Table 1. C:N ranges (CNR) of leaves, fine roots, and stems/wood for each plant function type (PFT).

($CNRmin$ and $CNRmax$ are the minimum and the maximum C/N ratio for each PFT's components. Data are from DayCent-SOM's user manual and other publications (Parton et al., 1993; Parton et al., 2007))

PFT	Plant part	C:N Minimum	C:N Maximum
Broadleaf deciduous	leaves	20	50
	roots	40	70
	wood	200	500
Broadleaf Evergreen	leaves	20	40
	roots	40	70
	wood	150	300
Needleleaf Evergreen	leaves	30	60
	roots	40	60
	wood	400	800
C3 grass	leaves	20	40
	roots	40	50
	wood	40	80
C4 grass	leaves	20	60
	roots	60	100
	wood	60	100
shrub	leaves	20	40
	roots	40	70
	wood	200	400
tundra shrub	leaves	20	40
	roots	40	80
	wood	300	700

Table 2. Experimental design

100-year equilibrium	*Initial condition* →	Real-forcing simulation 1948-2007
Fixed climatology forcing		*Transient forcing*
Control experiment		**SSiB4:** Control experiment **DlPSN:** **N**itrogen **l**imitation on **p**hoto**syn**thesis(Vmax) **DlNPP:** **N**itrogen **l**imitation on photosynthesis(**NPP**) **DlGPP:** **N**itrogen **l**imitation on photosynthesis(**GPP**) **SSiB5:** including all four nitrogen processes

Table 3 The information of FLUXNET sites used for model validation

Site_ID	Site name	LAT	LONG	PFT	Time
CN-Dan	Dangxiong	30.50	91.07	C3 grass	2004-2005
US-KS2	Kennedy Space Center (scrub oak)	28.61	-80.67	Broadleaf deciduous	2003-2006
BR-Sa1	Santarem-Km67-Primary Forest	-2.86	-54.96	Broadleaf Evergreen	2002-2011

Table 4. The intercomparisons of bias, standard deviation and RMSE between SSiB4 and SSiB5 over three sites.

Site_ID	Bias (gC d^{-1})		Standard deviation (gC d^{-1})			RMSE (gC d^{-1})	
	SSiB4	SSiB5	OBS	SSiB4	SSiB5	SSiB4	SSiB5
CN-Dan	0.873	0.516	0.949	1.485	1.071	0.60	0.30
US-KS2	0.125	-0.033	1.391	1.574	1.543	3.92	3.72
BR-Sa1	0.040	0.036	1.550	1.241	1.241	3.01	3.00

Table 5. Regional and Global GPP for (a) FLUXNET-MTE GPP, (b) SSiB4 (control), (c) NlPSN (N limitation on photosynthesis only) and (d) SSiB5 (N limitation on photosynthesis, autotrophic respiration, and phenology).

Regions	Sub-regions	GPP Mean (gC m^{-2} yr^{-1})							
		MTE		SSiB4		NlPSN		SSiB5	
		mean	bias	mean	bias	mean	bias	mean	bias
Arid and Semi-Arid Areas	West Africa	893		1147	254(28.5%)	963	70(7.9%)	915	22(2.5%)
	West NA	438		549	111(25.4%)	454	16(3.5%)	431	-7(-1.6%)
	SA Savanna	1665		1860	195(11.7%)	1763	98(5.9%)	1675	10(0.6%)
	East Africa	1228		1533	306(24.9%)	1427	199(16.2%)	1356	128(10.4%)
	East Asian semi-arid	1440		1470	30(2.1%)	1199	-241(-16.7%)	1139	-301(-20.9%)
NH High-Mid Latitude Areas	NA High-Mid Latitude	552		814	262(47.6%)	700	149(27.0%)	665	114(20.6%)
	Eurasian High-Mid	844		966	122(14.5%)	871	27(3.2%)	827	16(-2.0%)
Equator	Amazon Basin	2993		2668	-326(-10.9%)	2631	-362(-12.1%)	2500	-494(-16.5%)
	Southeast Asia	2778		2540	-238(-8.6%)	2419	-359(-12.9%)	2298	-480(-17.3%)
	Equator Africa	2522		2645	123(4.9%)	2611	89(3.5%)	2481	-42(-1.7%)
Subarctic Areas and Tibet	NA Subarctic	234		364	130(55.7%)	240	6(2.4%)	228	-6(-2.7%)
	Eurasian Subarctic	331		484	153(46.2%)	328	-3(-1.0%)	311	-20(-6.0%)
	Tibet	409		561	153(37.3%)	298	-111(-27.2%)	283	126(-30.8%)
Global		**863**		**1082**	**220(25.4%)**	**991**	**129(14.9%)**	**942**	**79(9.1%)**

Note: the numbers in parentheses are relative biases

Table 6. Same as Table 5, but for LAI.

Regions	Sub-regions	LAI Mean ($m^2 m^{-2}$)									
		GIMMS		GLASS		SSiB4		NIPSN		SSiB5	
		mean	bias	mean	bias	mean	bias	mean	bias	mean	bias
Arid and Semi-Arid Areas	West Africa	1.08		1.01	-0.07(-6.5%)	2.04	0.96(88.9%)	1.89	0.81(75.0%)	1.73	0.65(60.2%)
	West NA	0.62		0.49	-0.13(-21.0%)	1.38	0.76(122.6%)	1.18	0.56(90.3%)	1.09	0.47(75.8%)
	SA Savanna	1.99		1.91	-0.18(-4.0%)	3.34	1.35(67.8%)	3.23	1.24(62.3%)	2.97	0.98(49.2%)
	East Africa	1.59		1.55	-0.04(-2.5%)	3.02	1.43(89.9%)	2.89	1.30(81.8%)	2.66	1.07(67.3%)
	East Asian semi-arid	1.60		1.36	-0.24(-15.0%)	3.35	1.75(109.4%)	2.84	1.24(77.5%)	2.61	1.01(63.1%)
NH High-Mid Latitude Areas	NA High-Mid Latitude	0.84		0.49	-0.35(-41.7%)	1.91	1.07(127.4%)	1.66	0.82(97.6%)	1.53	0.69(82.1%)
	Eurasian High-Mid	1.14		0.57	-0.57(-50.0%)	2.29	1.15(100.9%)	2.08	0.94(82.5%)	1.91	0.77(67.5%)
Equator	Amazon Basin	4.19		4.08	-0.11(-2.6%)	6.01	1.82(43.4%)	5.98	1.79(42.7%)	5.50	1.31(31.3%)
	Southeast Asia	3.93		3.88	-0.05(-1.3%)	4.68	0.75(19.1%)	4.68	0.75(19.1%)	4.31	0.38(9.7%)
	Equator Africa	3.83		3.76	-0.07(-1.8%)	5.74	1.91(49.9%)	5.72	1.89(49.3%)	5.27	1.44(37.6%)
Subarctic Areas and Tibet	NA Subarctic	0.32		0.14	-0.18(-56.3%)	0.71	0.39(121.9%)	0.51	0.19(59.4%)	0.47	0.15(46.9%)
	Eurasian Subarctic	0.33		0.12	-0.21(-63.6%)	0.87	0.54(163.6%)	0.65	0.32(97.0%)	0.60	0.27(81.8%)
	Tibet	0.64		0.54	-0.10(-15.6%)	1.36	0.72(112.5%)	0.81	0.17(26.6%)	0.75	0.11(17.2%)
Global		**1.18**		**1.00**	**-0.18(-15.3%)**	**2.44**	**1.26(110.8%)**	**2.31**	**1.13(95.8%)**	**2.12**	**0.94(79.7%)**

Note: the numbers in parentheses are relative biases.

Table 7. The spatial correlation coefficient (SCC) between model simulations and OBS.

LAI SCC	NlPSN	NlNPP	NlGPP
OBS	0.8370**	0.8340**	0.8246**
GPP SCC	NlPSN	NlNPP	NlGPP
OBS	0.9020**	0.8998**	0.8900**

Note: ** indicates correlation is significant at $p < 0.01$.

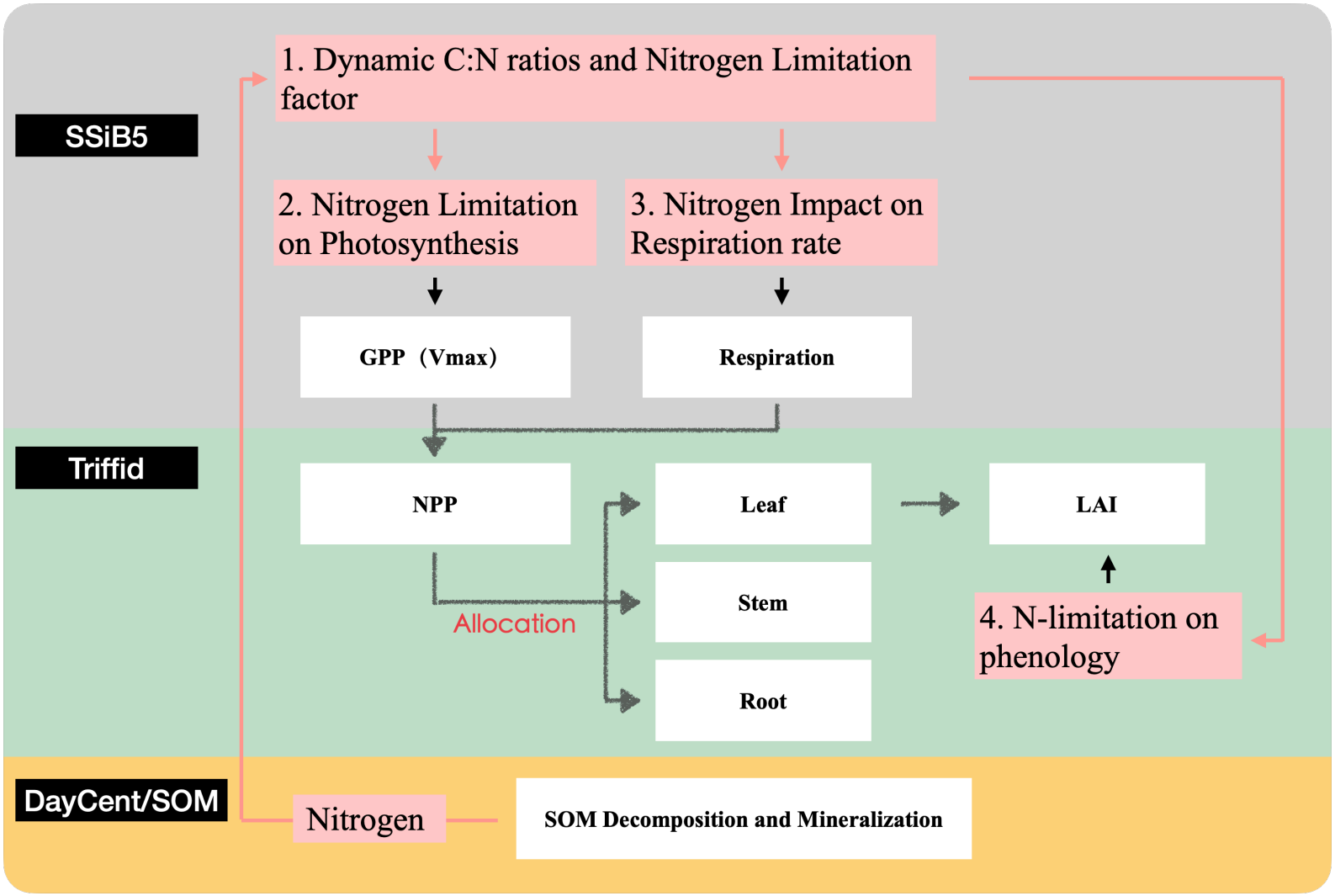

Figure 1. Schematic diagram of plant biogeochemistry and nitrogen impacts in SSiB5/TRIFFID/DayCent-SOM.

Notes: (1) Different background colors represent three different modules: SSiB, TRIFFID, and DayCent/SOM; (2) Boxes with white color indicate the main processes in C-N coupling in different modules; (3) Boxes with vermeil color indicates how the nitrogen influence plant biogeochemistry through our C-N framework.

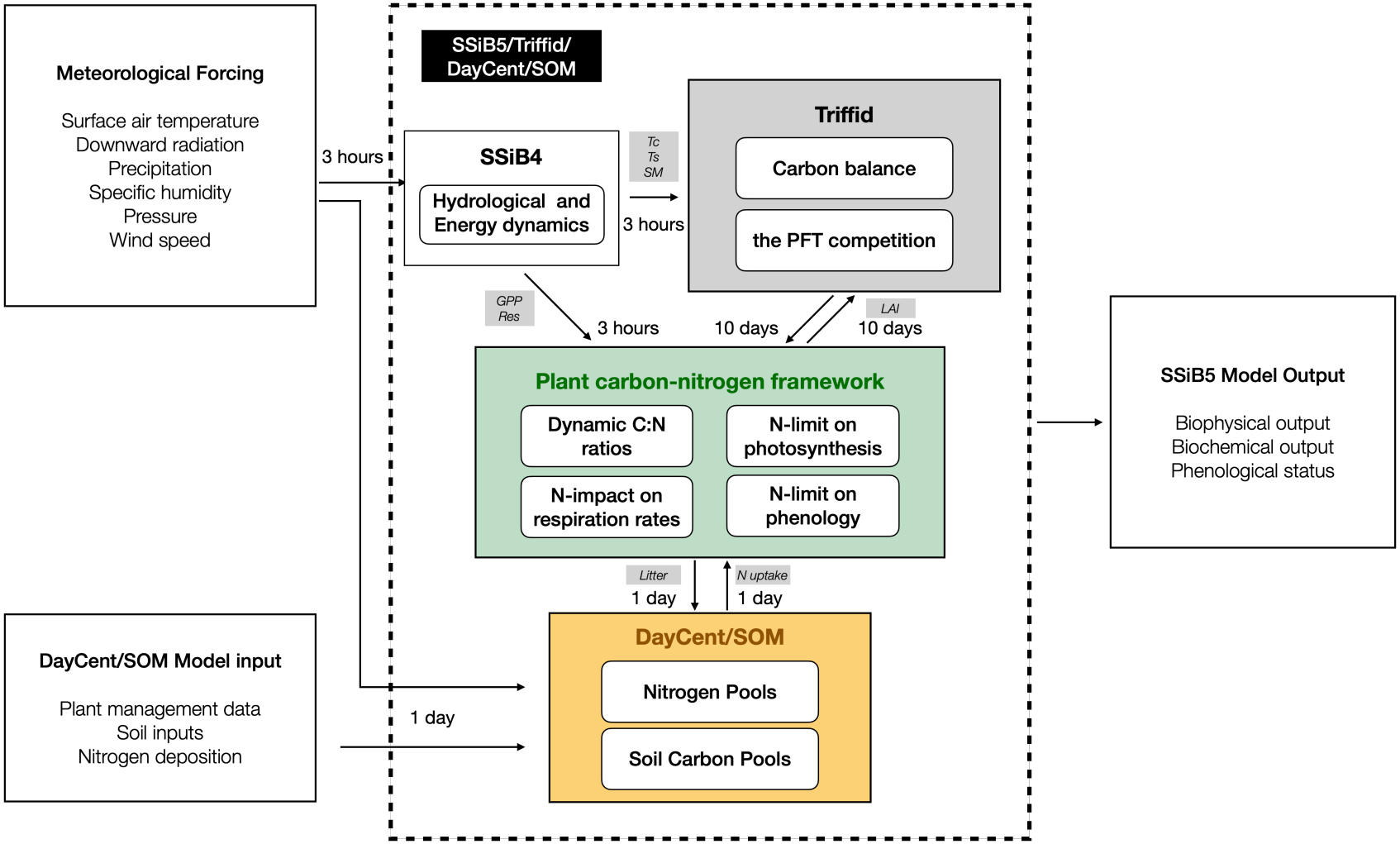

Figure 2. The flowchart of plant carbon-nitrogen interactions in SSiB5/TRIFFID/DayCent-SOM, main variables are listed between two modules

Notes: Tc: canopy temperature; Ts: land surface temperature; SM: soil moisture; GPP: gross primary productivity; Res: autotrophic respiration.

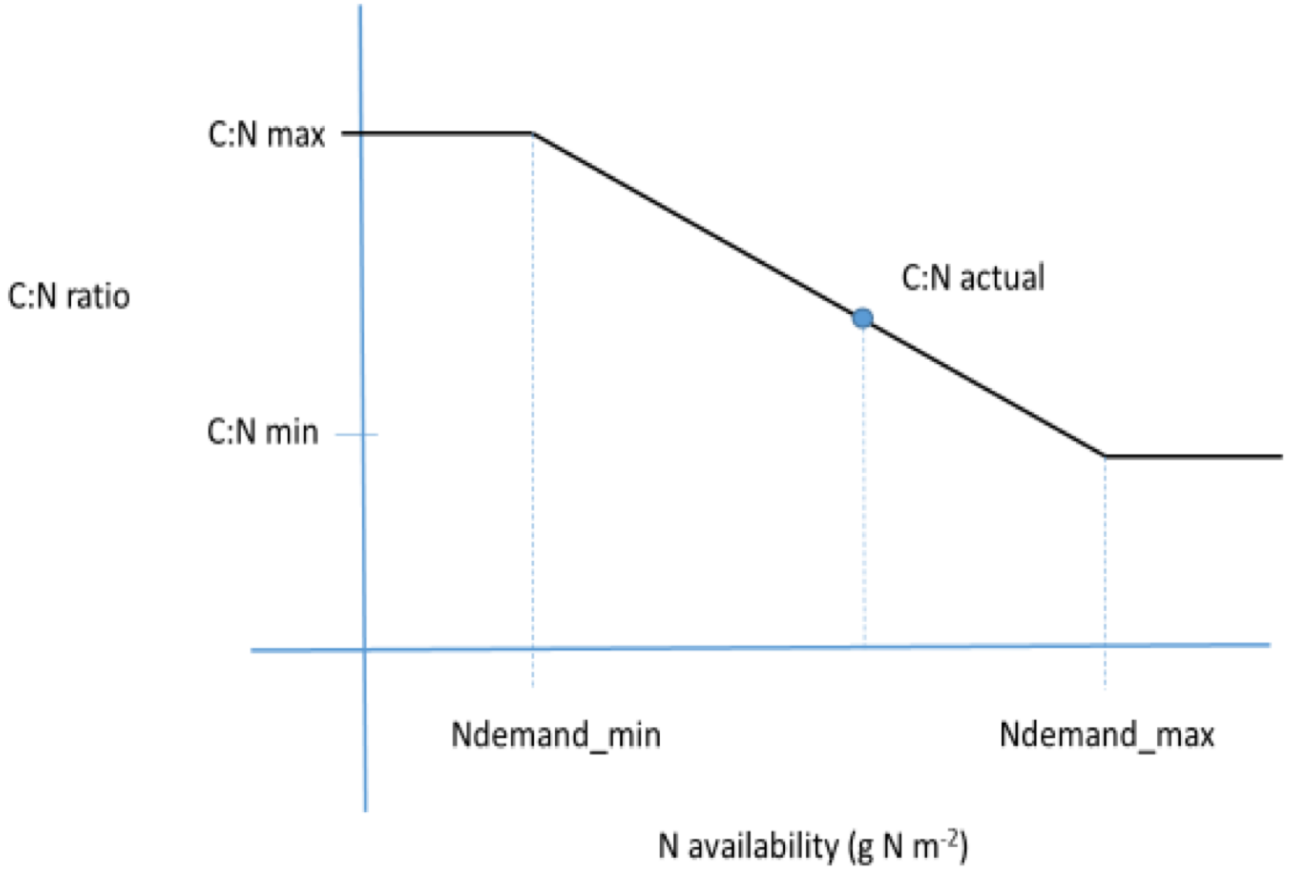

Figure 3. The relationship between the soil nitrogen availability and plant carbon-nitrogen ratios

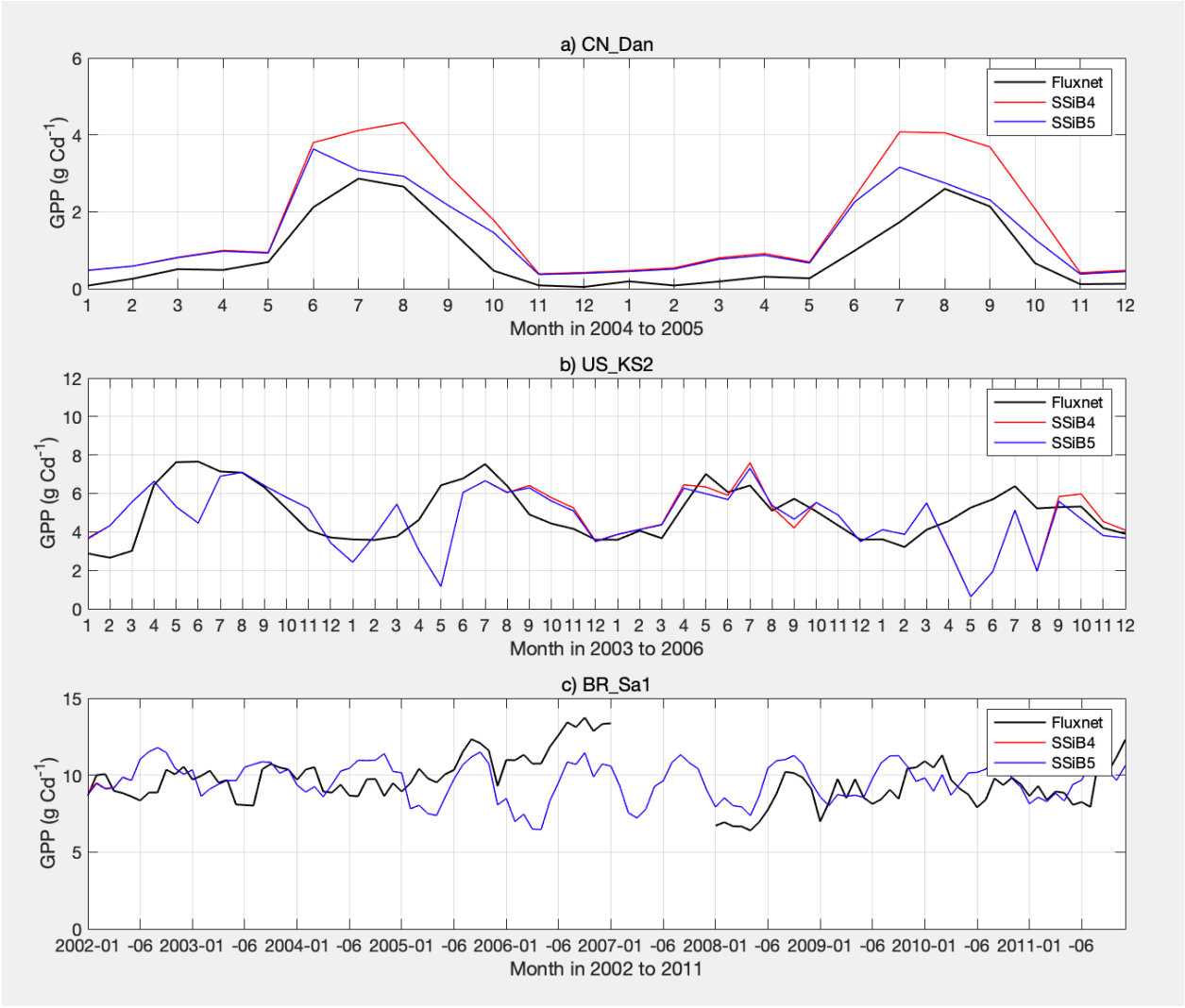

Figure 4. Simulated seasonal variations of GPP against observations at three FLUXNET sites representing different SSiB5 PFTs (C3 grass, broadleaf deciduous tree, and broadleaf evergreen tree).

Note: the information of three FLUXNET sites, CN_Dan, US-KS2 and BR-Sa1, are listed in Table 3.

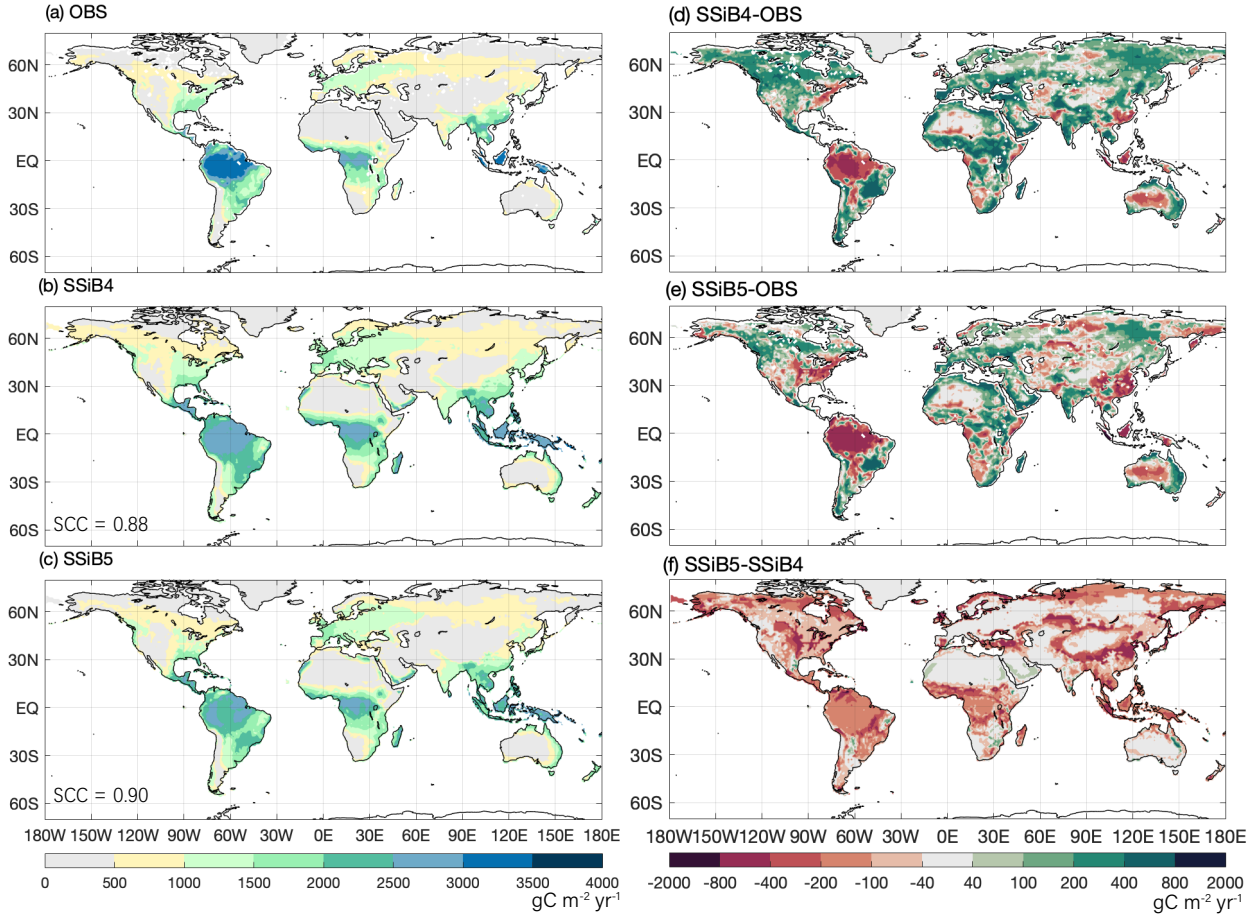

Figure 5. The 1982-2007 average gross primary production comparison for (a) FLUXNET-MTE GPP (OBS), (b) SSiB4/TRIFFID (SSiB4), and (c) SSiB5/TRIFFID/DayCent/SOM (SSiB5), and difference between (d) SSiB4-OBS, and (e) SSiB5-OBS, (f) SSiB5-SSiB4.

Note: SCC indicates the spatial correlation coefficient between model simulation and satellite-derived datasets (OBS).

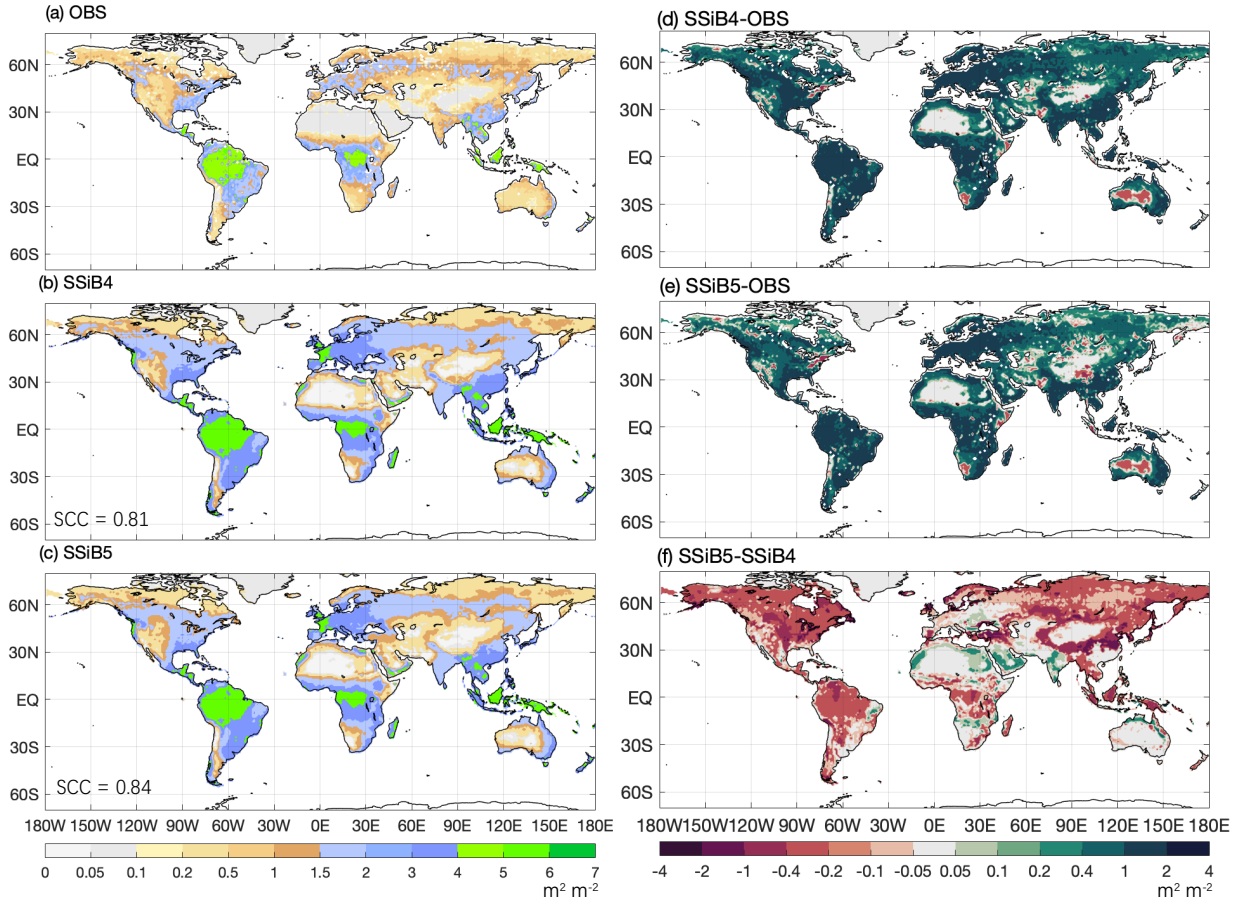

Figure 6. Same as Figure 5, but for LAI.

Note: SCC indicates the spatial correlation coefficient between model simulation and GIMMS LAI (OBS).

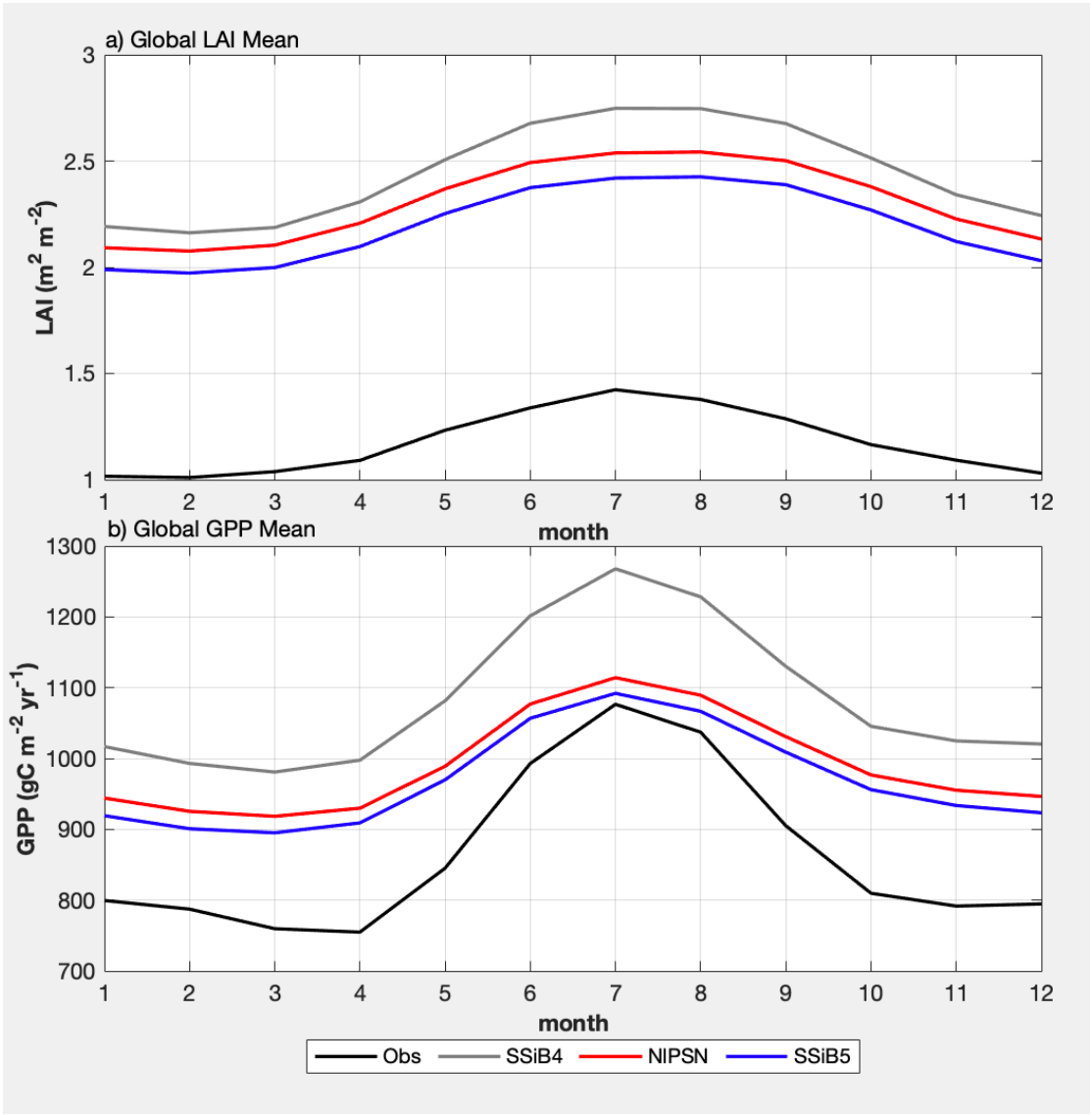

Figure 7. Intercomparisons of monthly LAI and GPP among OBS, SSiB4, NlPSN, and SSiB5 over the period 1982-2007.

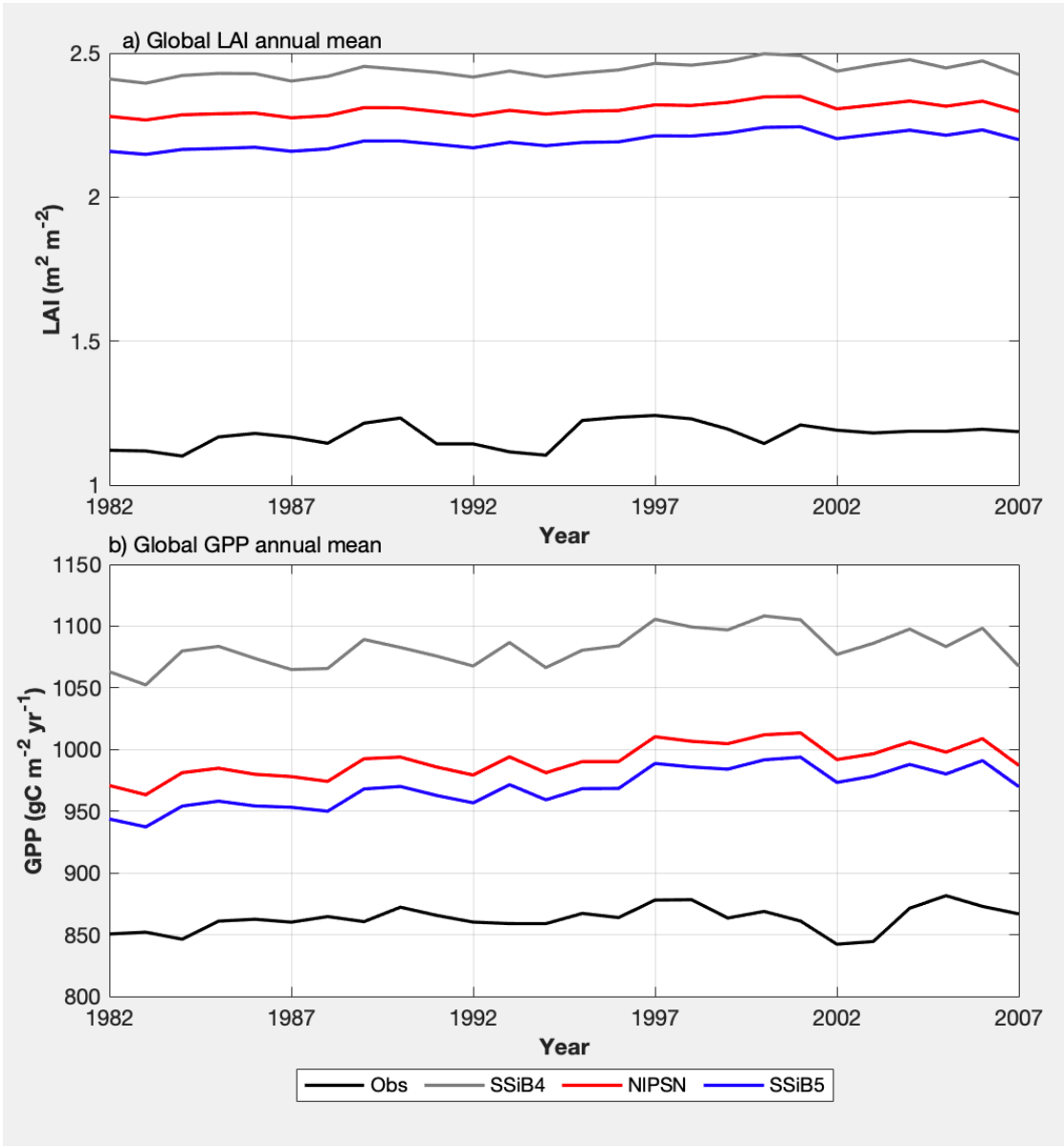

Figure 8. Same as figure 7, but for annual LAI and GPP.

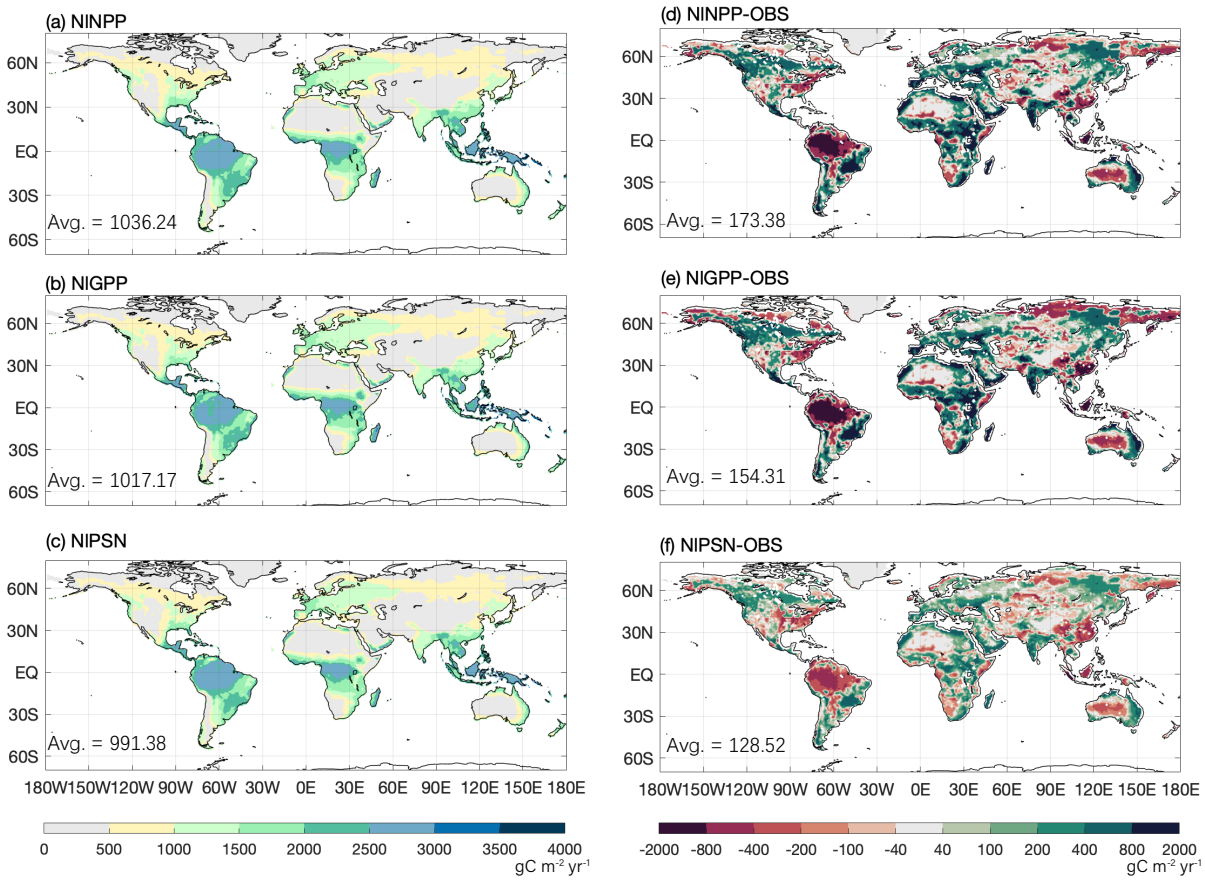

Figure 9. The 1982-2007 average gross primary production comparison for (a) NlNPP, (b) NlGPP and (c) NlPSN, (d) NlNPP- OBS, (e) NlGPP- OBS and (f) NlPSN- OBS.

Notes: (1) NlPSN is N limitation on photosynthesis (Vmax) only; NINPP is N limitation on NPP only; and NIGPP is N limitation on GPP only. (2). OBS is FLUXNET-MTE GPP (OBS). (3). Avg. indicates the global average.

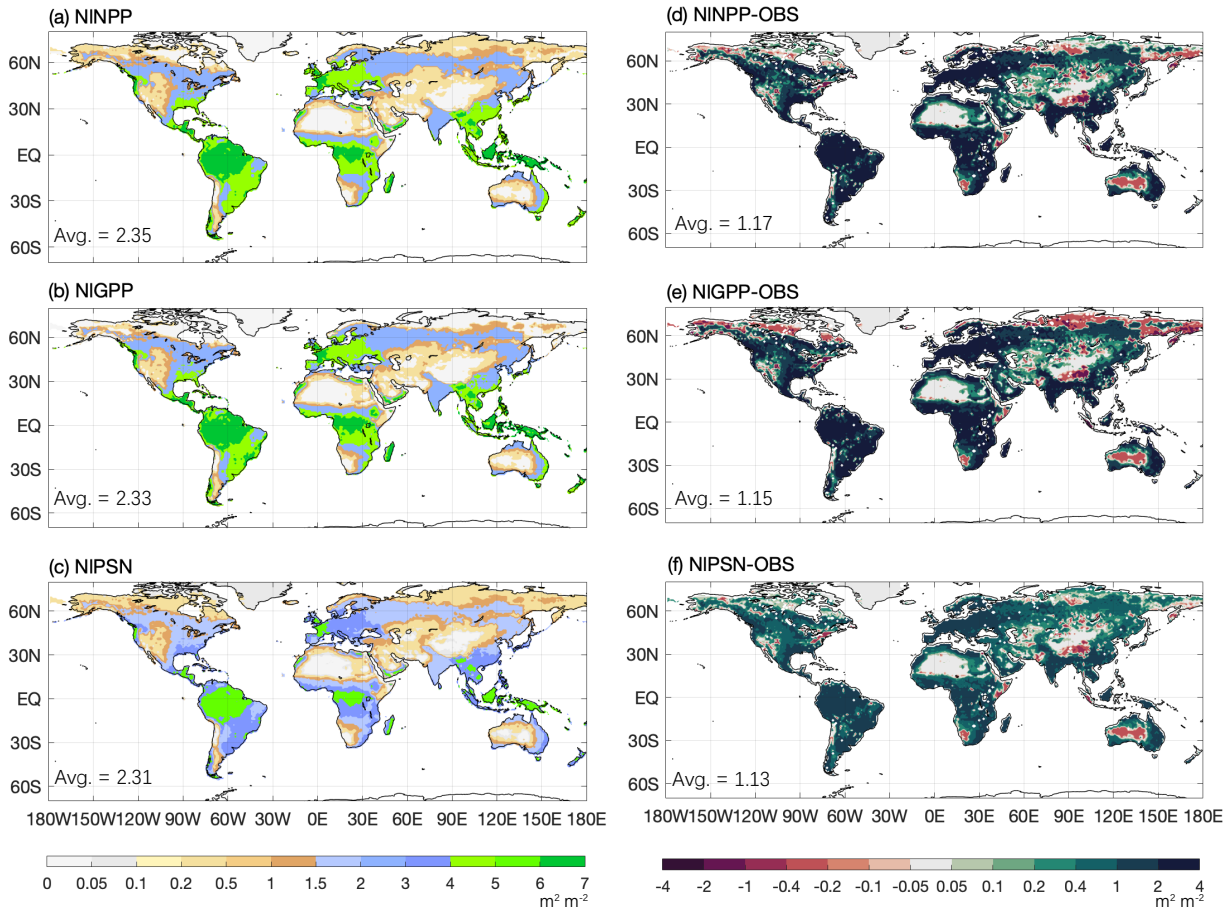

Figure 10. Same as Figure 9, but for LAI.

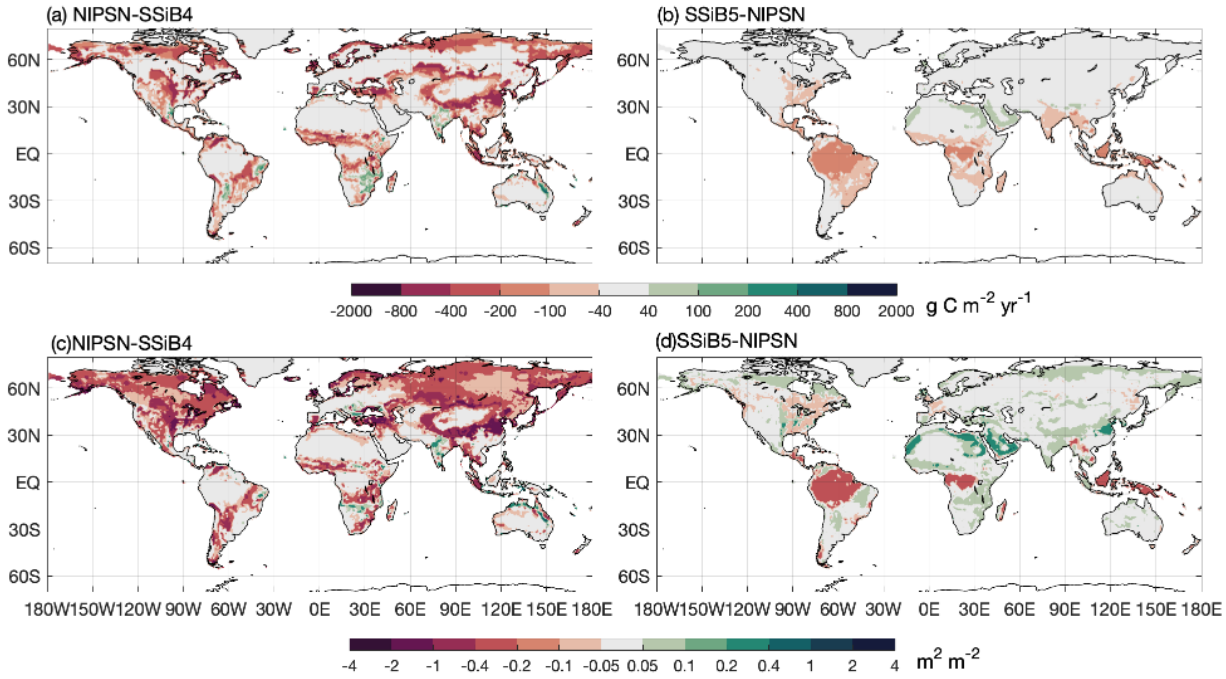

Figure 11. The 1982-2007 average gross primary production difference (a) NlPSN-SSiB4, (b) SSiB5-NlPSN, and leaf area index difference (c) NlPSN- SSiB4, (d) SSiB5- NlPSN

Note: NlPSN is N limitation on photosynthesis (V_{max}) only.