

图 1 全球气候模式CCSM4和格点观测数据GMFD分辨率对比

Fig. 1 The Comparison of CCSM4 and GMFD's grids

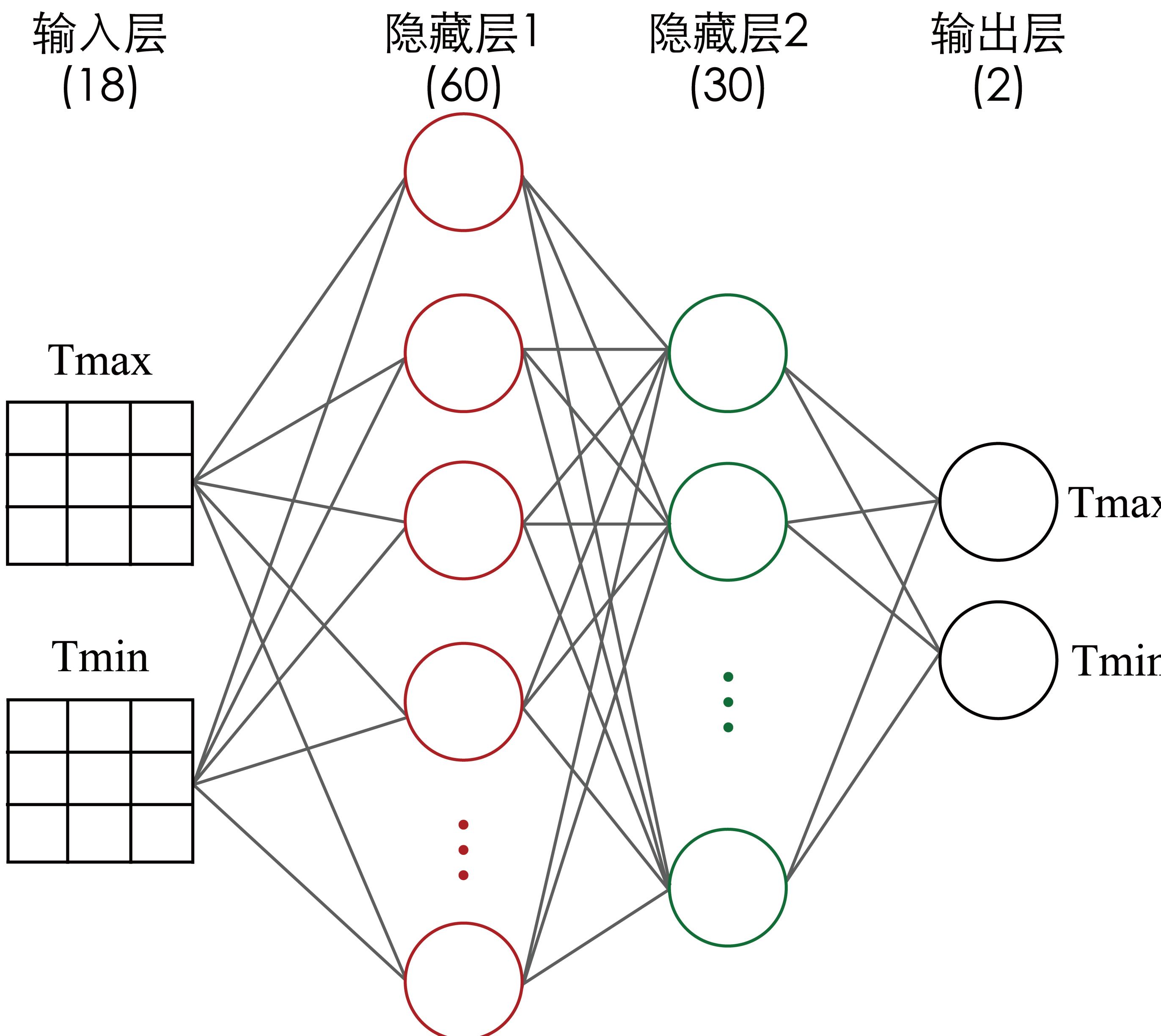
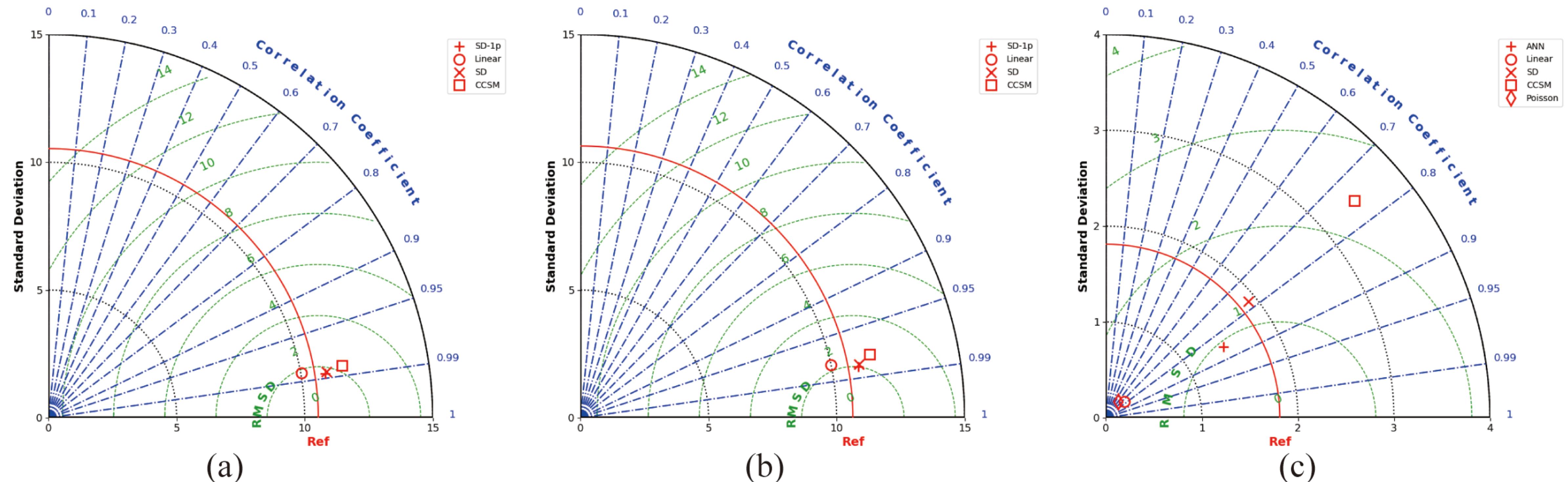


图 2 多层感知器神经网络结构

Fig. 2 The Architecture of MLP Regressor



(a) 1月日最低温; (b) 7月日最高温; (c) 7月日降水量。其中，径向坐标是标准差，角向坐标是相关系数。正十字是仅使用1个CCSM格点输入并进行偏差校正的方法，圆是多元线性回归方法，斜十字是SD方法，正方形是CCSM原始数据，菱形是泊松回归方法

图 3 日最低温、日最高温和日降水量在北京格点的不同统计降尺度方法泰勒图
Fig. 3 Taylor diagram for Tmin, Tmax, and precipitation in Beijing

表 1 全国平均日最低温、日最高温和日降水量在训练集上的表现

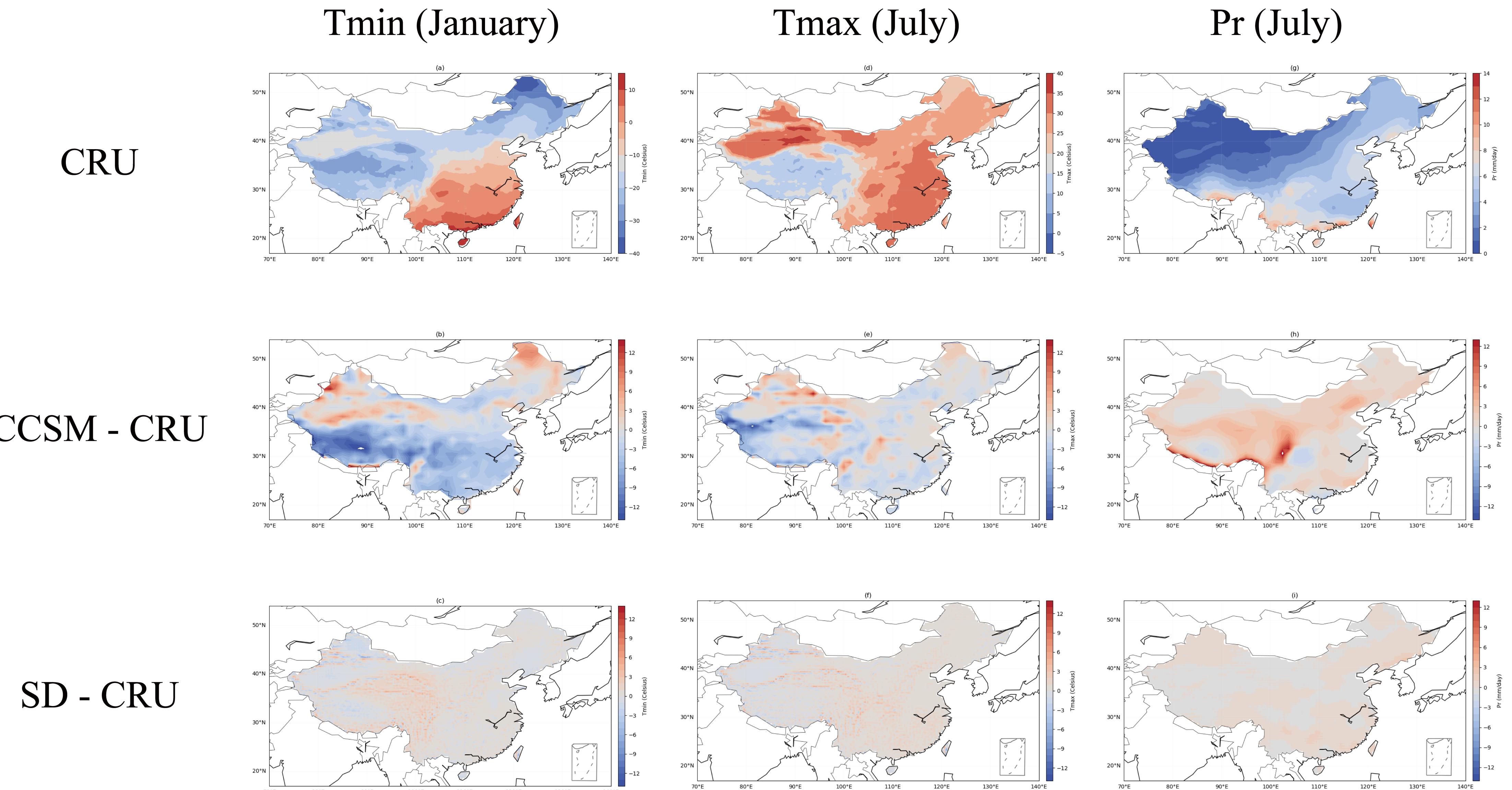
Table 1 The statistics of Tmin, Tmax, and precipitation of China on training samples

	Tmax			Tmin			Pr		
	OBS	CCSM	SD	OBS	CCSM	SD	OBS	CCSM	SD
Mean	25.05	24.56	25.25	-13.79	-16.38	-13.62	3.66	4.64	3.67
StdDev	0.43	0.73	0.66	1.10	1.12	0.86	0.33	0.47	0.42
RMSE	N/A	0.91	0.73	N/A	2.98	1.28	N/A	1.17	0.59

表 2 全国平均日最低温、日最高温和日降水量在验证集上的表现

Table 2 The statistics of Tmin, Tmax, and precipitation of China on validation samples

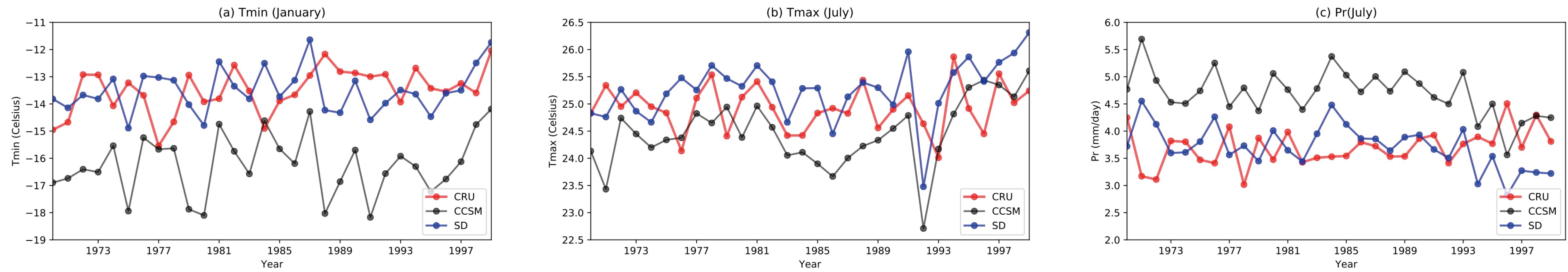
	Tmax			Tmin			Pr		
	OBS	CCSM	SD	OBS	CCSM	SD	OBS	CCSM	SD
Mean	25.17	24.52	25.21	-13.89	-16.17	-13.70	3.69	4.68	3.74
StdDev	0.56	0.69	0.59	0.85	0.88	0.71	0.22	0.40	0.34
RMSE	N/A	0.89	0.55	N/A	2.49	1.01	N/A	1.09	0.44



第一列(a-c)是1月日最低温，第二列(d-f)是7月日最高温，第三列(g-i)是7月日降水量。第一行(a, d, g)是1970-1999年平均CRU气候态；第二行(b, e, h)是CCSM4和CRU的差值；第三行(c, f, i)是SD和CRU的差值

图 4 1970-1999年平均日最低温、日最高温和日降水量空间分布

Fig. 4 The spatial distribution of Tmin, Tmax, and precipitation in 1970-1999



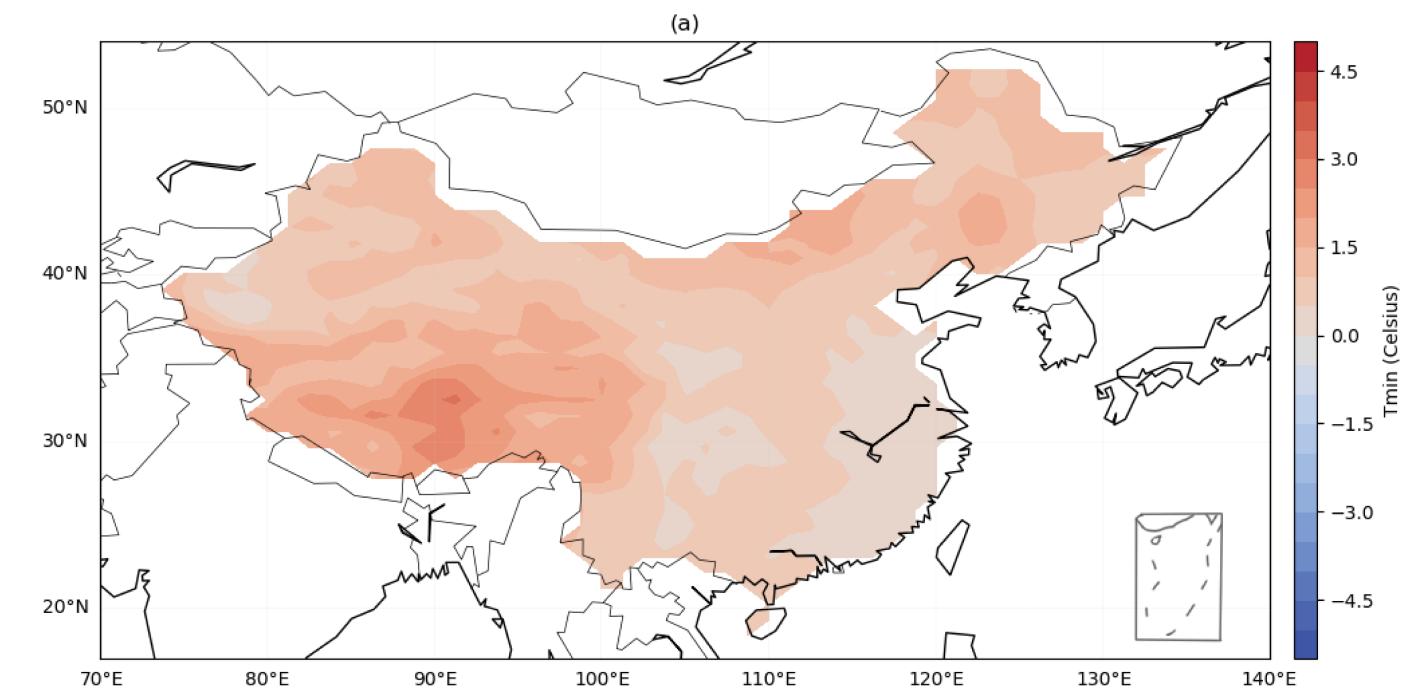
(a) 1970-1999年中国所有格点加权平均后1月日最低温时间序列；(b) 1970-1999年中国所有格点加权平均后7月日最高温时间序列；
(c) 1970-1999年中国所有格点加权平均后7月日降水量时间序列。其中，红色实线是CRU，黑色实线是CCSM4，蓝色实线是SD

图 5 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

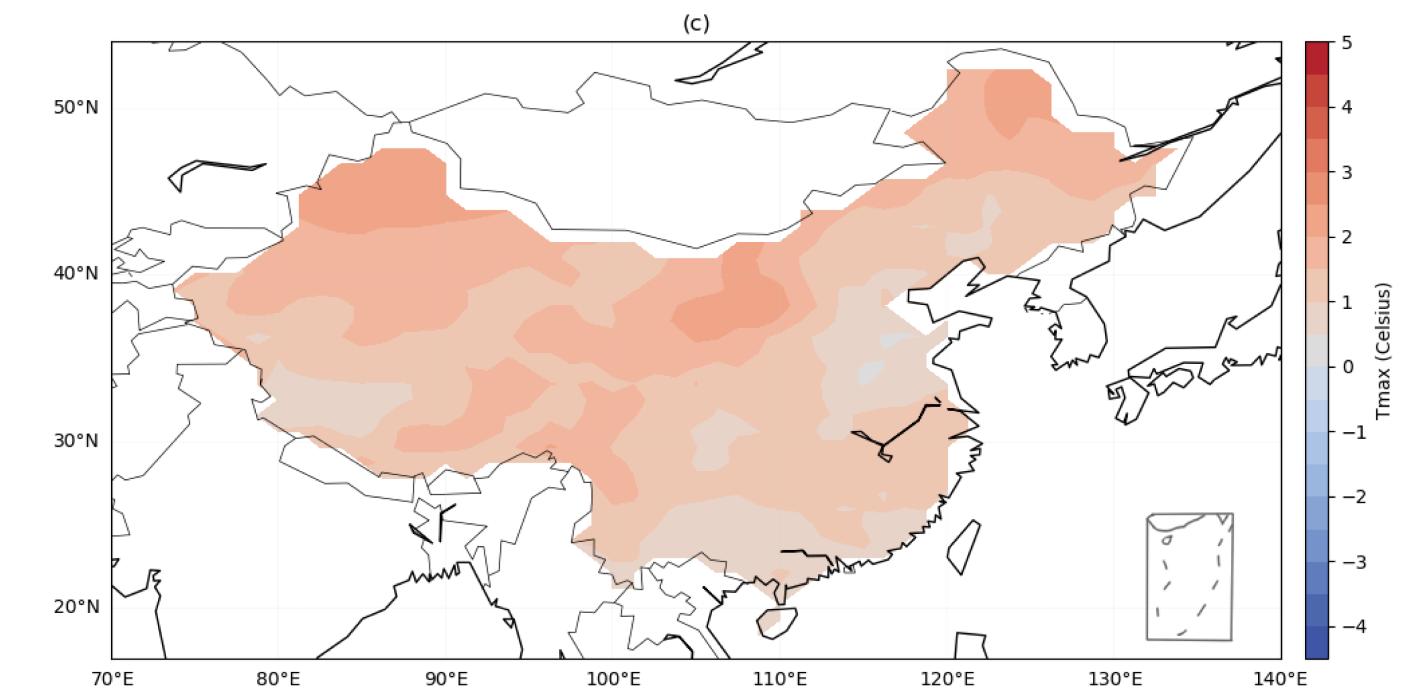
Fig. 5 The time series of China's Tmin, Tmax, and precipitation in 1970-1999

CCSM

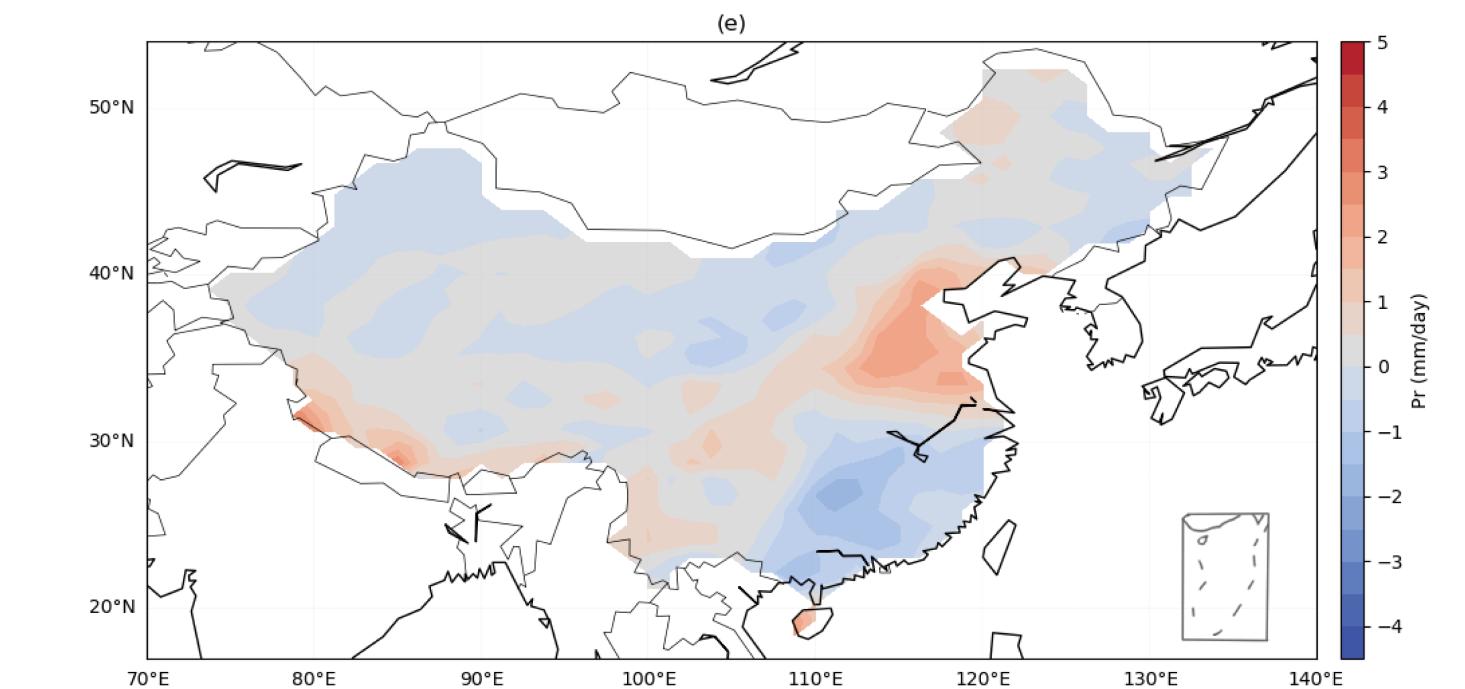
Tmin (January)



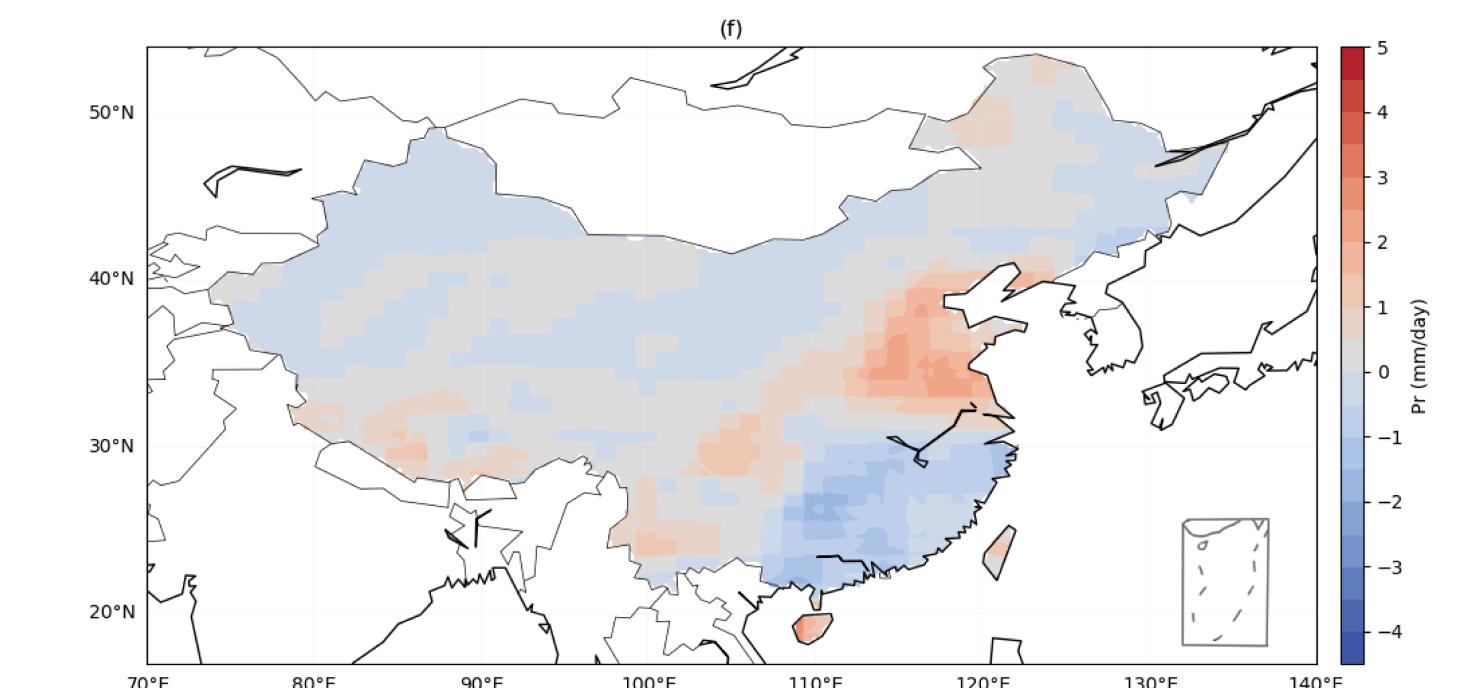
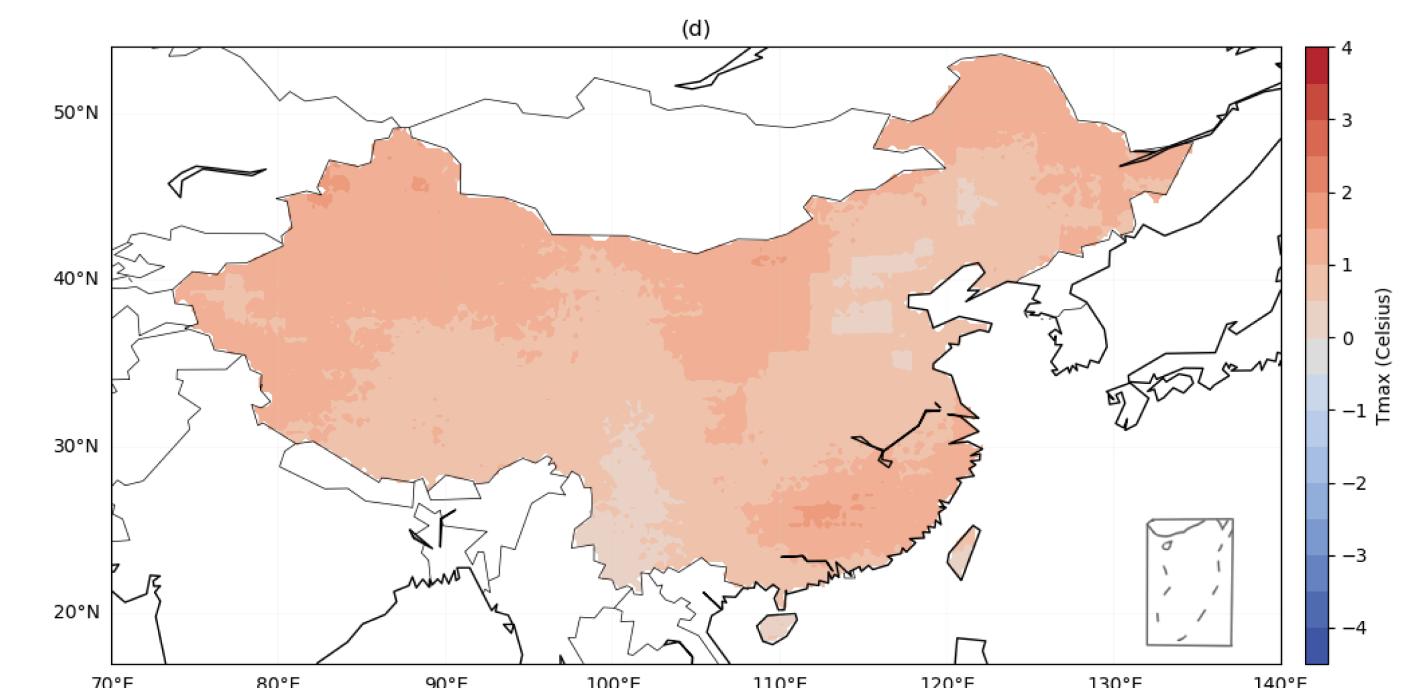
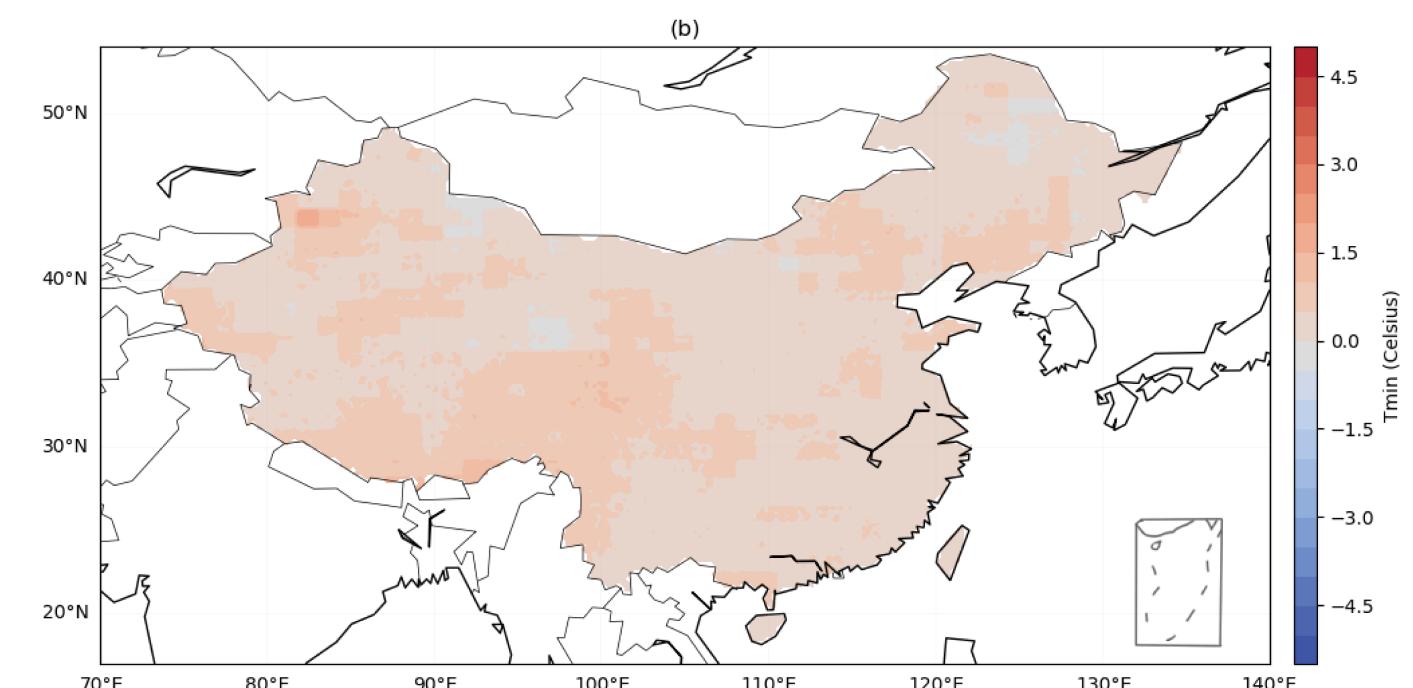
Tmax (July)



Pr (July)



SD



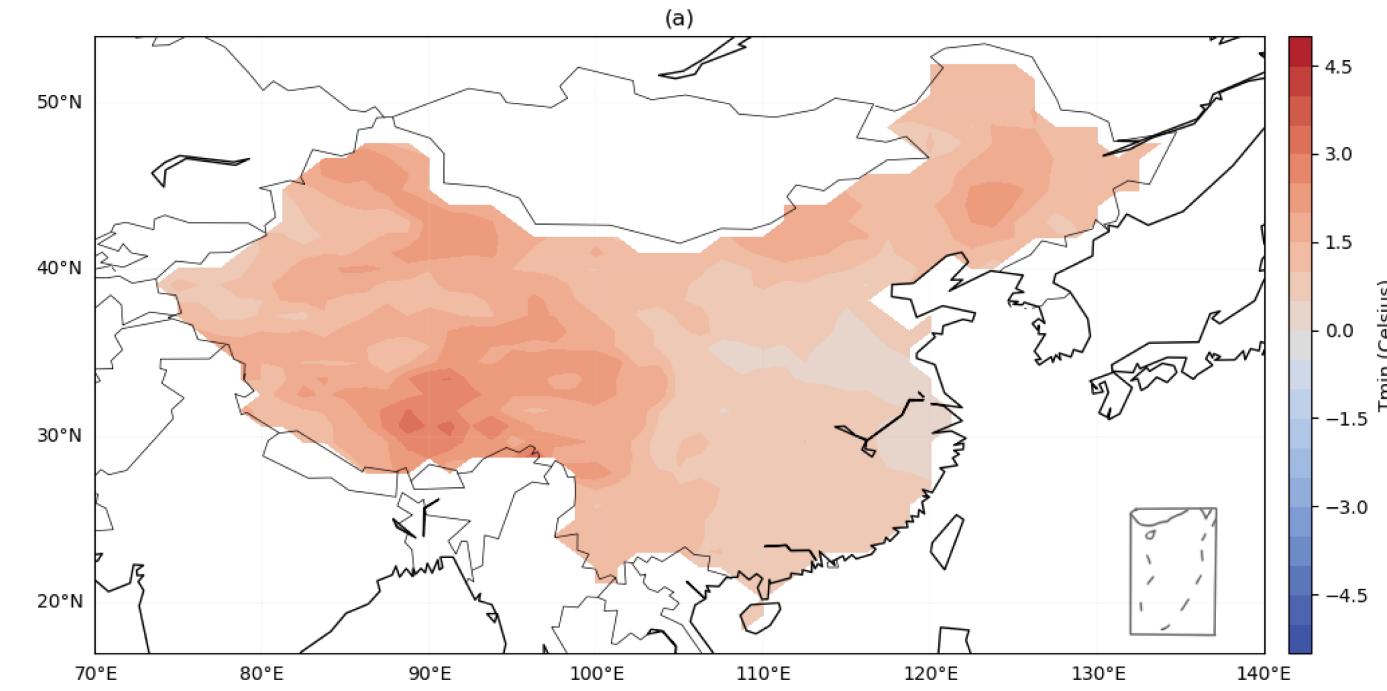
第一列(a-b)是1月日最低温；第二列(c-d)是7月日最高温；第三列(e-f)是7月日降水量。第一行(a, c, e)是CCSM4在近未来时段(2020-2049)与历史气候态(1970-1999)的差值；第二行(b, d, f)是SD在近未来时段(2020-2049)与历史气候态(1970-1999)的差值

图 6 RCP2.6情景中，近未来时段(2020-2049年)相对于历史气候态(1970-1999年)日最低温、日最高温和日降水量的变化

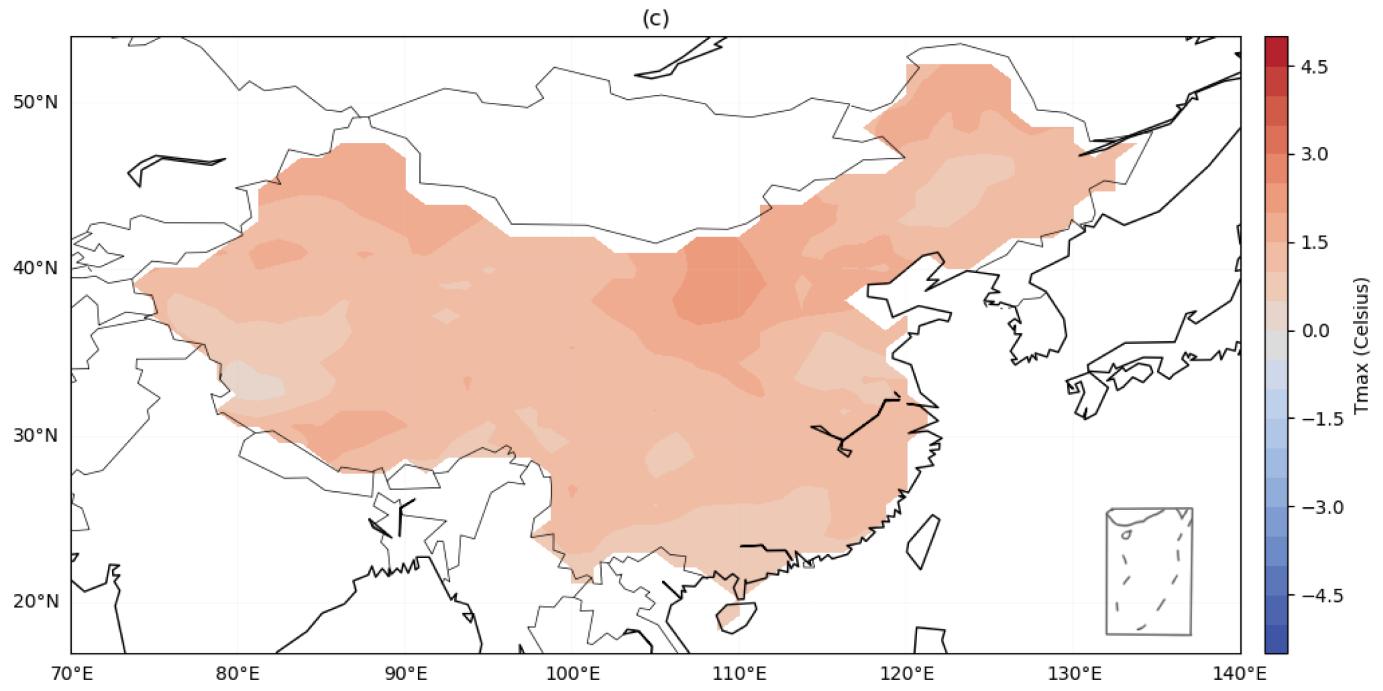
Fig. 6 The differences of Tmin, Tmax, and precipitation between near-term future (2020-2049) and historical climatology (1970-1999) in RCP2.6 scenario

CCSM

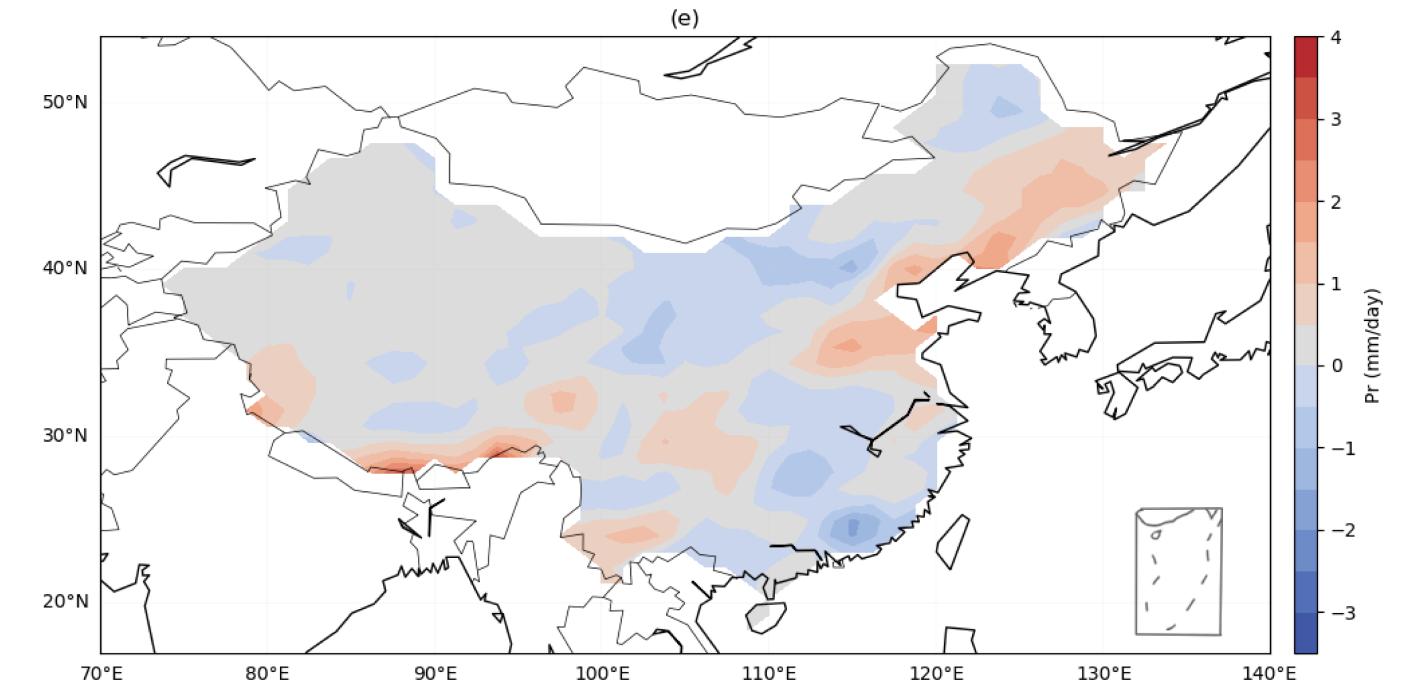
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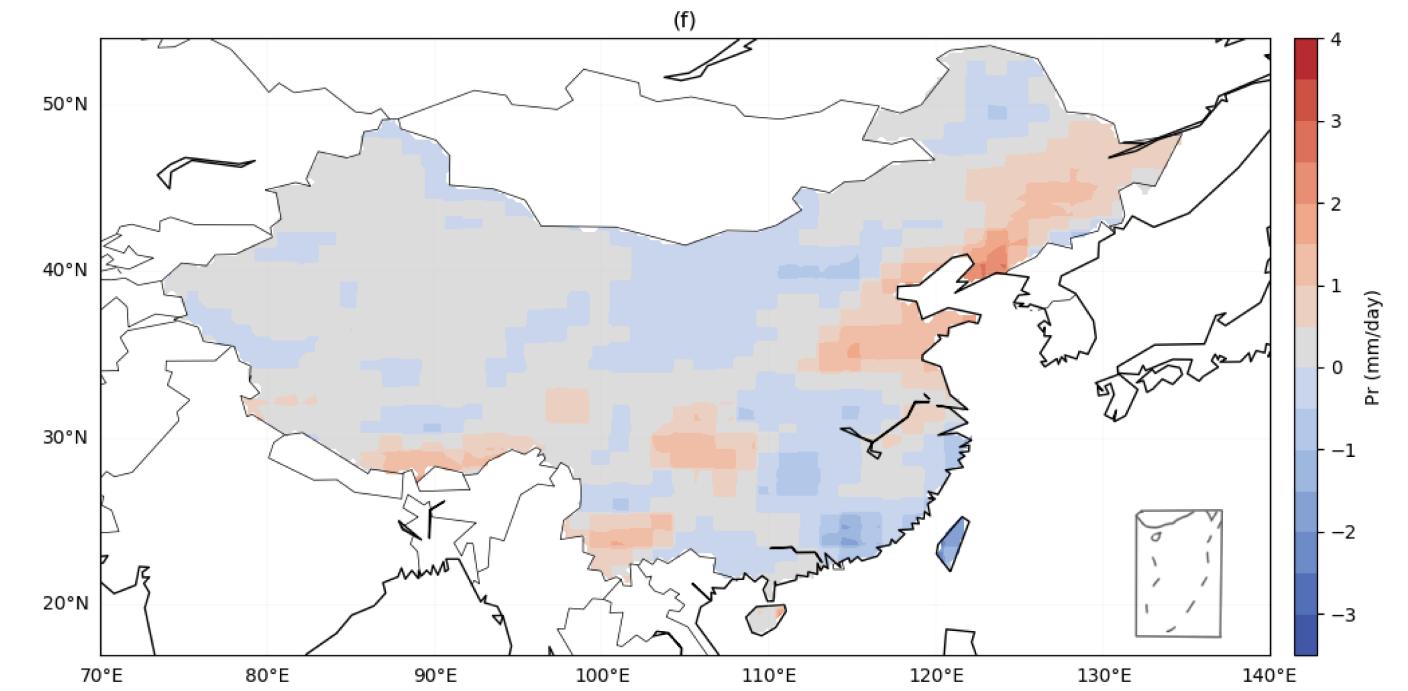
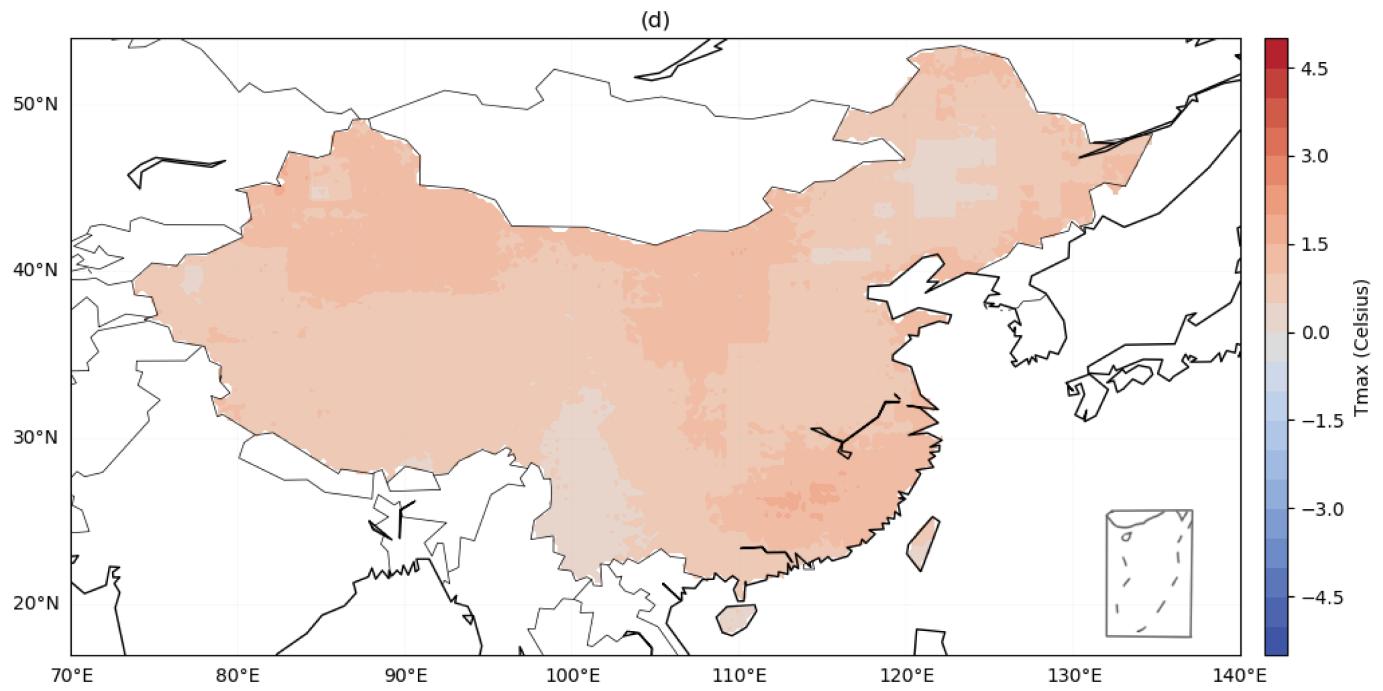
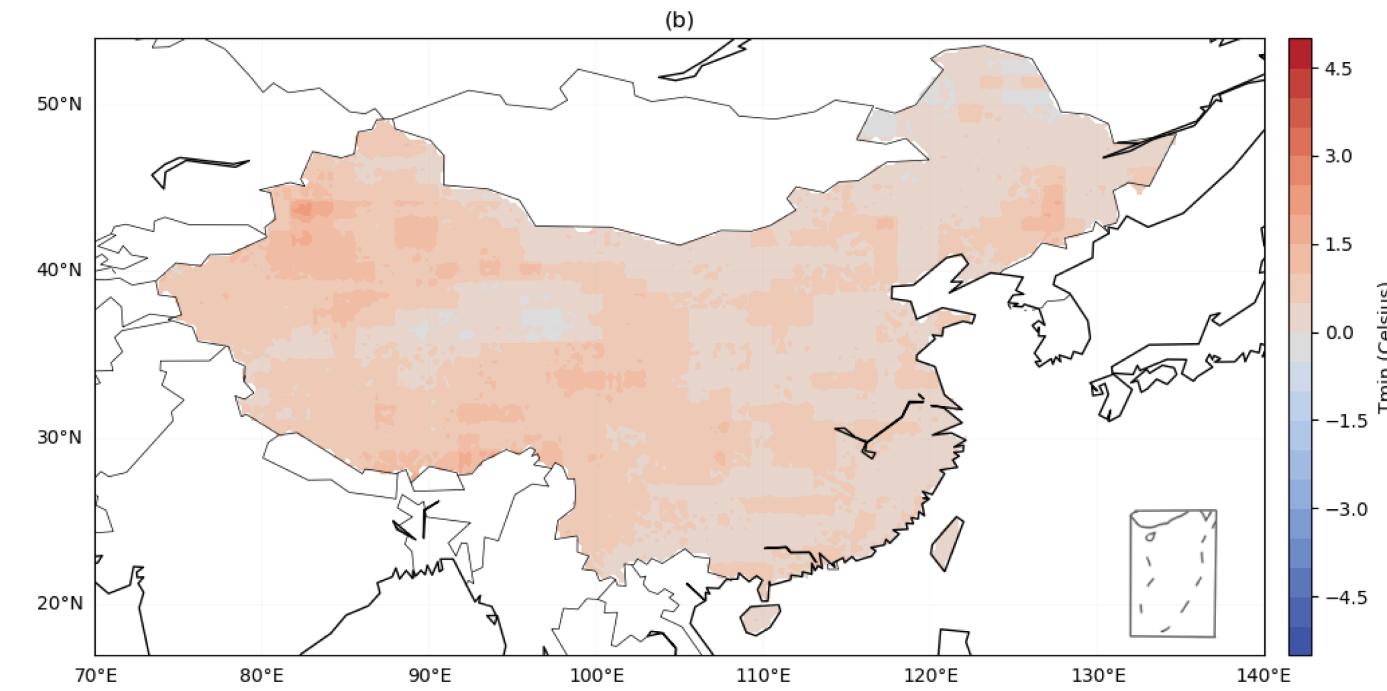
Tmax (July)



Pr (July)



SD



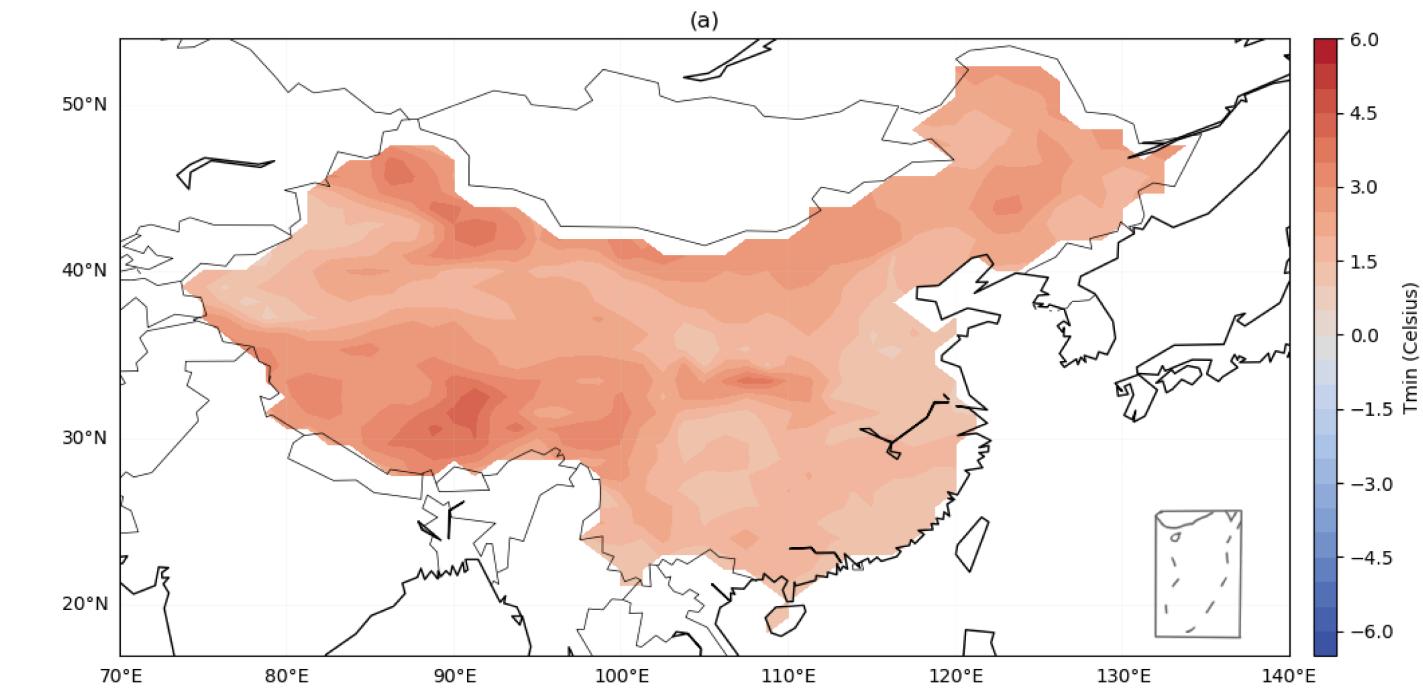
第一列(a-b)是1月日最低温；第二列(c-d)是7月日最高温；第三列(e-f)是7月日降水量。第一行(a, c, e)是CCSM4在远未来时段(2070-2099)与历史气候态(1970-1999)的差值；第二行(b, d, f)是SD在远未来时段(2070-2099)与历史气候态(1970-1999)的差值

图 7 RCP2.6情景中，远未来时段(2070-2099年)相对于历史气候态(1970-1999年)日最低温、日最高温和日降水量的变化

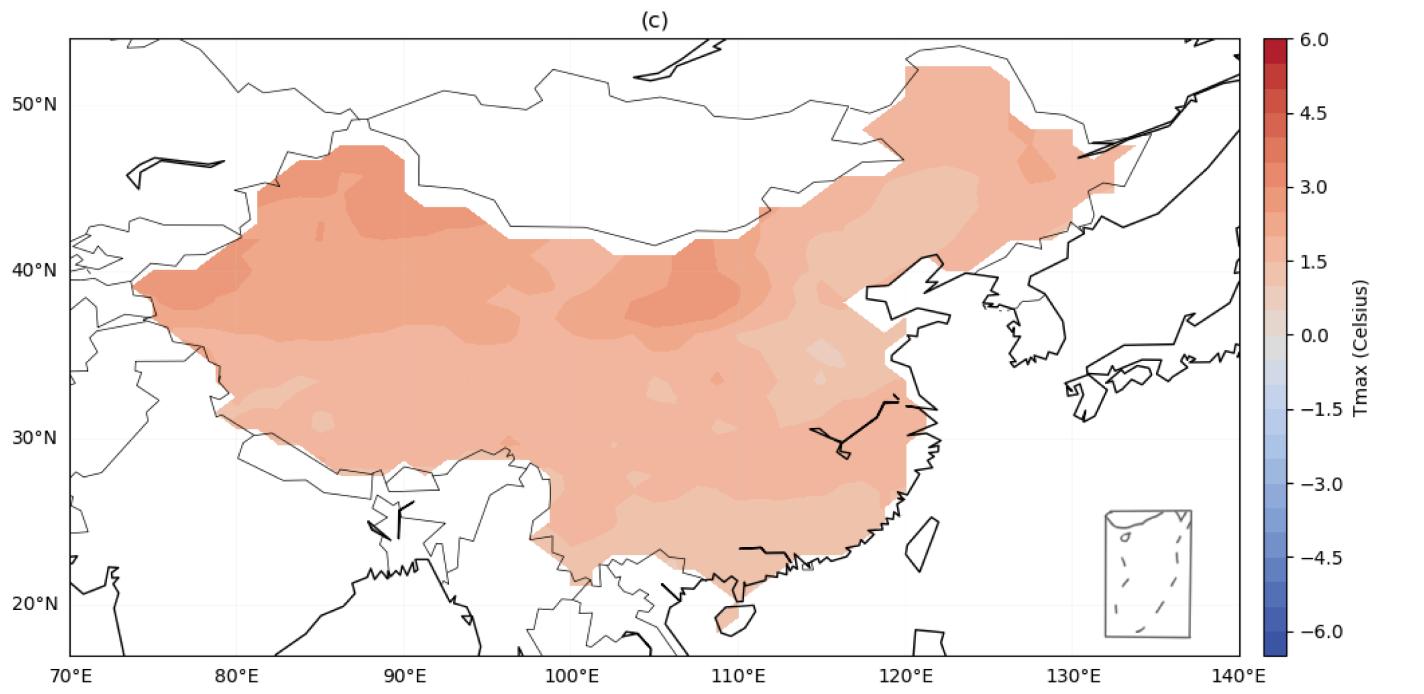
Fig. 7 The differences of Tmin, Tmax, and precipitation between near-term future (2070-2099) and historical climatology (1970-1999) in RCP2.6 scenario

CCSM

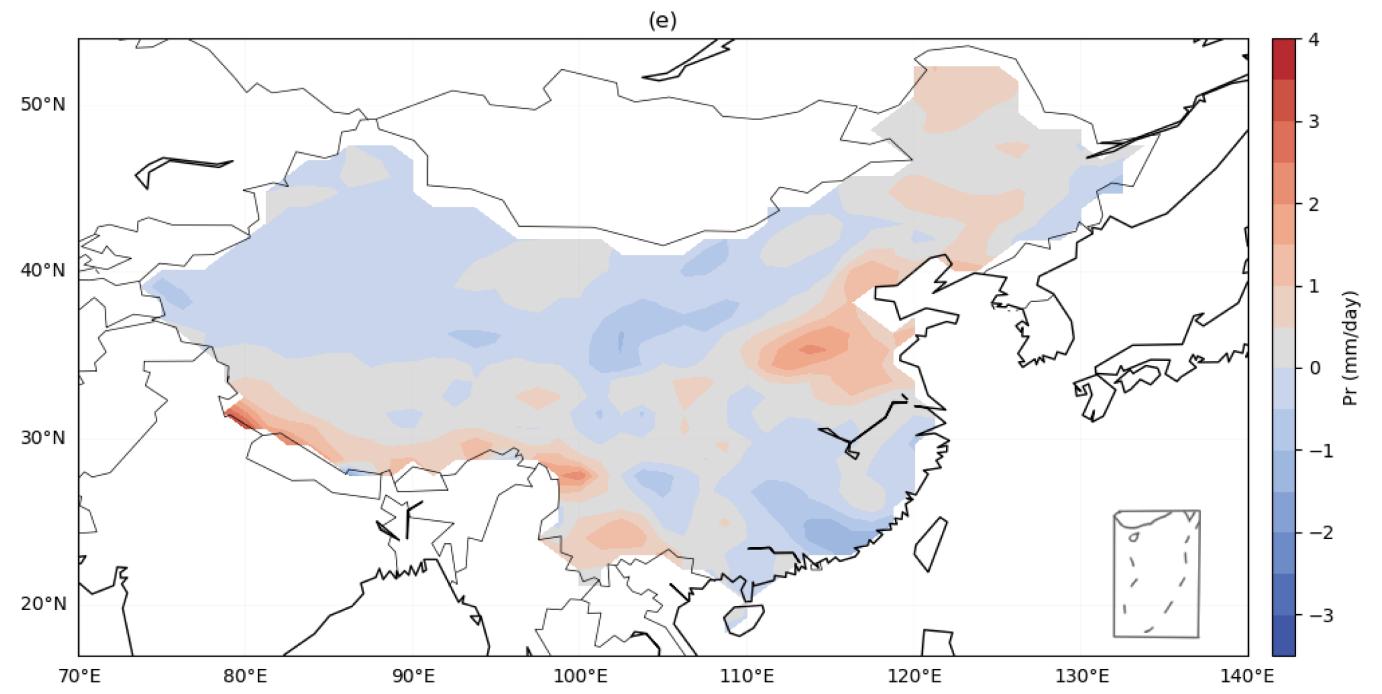
Tmin (January)



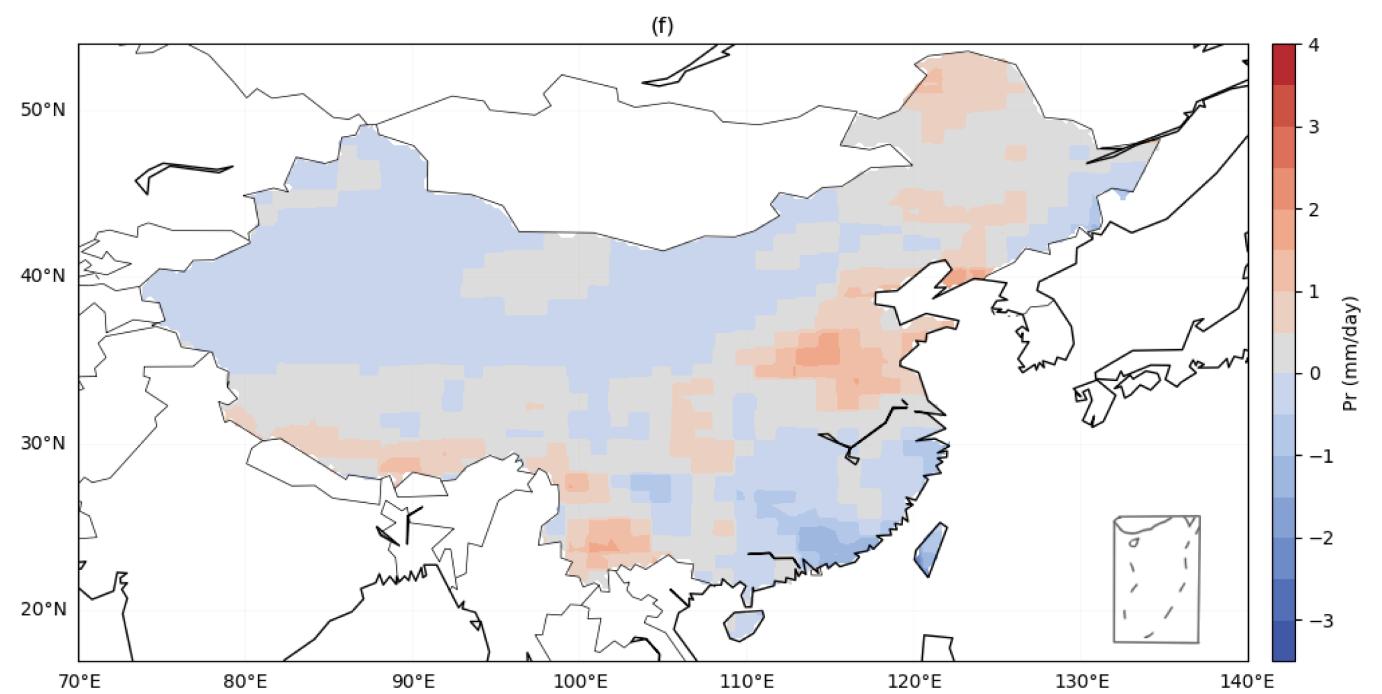
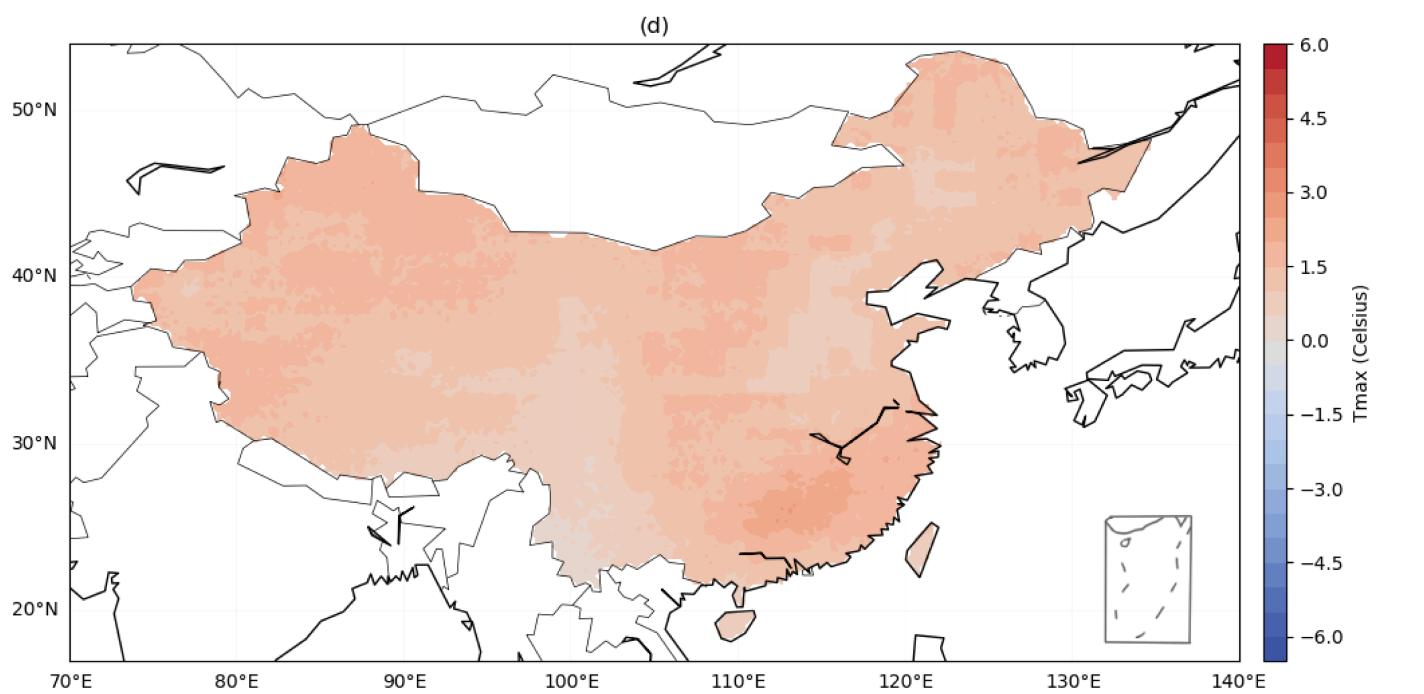
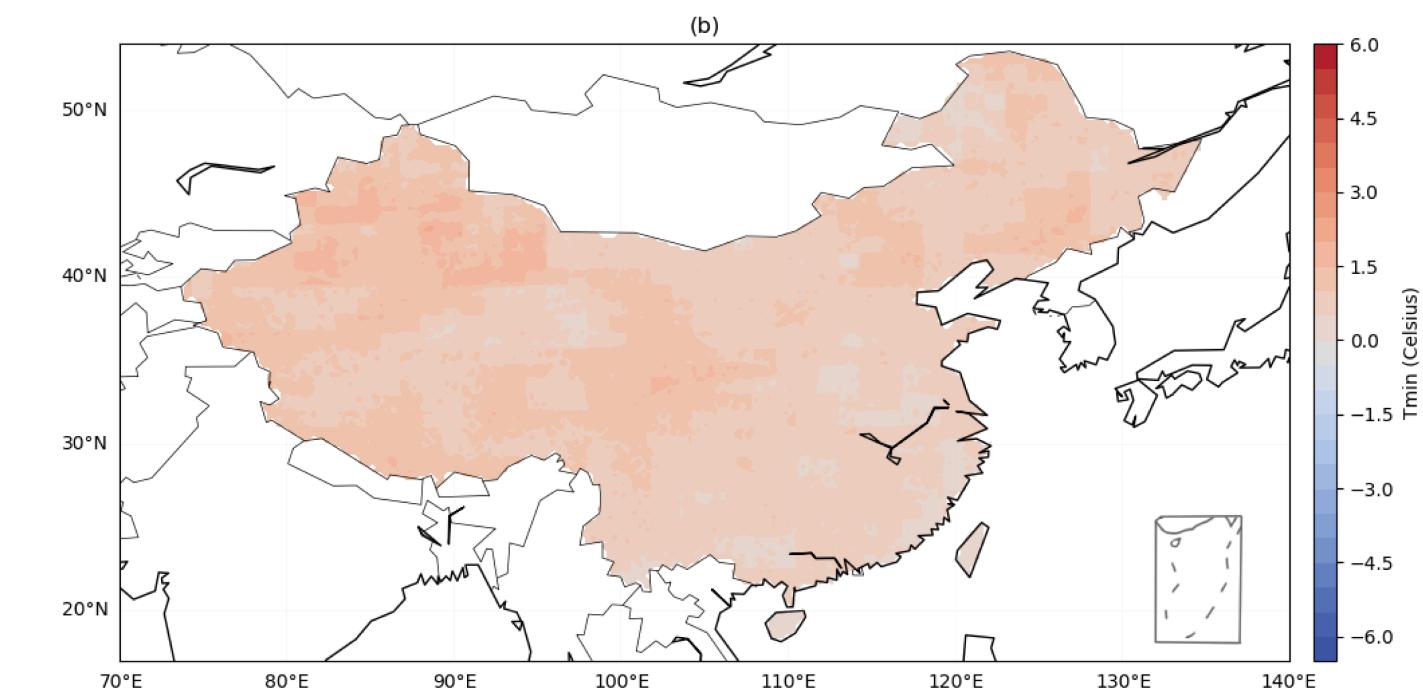
Tmax (July)



Pr (July)



SD



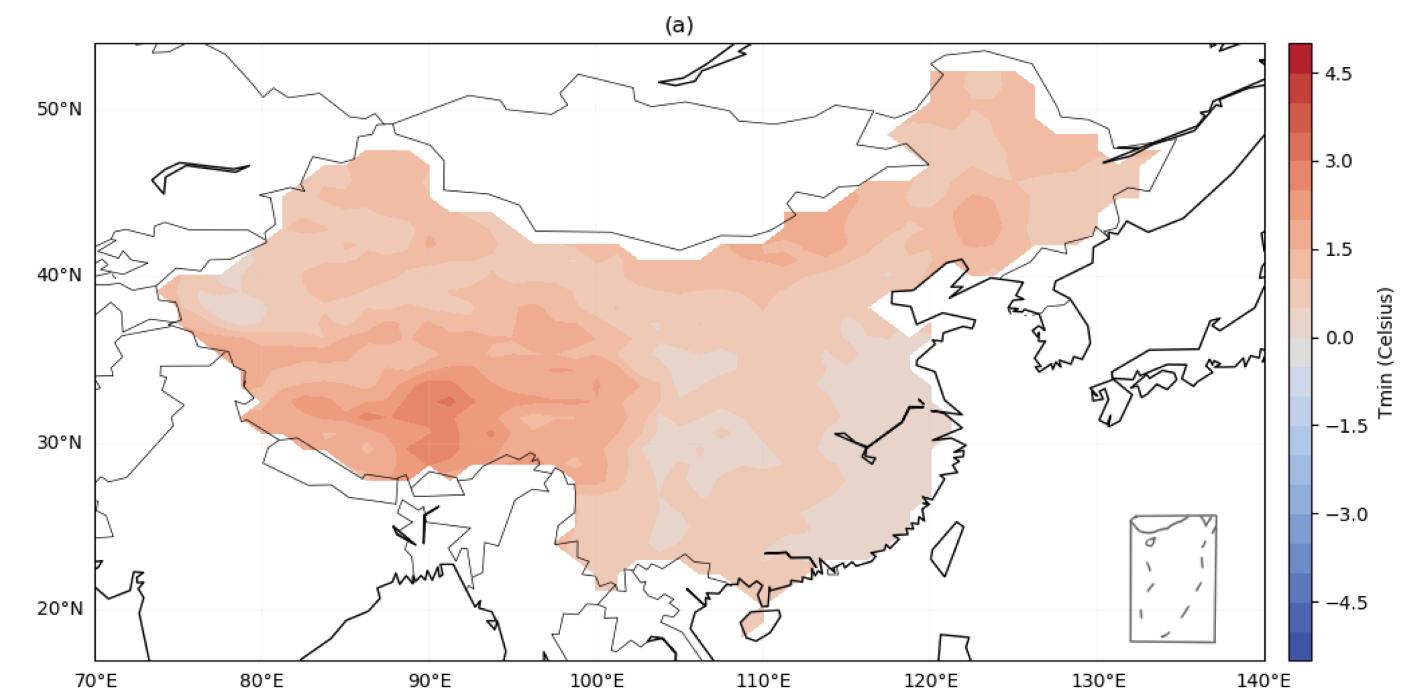
第一列(a-b)是1月日最低温；第二列(c-d)是7月日最高温；第三列(e-f)是7月日降水量。第一行(a, c, e)是CCSM4在近未来时段(2020-2049)与历史气候态(1970-1999)的差值；第二行(b, d, f)是SD在近未来时段(2020-2049)与历史气候态(1970-1999)的差值

图 8 RCP8.5情景中，近未来时段(2020-2049年)相对于历史气候态(1970-1999年)日最低温、日最高温和日降水量的变化

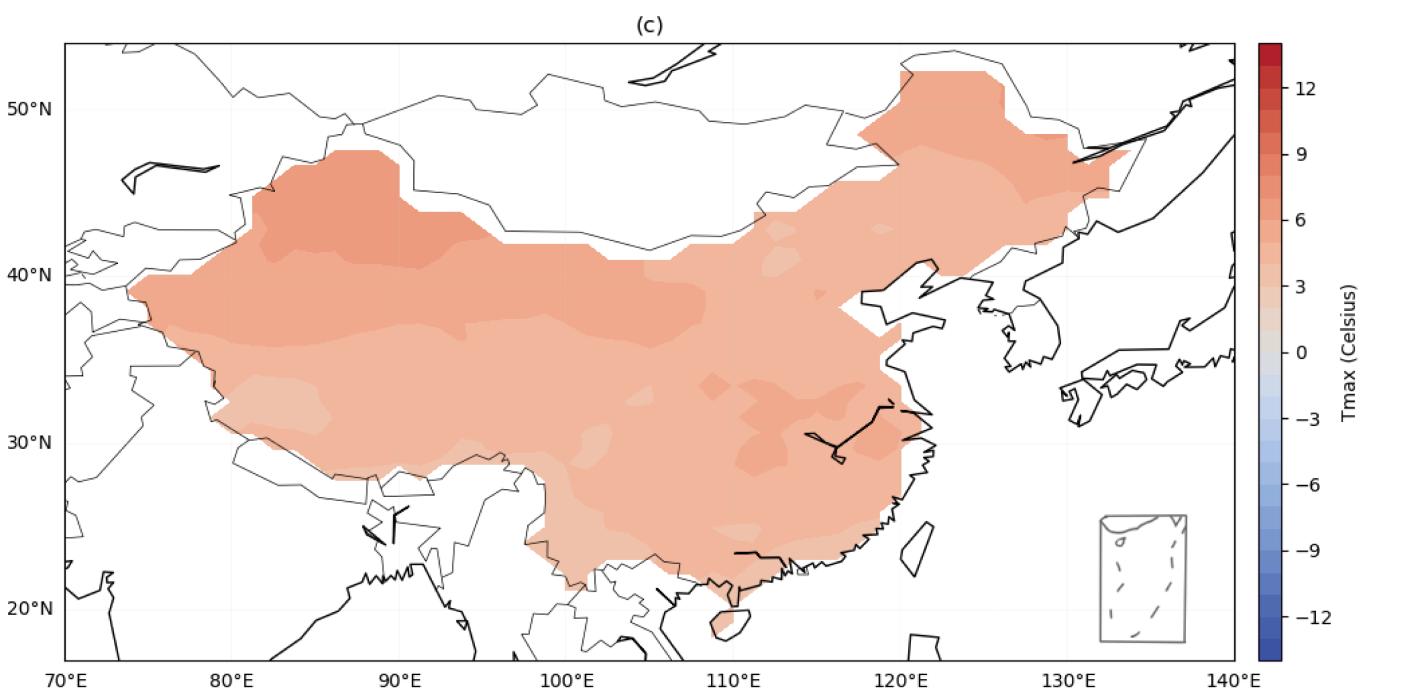
Fig. 8 The differences of Tmin, Tmax, and precipitation between near-term future (2020-2049) and historical climatology (1970-1999) in RCP8.5 scenario

CCSM

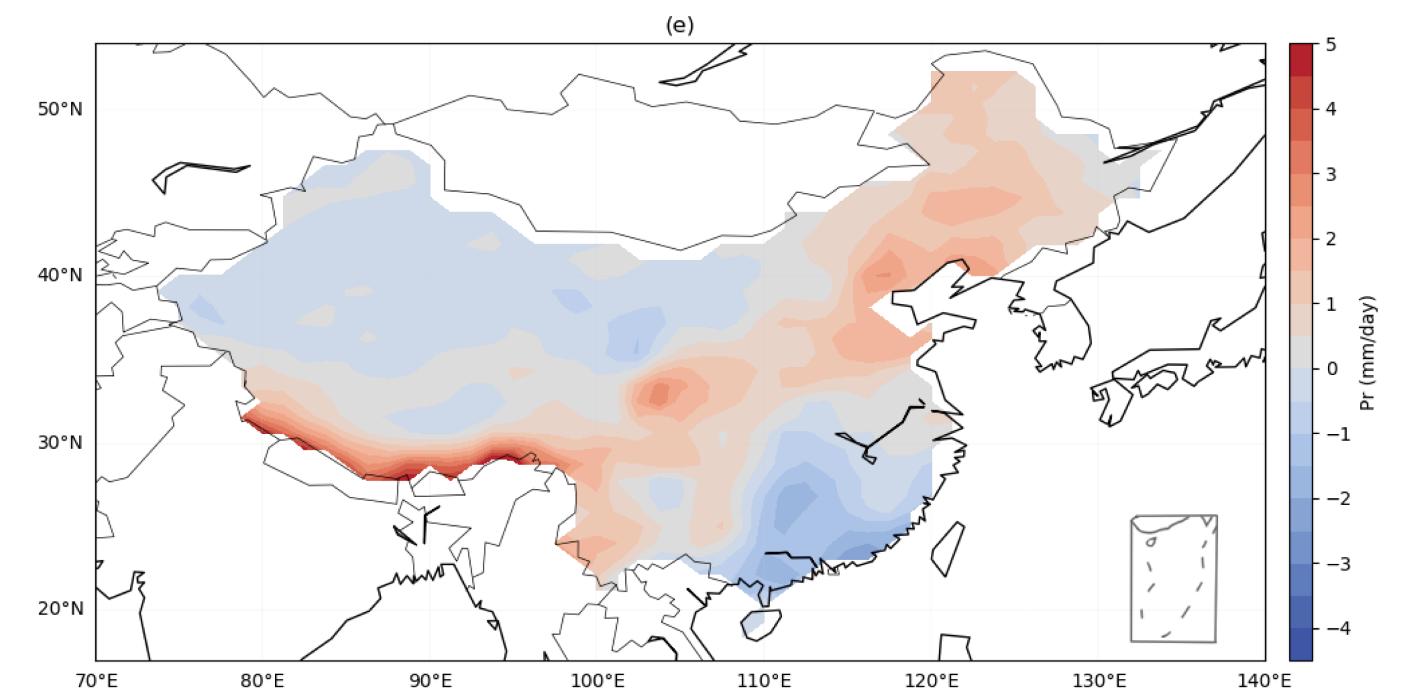
Tmin (January)



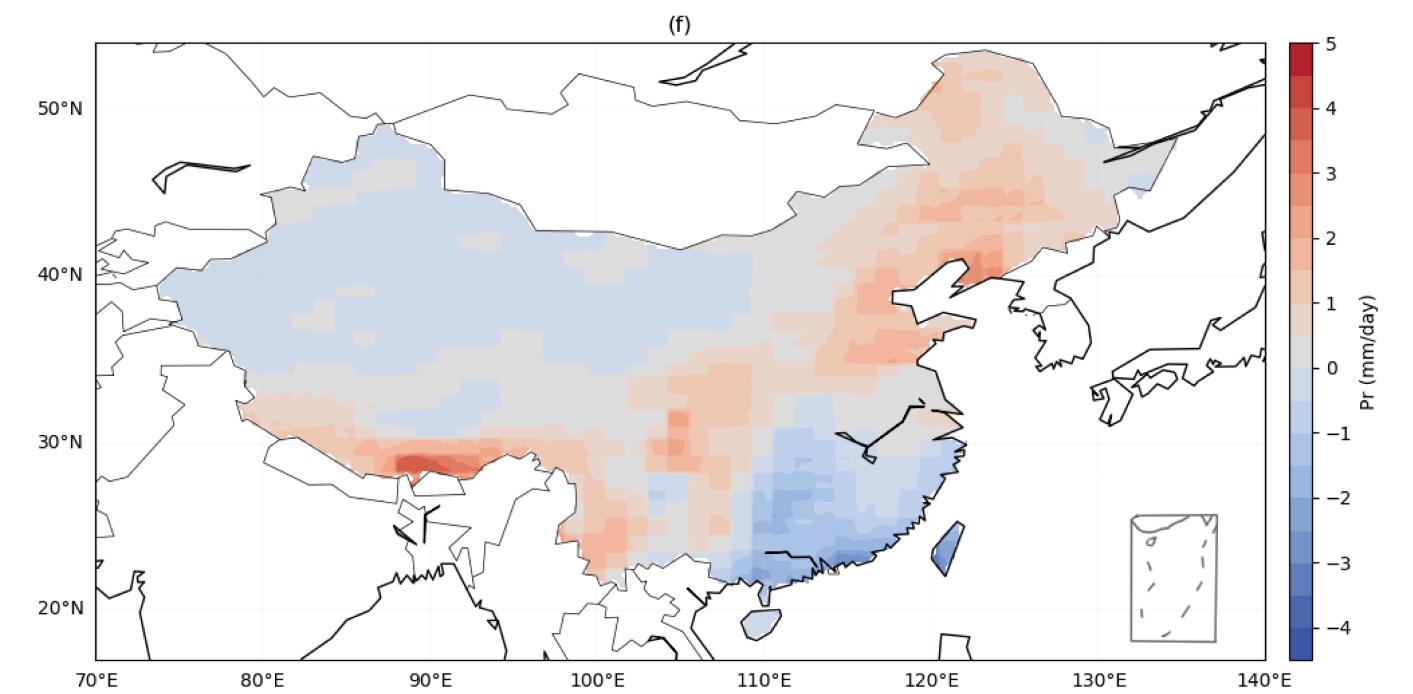
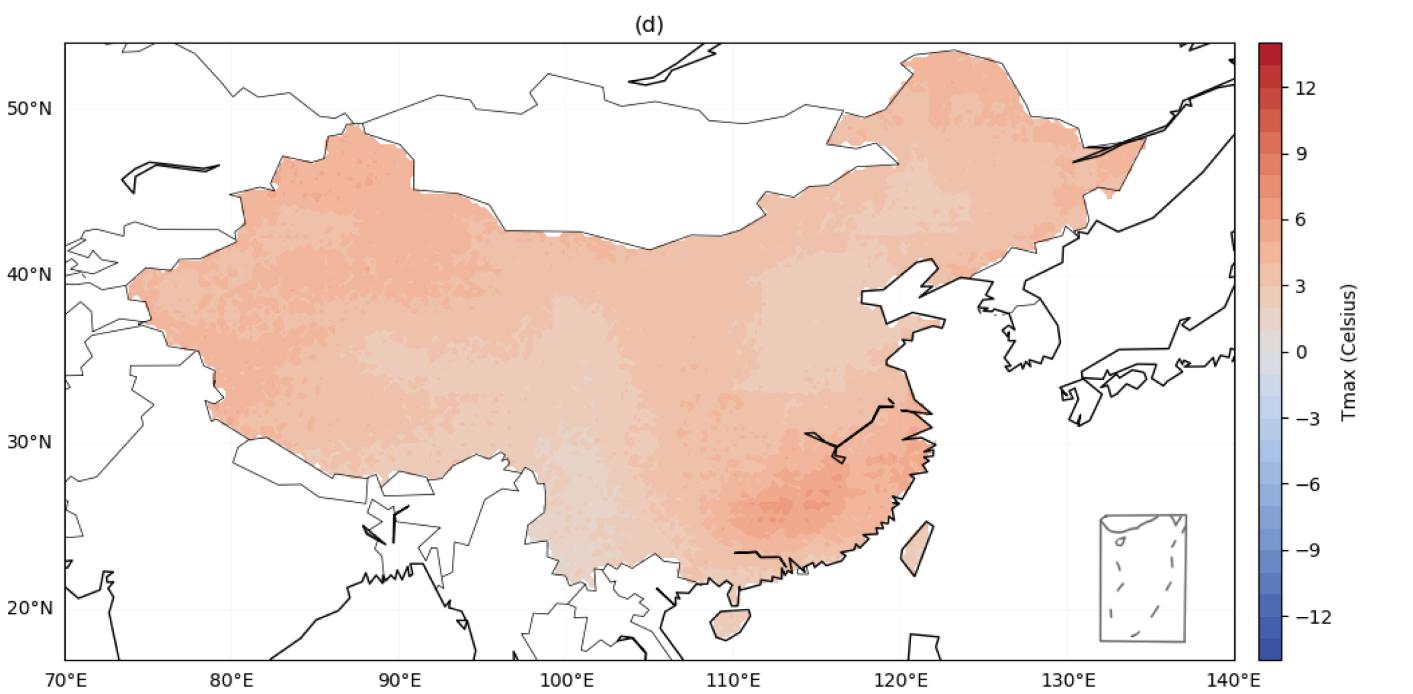
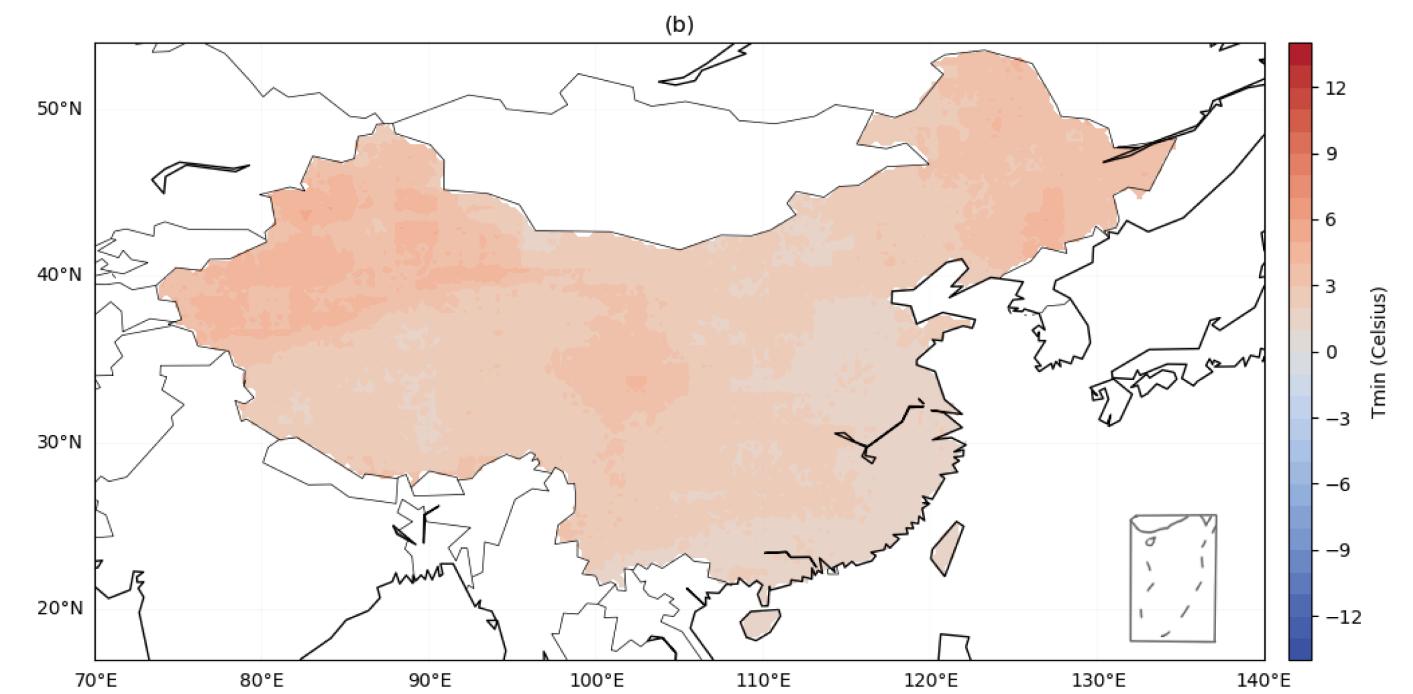
Tmax (July)



Pr (July)



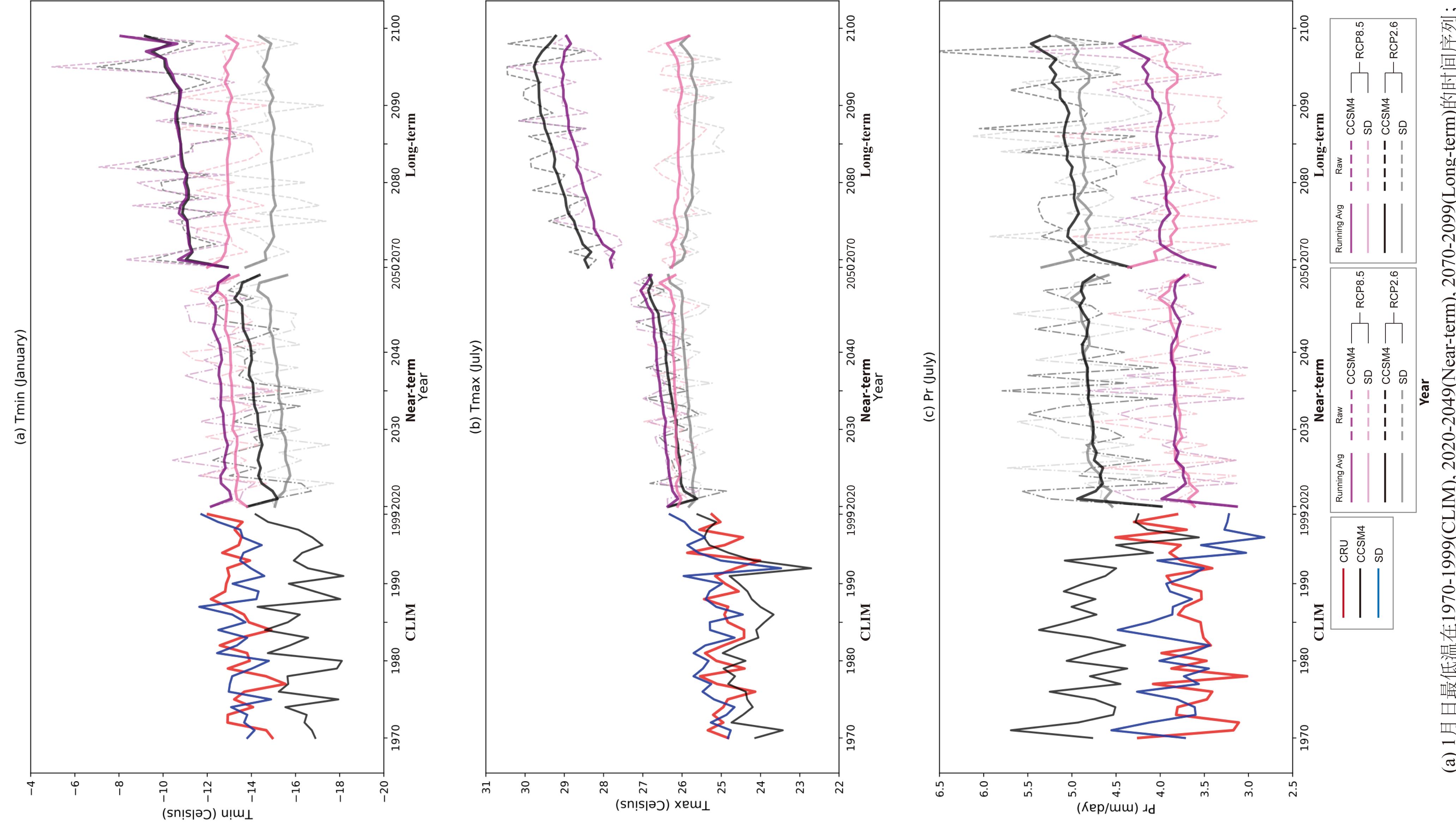
SD



第一列(a-b)是1月日最低温；第二列(c-d)是7月日最高温；第三列(e-f)是7月日降水量。第一行(a, c, e)是CCSM4在远未来时段(2070-2099)与历史气候态(1970-1999)的差值；第二行(b, d, f)是SD在远未来时段(2070-2099)与历史气候态(1970-1999)的差值

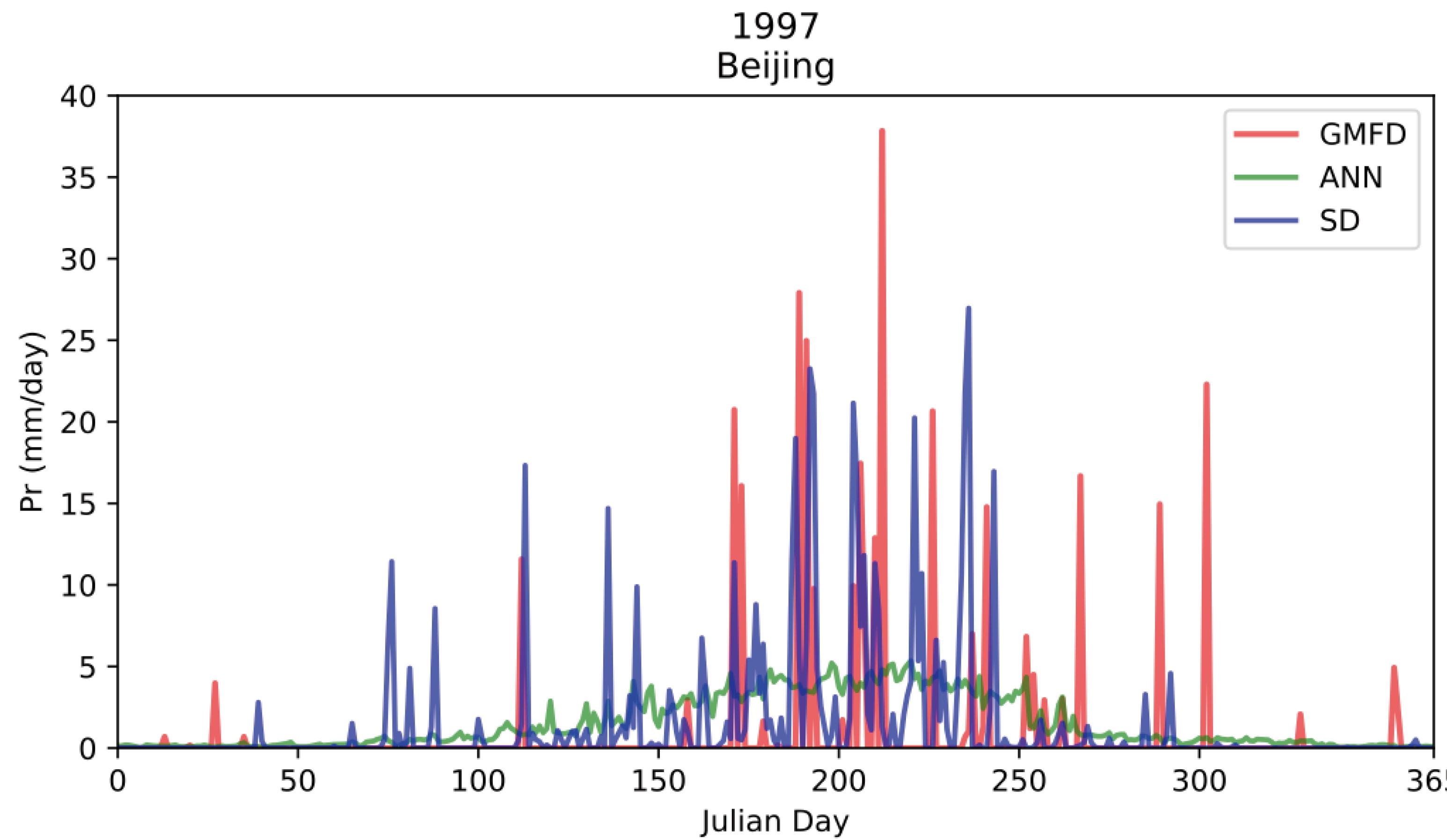
图 9 RCP8.5情景中，远未来时段(2070-2099年)相对于历史气候态(1970-1999年)日最低温、日最高温和日降水量的变化

Fig. 9 The differences of Tmin, Tmax, and precipitation between near-term future (2070-2099) and historical climatology (1970-1999) in RCP8.5 scenario



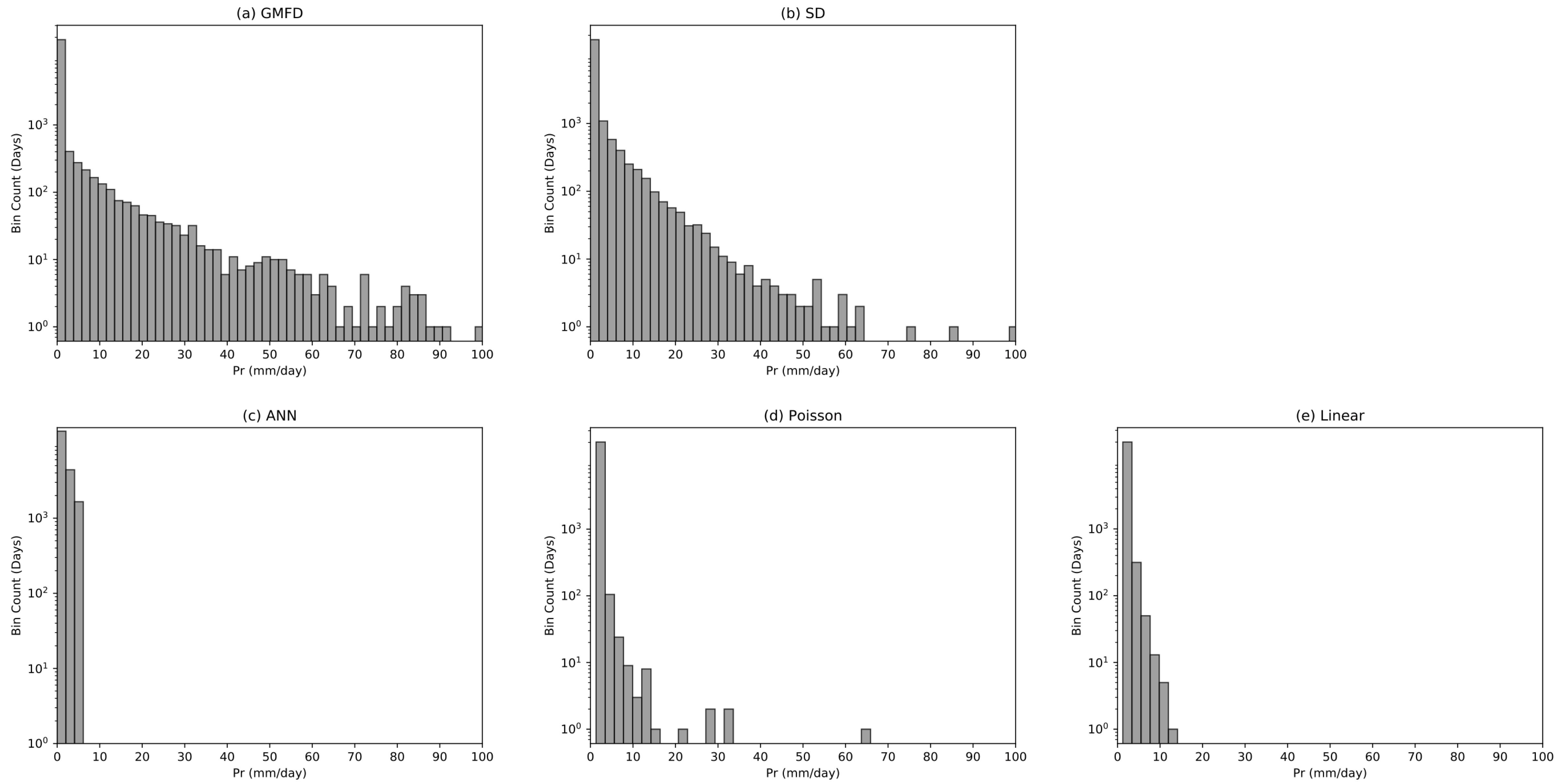
(a) 1月日最低温在1970-1999(CLIM), 2020-2049(Near-term), 2070-2099(Long-term)的时间序列；
 (b) 7月日最高温；(c) 7月日降水量。

**图 10 全中国平均的日最低温、日最高温和日降水量在历史气候态(1970-1999年)、
 近未来时段(2020-2049年)和远未来时段(2070-2099年的时序列]**
**Fig. 10 The time series of China's Tmin, Tmax, and precipitation in historical climatology(1970-1999),
 near-term future years(2020-2049), and long-term future years(2070-2099)**



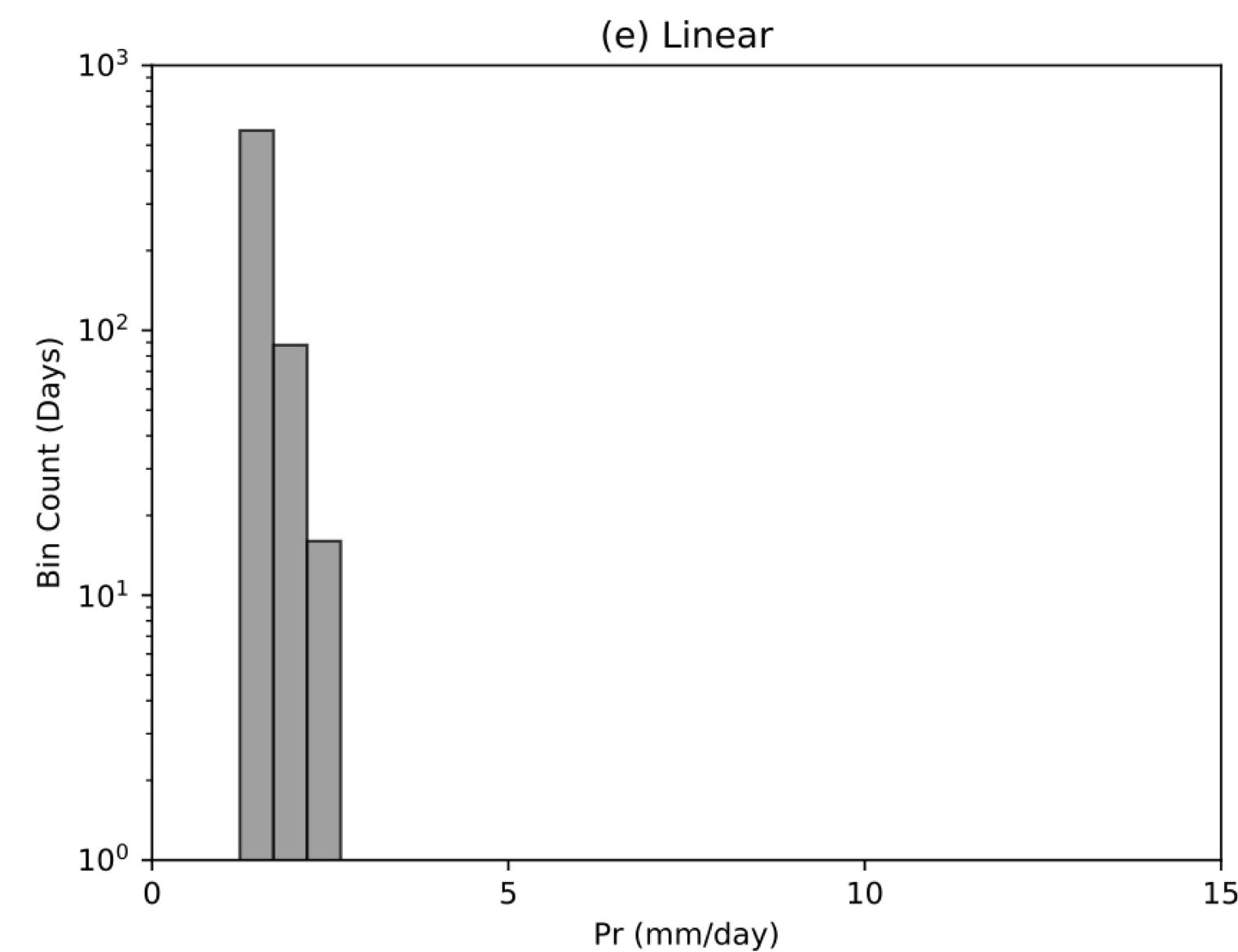
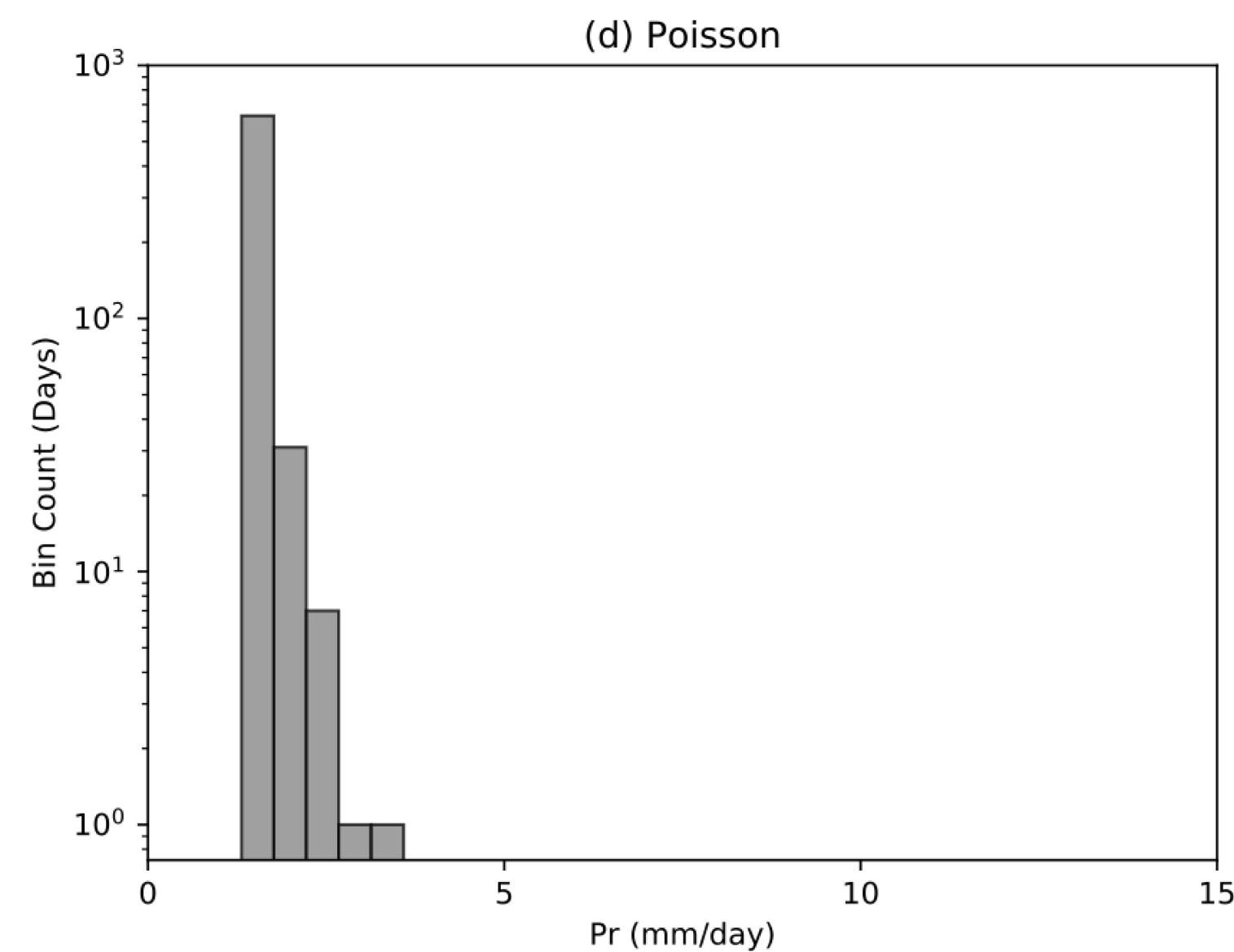
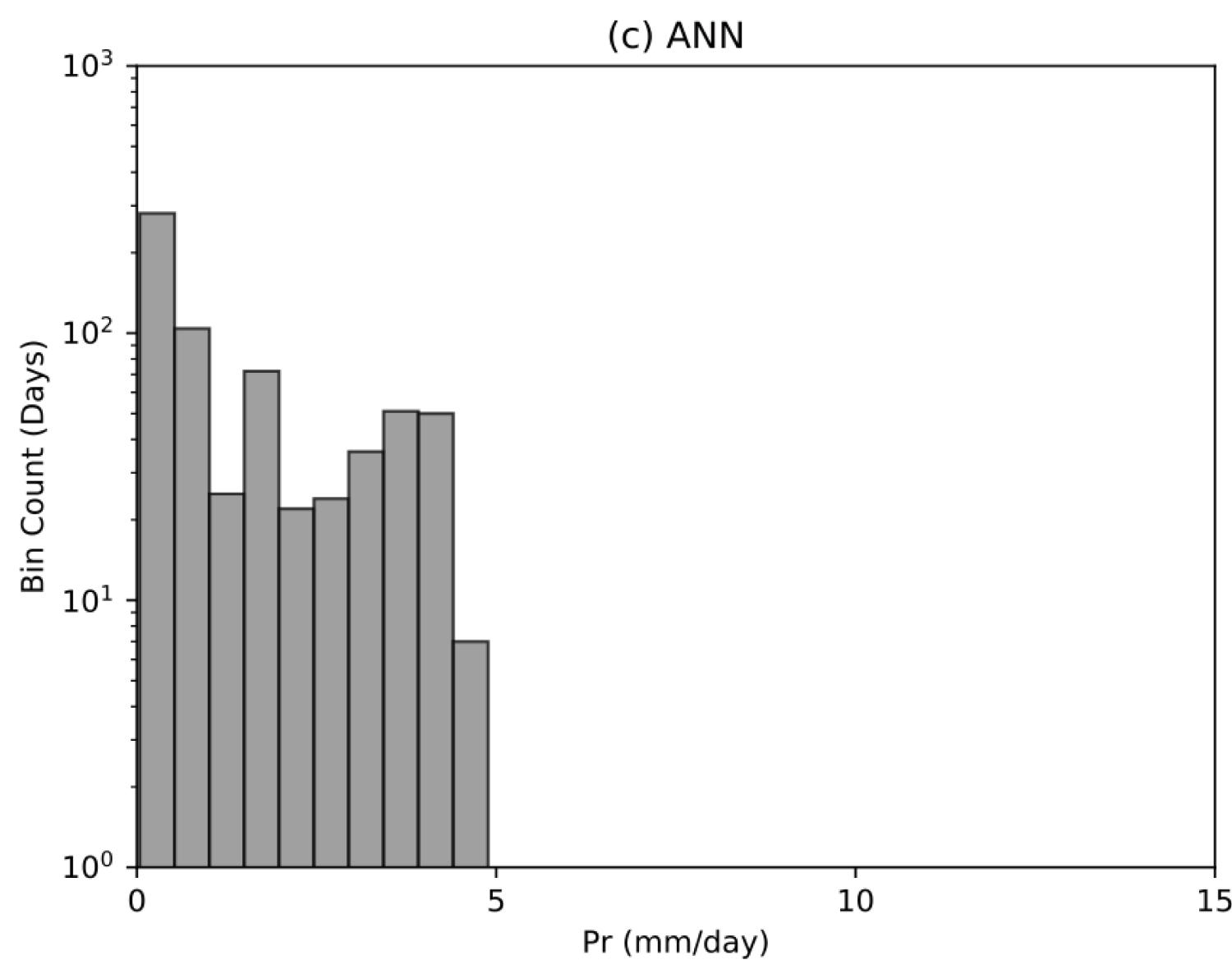
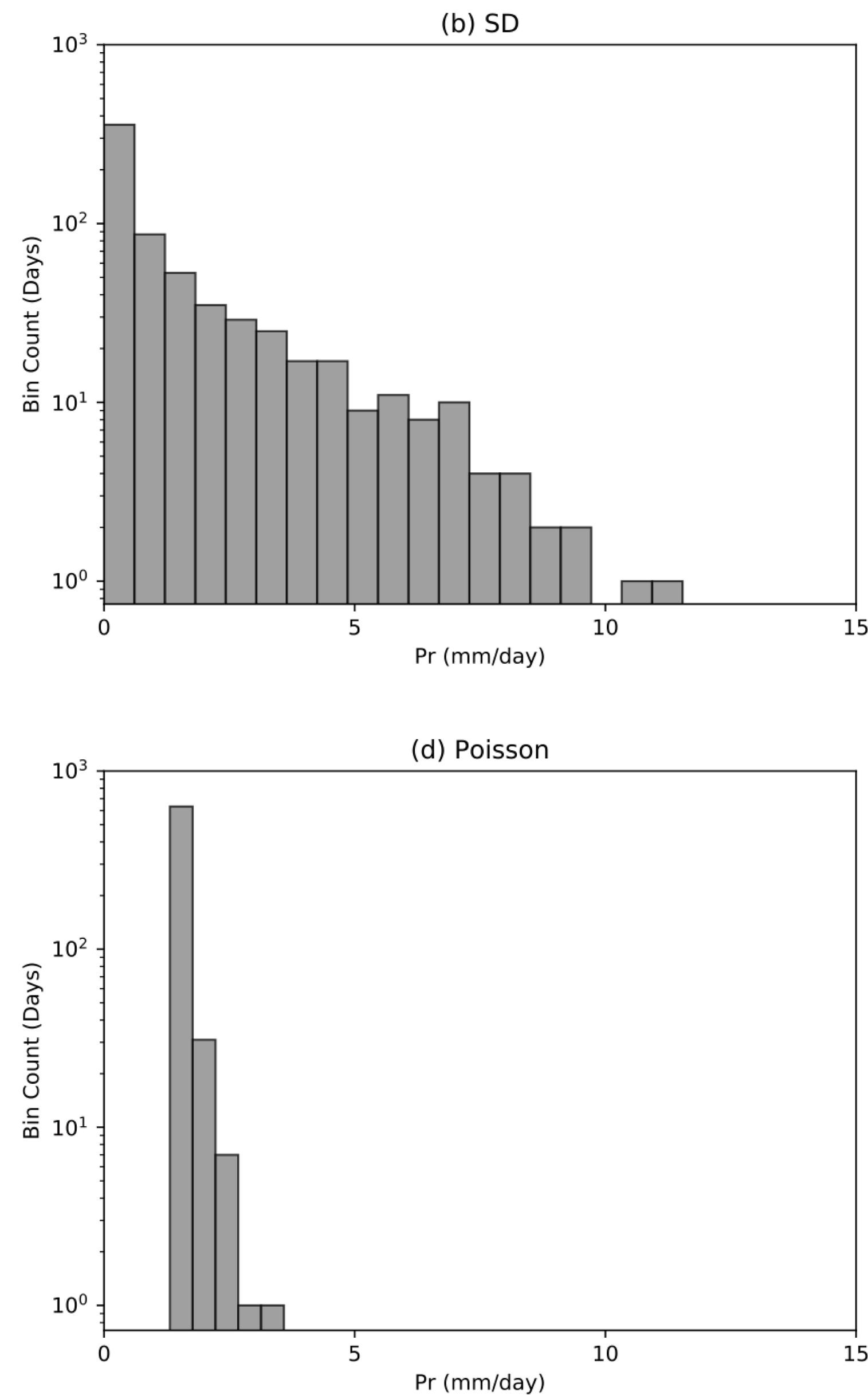
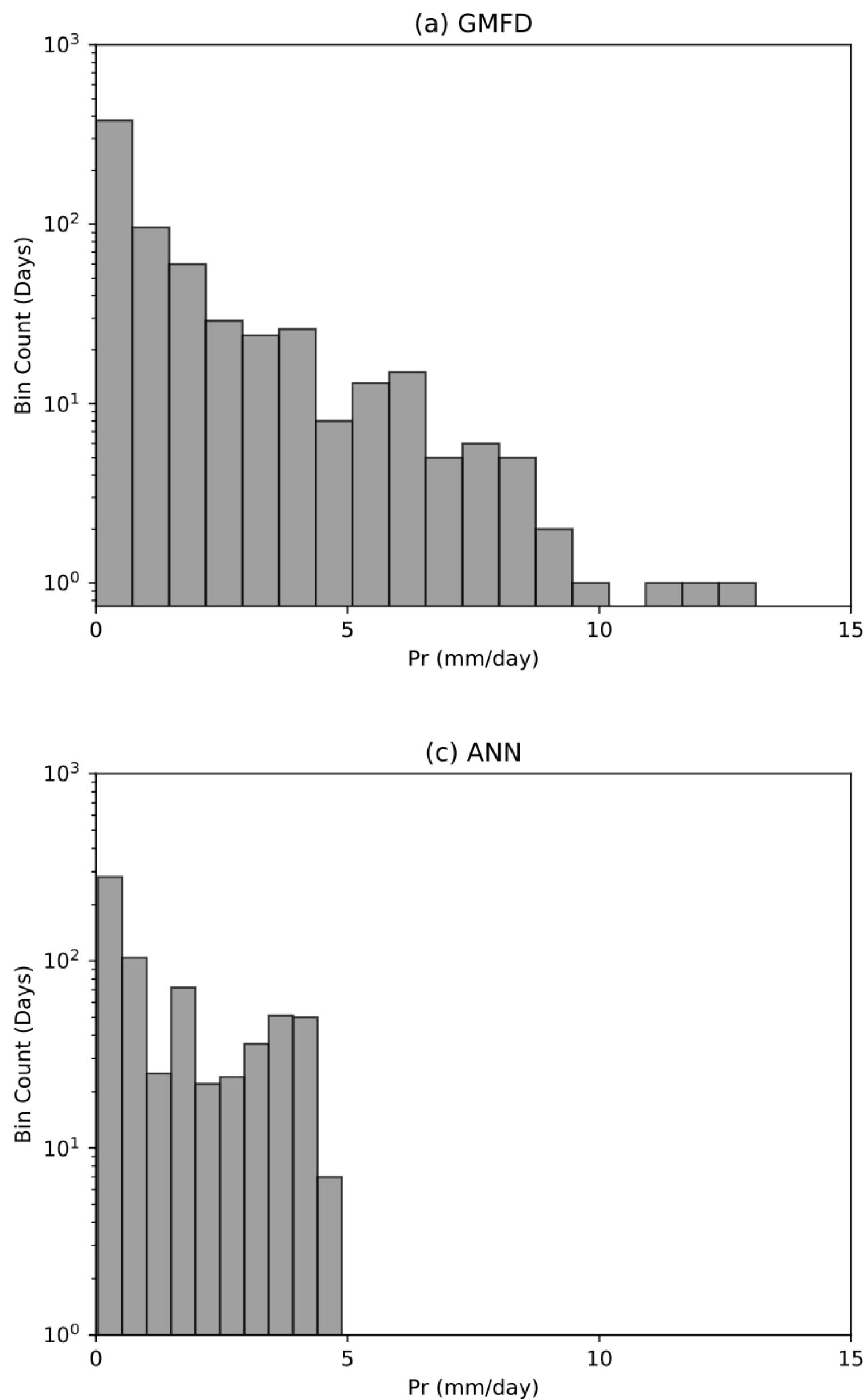
附图 1 观测和统计降尺度的日降水在验证集(以北京1997年为例)上的时间序列

Appendix Fig. 1 The time series of observed and downscaled daily precipitation in Beijing in 1997 as one sample of validation set



附图 2 日尺度日降水量直方图方法比较

Appendix Fig. 2 The comparison of different statistical downscaling methods of daily precipitation

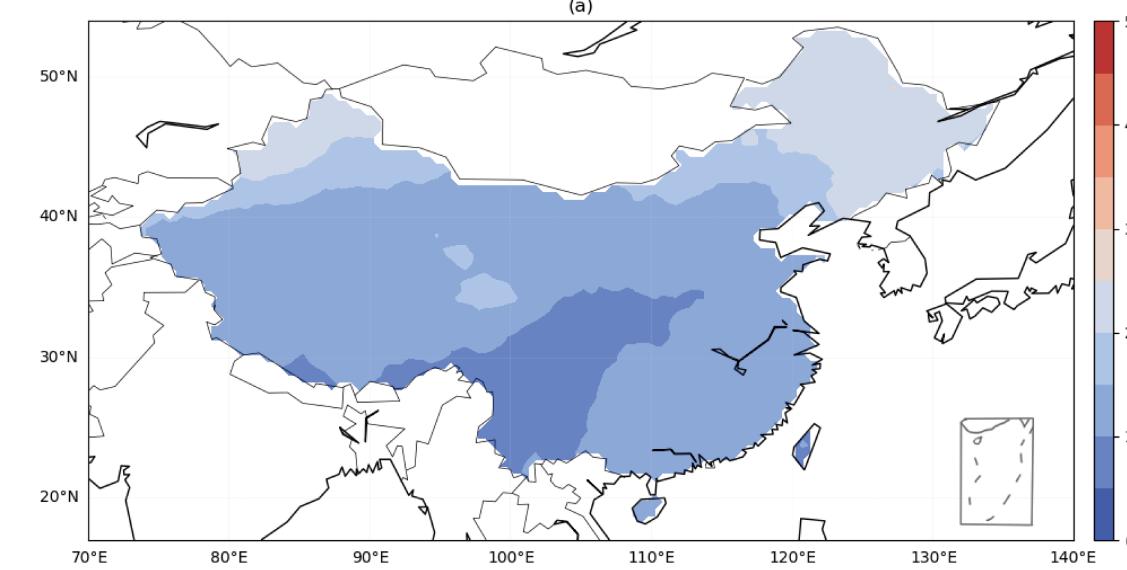


附图 3 月尺度日降水量直方图方法比较

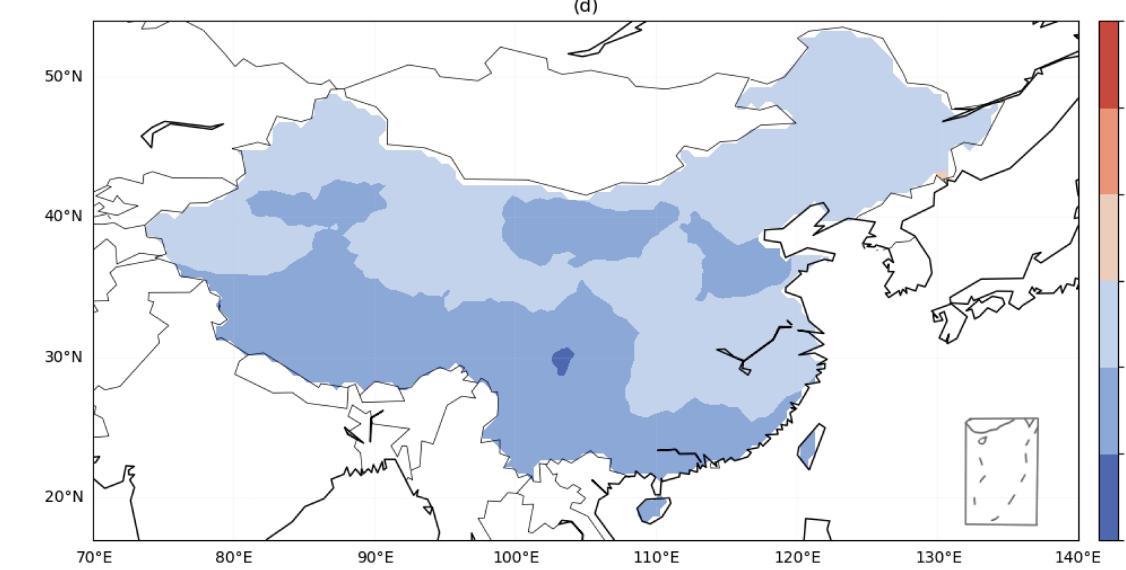
Appendix Fig. 3 The comparison of different statistical downscaling methods of monthly precipitation

CRU

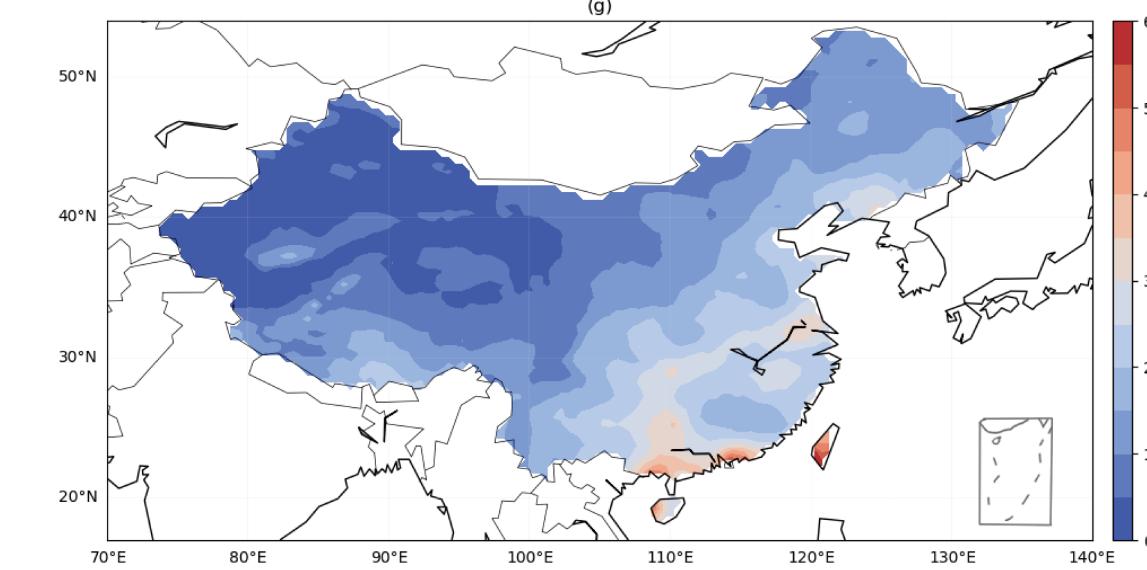
Tmin (January)



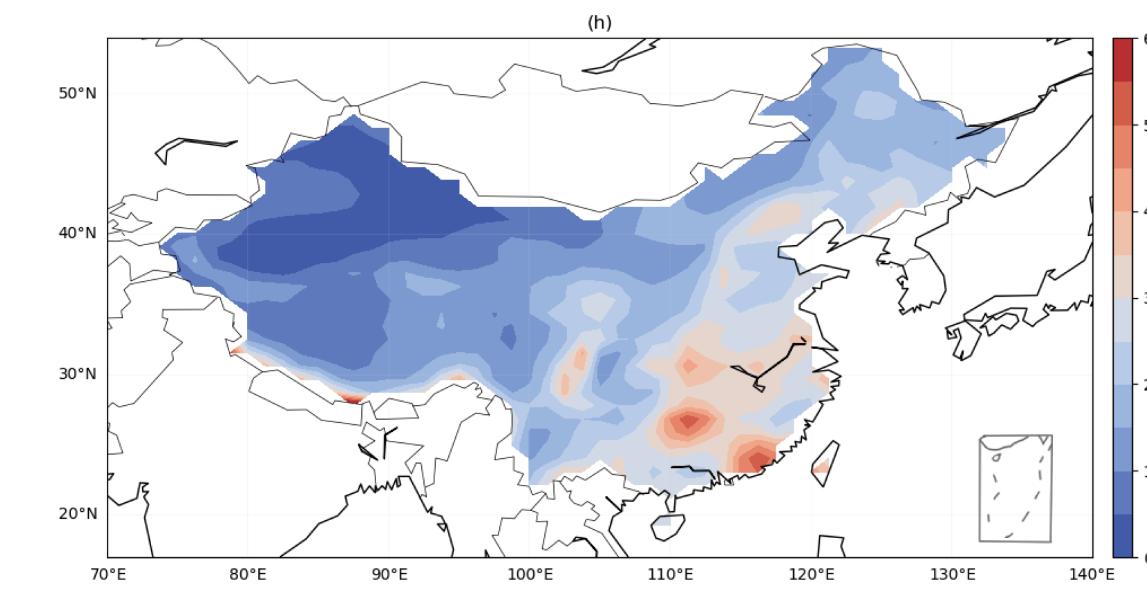
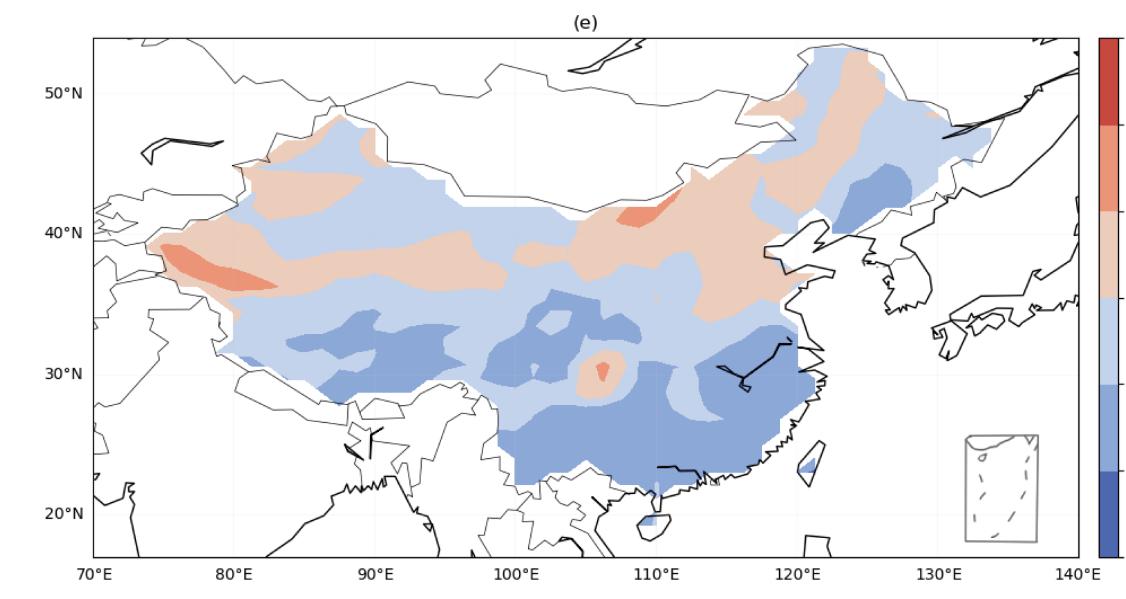
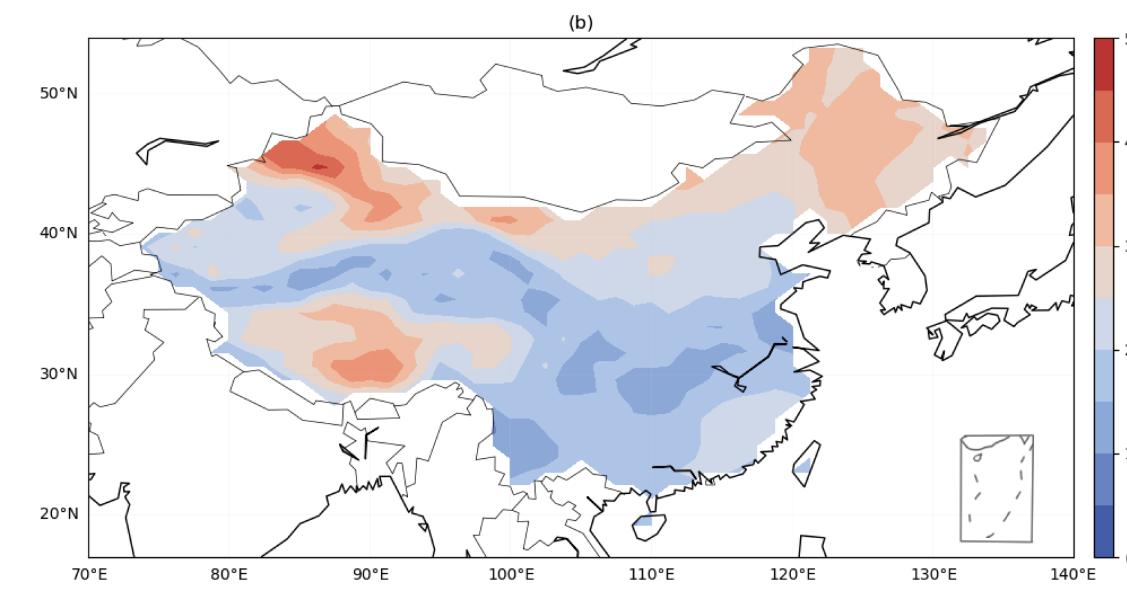
Tmax (July)



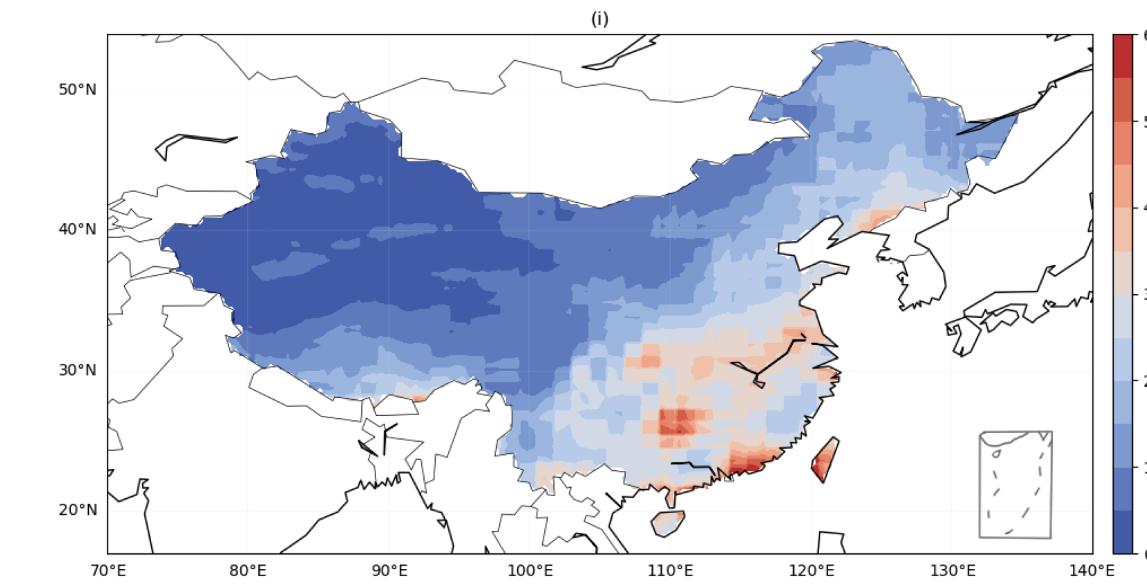
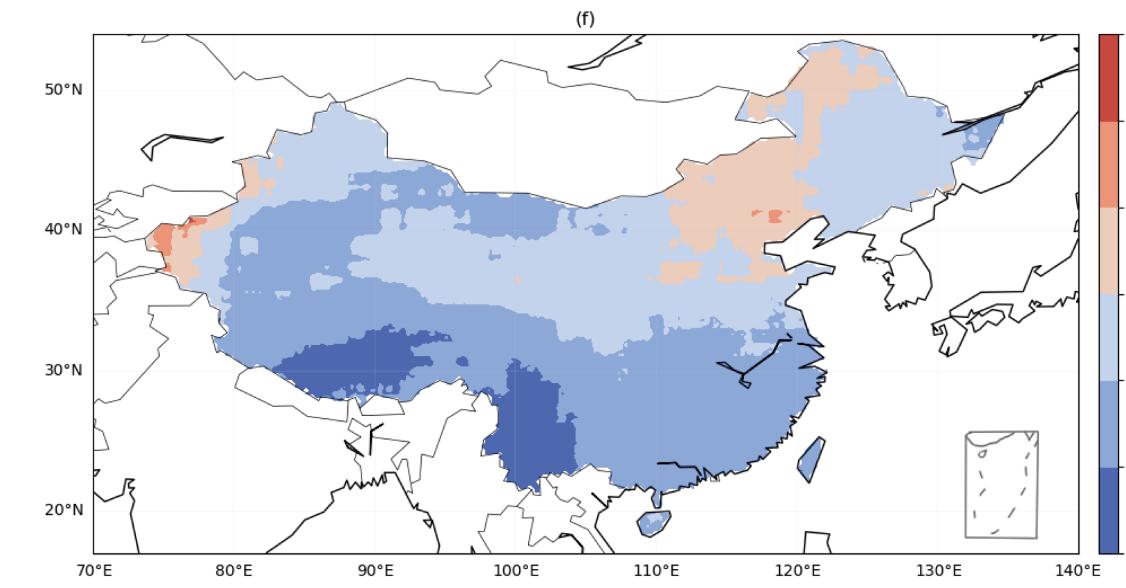
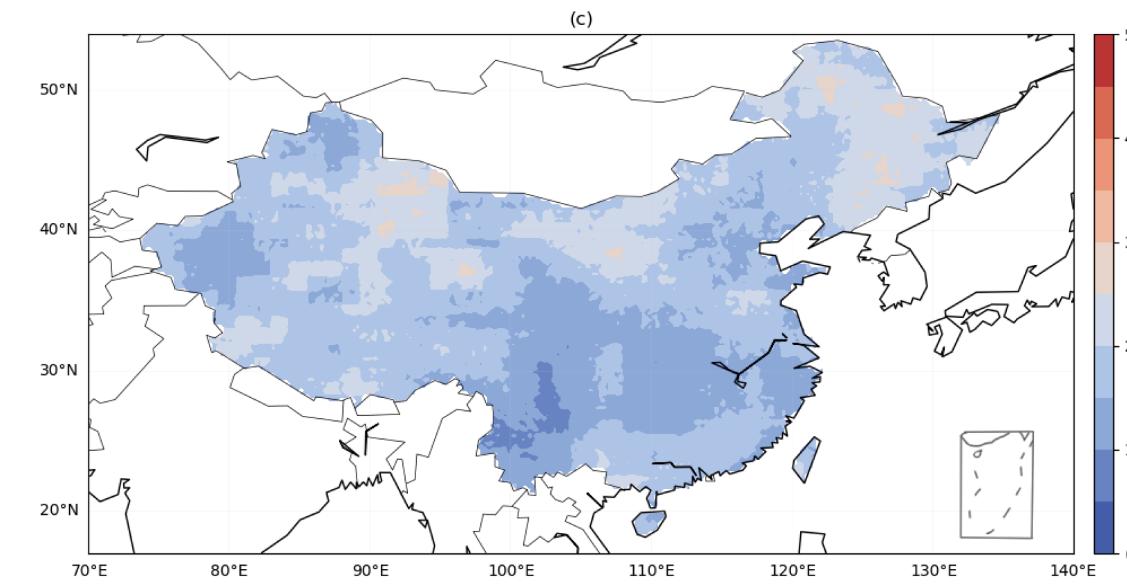
Pr (July)



CCSM



SD



第一列(a-c)是1月日最低温，第二列(d-f)是7月日最高温，第三列(g-i)是7月日降水量。第一行(a, d, g)是1970-1999年CRU气候态标准差；第二行(b, e, h)是CCSM4标准差；第三行(c, f, i)是SD标准差

附图 4 1970-1999年日最低温、日最高温和日降水量标准差的空间分布

Appendix Fig. 4 The spatial distribution of Tmin, Tmax, and precipitation's standard deviation in 1970-1999