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Supplement of

The effect of GCM biases on global runoff simulations of a land surface model

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Table S 1. Basin station information

Basins	GRDC station number	GRDC station name	Area [km ²]
Amazon	3629001	Obidos	4680000
Congo	1147010	Kinshasa	3475000
Mississippi	4127800	Vicksburg MS	2964255
Lena	2903430	Stolb	2460000
Volga	6977100	Volgograd power plant	1360000
Ganges	2646200	Hardinge bridge	846300
Danube	6742900	Ceatal Izmail	807000
Elbe	6340110	Neu-Darchau	131950
Kemijoki	6854700	Isohaara	50686

Table S 2. Values of input variables, for each GCM (GFDL, IPSL and MIROC), the ensemble mean (Ens.Mean) and WFDEI data, spatially averaged for 24 Giorgi regions.

P [mm/day]					T [K]					
	GFDL	IPSL	MIROC	Ens.Mean	WFDEI	GFDL	IPSL	MIROC	Ens.Mean	WFDEI
NEU	2.61	2.30	2.53	2.48	2.43	277.90	277.15	281.16	278.74	279.50
MED	1.44	1.08	1.44	1.32	1.56	288.73	287.57	290.13	288.81	288.26
NEE	1.71	1.67	1.79	1.72	1.67	274.42	274.15	277.89	275.49	276.75
NAS	1.59	1.66	1.78	1.68	1.25	267.91	269.70	270.71	269.44	267.53
CAS	0.92	0.79	1.36	1.02	0.93	284.84	284.00	287.60	285.48	285.79
TIB	1.36	1.05	1.99	1.47	0.63	274.44	271.79	273.20	273.14	275.70
EAS	2.96	2.88	2.96	2.94	2.57	286.26	285.73	288.39	286.79	284.48
SEA	8.77	6.74	6.80	7.44	6.96	299.45	299.15	298.99	299.19	299.21
NAU	2.97	1.37	3.46	2.60	1.65	297.80	297.47	298.36	297.87	297.40
SAU	1.79	1.60	2.28	1.89	1.28	289.28	286.59	287.49	287.79	290.68
SAH	0.22	0.06	0.35	0.21	0.15	297.02	294.15	296.73	295.97	298.18
WAF	4.60	2.92	4.02	3.85	2.86	298.65	298.50	299.70	298.95	300.57
EAF	2.15	1.52	2.87	2.18	1.99	297.86	297.14	298.09	297.69	298.99
EQF	2.87	3.34	2.80	3.00	2.67	295.21	295.47	295.61	295.43	296.00
SQF	3.33	3.18	2.79	3.10	3.04	295.89	295.95	296.37	296.07	295.96
SAF	2.37	1.62	2.20	2.06	1.27	291.60	290.33	290.83	290.92	290.89
WNA	1.92	1.88	2.32	2.04	1.49	282.01	282.41	284.29	282.90	282.96
CNA	2.48	2.11	2.12	2.23	2.62	283.22	283.91	286.66	284.59	284.58
ENA	3.53	3.49	3.77	3.60	3.20	286.57	287.57	289.45	287.86	282.26
CAM	3.43	2.17	2.22	2.60	2.84	295.70	295.89	297.40	296.33	295.32
AMZ	3.57	3.55	4.06	3.72	5.32	297.74	297.44	297.66	297.61	297.94
CSA	2.37	1.71	2.20	2.09	2.83	291.79	290.06	291.07	290.97	290.61
SSA	2.58	2.76	2.70	2.68	2.57	281.71	278.10	279.75	279.85	281.32
SAS	3.61	2.94	4.76	3.77	3.75	296.89	296.78	297.21	296.96	296.36
R1 [W/m2]					Rs [W/m2]					
	GFDL	IPSL	MIROC	Ens.Mean	WFDEI	GFDL	IPSL	MIROC	Ens.Mean	WFDEI
NEU	298.76	289.91	313.39	300.69	295.33	106.90	113.95	105.91	108.92	115.03
MED	325.96	306.36	328.73	320.35	314.19	194.08	207.62	202.13	201.27	199.11
NEE	283.96	268.51	293.05	281.84	286.82	113.46	130.74	131.76	125.32	113.86
NAS	255.12	250.35	261.36	255.61	245.13	115.27	125.07	132.40	124.24	117.66
CAS	294.43	276.17	300.68	290.43	295.95	208.62	212.39	224.00	215.01	204.59
TIB	254.00	226.63	239.74	240.12	239.85	193.41	203.32	238.30	211.68	216.40
EAS	330.69	311.34	329.96	324.00	310.11	175.70	203.77	197.67	192.38	171.51
SEA	412.92	398.55	404.30	405.26	415.89	217.69	235.62	220.55	224.62	194.56
NAU	375.94	353.13	375.57	368.22	357.89	245.74	275.31	245.39	255.48	248.10
SAU	330.27	314.19	326.86	323.77	326.54	197.93	190.86	185.11	191.30	216.98
SAH	337.31	309.98	339.92	329.07	337.15	262.15	275.38	277.74	271.75	264.56
WAF	384.32	363.56	388.70	378.86	392.92	230.64	281.46	240.12	250.74	231.51

EAF	371.89	347.30	372.53	363.91	384.45	251.09	292.60	247.54	263.74	237.33
EQF	372.31	356.07	365.27	364.55	377.08	240.21	278.16	231.80	250.05	232.56
SQF	378.02	362.43	370.00	370.15	373.27	234.04	268.65	237.10	246.60	223.85
SAF	344.64	323.67	334.37	334.23	321.71	217.70	237.28	219.01	224.66	232.14
WNA	296.89	293.37	302.39	297.55	281.30	196.70	183.22	195.71	191.87	205.10
CNA	311.69	298.60	310.79	307.03	308.70	178.09	198.56	207.13	194.59	185.28
ENA	339.03	327.43	341.57	336.01	305.46	171.46	189.71	187.69	182.95	164.46
CAM	377.27	360.63	370.16	369.35	366.67	229.89	252.57	248.63	243.70	229.00
AMZ	386.81	370.84	385.43	381.03	410.20	236.57	276.72	229.83	247.71	195.18
CSA	345.94	327.65	331.53	335.04	336.63	213.80	221.64	223.21	219.55	210.34
SSA	306.49	300.96	309.79	305.75	296.61	143.79	119.23	129.33	130.78	149.19
SAS	376.44	362.65	375.76	371.62	373.47	232.43	252.54	230.45	238.47	207.03
H [kg/kg]					Ps [HPa]					
	GFDL	IPSL	MIROC	Ens.Mean	WFDEI	GFDL	IPSL	MIROC	Ens.Mean	WFDEI
NEU	0.0051	0.0048	0.0066	0.0055	0.0055	995.14	994.72	992.99	994.28	983.13
MED	0.0075	0.0075	0.0087	0.0079	0.0076	981.06	979.10	980.40	980.19	958.26
NEE	0.0042	0.0041	0.0054	0.0046	0.0045	998.58	997.13	995.35	997.02	994.48
NAS	0.0031	0.0036	0.0042	0.0037	0.0033	966.94	964.29	964.13	965.12	955.25
CAS	0.0044	0.0044	0.0057	0.0048	0.0055	900.50	896.25	899.36	898.70	893.06
TIB	0.0033	0.0034	0.0042	0.0036	0.0034	735.65	728.50	736.90	733.68	734.45
EAS	0.0090	0.0089	0.0108	0.0096	0.0078	974.67	969.55	973.25	972.49	947.43
SEA	0.0176	0.0178	0.0186	0.0180	0.0176	1000.13	1001.34	1003.18	1001.55	977.85
NAU	0.0121	0.0117	0.0140	0.0126	0.0096	991.65	994.78	994.03	993.49	978.92
SAU	0.0079	0.0068	0.0081	0.0076	0.0071	1004.23	1001.10	1002.27	1002.53	988.15
SAH	0.0061	0.0055	0.0068	0.0061	0.0061	965.67	965.58	966.70	965.98	955.18
WAF	0.0132	0.0123	0.0145	0.0133	0.0124	982.76	982.58	982.96	982.77	970.86
EAF	0.0113	0.0112	0.0130	0.0118	0.0122	939.81	936.28	940.58	938.89	928.97
EQF	0.0126	0.0135	0.0132	0.0131	0.0131	927.28	923.68	927.22	926.06	897.12
SQF	0.0134	0.0136	0.0144	0.0138	0.0123	964.04	963.95	964.50	964.16	924.14
SAF	0.0104	0.0094	0.0104	0.0101	0.0077	970.87	970.37	970.88	970.71	909.10
WNA	0.0059	0.0062	0.0074	0.0065	0.0051	908.11	909.20	907.96	908.42	867.44
CNA	0.0071	0.0067	0.0078	0.0072	0.0071	970.30	967.75	964.45	967.50	967.64
ENA	0.0092	0.0097	0.0113	0.0101	0.0068	1005.31	1003.65	1001.77	1003.58	986.35
CAM	0.0135	0.0136	0.0147	0.0140	0.0122	983.62	983.88	982.98	983.49	928.03
AMZ	0.0135	0.0140	0.0158	0.0144	0.0158	969.59	970.66	970.49	970.25	956.50
CSA	0.0100	0.0091	0.0096	0.0096	0.0095	976.00	975.62	973.88	975.17	935.84
SSA	0.0060	0.0047	0.0057	0.0055	0.0050	997.59	994.17	993.09	994.95	957.83
SAS	0.0134	0.0136	0.0152	0.0141	0.0132	965.75	965.46	965.67	965.63	932.59
W [m/s]										
	GFDL	IPSL	MIROC	Ens.Mean	WFDEI					
NEU	5.50	4.47	4.10	4.69	3.64					
MED	4.02	3.99	4.32	4.11	3.17					
NEE	3.61	2.93	3.01	3.18	3.56					
NAS	3.57	3.46	3.85	3.63	3.05					

CAS	2.85	3.64	4.33	3.61	3.27
TIB	2.46	3.98	5.50	3.98	3.49
EAS	4.54	4.39	4.18	4.37	3.15
SEA	5.09	3.75	3.89	4.24	1.83
NAU	4.48	3.93	4.24	4.22	4.24
SAU	6.46	6.87	7.14	6.83	4.16
SAH	3.59	4.12	4.53	4.08	4.33
WAF	2.84	2.54	3.12	2.83	2.77
EAF	2.95	3.23	3.85	3.34	3.24
EQF	3.08	2.75	3.19	3.01	2.68
SQF	3.82	3.55	4.01	3.79	2.49
SAF	5.15	5.40	5.78	5.44	3.79
WNA	3.88	3.50	4.78	4.05	3.06
CNA	3.29	3.28	3.34	3.30	3.90
ENA	5.22	4.72	4.46	4.80	2.86
CAM	4.48	3.89	4.55	4.31	2.50
AMZ	2.91	2.73	2.10	2.58	1.71
CSA	4.68	4.83	5.11	4.87	3.24
SSA	7.94	7.90	8.54	8.12	5.14
SAS	4.31	3.56	3.13	3.67	2.49

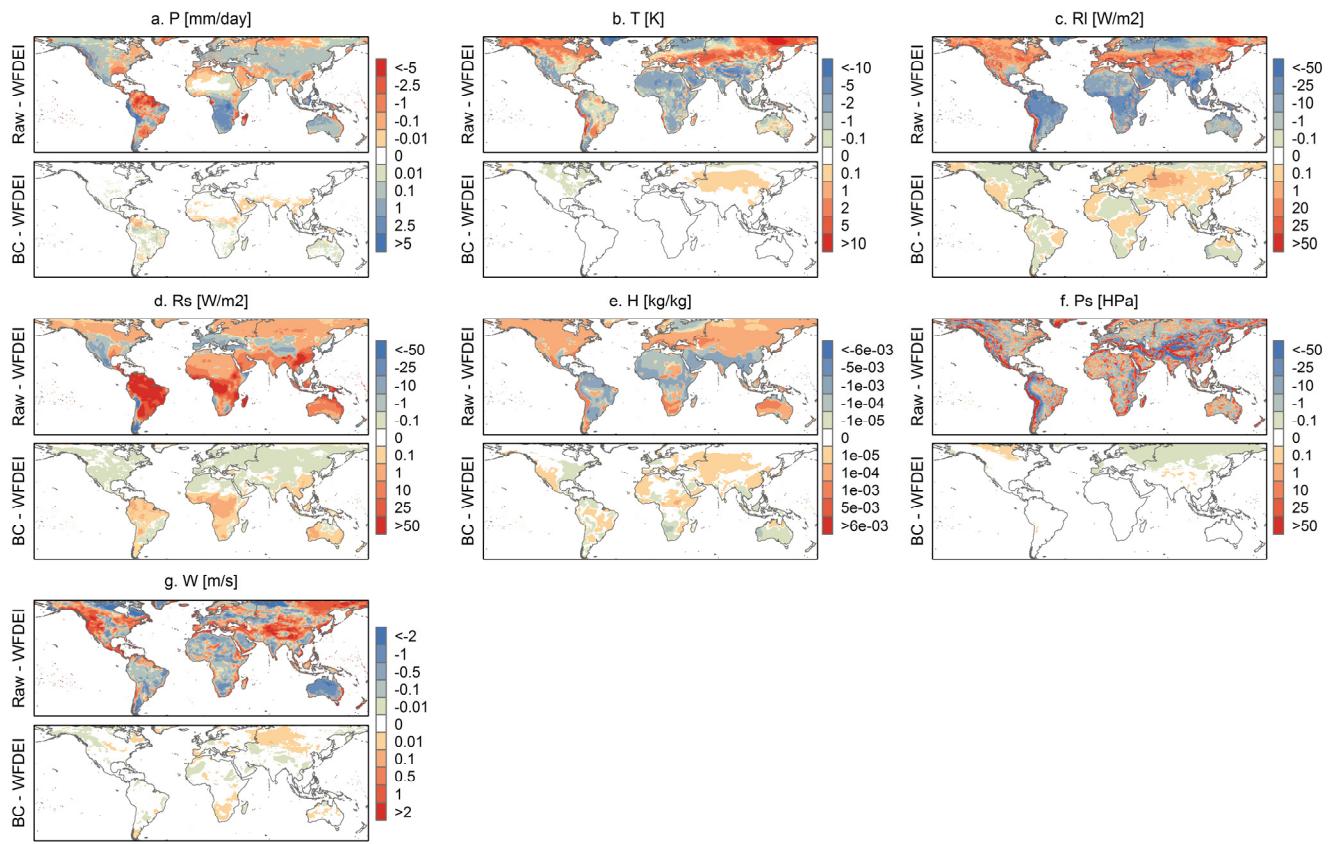


Figure S 1. Difference maps, showing initial (Raw-WFDEI) and remaining (BC-WFDEI) biases of the GCM ensemble forcing variables: a.Precipitation, b.Temperature, c.Longwave downward radiation, d.Shortwave downward radiation, e.Specific humidity, h.Surface pressure, g.Wind. Differences are calculated between the December-January-February averages (DJF) of the 1981-2010 period.

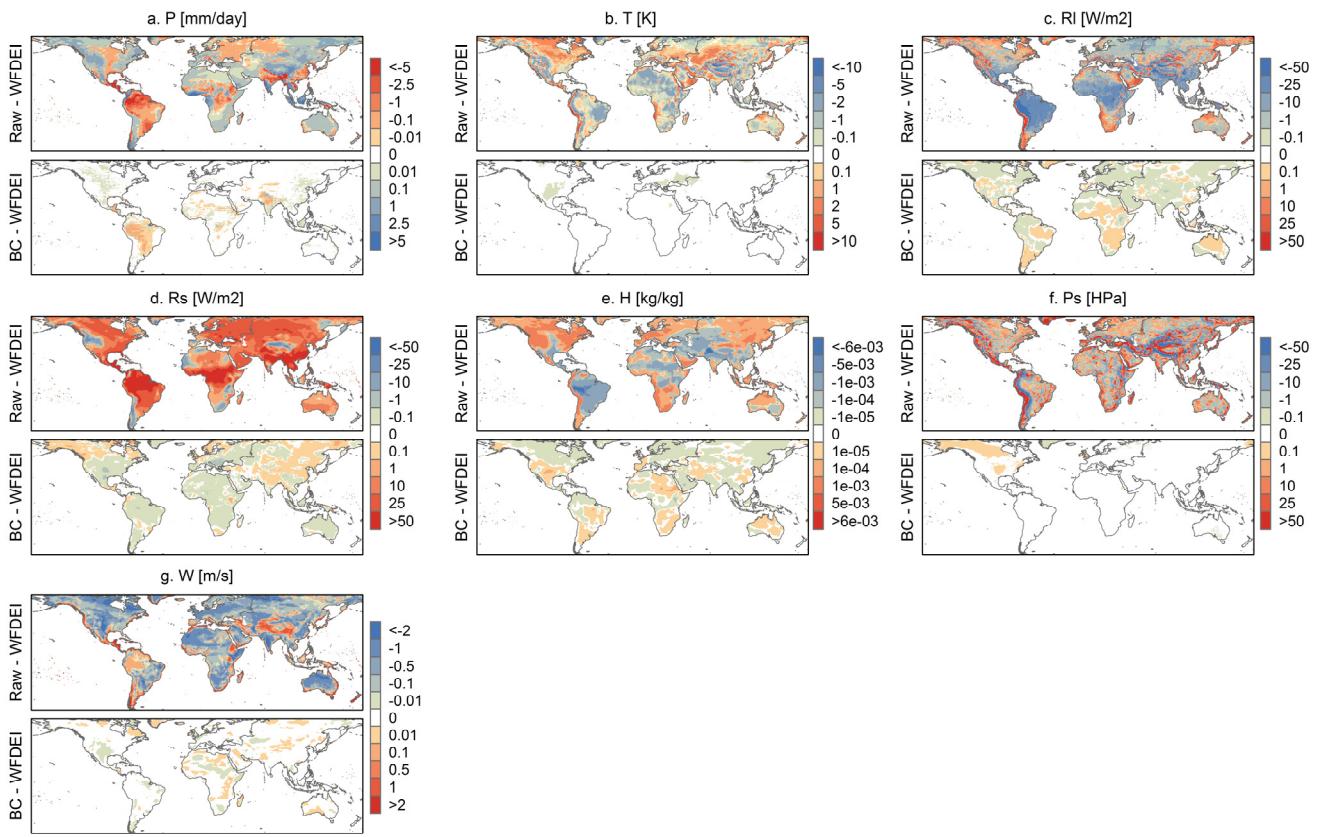


Figure S 2. Difference maps, showing initial (Raw-WFDEI) and remaining (BC-WFDEI) biases of the GCM ensemble forcing variables: a.Precipitation, b.Temperature, c.Longwave downward radiation, d.Shortwave downward radiation, e.Specific humidity, h.Surface pressure, g.Wind. Differences are calculated between the June-July-August averages (JJA) of the 1981-2010 period.

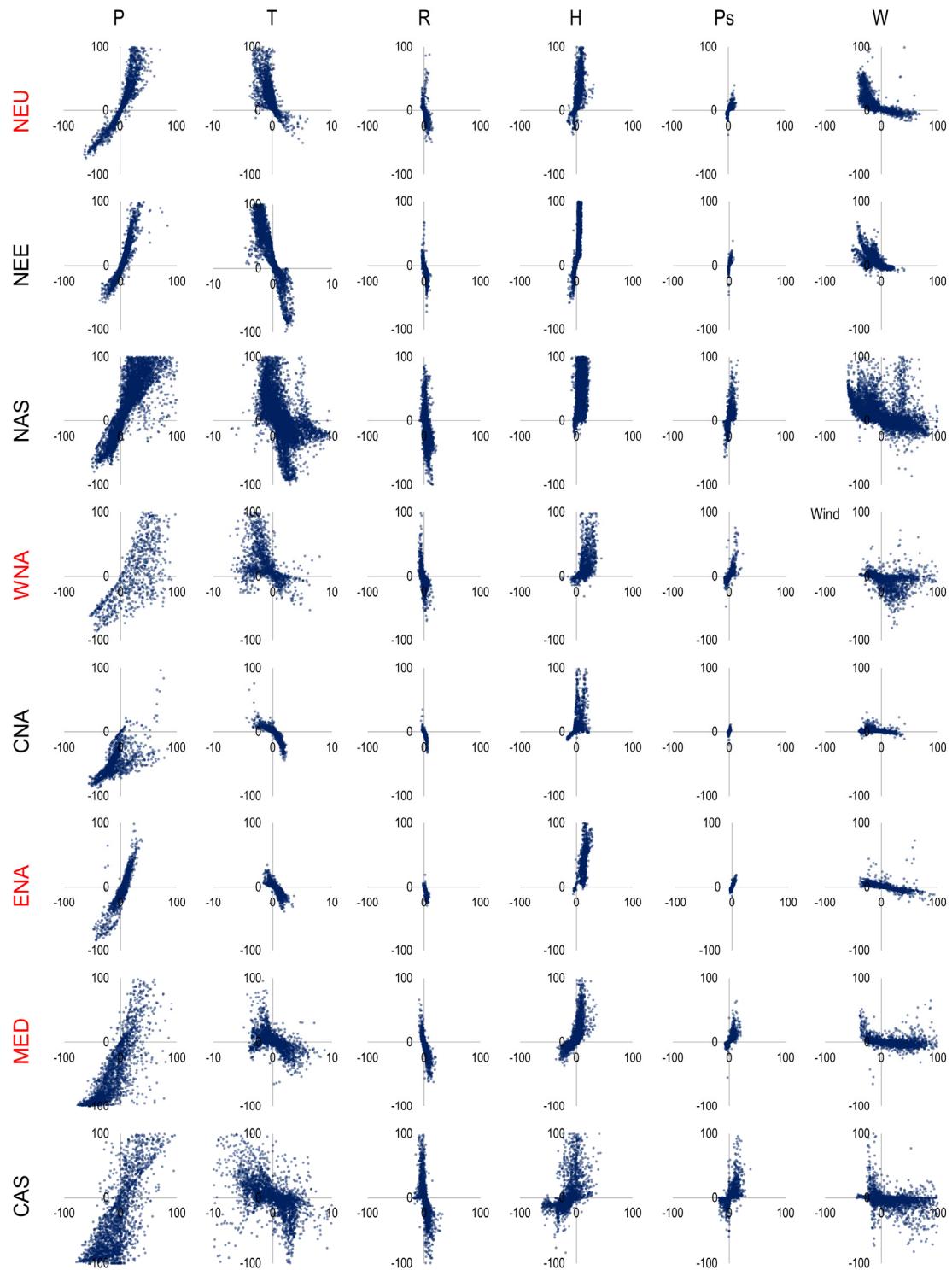


Figure S 3. Scatterplots of relative changes in forcing variable (ΔV , x axis) and corresponding relative changes in runoff (ΔRF , y axis), for all the forcing variables and for the 24 regions. In each panel, each dot represents the $\Delta RF / \Delta V$ relationship of each land grid box in the examined region. The regions names in red colour correspond to the selected focus regions that are presented in the main paper.

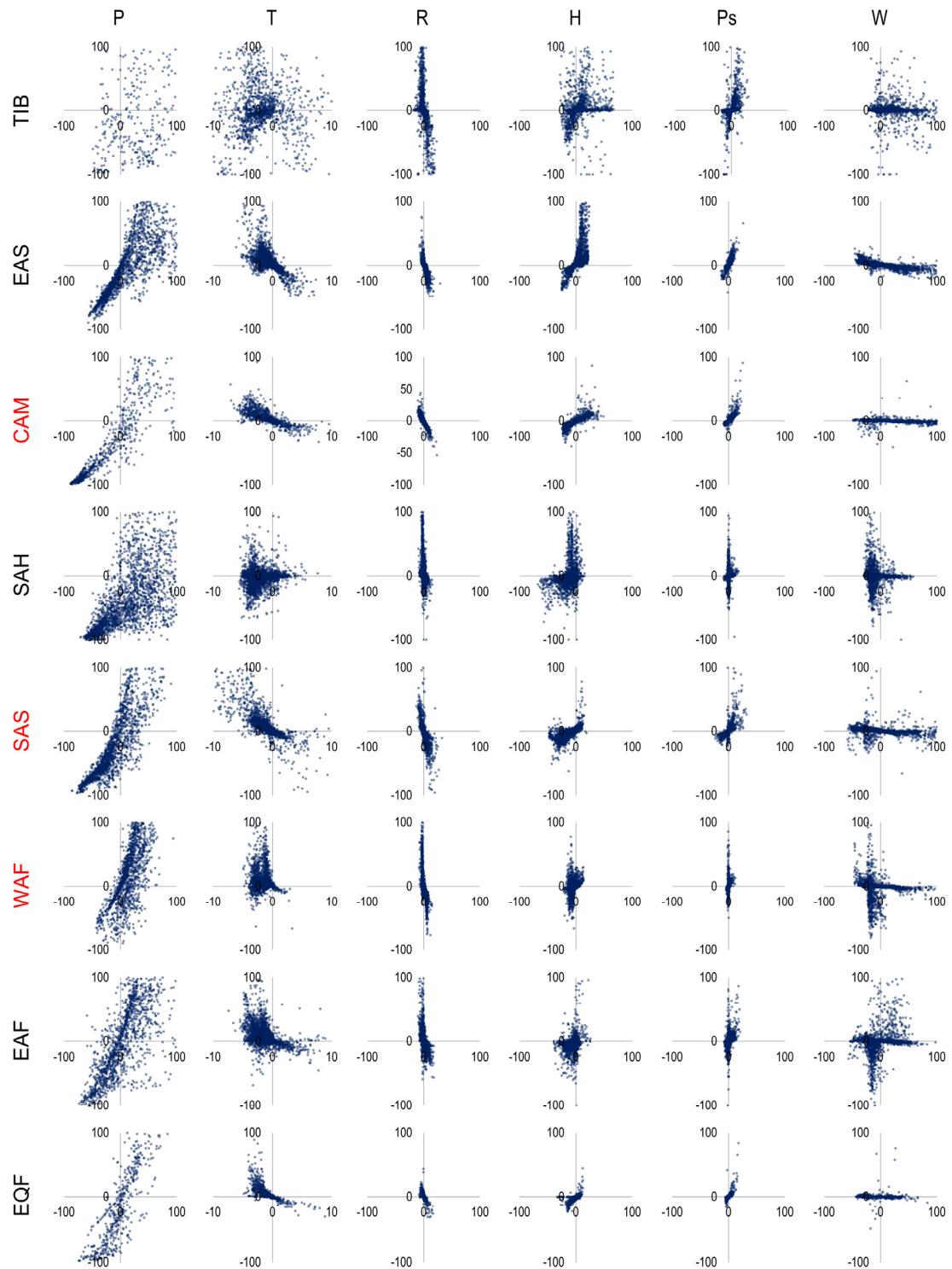


Figure S 3 (continued).

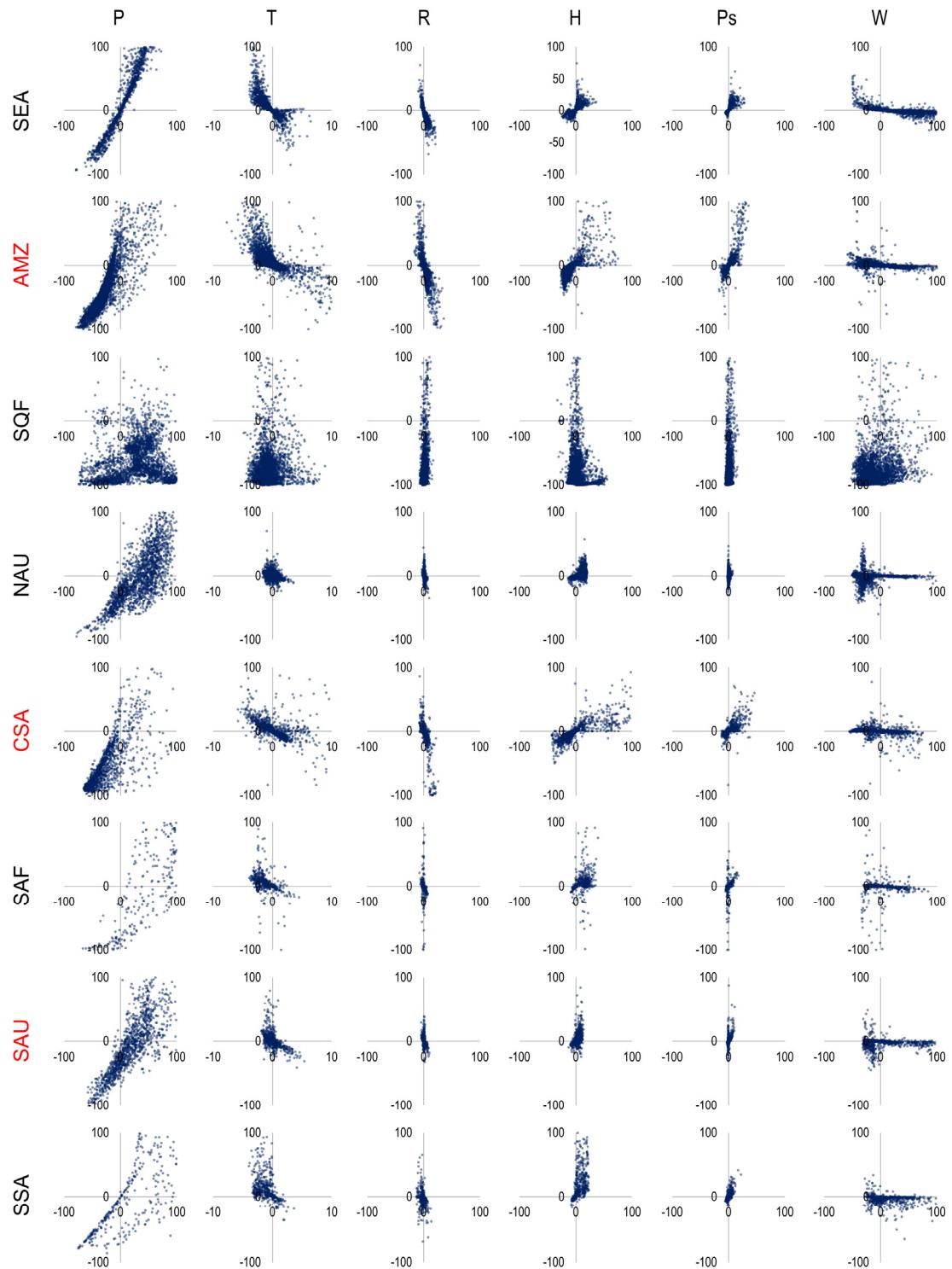


Figure S 3 (continued).

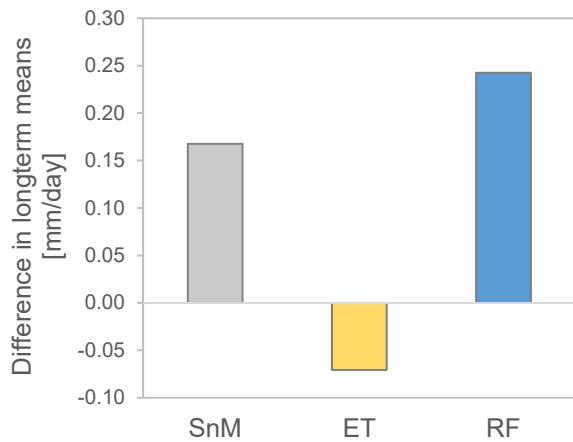


Figure S 4. Difference between the long term means (of the 1981-2010 period) of three fluxes (SnM:snowmelt, ET: evapotranspiration and RF:runoff), forced with raw and bias corrected humidity (forced with Raw H- forced with BC H). The fluxes are calculated for a representative grid box with center location at 60.25 Longitude and 60.25 Latitude.

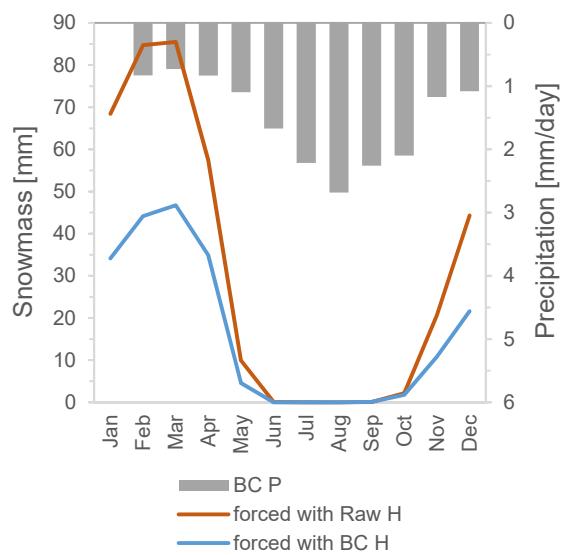


Figure S 5. Annual cycle of JULES' snowmass, forced with raw and bias corrected humidity [mm/day] and bias corrected precipitation (common forcing for both runs). Annual cycles are calculated from the 1981-2010 period, for a representative grid box with center location at 60.25 Longitude and 60.25 Latitude.

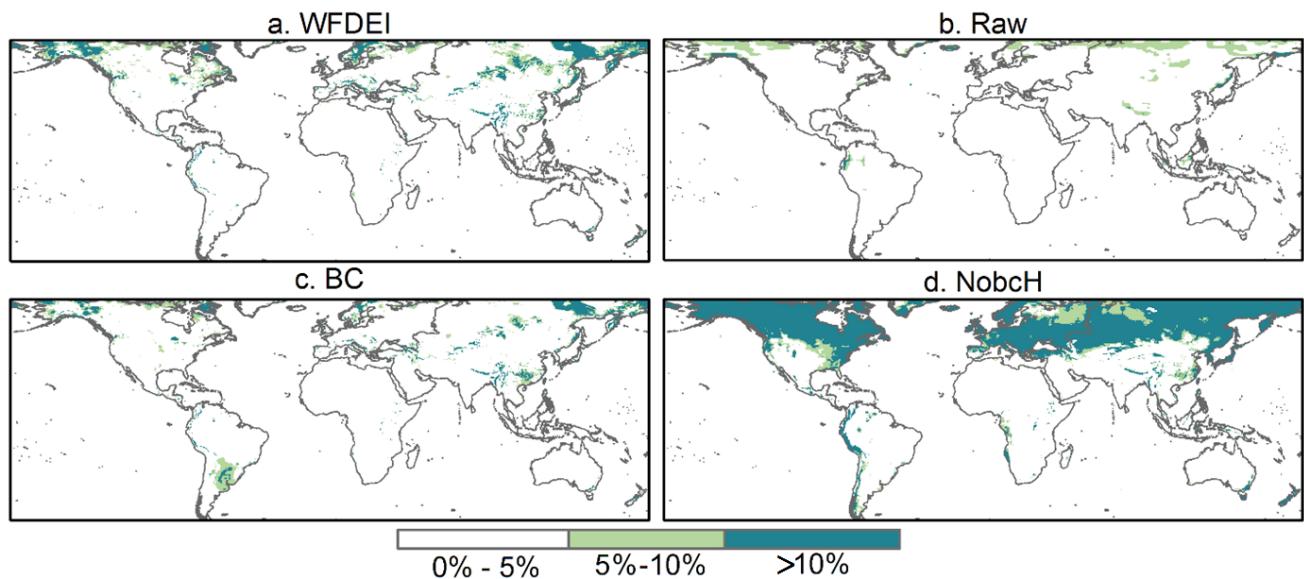


Figure S 6. Fraction of time under supersaturated air conditions (Relative humidity $>100\%$), calculated from specific humidity H, temperature T and surface pressure Ps for: a. WFDEI data, b. Raw GCM data, c. BC GCM data and d. data corresponding to NobcH (raw H, BC T and BC Ps). Calculation of relative humidity uses the Clausius-Clapeyron equation. Fraction of time refers to the historical period 1981-2010.