

SUPPORTING INFORMATION

Table S1. TWSA trends (mm/year) derived from JPL and CSR in HRB's sub-regions (Beijing (BJ), Tianjin (TJ), Hebei (HB), Shanxi (SX), Shandong (SD), and Henan (HN)).

Region	JPL	CSR
HRB	-17.31±0.85	-13.67±0.97
BJ	-8.24±0.44	-6.18±0.64
TJ	-14.96±1.07	-6.13±0.87
HB	-14.59±0.72	-12.77±0.95
SX	-20.22±0.86	-19.17±1.21
SD	-28.04±1.95	-14.01±1.51
HN	-36.89±1.92	-31.12±2.85

Table S2. Trends of TWSA, SMSA, and GWSA (mm/year) derived from HMs and reference values in BJ.

	TWSA	SMSA	GWSA
NOAH	0.58±0.54	0.58±0.54	--
VIC	-1.17±0.45	-1.17±0.45	--
CLSM2.1	1.31±0.56	0.28±0.15	1.03±0.42
CLSM2.0	2.64±0.71	0.55±0.18	2.09±0.53
WGHM	-33.34±0.91	0.14±0.09	-33.48±0.33
PCR	-20.12±0.99	0.08±0.34	-20.20±0.19
CLM	-3.09±0.99	4.06±0.84	-7.15±0.50
Reference	-7.28±0.48	1.16±0.54	-8.44±0.38

Table S3. Trends of TWSA, SMSA, and GWSA (mm/year) derived from HMs and reference values in TJ.

	TWSA	SMSA	GWSA
NOAH	-1.65±0.77	-1.65±0.77	--
VIC	0.17±0.65	0.17±0.65	--
CLSM2.1	0.52±0.73	-0.02±0.21	0.54±0.60
CLSM2.0	4.80±0.87	0.42±0.24	4.38±0.70
WGHM	-1.96±1.05	0.00±0.09	-1.96±0.31
PCR	-20.46±0.68	-0.25±0.53	-20.21±0.15
CLM	4.43±1.63	9.91±1.24	-5.48±0.99
Reference	-10.73±0.88	2.81±0.81	-13.54±0.63

Table S4. Trends of TWSA, SMSA, and GWSA (mm/year) derived from HMs and reference values in HB.

	TWSA	SMSA	GWSA
NOAH	-2.33±0.66	-2.33±0.66	--
VIC	-0.96±0.48	-0.96±0.48	--
CLSM2.1	-0.60±0.69	-0.17±0.18	-0.43±0.54
CLSM2.0	0.15±0.82	-0.05±0.21	0.20±0.64
WGHM	-22.54±0.42	-0.02±0.11	-22.52±0.19

PCR	-23.77±0.76	-0.84±0.37	-22.93±0.14
CLM	-3.33±0.99	2.05±0.80	-5.38±0.50
Reference	-13.79±0.74	-0.41±0.60	-13.38±0.43

Table S5. Trends of TWSA, SMSA, and GWSA (mm/year) derived from HMs and reference values in SX.

	TWSA	SMSA	GWSA
NOAH	-2.60±0.60	-2.60±0.60	--
VIC	-2.10±0.49	-2.10±0.49	--
CLSM2.1	-1.66±0.71	-0.45±0.19	-1.21±0.52
CLSM2.0	-1.32±1.01	-0.38±0.28	-0.92±0.73
WGHM	-3.19±0.34	0.07±0.14	-3.26±0.13
PCR	-5.46±0.43	-0.80±0.37	-4.66±0.07
CLM	-4.06±0.93	3.09±0.84	-7.15±0.32
Reference	-19.91±0.91	-0.54±0.61	-19.38±0.64

Table S6. Trends of TWSA, SMSA, and GWSA (mm/year) derived from HMs and reference values in SD.

	TWSA	SMSA	GWSA
NOAH	-5.23±1.44	-5.23±1.44	--
VIC	-1.59±0.77	-1.59±0.77	--
CLSM2.1	-4.31±1.32	-1.01±0.30	-3.30±1.12
CLSM2.0	-7.75±1.60	-1.61±0.35	-6.14±1.35
WGHM	-0.51±0.82	-0.08±0.09	-0.43±0.47
PCR	-32.71±1.45	-3.69±0.71	-29.02±0.43
CLM	5.49±1.78	3.14±1.51	2.35±0.94
Reference	-21.28±1.51	-1.23±1.13	-20.05±1.03

Table S7. Trends of TWSA, SMSA, and GWSA (mm/year) derived from HMs and reference values in HN.

	TWSA	SMSA	GWSA
NOAH	-7.67±1.21	-7.67±1.21	--
VIC	-2.44±0.63	-2.44±0.63	--
CLSM2.1	-7.28±1.24	-1.52±0.29	-5.76±0.99
CLSM2.0	-11.48±1.50	-2.52±0.36	-8.96±1.16
WGHM	-14.11±0.61	-0.11±0.07	-14.00±0.44
PCR	-62.34±0.73	-3.63±0.53	-58.71±0.20
CLM	-7.10±1.61	-1.42±1.43	-5.68±0.76
Reference	-34.57±2.06	-3.84±1.02	-30.73±1.35

Table S8. Indices of TWSA, SMSA, and GWSA between reference values and HMs in BJ.

	TWSA			SMSA			GWSA		
	<i>RMSE</i> <i>mm</i>	<i>NSE</i>	<i>r</i>	<i>RMSE</i> <i>mm</i>	<i>NSE</i>	<i>r</i>	<i>RMSE</i> <i>mm</i>	<i>NSE</i>	<i>r</i>
Noah	36.10	-0.27	0.37	11.05	0.76	0.9	-	-	-

VIC	32.01	0.00	0.55	14.48	0.6	0.79	-	-	-
CLSM2.1	41.46	-0.68	0.23	18.64	0.33	0.8	50.41	-1.31	-0.37
CLSM2.0	50.54	-1.49	0.03	18.4	0.35	0.71	56.84	-1.93	-0.5
WGHM	90.25	-6.95	0.86	22.23	0.05	0.37	102.46	-8.52	0.88
PCR	46.69	-1.13	0.84	19.26	0.28	0.57	47.69	-1.06	0.87
CLM	40.34	-0.59	0.57	21.59	0.1	0.89	31.58	0.1	0.62

Table S9. Indices of TWSA, SMSA, and GWSA between reference values and HMs in TJ.

	TWSA			SMSA			GWSA		
	<i>RMSE</i> <i>mm</i>	<i>NSE</i>	<i>r</i>	<i>RMSE</i> <i>mm</i>	<i>NSE</i>	<i>r</i>	<i>RMSE</i> <i>mm</i>	<i>NSE</i>	<i>r</i>
Noah	43.63	0.29	0.68	23.37	0.55	0.82	-	-	-
VIC	52.23	-0.01	0.48	19.08	0.7	0.87	-	-	-
CLSM2.1	52.06	0	0.48	30.31	0.24	0.71	69.11	-0.66	-0.08
CLSM2.0	71.32	-0.89	0.15	29.35	0.28	0.69	85.83	-1.56	-0.42
WGHM	59.15	-0.3	0.34	33.76	0.05	0.56	57.79	-0.16	0.31
PCR	49.77	0.08	0.79	28.79	0.31	0.61	35.41	0.56	0.88
CLM	92.9	-2.2	0.18	40.01	-0.33	0.88	66.56	-0.54	0.32

Table S10. Indices of TWSA, SMSA, and GWSA between reference values and HMs in HB.

	TWSA			SMSA			GWSA		
	<i>RMSE</i> <i>mm</i>	<i>NSE</i>	<i>r</i>	<i>RMSE</i> <i>mm</i>	<i>NSE</i>	<i>r</i>	<i>RMSE</i> <i>mm</i>	<i>NSE</i>	<i>r</i>
Noah	51.57	0.17	0.68	10.83	0.81	0.94	-	-	-
VIC	58.76	-0.07	0.53	11.57	0.78	0.89	-	-	-
CLSM2.1	61.05	-0.16	0.46	19.49	0.39	0.81	63.98	-0.67	0.06
CLSM2.0	65.22	-0.32	0.36	18.95	0.42	0.78	67.51	-0.85	-0.03
WGHM	37.63	0.56	0.9	22.83	0.16	0.53	38.58	0.39	0.94
PCR	38.49	0.54	0.9	19.85	0.36	0.61	39.33	0.37	0.94
CLM	56.4	0.01	0.61	16.94	0.54	0.9	45.64	0.15	0.68

Table S11. Indices of TWSA, SMSA, and GWSA between reference values and HMs in SX.

	TWSA			SMSA			GWSA		
	<i>RMSE</i> <i>mm</i>	<i>NSE</i>	<i>r</i>	<i>RMSE</i> <i>mm</i>	<i>NSE</i>	<i>r</i>	<i>RMSE</i> <i>mm</i>	<i>NSE</i>	<i>r</i>
Noah	77.53	0.03	0.65	12.06	0.77	0.93	-	-	-
VIC	84.43	-0.15	0.51	12.79	0.74	0.87	-	-	-
CLSM2.1	85.78	-0.19	0.43	20.54	0.34	0.76	89.41	-0.53	0.18
CLSM2.0	86.99	-0.23	0.41	18.54	0.46	0.78	91.17	-0.6	0.15
WGHM	77.68	0.02	0.7	23.95	0.1	0.47	75.45	-0.09	0.86
PCR	70.03	0.21	0.75	22.81	0.19	0.5	70.3	0.05	0.92
CLM	75.45	0.08	0.65	20.06	0.37	0.9	59.7	0.32	0.91

Table S12. Indices of TWSA, SMSA, and GWSA between reference values and HMs in SD.

	TWSA			SMSA			GWSA		
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	<i>RMSE</i> <i>mm</i>	<i>NSE</i>	<i>r</i>	<i>RMSE</i> <i>mm</i>	<i>NSE</i>	<i>r</i>	<i>RMSE</i> <i>mm</i>	<i>NSE</i>	<i>r</i>
Noah	85.04	0.22	0.7	28.64	0.62	0.92	-	-	-
VIC	104.1	-0.16	0.41	31.51	0.54	0.75	-	-	-
CLSM2.1	85.78	0.21	0.69	36.83	0.38	0.85	96.36	-0.4	0.32
CLSM2.0	69.1	0.49	0.77	36.64	0.38	0.78	83.67	-0.06	0.48
WGHM	108.2	-0.26	0.29	45.19	0.06	0.48	102.24	-0.58	0
PCR	71.68	0.45	0.85	32.77	0.51	0.77	54.25	0.56	0.85
CLM	129.53	-0.8	0.25	31.46	0.55	0.92	108.42	-0.77	-0.04

Table S13. Indices of TWSA, SMSA, and GWSA between reference values and HMs in HN.

	TWSA			SMSA			GWSA		
	<i>RMSE</i> <i>mm</i>	<i>NSE</i>	<i>r</i>	<i>RMSE</i> <i>mm</i>	<i>NSE</i>	<i>r</i>	<i>RMSE</i> <i>mm</i>	<i>NSE</i>	<i>r</i>
Noah	129.29	0.23	0.81	20.51	0.79	0.96	-	-	-
VIC	156.68	-0.14	0.56	25.87	0.66	0.84	-	-	-
CLSM2.1	134.76	0.16	0.76	33.11	0.44	0.9	125.94	-0.1	0.6
CLSM2.0	108.32	0.46	0.86	29.78	0.55	0.9	106.79	0.21	0.73
WGHM	111.54	0.42	0.91	43.33	0.04	0.34	89.15	0.45	0.92
PCR	129.66	0.22	0.85	29.48	0.56	0.79	117.25	0.05	0.9
CLM	126.51	0.26	0.73	24.11	0.7	0.94	115.26	0.08	0.68

Table S14. Trends of TWSA, SMSA, and GWSA (mm/year) derived from HMs in HRB's plains.

	TWSA	SMSA	GWSA
NOAH	-4.13±0.98	-4.13±0.98	-
VIC	-0.68±0.60	-0.68±0.60	-
CLSM2.1	-2.17±0.92	-0.54±0.23	-1.63±0.76
CLSM2.0	-2.48±1.10	-0.68±0.26	-1.80±0.90
WGHM	-33.59±0.71	-0.02±0.09	-33.57±0.37
PCR	-42.73±0.95	-1.99±0.55	-40.74±0.35
CLM	2.08±1.37	5.63±1.18	-3.55±0.71
Reference	-17.17±1.05	0.27±0.85	-17.44±0.68

Table S15. Trends of TWSA, SMSA, and GWSA (mm/year) derived from HMs in HRB's mountains.

	TWSA	SMSA	GWSA
NOAH	-1.75±0.54	-1.75±0.54	-
VIC	-1.40±0.45	-1.40±0.45	-
CLSM2.1	-0.78±0.64	-0.21±0.17	-0.57±0.49
CLSM2.0	-0.13±0.79	-0.07±0.21	-0.06±0.59
WGHM	-11.04±0.34	0.01±0.14	-11.05±0.11
PCR	-11.93±0.59	-0.66±0.31	-11.27±0.07
CLM	-4.95±0.87	1.13±0.72	-6.08±0.36
Reference	-14.19±0.69	-0.67±0.54	-13.52±0.42

Table S16. Indices of TWSA, SMSA, and GWSA between reference values and HMs in HRB's

plains.

	TWSA			SMSA			GWSA		
	<i>RMSE</i> <i>mm</i>	<i>NSE</i>	<i>r</i>	<i>RMSE</i> <i>mm</i>	<i>NSE</i>	<i>r</i>	<i>RMSE</i> <i>mm</i>	<i>NSE</i>	<i>r</i>
Noah	62.55	0.28	0.73	23.23	0.56	0.88			
VIC	79.94	-0.18	0.39	20.84	0.65	0.82			
CLSM2.1	70.43	0.08	0.62	27.97	0.36	0.83	80.58	-0.46	0.22
CLSM2.0	67.8	0.15	0.63	27.18	0.4	0.82	79.73	-0.43	0.24
WGHM	68.95	0.12	0.87	33.32	0.1	0.6	67.33	-0.02	0.91
PCR	106.35	-1.09	0.87	25.42	0.47	0.73	92.41	-0.92	0.91
CLM	95.93	-0.7	0.3	30.43	0.25	0.89	72.73	-0.19	0.44

Table S17. Indices of TWSA, SMSA, and GWSA between reference values and HMs in HRB's mountains.

	TWSA			SMSA			GWSA		
	<i>RMSE</i> <i>mm</i>	<i>NSE</i>	<i>r</i>	<i>RMSE</i> <i>mm</i>	<i>NSE</i>	<i>r</i>	<i>RMSE</i> <i>mm</i>	<i>NSE</i>	<i>r</i>
Noah	55.69	0.04	0.63	7.25	0.89	0.96			
VIC	59.46	-0.1	0.54	10.05	0.8	0.89			
CLSM2.1	63.31	-0.24	0.42	17.76	0.37	0.76	64.77	-0.68	0.09
CLSM2.0	66.68	-0.38	0.34	17.28	0.4	0.72	67.42	-0.82	0.03
WGHM	28.88	0.74	0.92	20.23	0.18	0.5	22.21	0.8	0.94
PCR	32.72	0.67	0.87	19.45	0.24	0.51	22.27	0.8	0.94
CLM	49.73	0.23	0.71	13.86	0.61	0.91	41.3	0.32	0.81