Acclimation of phenology relieves leaf longevity constraints in deciduous forests

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Content

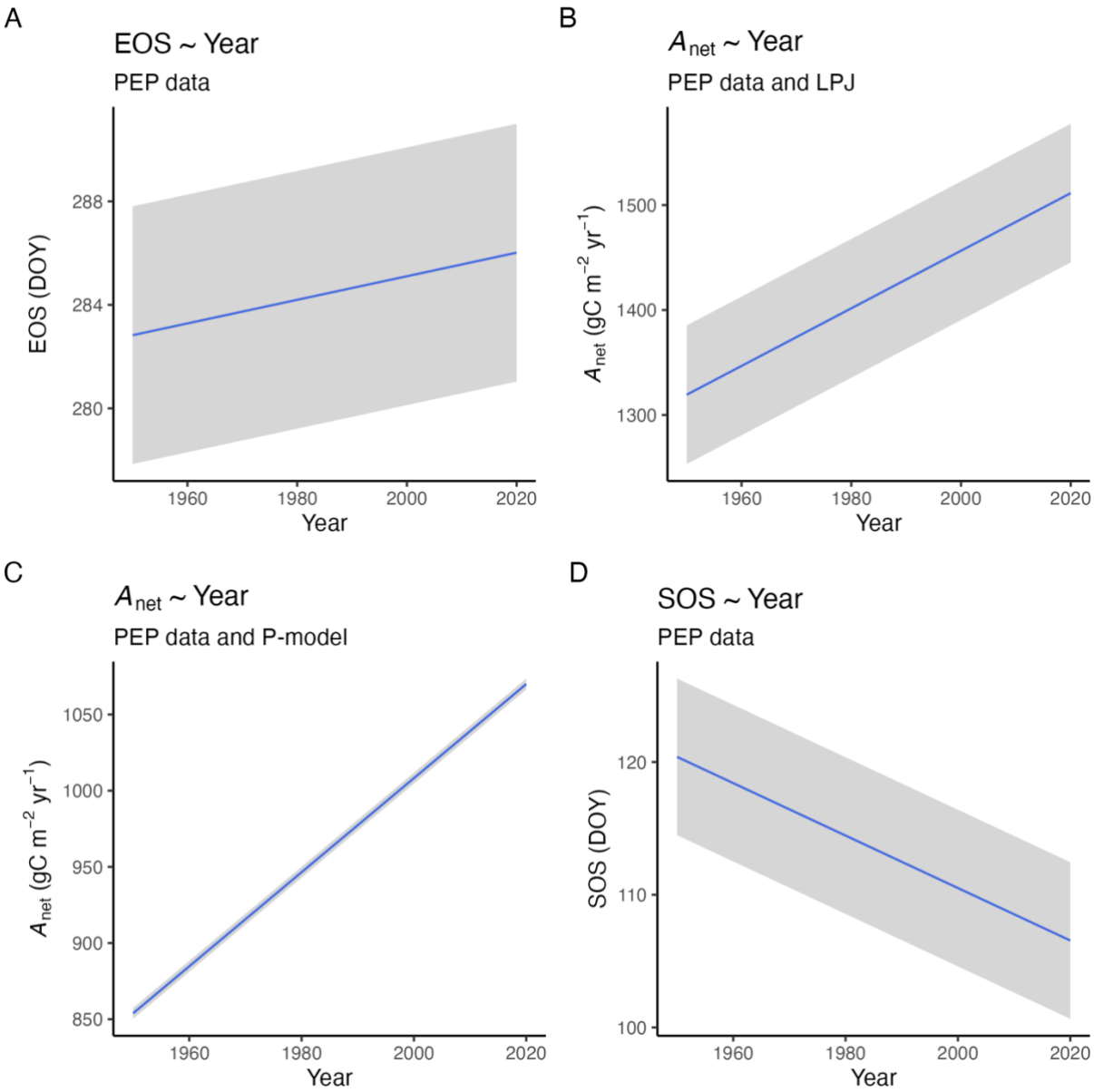

Fig. S1. Temporal trends of CO_2 assimilation and phenological dates from local observations (PEP725 data). (**A**) Trends towards later EOS, (**B**) higher A_{net} from LPJ simulations and (**C**) from P-model simulations, and (**D**) earlier SOS based on an LMM with year as a single fixed effect and site and species as grouping variables of the random intercepts. Blue lines represent the expected values from LMMs and grey ranges their 95% confidence intervals.

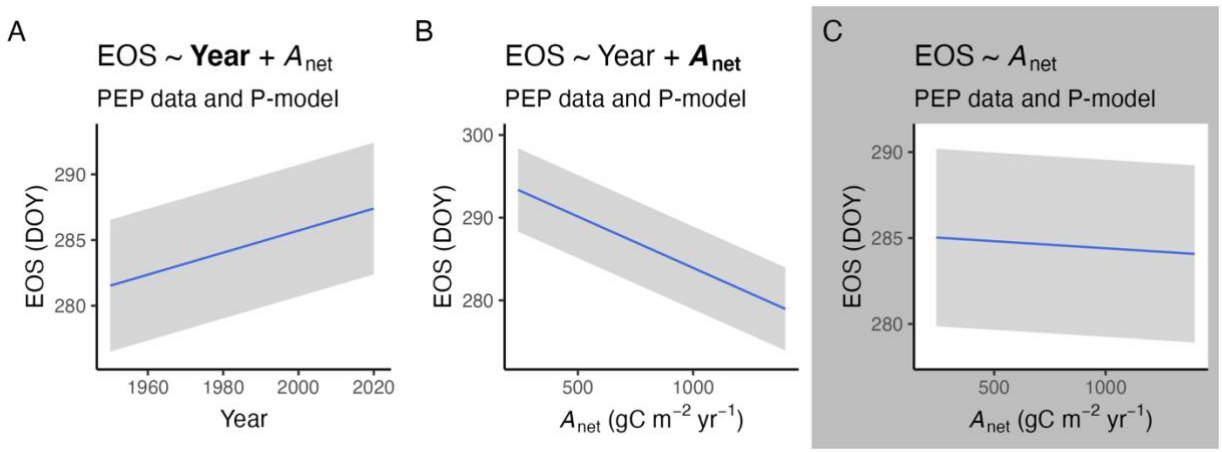

Fig. S2. Relationship of CO_2 assimilation and autumn phenology from local observations (PEP725 data). (**A, B**) Partial relationships of a multiple LMM, where end-of-season (EOS, expressed as day-of-year, DOY) is the response variable and (**A**) the long-term trend (year) and (**B**) A_{net} (simulated using the P-model) are treated as fixed effects. (**C**) EOS versus A_{net} based on an LMM with A_{net} as a single fixed effect. Blue lines represent the expected values from LMMs and grey ranges their 95% confidence intervals. In both bivariate and univariate models, site and species are treated as grouping variables of random intercepts.

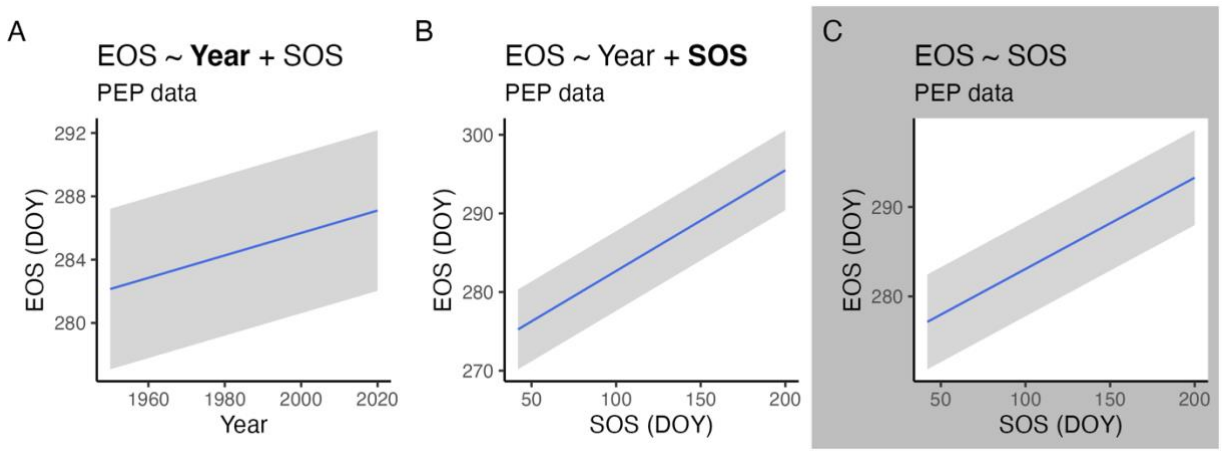

Fig. S3. Relationship of spring and autumn phenological dates from local observations (PEP725 data). (**A, B**) Partial relationships of a multiple LMM, where end-of-season (EOS, expressed as day-of-year, DOY) is the response variable and (**A**) the long-term trend (year) and (**B**) SOS are treated as fixed effects. (**C**) EOS versus SOS based on an LMM with SOS as a single fixed effect. Blue lines represent the expected values from LMMs and grey ranges their 95% confidence intervals. In both bivariate and univariate models, site and species are treated as grouping variables of random intercepts.

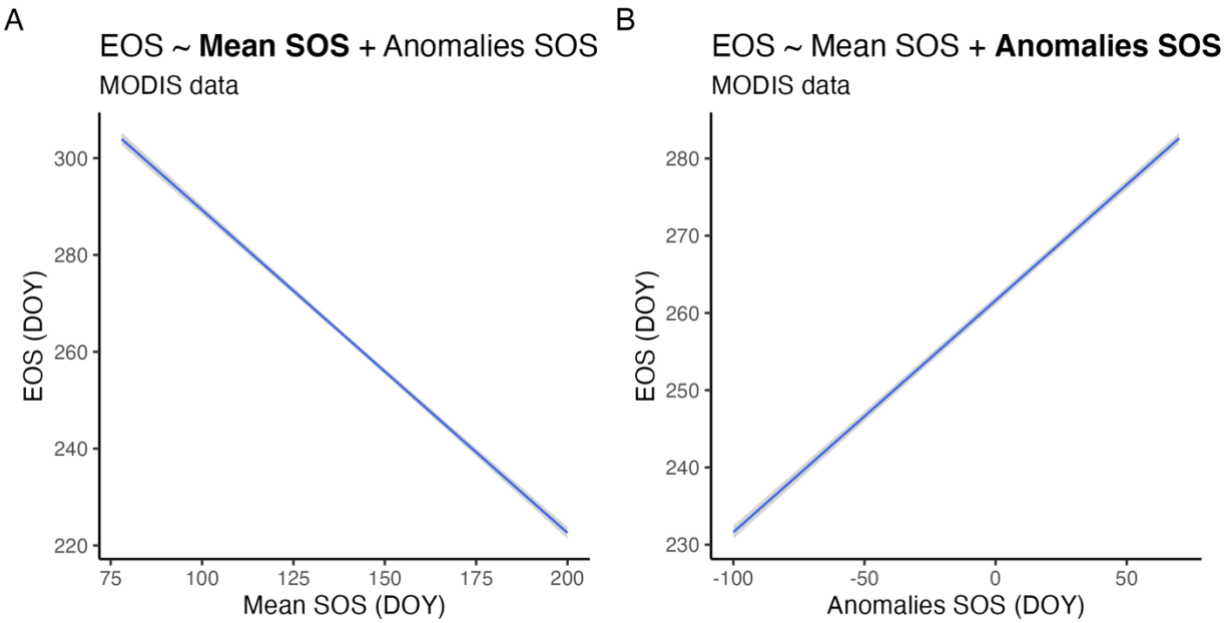

Fig. S4. Relationships of phenological dates from remote-sensing observations (MODIS C6 MCD12Q2 data). (**A, B**) Partial relationships of a multiple LMM where both (**A**) SOS mean and (**B**) anomalies relative to the mean value from 2001 to 2018 are treated as fixed effects, and site and year are treated as grouping variables of random intercepts. Blue lines represent the expected values from LMMs and grey ranges their 95% confidence intervals.

Table S1. Main statistics of the bivariate and univariate LMMs. Models were fitted to describe the relationships of CO_2 assimilation and phenological dates from local observations and remote-sensing estimates. Variables were standardized so effect sizes are directly comparable. σ_u denotes the standard deviation of the random intercepts.

Model / Figure	Response variable	Predictor	Estimate	Standard Error	*P-value*	Random effects (σ_u)	Data
Bivariate 1A - B	EOS	(Intercept)	282.823	1.064	<0.001	Site (9.614)	PEP725
		Year	4.139	0.018	<0.001	Species (2.579)	
		A_{net} (LPJ)	-10.451	0.020	<0.001		
Univariate 1C	EOS	(Intercept)	283.167	1.701	<0.001	Site (9.011)	PEP725
		A_{net} (LPJ)	-8.797	0.019	<0.001	Species (4.152)	
Bivariate 2A - B	EOS	(Intercept)	261.606	0.264	<0.001	Site (6.113)	MODIS
		Mean A_{net} (P-model)	10.823	0.090	<0.001	Year (1.049)	
		Anomalies A_{net} (P-model)	-0.442	0.024	<0.001		
Univariate	EOS	(Intercept)	261.614	0.123	<0.001	Site (8.498)	MODIS
		A_{net} (P-model)	4.976	0.093	<0.001		
Bivariate S2A - B	EOS	(Intercept)	284.441	2.557	<0.001	Site (6.605)	PEP725
		Year	1.375	0.029	<0.001	Species (6.257)	
		A_{net} (P-model)	-1.023	0.030	<0.001		
Univariate S2C	EOS	(Intercept)	284.438	2.630	<0.001	Site (6.539)	PEP725
		A_{net} (P-model)	-0.068	0.023	0.003	Species (6.435)	
Bivariate S3A - B	EOS	(Intercept)	284.602	2.587	<0.001	Site (6.560)	PEP725
		Year	1.162	0.022	<0.001	Species (6.330)	
		SOS	1.654	0.024	<0.001		
Univariate S3C	EOS	(Intercept)	284.598	2.702	<0.001	Site (6.600)	PEP725
		SOS	1.317	0.023	<0.001	Species (6.613)	
Bivariate S4A - B	EOS	(Intercept)	261.615	0.276	<0.001	Site (8.690)	MODIS
		Mean SOS	-8.906	0.126	<0.001	Year (1.044)	
		Anomalies SOS	1.876	0.021	<0.001		
Univariate	EOS	(Intercept)	261.622	0.216	<0.001	Site (14.993)	MODIS
		SOS	3.647	0.047	<0.001		