

## **Supplementary Information for**

CEDAR-GPP: spatiotemporally upscaled estimates of gross primary productivity  
incorporating CO<sub>2</sub> fertilization

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Table S1. List of predictors used in different temporal model setup.

Name	Source/Dataset	Unit	Used in	
			Short-term	Long-term
Air temperature	ERA5-Land	K	✓	✓
Skin temperature		K	✓	✓
Precipitation		m	✓	✓
Precipitation 3-month lag		m	✓	✓
VPD		kPa	✓	✓
Potential ET		m	✓	✓
Surface downwelling solar radiation		J/m <sup>2</sup>		✓
Surface reflectance Band 1 (red)	MCD43C4	-	✓	
Surface reflectance Band 2 (nir)		-	✓	
Surface reflectance Band 3 (blue)		-	✓	
Surface reflectance Band 4 (green)		-	✓	
Surface reflectance Band 5 (SWIR1)		-	✓	
Surface reflectance Band 6 (SWIR2)		-	✓	
Surface reflectance Band 7 (SWIR3)		-	✓	
Normalized Difference Vegetation Index (NDVI)		-	✓	
kNDVI <sup>a</sup>		-	✓	
Enhanced Vegetation Index (EVI)		-	✓	
Normalized Different Water Index (NDWI) <sup>b</sup>		-	✓	
CI <sub>Green</sub> <sup>c</sup>		-	✓	
NIRv <sup>d</sup>		-	✓	
Percentage of snow cover		%	✓	
fPAR	MCD15A3H	-	✓	
LAI	(after 2002/07) MOD15A2H (before 2002/07)	-	✓	
NDVI	GIMMS NDVI4g	-		✓
LAI	GIMMS LAI4g	-		✓
Daytime land surface temperature	MYD11A1 (after 2002/07) MOD11A1 (before 2002/07)	K	✓	
Nighttime land surface temperature		K	✓	
All-sky daily average SIF	CSIF	mW m <sup>-2</sup> nm <sup>-1</sup> sr <sup>-1</sup>	✓	
Photosynthetic Active Radiation (PAR)	BESS PAR	W/m <sup>2</sup>	✓	
Diffuse PAR		W/m <sup>2</sup>	✓	
Shortwave downwelling radiation		W/m <sup>2</sup>	✓	
Soil moisture	ESACCI Soil Moisture	%	✓	
Plant Function Type (one-hot encoding)	MCD12Q1	-	✓	✓

Climate zone (one-hot encoding)	Koppen-Geiger	-	✓	✓
C4 vegetation percentage	ISLSCP II C4 Vegetation Percentage	%	✓ (only in ST_CFE-ML and ST_CFE-Hybrid setups)	✓ (only in LT_CFE-Hybrid setup)
Atmospheric CO <sub>2</sub> concentration	ESLR	ppm	✓ (only in CFE-ML and CFE-Hybrid setups)	✓ (only in LT_CFE-Hybrid setup)

- a. kNDVI (Camps-Valls et al., 2021)
- b. NDWI reference (Gao, 1996)
- c. CIgreen (Gitelson, 2005)
- d. NIRv (Badgley et al., 2017)

Table S2. Machine learning model performance for different model setups. Models were trained using GPP from on DT partitioning.

Model Setup	Monthly			MSC			Monthly anomalies			Cross-site		
	RMSE	Bias	r2	RMSE	Bias	r2	RMSE	Bias	r2	RMSE	Bias	r2
ST_Baseline_DT	1.84	-0.04	0.75	1.46	0.02	0.81	1.20	0.00	0.11	1.01	0.03	0.69
ST_CFE-ML_DT	1.86	-0.04	0.74	1.47	0.03	0.80	1.20	0.00	0.11	1.01	0.03	0.69
ST_CFE-Hybrid_DT	1.86	-0.01	0.74	1.48	0.06	0.80	1.20	0.00	0.11	1.01	0.07	0.69
LT_Baseline_DT	2.04	-0.08	0.69	1.69	0.03	0.74	1.24	0.00	0.04	1.18	0.04	0.58
LT_CFE-Hybrid_DT	2.02	-0.03	0.69	1.66	0.08	0.75	1.23	0.00	0.06	1.15	0.08	0.60

Figure S1. Global patterns of mean annual GPP from CEDAR-GPP product and other GPP datasets.

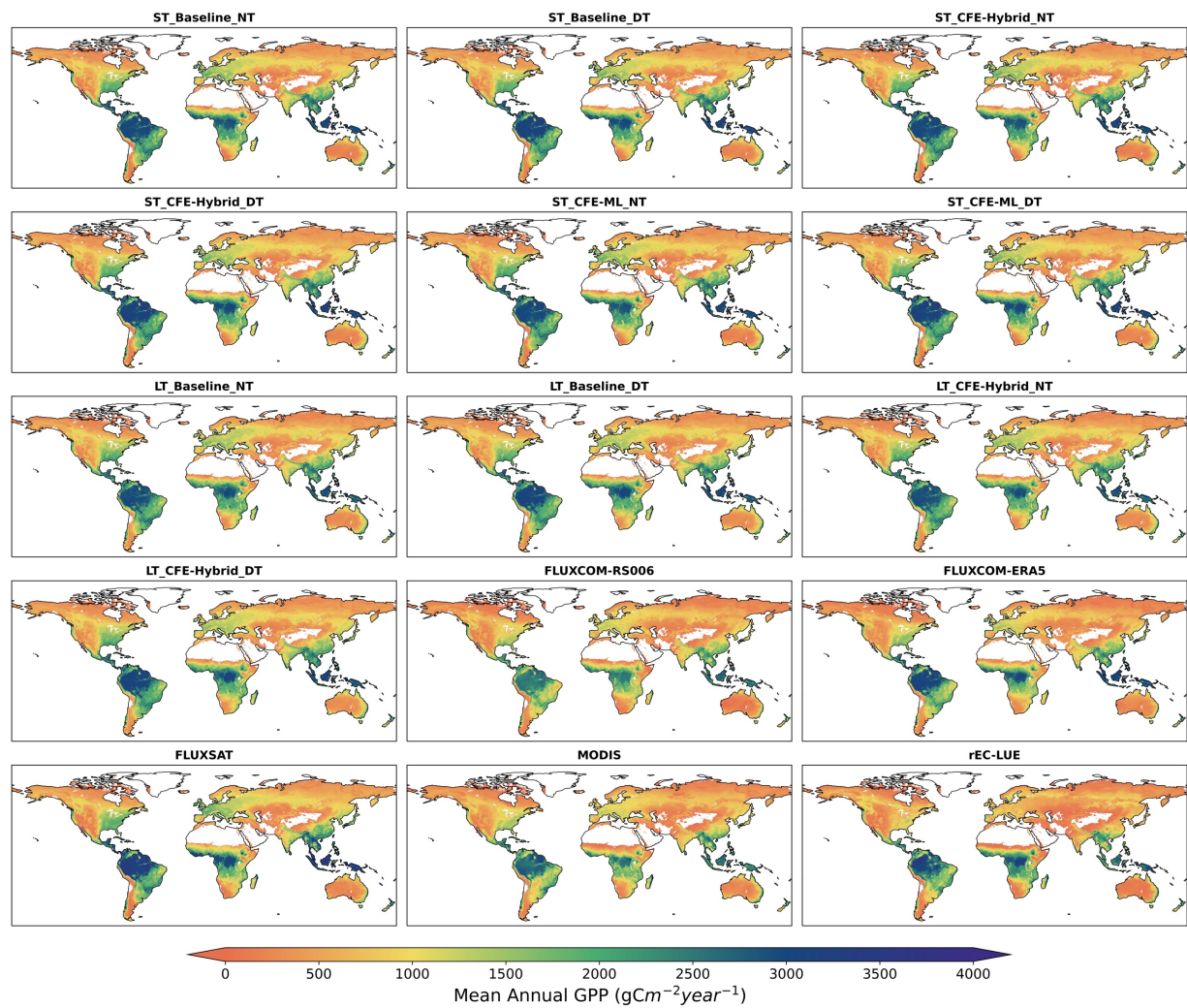


Figure S2. GPP mean seasonal cycle from CEDAR-GPP short-term (a) and long-term (b) datasets.

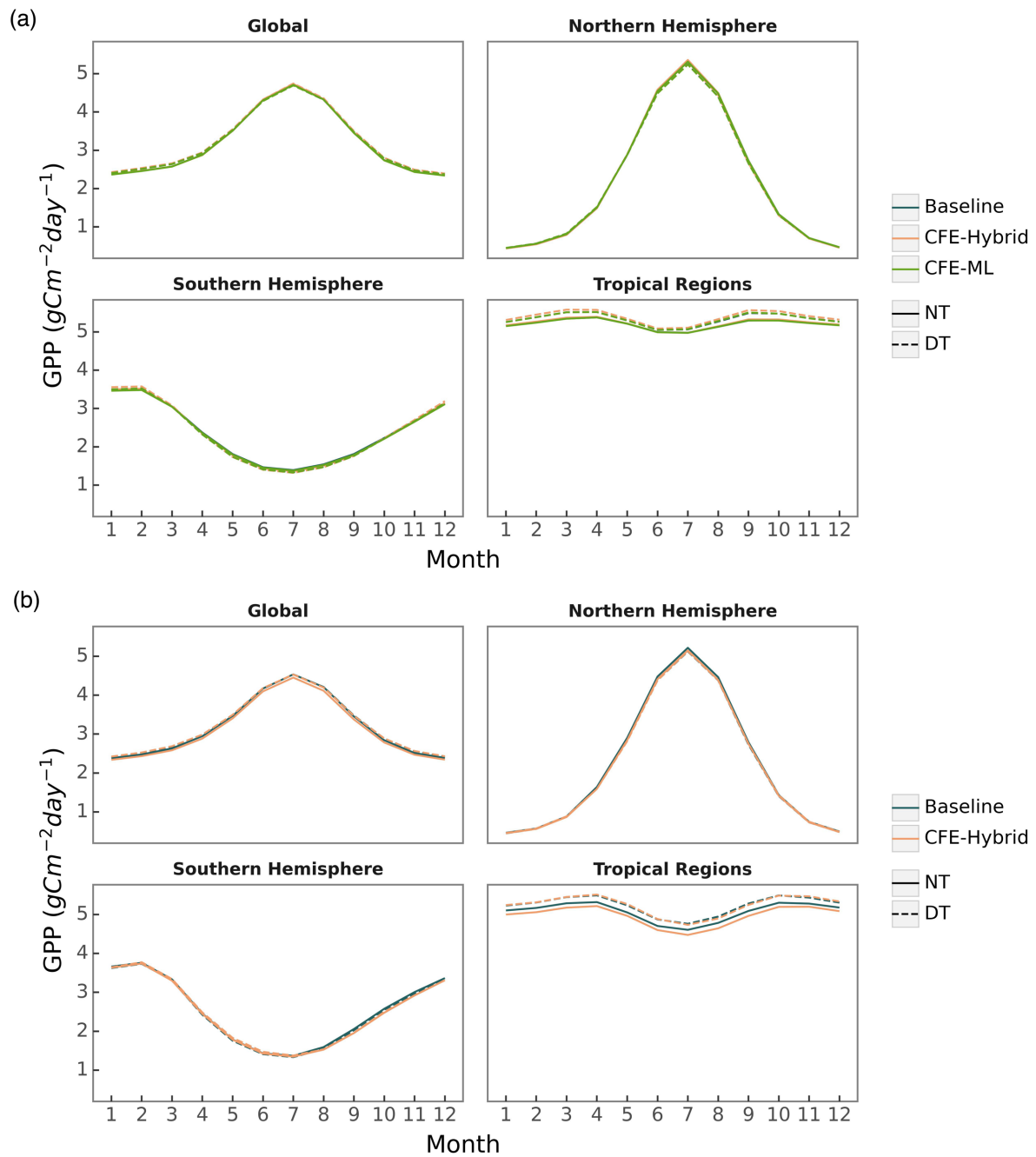


Figure S3. Spatial patterns of GPP interannual variability from ten CEDAR-GPP extracted from 2001 to 2018.

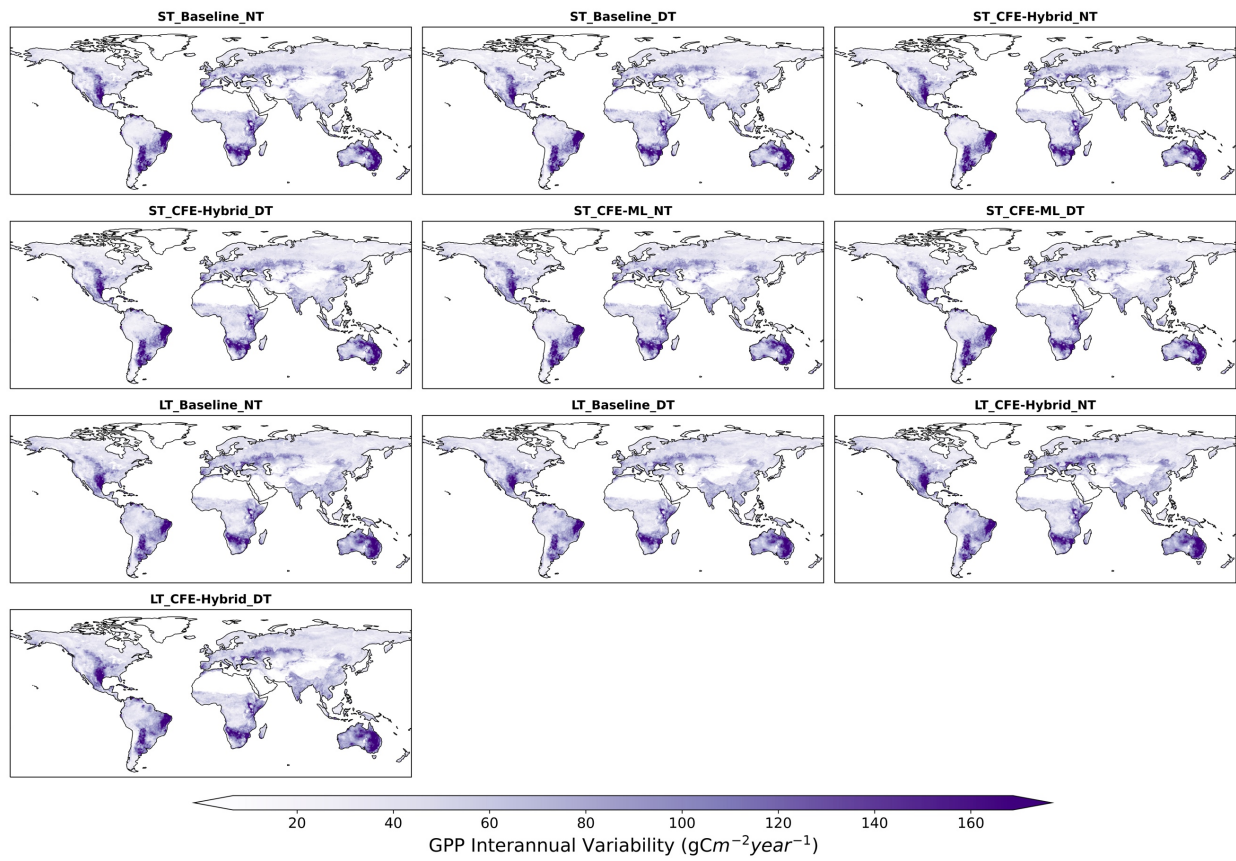


Figure S4. Global pattern of GPP annual trend from ten CEDAR-GPP products. Hatched areas indicate the GPP trend that is statistically significant at  $p < 0.05$  level under the Mann-Kendal test.

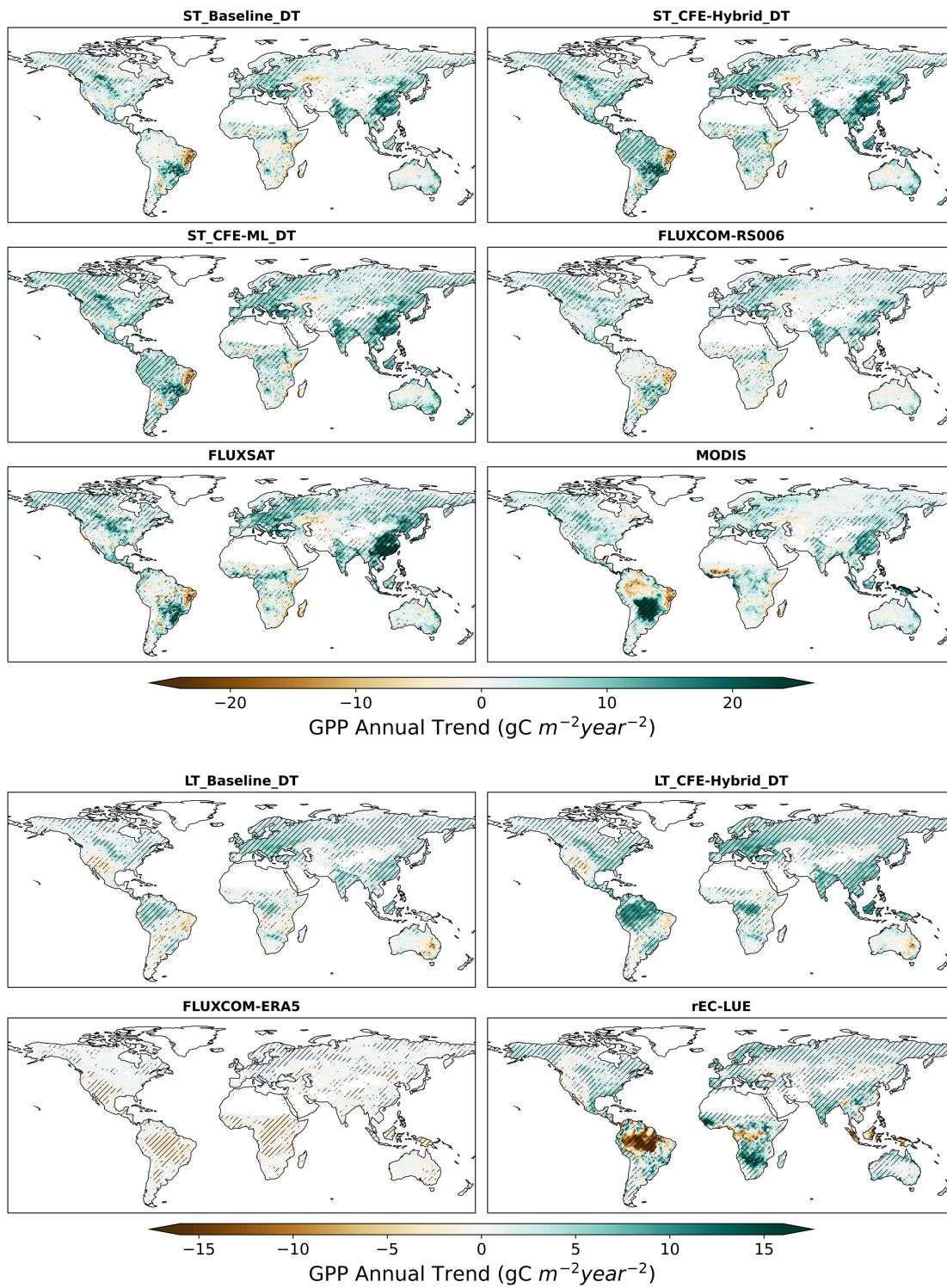
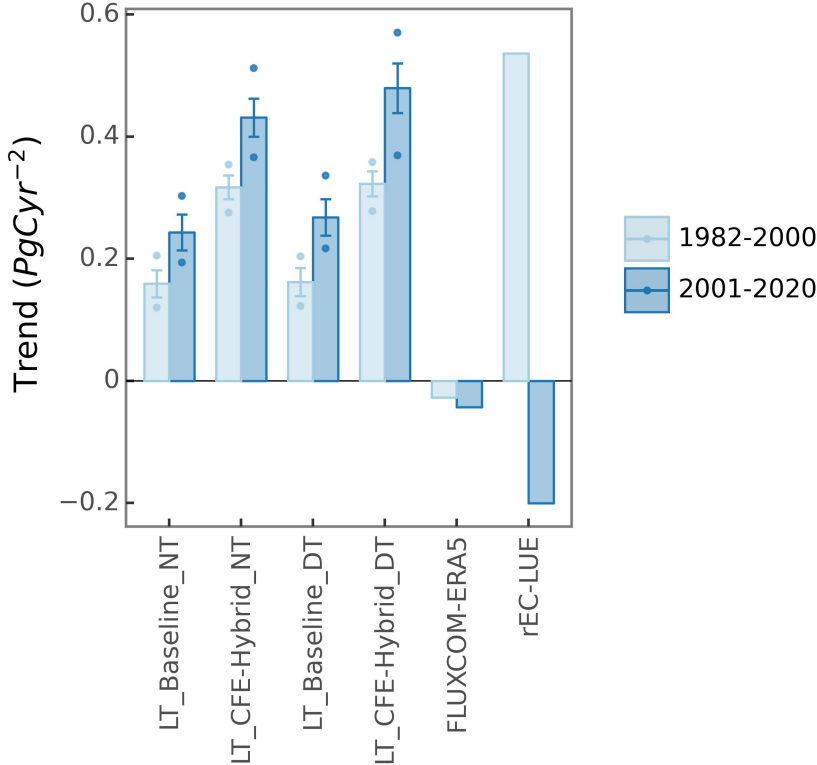


Figure S5. Comparison of global annual GPP trend over 1982-2000 and over 2001-2020 in CEDAR-GPP, FLUXCOM-ERA5, and rEC-LUE.



## SI References

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