



Supplement of

Synergy between TROPOMI sun-induced chlorophyll fluorescence and MODIS spectral reflectance for understanding the dynamics of gross primary productivity at Integrated Carbon Observatory System (ICOS) ecosystem flux sites

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Tab S1: Information on the sites used in this study from the ICOS release 2018 and 2021. The PFT represents the plant functional type corresponding to each site: MF (mixed forests), CRO (croplands), DBF (deciduous broadleaf forests), EBF (evergreen broadleaf forests), ENF (evergreen needleleaf forests), GRA (grasslands), OSH (open shrublands), and WET (wetlands). Years denote the year of data flux available for each site.

Site ID	Site name	Latitude (°)	Longitude (°)	PFT	Years
BE-Bra	Brasschaat	51.307617	4.519844	MF	2018
BE-Lcr	Lochristi	51.112184	3.850433	CRO	2019, 2020
BE-Lon	Lonzee	50.551586	4.7461305	CRO	2019, 2020
BE-Vie	Vielsalm	50.305068	5.998052	ENF	2018
CH-Dav	Davos	46.815283	9.855009	ENF	2018, 2019, 2020
CZ-BK1	Bily Kriz forest	49.50213	18.53685	ENF	2018
CZ-Lnz	Lanzhot	48.681611	16.946416	MF	2018
CZ-Wet	Trebon	49.024657	14.7703419	WET	2018
DE-Geb	Gebesee	51.099714	10.914629	CRO	2018
DE-Gri	Grillenburg	50.950046	13.512681	GRA	2018, 2019, 2020
DE-Hai	Hainich	51.079189	10.452336	DBF	2018, 2019, 2020
DE_HoH	Hohes Holz	52.086484	11.222468	DBF	2018, 2019, 2020
DE-Hzd	Hetzdorf	50.963566	13.490172	DBF	2018
DE-Kli	Klingenber g	50.892881	13.5225056	CRO	2018, 2019, 2020
DE-RuR	Rollesbroic h	50.621914	6.3041256	GRA	2018
DE-RuS	Selhausen Juelich	50.865912	6.4471689	CRO	2018, 2019, 2020
DE-RuW	Wustebach	50.504907	6.33101886	ENF	2018
DE-Tha	Tharandt	50.962631	13.565225	ENF	2018
DK-Sor	Soroe	55.485869	11.644644	DBF	2018
FI-Hyy	Hyytiala	61.84741	24.29477	ENF	2018, 2020
FI-Sii	Siikaneva	61.832683	24.19278333	WET	2018, 2019, 2020
FI-Var	Varrio	67.7549	29.61	ENF	2018, 2019, 2020
FR-Aur	Aurade	43.54965	1.10615	CRO	2019, 2020
FR-Bil	Bilos - Salles	44.49389	-0.95592	ENF	2018, 2019, 2020
FR-EM2	Estrees- Mons A28	49.872108	3.02065	CRO	2018, 2019, 2020

FR-Fon	Fontaineble au-Barbeau	48.476339	2.780136	DBF	2018, 2019, 2020
FR-Hes	Hesse	48.84415	1.951910019	DBF	2018
FR-LGt	La Guette	48.67416	7.06461667	WET	2018, 2019, 2020
FR-Mej	Mejusseau me	48.117707	-1.798283	CRO	2019, 2020
GF-Guy	Guyaflux	5.2787	-52.9248	EBF	2018, 2019, 2020
IT-BCi	Borgo Cioffi	40.52375	14.957444	CRO	2018
IT-Cp2	Castelporzi ano2	41.704267	12.357293	EBF	2018
IT-Lsn	Lison	45.740481	12.750297	OSH	2018, 2019, 2020
IT-SR2	San Rossore 2	43.73203	10.29095	ENF	2018, 2019, 2020
IT-Tor	Torgnon	45.844444	7.578055556	GRA	2018, 2019, 2020
NL-Loo	Loobos	52.16648	5.74355	ENF	2018
SE-Deg	Degero	64.182	19.556694	WET	2018, 2020
SE-Htm	Hyltemossa	56.09763	13.41897	ENF	2018, 2019, 2020
SE-Nor	Norunda	60.086441	17.479455	ENF	2018, 2019, 2020
SE-Svb	Svartberget	64.256097	19.77451111	ENF	2018, 2019, 2020

Tab S2: MODIS Terra and Aqua surface spectral reflectance bands. NIR denotes for near-infrared, SWNIR for shortwave near-infrared, SWIR shortwave infrared, and VNIR visible near-infrared.

Acronym	Full Name	Wavelengths (nm)	Band name	Spatial Resolution
B ₁	Surface Reflectance for B ₁	620-670	Red	500 m
B ₂	Surface Reflectance for B ₂	841-876	NIR	
B ₃	Surface Reflectance for B ₃	459-479	Blue	
B ₄	Surface Reflectance for B ₄	545-565	Green	
B ₅	Surface Reflectance for B ₅	1230-1250	SWNIR	
B ₆	Surface Reflectance for B ₆	1628-1652	SWIR	

B ₇	Surface Reflectance for B ₇	2105-2155	SWIR	
B ₈	Surface Reflectance for B ₈	405-420	Blue	1 km
B ₉	Surface Reflectance for B ₉	438-448	Blue	
B ₁₀	Surface Reflectance for B ₁₀	483-493	Blue	
B ₁₁	Surface Reflectance for B ₁₁	526-536	Green	
B ₁₂	Surface Reflectance for B ₁₂	546-556	Green	
B ₁₃	Surface Reflectance for B ₁₃	662-672	Red	
B ₁₄	Surface Reflectance for B ₁₄	673-683	VNIR	
B ₁₅	Surface Reflectance for B ₁₅	743-753	VNIR	
B ₁₆	Surface Reflectance for B ₁₆	862-877	NIR	

Tab S3: Detailed results and statistics of the site-specific hyperbolic relationships between GPP and SIF_d. R² denotes for the coefficient of determination. The unit of RMSE (Root Mean Squared Error) is in (gC m⁻² d⁻¹). PFT represents the plant functional type of each site: MF (mixed forests), CRO (croplands), DBF (deciduous broadleaf forests), EBF (evergreen broadleaf forests), ENF (evergreen needleleaf forests), GRA (grasslands), OSH (open shrublands), and WET (wetlands). All pairwise hyperbolic relationships between GPP and SIF_d were statistically significant with p<0.0001, except for IT-Cp2, Guy and FR-Mej sites. a and b denote the fitted parameters from the hyperbolic model.

Site ID	R ²	a	b	RMSE	N	PFT
BE-Bra	0.64	16.15	0.37	1.92	288	MF
BE-Lcr	0.24	14.12	0.28	4.03	618	CRO
BE-Lon	0.37	79.75	4.36	6.16	572	CRO
BE-Vie	0.28	8.60	0.07	2.42	220	ENF
CH-Dav	0.21	4.87	0.05	1.76	350	ENF
CZ-BK1	0.34	12.23	0.04	3.62	160	ENF
CZ-Lnz	0.46	16.31	0.28	3.28	332	MF
CZ-Wet	0.28	13.11	0.31	3.66	292	WET
DE-Geb	0.56	19.49	0.63	3.44	236	CRO
DE-Gri	0.34	12.66	0.33	3.34	818	GRA
DE-Hai	0.57	21.80	1.12	2.94	802	DBF
DE-HoH	0.43	19.63	0.67	4.36	944	DBF
DE-Hzd	0.50	16.20	0.63	2.87	248	DBF
DE-Kli	0.35	28.94	1.90	3.88	850	CRO
DE-RuR	0.22	11.02	0.15	3.88	274	GRA

DE-RuS	0.28	31.74	0.97	6.30	678	CRO
DE-RuW	0.10	8.94	0.02	2.62	216	ENF
DE-Tha	0.74	10.40	0.21	1.79	268	ENF
DK-Sor	0.87	74.20	3.51	2.71	298	DBF
FI-Hyy	0.36	9.14	0.13	2.54	498	ENF
FI-Sii	0.37	4.36	0.23	1.10	766	WET
FI-Var	0.12	4.83	0.02	2.08	560	ENF
FR-Aur	0.22	16.48	1.05	3.74	854	CRO
FR-Bil	0.19	8.02	0.07	3.32	836	ENF
FR-EM2	0.13	9.22	0.25	4.99	762	CRO
FR-Fon	0.75	23.71	0.77	2.72	932	DBF
FR-Hes	0.56	27.10	0.94	3.80	342	DBF
FR-LGt	0.44	11.10	0.40	2.22	1050	WET
FR-Mej	0.07	9.75	0.18	5.17	668	CRO
GF-Guy	0.012	12.36	0.02	2.65	774	EBF
IT-BCi	0.19	18.71	0.27	6.18	300	CRO
IT-Cp2	0.002	9.56	0.00	2.01	182	EBF
IT-Lsn	0.61	13.44	0.50	2.10	1510	OSH
IT-SR2	0.30	10.43	0.07	2.99	750	ENF
IT-Tor	0.50	11.99	0.25	2.91	566	GRA
NL-Loo	0.40	9.67	0.05	1.98	234	ENF
SE-Deg	0.42	2.16	0.18	0.55	602	WET
SE-Htm	0.35	9.91	0.10	2.91	808	ENF
SE-Nor	0.68	12.16	0.23	2.12	640	ENF
SE-Svb	0.18	7.00	0.03	2.70	900	ENF

Tab S4: Detailed results and statistics of the site-specific linear relationships between GPP and SIF_d. The sign $\pm$ denotes the 95% confidence interval on the slope and on the intercept for each relationship. R^2 denotes for the coefficient of determination. The units are for the slope in ($\text{gC m}^{-2} \text{d}^{-1}/(\text{mW m}^{-2} \text{sr}^{-1} \text{nm}^{-1})$), intercept in ($\text{gC m}^{-2} \text{d}^{-1}$), and RMSE (Root Mean Squared Error) in ($\text{gC m}^{-2} \text{d}^{-1}$). PFT represents the plant functional type of each site: MF (mixed forests), CRO (croplands), DBF (deciduous broadleaf forests), EBF (evergreen broadleaf forests), ENF (evergreen needleleaf forests), GRA (grasslands), OSH (open shrublands), and WET (wetlands). All pairwise linear relationships between GPP and SIF_d were statistically significant with $p < 0.0001$, except for IT-Cp2 site ($p < 0.604$).

Relatively moderate and strong relationships were found at DK-Sor, FR-Fon, BE-Bra, DE-Hai, DE-Tha, and IT-Lsn, which are DBF, MF, ENF and OSH vegetation type sites, with R^2 values being between 0.54 and 0.81 ($p < 0.0001$). The weakest relationships were recorded at FI-Var, FR-EM2 and FR-Mej sites, and no significant relationship was found at GF-Guy and IT-Cp2.

Site ID	R^2	Slope	Intercept	RMSE	N	PFT
BE-Bra	0.59	11.27 $\pm$ 1.07	3.33 $\pm$ 0.45	2.00	300	MF
BE-Lcr	0.20	9.02 $\pm$ 1.39	4.06 $\pm$ 0.66	4.06	630	CRO
BE-Lon	0.27	12.33 $\pm$ 1.64	2.1 $\pm$ 0.89	6.05	582	CRO
BE-Vie	0.20	4.75 $\pm$ 1.24	4.84 $\pm$ 0.60	2.44	228	ENF
CH-Dav	0.15	4.17 $\pm$ 0.96	2.67 $\pm$ 0.26	1.74	406	ENF
CZ-BK1	0.35	18 $\pm$ 3.62	5.92 $\pm$ 0.79	3.38	178	ENF
CZ-Lnz	0.42	9.98 $\pm$ 1.25	4.76 $\pm$ 0.60	3.18	346	MF
CZ-Wet	0.20	9.46 $\pm$ 2.16	3.12 $\pm$ 0.71	3.68	306	WET

DE-Geb	0.53	10.04±1.18	2.12±0.68	3.80	254	CRO
DE-Gri	0.28	8.58±0.94	2.89±0.38	3.26	842	GRA
DE-Hai	0.57	9.23±0.54	1.40±0.32	2.91	852	DBF
DE-HoH	0.35	9.29±0.79	3.04±0.41	4.14	1002	DBF
DE-Hzd	0.41	8.56±1.25	2.40±0.57	2.73	260	DBF
DE-Kli	0.31	9.05±0.89	1.18±0.40	3.85	886	CRO
DE-RuR	0.17	6.87±1.76	4.59±0.87	3.80	280	GRA
DE-RuS	0.29	17.04±1.97	1.81±0.80	6.22	708	CRO
DE-RuW	0.16	5.02±1.51	6.42±0.57	2.61	230	ENF
DE-Tha	0.56	6.43±0.68	3.54±0.31	1.61	280	ENF
DK-Sor	0.81	14.06±0.77	2.09±0.56	2.73	310	DBF
FI-Hyy	0.27	8.05±1.10	3.33±0.34	2.68	554	ENF
FI-Sii	0.32	4.01±0.40	1.06±0.12	1.10	850	WET
FI-Var	0.13	4.73±0.92	3.23±0.20	2.00	690	ENF
FR-Aur	0.23	7.98±0.97	1.08±0.41	3.65	908	CRO
FR-Bil	0.17	6.47±0.95	3.98±0.32	3.13	884	ENF
FR-EM2	0.11	5.10±1.02	2.99±0.59	4.85	780	CRO
FR-Fon	0.66	11.91±0.53	2.48±0.27	2.71	986	DBF
FR-Hes	0.50	12.12±1.28	2.55±0.66	3.78	352	DBF
FR-LGt	0.43	8.02±0.55	1.76±0.22	2.29	1114	WET
FR-Mej	0.04	4.72±1.65	4.40±0.84	5.22	672	CRO
GF-Guy	0.02	1.86±0.91	10.79±0.57	2.63	774	EBF
IT-BCi	0.16	13.43±3.5	5.10±1.39	6.11	306	CRO
IT-Cp2	0.001	0.36±1.37	9.37±0.54	2.01	190	EBF
IT-Lsn	0.54	8±0.36	2.17±0.17	2.10	1594	OSH
IT-SR2	0.21	6.78±0.94	5.78±0.36	2.95	774	ENF
IT-Tor	0.42	11.31±1.02	2.30±0.30	2.83	646	GRA
NL-Loo	0.24	5.36±1.22	5.96±0.48	2.19	242	ENF
SE-Deg	0.35	2.04±0.21	0.61±0.06	0.54	680	WET
SE-Htm	0.29	6.34±0.66	4.70±0.30	2.72	860	ENF
SE-Nor	0.51	8.35±0.62	3.53±0.25	2.14	684	ENF
SE-Svb	0.20	7.61±0.93	3.88±0.24	2.75	1056	ENF

Tab S5: Summary statistics of plant functional type-specific linear relationship between GPP and SIF_d in eight major PFT. All pairwise linear relationships between GPP and SIF_d were statistically significant with $p < 0.0001$. The units are for the slope in ($\text{gC m}^{-2} \text{d}^{-1} / (\text{mW m}^{-2} \text{sr}^{-1} \text{nm}^{-1})$), intercept in ($\text{gC m}^{-2} \text{d}^{-1}$), and RMSE in ($\text{gC m}^{-2} \text{d}^{-1}$). The sign $\pm$ denotes the 95% confidence interval on the slope and intercept of the relationships between SIF_d and GPP. Relatively moderate and goodness of fits were found in MF, DBF and OSH biomes, and the lowest in EBF and CRO vegetation types.

PFT	Sites	R ²	Slope	Intercept	RMSE	N
CRO	9	0.18	8.93±0.49	2.61±0.24	5.24	5726
DBF	6	0.52	10.75±0.33	2.32±0.18	3.50	3762
EBF	2	0.07	3.08±0.72	9.76±0.42	2.62	964
ENF	13	0.26	7.28±0.28	4.07±0.10	2.85	7066
GRA	3	0.33	9.39±0.62	2.79±0.24	3.24	1768
MF	2	0.47	10.53±0.87	4.10±0.39	2.74	646
OSH	1	0.54	8.00±0.36	2.17±0.17	2.10	1594

WET	4	0.29	7.14±0.40	1.15±0.14	2.44	2950
ALL	40	0.30	9.12±0.17	2.87±0.08	3.82	24476

Tab S6: The generalized linear model results statistics (GLM). The following equation was fitted to investigate the effects of the site, year, and PFT and their interactions on the seasonal and interannual variations of SIF_d and its relationship with GPP. $SIF_d = 1 + \text{Year} + \text{Site} + \text{PFT} + \text{GPP} + \text{Year} \times \text{GPP} + \text{Site} \times \text{GPP} + \text{PFT} \times \text{GPP}$. All pairwise relationships between GPP and SIF_d were statistically significant with $p < 0.001$, except for Site×GPP interaction ($p < 0.896$).

Parameters	Estimate	Std. Error	p-value
Intercept	-3.01E+01	5.79E+00	2.00E-07
Year	1.50E-02	2.87E-03	1.66E-07
Site	-1.06E-03	2.49E-04	2.13E-05
PFT	-1.31E-02	1.02E-03	< 2e-16
GPP	3.09E+00	7.60E-01	4.83E-05
Year×GPP	-1.52E-03	3.76E-04	5.70E-05
Site×GPP	-4.17E-06	3.19E-05	0.896
PFT×GPP	1.88E-03	1.59E-04	< 2e-16

Tab S7: Detailed results and statistics of the site-specific comparison between tower-based observed GPP against the RF predicted GPP. PFT denotes plant functional type of each site, including MF (mixed forests), CRO (croplands), DBF (deciduous broadleaf forests), EBF (evergreen broadleaf forests), ENF (evergreen needleleaf forests), GRA (grasslands), OSH (open shrublands), and WET (wetlands). The adj. R^2 denotes for the adjusted coefficient of determination. The units are for the slope in ($\text{gC m}^{-2} \text{d}^{-1}/(\text{mW m}^{-2} \text{sr}^{-1} \text{nm}^{-1})$), intercept in ($\text{gC m}^{-2} \text{d}^{-1}$), and RMSE (Root Mean Squared Error) in ($\text{gC m}^{-2} \text{d}^{-1}$). The sign $\pm$ denotes the confidence interval at 95% probability level on the slope and on the intercept for each relationship. RF-R model includes only surface spectral reflectance as explanatory variables, RF-SIF-R uses SIF_d and spectral bands inputs to predict GPP, RF-SIF-VI explores SIF_d and VIs as inputs, and RF-SIF-PFT establishes based on SIF_d , spectral bands and vegetation type as categorical variable to estimate GPP.

Site ID	PFT	N	RF-R				RF-SIF-R			
			adj. R^2	Slope	Intercept	RMSE	adj. R^2	Slope	Intercept	RMSE
BE-Bra	MF	55	0.62	0.84±0.18	1.29±1.43	1.70	0.71	0.98±0.17	0.15±1.37	1.49
BE-Lcr	CRO	124	0.92	1.03±0.05	-0.14±0.47	1.26	0.9	1.06±0.06	-0.39±0.54	1.40
BE-Lon	CRO	111	0.91	1.03±0.06	-0.24±0.55	1.93	0.88	1.09±0.07	-0.45±0.65	2.22
BE-Vie	ENF	41	0.81	1.02±0.16	-0.07±1.04	1.08	0.70	1.00±0.21	-0.20±1.43	1.37
CH-Dav	ENF	95	0.84	0.95±0.09	-0.01±0.34	0.79	0.75	0.87±0.10	0.04±0.43	0.98
CZ-BK1	ENF	23	0.63	0.96±0.32	0.86±3.03	2.28	0.70	1.31±0.37	-1.22±3.16	2.04
CZ-Lnz	MF	62	0.93	1.13±0.08	-0.81±0.78	1.12	0.87	1.15±0.12	-0.67±1.08	1.53
CZ-Wet	WET	54	0.88	0.98±0.10	-0.02±0.74	1.48	0.79	1.09±0.16	-0.52±1.09	1.97
DE-Geb	CRO	48	0.83	1.06±0.14	-0.14±1.11	2.23	0.87	1.05±0.12	0.11±0.93	1.95
DE-Gri	GRA	169	0.81	1.09±0.08	-0.49±0.52	1.58	0.77	1.12±0.09	-0.61±0.60	1.74
DE-Hai	DBF	161	0.90	1.01±0.05	-0.26±0.38	1.46	0.87	1.01±0.06	-0.57±0.46	1.66
DE-HoH	DBF	183	0.94	1.00±0.04	-0.06±0.33	1.28	0.90	1.04±0.05	-0.29±0.43	1.61
DE-Hzd	DBF	61	0.84	1.03±0.12	0.02±0.74	1.43	0.84	1.14±0.13	-0.83±0.83	1.44
DE-Kli	CRO	177	0.88	1.02±0.06	-0.58±0.35	1.59	0.83	1.08±0.07	-1.12±0.47	1.93
DE-RuR	GRA	61	0.75	0.95±0.14	0.66±1.14	1.82	0.59	1.05±0.23	0.19±1.71	2.33
DE-RuS	CRO	148	0.79	0.98±0.08	0.68±0.77	3.13	0.74	0.98±0.09	0.82±0.87	3.50
DE-RuW	ENF	46	0.81	0.96±0.14	0.38±1.13	1.14	0.54	0.94±0.26	0.78±2.03	1.78
DE-Tha	ENF	52	0.77	0.93±0.14	0.61±0.90	1.14	0.67	0.85±0.17	0.85±1.10	1.38

DK-Sor	DBF	59	0.94	1.05±0.07	0.15±0.88	1.56	0.93	1.04±0.08	0.39±0.96	1.73
FI-Hyy	ENF	104	0.92	1.02±0.06	-0.15±0.37	0.91	0.81	1.05±0.10	-0.23±0.61	1.41
FI-Sii	WET	163	0.86	0.91±0.06	0.01±0.15	0.49	0.69	0.68±0.08	0.30±0.21	0.72
FI-Var	ENF	139	0.79	0.97±0.08	0.13±0.38	1.05	0.74	0.96±0.10	0.12±0.43	1.16
FR-Aur	CRO	205	0.86	1.00±0.06	-0.14±0.28	1.45	0.83	1.00±0.06	-0.10±0.32	1.61
FR-Bil	ENF	168	0.89	1.05±0.06	-0.13±0.35	1.15	0.82	1.09±0.08	-0.35±0.48	1.48
FR-EM2	CRO	169	0.62	0.94±0.11	0.62±0.75	2.97	0.59	0.86±0.11	1.03±0.74	3.08
FR-Fon	DBF	210	0.95	1.01±0.03	-0.20±0.25	0.97	0.95	1.02±0.03	-0.34±0.28	1.06
FR-Hes	DBF	74	0.83	1.00±0.10	-0.70±0.98	2.07	0.80	1.08±0.12	-1.43±1.14	2.24
FR-LGt	WET	239	0.93	1.03±0.04	-0.34±0.19	0.82	0.85	1.01±0.05	-0.45±0.28	1.15
FR-Mej	CRO	120	0.81	0.98±0.09	0.21±0.74	2.44	0.74	1.09±0.12	-0.34±0.95	2.89
GF-Guy	EBF	146	0.80	0.99±0.53	0.21±0.96	1.18	0.71	1.00±0.10	0.35±1.20	1.42
IT-BCi	CRO	69	0.21	1.16±0.53	0.94±5.08	5.98	0.21	0.61±0.28	5.31±3.23	5.98
IT-Cp2	EBF	42	0.36	0.65±0.27	3.89±2.51	1.25	0.25	0.58±0.31	4.85±2.73	1.36
IT-Lsn	OSH	317	0.91	1.02±0.04	-0.09±0.22	0.99	0.88	1.01±0.04	0.01±0.24	1.10
IT-SR2	ENF	160	0.60	0.96±0.12	0.55±1.02	2.04	0.56	1.08±0.15	-0.08±1.18	2.12
IT-Tor	GRA	134	0.79	0.97±0.09	0.19±0.43	1.60	0.75	1.00±0.10	0.13±0.49	1.74
NL-Loo	ENF	47	0.77	1.11±0.18	-0.46±1.32	1.30	0.66	1.19±0.25	-0.55±1.73	1.58
SE-Deg	WET	143	0.38	0.37±0.08	0.56±0.13	0.53	0.41	0.34±0.07	0.49±0.14	0.52
SE-Htm	ENF	167	0.78	1.02±0.08	-0.03±0.63	1.52	0.70	1.04±0.10	-0.17±0.78	1.77
SE-Nor	ENF	144	0.87	0.97±0.06	0.15±0.41	1.05	0.79	0.99±0.09	0.16±0.55	1.33
SE-Svb	ENF	199	0.92	1.01±0.04	0.00±0.02	0.91	0.86	1.05±0.06	-0.21±0.34	1.15
			RF-SIF-VI				RF-SIF-R-PFT			
Site ID	PFT	N	adj. R ²	Slope	Intercept	RMSE	adj. R ²	Slope	Intercept	RMSE
BE-Bra	MF	55	0.59	0.85±0.19	1.18±1.53	1.76	0.72	0.97±0.16	0.14±1.34	1.47
BE-Lcr	CRO	124	0.85	1.08±0.08	-0.13±0.68	1.77	0.91	1.05±0.06	-0.33±0.53	1.39
BE-Lon	CRO	111	0.83	1.12±0.10	-0.54±0.82	2.72	0.88	1.08±0.07	-0.36±0.65	2.22
BE-Vie	ENF	41	0.67	0.95±0.21	0.13±1.45	1.42	0.75	1.05±0.19	-0.61±1.32	1.23
CH-Dav	ENF	95	0.71	0.85±0.11	0.16±0.46	1.05	0.76	0.88±0.10	0.02±0.42	0.96
CZ-BK1	ENF	23	0.40	1.04±0.55	1.68±4.24	2.90	0.67	1.30±0.40	-1.21±3.40	2.15
CZ-Lnz	MF	62	0.75	1.11±0.16	-0.34±1.54	2.11	0.86	1.16±0.12	-0.90±1.12	1.55
CZ-Wet	WET	54	0.68	1.13±0.21	-0.59±1.42	2.42	0.82	1.11±0.14	-0.34±0.96	1.81
DE-Geb	CRO	48	0.8	0.99±0.14	0.31±1.15	2.40	0.87	1.05±0.12	0.15±0.92	1.92
DE-Gri	GRA	169	0.65	1.03±0.12	-0.37±0.77	2.16	0.78	1.13±0.09	-0.84±0.59	1.69
DE-Hai	DBF	161	0.82	0.99±0.07	-0.72±0.54	1.91	0.88	1.02±0.06	-0.48±0.43	1.58
DE-HoH	DBF	183	0.87	1.09±0.06	-0.52±0.52	1.88	0.90	1.03±0.05	-0.17±0.43	1.61
DE-Hzd	DBF	61	0.74	1.07±0.16	-0.67±1.06	1.81	0.86	1.09±0.11	-0.34±0.71	1.34
DE-Kli	CRO	177	0.71	1.03±0.10	-1.15±0.63	2.49	0.84	1.07±0.07	-1.07±0.44	1.84
DE-RuR	GRA	61	0.57	0.97±0.22	-0.01±1.81	2.37	0.60	1.07±0.22	0.02±1.69	2.28
DE-RuS	CRO	148	0.72	1.05±0.11	0.77±0.91	3.62	0.75	0.98±0.09	0.84±0.85	3.45
DE-RuW	ENF	46	0.35	0.74±0.30	2.53±2.24	2.12	0.56	0.97±0.26	0.54±2.00	1.74
DE-Tha	ENF	52	0.54	0.74±0.19	1.32±1.31	1.63	0.69	0.93±0.18	0.34±1.16	1.35
DK-Sor	DBF	59	0.90	1.06±0.09	0.58±1.10	1.98	0.93	1.04±0.08	0.34±0.95	1.71
FI-Hyy	ENF	104	0.74	1.06±0.12	-0.17±0.73	1.65	0.81	1.06±0.10	-0.35±0.62	1.41
FI-Sii	WET	163	0.68	0.64±0.07	0.27±0.21	0.73	0.78	0.89±0.07	0.10±0.18	0.60
FI-Var	ENF	139	0.66	0.90±0.11	0.28±0.50	1.32	0.73	0.94±0.10	0.14±0.44	1.18
FR-Aur	CRO	205	0.79	0.99±0.07	-0.18±0.36	1.80	0.83	0.99±0.06	-0.06±0.32	1.62

FR-Bil	ENF	168	0.71	1.05±0.10	-0.05±0.62	1.87	0.82	1.10±0.08	-0.57±0.49	1.47
FR-EM2	CRO	169	0.55	0.85±0.12	1.09±0.80	3.25	0.60	0.86±0.11	1.05±0.74	3.07
FR-Fon	DBF	210	0.87	1.00±0.05	-0.22±0.44	1.63	0.95	1.02±0.03	-0.29±0.27	1.03
FR-Hes	DBF	74	0.60	1.01±0.19	-0.87±1.72	3.18	0.81	1.07±0.12	-1.24±1.12	2.22
FR-LGt	WET	239	0.74	0.90±0.07	-0.38±0.40	1.53	0.88	1.06±0.05	-0.39±0.25	1.05
FR-Mej	CRO	120	0.68	1.07±0.13	-0.37±1.09	3.20	0.75	1.08±0.11	-0.28±0.92	2.81
GF-Guy	EBF	146	0.53	0.89±0.14	2.07±1.51	1.81	0.75	1.05±0.10	-0.36±1.17	1.33
IT-BCi	CRO	69	0.21	0.63±0.29	5.16±3.33	6.00	0.20	0.60±0.28	5.46±3.24	6.02
IT-Cp2	EBF	42	0.10	0.35±0.29	7.13±2.42	1.49	0.3	0.65±0.31	3.95±2.84	1.31
IT-Lsn	OSH	317	0.83	0.98±0.05	0.21±0.29	1.33	0.89	1.02±0.04	-0.06±0.24	1.08
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SE-Svb	ENF	199	0.68	0.99±0.09	0.16±0.55	1.76	0.87	1.04±0.06	-0.26±0.35	1.15

Figure S1: Site-specific linear relationships tower-based GPP and SIF_d at daily timescale. The R² represents the coefficient of determination of the relationship between GPP and SIF_d for each site. The color code represents the eight different plant functional types encountered in the study sites: Red color stands for CRO (croplands), green for DBF (deciduous broadleaf forests), yellow for EBF (evergreen broadleaf forests), magenta for ENF (evergreen needleleaf forests), blue for GRA (grasslands), Cyan for MF (mixed forests), lime for OSH (open shrubland), and dimgrey for WET (wetland). The shaded area depicted in each line is the 95% confidence interval of the linear relationship between GPP and SIF_d.

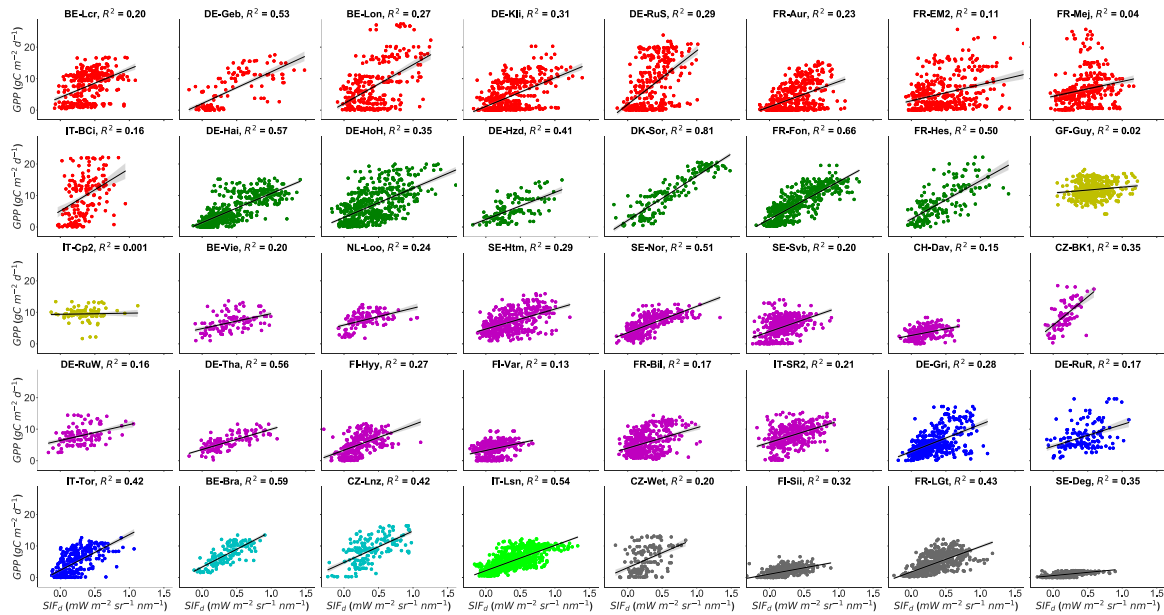


Figure S2: linear relationships between tower-based GPP and SIF_d in eight plant functional types: MF, CRO, ENF, DBF, EBF, GRA, OSH, and WET at daily timescale. The R² represents the coefficient of determination of the relationship between GPP and SIF_d. p is the probability value of the linear model. The shaded area depicted in each line is the 95% confidence interval of the linear relationships between GPP and SIF_d.

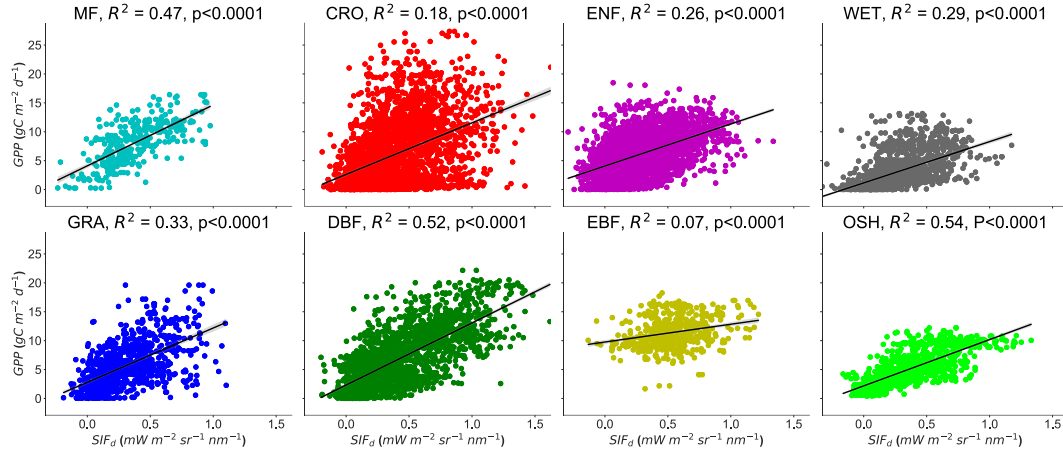


Figure S3: Scatterplots of the linear relationships between tower-based GPP and SIF_d in eight PFT pooled together across all sites. The shaded area depicted in each line is the 95% confidence interval of the linear relationships between GPP and SIF_d .

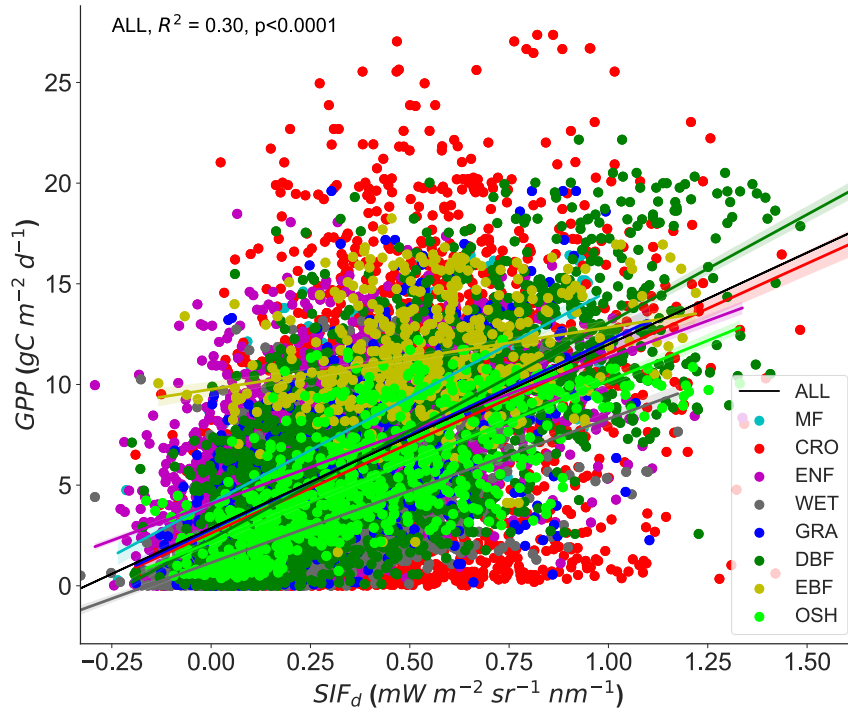


Figure S4: Correlation matrix between variables. B_1 to B_{16} denote the spectral reflectance of MODIS bands, SIF_d is the daily TROPOMI sun-induced chlorophyll fluorescence, GPP is the tower-based daily gross primary production, NDVI (normalized difference vegetation index), NIR_v (near infrared reflectance of vegetation index), and PRI (photochemical reflectance index). The correlation matrix shows strong relations between variables. Based on these observations B_{10} , B_{12} and B_{14} were excluded from the explanatory variables for establishing the RF regression models. Furthermore, B_{15} and B_{16} were excluded from the analyses due to many missing values that they contained.

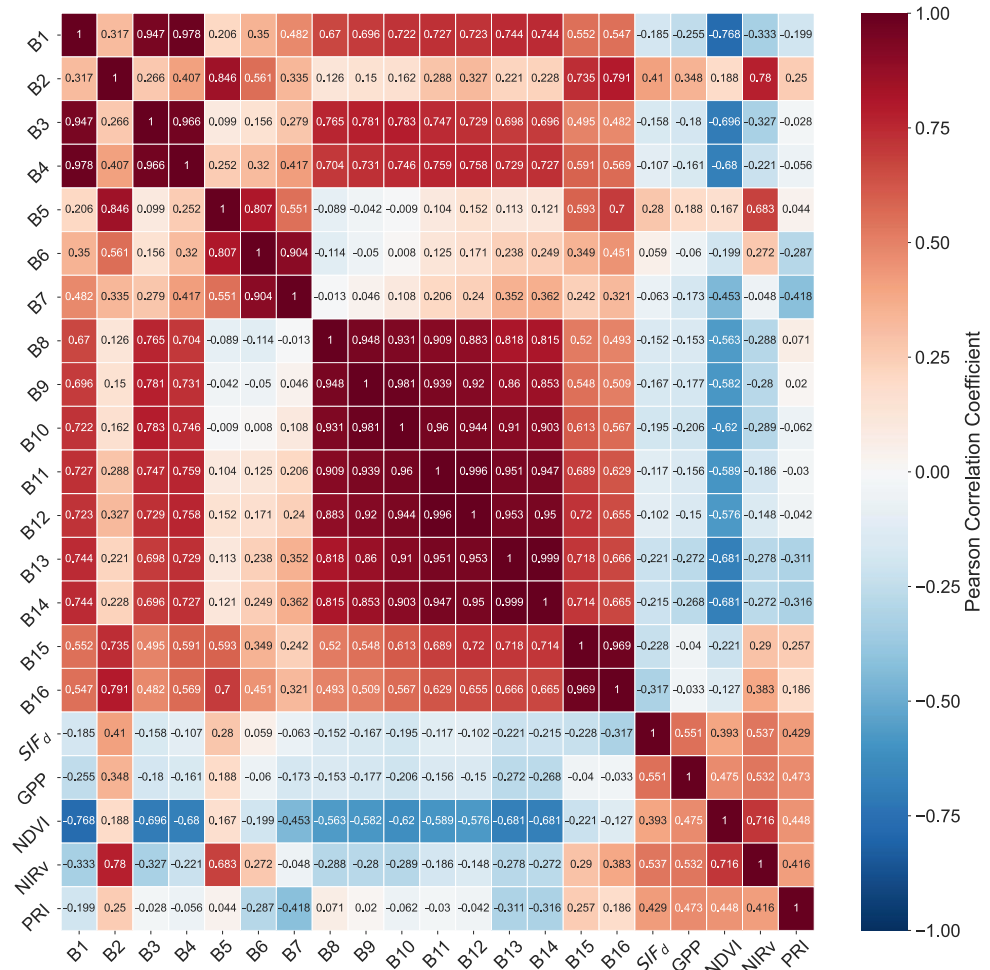


Figure S5: Comparison between RF models estimated GPP and observed tower-based GPP across all ICOS flux tower sites. Overall, our RF models show a high explanation of GPP variability across different vegetation types. However, the RF-SIF-VI shows some limits in some sites in predicting tower-based GPP as it overestimates (for instance at *SE-Deg*) and underestimates (for instance at *IT-Cp2*) tower-based GPP. The color code represents the different RF GPP predictions and the observed GPP: Red color stands for RF-SIF-R, green for RF-SIF-R-PFT, blue for RF-R, Cyan for RF-SIF-VI, and black for the observed tower-based GPP.

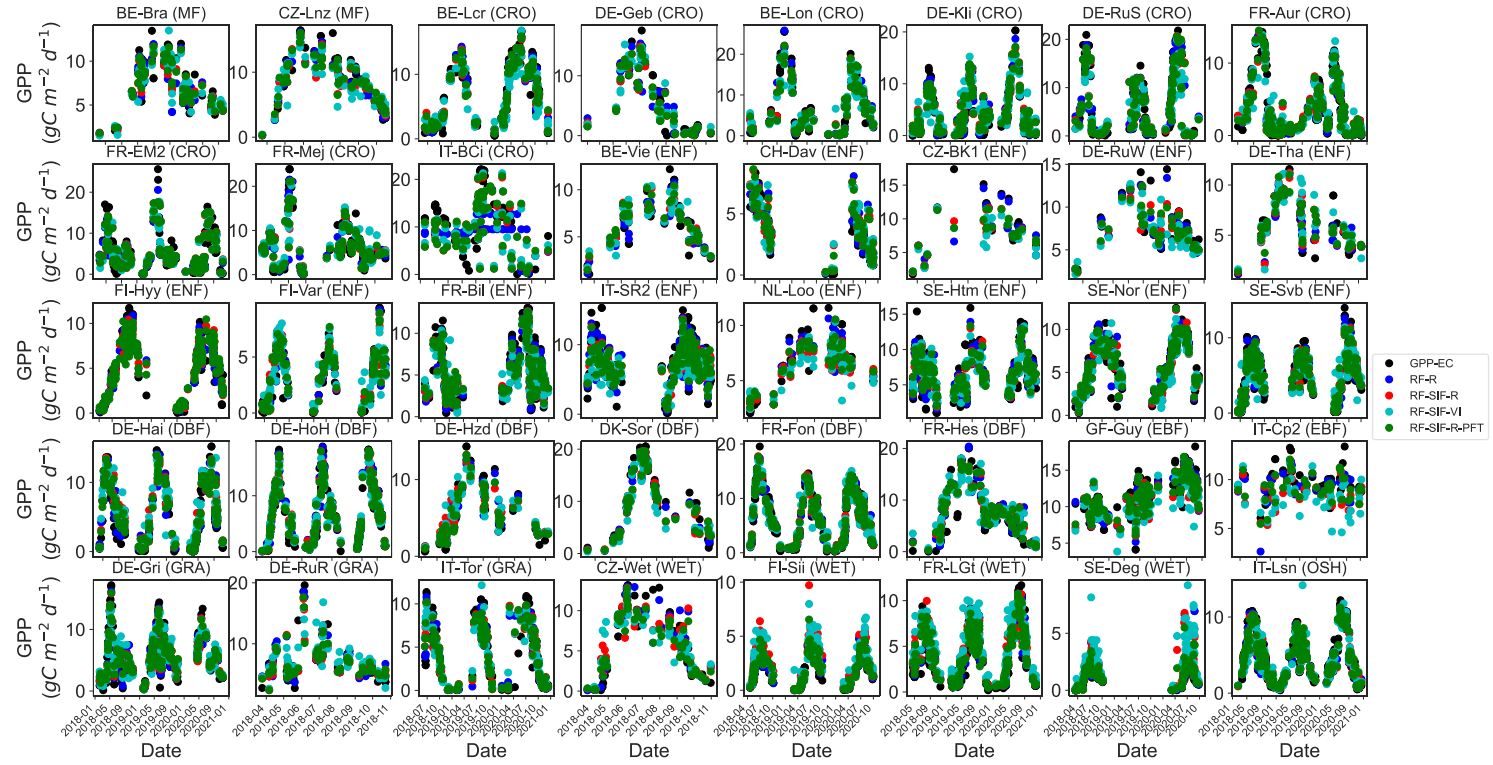


Figure S6-a RF-R: Scatterplots between tower-based GPP and RF-R predicted GPP of each site. The adj. R^2 represents the adjusted coefficient of determination of the relationships between observed GPP and predicted GPP. The color code represents the eight different plant functional types encountered in the study sites: Red color stands for CRO (croplands), green for DBF (deciduous broadleaf forests), yellow for EBF (evergreen broadleaf forests), magenta for ENF (evergreen needleleaf forests), blue for GRA (grasslands), Cyan for MF (mixed forests), lime for OSH (open shrubland), and dimgrey for WET (wetland). The shaded area depicted in each line is the 95% confidence interval of the relationships between predicted GPP and observed GPP.

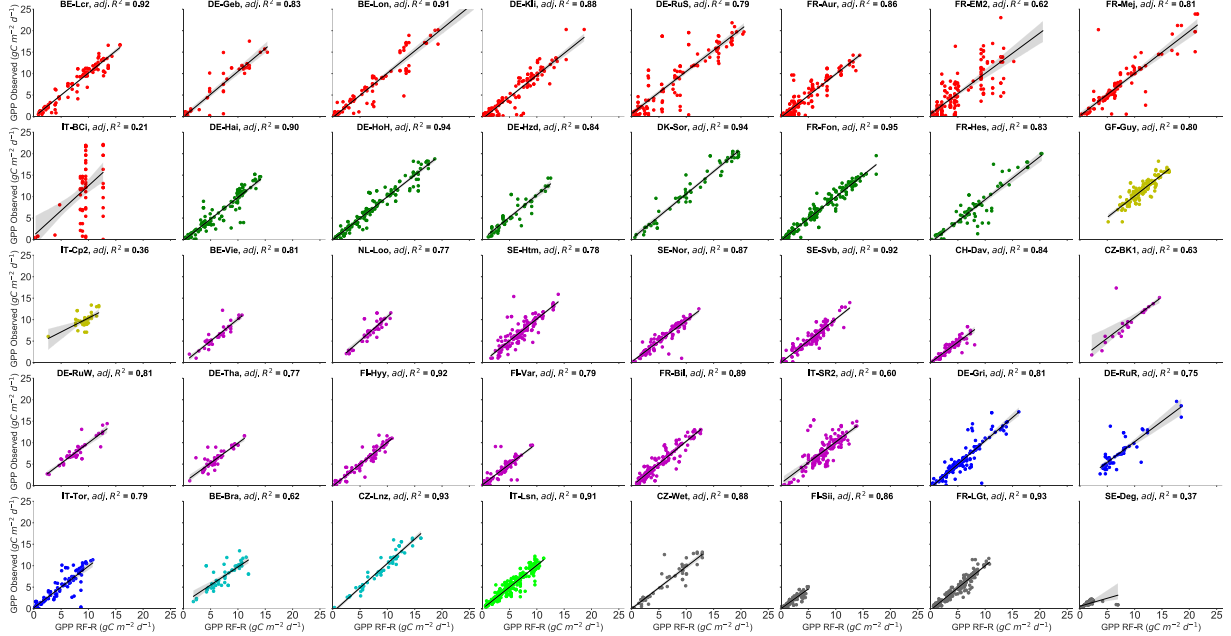


Figure S6-b RF-R: Scatterplots of the tower-based GPP against RF-R predicted GPP based on each PFT: mixed forests (MF), croplands (CRO), evergreen needleleaf forests (ENF), deciduous broadleaf forests (DBF), evergreen broadleaf forests (EBF), grasslands (GRA), open shrublands (OSH), and wetlands (WET) at daily timescale. The adj. R^2 represents the adjusted coefficient of determination of the relationship between observed GPP and predicted GPP. p denotes the statistically significant level of the relationships. The shaded area depicted in each line is the 95% confidence interval of the relationships between predicted GPP and observed GPP.

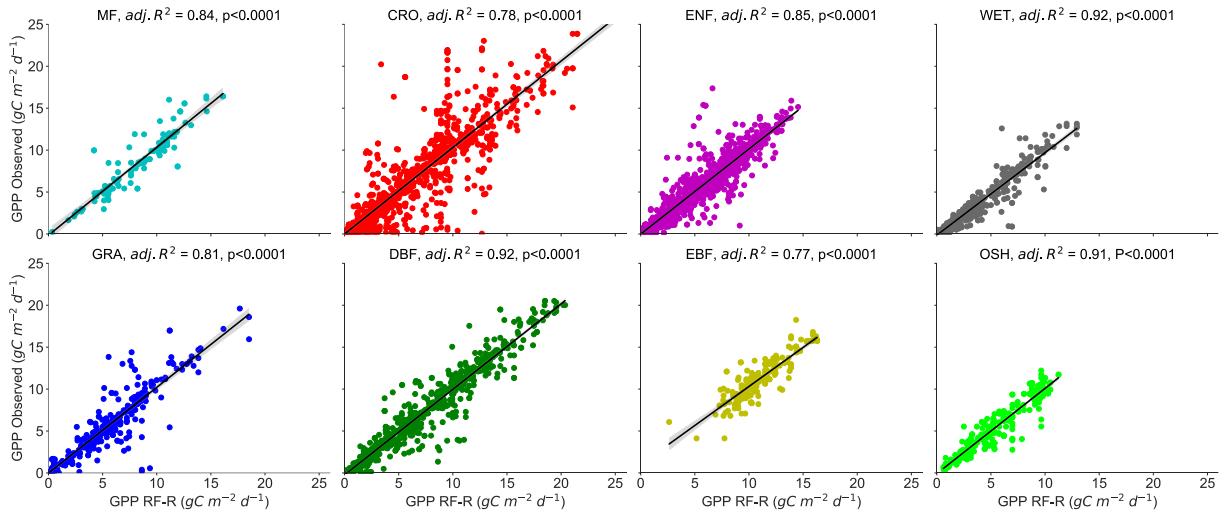


Figure S7-a RF-SIF-VI: Scatterplots between tower-based GPP and RF-SIF-VI predicted GPP for each site. The adj. R^2 represents the adjusted coefficient of determination of the relationships between observed GPP and predicted GPP. The color code represents the eight different vegetation types encountered in the study sites: Red color stands for CRO (croplands), green

for DBF (deciduous broadleaf forests), yellow for EBF (evergreen broadleaf forests), magenta for ENF (evergreen needleleaf forests), blue for GRA (grasslands), Cyan for MF (mixed forests), lime for OSH (open shrubland), and dimgrey for WET (wetland). The shaded area depicted in each line is the 95% confidence interval of the relationships between predicted GPP and observed GPP.

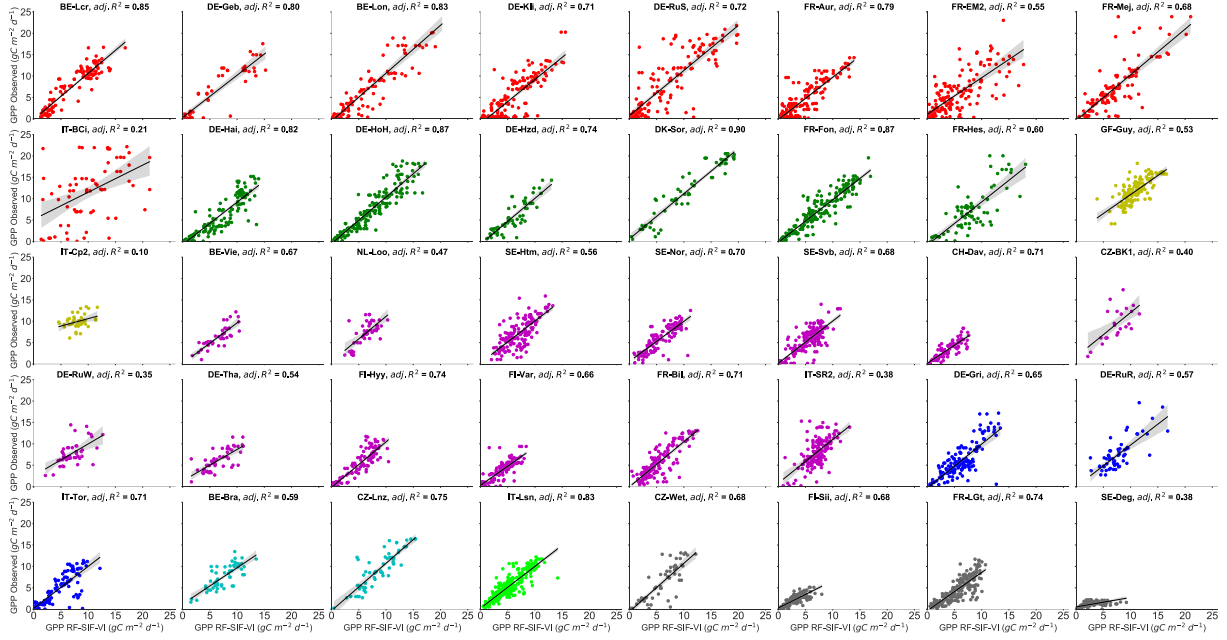


Figure S7-b RF-SIF-VI: Scatterplots of the tower-based GPP against RF-SIF-VI predicted GPP for each plant functional types: mixed forests (MF), croplands (CRO), evergreen needleleaf forests (ENF), deciduous broadleaf forests (DBF), evergreen broadleaf forests (EBF), grasslands (GRA), open shrublands (OSH), and wetlands (WET) at daily timescale. The adj. R^2 represents the adjusted coefficient of determination of the relationship between observed GPP and predicted GPP. p denotes the statistically significant level of the relationships. The shaded area depicted in each line is the 95% confidence interval of the relationships between predicted GPP and observed GPP. The strongest correlations between observed and predicted GPP are observed in DBF and OSH vegetation types, while the lowest are recorded in EBF and ENF.

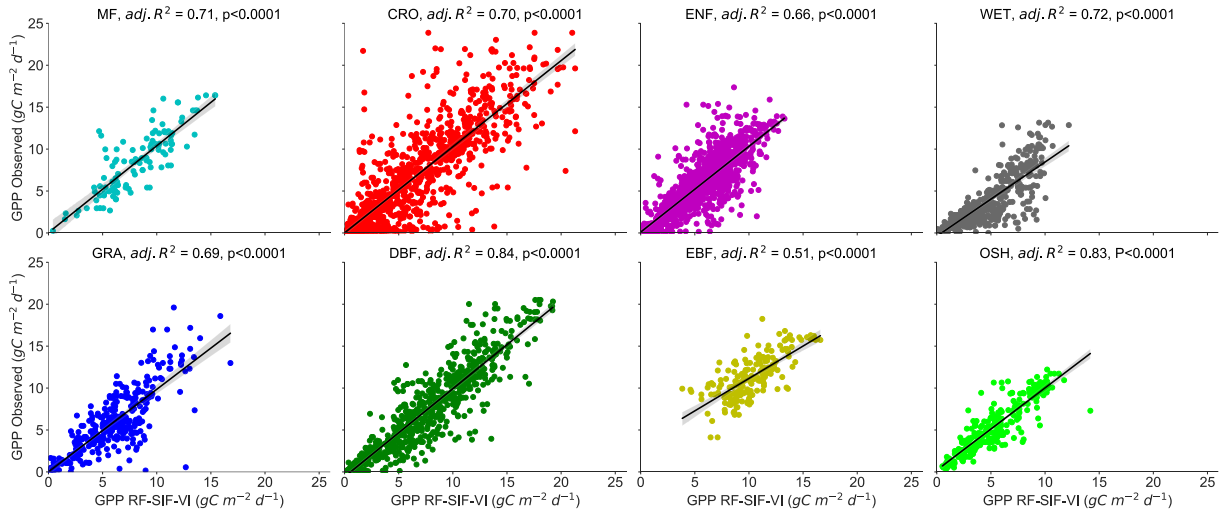


Figure S8-a RF-SIF-R-PFT: Scatterplots between tower-based GPP and RF-SIF-R-PFT predicted GPP for each site. The adj. R^2 represents the adjusted coefficient of determination of the agreement between predicted GPP and observed GPP. The color code represents the eight different vegetation types encountered in the study sites: Red color stands for CRO (croplands), green for DBF (deciduous broadleaf forests), yellow for EBF (evergreen broadleaf forests), magenta for ENF (evergreen needleleaf forests), blue for GRA (grasslands), Cyan for MF (mixed forests), lime for OSH (open shrubland), and dimgrey for WET

(wetland). The shaded area depicted in each line is the 95% confidence interval of relationships between predicted GPP and observed GPP.

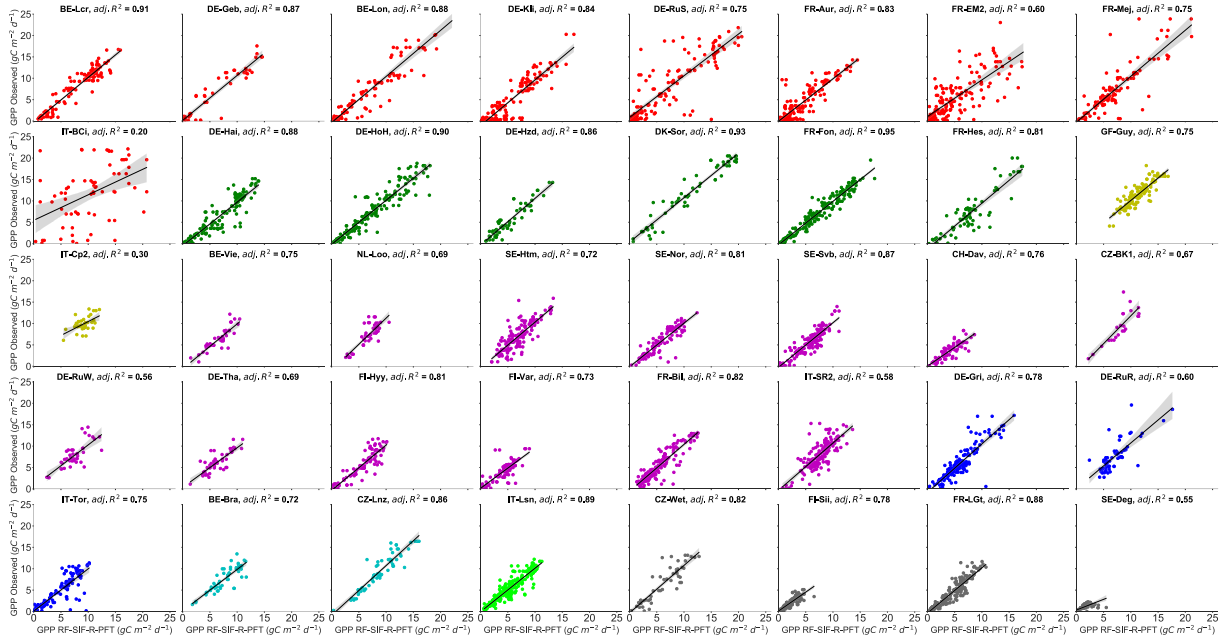


Figure S8-b RF-SIF-R-PFT: Scatterplots of the ICOS tower-based GPP against RF-SIF-R-PFT predicted GPP for each plant functional type: mixed forests (MF), croplands (CRO), evergreen needleleaf forests (ENF), deciduous broadleaf forests (DBF), evergreen broadleaf forests (EBF), grasslands (GRA), open shrublands (OSH), and wetlands (WET) at daily timescale. The $adj. R^2$ represents the adjusted coefficient of determination of the relationship between observed GPP and predicted GPP. p denotes the statistically significant level of the relationships. The shaded area depicted in each line is the 95% confidence interval of the relationships between GPP predicted and GPP observed.

