

# Supplementary Information: Global patterns of forest autotrophic carbon fluxes

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Table S1. Climate variable definitions, sources, and abbreviations

Abbreviation	Climate variable	Units	Definition	Time span	Source
MAT	Mean annual temperature	°C	Annual mean temperature, from primary literature or WorldClim if not reported	NA	Primary literature; WorldClim <sup>1</sup>
MAP	Mean annual precipitation	mm $yr^{-1}$	Annual mean precipitation, from primary literature or WorldClim if not reported	NA	Primary literature; WorldClim <sup>1</sup>
T Seas	Temperature seasonality	°C x 100	Standard deviation (variation) of monthly temperature averages	NA	WorldClim <sup>1</sup>
P Seas	Precipitation seasonality	%	Coefficient of variation of mean monthly precipitation x 100	NA	WorldClim <sup>1</sup>
ART	Annual temperature range	°C	Maximum temperature of warmest month - minimum temperature of coldest month	NA	WorldClim <sup>1</sup>
Solar R	Solar radiation	$\text{kJ } m^{-2} yr^{-1}$	Solar radiation	NA	WorldClim <sup>2</sup>
Cloud	Cloud cover	%	Cloud percentage cover	NA	CRU time-series dataset v 4.03 <sup>3</sup>
AFD	Annual frost days	days $yr^{-1}$	Number of freeze days annually	NA	CRU time-series dataset v 4.03 <sup>3</sup>
AWD	Annual wet days	days $yr^{-1}$	Number of days with precipitation >0.1 mm annually	NA	CRU time-series dataset v 4.03 <sup>3</sup>
PET	Potential evapotranspiration	mm $yr^{-1}$	Mean annual potential evapotranspiration	NA	Global Aridity Index and Potential Evapotranspiration Climate Database <sup>4</sup>
AI	Aridity		MAP/mean annual PET	NA	Global Aridity Index and Potential Evapotranspiration Climate Database <sup>4</sup>
VPD	Vapour pressure deficit	kPa	Vapour pressure deficit	NA	TerraClimate <sup>5</sup>
Max VPD	Maximum vapour pressure deficit	kPa	Maximum vapour pressure deficit	NA	Derived
WSM	Water stress months	months $yr^{-1}$	Number of months annually with MAP < PET	NA	Derived
LGS	Length of growing season	months $yr^{-1}$	Number of months annually with mean minimum temperature > 0.5°C	NA	Derived
gsT	growing season temperature	°C		NA	Derived
gsP	growing season precipitation			NA	Derived
gsPET	growing season PET			NA	Derived
gsR	growing season solar radiation			NA	Derived

<sup>1</sup> Hijmans et al. (2005) <sup>2</sup> Fick et al. (2017) <sup>3</sup> Harris et al. (2017) <sup>4</sup> Trabucco and Zomer (2019) <sup>5</sup> Abatzoglou et al. (2018)

Table S2. Model form, delta AIC, and R2 for each climate variables as a single fixed effect in models for each C flux. Model forms include first-order linear (Lin), second-order polynomial (Poly), and logarithmic (Log).

Carbon flux	Latitude		MAT		MAP		T Seas		P Seas		ATR		Solar R		AI	
	Model	R-squared	Model	R-squared	Model	R-squared	Model	R-squared	Model	R-squared	Model	R-squared	Model	R-squared	Model	R-squared
GPP	Linear	0.6387	Linear	0.6094	Linear	0.1764	Polynomial	0.7076	-	-	Polynomial	0.6879	Linear	0.1554	-	-
NPP	Linear	0.5108	Linear	0.4171	Polynomial	0.2138	Polynomial	0.4905	-	-	Polynomial	0.4798	Polynomial	0.1634	Linear	0.03795
ANPP	Linear	0.4351	Linear	0.4444	Polynomial	0.1625	Polynomial	0.4126	-	-	Polynomial	0.3740	Linear	0.1061	Linear	0.04851
ANPP woody stem	Linear	0.1773	Linear	0.2396	-	-	Linear	0.1416	Polynomial	0.0538	Linear	0.1157	Linear	0.05048	Linear	0.06607
ANPP foliage	Linear	0.4999	Linear	0.5826	Polynomial	0.2509	Linear	0.4823	-	-	Linear	0.5033	Linear	0.172	Linear	0.1084
BNPP root	Linear	0.3373	Linear	0.2833	Polynomial	0.1452	Linear	0.3300	-	-	Polynomial	0.3185	Polynomial	0.2886	-	-
BNPP fine root	Linear	0.1704	Linear	0.1477	Linear	0.08935	Linear	0.1721	-	-	Linear	0.1790	Linear	0.1393	-	-
Autotrophic respiration	Linear	0.6534	Linear	0.5909	Polynomial	0.604	Linear	0.4873	-	-	Linear	0.4900	Linear	0.26	Polynomial	0.4804
Root respiration	Linear	0.2612	Linear	0.2418	Linear	0.1493	Linear	0.1510	-	-	Polynomial	0.2371	-	-	Linear	0.1567

Carbon flux	Cloud		AFD		AWD		PET		VPD		Max VPD		WSM		LGS	
	Model	R-squared	Model	R-squared	Model	R-squared	Model	R-squared	Model	R-squared	Model	R-squared	Model	R-squared	Model	R-squared
GPP	-	-	Linear	0.5498	Linear	0.11	Polynomial	0.3602	Polynomial	0.3076	-	-	-	-	Linear	0.5312
NPP	Linear	0.0634	Linear	0.4036	Linear	0.1118	Polynomial	0.3165	Polynomial	0.178	-	-	Linear	0.03561	Linear	0.3782
ANPP	Polynomial	0.0906	Linear	0.3668	Linear	0.1732	Polynomial	0.2672	Polynomial	0.2294	Polynomial	0.0632	Polynomial	0.06269	Linear	0.3425
ANPP woody stem	Polynomial	0.0904	Linear	0.1380	-	-	Polynomial	0.2024	Polynomial	0.2146	Linear	0.07403	-	-	Linear	0.1041
ANPP foliage	-	-	Linear	0.5306	Linear	0.1469	Linear	0.3076	Polynomial	0.3751	Polynomial	0.07489	Polynomial	0.1724	Linear	0.4552
BNPP root	-	-	Linear	0.2799	Polynomial	0.1113	Polynomial	0.3601	Polynomial	0.2584	-	-	-	-	Linear	0.2550
BNPP fine root	-	-	Linear	0.1631	Linear	0.08161	Linear	0.1376	-	-	-	-	-	-	Linear	0.1335
Autotrophic respiration	-	-	Linear	0.5502	Linear	0.226	Linear	0.3298	Linear	0.2807	-	-	Linear	0.2613	Linear	0.4664
Root respiration	Linear	0.1578	Linear	0.1647	Linear	0.1698	Polynomial	0.1905	Polynomial	0.272	-	-	Linear	0.1388	Linear	0.1889

Table S3. Joint effects of MAT and MAP on forest C fluxes

Carbon flux	Significant interactive effect	Significant additive effect	Significant effect of MAT	p-value	R-squared value
GPP	FALSE	TRUE	TRUE	<0.0001	0.66
NPP	TRUE	TRUE	TRUE	0.018	0.48
ANPP	FALSE	TRUE	TRUE	0.0349	0.45
ANPP woody stem	TRUE	TRUE	TRUE	0.021	0.26
ANPP foliage	FALSE	FALSE	TRUE	<0.0001	0.59
BNPP root	FALSE	FALSE	TRUE	<0.0001	0.29
BNPP fine root	FALSE	FALSE	TRUE	0.002	0.15
Autotrophic respiration	FALSE	TRUE	TRUE	0.041	0.71
Root respiration	FALSE	FALSE	TRUE	0.001	0.25

Table S4. Comparison of growing season length and MAT as predictors of forest C fluxes

Fixed effect	AIC value	Delta AICc	Marginal R squared
<b>GPP</b>			
MAT	126.42617	0.000000	0.6196780
Growing season length	140.80589	14.379717	0.5411935
None	178.96179	52.535617	0.0000000
<b>NPP</b>			
MAT	174.88249	0.000000	0.5156614
Growing season length	191.53714	16.654650	0.4006999
None	216.16976	41.287265	0.0000000
<b>ANPP</b>			
MAT	249.50512	0.000000	0.2925950
Growing season length	254.20763	4.702509	0.2612187
None	268.94008	19.434966	0.0000000
<b>ANPP woody stem</b>			
MAT	235.95797	0.000000	0.1548800
Growing season length	237.28992	1.331943	0.1370243
None	243.13700	7.179027	0.0000000
<b>ANPP foliage</b>			
MAT	484.87610	0.000000	0.4462629
Growing season length	520.96482	36.088722	0.3497750
None	560.34915	75.473049	0.0000000
<b>BNPP root</b>			
MAT	184.54480	0.000000	0.5921282
Growing season length	204.92685	20.382054	0.4644116
None	237.46554	52.920743	0.0000000
<b>BNPP fine root</b>			
MAT	540.19217	0.000000	0.2429540
Growing season length	566.36955	26.177388	0.1060029
None	578.65529	38.463119	0.0000000
<b>Autotrophic respiration</b>			
MAT	45.25818	0.000000	0.6271133
Growing season length	50.35515	5.096972	0.5041004
None	56.16877	10.910597	0.0000000
<b>Root respiration</b>			
MAT	133.53500	0.000000	0.2507631
Growing season length	135.92632	2.391311	0.1990489
None	141.78719	8.252190	0.0000000

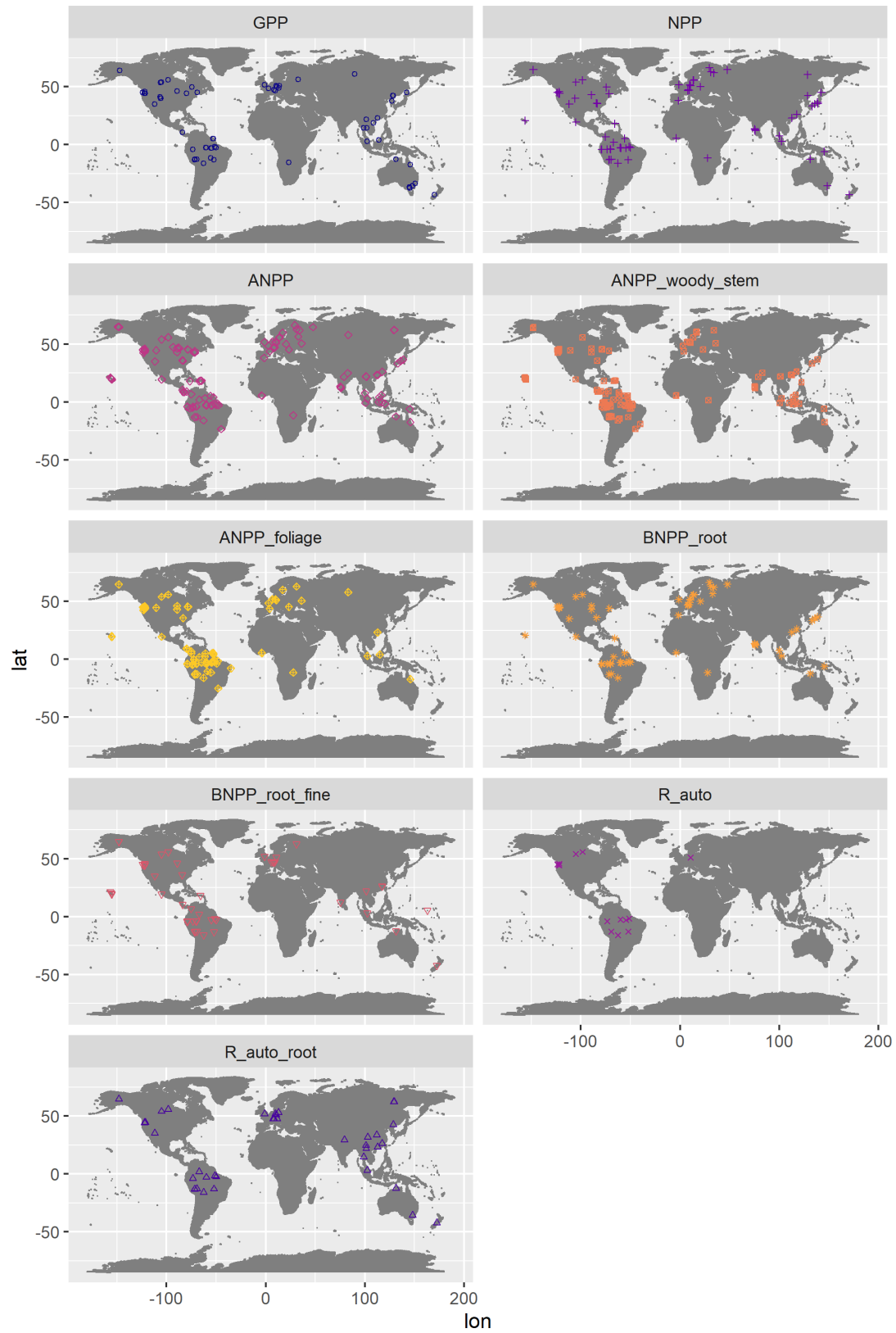


Figure S1: Maps showing distribution of samples for the nine forest C fluxes analyzed here

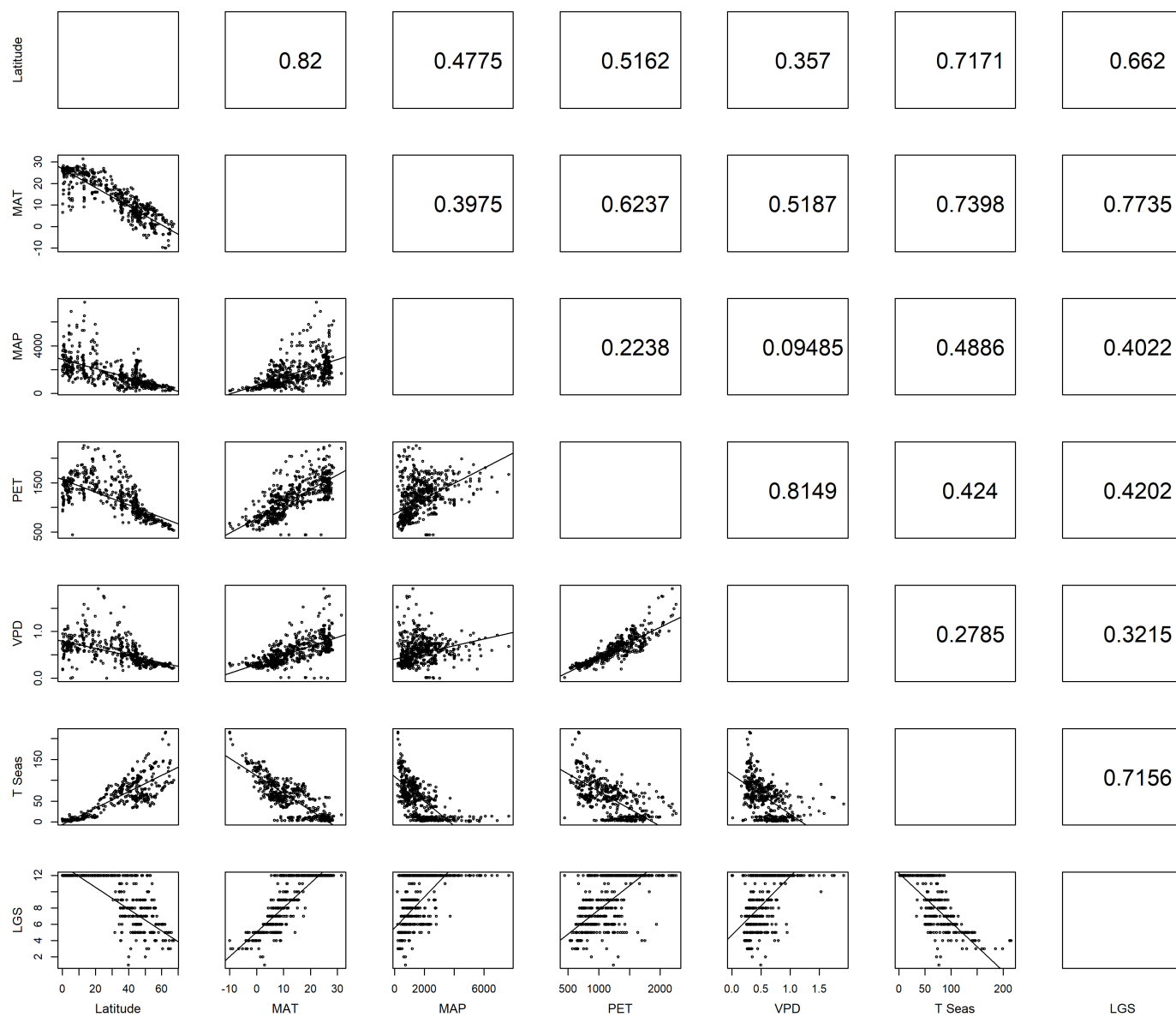


Figure S2: Correlations among latitude and climate variables

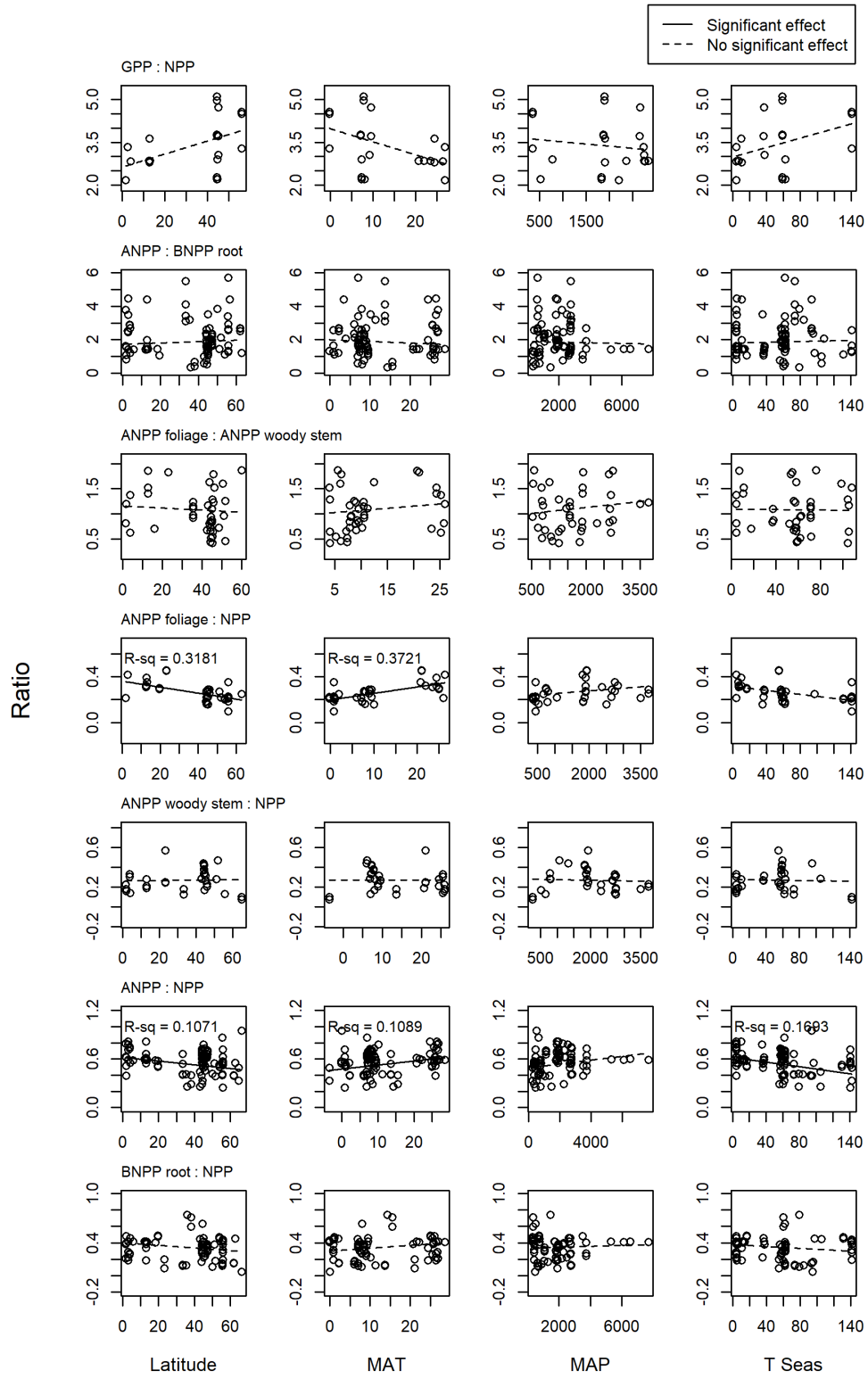


Figure S3: Ratios among forest C fluxes as a function of latitude and climate variables



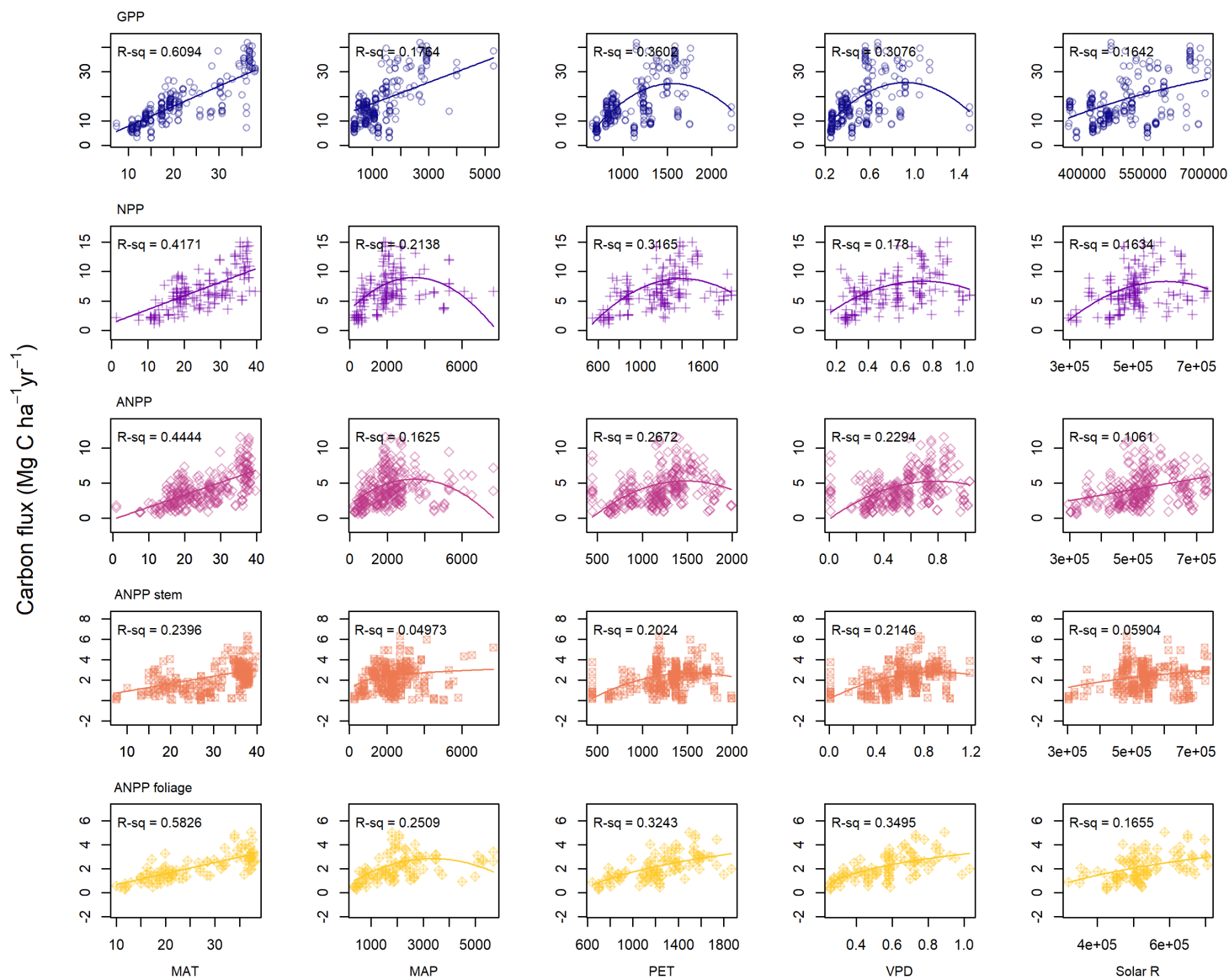


Figure S4: Individual plots of forest C fluxes in relation to mean annual climate, part 1.

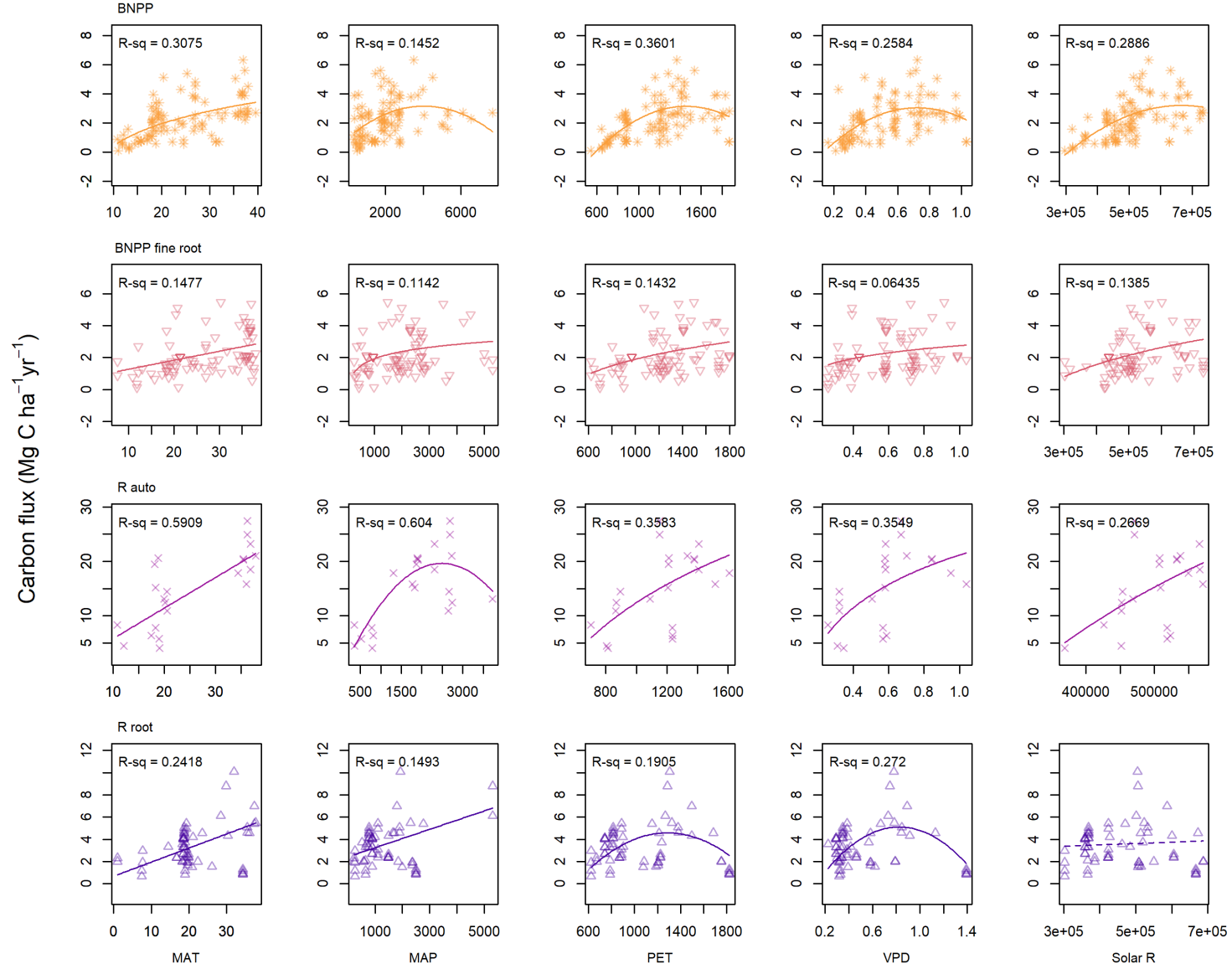


Figure S5: Individual plots of forest C fluxes in relation to mean annual climate, part 2.

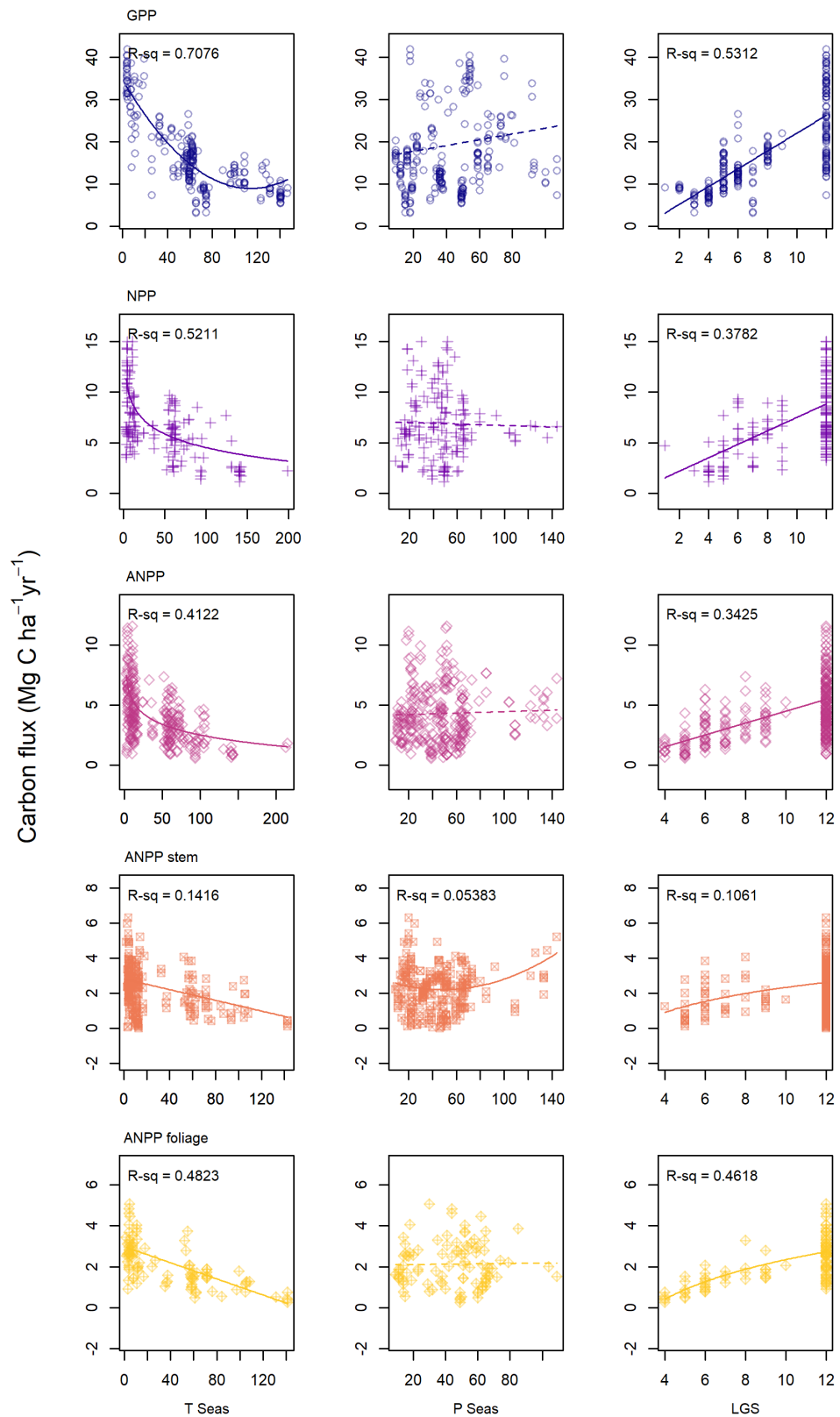


Figure S6: Individual plots of forest C fluxes in relation to mean climate seasonality, part 1.

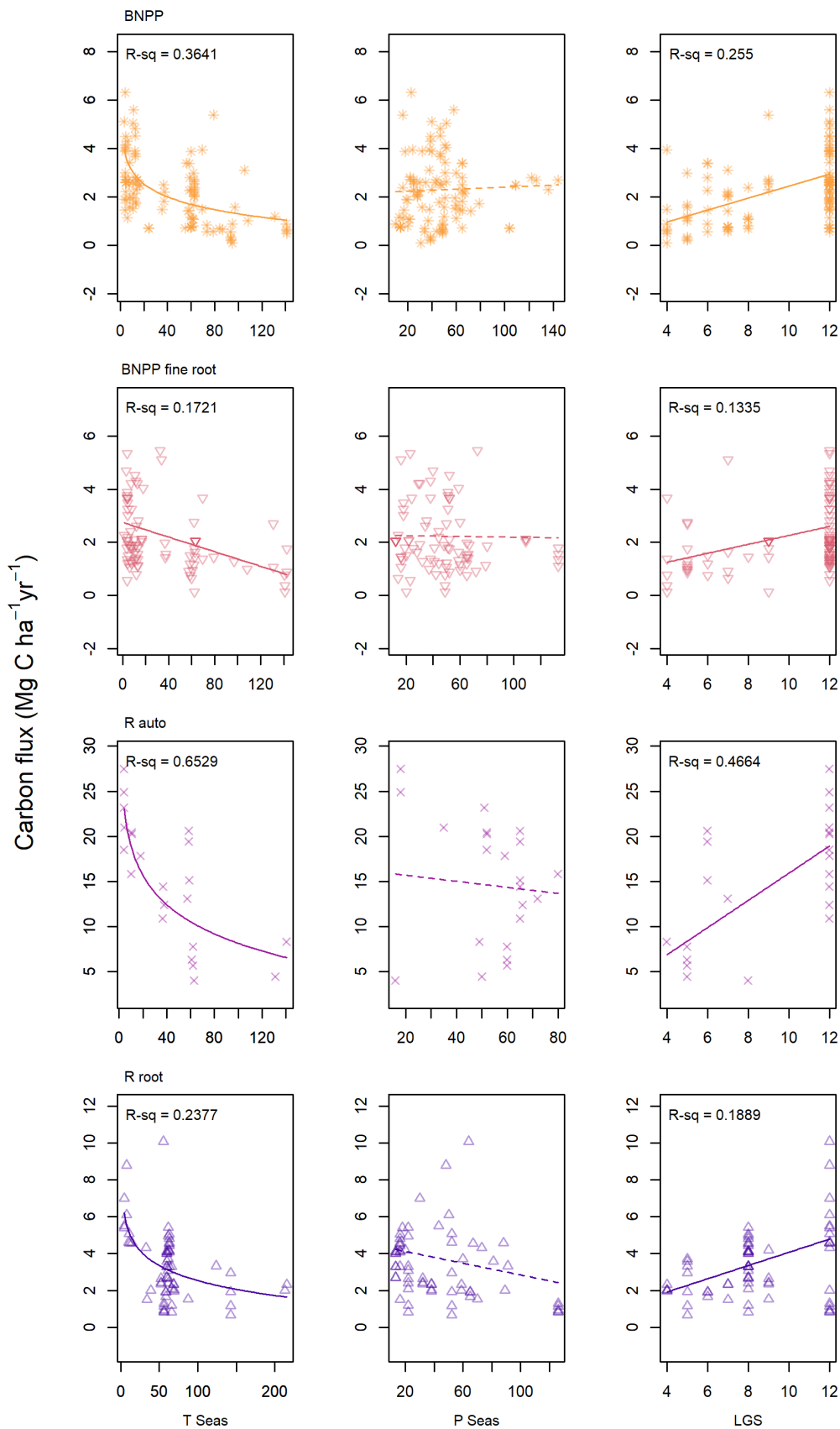


Figure S7: Individual plots of forest C fluxes in relation to mean climate seasonality, part 2.

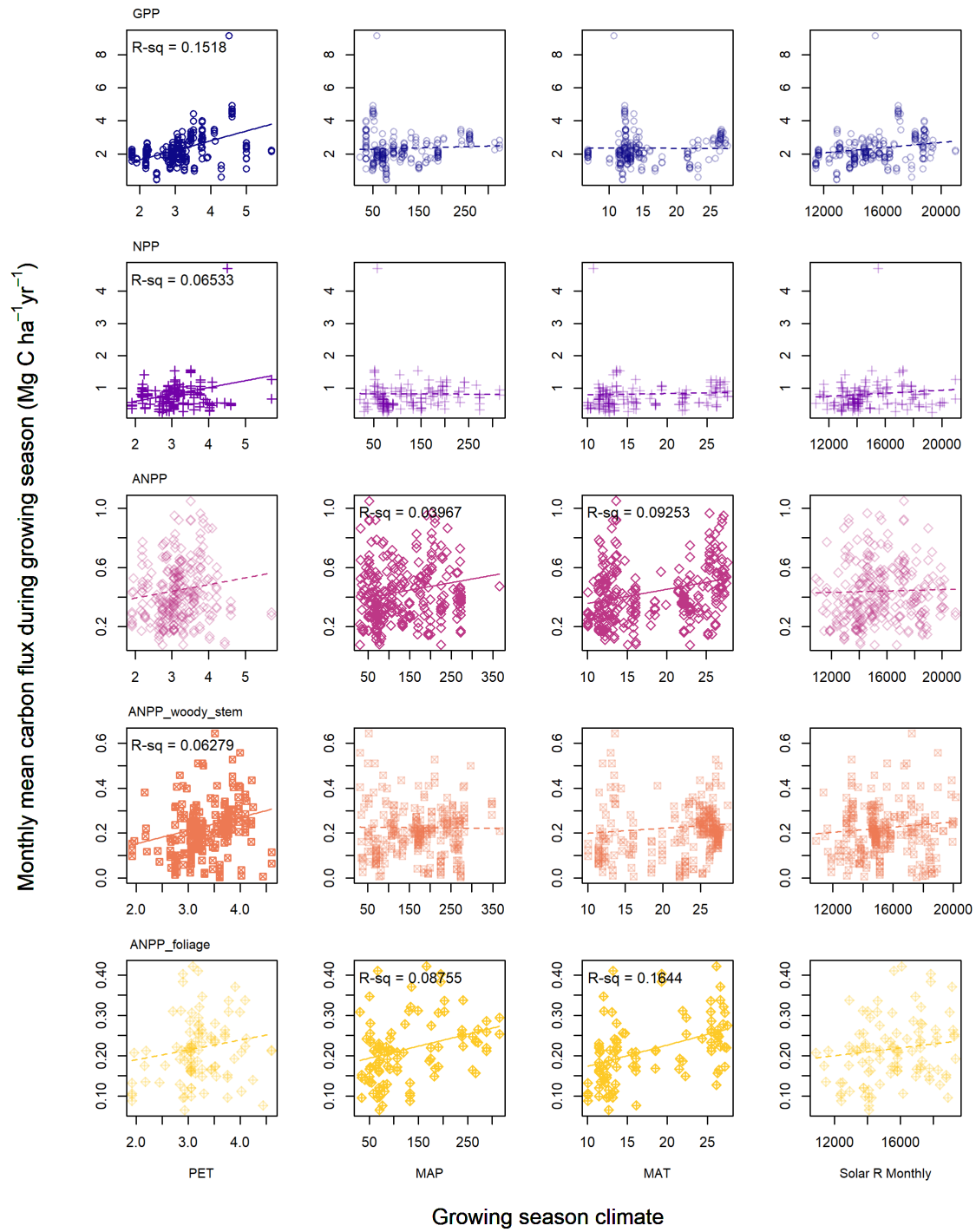


Figure S8: Growing season length-standardized forest C fluxes in relation to mean growing season climate, part 1.

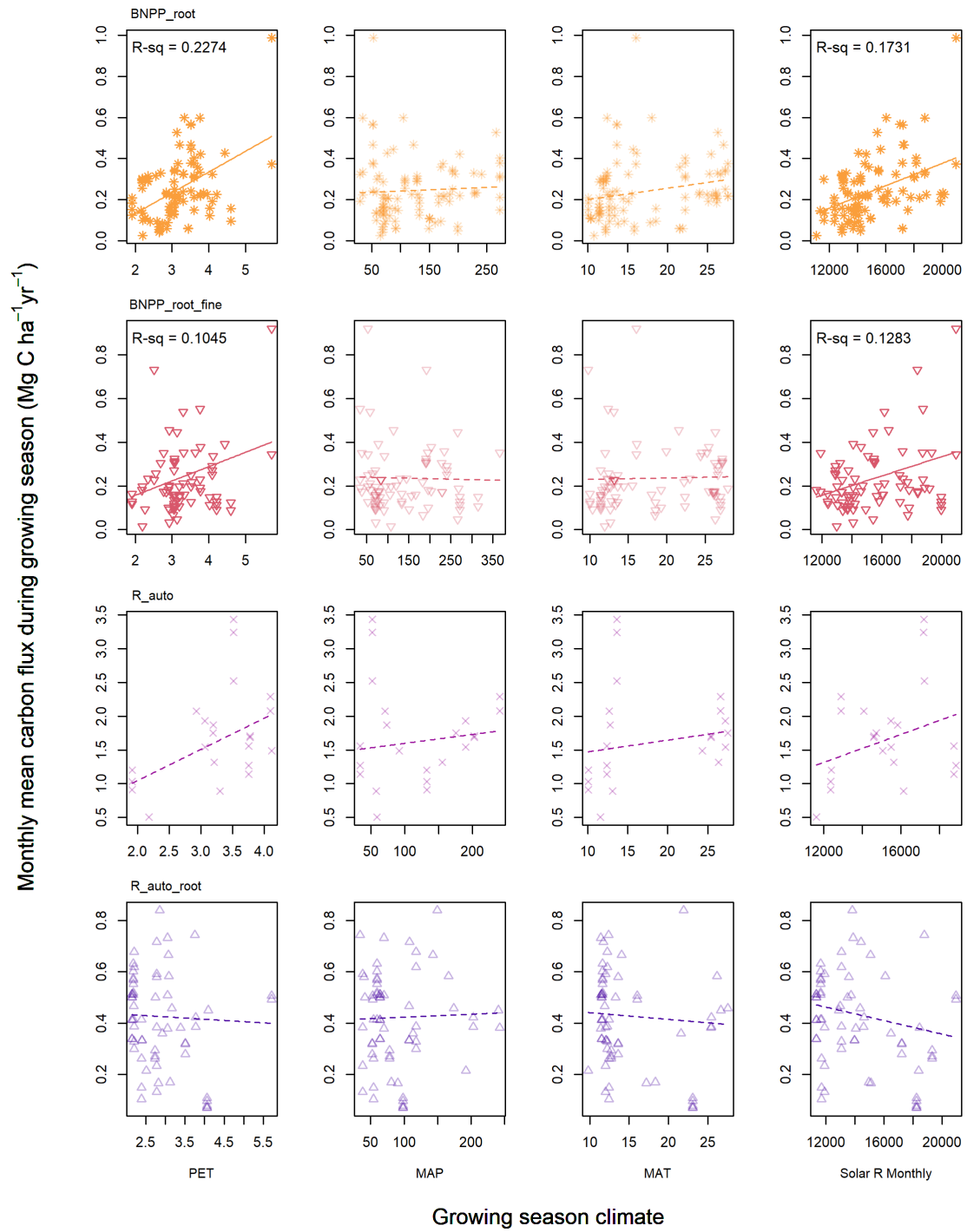


Figure S9: Growing season length-standardized forest C fluxes in relation to mean growing season climate, part 2.