Supplementary Material:

Table S1: The information of ground meteorological observation sites of China Meteorological Administration.

Station name	Altitude (°)	Longitude (°)	Elevation (m)
Naqu	31.5	92.1	4508.0
Dangxiong	30.5	91.1	4201.1
Zedang	29.3	91.8	3553.2
Tuotuohe	34.2	92.4	4534.3
Zaduo	32.9	95.3	4068.5
Qumalai	34.1	95.8	4176.4
Yushu	33.0	97.0	3682.2
Maduo	34.9	98.2	4273.3
Qingshuihe	33.8	97.1	4417.5
Shiqu	33.0	98.1	4201.0
Guoluo	34.5	100.2	3720.0
Dari	33.8	99.7	3968.5
Henan	34.7	101.6	3501.0
Jiuzhi	33.4	101.5	3630.0
Maqu	34.0	102.1	3473.2
Ruoergai	33.6	103.0	3441.1
Hezuo	35.0	102.9	2910.5
Minxian	34.4	104.0	2315.8
Wudou	33.4	104.9	1081.7
Dingqing	31.4	95.6	3874.0
Nangqian	32.2	96.5	3645.0
Changdu	31.2	97.2	3307.1
Dege	31.8	98.6	3199.3
Ganzi	31.6	100.0	3394.2
Banma	32.9	100.8	3530.0

Seda	32.3	100.3	3895.8
Daofu	31.0	101.1	3008.6
Maerkang	31.9	102.2	2665.9
Hongyuan	32.8	102.6	3492.7
Xiaojin	31.0	102.4	2368.6
Songpan	32.7	103.6	2852.1
Doujiangyan	31.0	103.7	707.0
Bomi	29.9	95.8	2737.0
Batang	30.0	99.1	2589.1
Xinlong	30.9	100.3	2999.2
Litang	30.0	100.3	3950.5
Tianquan	30.1	102.8	818.7
Pujiang	30.2	103.5	578.4
Linzhi	29.7	94.3	3001.0
Daocheng	29.1	100.3	3728.6
Kangding	30.1	102.0	2615.5
Emeishan	29.5	103.3	3048.6
Leshan	29.6	103.8	422.1
Chayu	28.7	97.5	2331.2
Deqin	28.5	98.9	3488.0
Jiulong	29.0	101.5	2993.7
Yuexi	28.7	102.5	1660.1
Leibo	28.3	103.6	253.9
Yibing	28.8	104.6	502.8
Gaoxian	28.4	104.5	378.1
Tianshui	34.6	105.8	1142.6
Baoji	34.4	107.1	610.3
Wugong	34.3	108.2	449.1
Yaozhou	35.0	109.0	723.3

Lueyang	33.3	106.2	797.3
Hanzhong	33.1	107.0	509.3
Foping	33.5	108.0	1088.6
Shangzhou	33.9	110.0	747.2
Zhenan	33.4	109.2	693.6
Shiquan	33.1	108.3	485.0
Wanyuan	32.1	108.0	674.0
Ankang	32.7	109.0	291.2
Langzhong	31.6	106.0	385.4
Bazhong	31.9	107.8	360.0
Dazhuan	31.2	107.5	344.3
Fengjie	31.0	109.5	608.3
Suining	30.5	105.6	279.5
Tongnan	30.2	105.8	331.7
Nanchong	30.8	106.1	309.7
Wanxianshi	30.8	108.4	188.8
Exi	30.3	109.5	458.0
Chongqing	29.6	106.5	260.4
Xuanen	30.0	109.5	571.8
Laifeng	29.5	109.4	460.4
Tongzi	28.1	106.8	972.0
Xuyong	28.2	105.4	379.2
Mouyang	28.8	108.8	665.8
Jishou	28.2	109.7	204.4

Table S2: The information of radiosonde stations of China Meteorological Administration.

Station name	Altitude (°)	Longitude (°)	Elevation(m)
Naqu	31.4	92.0	4507.0
Linzhi	29.6	94.3	2991.8

Yushu	33.0	96.9	3716.9
Changdu	31.1	97.1	3315.0
Batang	30.0	99.1	2589.2
Ganzi	31.6	100.0	3393.5
Hongyuan	32.8	102.5	3491.6
Wenjiang	30.7	103.8	547.7
Wudou	33.4	104.9	1079.1
Hanzhong	33.0	107.0	509.5
Daxian	31.2	107.5	344.9
Shapingba	29.5	106.4	259.1
Ankang	32.7	109.0	290.8
Yibing	28.7	104.5	287.0

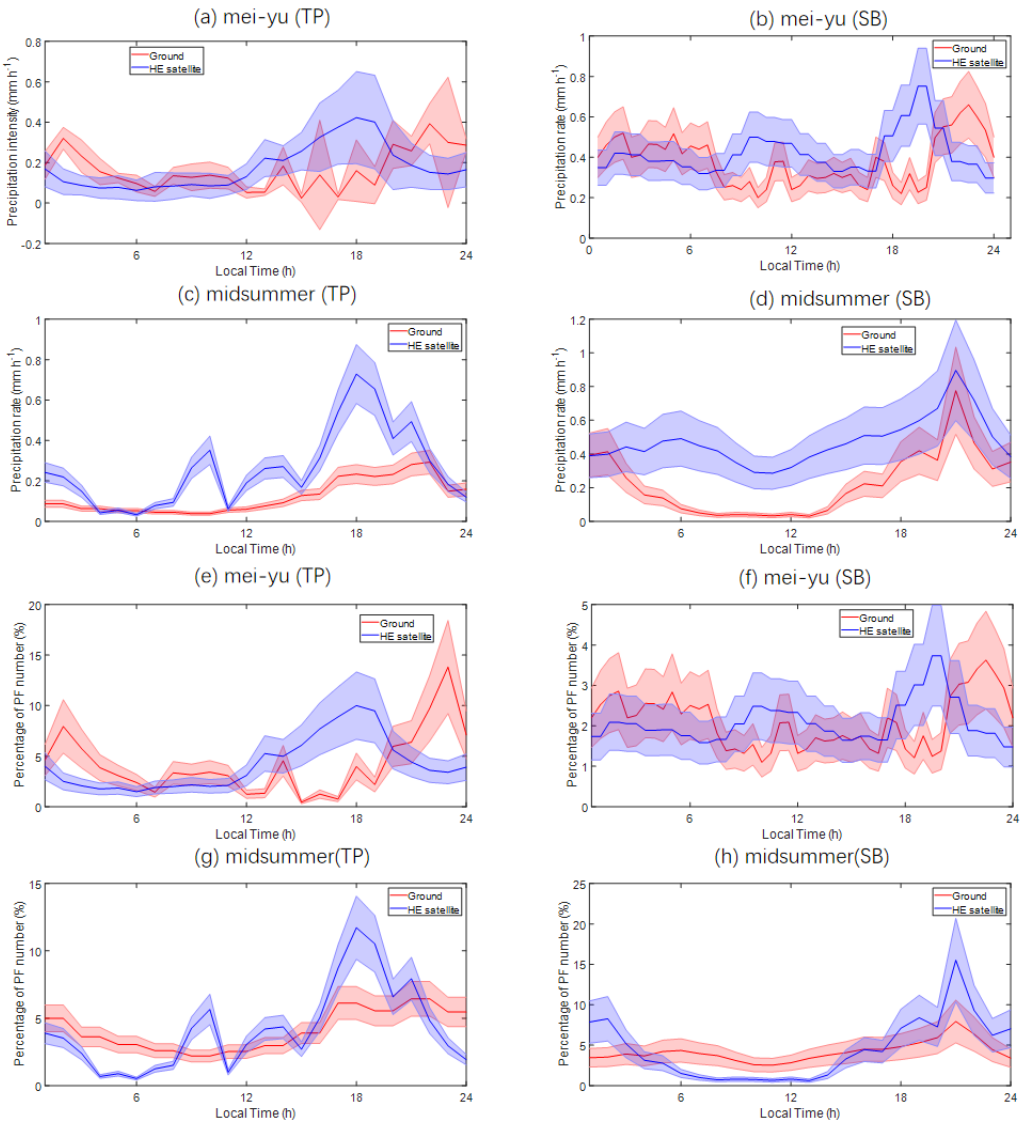

Figure S1: The precipitation from Hydro Estimator satellite estimates (blue line) and ground observations (red line) during (a, b) meiyu and (c, d) midsummer period over the (a, c) Tibetan Plateau and (b, d) Sichuan Basin. Blue shaded area is the standard error of precipitation from Hydro Estimator satellite estimates and red shaded area is the standard error of precipitation from ground observations. The percentage of precipitation feature number during (e, f) mei-yu and (g, h) midsummer period over the (e, g) Tibetan Plateau and (f, h) Sichuan Basin and their error bar. Blue shaded area is the standard error of the percentage of precipitation feature from Hydro Estimator satellite estimates and red shaded area is the standard error of percentage of precipitation feature from ground observations.

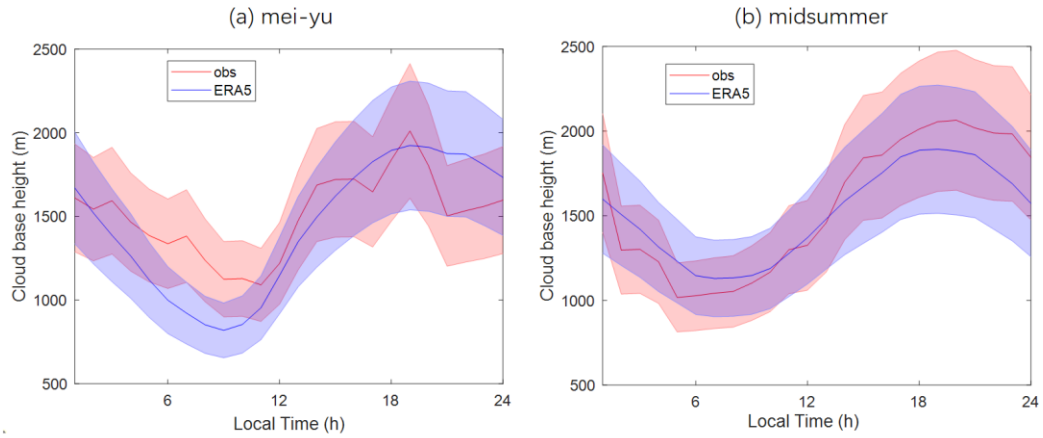

Figure S2: The comparison of cloud base height from ERA5 dataset (blue line) and cloud radar observations (red line) and their standard error (blue shaded area for ERA5 and red shaded area for observations) during the (a) mei-yu and (b) midsummer period.

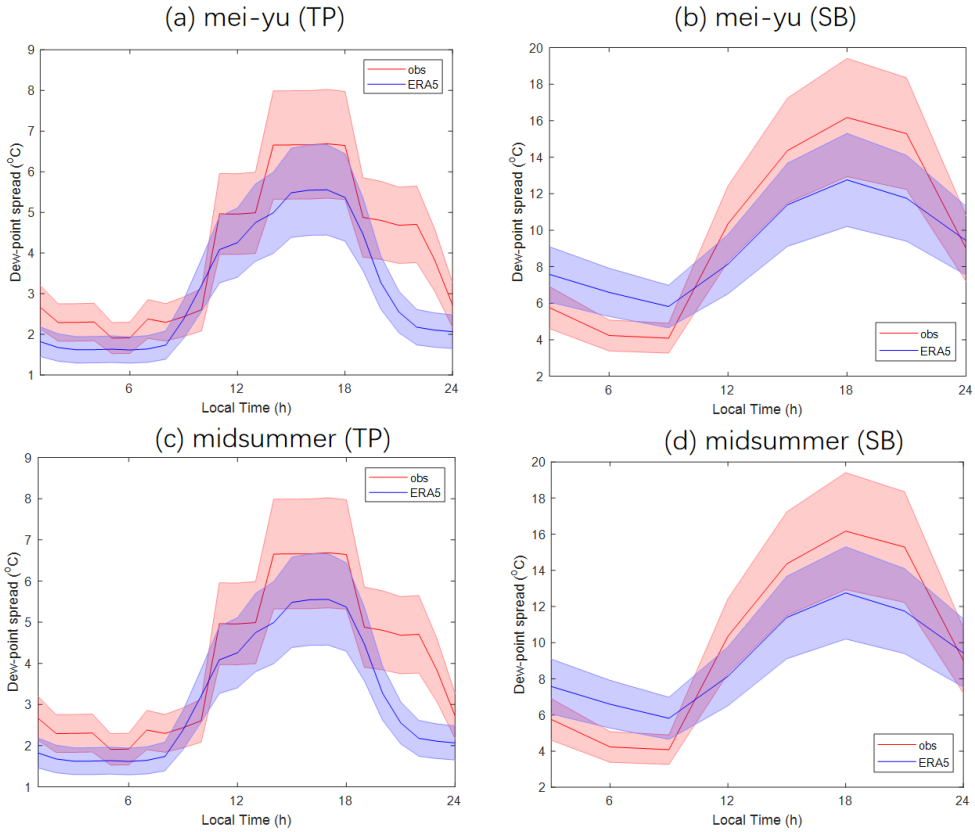

Figure S3: The comparison of dew point spread from the ERA5 dataset (blue line) and ground observations (red line) and their standard error (blue shaded area for ERA5 dataset, and red shaded area for observations) during the (a,b) mei-yu and (c,d) midsummer period over the (a,c) Tibetan Plateau and (b,d) Sichuan Basin.