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Variation and attribution of probable maximum precipitation of China using a high-resolution dataset in a changing climate

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Table S1. Specific dates and reasons for extremely high precipitation higher than the 99.9% of observations (327 mm/d) in China during 1951-2019 from the HRLT precipitation dataset.

Dates	No. days of the year	Reason
1963/9/8	251	Extreme precipitation event
1975/8/7	219	Extreme precipitation event
1977/7/21	202	Extreme precipitation event
1996/9/21	265	Extreme precipitation event
1999/10/9	282	Extreme precipitation event
2001/8/30	242	Extreme precipitation event
2005/7/19	200	Extreme precipitation event
2005/9/3	246	Extreme precipitation event
2015/11/14	318	Bias in raw precipitation record
2015/11/23	327	Bias in raw precipitation record
2015/12/7	341	Bias in raw precipitation record
2016/3/22	82	Bias in raw precipitation record
2016/3/29	89	Bias in raw precipitation record
2016/5/1	122	Bias in raw precipitation record
2016/5/5	126	Bias in raw precipitation record
2016/5/6	127	Bias in raw precipitation record
2016/5/12	133	Bias in raw precipitation record
2016/5/13	134	Bias in raw precipitation record
2016/5/14	135	Bias in raw precipitation record
2016/5/18	139	Bias in raw precipitation record
2016/5/20	141	Bias in raw precipitation record
2016/5/22	143	Bias in raw precipitation record
2016/6/15	167	Bias in raw precipitation record
2016/6/21	173	Bias in raw precipitation record
2016/7/17	199	Bias in raw precipitation record
2016/7/19	201	Bias in raw precipitation record
2016/7/22	204	Bias in raw precipitation record
2016/7/24	206	Bias in raw precipitation record
2016/8/18	231	Extreme precipitation event
2016/9/29	273	Extreme precipitation event
2019/6/2	153	Bias in raw precipitation record
2019/8/11	223	Extreme precipitation event

Table S2. Data availability of different variables in different models. A tick '✓' (cross '✕') symbol means the data is (not) available currently. 'hfls' is the surface upward latent heat flux [W m-2]. 'hfss' is the surface upward sensible heat flux [W m-2]. 'pr' is the precipitation [kg m-2 s-1]. 'tasmax' is the daily maximum near-surface air temperature [K]. Refer to main text for the meaning of other abbreviations.

Experiment	Scenario	Variable	CMCC-ESM2	CNRM-CM6-1	EC-Earth3	IPSL-CM6A-LR	MIROC6	MPI-ESM1-2-LR
CMIP	historical	hfls	✓	✓	✓	✓	✓	✓
		hfss	✓	✓	✓	✓	✓	✓
		pr	✓	✓	✓	✓	✓	✓
SMIP	SSP126	hfls	✓	✓	✓	✓	✓	✓
		hfss	✓	✓	✓	✓	✓	✓
		pr	✓	✓	✓	✓	✓	✓
	SSP585	hfls	✓	✓	✓	✓	✓	✓
		hfss	✓	✓	✓	✓	✓	✓
		pr	✓	✓	✓	✓	✓	✓
LS3MIP	lfmip-pdLC (SSP126)	hfls	✕	✕	✓	✓	✕	✓
		hfss	✕	✕	✓	✓	✓	✓
		pr	✓	✕	✓	✓	✓	✓
	lfmip-pdLC (SSP585)	hfls	✕	✕	✓	✓	✕	✓
		hfss	✕	✕	✓	✓	✓	✓
		pr	✓	✓	✓	✓	✓	✓

Table S3. Detailed information of daily precipitation estimations of major Chinese water conservancy projects and their catchment area (GIWCHPD, 1982, 1990). Subset I and II mean the completion of version one (published in 1982) and two (published in 1990), respectively.

Source	ID	Name	PMP (mm)	Drainage area (km^2)
Subset I	8	Tankeng	522	30,200
Subset I	22	Pankou	213	8,950
Subset I	27	Daguangba	880	3,498
Subset I	33	Baozhusi	246	28,428
Subset I	53	Zhikong	45	20,179
Subset II	10	Zhuzhuang	761	1,220
Subset II	12	Kundulun	280	2,581
Subset II	22	Erlongshan	380	3,796
Subset II	23	Xinlicheng	400	1,970
Subset II	24	Shitoukoumen	267	4,944
Subset II	29	Longfengshan	403	1,740
Subset II	30	Hunanzhen	473	2,151
Subset II	31	Huangtankou	473	2,388
Subset II	32	Xinanjiang	330	10,442
Subset II	33	Fuchunjiang	223	31,645
Subset II	34	Tingxia	1010	176
Subset II	35	Jinshuitan	450	2,761
Subset II	36	Longhekou	680	1,120
Subset II	37	Chitan	315	4,766
Subset II	38	Gutian-I	406	1,325
Subset II	40	Shanmei	810	1,023
Subset II	41	Tuolin	388	9,340
Subset II	44	Wuhushan	728	557
Subset II	45	Taihe	707	780
Subset II	46	Xiashan	593	4,210
Subset II	49	Yahekou	577	3,030
Subset II	50	Banqiao	928	762
Subset II	57	Xiongdu	782	1,015
Subset II	58	Lushui	306	3,400
Subset II	60	Fushui	565	2,450
Subset II	62	Wuqiangxi	121	83,800
Subset II	66	Fengshuba	337	5,150
Subset II	67	Xinfengjiang	325	5,740
Subset II	69	Liuxihe	540	539
Subset II	70	Tiantangshan	666	461
Subset II	71	Songtao	900	1,440
Subset II	73	Chengbihe	897	2,000
Subset II	82	Tongjiezi	110	86,420
Subset II	83	Bikou	191	26,000
Subset II	85	Shengzhong	590	1,756
Subset II	87	Longxihe-I (Shizitan)	370	3,020
Subset II	91	Tianshengqiao	110	50,194
Subset II	92	Maotiaohe-I (Hongfeng)	386	1,596
Subset II	93	Maotiaohe-II (Baihua)	370	1,895

Subset II	98	Wujiangdu	131	27,800
Subset II	108	Lubuge	324	7,283
Subset II	110	Wangyao	265	820
Subset II	111	Shitouhe	310	673
Subset II	112	Shibianyu	420	132
Subset II	114	Shiquan	137	23,400
Subset II	115	Ankang	140	35,700
Subset II	122	Bajiazui	163	3,522

Table S4. Detailed information on the historical maximum precipitation over China (Wang, 2002).

Longitude	Latitude	Precipitation (mm)	Longitude	Latitude	Precipitation (mm)
112.33	16.83	642.0	118.80	32.00	134.7
108.87	18.75	962.2	120.15	32.52	205.4
109.63	19.20	642.6	121.15	32.30	822.0
109.38	19.18	632.0	92.07	33.62	69.6
110.28	19.05	516.0	101.70	33.78	98.2
109.78	20.95	694.4	101.48	33.43	43.2
107.9	21.58	657.5	107.08	33.33	500.0
107.65	21.68	641.7	108.83	33.30	310.8
108.00	21.78	452.0	108.32	33.75	327.5
110.68	21.37	794.0	110.40	33.72	1300.0
111.38	21.82	858.0	112.67	33.62	479.0
111.80	21.95	785.0	112.00	33.22	167.8
111.53	21.80	738.0	113.38	33.02	586.0
112.43	21.87	851.0	113.65	33.05	1060.3
112.72	21.95	674.0	113.32	33.38	334.0
99.43	22.78	197.9	115.35	33.27	470.8
101.02	22.58	312.9	118.08	33.65	553.6
102.25	22.82	113.1	120.55	33.45	672.6
104.77	22.95	240.4	98.13	34.95	59.6.0
108.85	22.10	564.4	104.67	34.85	440.0
109.10	22.23	643.5	107.05	34.28	126.1
112.48	22.30	656.0	108.05	34.72	146.0
113.92	22.27	643.5	108.22	34.05	90.1
115.67	22.98	884.0	108.53	34.02	262.1
99.62	23.73	78.1	109.62	34.27	345.0
101.30	23.63	137.7	111.92	34.82	650.0
104.58	23.38	177.9	112.18	34.32	734.3
106.95	23.97	385.8	115.05	34.60	451.5
106.67	23.07	302.0	116.82	34.77	230.0
109.67	23.30	617.0	119.37	34.75	599.1
111.30	23.48	82.0	119.57	34.20	825.0
113.02	23.72	646.7	93.38	35.37	60.1
113.52	23.27	211.0	103.85	35.45	401.0
113.22	23.67	939.3	105.97	35.55	255.0
114.25	23.33	432.0	108.38	35.22	298.0
114.95	23.03	670.3	113.67	35.80	484.0
114.97	23.33	145.7	113.67	35.87	771.5
115.75	23.05	915.6	114.22	35.32	530.0
115.42	23.32	491.0	118.13	35.22	537.0
115.72	23.22	494.0	119.40	35.97	599.6
115.88	23.63	786.2	81.47	36.47	52.6
116.37	23.78	630.0	94.90	36.42	35.2
116.85	23.45	756.1	99.07	36.78	79.6
120.58	23.70	1001.1	102.77	36.22	142.5
120.73	23.52	1748.5	108.32	36.98	356.0
97.70	24.75	285.7	109.17	36.80	400.0

98.58	24.48	195.7	111.35	36.43	457.2
106.63	24.08	61.3	113.72	36.17	483.5
109.97	24.98	300.0	119.08	36.12	498.6
112.17	24.33	298.1	120.68	36.93	740.0
115.65	24.95	283.3	120.57	36.27	536.0
118.27	24.85	592.6	76.32	37.80	92.3
118.58	24.63	632.5	95.50	37.72	29.7
121.22	24.55	1248.2	97.45	37.38	84.0
121.75	24.62	1672.6	101.58	37.00	240.0
100.22	25.52	91.0	103.07	37.62	228.0
102.72	25.03	256.7	103.20	37.38	472.0
105.38	25.85	253.4	107.22	37.77	448.0
109.18	25.37	779.1	110.05	37.08	85.0
109.38	25.22	355.0	110.88	37.30	422.5
110.4	25.72	290.6	112.17	37.82	57.3
113.17	25.75	461.1	114.22	37.37	950.0
113.03	25.8	295.3	114.10	37.20	589.8
114.7	25.42	147.5	116.92	37.03	466.2
116.95	25.6	491.1	116.12	37.38	643.0
116.07	25.77	379.4	121.77	37.33	308.3
118.83	25.53	571.5	77.27	38.43	43.5
119.57	25.47	737.7	85.55	38.15	42.9
101.73	26.68	275.8	102.38	38.58	232.0
104.62	26.78	333.5	105.90	38.77	212.5
106.67	26.48	415.8	105.93	38.62	202.7
108.42	26.40	327.6	109.4	38.92	1400.0
108.67	26.25	441.5	110.68	38.63	408.7
111.60	26.27	201.9	111.68	38.82	122.2
112.03	26.07	347.2	113.77	38.20	385.0
113.92	26.78	344.9	115.05	38.97	762.0
114.50	26.08	304.9	117.53	38.67	539.9
115.08	26.50	420.0	75.35	39.58	70.0
116.30	26.33	130.2	88.17	39.03	73.5
116.80	26.35	252.9	94.27	39.40	123.3
117.35	26.33	294.9	97.55	39.80	88.5
89.13	27.73	120.6	98.82	39.35	66.1
98.65	27.77	116.4	116.47	39.95	609.0
101.13	27.32	227.8	117.40	39.77	462.5
104.03	27.65	235.4	117.18	39.88	543.7
107.75	27.93	301.3	117.38	39.90	476.2
110.55	27.77	291.0	122.30	39.95	684.3
113.93	27.27	400.0	123.38	39.90	537.1
117.62	27.80	526.0	84.02	40.10	28.6
117.63	27.67	261.5	109.82	40.02	186.3
120.2	27.57	451.1	111.68	40.82	300.0
120.2	27.97	512.6	111.83	40.55	520.0
120.4	27.38	514.9	114.58	40.33	600.0
120.28	27.28	691.5	116.22	40.22	275.0

85.97	28.18	195.5	117.70	40.37	354.0
97.47	28.65	120.2	117.83	40.00	521.7
102.02	28.68	253.5	124.62	40.28	588.1
105.43	28.95	393.8	124.62	40.28	429.1
108.77	28.83	141.5	124.60	40.57	511.5
114.40	28.65	336.7	124.6	40.57	657.9
115.33	28.92	318.6	124.57	40.62	325.0
116.60	28.23	493.0	80.48	41.52	87.5
117.03	28.05	234.4	80.93	41.82	111.5
120.90	28.25	292.0	94.67	41.53	36.3
120.67	28.02	411.0	107.22	41.35	500.0
121.00	28.40	617.4	113.22	41.87	620.0
121.00	28.37	303.6	114.58	41.08	300.0
121.02	28.38	622.5	114.30	41.88	550.0
88.88	29.25	39.7	114.03	41.02	430.0
89.78	29.38	32.1	117.93	41.78	280.0
91.90	29.95	54.5	118.93	41.50	489.0
91.15	29.63	61.7	120.23	41.00	526.9
91.78	29.88	32.4	121.40	41.55	1000.0
100.38	29.70	109.7	124.20	41.62	429.0
103.53	29.75	565.0	86.90	42.37	79.9.0
103.65	29.30	571.8	89.20	42.93	36.0
109.73	29.40	414.0	117.97	42.52	120.0
110.77	29.93	550.0	118.62	42.03	600.0
111.30	29.48	325.3	119.13	42.27	401.0
112.75	29.92	226.0	124.70	42.57	283.5
113.37	29.67	342.3	128.05	42.05	189.8
115.20	29.83	644.8	81.88	43.13	93.0.0
118.60	29.43	346.3	88.12	43.88	120.4
121.75	29.80	519.0	88.32	43.35	78.9
121.30	29.40	520.7	94.35	43.08	93.4
81.25	30.28	47.0	94.07	43.08	70.0
106.72	30.03	371.9	116.25	43.75	350
108.27	30.2	326.9	127.08	43.13	126.6
110.98	30.43	630.4	129.30	43.73	181.5
115.85	30.23	515.1	131.07	43.15	335.0
115.02	30.25	360.0	85.32	44.35	240.0
116.63	30.95	487.9	93.30	44.20	16.6
118.15	30.08	335.0	120.98	44.37	196.3
119.60	30.45	682.1	126.73	44.68	241.1
119.38	30.38	584.7	128.97	44.05	154.5
90.02	31.37	44.9	90.53	45.37	66.9
96.98	31.18	55.3	121.33	45.63	350.0
104.13	31.37	440.3	122.20	45.78	335.0
106.72	31.65	477.1	123.23	45.58	89.5
111.63	31.07	417.9	126.77	45.75	99.1
115.57	31.20	430.0	127.32	45.10	480.0
115.57	31.20	356.1	84.38	46.77	122.1

119.95	31.77	166.0	84.38	46.77	97.5
121.38	31.35	581.3	133.15	46.25	162.4
121.43	31.17	278.0	123.18	47.33	191.8
80.08	32.50	34.6	123.50	47.93	201.6
84.07	32.30	36.3	86.35	48.05	54.0
96.57	32.13	61.9	122.73	48.02	174.8
102.38	32.25	44.2	125.98	48.07	220.7
105.47	32.30	418.5	127.65	48.47	239.1
105.20	32.05	578.5	128.72	48.03	140.5
106.05	32.52	307.9	128.25	48.03	114.7
106.08	32.12	371.7	128.68	48.30	214.4
108.27	32.20	450.5	118.12	49.28	138.0
111.48	32.17	581.4	121.05	49.10	164.8
113.98	32.42	431.5	125.37	50.07	144.9
115.73	32.30	202.9	126.97	50.58	183.8
118.42	32.67	653.0	122.37	53.48	129.9

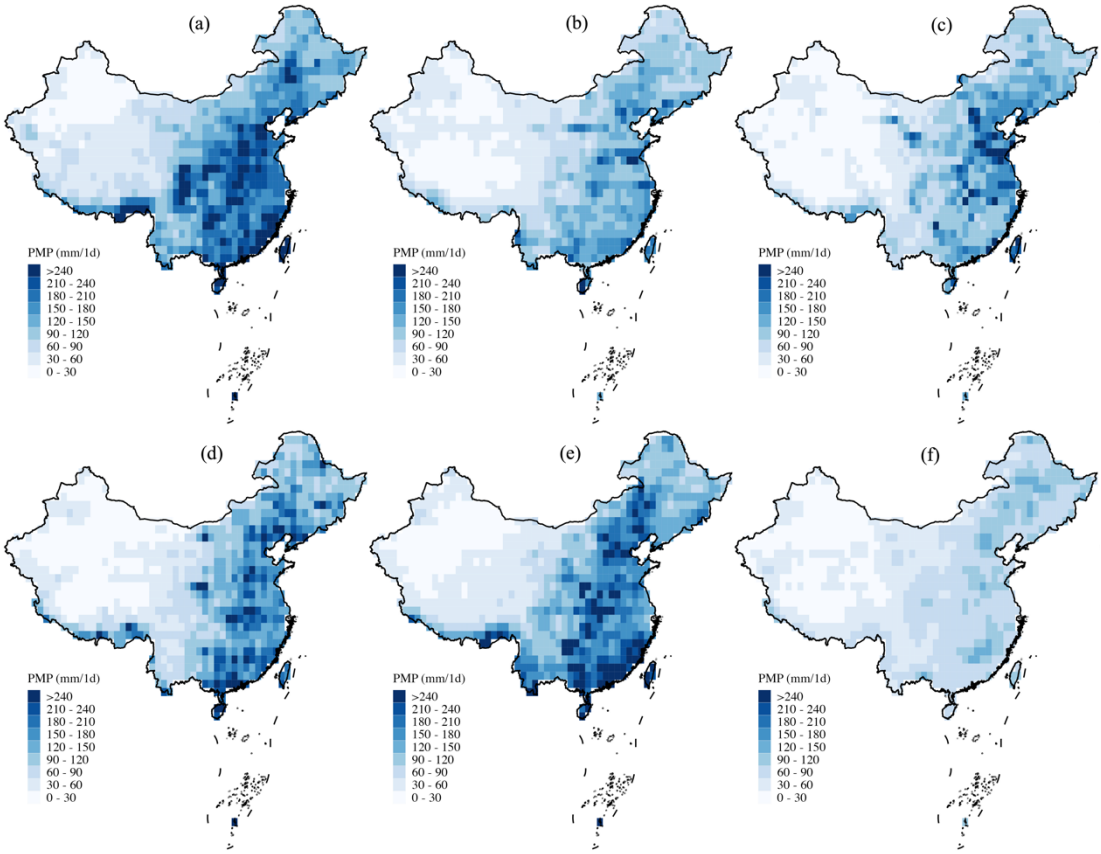

Figure S1. Spatial distribution of 1d PMP estimates during 1980-2014 over China from the (a) CMCC-ESM2, (b) CNRM-CM6-1, (c) EC-Earth3, (d) IPSL-CM6A-LR, (e) MIROC6, and (f) MPI-ESM1-2-LR models of the CMIP experiment, respectively.

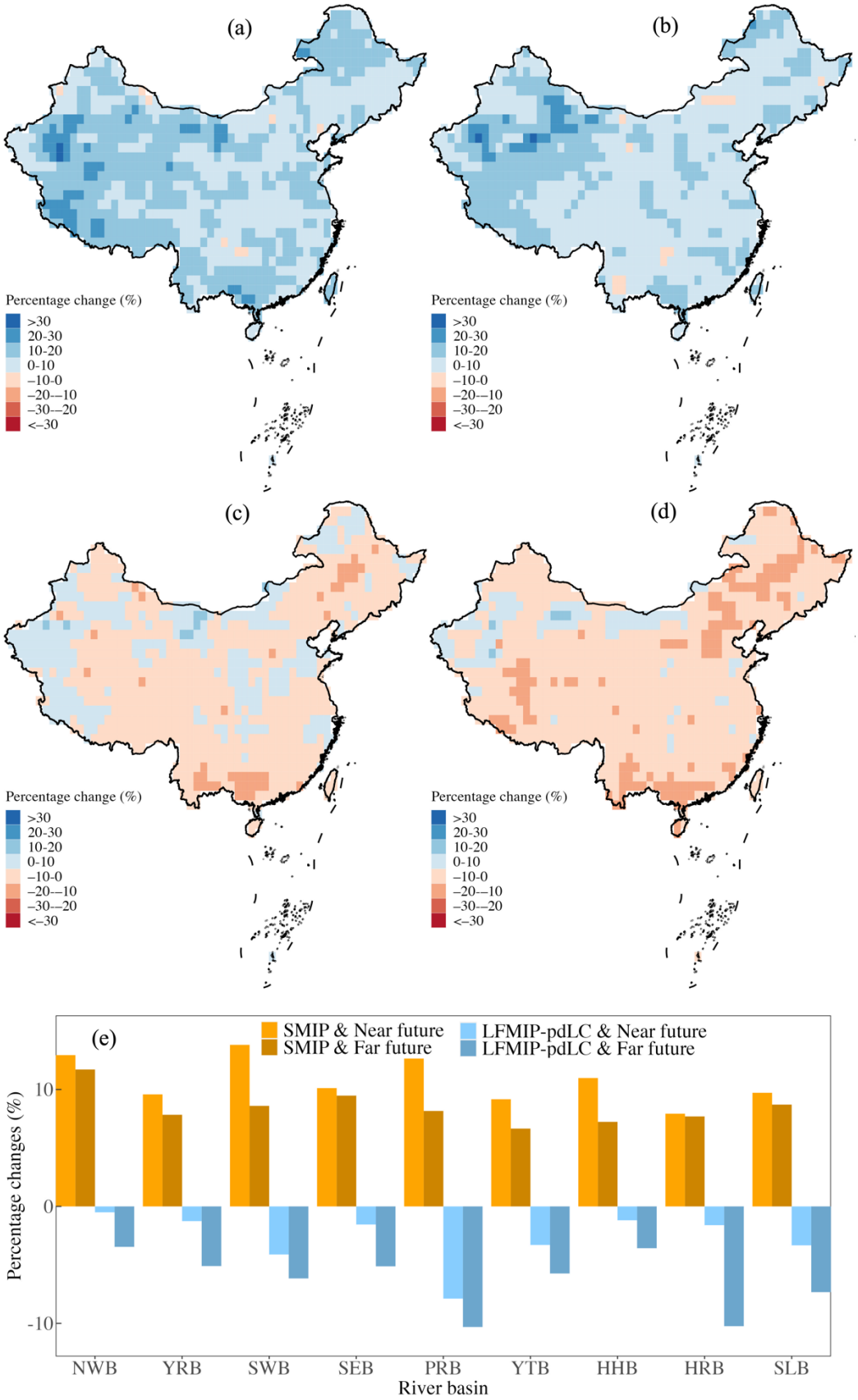

Figure S2. Multi-model mean percentage changes in 1d $\boldsymbol{X'_n}$ from (a, c) 2030-2064 and (b, d) 2065-2099 period to 1980-2014 under SSP126 scenario over China from (a, b) SMIP and (c, d) LFMIP-pdLC ensembles. (e) Regional summary of the percentage changes in 1d $\boldsymbol{X'_n}$. Please refer to Figure 1 for more details on the regional abbreviations.

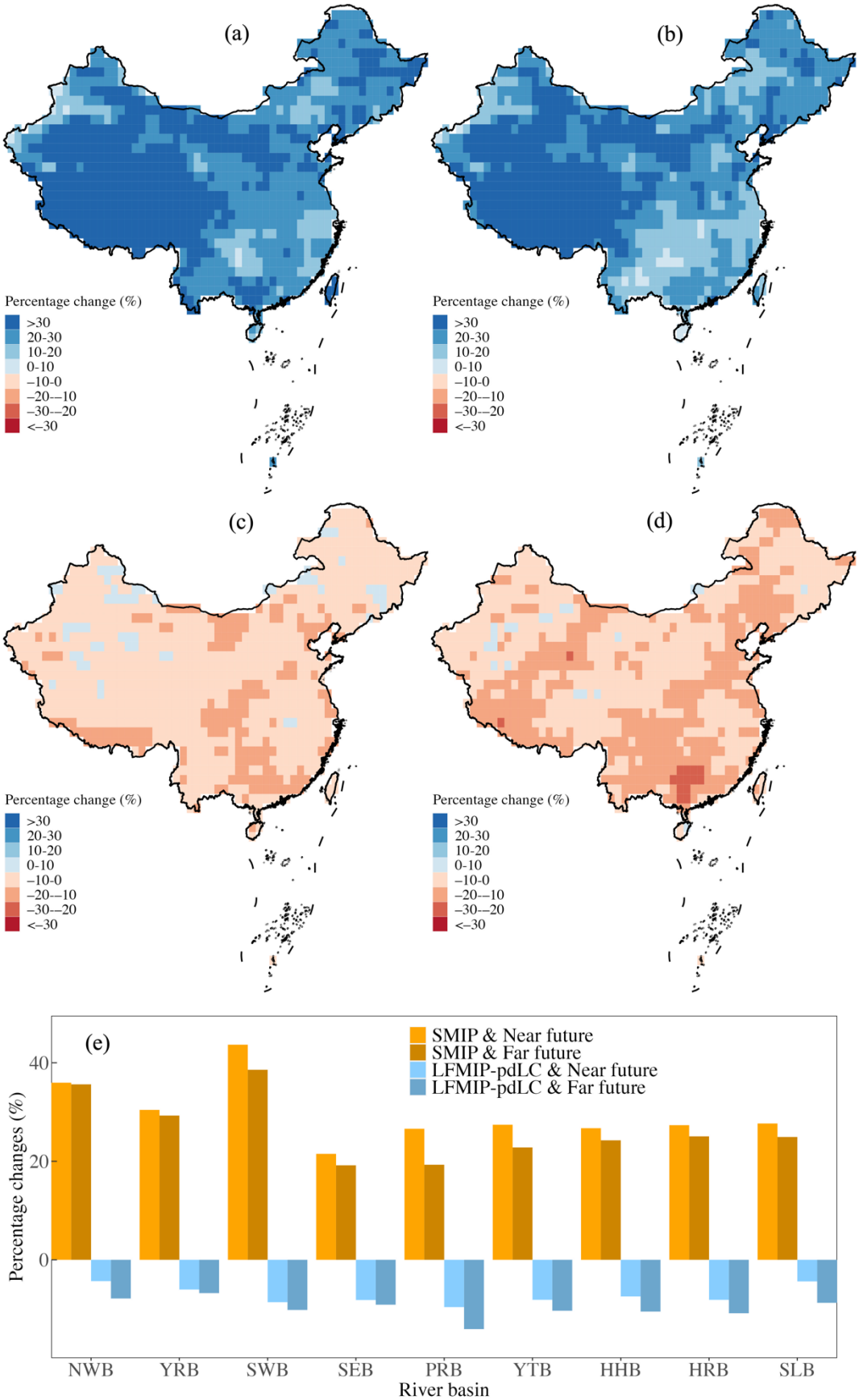

Figure S3. Same as Figure S2, but for the SSP585 scenario.

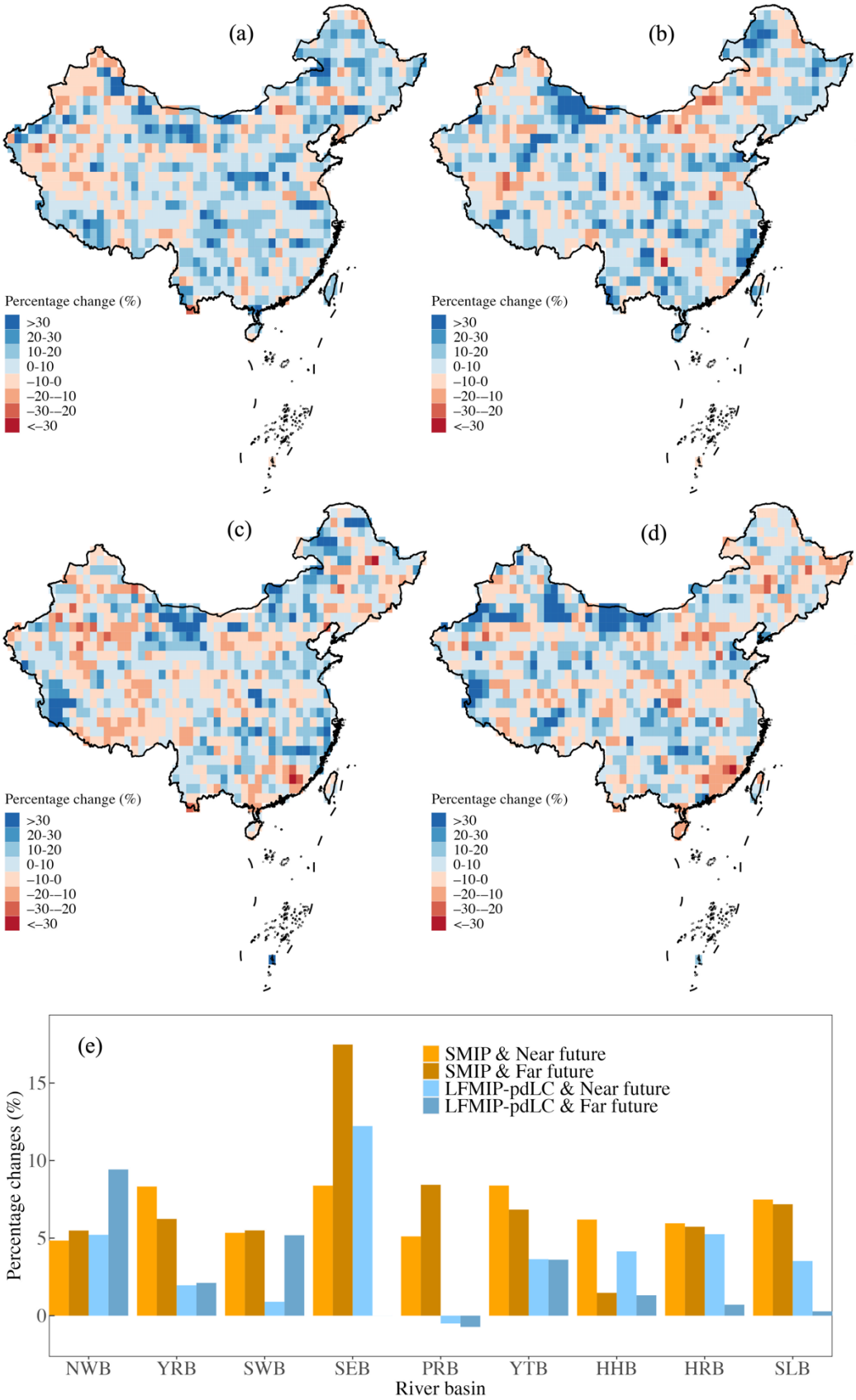

Figure S4. Multi-model mean percentage changes in 1d *K* factor from (a, c) 2030-2064 and (b, d) 2065-2099 period to 1980-2014 under SSP126 scenario over China from (a, b) SMIP and (c, d) LFMIP-pdLC ensembles. (e) Regional summary of the percentage changes in 1d *K* factor. Please refer to Figure 1 for more details on the regional abbreviations.

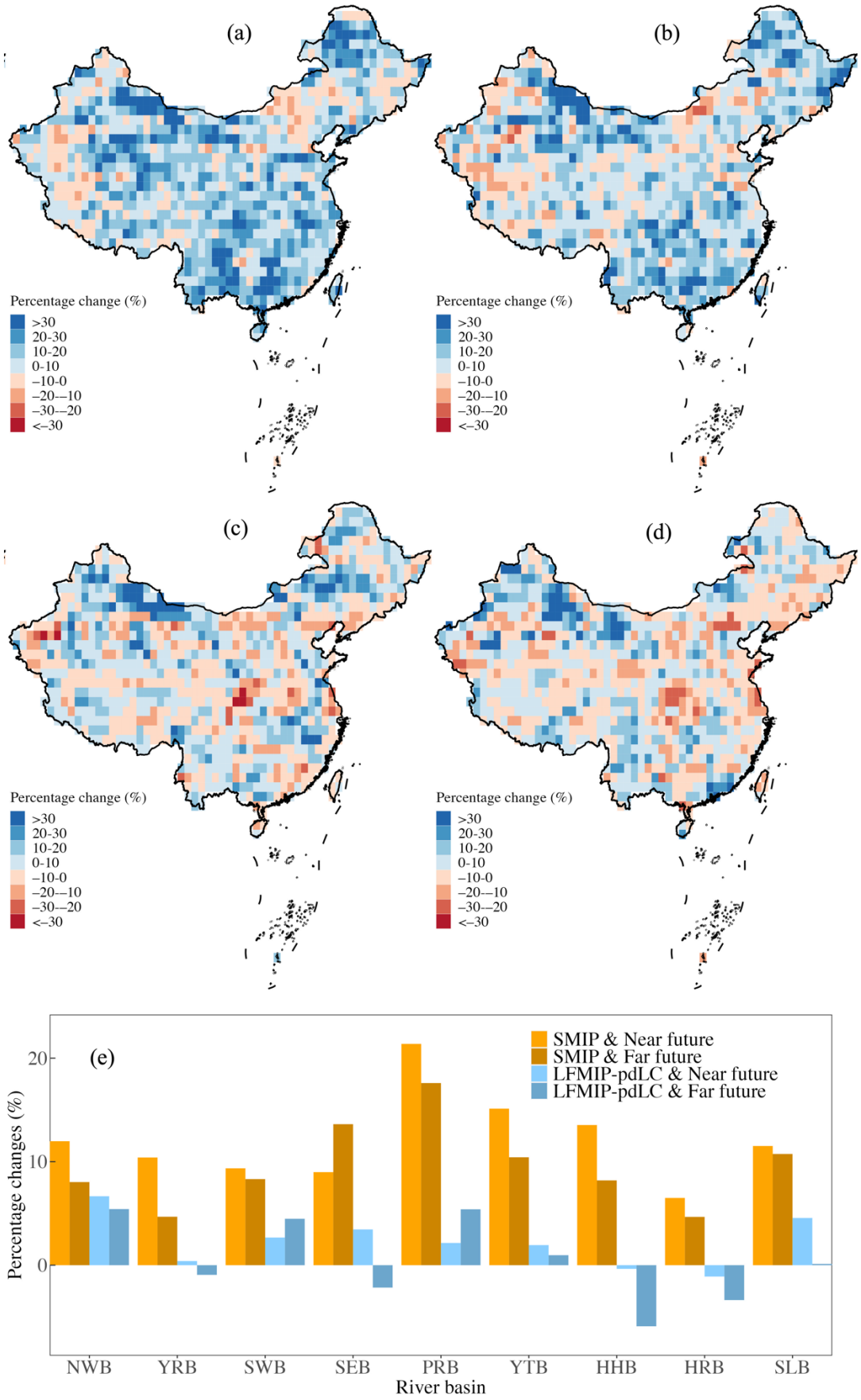

Figure S5. Same as Figure S4, but for the SSP585 scenario.

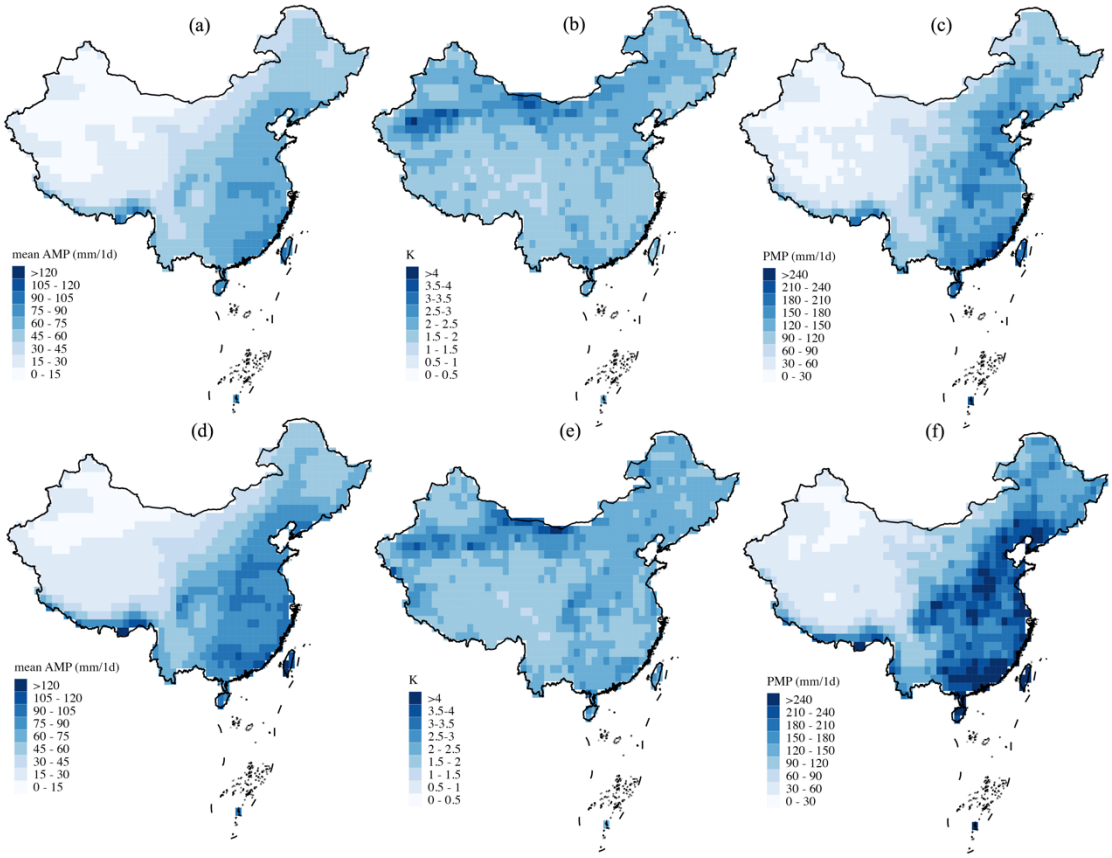

Figure S6. Estimates of 1d (a, d) $\boldsymbol{X}'_{\boldsymbol{n}}$, (b, e) *K* factor, and (c, f) PMP from ensemble mean of the (upper panel) CMIP and (lower panel) LFMIP-pdLC experiments during 1980-2014 over China.

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Wang, J. Q. (2002). Rainstorms in China. China Water & Power Press, Beijing.