Supplementary Information for: "On the relationship between sub-daily instantaneous and daily total gross primary production: implications for interpreting satellite-based SIF retrievals"

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Table S1. List of 136 eddy covariance flux tower sites used in this study. The five sites used for the SCOPE simulation are colored in red. IGBP refers to the International Geosphere-Biosphere Programme land cover classification. A list of abbreviations of the land cover types can be found at the end of the table.

Site ID	Site name	Latitude	Longitude	IGBP	Reference
AR-SLu	San Luis	-33.4648	-66.4598	MF	-
AR-Vir	Virasoro	-28.2395	-56.1886	ENF	-
AT-Neu	Neustift/Stubai Valley	47.1167	11.3175	GRA	(Wohlfahrt et al. 2008)
AU-Ade	Adelaide River	-13.0769	131.1178	WSA	-
AU-ASM	Alice Springs	-22.283	133.249	ENF	-
AU-Cpr	Calperum	-34.0021	140.5891	SAV	-
AU-Cum	Cumberland Plains	-33.6133	150.7225	EBF	-
AU-DaP	Daly River Savanna	-14.0633	131.3181	GRA	-
AU-DaS	Daly River Cleared	-14.1593	131.3881	SAV	-
AU-Dry	Dry River	-15.2588	132.3706	SAV	-
AU-Emr	Emerald, Queensland, Australia	-23.8587	148.4746	GRA	(Etheridge et al. 2014)
AU-Fog	Fogg Dam	-12.5452	131.3072	WET	(Guerschman et al. 2009)
AU-GWW	Great Western Woodlands, Western Australia, Australia	-30.1913	120.6541	SAV	-
AU-RDF	Red Dirt Melon Farm, Northern Territory	-14.5636	132.4776	WSA	-
AU-Rig	Riggs Creek	-36.6499	145.5759	GRA	-
AU-Rob	Robson Creek, Queensland, Australia	-17.1175	145.6301	EBF	-
AU-Tum	Tumbarumba	-35.6566	148.1517	EBF	(Leuning et al. 2005)
AU-Whr	Whroo	-36.6732	145.0294	EBF	-
BE-Bra	Brasschaat (De Inslag Forest)	51.3092	4.5206	MF	(Janssens et al. 2001)
BE-Lon	Lonzee	50.5516	4.7461	CRO	(Moureaux et al. 2006)
BE-Vie	Vielsalm	50.3051	5.9981	MF	(Aubinet et al. 2001)
BR-Sa3	Santarem-Km83-Logged Forest	-3.018	-54.9714	EBF	(Steininger 2004)

CA-Gro	Ontario - Groundhog River, Boreal Mixedwood Forest.	48.2167	-82.1556	MF	(McCaughey et al. 2006)
CA-NS1	UCI-1850 burn site	55.8792	-98.4839	ENF	(Goulden et al. 2006)
CA-NS3	UCI-1964 burn site	55.9117	-98.3822	ENF	(Goulden et al. 2006)
CA-NS4	UCI-1964 burn site wet	55.9117	-98.3822	ENF	(Bond-Lamberty et al. 2004)
CA-NS5	UCI-1981 burn site	55.8631	-98.485	ENF	(Wang et al. 2002)
CA-NS6	UCI-1989 burn site	55.9167	-98.9644	OSH	(Bond-Lamberty et al. 2004)
CA-NS7	UCI-1998 burn site	56.6358	-99.9483	OSH	(Bond-Lamberty et al. 2004)
CA-Qfo	Quebec - Eastern Boreal, Mature Black Spruce.	49.6925	-74.3421	ENF	(Bergeron et al. 2007)
CA-SF1	Saskatchewan - Western Boreal, forest burned in 1977.	54.485	-105.818	ENF	(Amiro et al. 2006)
CA-SF2	Saskatchewan - Western Boreal, forest burned in 1989.	54.2539	-105.878	ENF	(Amiro et al. 2003)
CA-SF3	Saskatchewan - Western Boreal, forest burned in 1998.	54.0916	-106.005	OSH	(Amiro et al. 2006)
CA-TP2	Ontario - Turkey Point 1989 Plantation White Pine	42.7744	-80.4588	ENF	(Arain and Restrepo-Coupe 2005)
CG-Tch	Tchizalamou	-4.2892	11.6564	SAV	(Caquet et al. 2012)
CH-Cha	Chamau grassland	47.2102	8.4104	GRA	(Merbold et al. 2014)
CH-Fru	Fruebuel grassland	47.1158	8.5378	GRA	(Zeeman et al. 2010)
CH-Oe1	Oensingen1 grass	47.2858	7.7319	GRA	(Ammann et al. 2009)
CN-Cha	Changbaishan	42.4025	128.0958	MF	(Zhang et al. 2010)
CN-Cng	Changling	44.5934	123.5092	GRA	-
CN-Dan	Dangxiong	30.4978	91.0664	GRA	-
CN-Din	Dinghushan	23.1733	112.5361	EBF	(Zhang et al. 2010)
CN-Du2	Duolun_grassland (D01)	42.0467	116.2836	GRA	(Sun et al. 2011)
CN-Du3	Duolun Degraded Meadow	42.0551	116.2809	GRA	(Sun et al. 2011)
CN-Ha2	Haibei Shrubland	37.6086	101.3269	WET	(Li et al. 2016)
CN-HaM	Haibei Alpine Tibet site	37.37	101.18	GRA	(Kato et al. 2006)
CN-Qia	Qianyanzhou	26.7414	115.0581	ENF	(Zhang et al. 2010)
CN-Sw2	Siziwang Grazed (SZWG)	41.7902	111.8971	GRA	(Shao et al. 2013)
CZ-BK1	Bily Kriz- Beskidy Mountains	49.5047	18.5411	ENF	(Marek et al. 2011)
CZ-BK2	Bily Kriz- grassland	49.4944	18.5429	GRA	(Marek et al. 2011)
DE-Akm	Anklam	53.8662	13.6834	WET	-
DE-Gri	Grillenburg- grass station	50.9495	13.5125	GRA	(Hussain et al. 2011)
DE-Hai	Hainich	51.0792	10.453	DBF	(Anthoni et al. 2004)
DE-Kli	Klingenberg - cropland	50.8929	13.5225	CRO	(Prescher et al. 2010)

DE-Lkb	Lackenberg	49.0996	13.3047	ENF	(Lindauer et al. 2014)
DE-Obe	Oberbarenburg	50.7836	13.7196	ENF	-
DE-RuS	Selhausen Juelich	50.8657	6.4472	CRO	(Eder et al. 2015)
DE-Spw	Spreewald	51.8923	14.0337	WET	-
DE-Tha	Anchor Station Tharandt - old spruce	50.9636	13.5669	ENF	(Grunwald and Bernhofer 2007)
DE-Zrk	Zarnekow	53.8759	12.889	WET	(Hahn-Schofl et al. 2011)
DK-Eng	Enghave	55.6905	12.1918	GRA	-
DK-NuF	Nuuk Fen	64.1308	-51.3861	WET	(Westergaard-Nielsen et al. 2013)
DK-Sor	Soroe- LilleBogeskov	55.4859	11.6446	DBF	(Pilegaard et al. 2001)
DK-ZaF	Zackenberg Fen	74.4791	-20.5557	WET	-
DK-ZaH	Zackenberg Heath	74.4732	-20.5503	GRA	(Lund et al. 2012)
ES-LgS	Laguna Seca	37.0979	-2.9658	OSH	(Reverter et al. 2010)
ES-LJu	Llano de los Juanes	36.9266	-2.7521	OSH	(Serrano-Ortiz et al. 2007)
ES-Ln2	Lanjaron-Salvage logging	36.9695	-3.4758	OSH	(Serrano-Ortiz et al. 2011)
FI-Hyy	Hyytiala	61.8475	24.295	ENF	(Suni et al. 2003)
FI-Jok	Jokionen agricultural field	60.8986	23.5135	CRO	(Lohila et al. 2004)
FR-Gri	Grignon (after 6/5/2005)	48.8442	1.9519	CRO	(Loubet et al. 2011)
FR-Pue	Puechabon	43.7414	3.5958	EBF	(Lhomme et al. 2001)
GF-Guy	Guyaflux	5.2788	-52.9249	EBF	(Epron et al. 2006)
GH-Ank	Ankasa	5.2685	-2.6942	EBF	-
IT-CA1	Castel d'Asso1	42.3804	12.0266	DBF	(Sabbatini et al. 2016)
IT-CA2	Castel d'Asso2	42.3772	12.026	GRA	(Sabbatini et al. 2016)
IT-CA3	Castel d'Asso 3	42.38	12.0222	DBF	(Sabbatini et al. 2016)
IT-Cp2	Castelporziano2	41.7043	12.3573	EBF	-
IT-Isp	Ispra ABC-IS	45.8126	8.6336	DBF	(Ferrea et al. 2012)
IT-La2	Lavarone2	45.9542	11.2853	ENF	-
IT-Lav	Lavarone (after 3/2002)	45.9562	11.2813	ENF	(Fiora and Cescatti 2006)
IT-Noe	Sardinia/Arca di Noè	40.6061	8.1515	CSH	(Beier et al. 2009)
IT-PT1	Zerbolo-Parco Ticino-Canarazzo	45.2009	9.061	DBF	(Migliavacca et al. 2009)
IT-Ren	Renon/Ritten (Bolzano)	46.5869	11.4337	ENF	(Marcolla et al. 2005)
IT-Ro1	Roccarespampani 1	42.4081	11.93	DBF	(Rey et al. 2002)
IT-Ro2	Roccarespampani 2	42.3903	11.9209	DBF	(Tedeschi et al. 2006)

IT-SRo	San Rossore	43.7279	10.2844	ENF	(Chiesi et al. 2005)
IT-Tor	Torgnon	45.8444	7.5781	GRA	(Galvagno et al. 2013)
JP-MBF	Moshiri Birch Forest Site	44.3869	142.3186	DBF	-
JP-SMF	Seto Mixed Forest Site	35.2617	137.0788	MF	-
MY-PSO	Pasoh Forest Reserve (PSO)	2.973	102.3062	EBF	-
NL-Hor	Horstermeer	52.2404	5.0713	GRA	-
NL-Loo	Loobos	52.1666	5.7436	ENF	(Dolman et al. 2002)
NO-Adv	Adventdalen	78.186	15.923	WET	-
PA-SPn	Sardinilla Plantation	9.3181	-79.6346	DBF	(Wolf et al. 2011)
PA-SPs	Sardinilla Pasture	9.3138	-79.6314	GRA	(Wolf et al. 2011)
RU-Che	Cherskii	68.613	161.3414	WET	(Corradi et al. 2005)
RU-Cok	Chokurdakh	70.8291	147.4943	OSH	(van Huissteden et al. 2005)
RU-Fyo	Fyodorovskoye wet spruce stand	56.4615	32.9221	ENF	(Kurbatova et al. 2008)
RU-Ha1	Ubs Nur-Hakasija-grassland	54.7252	90.0022	GRA	-
RU-Sam	Samoylov Island- Lena Delta	72.3738	126.4958	GRA	(Kutzbach et al. 2007)
RU-SkP	Spasskaya Pad larch	62.255	129.168	DNF	-
RU-Vrk	Seida/Vorkuta	67.0547	62.9405	CSH	-
SD-Dem	Demokeya	13.2829	30.4783	SAV	(Ardö et al. 2008)
SE-St1	Stordalen Forest-Mountain Birch	68.3542	19.0503	WET	-
US-AR1	ARM USDA UNL OSU Woodward Switchgrass 1	36.4267	-99.42	GRA	-
US-AR2	ARM USDA UNL OSU Woodward Switchgrass 2	36.6358	-99.5975	GRA	-
US-ARM	ARM Southern Great Plains site- Lamont	36.6058	-97.4888	CRO	(Fischer et al. 2007)
US-Blo	Blodgett Forest	38.8953	-120.633	ENF	(Misson et al. 2005)
US-CRT	Curtice Walter-Berger cropland	41.6285	-83.3471	CRO	(Chu et al. 2014)
US-Goo	Goodwin Creek	34.2547	-89.8735	GRA	-
US-Ha1	Harvard Forest EMS Tower (HFR1)	42.5378	-72.1715	DBF	(Goulden et al. 1996)
US-IB2	Fermi National Accelerator Laboratory- Batavia (Prairie site)	41.8406	-88.241	GRA	(Matamala et al. 2008)
US-Ivo	Ivotuk	68.4865	-155.75	WET	(Epstein et al. 2004)
US-Lin	Lindcove Orange Orchard	36.3566	-119.842	CRO	
US-Los	Lost Creek	46.0827	-89.9792	WET	(Sulman et al. 2009)
US-Me6	Metolius Young Pine Burn	44.3233	-121.608	ENF	(Ruehr et al. 2012)
US-MMS	Morgan Monroe State Forest	39.3232	-86.4131	DBF	(Schmid et al. 2000)
US-Myb	Mayberry Wetland	38.0498	-121.765	WET	-
US-Ne1	Mead-irrigated continuous maize site	41.1651	-96.4766	CRO	(Suyker et al. 2005)
US-Ne2	Mead-irrigated maize-soybean	41.1649	-96.4701	CRO	(Suyker et al. 2005)

	rotation site				
US-Ne3	Mead-rainfed maize-soybean rotation site	41.1797	-96.4397	CRO	(Suyker et al. 2004)
US-Oho	Oak Openings	41.5545	-83.8438	DBF	(Noormets et al. 2008)
US-SRM	Santa Rita Mesquite	31.8214	-110.866	WSA	(Scott et al. 2009)
US-Syv	Sylvania Wilderness Area	46.242	-89.3477	MF	(Desai et al. 2005)
US-Ton	Tonzi Ranch	38.4316	-120.966	WSA	(Xu et al. 2004)
US-Tw3	Twitchell Alfalfa	38.1159	-121.647	CRO	-
US-UMd	UMBS Disturbance	45.5625	-84.6975	DBF	(Nave et al. 2011)
US-Var	Vaira Ranch-Ione	38.4133	-120.951	GRA	(Ma et al. 2007)
US-WCr	Willow Creek	45.8059	-90.0799	DBF	(Cook et al. 2004)
US-Whs	Walnut Gulch Lucky Hills Shrub	31.7438	-110.052	OSH	(Scott et al. 2006)
US-Wkg	Walnut Gulch Kendall Grasslands	31.7365	-109.942	GRA	(Scott et al. 2010)
US-WPT	Winous Point North Marsh	41.4646	-82.9962	WET	(Chu et al. 2014)
ZA-Kru	Skukuza- Kruger National Park	-25.0197	31.4969	SAV	(Williams et al. 2009)
ZM-Mon	Mongu	-15.4378	23.2528	DBF	(Merbold et al. 2011)

ENF: evergreen needleleaf forest; EBF: evergreen broadleaf forest; DNF: deciduous needleleaf forest; DBF: deciduous broadleaf forest; MF: mixed forest; OSH: open shrubland; CSH: closed shrubland; SAV: savannas; WSA: woody savannas; GRA: grassland; CRO: cropland; WET: wetland.

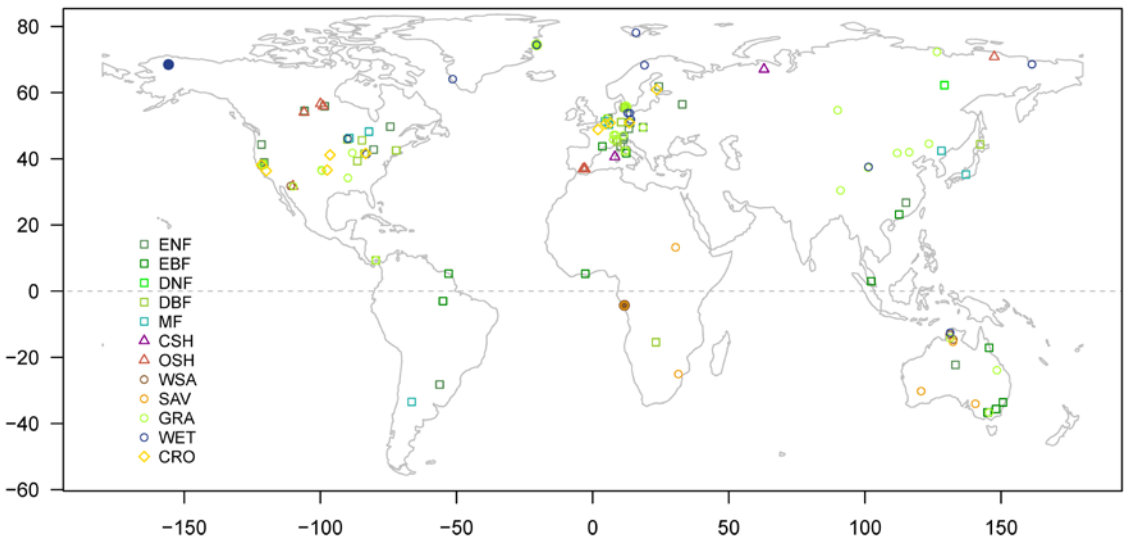

Figure S1. The spatial distribution of the 136 flux tower sites used in this study. The filled symbols indicate the five sites used for the SCOPE simulation.

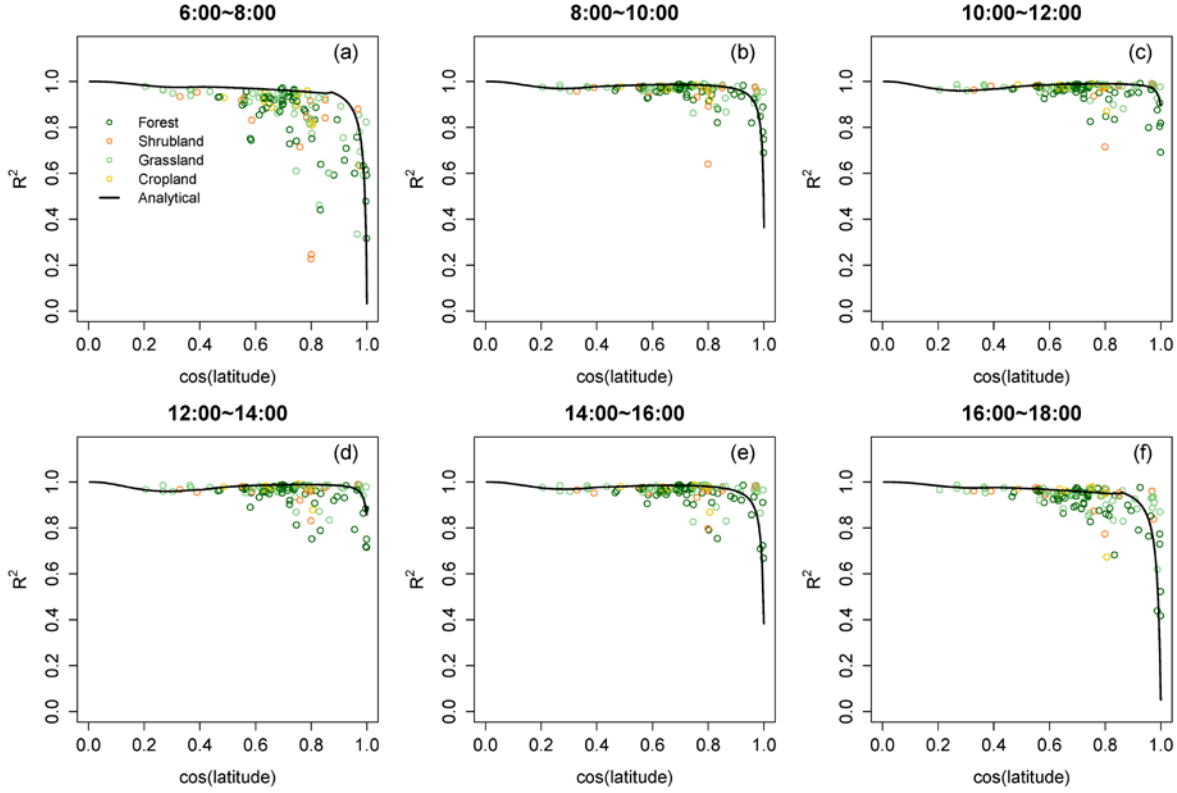

Figure S2. The coefficient of determination (R^2) for the correlation between instantaneous and daily GPP estimates from flux tower. The black line represents the predicted R^2 using the incoming solar radiation calculated from the analytical method.

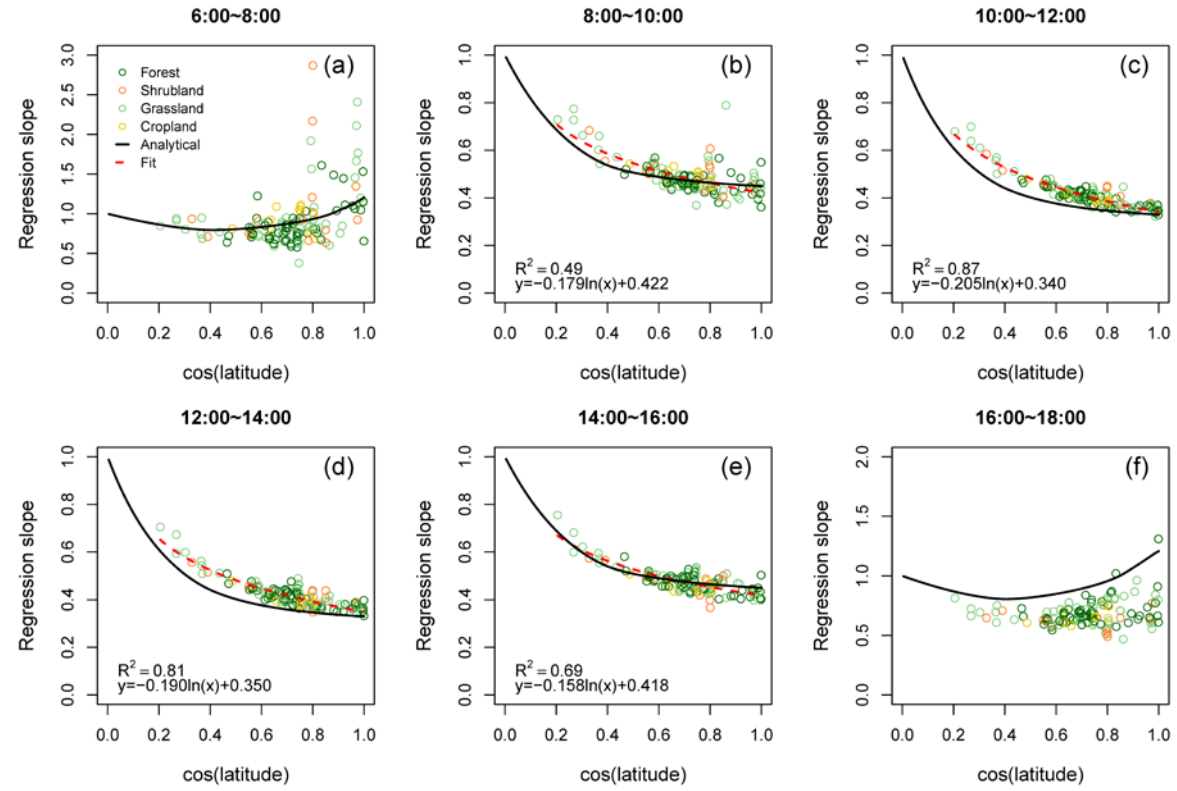

Figure S3. Latitudinal distribution of regression slopes between daily and instantaneous GPP (γ_{GPP}). GPP

partitioned by the daytime method were used.

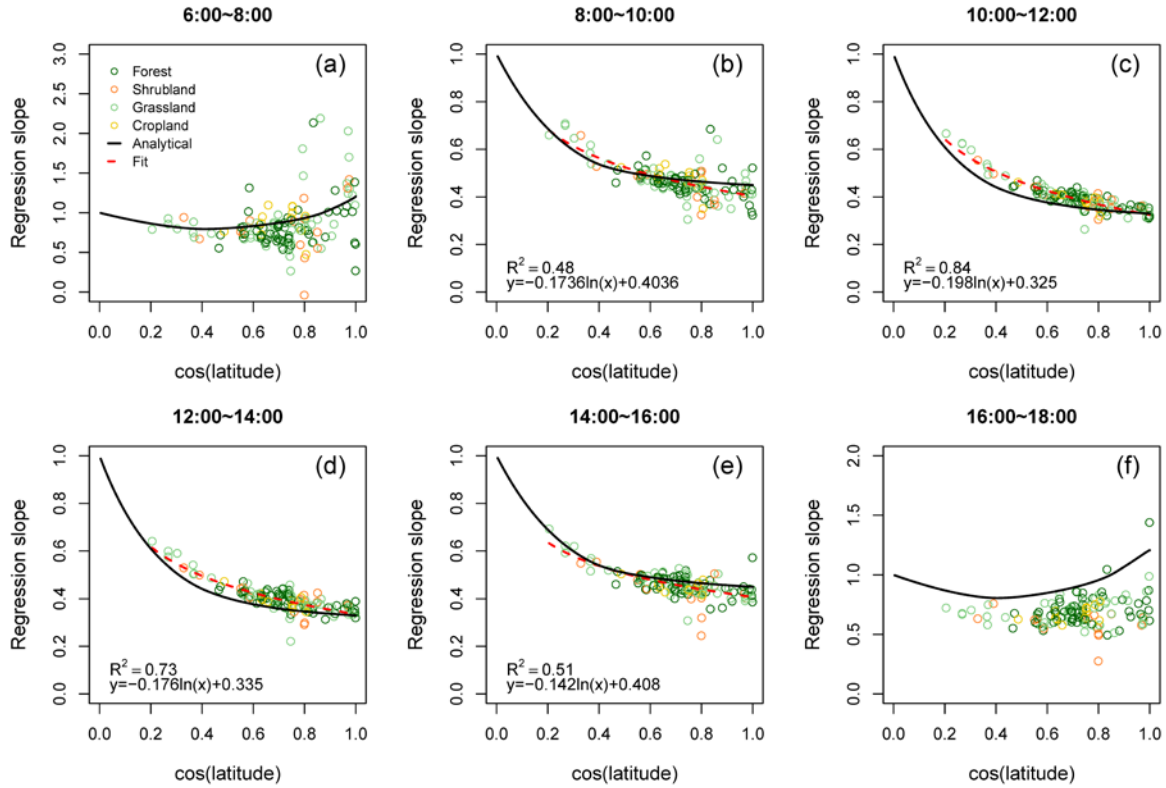

Figure S4. Latitudinal distribution of regression slopes between daily and instantaneous GPP (γ_{GPP}). GPP partitioned by the nighttime method were used.

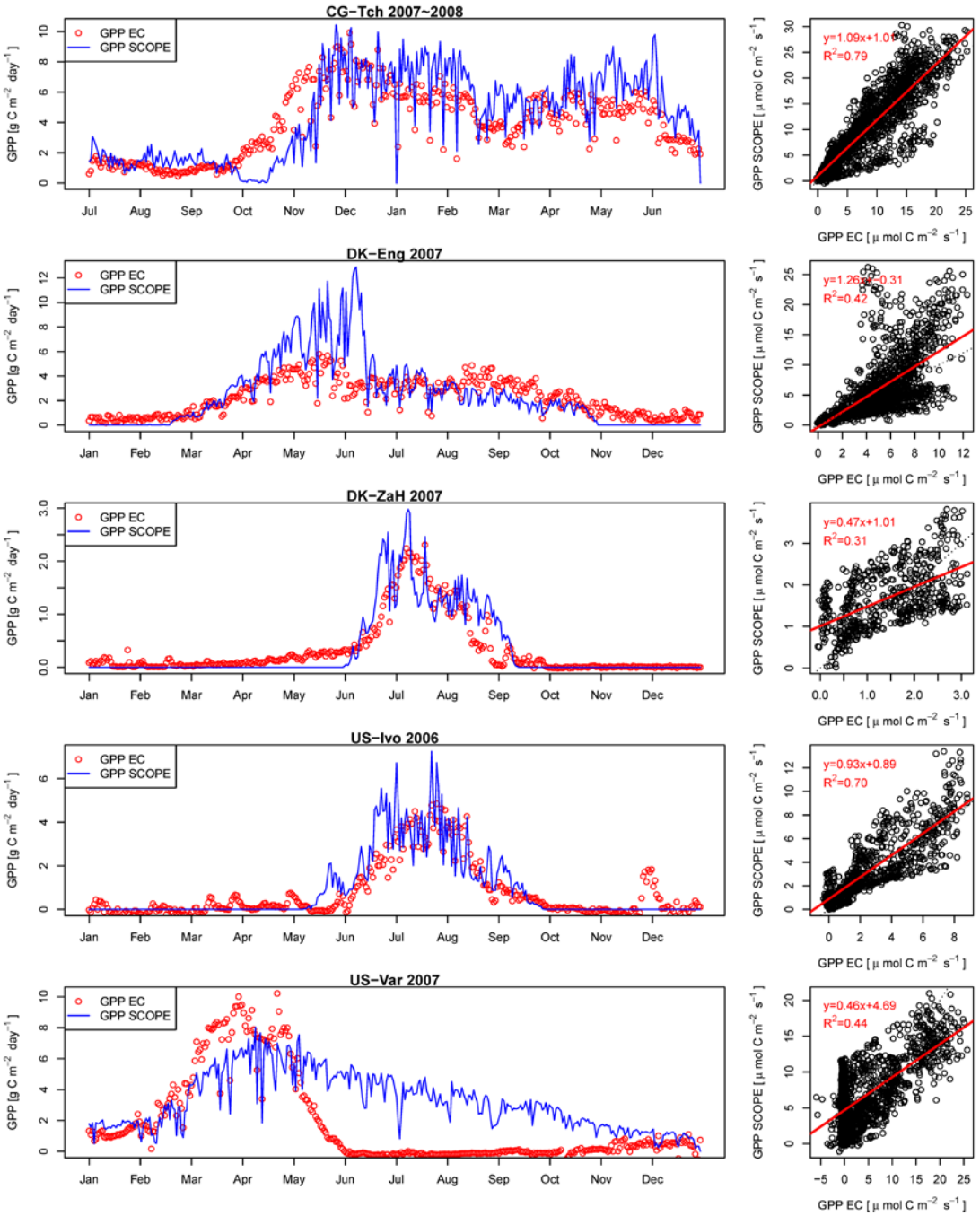

Figure S5. Comparison between the SCOPE simulated GPP and eddy covariance flux tower derived GPP. The left column shows the seasonal variations in the daily aggregated GPP value. The right column compares the raw GPP data at half-hour scale from EC and SCOPE. The big difference between GPP EC and GPP SCOPE for US-Var is caused by pixel mixture: within the MODIS LAI footprint (5 km), some evergreen trees contributed to the satellite signal while the EC tower only measures the GPP of the seasonal grassland.

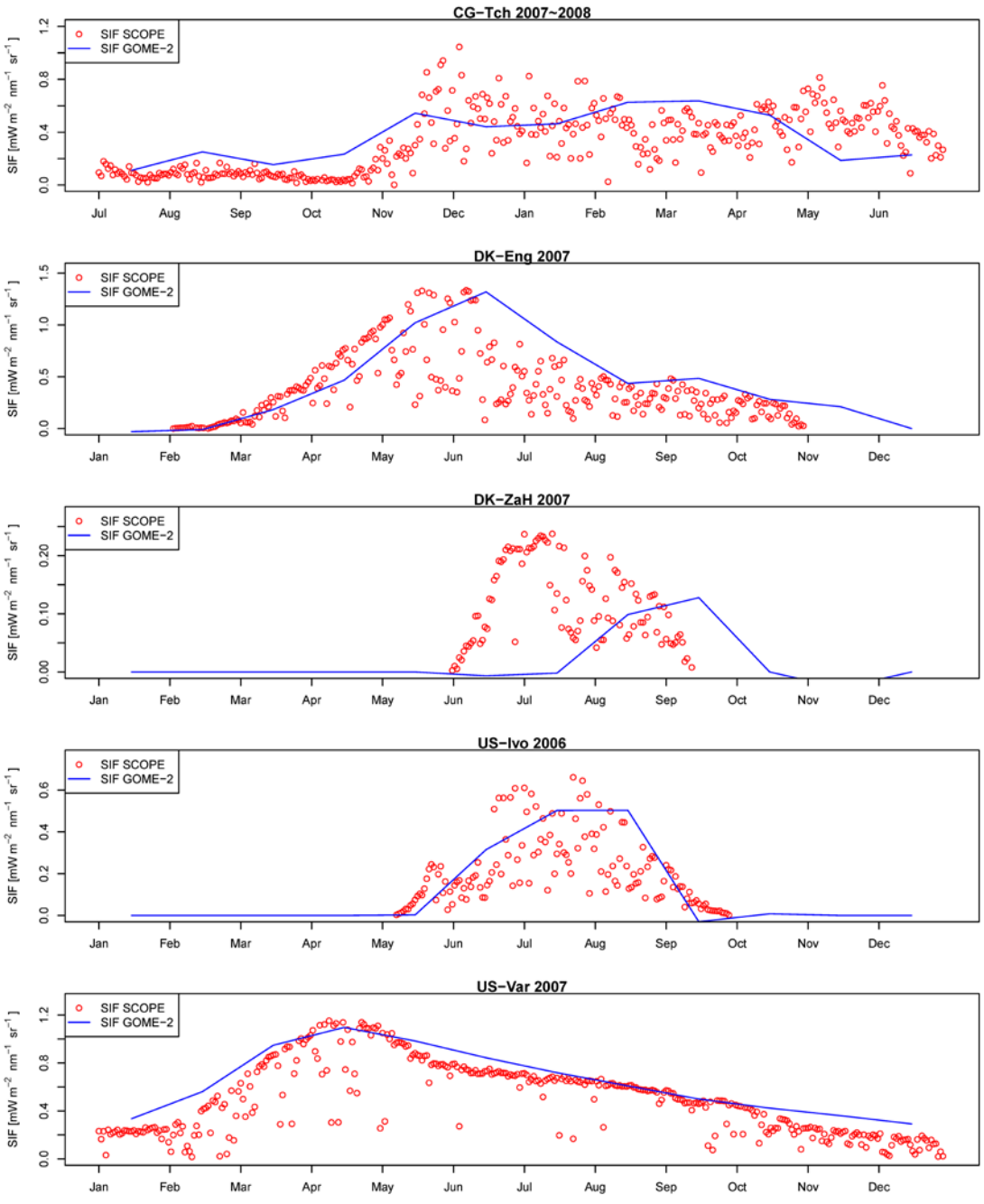

Figure S6. Comparison between the SIF simulated from the SCOPE model and from the GOME-2 satellite. SCOPE SIF simulation at 9:30 am solar time is used to compare with GOME-2 v26 SIF monthly data. The GOME-2 data are averaged over the period 2007-2015 to reduce uncertainty. The large discrepancy for DK-ZaH site is caused by the relative location of the EC flux tower footprint within the satellite gridcell: most of the area in this gridcell is either all-year snow covered mountain peaks or ocean. For other sites, the model simulation and satellite observation are similar.

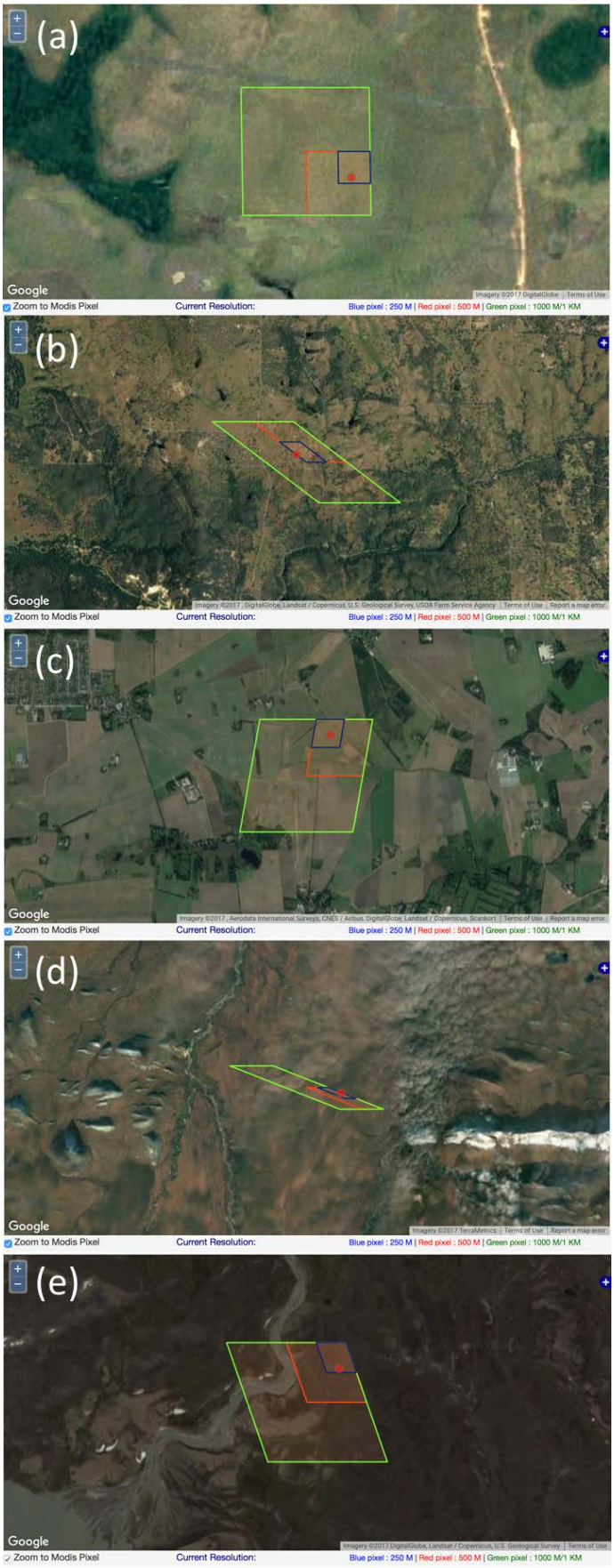

Figure S7. Location of site (a) CG-Tch, (b) US-Var, (c) DK-Eng, (d) US-Ivo, (e) DK-ZaH with a

background of google map. The parallelograms in blue, red, and green color correspond to 250, 500, and 1000 m size MODIS pixels. The red dot is the flux tower location.

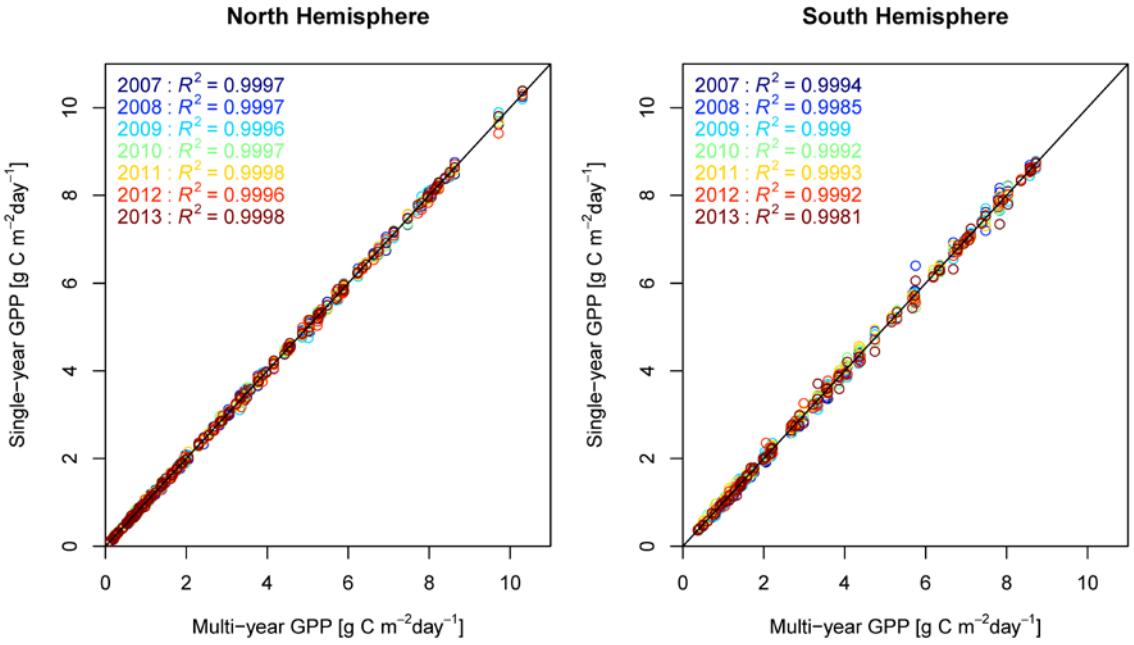

Figure S8. A comparison between average GPP between 2007-2013 with GPP from each individual year. Each point represents an average GPP of one biome type for each month. Different color represents GPP from different years.

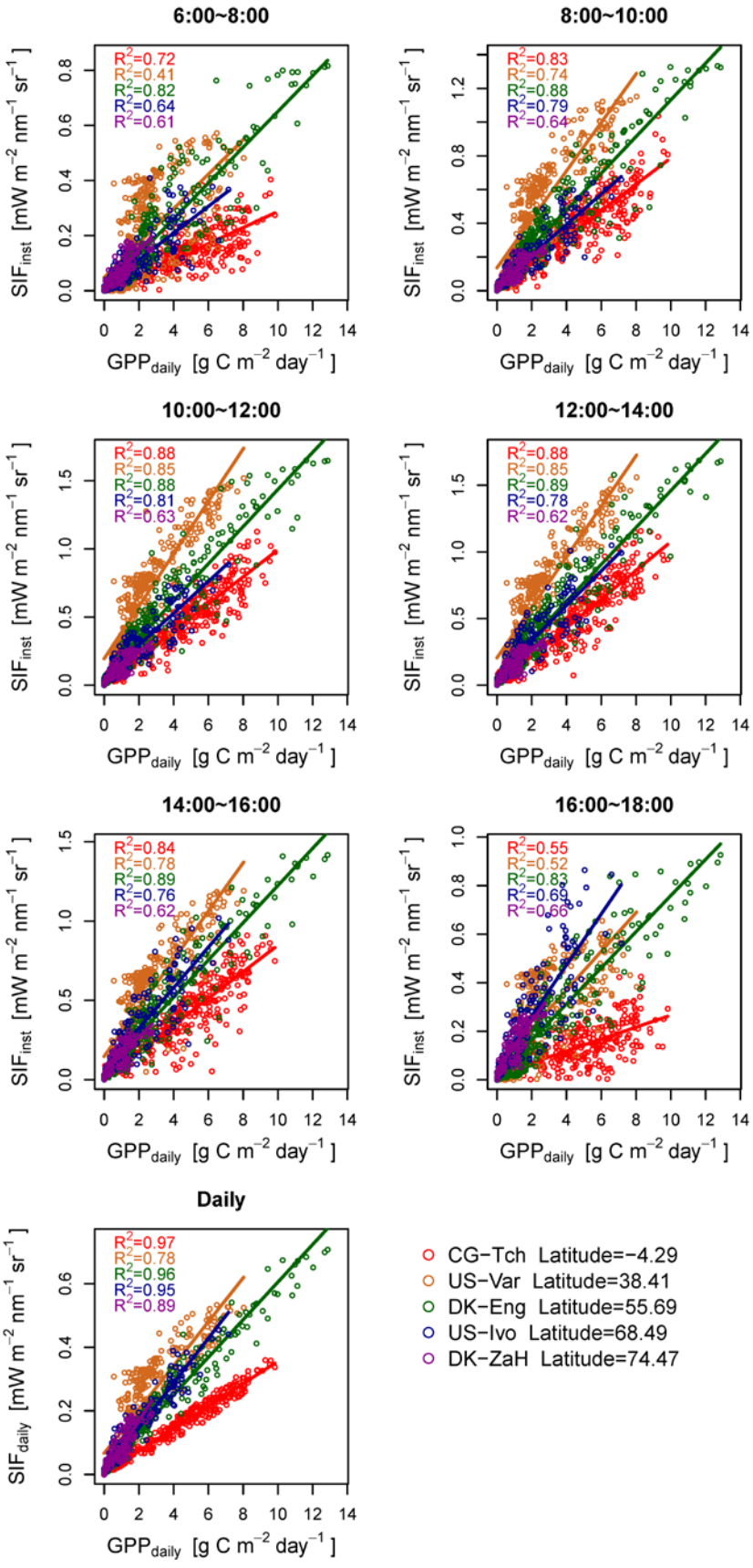
6:00~8:00
8:00~10:00
10:00~12:00
12:00~14:00
14:00~16:00
16:00~18:00
Daily
SIF_inst [mW m^-2 nm^-1 sr^-1]
SIF_daily [mW m^-2 nm^-1 sr^-1]
GPP_daily [g C m^-2 day^-1]
R2=0.72 R2=0.41 R2=0.82 R2=0.64 R2=0.61
R2=0.83 R2=0.74 R2=0.88 R2=0.79 R2=0.64
R2=0.88 R2=0.85 R2=0.88 R2=0.81 R2=0.63
R2=0.88 R2=0.85 R2=0.89 R2=0.78 R2=0.62
R2=0.84 R2=0.78 R2=0.89 R2=0.76 R2=0.62
R2=0.55 R2=0.52 R2=0.83 R2=0.69 R2=0.66
R2=0.97 R2=0.78 R2=0.96 R2=0.95 R2=0.89
CG−Tch Latitude=−4.29
US−Var Latitude=38.41
DK−Eng Latitude=55.69
US−Ivo Latitude=68.49
DK−ZaH Latitude=74.47

Figure S9. Similar with Figure 8, but using a variable Vcmax value based on its linear relationship with Cab ($V_{cmax} = \frac{Cab - \min(Cab)}{\max(Cab) - \min(Cab)} \times 0.5 \times V_{cmax,0} + 0.5 \times V_{cmax,0}$). $V_{cmax,0}$ is the fixed value used in the Figure 8 (52 for C3 grass and 30 for C4 grass).

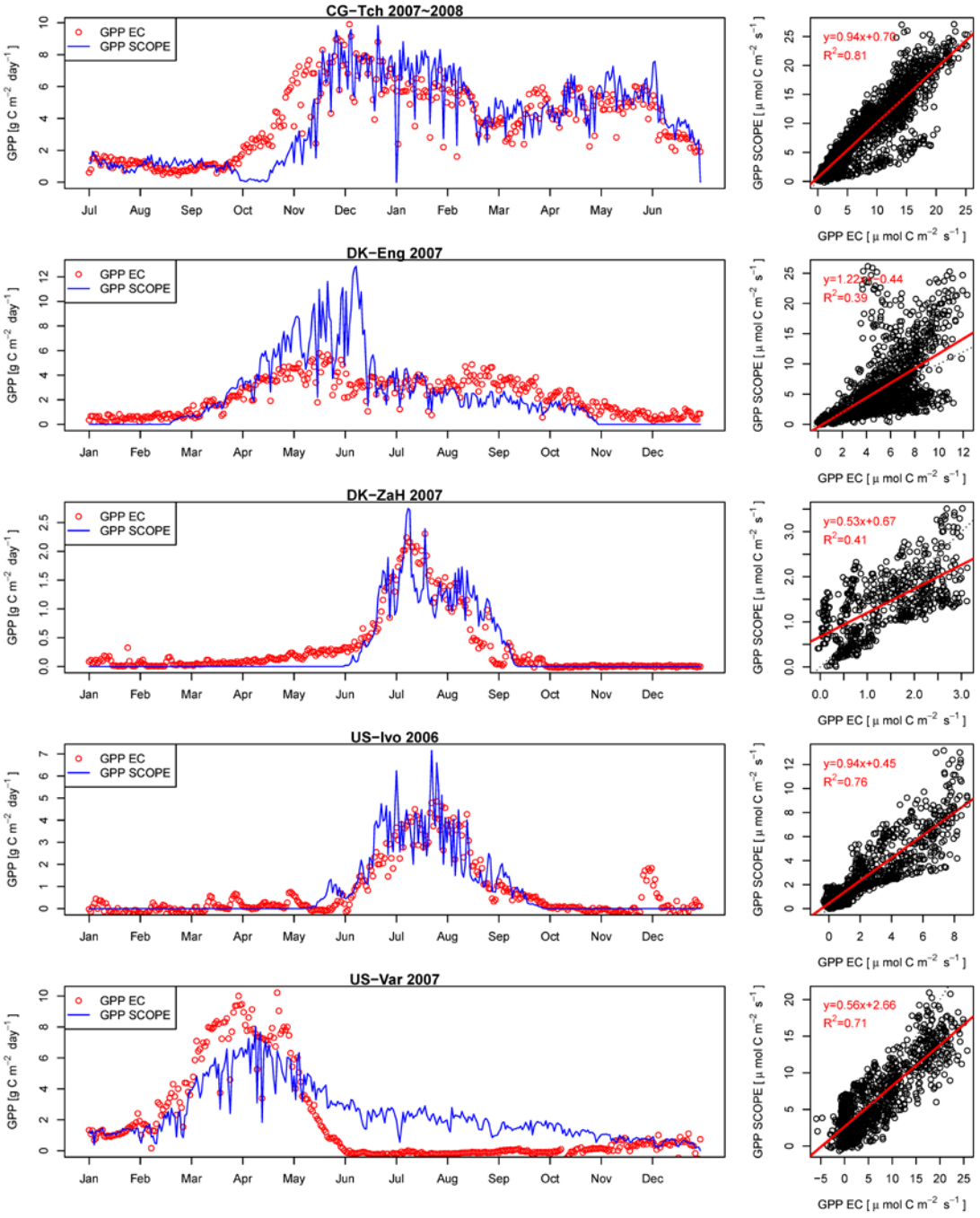

Figure S10. Same as Figure S5, but using a variable V_{cmax} value.

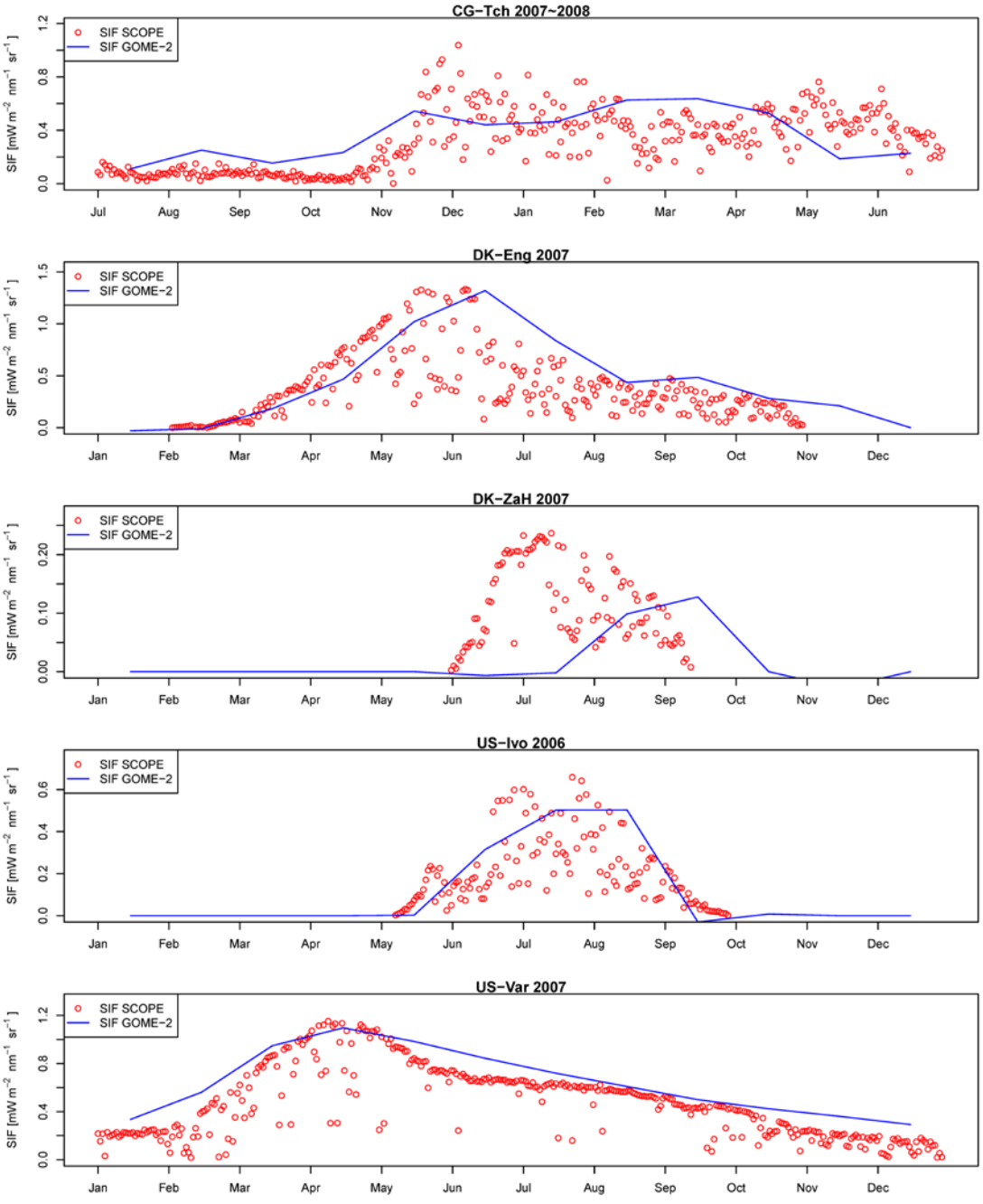

Figure S11. Same as Figure S6, but using a variable V_{cmax} value.

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