

Supplementary Materials

Assessment of model performance regarding precipitation extremes over the mid-high latitudes of Asia: From CMIP5 to CMIP6

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Table S1: CMIP6 and CMIP5 models employed in this study

	Model	Modeling Center	Resolution (Lat × Lon)
1	BCC-CSM2-MR (BCC-CSM1-1)	Beijing Climate Center (BCC), China	$2.25^{\circ} \times 1.125^{\circ}$ ($2.784^{\circ} \times 2.8125^{\circ}$)
2	CanESM5 (CanESM2)	Canadian Climate Centre, Canada	$5.625^{\circ} \times 2.8125^{\circ}$ ($2.784^{\circ} \times 2.8125^{\circ}$)
3	EC-Earth3 (EC-Earth)	European Centre for Medium-Range Weather Forecasts (ECWMF), Europe	$1.406^{\circ} \times 0.703^{\circ}$ ($1.125^{\circ} \times 1.125^{\circ}$)
4	FGOALS-g3 (FGOALS-g2)	Institute of Atmospheric Physics (IAP), Chinese Academy of Sciences (CAS), China	$4.5^{\circ} \times 2.0^{\circ}$ ($3.1^{\circ} \times 2.8^{\circ}$)
5	GFDL-CM4 (GFDL-CM3)	Geophysical Fluid Dynamics Laboratory (GFDL), National Oceanic and Atmospheric Administration (NOAA), USA	$2.0^{\circ} \times 1.25^{\circ}$ ($2.0225^{\circ} \times 2.5^{\circ}$)
6	GFDL-ESM4 (GFDL-ESM2M)	Geophysical Fluid Dynamics Laboratory (GFDL), National Oceanic and Atmospheric Administration (NOAA), USA	$2.0^{\circ} \times 1.25^{\circ}$ ($2.0225^{\circ} \times 2.5^{\circ}$)
7	INMCM5.0 (INMCM4)	Institute of numerical mathematics (INM) of the Russian Academy of Sciences, Russia	$3.0^{\circ} \times 2.0^{\circ}$ ($1.5^{\circ} \times 2^{\circ}$)
8	IPSL-CM6A-LR (IPSL-CM5A-LR)	Institute Pierre Simon Laplace (IPSL), France	$2.517^{\circ} \times 2.5^{\circ}$ ($1.895^{\circ} \times 3.75^{\circ}$)
9	MIROC6 (MIROC5)	The center for climate system research, the university of Tokyo, the Japan Agency for MarineEarth Science and Technology, and the national institute for environmental studies, Japan	$2.8125^{\circ} \times 1.40625^{\circ}$ ($1.397^{\circ} \times 1.406^{\circ}$)
10	MPI-ESM1-2-HR (MPI-ESM-LR)	Max Planck Institute (MPI), Germany	$1.875^{\circ} \times 0.9375^{\circ}$ ($1.861^{\circ} \times 1.875^{\circ}$)
11	MRI-ESM2-0 (MRI-CGCM3)	Meteorological Research Institute (MRI), Japan	$2.25^{\circ} \times 1.125^{\circ}$ ($1.119^{\circ} \times 1.125^{\circ}$)
12	NorESM2-LM (NorESM1-M)	Norwegian Climate Centre (NCC), Norway	$3.75^{\circ} \times 2.5^{\circ}$ ($1.895^{\circ} \times 2.5^{\circ}$)

Table S2: 11 extreme precipitation indices used here

Index	Index name	Definition	Units
CDD	Consecutive dry days	Maximum annual number of consecutive dry days when precipitation < 1 mm	days
CWD	Consecutive wet days	Maximum annual number of consecutive wet days when precipitation ≥ 1 mm	days
PRCPTOT	Total wet day precipitation	Annual sum of daily precipitation ≥ 1 mm	mm
R1mm	Number of wet days	Annual number of days when precipitation ≥ 1 mm	days
R10mm	Heavy precipitation days	Annual number of days when precipitation ≥ 10 mm	days
R20mm	Very heavy precipitation days	Annual number of days when precipitation ≥ 20 mm	days
R95p	Very wet days	Annual sum of daily precipitation > 95 th percentile	mm
R99p	Extremely wet days	Annual sum of daily precipitation > 99 th percentile	mm
RX1day	Maximum 1-day precipitation	Maximum 1-day precipitation total	mm
RX5day	Maximum 5-day precipitation	Maximum 5-day precipitation total	mm
SDII	Simple daily intensity index	Annual total precipitation divided by the number of wet days	mm

Table S3. List of S index calculated by the CMIP5 and CMIP6 individual models (Taylor, 2001). The red value refers to for a particular index, improvements have been made from the CMIP5 to the new version of the CMIP6 model, and the blue value indicates the decreased skill, and the black value means no obvious change. The models in boldface indicated the improved skill in simulating the climate extremes when compared with the earlier versions according to the mean values of the 11 indices.

CMIP6 (CMIP5)	CDD	CWD	PRCPTOT	R1mm	R10mm	R20mm	R95p	R99p	RX1day	RX5day	SDII	Mean
BCC-CSM2-MR (BCC-CSM1-1)	0.52 (0.51)	0.51 (0.27)	0.84 (0.68)	0.67 (0.48)	0.89 (0.83)	0.96 (0.84)	0.93 (0.77)	0.92 (0.71)	0.97 (0.72)	0.91 (0.76)	0.81 (0.62)	0.81 (0.65)
CanESM5 (CanESM2)	0.74 (0.83)	0.58 (0.67)	0.86 (0.81)	0.89 (0.93)	0.76 (0.73)	0.78 (0.61)	0.85 (0.66)	0.82 (0.53)	0.86 (0.71)	0.79 (0.65)	0.77 (0.78)	0.79 (0.72)
EC-Earth3 (EC-Earth)	0.82 (0.97)	0.65 (0.72)	0.97 (1.00)	0.94 (0.99)	0.94 (0.99)	0.99 (0.99)	1.00 (0.98)	0.99 (0.91)	0.96 (0.83)	1.00 (0.91)	0.90 (0.82)	0.92 (0.92)
FGOALS-g3 (FGOALS-g2)	0.70 (0.19)	0.50 (0.27)	0.59 (0.63)	0.58 (0.28)	0.61 (0.81)	0.67 (0.87)	0.66 (0.75)	0.68 (0.69)	0.79 (0.73)	0.71 (0.73)	0.63 (0.63)	0.65 (0.60)
GFDL-CM4 (GFDL-CM3)	0.83 (0.82)	0.81 (0.53)	0.93 (0.78)	0.90 (0.74)	0.87 (0.79)	0.91 (0.85)	0.95 (0.81)	0.93 (0.77)	0.94 (0.78)	0.91 (0.78)	0.90 (0.64)	0.90 (0.75)
GFDL-ESM4 (GFDL-ESM2M)	0.79 (0.68)	0.68 (0.47)	0.90 (0.72)	0.88 (0.65)	0.85 (0.83)	0.89 (0.83)	0.89 (0.79)	0.82 (0.71)	0.93 (0.78)	0.89 (0.76)	0.83 (0.68)	0.85 (0.72)
INMCM5.0 (INMCM4)	0.55 (0.50)	0.73 (0.51)	0.93 (0.86)	0.78 (0.68)	0.91 (0.90)	0.78 (0.96)	0.89 (0.88)	0.83 (0.85)	0.92 (0.70)	0.88 (0.82)	0.85 (0.69)	0.82 (0.76)
IPSL-CM6A-LR (IPSL-CM5A-LR)	0.68 (0.65)	0.76 (0.45)	0.78 (0.82)	0.79 (0.73)	0.70 (0.82)	0.54 (0.85)	0.74 (0.82)	0.74 (0.74)	0.78 (0.78)	0.69 (0.77)	0.84 (0.73)	0.73 (0.74)
MIROC6 (MIROC5)	0.48 (0.65)	0.62 (0.61)	0.86 (0.87)	0.71 (0.71)	0.83 (0.88)	0.90 (0.89)	0.89 (0.89)	0.86 (0.82)	0.93 (0.89)	0.89 (0.91)	0.84 (0.82)	0.80 (0.81)
MPI-ESM1-2-HR (MPI-ESM-LR)	0.67 (0.67)	0.92 (0.69)	0.88 (0.85)	1.00 (0.83)	0.74 (0.78)	0.73 (0.77)	0.85 (0.78)	0.79 (0.70)	0.89 (0.87)	0.86 (0.88)	0.88 (0.94)	0.84 (0.80)
MRI-ESM2-0 (MRI-CGCM3)	0.75 (0.91)	0.54 (0.73)	0.72 (0.78)	0.79 (0.88)	0.65 (0.76)	0.78 (0.89)	0.80 (0.84)	0.79 (0.81)	0.94 (0.89)	0.85 (0.87)	0.79 (0.80)	0.76 (0.83)
NorESM2-LM (NorESM1-M)	0.59 (0.62)	0.77 (0.48)	0.92 (0.75)	0.94 (0.65)	0.85 (0.82)	0.90 (0.77)	0.87 (0.72)	0.74 (0.64)	0.75 (0.70)	0.82 (0.75)	0.77 (0.68)	0.81 (0.69)
CMIP6-MME (CMIP5-MME)	0.78 (0.82)	0.86 (0.78)	0.96 (0.90)	0.91 (0.83)	0.91 (0.91)	0.95 (0.94)	0.96 (0.91)	0.96 (0.91)	0.99 (0.87)	0.95 (0.89)	0.90 (0.81)	0.92 (0.87)

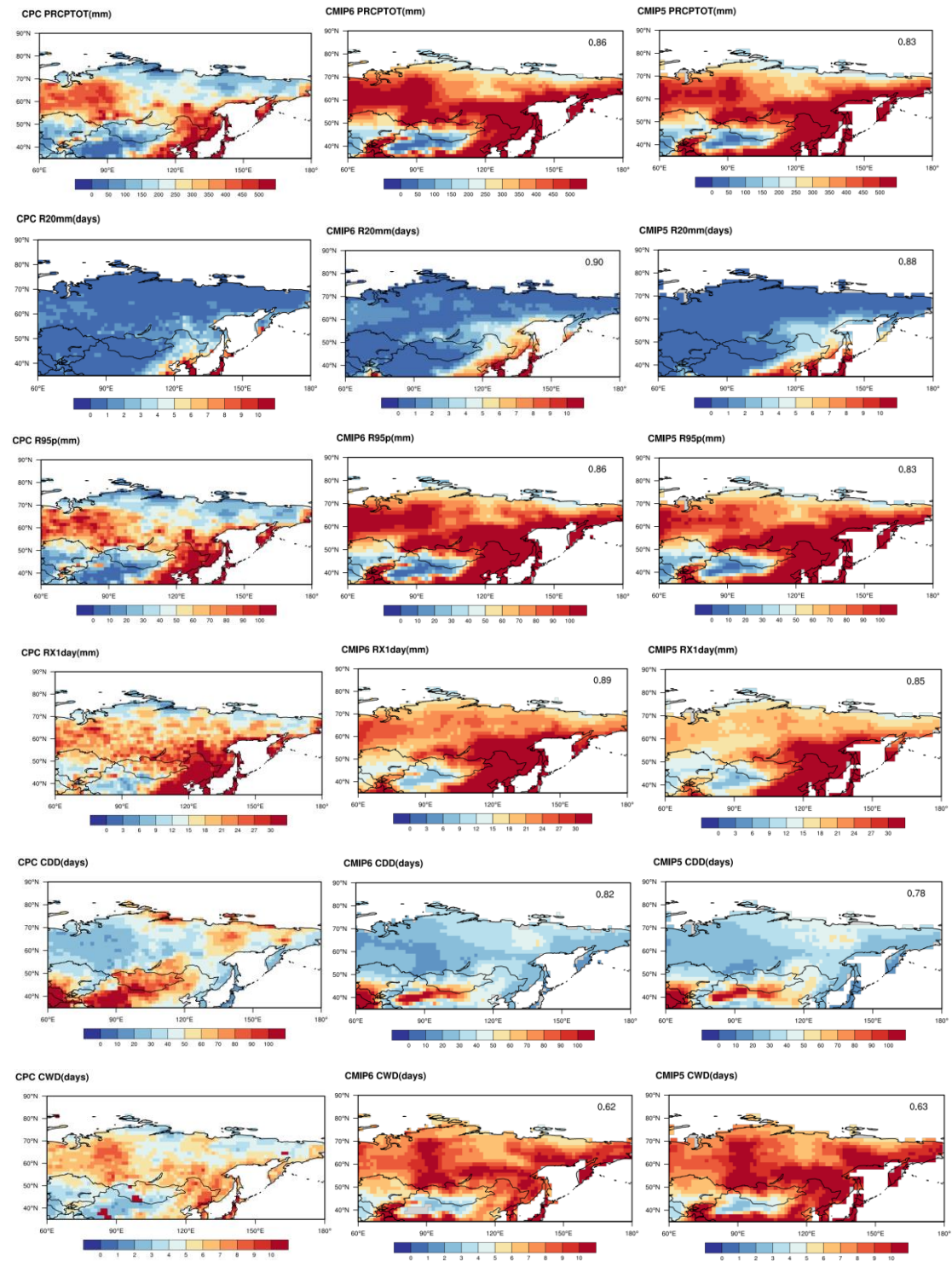


Figure S1. The mean of CPC (left column), CMIP5 and CMIP6 multimodel ensemble median (middle and right columns) for total wet day precipitation (PRCPTOT), very heavy precipitation days (R20mm), very wet days (R95p) and maximum 1-day precipitation (RX1day), consecutive dry days (CDD), consecutive wet days (CWD) during 1986-2005.

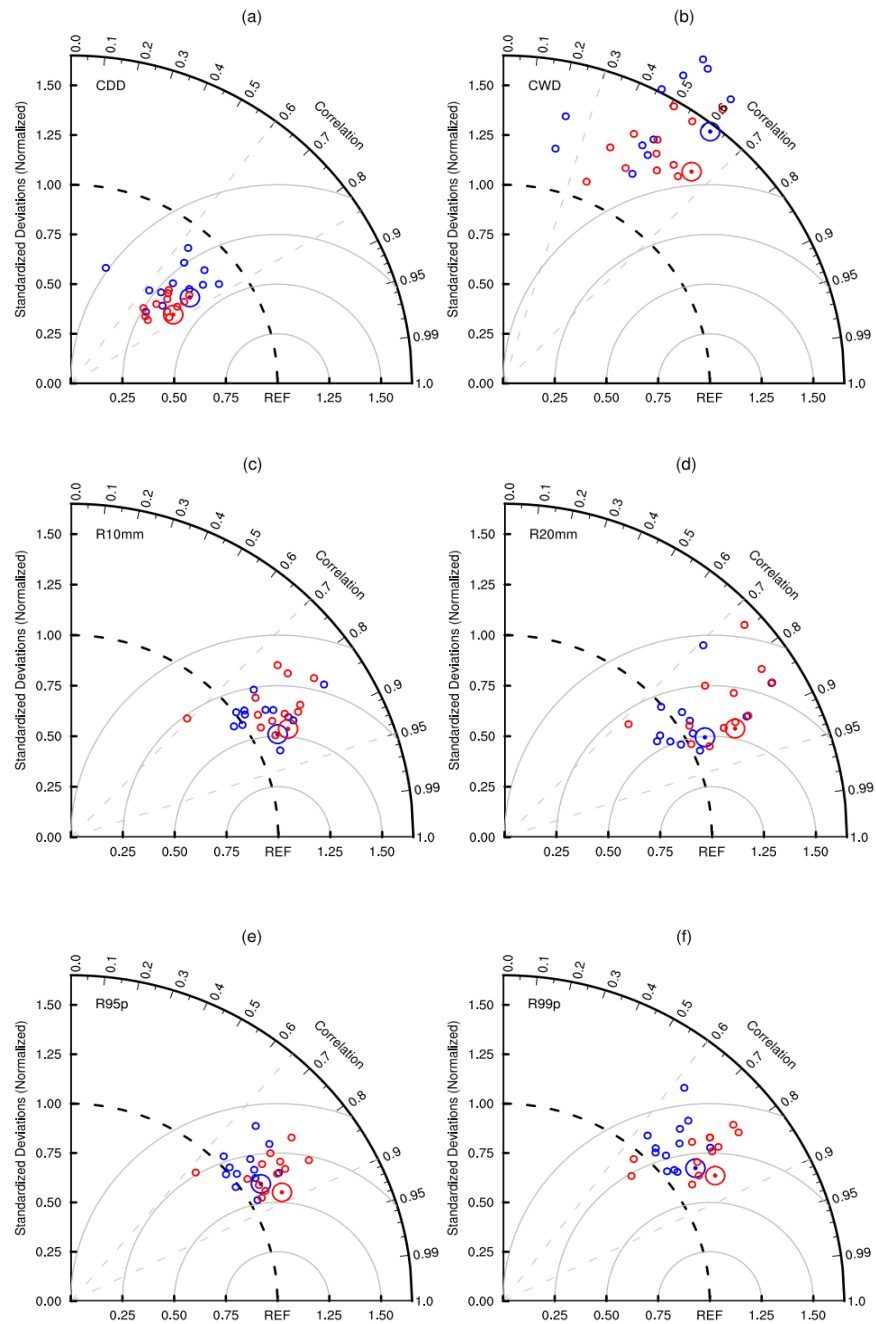


Figure S2. Same as Figure.1 but taylor diagrams of consecutive dry days (CDD), consecutive wet days (CWD), heavy precipitation days (R10mm), Very heavy precipitation days (R20mm), Very wet days (R95p) extremely wet days (R99p).

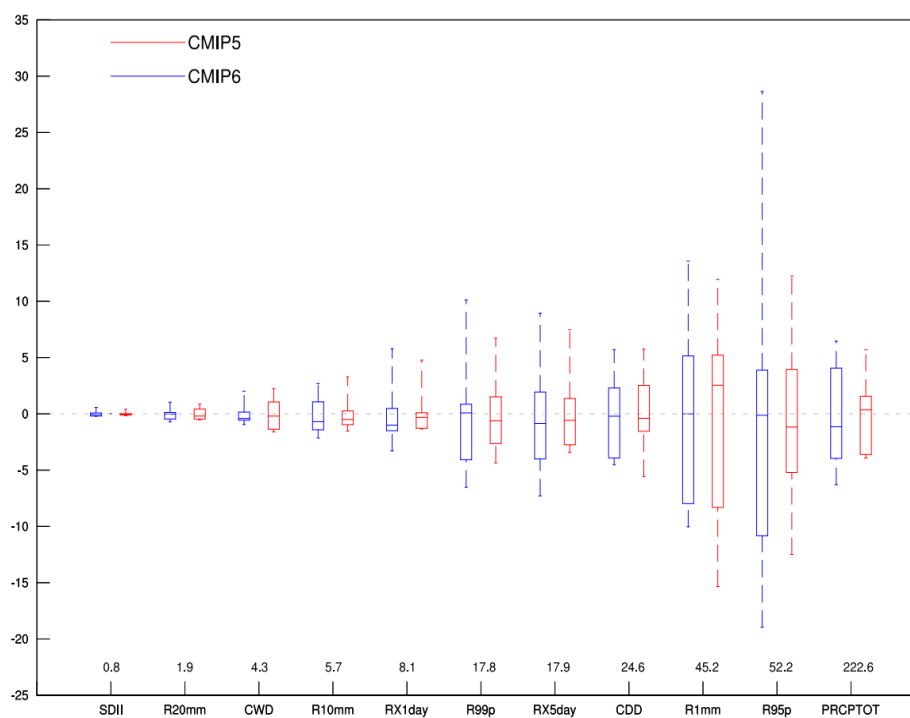


Figure S3. Box-and-whisker plots for the RMSEs of the climate means calculated from 12 CMIP6 and 12 CMIP5 models. Additionally, the RMSEs of PRCPTOT have been calculated one tenth of original in this plot.

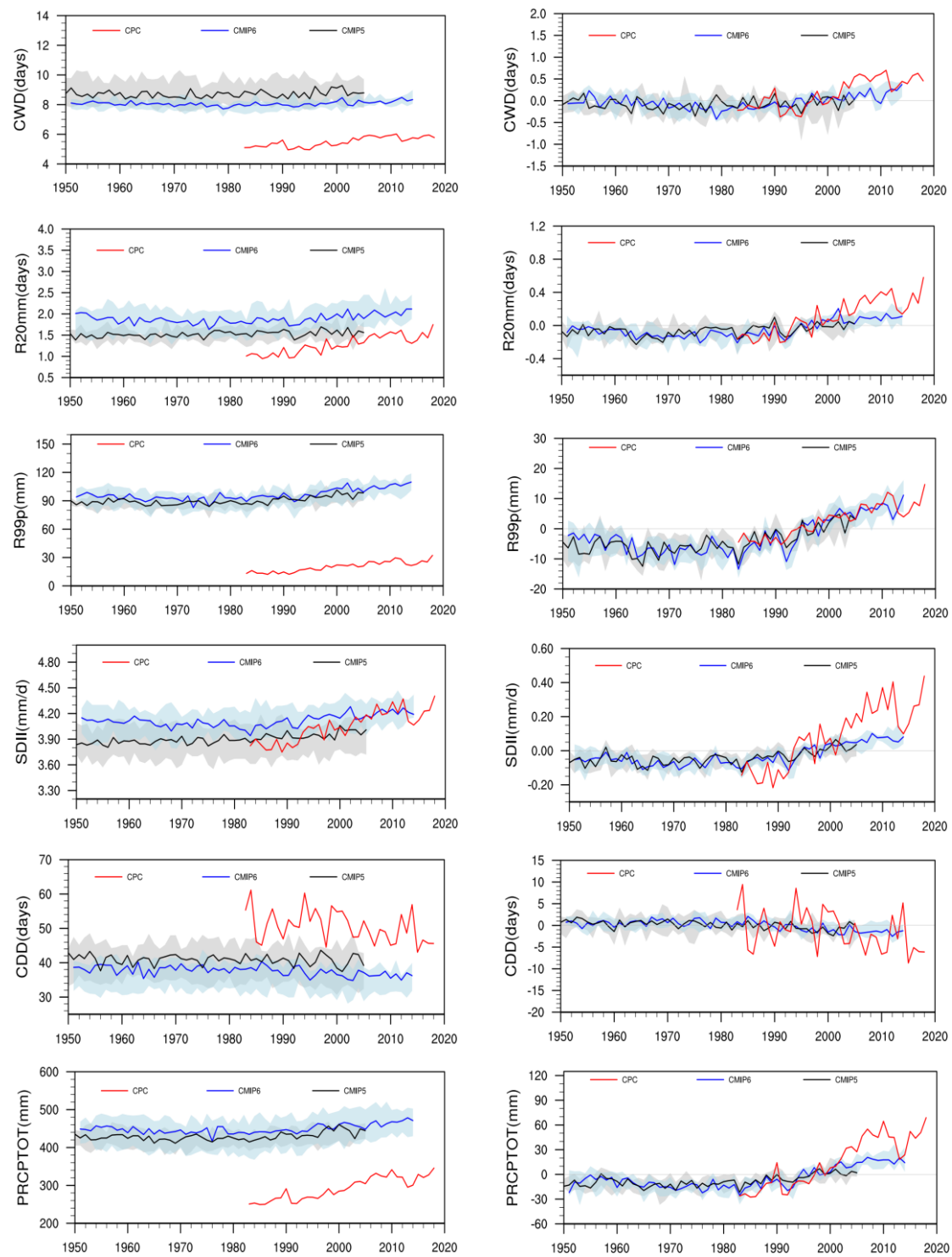


Figure S4. The series (left column) and anomaly series of (right columns) of precipitation extreme indices (consecutive wet days (CWD), very heavy precipitation days (R20mm), extremely wet days (R99p), simple daily intensity index (SDII)), total wet day precipitation (PRCPTOT) and consecutive dry days (CDD)). The results of CPC from 1983 to 2018 (red), CMIP5 from 1950 to 2005 (black) and CMIP6 from 1951-2014 (blue). The shading indicates the interquartile model spread (between the 25th and the 75th quartiles).