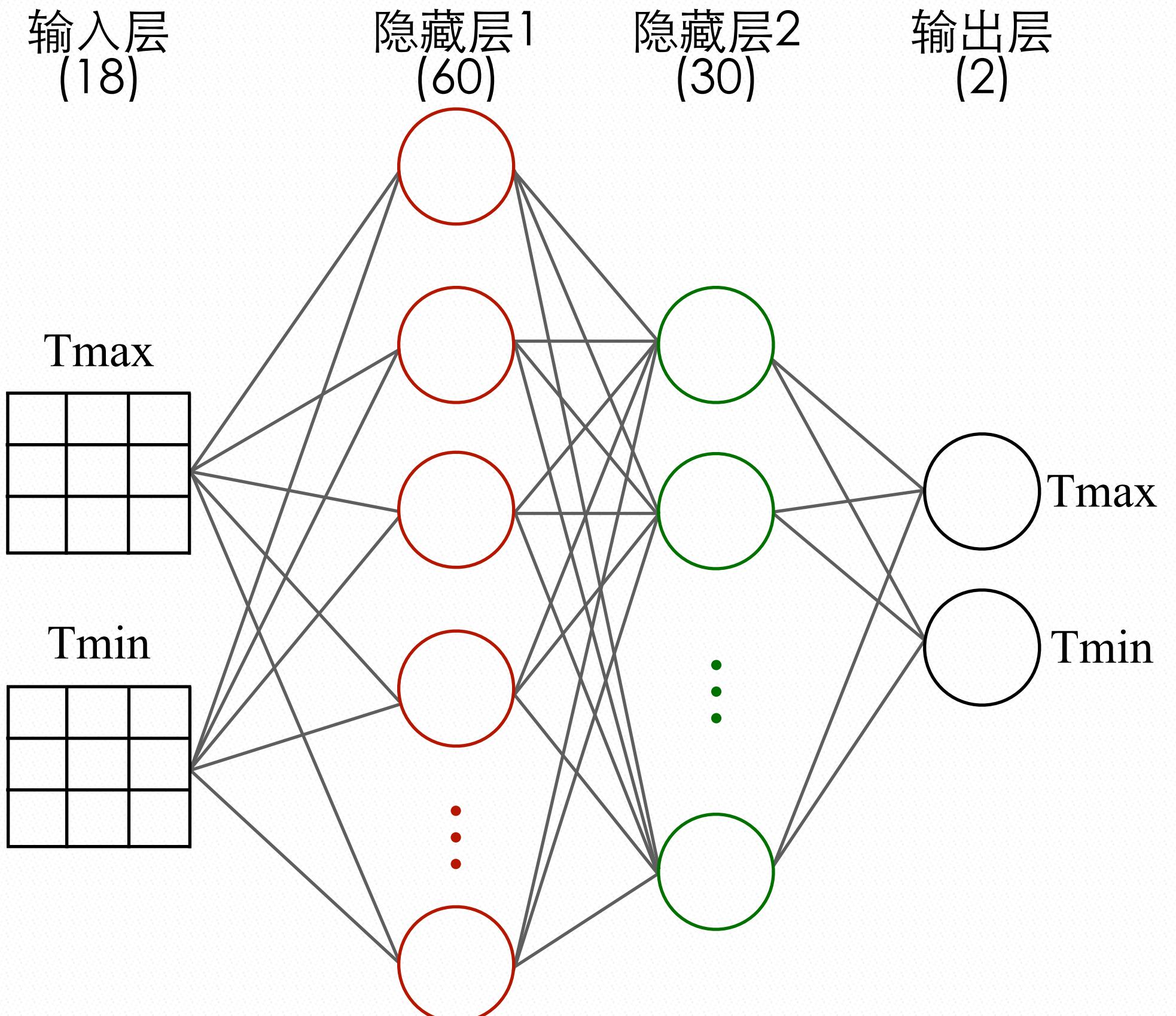
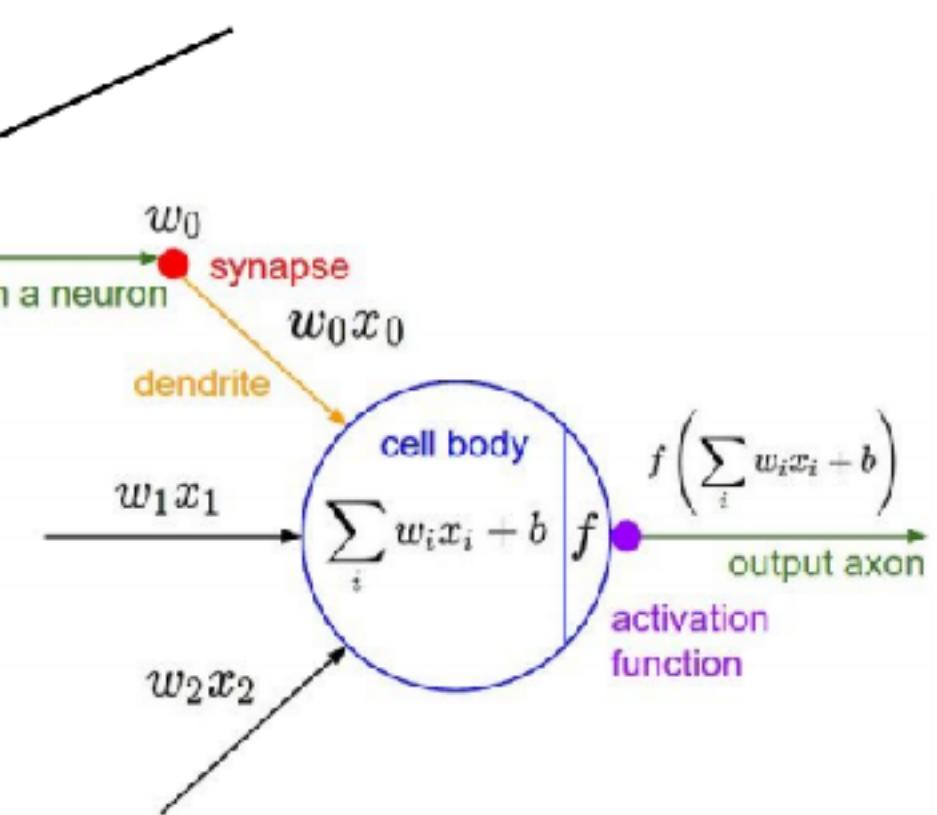


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sigmoid activation function

$$\frac{1}{1 + e^{-x}}$$

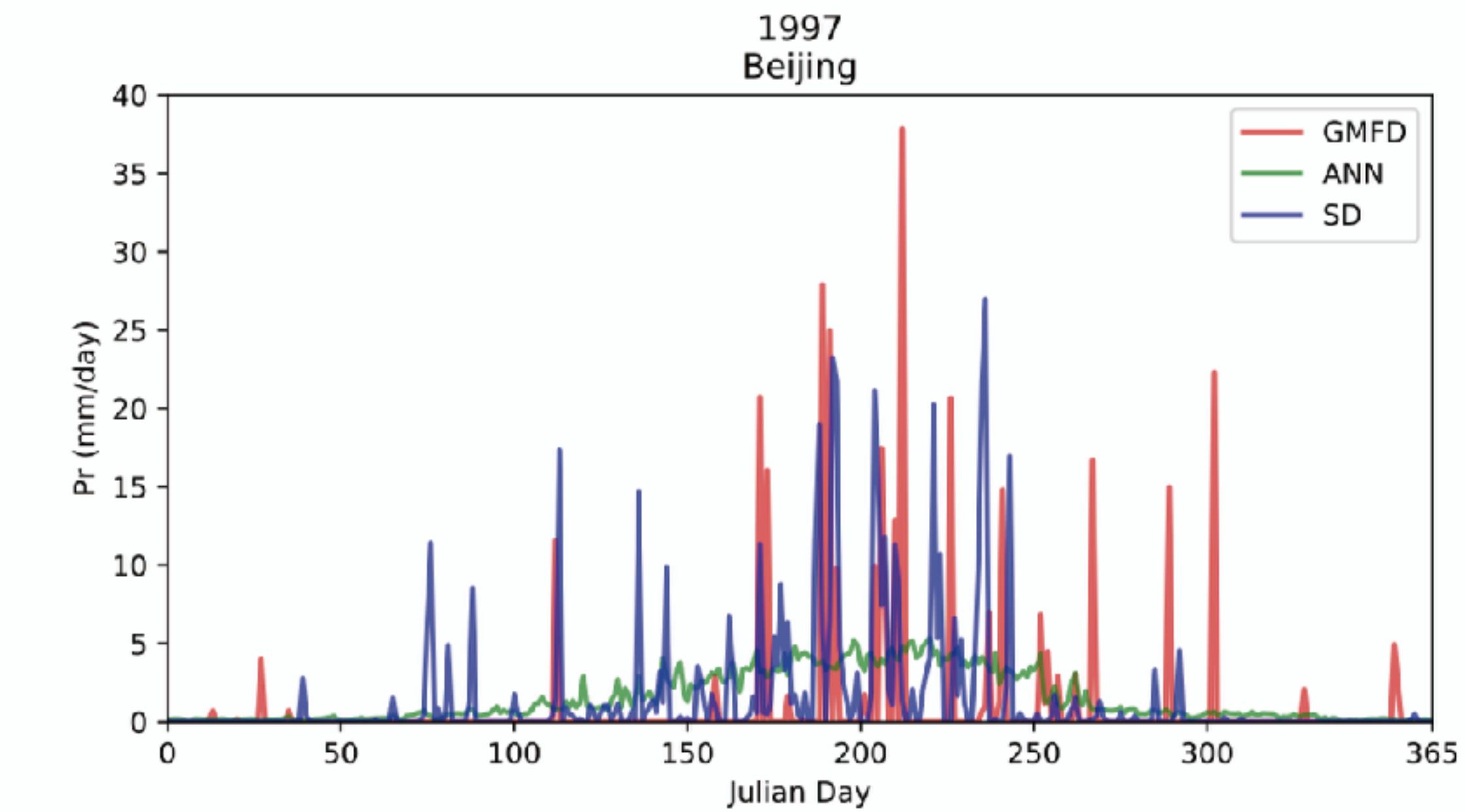
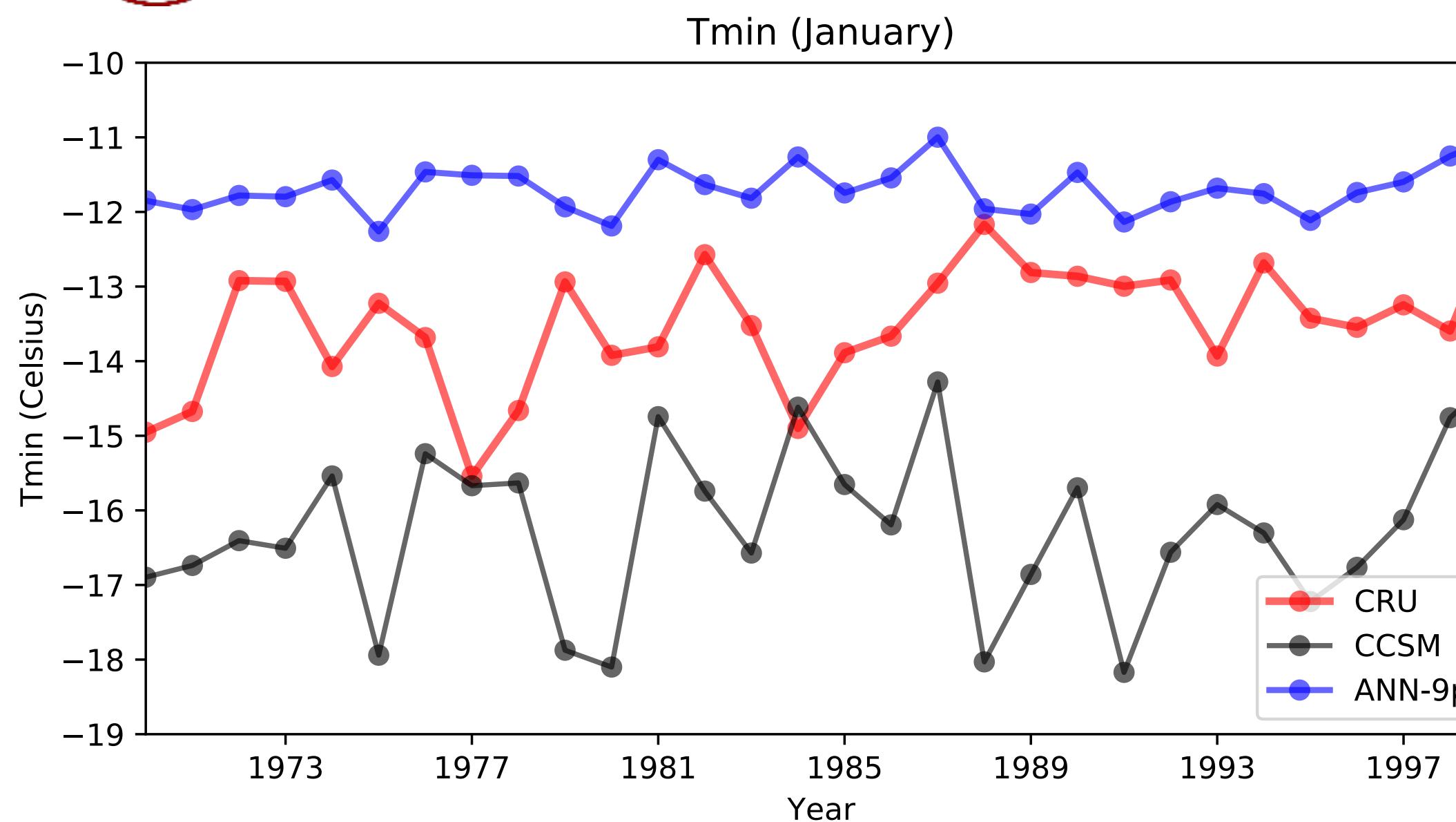


Fei-Fei Li CS231n

多层感知器神经网络结构



数据和方法



$$T_{BC}(t) = \bar{T}_{RAW} - (\bar{T}_{REF} - \bar{O}_{REF}) + \frac{\sigma_{O,REF}}{\sigma_{T,REF}}(T_{RAW}(t) - \bar{T}_{RAW})$$

Tmin
Tmax

ANN + BC
ANN + BC

SD

$$P_{BC}(t) = \frac{\sum_{i=1}^{42} P_{Obs}}{\sum_{i=1}^{42} P_{GCM}} P_{GCM}(t)$$

Precipitation

~~ANN~~

BC
SD

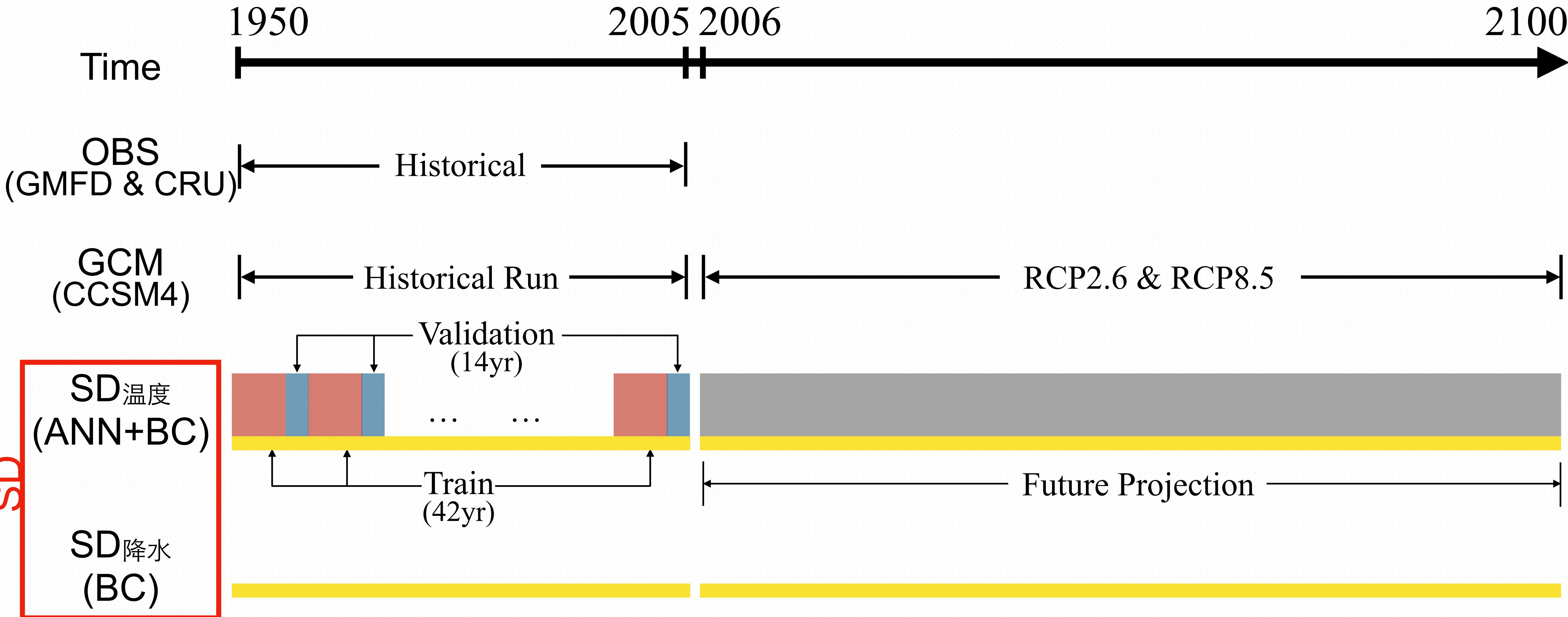


数据和方法

研究时段：1950-2100

Historical

Future



数据划分示意图



Part 03

研究结果



研究结果

历史阶段
气候态评估

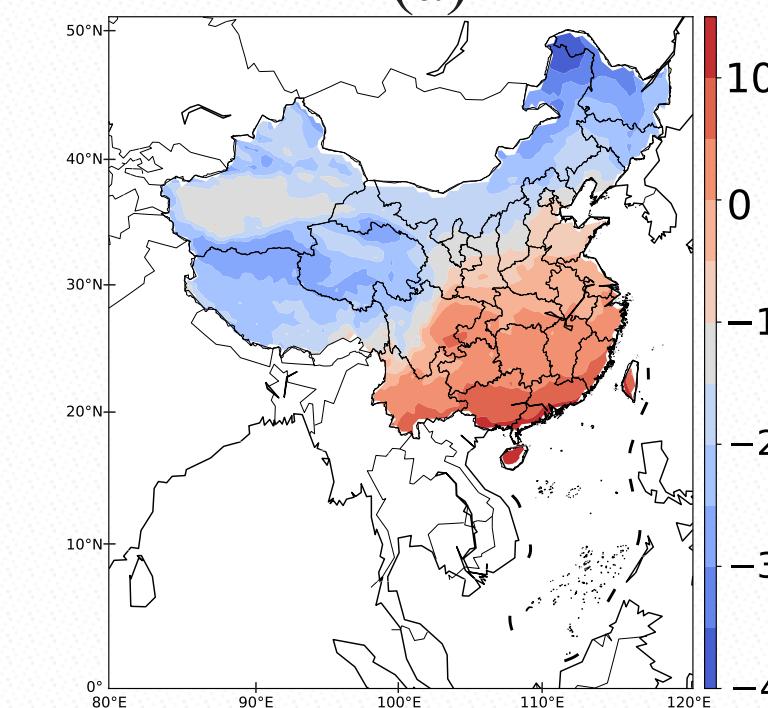
CCSM偏差较大

SD更接近观测数据

CRU

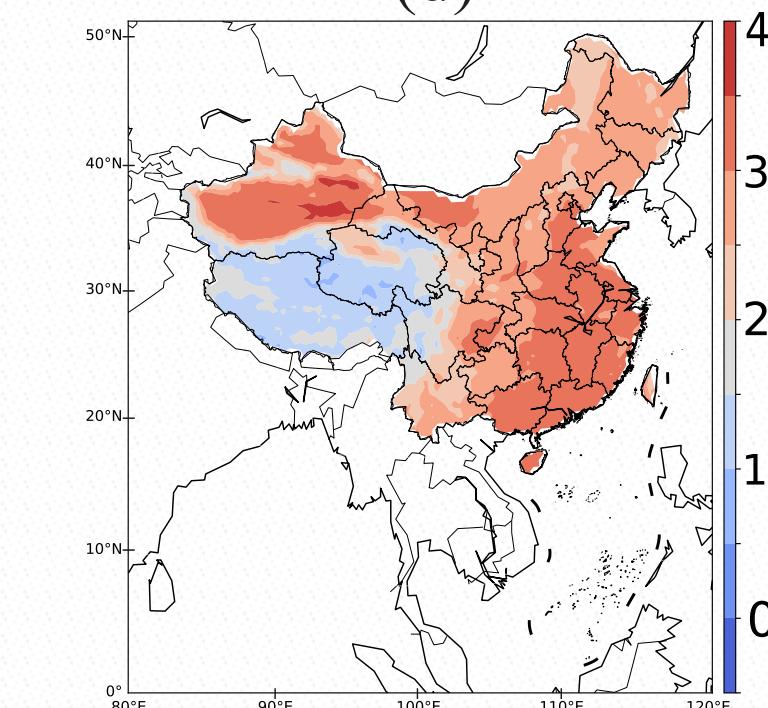
Tmin (January)

(a)



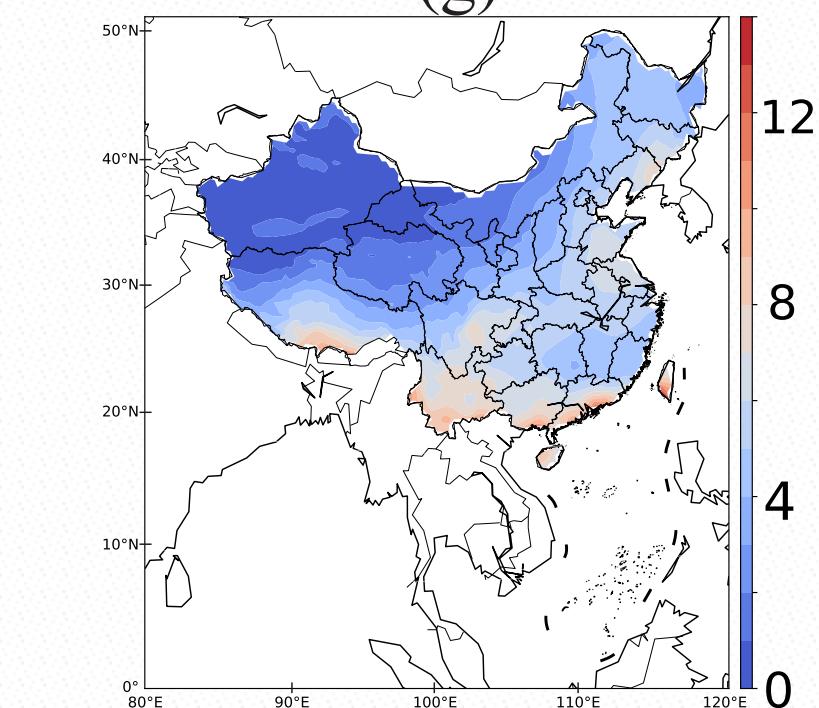
Tmax (July)

(d)



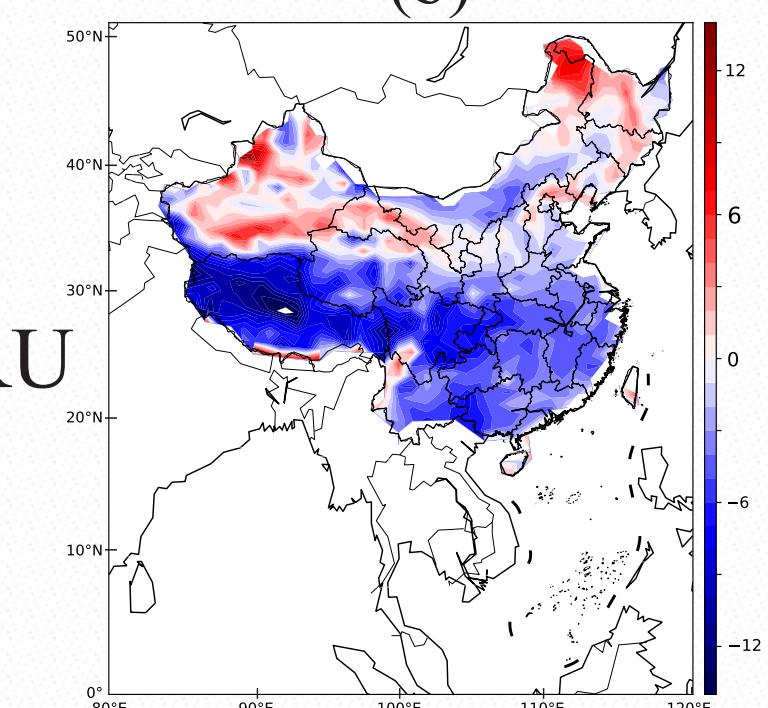
Pr (July)

(g)

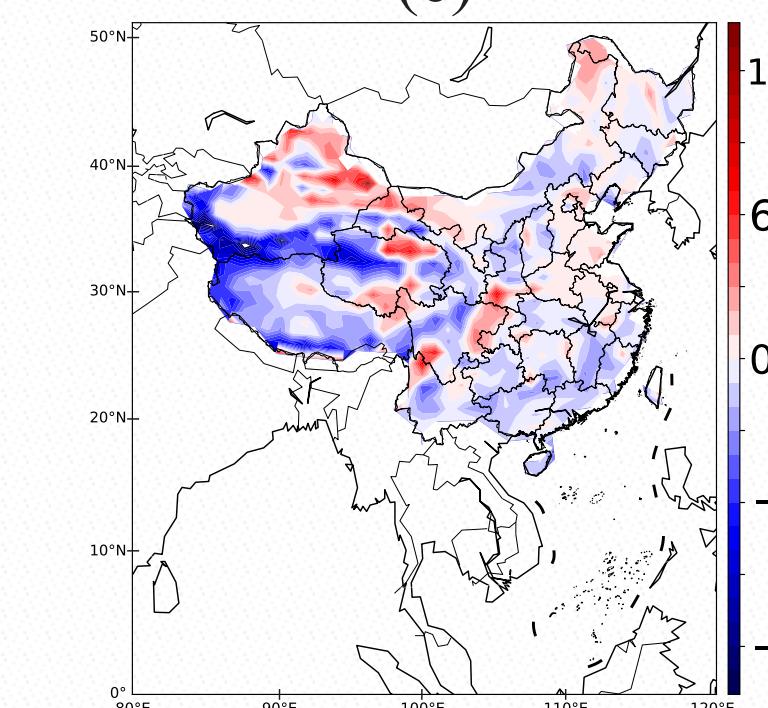


CCSM-CRU

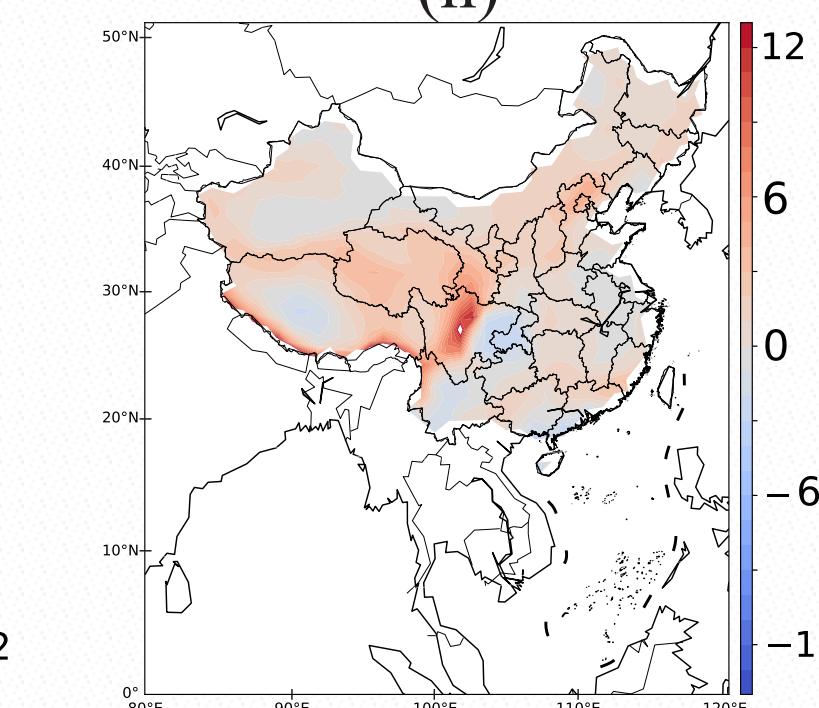
(b)



(e)

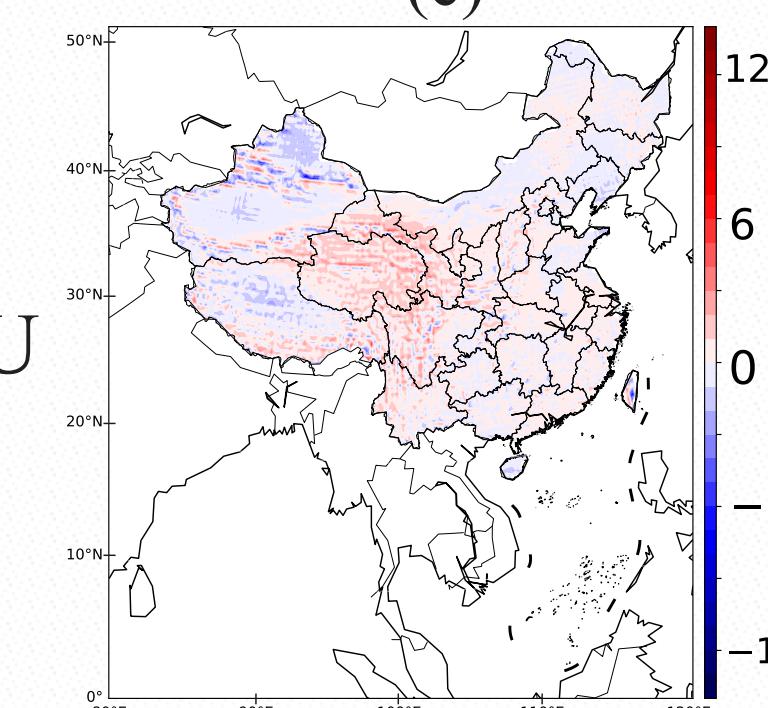


(h)

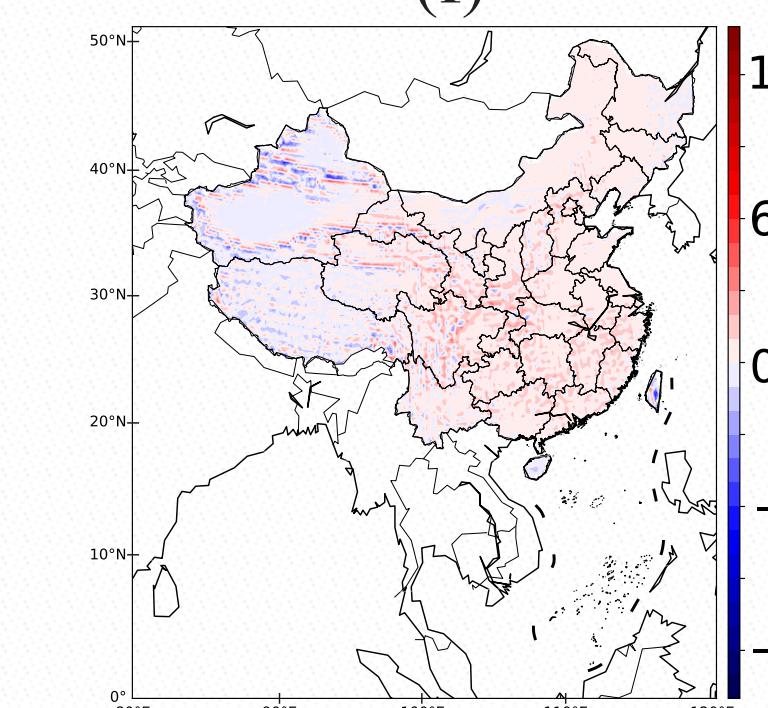


SD-CRU

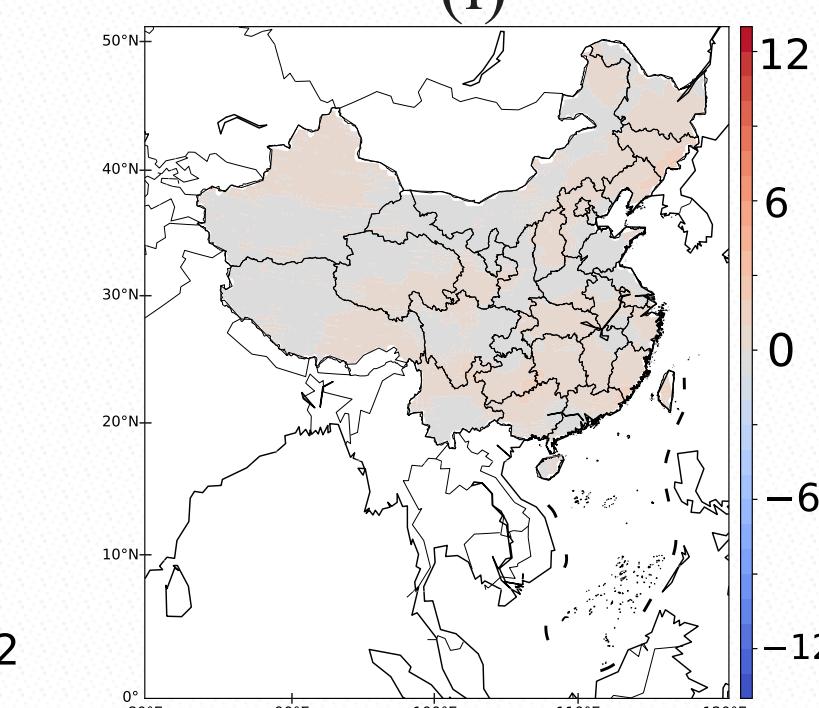
(c)



(f)



(i)



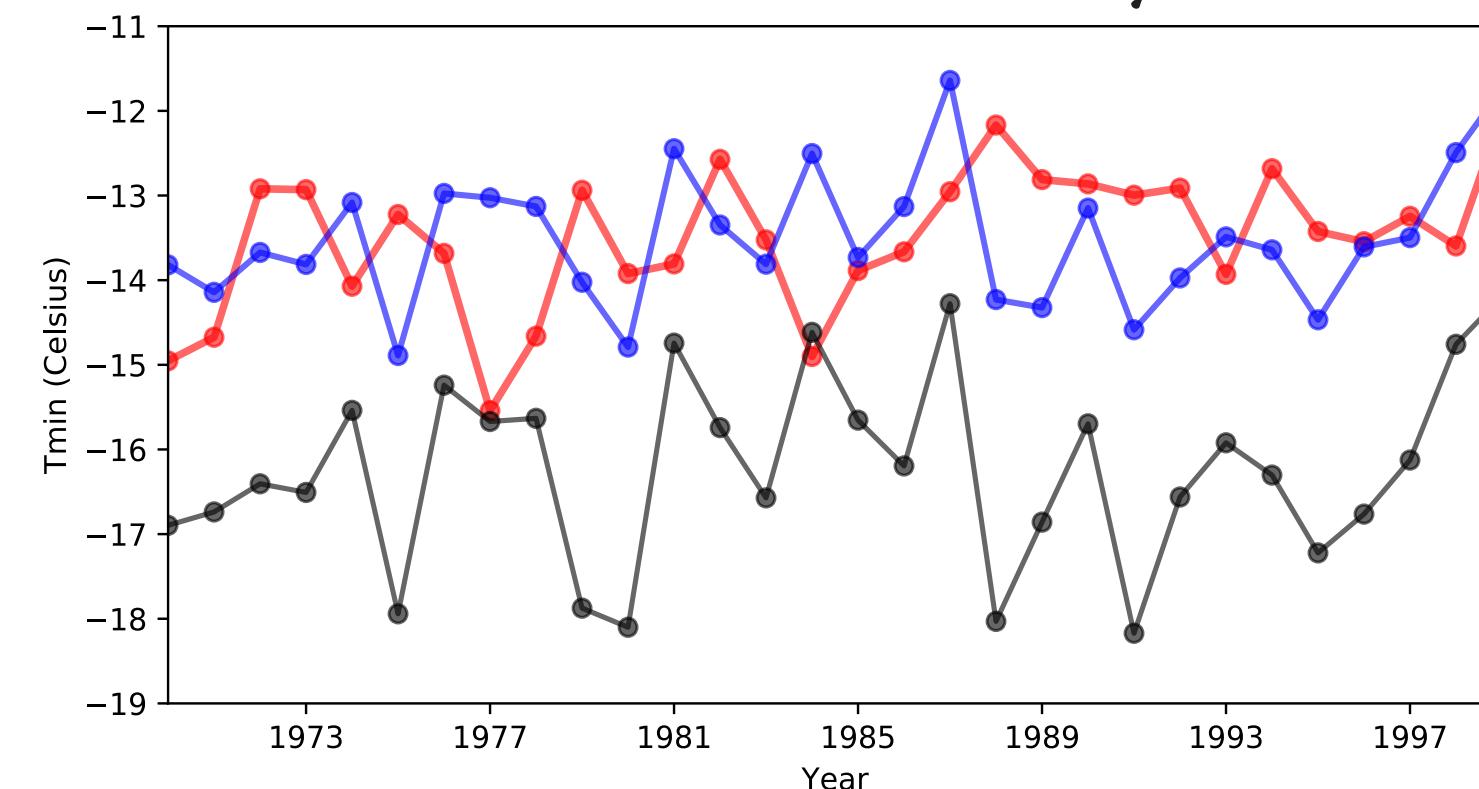
历史气候态空间分布



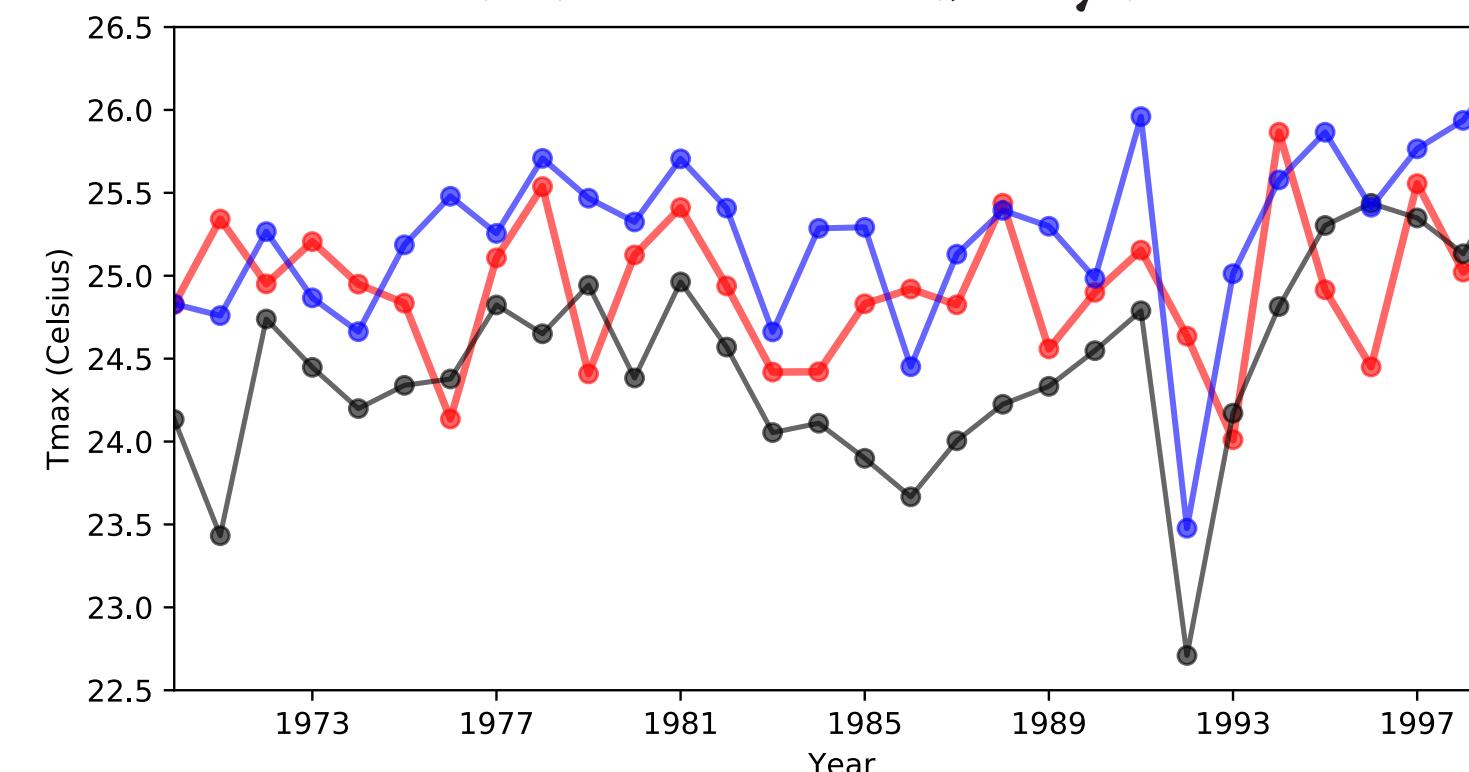
研究结果

历史阶段
气候态评估

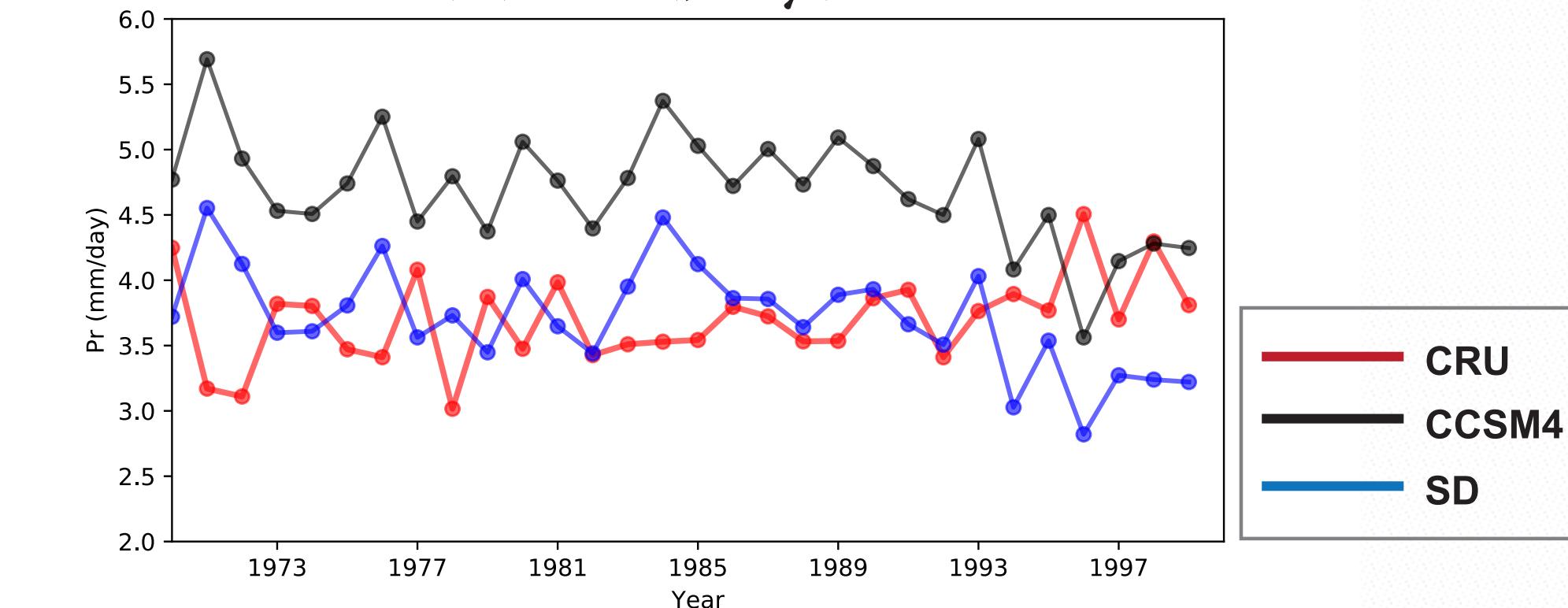
(a) Tmin (January)



(b) Tmax (July)



(c) Pr (July)



1970-1999年全中国平均日最低温、日最高温和日降水量时间序列

综上：历史阶段，SD比GCM更接近观测，把这种修正技巧应用到未来，我们期待SD给出比GCM具有更高可信度的预估结果。



研究结果

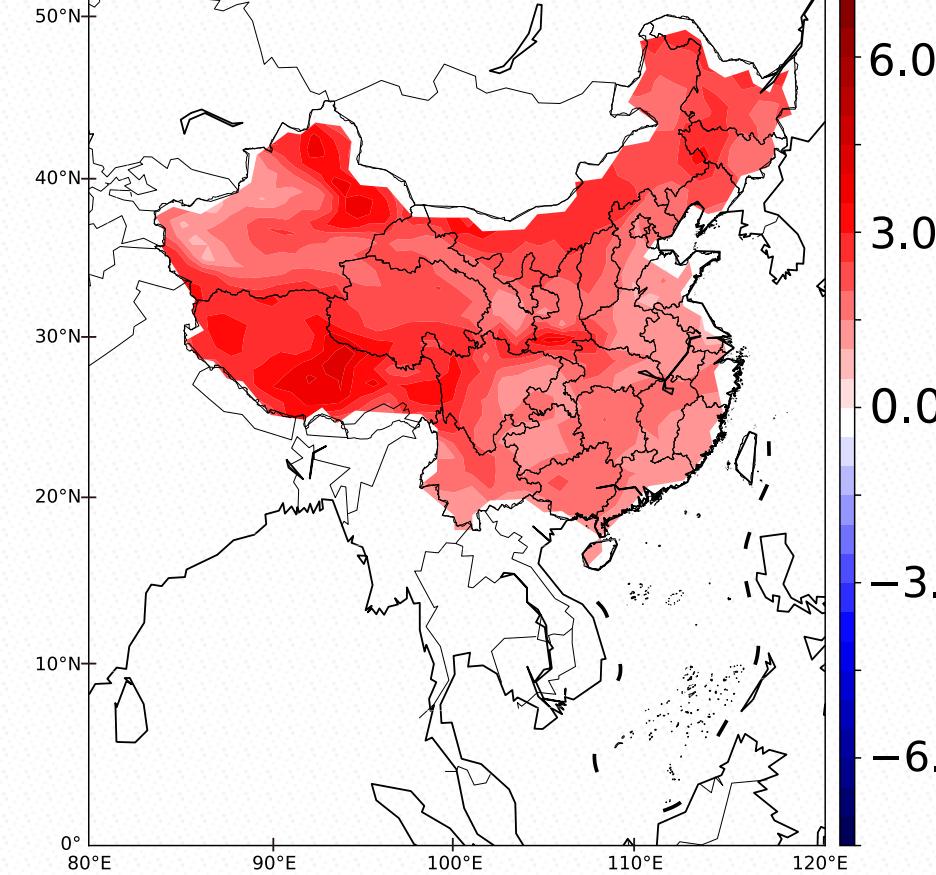
全国普遍增温2-
3°C、华北降水增加
1-2mm/day

CCSM

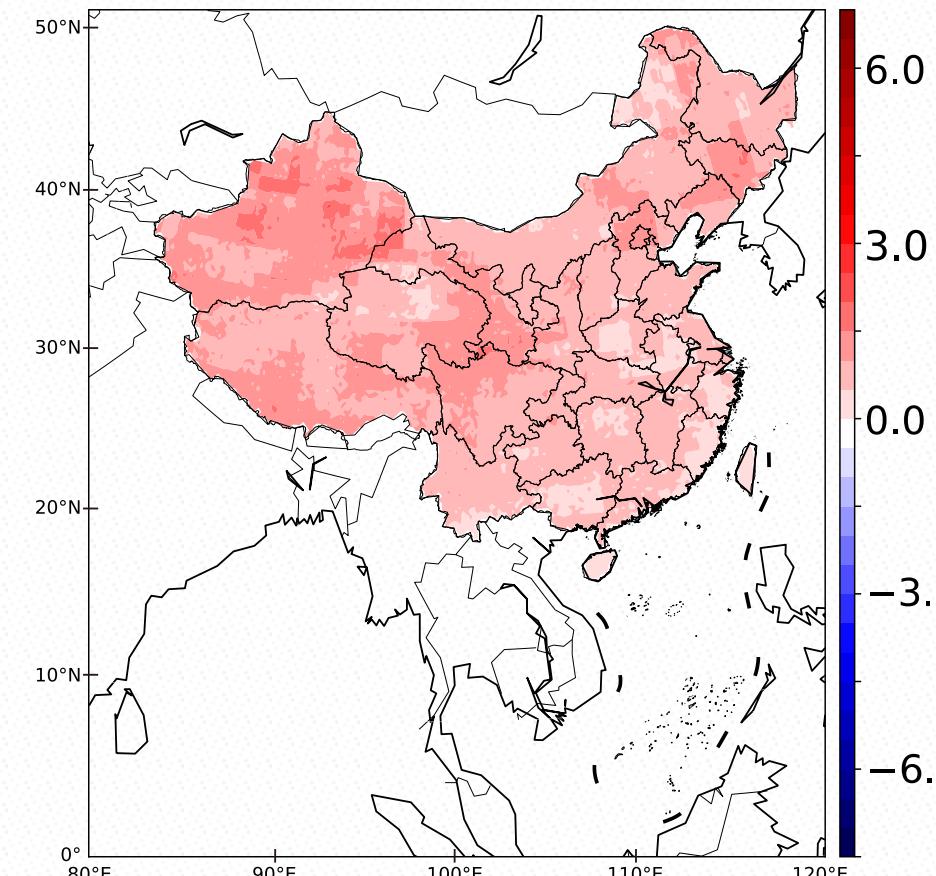
SD

Tmin (January)

(a)

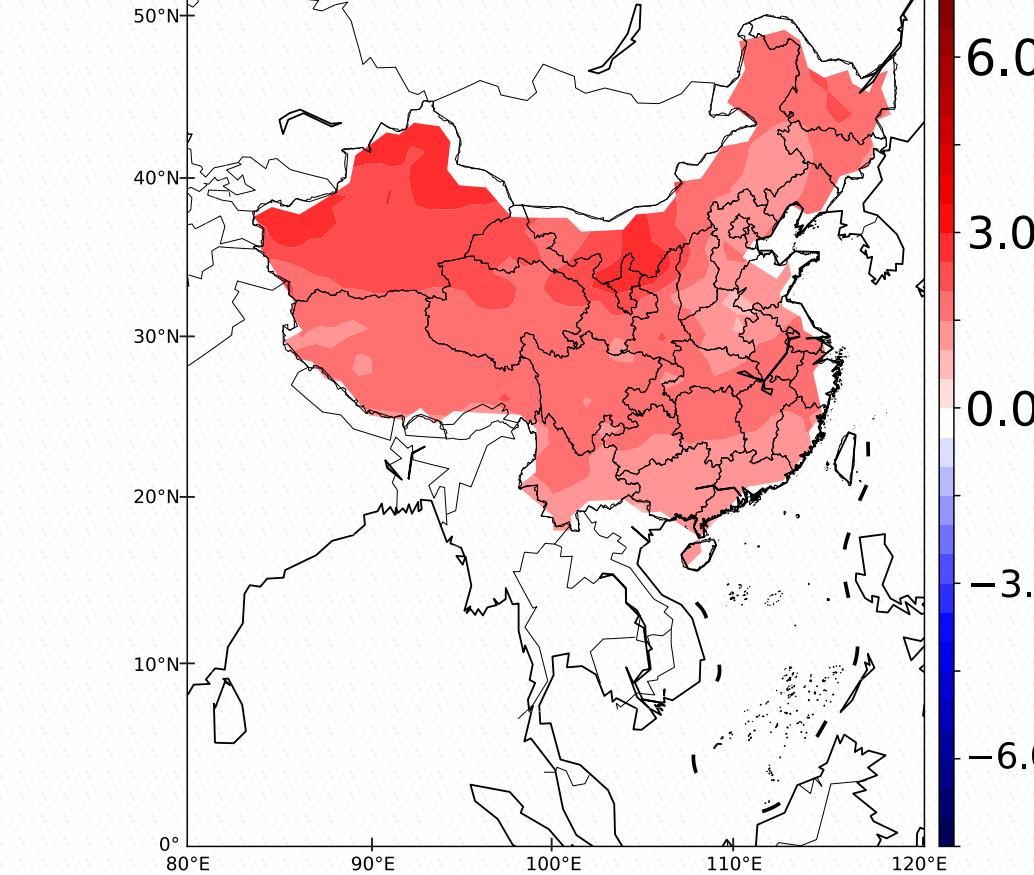


(b)

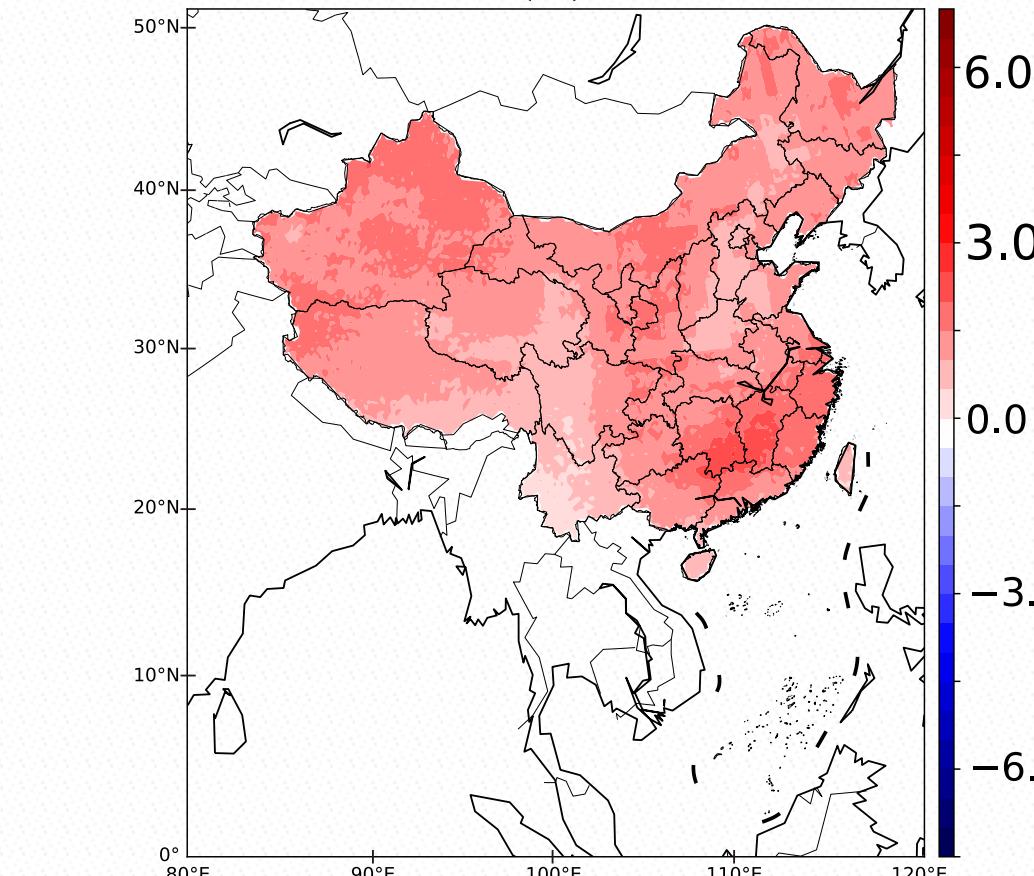


Tmax (July)

(c)

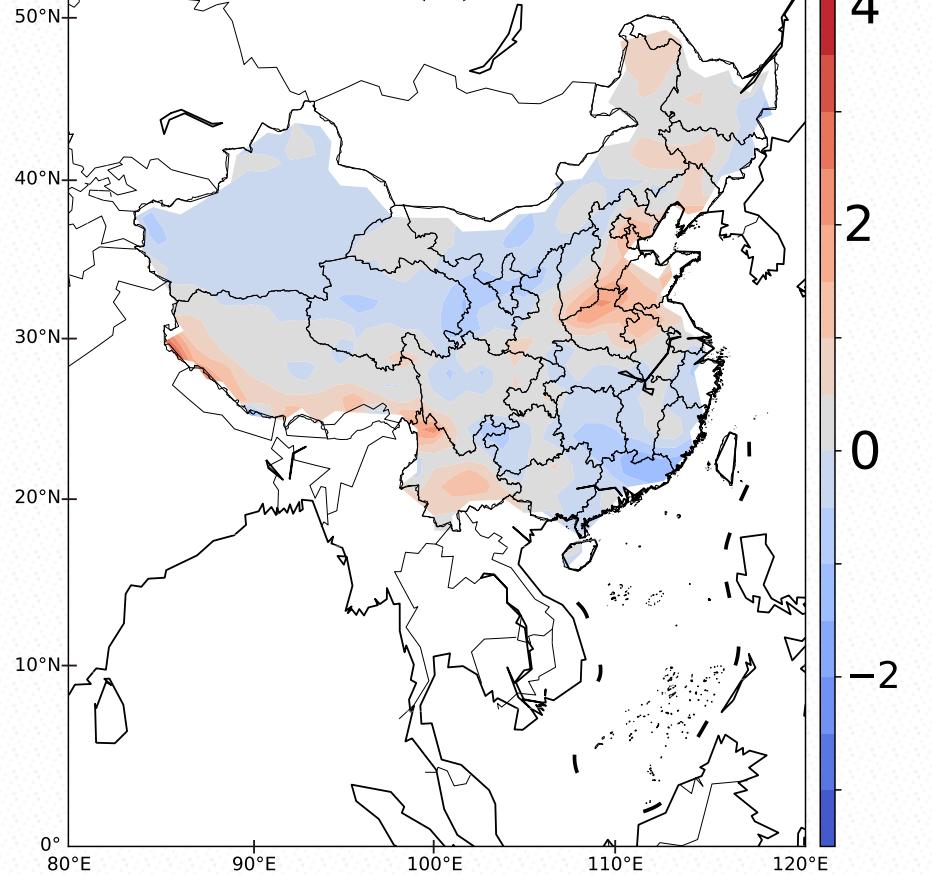


(d)

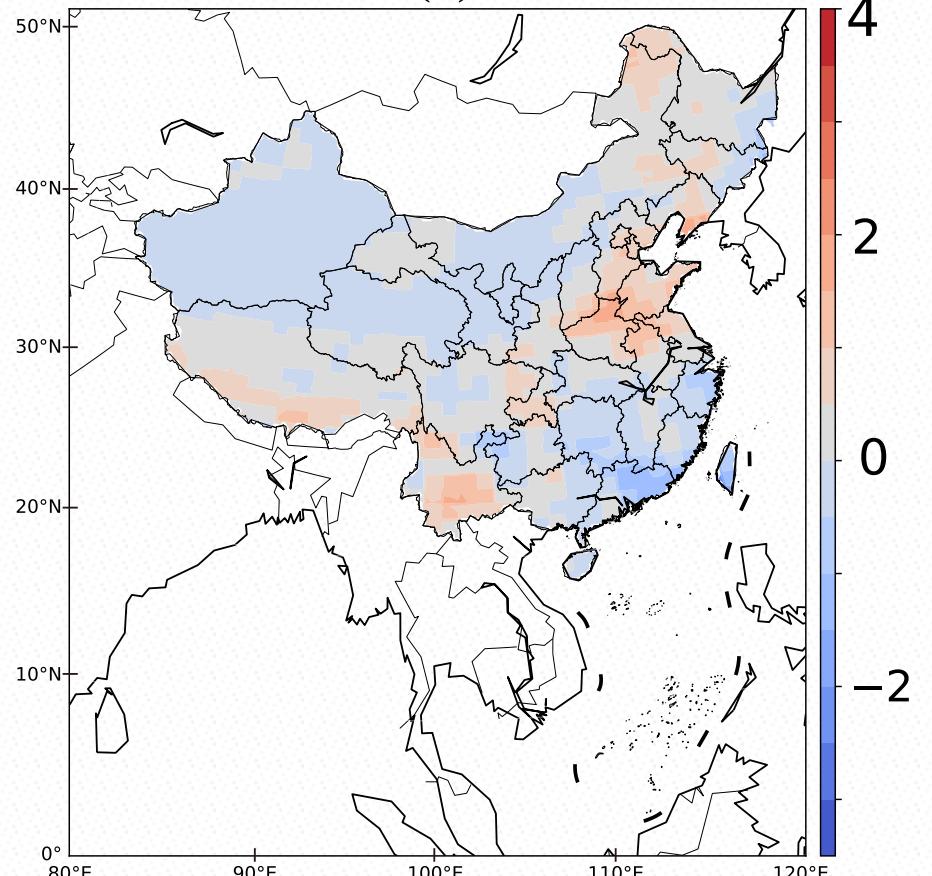


Pr (July)

(e)



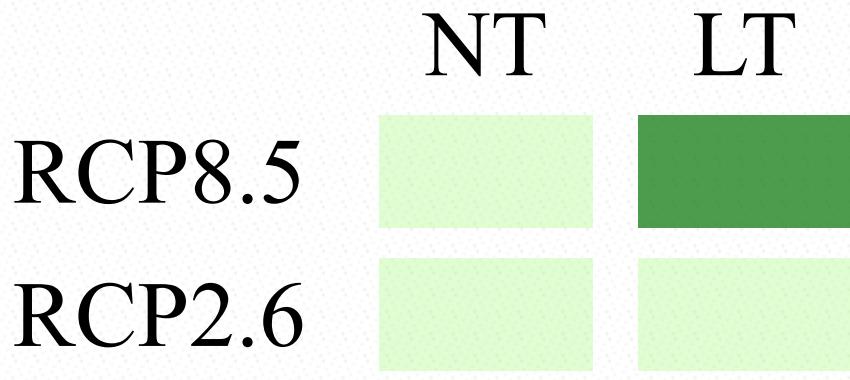
(f)



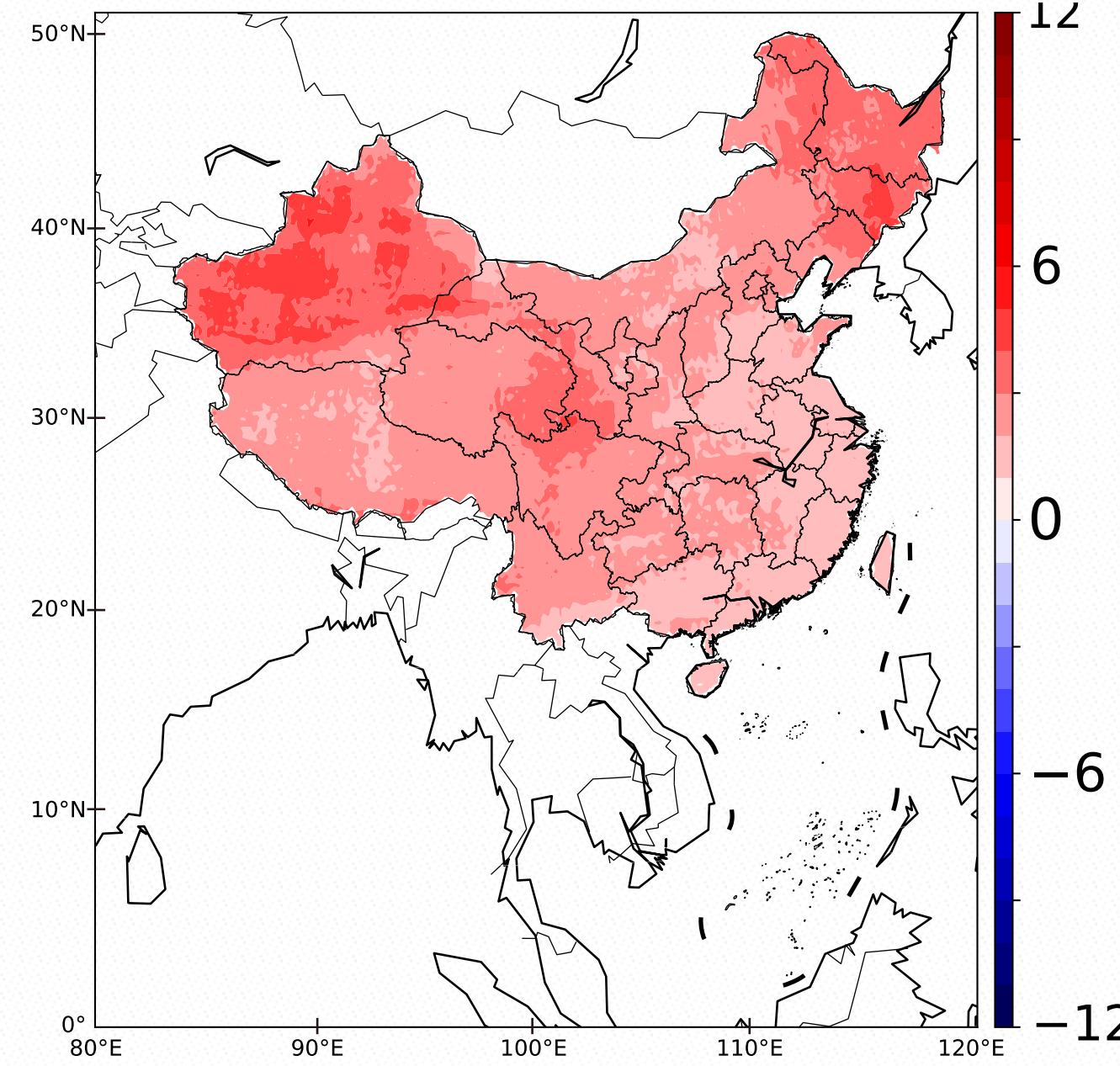


研究结果

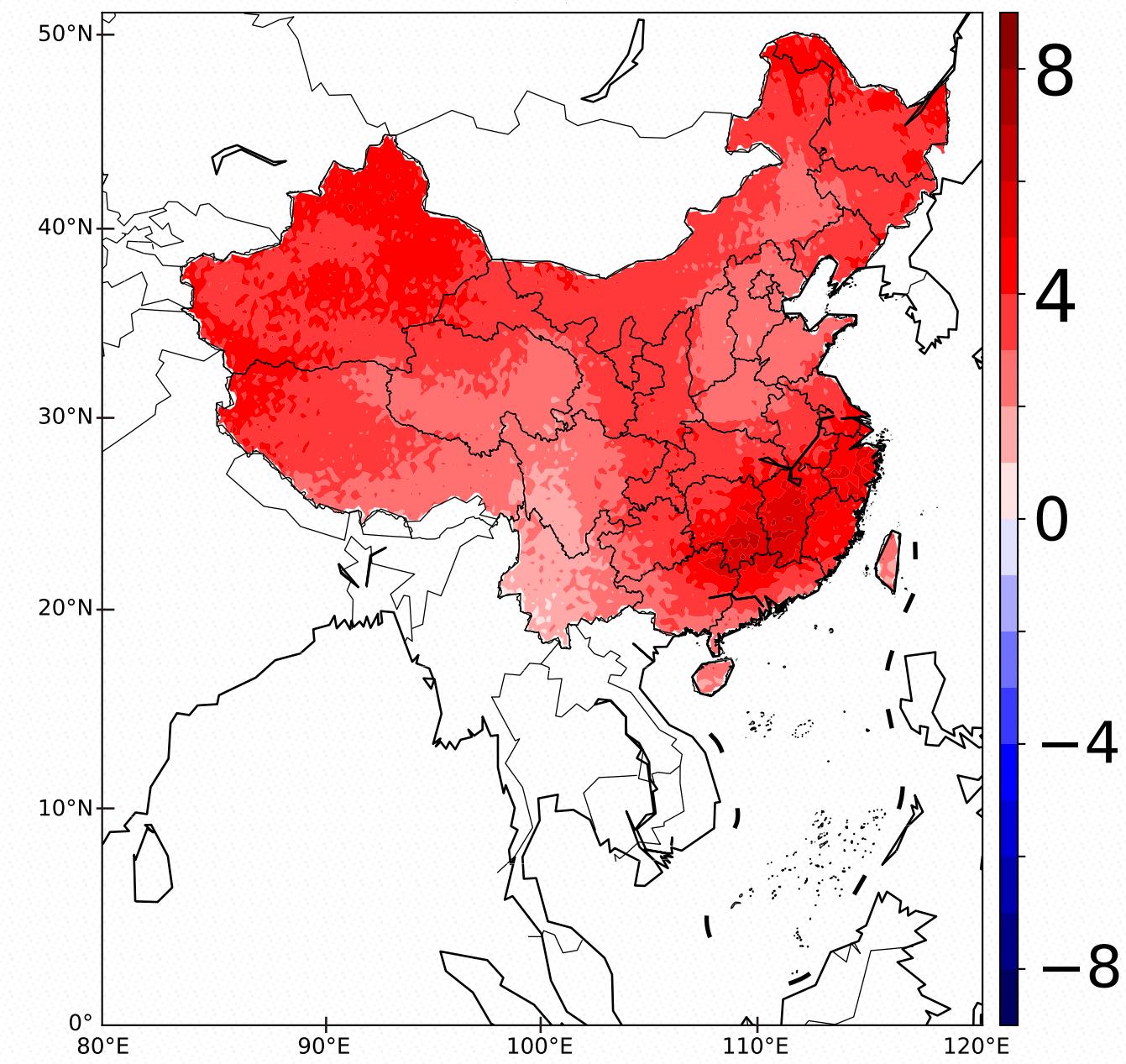
相较于NT时段，SD给出的本世纪末增温幅度更大，东北-华北-西南一线降水增加更显著



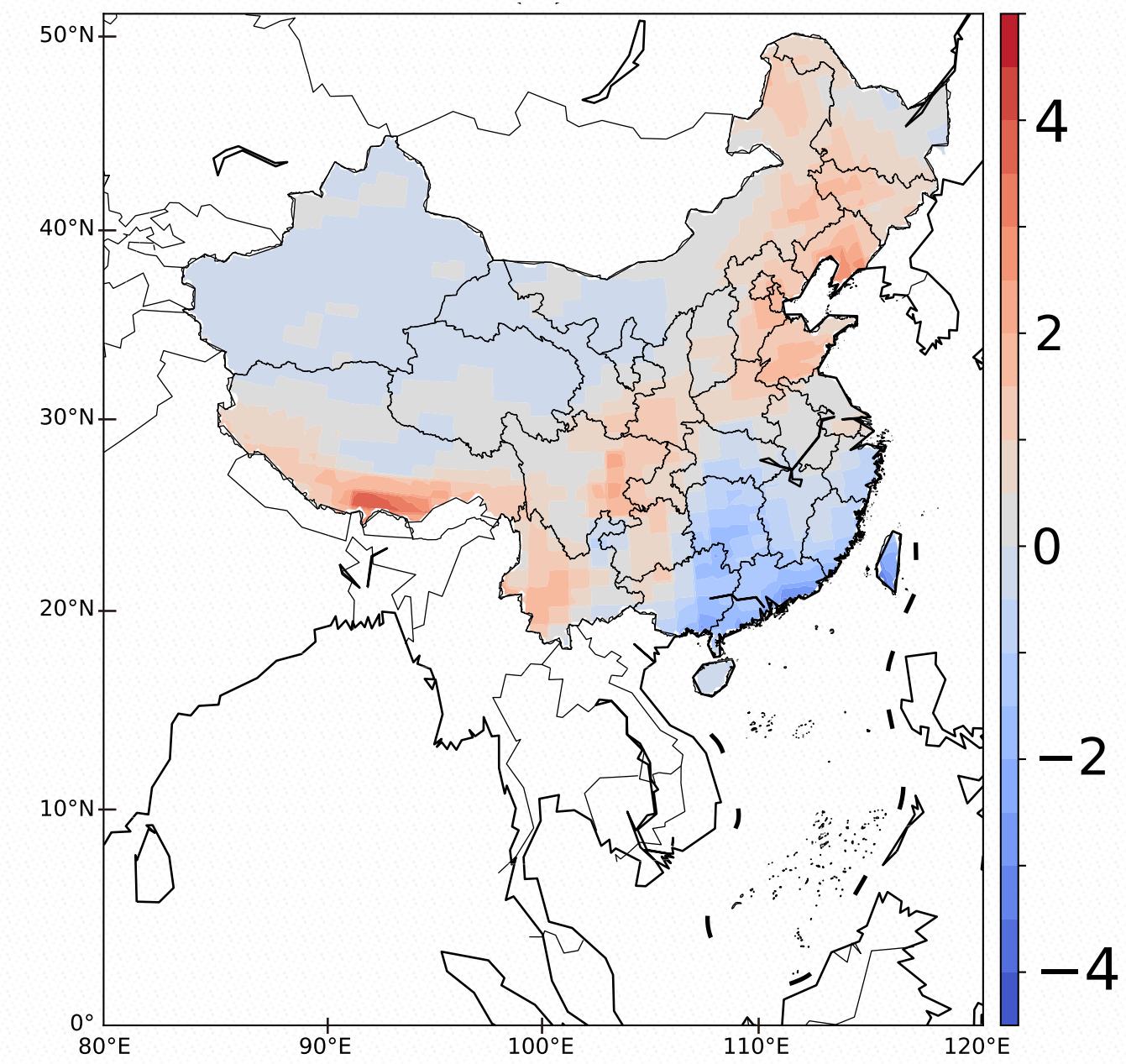
Tmin (January)



Tmax (July)

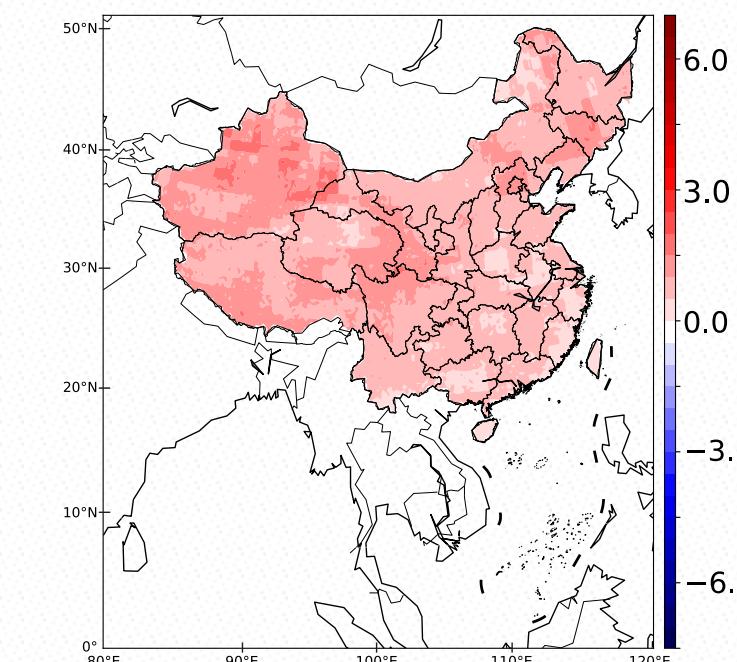


Pr (July)

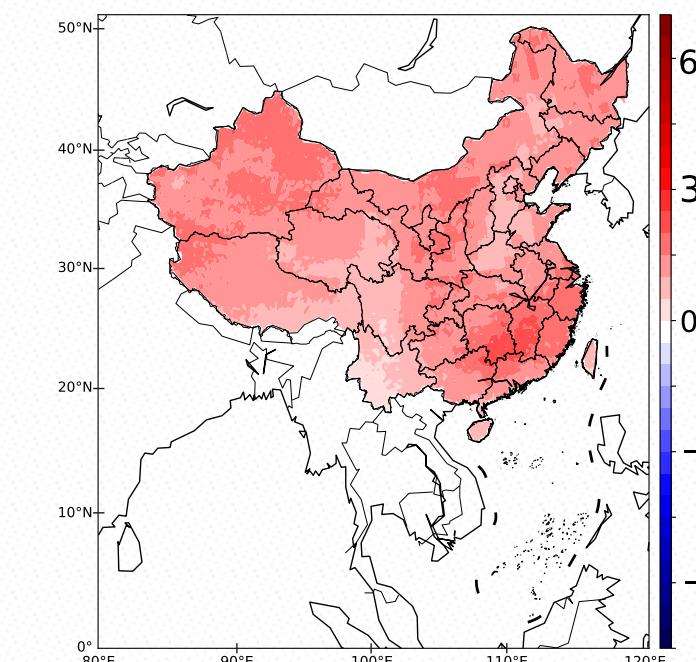


LT时段
SD

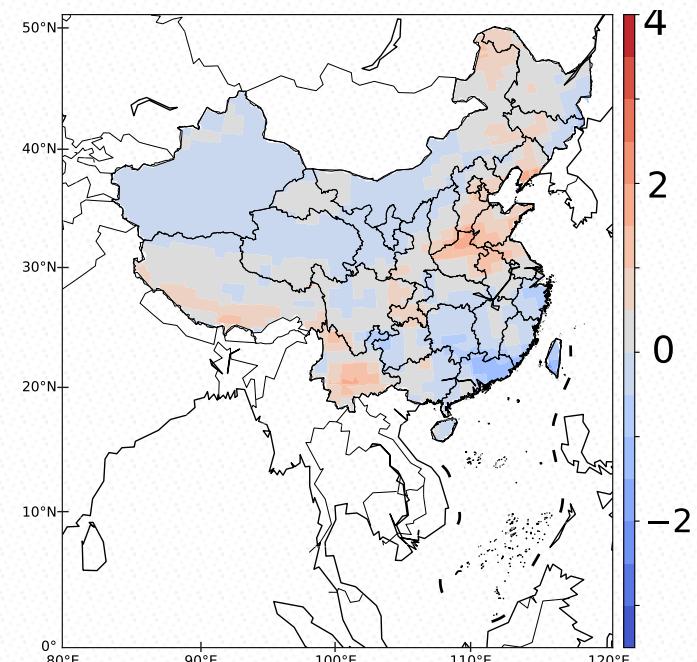
Tmin (January)



Tmax (July)



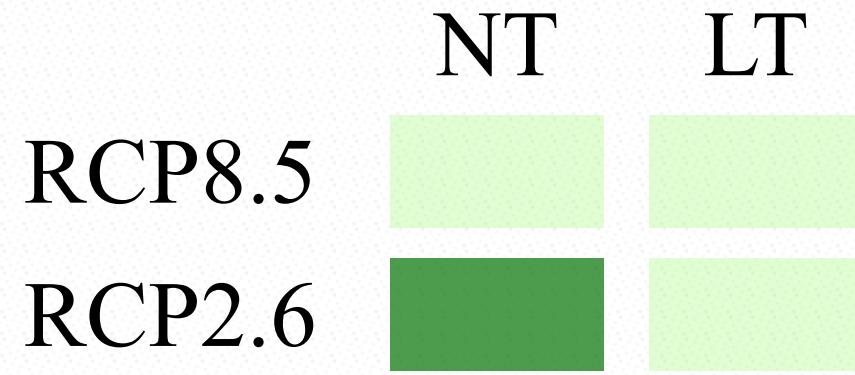
Pr (July)



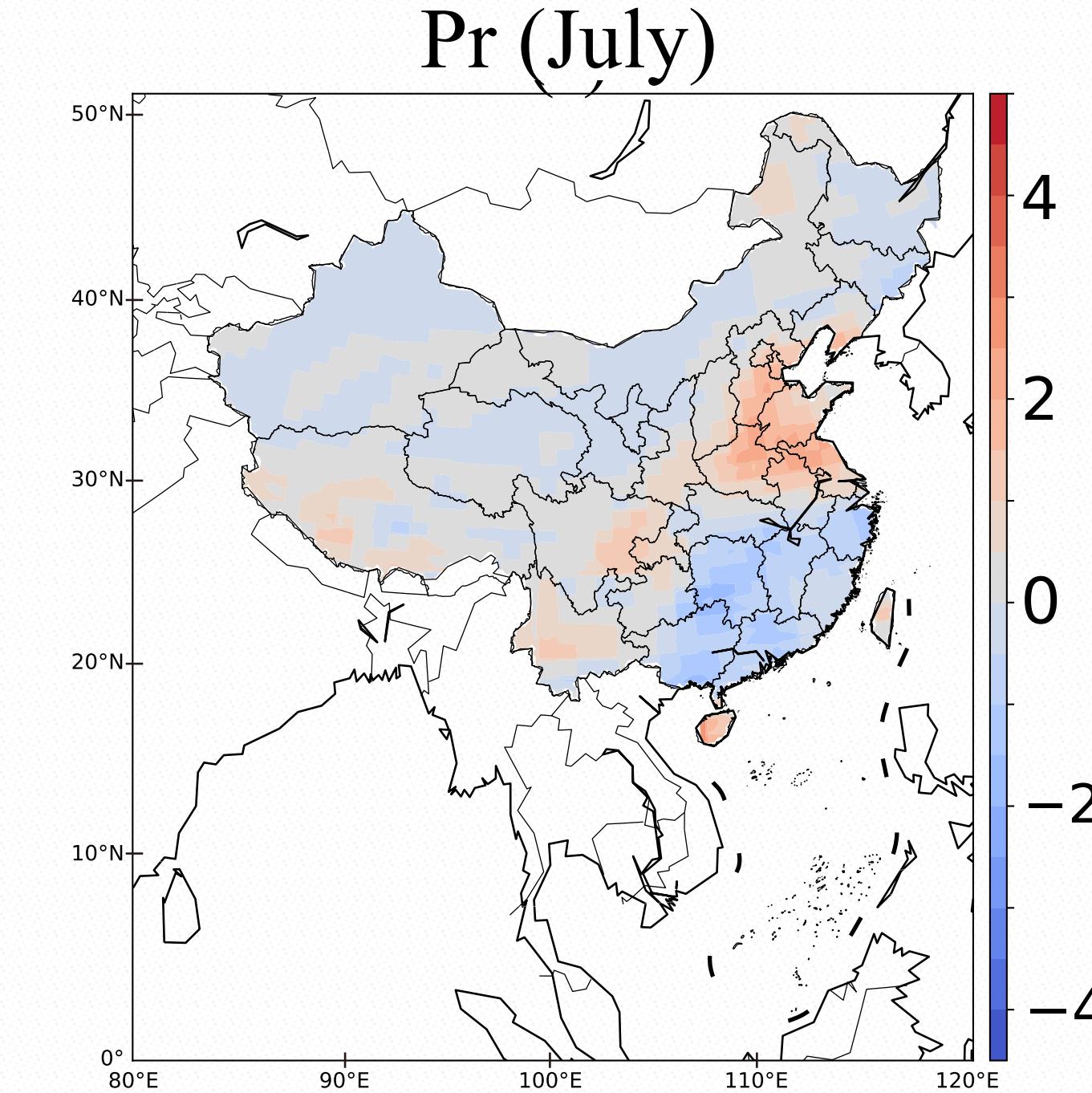
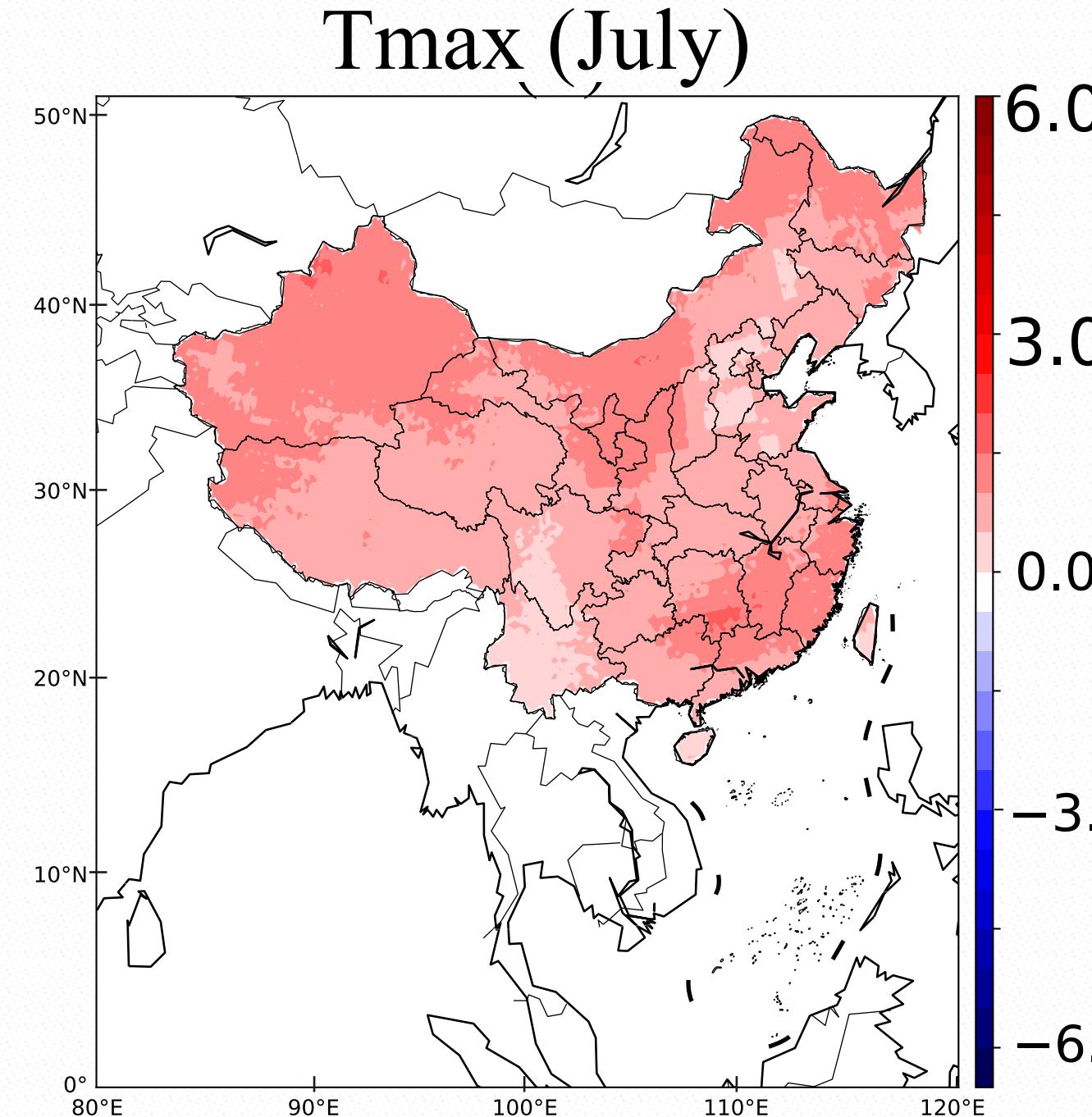
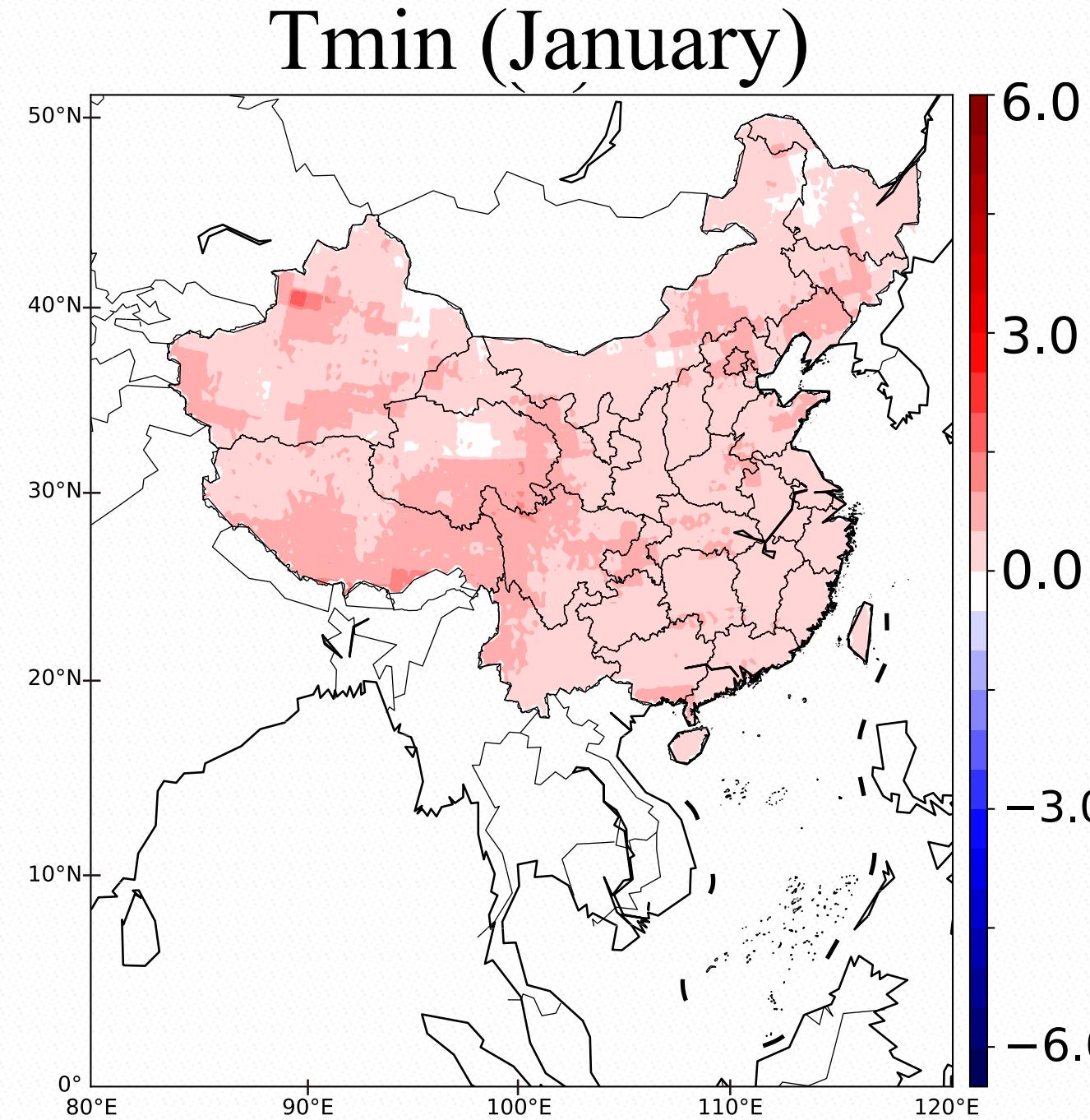


研究结果

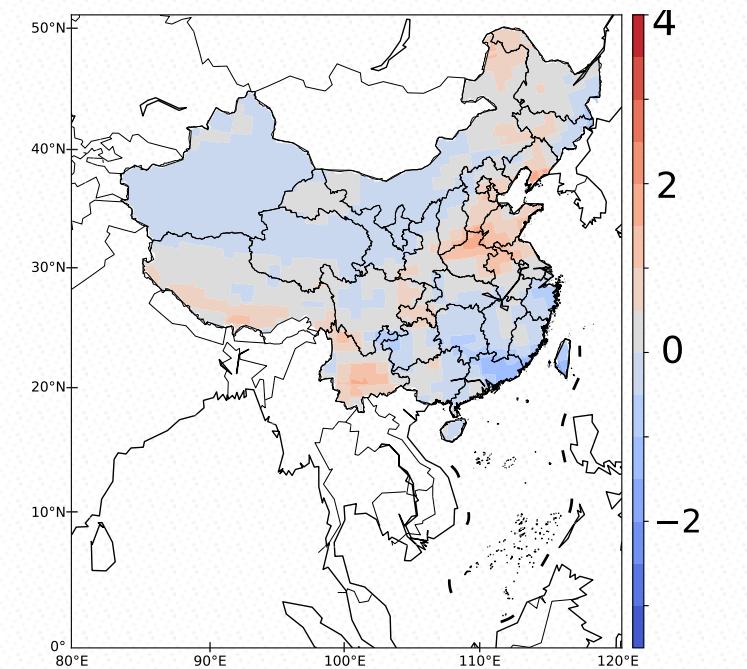
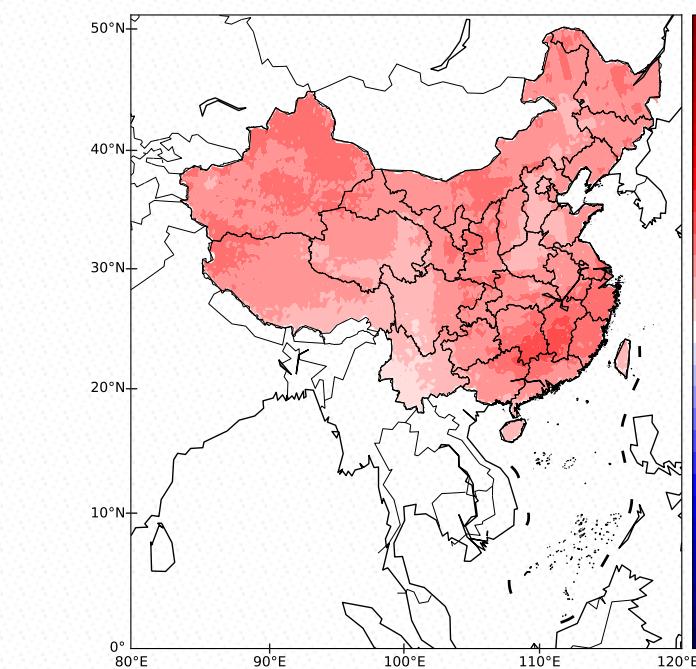
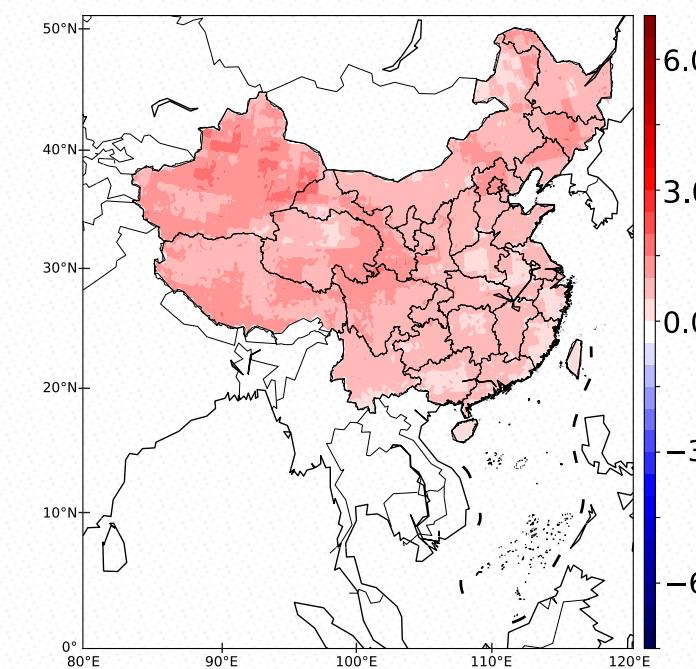
SD对增温幅度的估计比RCP8.5情景低1°C左右，
降水变化的估计几乎没有差异



RCP2.6
SD



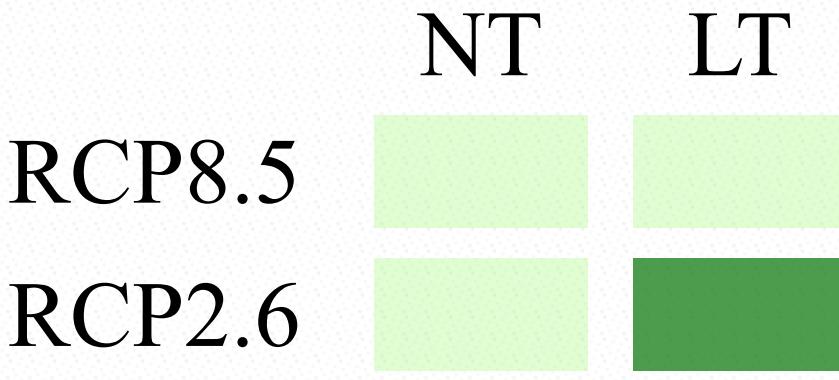
RCP8.5
SD





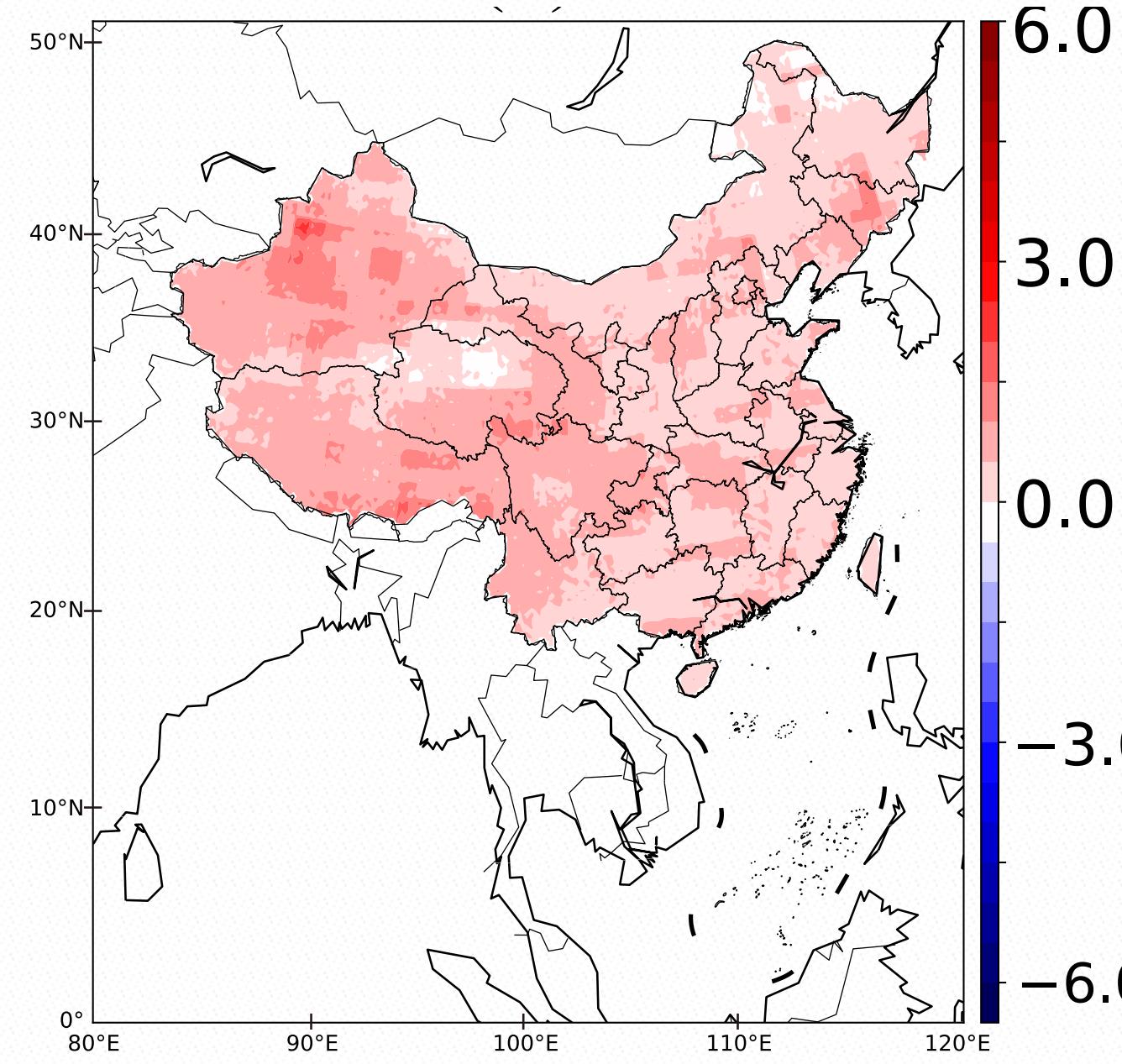
研究结果

SD对增温幅度的估计比RCP8.5情景低约3°C，对降水变化的估计和RCP8.5情景相比低约0.5mm/day

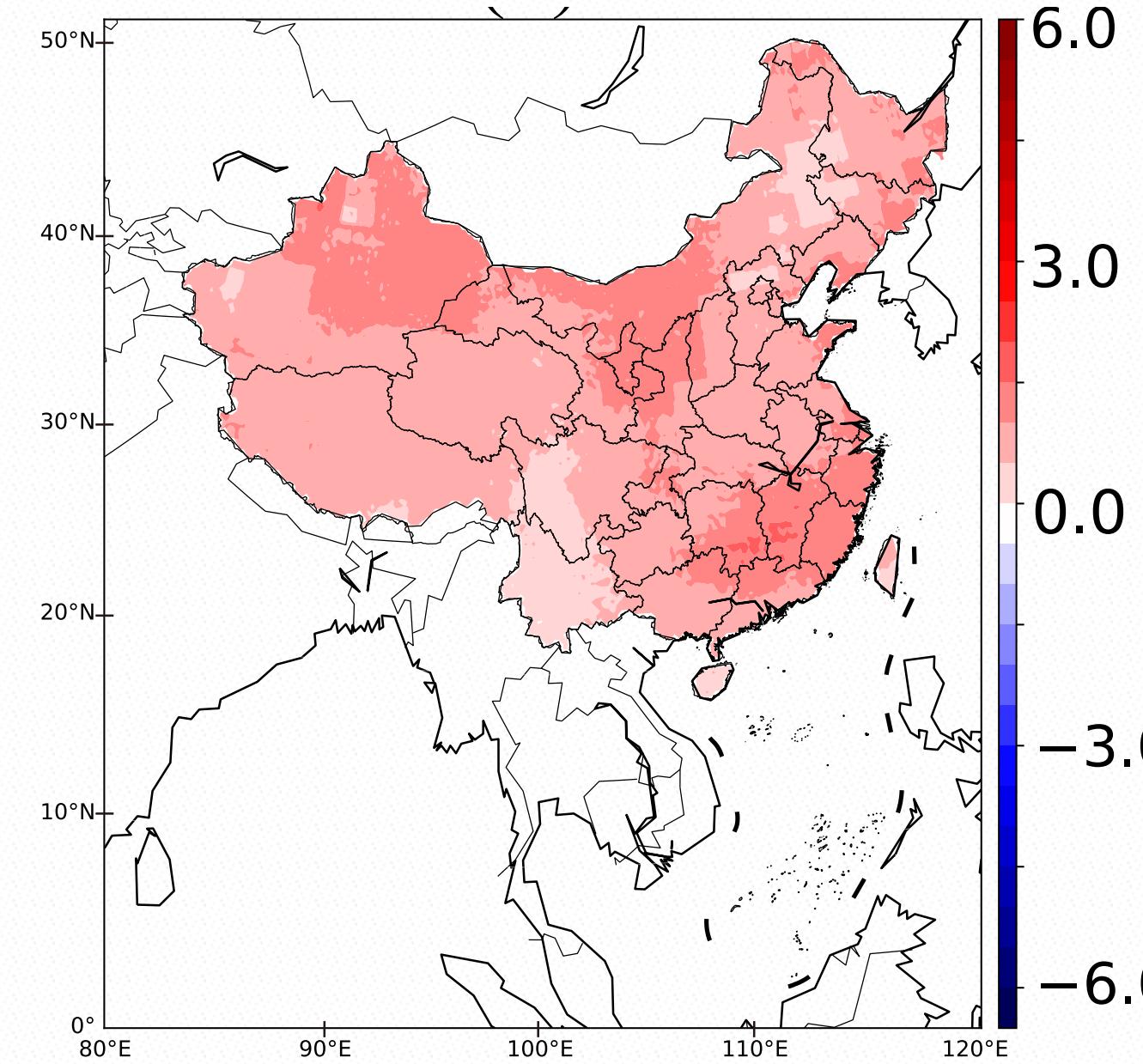


Tmin (January)

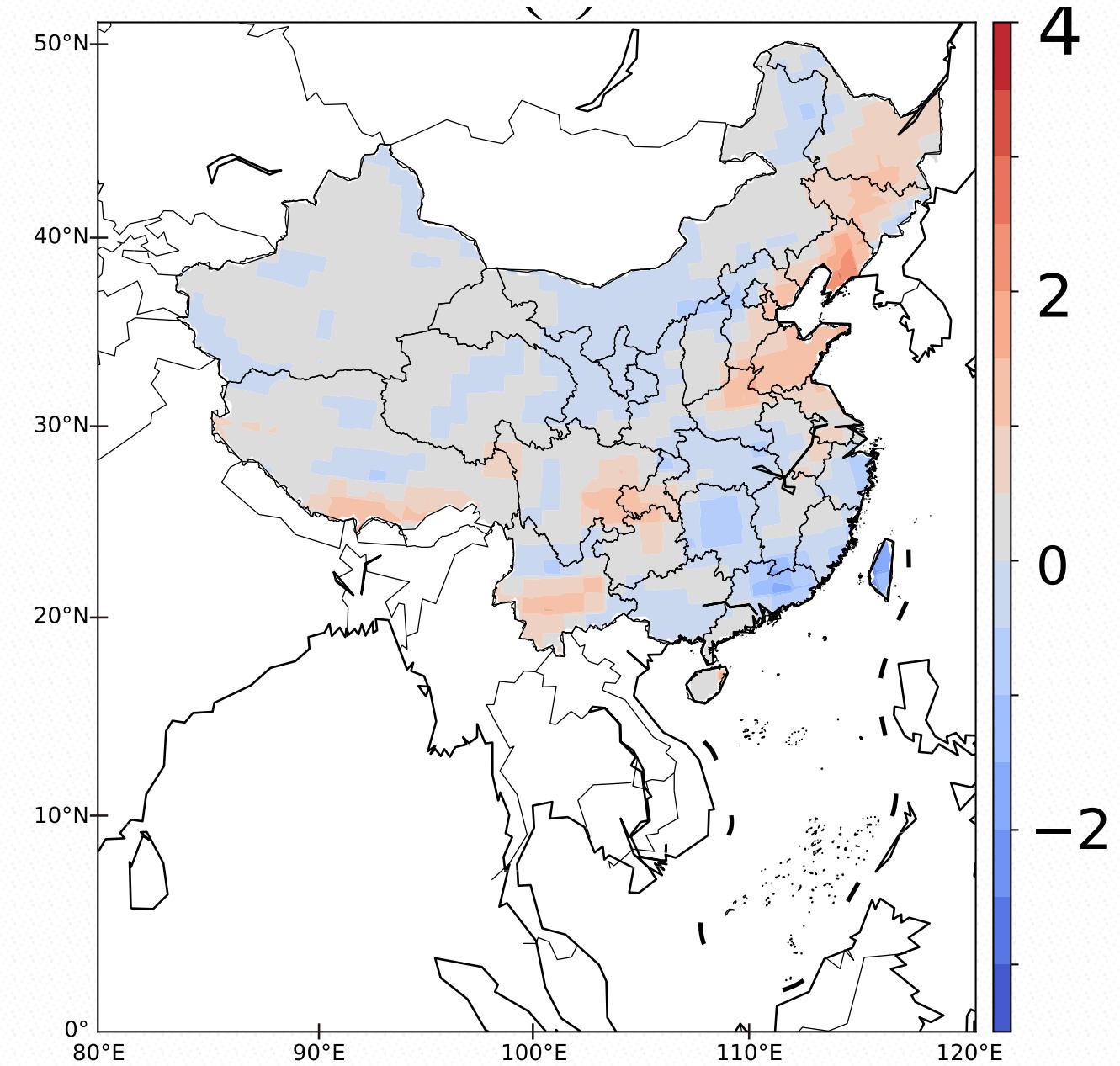
RCP2.6
SD



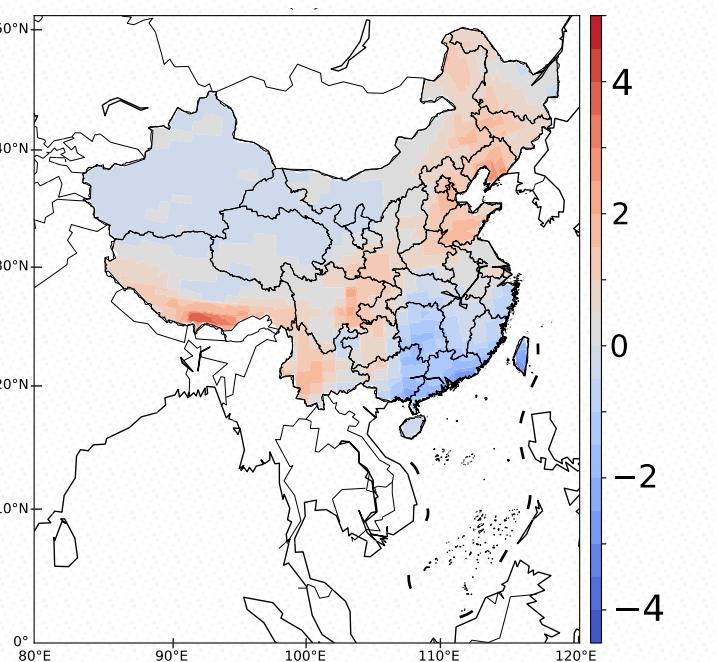
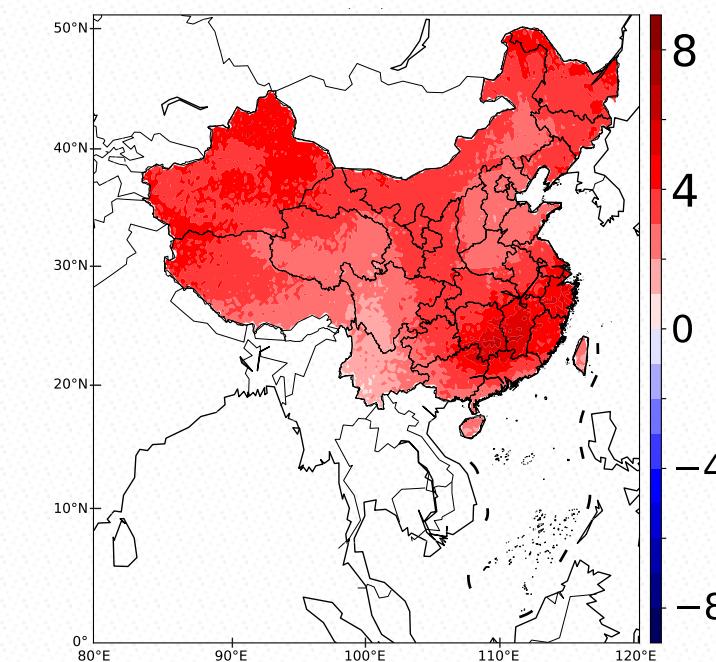
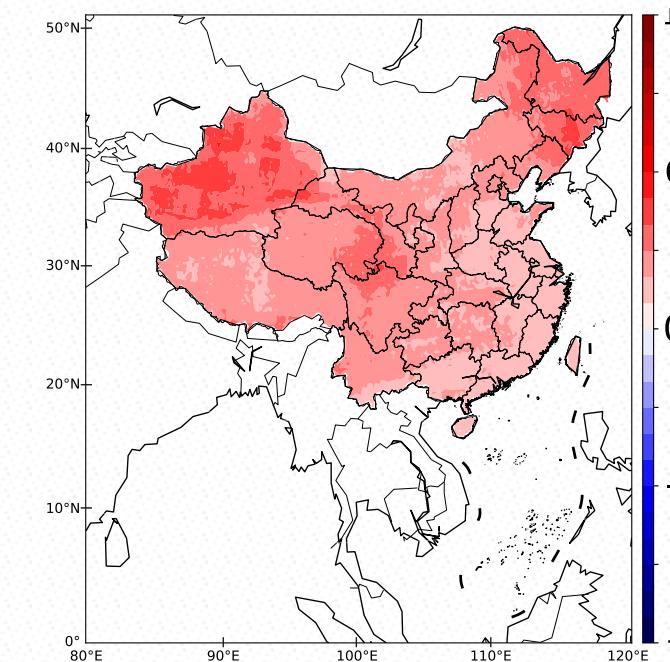
Tmax (July)



Pr (July)

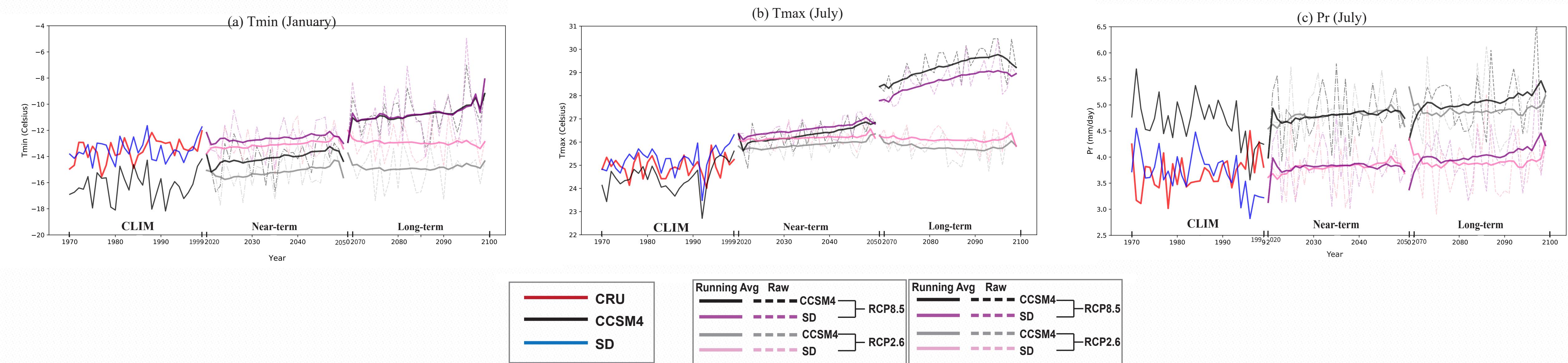


RCP8.5
SD





研究结果



全中国平均日最低温、日最高温和日降水量的时间序列



Part 04

结论与展望



结论

1. 成功发展了一套高时空分辨率的气候变化数据集(Statistical downscaling, SD);
2. 对于历史气候态, SD数据集相比于CMIP5 GCM的原始输出更接近观测, 温度和降水的气候态分布都得到显著改善;
3. 对于未来的气候预估, SD数据集总体上保留了CMIP5 GCM对未来气候变化趋势的估计, 并对幅度有微小修正, 进一步减少了CMIP5预估结果的不确定性。



展望

1. 尝试引入偏差更小的模式；
2. 后续研究可以增加对春季和秋季的讨论和分析；
3. 使用多模式平均的结果。

THANK YOU

