Global trends in carbon sinks and their relationships with CO_2 and temperature

Authors: M. Fernández-Martínez[*1], J. Sardans[2,3], F.. Chevallier[4], P. Ciais[4], M. Obersteiner[5], S. Vicca[1], J. G. Canadell[6], A. Bastos[4], P. Friedlingstein[7], S. Sitch[7], S.L. Piao[8,9], I.A. Janssens[1], J. Peñuelas[2,3].

Affiliations:

[1] Centre of Excellence PLECO (Plant and Vegetation Ecology), Department of Biology, University of Antwerp, 2610 Wilrijk, Belgium.

[2] CSIC, Global Ecology Unit, CREAF-CSIC-UAB, Cerdanyola del Vallès, 08193 Barcelona, Catalonia, Spain

[3] CREAF, Cerdanyola del Vallès, 08193 Barcelona, Catalonia, Spain

[4] Laboratoire des Sciences du Climat et de l'Environnement, CEA CNRS UVSQ, 91191 Gif-sur-Yvette, France

[5] International Institute for Applied Systems Analysis, Schlossplatz 1, 2361 Laxenburg, Austria

[6] Global Carbon Project, CSIRO Oceans and Atmosphere, Canberra, ACT 2601, Australia

[7] College of Engineering, Computing and Mathematics, University of Exeter, Exeter EX4 4QF, UK

[8]Sino-French Institute of Earth System Sciences, College of Urban and Environmental Sciences, Peking University, Beijing 100871, China

[9] Institute of Tibetan Plateau Research, Chinese Academy of Sciences, Beijing 100085, China

*Correspondence to: M. Fernández-Martínez, marcos.fernandez-martinez@uantwerpen.be

Supplementary Information

1. Supplementary discussion:

Atmospheric deposition and the terrestrial C balance

The effects of N_{OX} deposition were divergent in both the MACC-II and Jena CarboScope datasets for temporal and spatial variability. Conclusions about the effect of N_{OX} on regional NEP thus cannot be drawn from our analyses. The discrepancy in the results for N_{OX} in **Figure S1** and **Table S1** was due to the different NEP trends for Europe and the USA for both models. N_{RED} did not significantly contribute to the trends in NEP for either of the inversion models (**Figure S1),** mainly because it did not have a significant trend over time. N_{RED}, however, was a significant predictor of spatial and interannual NEP variability (see **Supplementary Information 2.8**), in contrast to N_{OX}. Analysing the deposition of oxidised and reduced N separately rather than only using the total amount of N, as has been done so far[1–4], may thus lead to a better understanding of the effect of total N deposition because of the different chemical properties of NO_3^- compared to NH_4^+, which is easier to acquire by plants[5]. S deposition did not significantly contribute to the trends in NEP, which contrasts with a recent study using eddy-covariance towers[6]. The lack of an effect of S in this case could be due to the local scale of its effects, which would be lost when analysing larger geographical scales. Also, the fact that this study began some years after S deposition started to decline in both continents (mainly during the 80s[7,8]), may have reduced the potential effect of S. The large spatial heterogeneity of sites in different stages of recovery from S deposition and soil properties, such as soil buffer capacity (pH responses to S inputs), could also play a role obfuscating the effects of S deposition when using data with such a coarse resolution.

Figure S1: Temporal contributions of the predictor variables to changes in NEP for the MACC-II and Jena CarboScope datasets. Units are g C m^{-2} y^{-2}. Error bars indicate 95% confidence intervals. Significance levels: *, *P* < 0.01; **, *P* < 0.005; ***, *P* < 0.001.

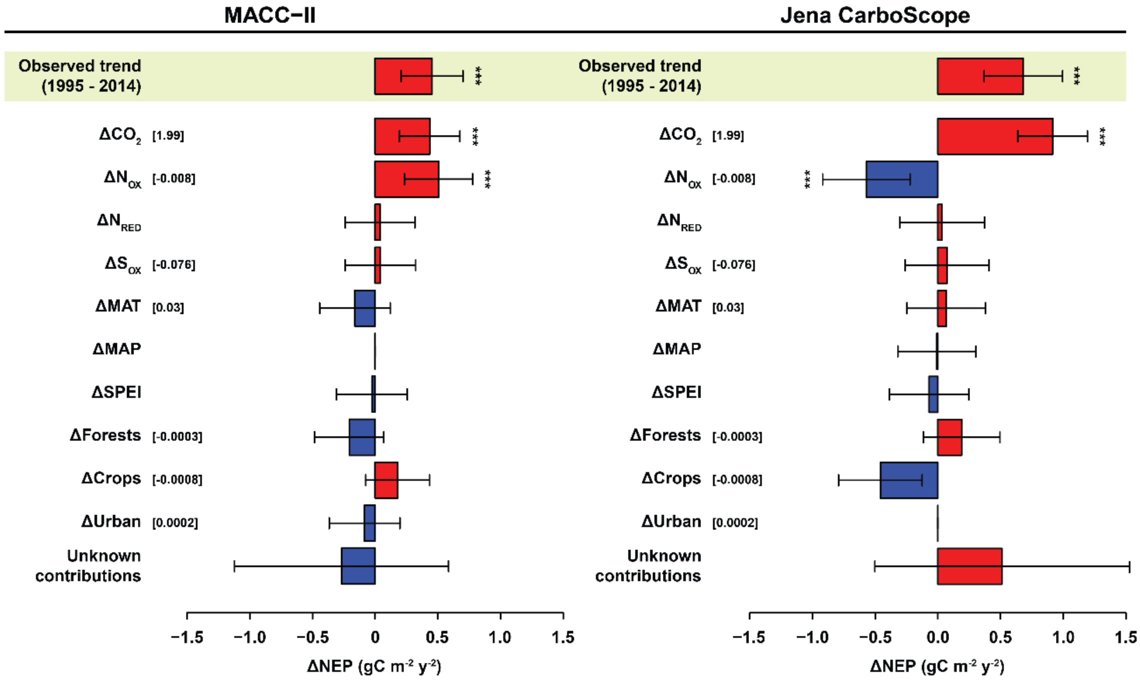

Table S1: Sensitivity of NEP to the predictor variables, including atmospheric deposition for Europe and the USA, for the MACC-II and Jena CarboScope datasets. Units are ppm for CO_2; kg ha^{-1} for N_{OX}, N_{RED}, and S; °C for MAT; mm y^{-1} for MAP, standard deviations for SPEI, and percentage of land-use cover per pixel for forests, crops, and urban areas. Statistically significant estimates are highlighted in bold.

	MACC-II		Jena CarboScope	
	Estimate	***P***	**Estimate**	***P***
CO_2	**0.22 ± 0.06**	**0.0006**	**0.46 ± 0.07**	**<0.0001**
N_{OX}	**-62.32 ± 19.08**	**0.0012**	**49.15 ± 17.12**	**0.0034**
N_{RED}	82.29 ± 357.59	n.s.	-21.60 ± 113.35	n.s.
S	-0.55 ± 1.89	n.s.	-0.84 ± 1.96	n.s.
MAT	-4.75 ± 4.23	n.s.	1.93 ± 4.59	n.s.
MAP	-	-	-0.05 ± 1.04	n.s.
SPEI	-26.58 ± 146.43	n.s.	-55.03 ± 131.25	n.s.
Forests	641.90 ± 440.54	n.s.	-464.58 ± 386.09	n.s.
Crops	-222.48 ± 162.43	n.s.	523.58 ± 203.08	0.0071
Urban	-457.84 ± 772.70	n.s.	-	-

2. Summary of the models predicting interannual variability in NEP (1995–2014)

Abbreviations: cdioxide, atmospheric CO_2 concentration; MAP.c, climatic mean annual precipitation; MAP.an, interannual deviation from the mean in annual precipitation; MAT.c, climatic mean annual temperature; MAT.an, interannual deviation from the mean in annual temperature; SPEI, Standardised Precipitation-Evapotranspiration Index. R^2_m is the variance explained by a fixed factor, and R^2_c is the total variance explained by the model (fixed + random factors). Suffix ".mean" indicates the average value per pixel, while suffix ".an" indicates the temporal anomaly. The two points ":" indicate the interaction between two predictors.

Table S2: Global model – MACC-II (R^2_m=0.09; R^2_c=0.49)

	Value	SE	DF	*t*	*P*
(Intercept)	21.281	15.459	54251	1.377	0.1686
cdioxide	-0.055	0.041	54251	-1.357	0.1749
MAP.c	-0.100	0.015	2851	-6.673	<0.0001
MAT.an	-60.487	9.998	54251	-6.050	<0.0001
MAT.c	2.804	0.755	2851	3.716	0.0002
Forests.mean	-107.499	33.336	2851	-3.225	0.0013
Urban.mean	247.026	61.719	54251	4.002	0.0001
Crops.mean	-720.527	67.026	54251	-10.750	<0.0001
Crops.an	4118.938	810.475	54251	5.082	<0.0001
cdioxide:MAP.c	0.000	0.000	54251	8.872	<0.0001
cdioxide:MAT.an	0.152	0.026	54251	5.770	<0.0001
cdioxide:MAT.c	-0.007	0.002	54251	-3.594	0.0003
MAT.an:MAT.c	-0.208	0.026	54251	-8.023	<0.0001
MAP.c:MAT.c	-0.002	0.000	2851	-11.604	<0.0001
cdioxide:Forests.mean	0.340	0.088	54251	3.882	0.0001
cdioxide:Crops.mean	2.096	0.176	54251	11.910	<0.0001
cdioxide:Crops.an	-9.797	2.115	54251	-4.632	<0.0001
Crops.mean:Crops.an	-994.684	152.061	54251	-6.541	<0.0001

Table S3: Global model – Jena CarboScope (R^2_m=0.11; R^2_c=0.82)

	Value	**SE**	**DF**	***t***	***P***
(Intercept)	46.927	19.714	21266	2.380	0.0173
cdioxide	-0.093	0.049	21266	-1.879	0.0602
MAP.c	-0.097	0.021	1114	-4.669	<0.0001
MAT.an	-143.210	13.490	21266	-10.616	<0.0001
MAT.c	-7.090	1.057	1114	-6.707	<0.0001
SPEI	-4.637	1.349	21266	-3.437	0.0006
Forests.mean	-16.117	10.138	1114	-1.590	0.1122
Forests.an	235.662	72.477	21266	3.252	0.0011
Urban.an	-1496.360	229.433	21266	-6.522	<0.0001
Crops.mean	-562.384	89.331	1114	-6.296	<0.0001
Crops.an	-454.663	66.259	21266	-6.862	<0.0001
cdioxide:MAP.c	0.000	0.000	21266	7.641	<0.0001
cdioxide:MAT.an	0.369	0.036	21266	10.365	<0.0001
cdioxide:MAT.c	0.017	0.003	21266	6.198	<0.0001
MAT.an:MAT.c	-0.481	0.036	21266	-13.202	<0.0001
MAP.c:MAT.c	-0.002	0.000	1114	-5.703	<0.0001
MAP.c:SPEI	0.006	0.001	21266	5.387	<0.0001
Forests.mean:Forests.an	-1763.944	174.199	21266	-10.126	<0.0001
cdioxide:Crops.mean	1.760	0.230	21266	7.640	<0.0001
Crops.mean:Crops.an	1153.391	204.403	21266	5.643	<0.0001

Table S4: Global model – TRENDY ensemble (R^2_m=0.24; R^2_c=0.46)

	Value	SE	DF	*t*	*P*
(Intercept)	-37.550	6.376	46021	-5.889	<0.0001
cdioxide	0.103	0.017	46021	6.143	<0.0001
MAP.an	0.252	0.027	46021	9.455	<0.0001
MAP.c	0.025	0.001	2418	17.313	<0.0001
MAT.an	-3.818	0.157	46021	-24.248	<0.0001
MAT.c	-2.646	0.306	2418	-8.638	<0.0001
SPEI	-9.012	0.544	46021	-16.554	<0.0001
Forests.mean	-70.832	16.879	2418	-4.197	<0.0001
Forests.an	277.493	24.897	46021	11.146	<0.0001
Urban.an	-378.896	91.627	46021	-4.135	<0.0001
Crops.mean	-1.708	2.346	46021	-0.728	0.4665
Crops.an	-226.309	22.942	46021	-9.865	<0.0001
cdioxide:MAP.an	0.000	0.000	46021	-4.100	<0.0001
MAP.an:MAP.c	0.000	0.000	46021	-58.983	<0.0001
cdioxide:MAT.c	0.008	0.001	46021	9.510	<0.0001
MAT.an:MAT.c	-0.663	0.014	46021	-47.737	<0.0001
MAP.c:MAT.c	-0.001	0.000	2418	-16.146	<0.0001
MAT.c:SPEI	1.104	0.028	46021	39.853	<0.0001
cdioxide:Forests.mean	0.207	0.044	46021	4.666	<0.0001
Forests.mean:Forests.an	-486.559	67.082	46021	-7.253	<0.0001
Crops.mean:Crops.an	296.646	61.259	46021	4.843	<0.0001

Table S5: Northern Hemisphere, latitudes >55° – MACC-II (R^2_m=0.22; R^2_c=0.60)

	Value	SE	DF	*t*	*P*
(Intercept)	134.541	26.474	17147	5.082	<0.0001
cdioxide	-0.183	0.068	17147	-2.691	0.0071
MAP.an	-1.714	0.141	17147	-12.205	<0.0001
MAP.c	-0.040	0.007	897	-6.148	<0.0001
MAT.an	-5.546	0.487	17147	-11.379	<0.0001
MAT.c	16.679	1.675	897	9.956	<0.0001
Forests.mean	-231.459	34.121	897	-6.784	<0.0001
Forests.an	7831.834	1975.517	17147	3.964	0.0001
Crops.mean	234.338	29.040	897	8.070	<0.0001
cdioxide:MAP.an	0.005	0.000	17147	12.253	<0.0001
cdioxide:MAT.c	-0.033	0.004	17147	-7.690	<0.0001
MAT.an:MAT.c	-0.439	0.048	17147	-9.219	<0.0001
MAP.c:MAT.c	-0.004	0.001	897	-6.481	<0.0001
cdioxide:Forests.mean	0.627	0.089	17147	7.018	<0.0001
cdioxide:Forests.an	-27.494	5.142	17147	-5.347	<0.0001
Forests.mean:Forests.an	3785.460	356.610	17147	10.615	<0.0001

Table S6: Northern Hemisphere, latitudes >55° – Jena CarboScope (R^2_m=0.31; R^2_c=0.75)

	Value	SE	DF	*t*	*P*
(Intercept)	-27.173	35.311	6490	-0.770	0.4416
cdioxide	0.279	0.088	6490	3.161	0.0016
MAP.c	-0.035	0.012	336	-3.010	0.0028
MAT.an	-64.639	10.004	6490	-6.461	<0.0001
MAT.c	4.918	0.700	336	7.026	<0.0001
Forests.mean	197.266	59.568	336	3.312	0.001
Forests.an	18735.355	2792.289	6490	6.710	<0.0001
Crops.mean	174.334	42.089	336	4.142	<0.0001
cdioxide:MAT.an	0.164	0.026	6490	6.196	<0.0001
MAT.an:MAT.c	-0.224	0.049	6490	-4.530	<0.0001
MAP.c:MAT.c	-0.005	0.001	336	-3.793	0.0002
cdioxide:Forests.mean	-0.621	0.156	6490	-3.991	0.0001
cdioxide:Forests.an	-58.567	7.282	6490	-8.043	<0.0001
Forests.mean:Forests.an	4383.258	534.136	6490	8.206	<0.0001

Table S7: Northern Hemisphere, latitudes >55° – TRENDY ensemble (R^2_m=0.29; R^2_c=0.44)

	Value	SE	DF	*t*	*P*
(Intercept)	-66.328	11.678	13040	-5.680	<0.0001
cdioxide	0.247	0.030	13040	8.113	<0.0001
MAP.an	-0.386	0.070	13040	-5.547	<0.0001
MAP.c	-0.001	0.002	681	-0.459	0.6464
MAT.an	20.290	4.335	13040	4.680	<0.0001
MAT.c	-1.307	0.804	681	-1.624	0.1048
SPEI	19.743	2.347	13040	8.411	<0.0001
Forests.mean	41.852	14.892	681	2.810	0.0051
Forests.an	287.470	92.025	13040	3.124	0.0018
Crops.mean	28.292	7.125	681	3.971	0.0001
cdioxide:MAP.an	0.001	0.000	13040	4.669	<0.0001
MAP.an:MAP.c	0.000	0.000	13040	4.239	<0.0001
cdioxide:MAT.an	-0.051	0.011	13040	-4.480	<0.0001
cdioxide:MAT.c	0.009	0.002	13040	4.257	<0.0001
MAP.c:MAT.c	-0.003	0.000	681	-10.990	<0.0001
MAP.c:SPEI	-0.029	0.004	13040	-6.745	<0.0001
MAT.c:SPEI	0.775	0.108	13040	7.205	<0.0001
cdioxide:Forests.mean	-0.123	0.039	13040	-3.152	0.0016
Forests.mean:Forests.an	-812.610	147.719	13040	-5.501	<0.0001

Table S8: Northern Hemisphere, latitudes between 35 and 55° – MACC-II (R^2_m=0.13; R^2_c=0.37)

	Value	**SE**	**DF**	***t***	***P***
(Intercept)	148.474	75.069	12204	1.978	0.0480
cdioxide	-0.459	0.197	12204	-2.327	0.0200
MAP.an	0.824	0.174	12204	4.746	<0.0001
MAP.c	-0.388	0.079	638	-4.934	<0.0001
MAT.an	-89.97	24.903	12204	-3.613	0.0003
MAT.c	20.781	6.061	638	3.429	0.0006
Forests.an	-16499.293	4157.812	12204	-3.968	0.0001
Urban.mean	595.477	98.535	12204	6.043	<0.0001
Crops.mean	-869.677	230.863	638	-3.767	0.0002
Crops.an	1277.898	226.561	12204	5.640	<0.0001
cdioxide:MAP.an	-0.002	0.000	12204	-4.842	<0.0001
cdioxide:MAP.c	0.001	0.000	12204	6.182	<0.0001
cdioxide:MAT.an	0.233	0.066	12204	3.556	0.0004
cdioxide:MAT.c	-0.051	0.016	12204	-3.211	0.0013
MAP.c:MAT.c	-0.009	0.001	638	-7.588	<0.0001
cdioxide:Forests.an	44.681	10.947	12204	4.082	<0.0001
cdioxide:Crops.mean	2.664	0.608	12204	4.379	<0.0001
Crops.mean:Crops.an	-3244.474	499.841	12204	-6.491	<0.0001

Table S9: Northern Hemisphere, latitudes between 35 and 55° – Jena CarboScope (R^2_m=0.12; R^2_c=0.74)

	Value	SE	DF	*t*	*P*
(Intercept)	-350.099	89.327	4393	-3.919	0.0001
cdioxide	1.220	0.233	4393	5.240	<0.0001
MAP.an	0.032	0.010	4393	3.198	0.0014
MAP.c	-0.291	0.093	226	-3.148	0.0019
MAT.an	-176.873	29.650	4393	-5.965	<0.0001
MAT.c	29.001	7.637	226	3.798	0.0002
SPEI	-24.019	4.322	4393	-5.557	<0.0001
Forests.mean	2909.782	258.050	226	11.276	<0.0001
Forests.an	-2076.464	228.800	4393	-9.075	<0.0001
Urban.mean	787.980	246.180	226	3.201	0.0016
Urban.an	-2473.911	584.642	4393	-4.231	<0.0001
Crops.mean	-1237.354	271.117	226	-4.564	<0.0001
Crops.an	-12046.724	2907.443	4393	-4.143	<0.0001
cdioxide:MAP.c	0.001	0.000	4393	2.946	0.0032
cdioxide:MAT.an	0.466	0.078	4393	5.963	<0.0001
cdioxide:MAT.c	-0.091	0.020	4393	-4.563	<0.0001
MAT.c:SPEI	1.686	0.439	4393	3.843	0.0001
cdioxide:Forests.mean	-7.801	0.675	4393	-11.553	<0.0001
cdioxide:Crops.mean	3.363	0.709	4393	4.746	<0.0001
cdioxide:Crops.an	30.215	7.661	4393	3.944	0.0001
Crops.mean:Crops.an	2766.726	571.8067	4393	4.839	<0.0001

Table S10: Northern Hemisphere, latitudes between 35 and 55° – TRENDY ensemble (R^2_m=0.31; R^2_c=0.39)

	Value	SE	DF	*t*	*P*
(Intercept)	-99.108	13.155	11387	-7.534	<0.0001
cdioxide	0.266	0.035	11387	7.702	<0.0001
MAP.an	0.170	0.007	11387	25.662	<0.0001
MAP.c	0.032	0.003	594	12.688	<0.0001
MAT.an	0.222	0.391	11387	0.567	0.5706
MAT.c	4.704	1.230	594	3.823	0.0001
SPEI	20.524	1.903	11387	10.784	<0.0001
Forests.mean	-7.570	2.528	594	-2.995	0.0029
Forests.an	342.651	64.642	11387	5.301	<0.0001
Crops.mean	19.192	2.341	594	8.197	<0.0001
Crops.an	1847.180	590.494	11387	3.128	0.0018
MAP.an:MAP.c	0.000	0.000	11387	-15.519	<0.0001
cdioxide:MAT.c	-0.013	0.003	11387	-3.909	0.0001
MAT.an:MAT.c	-0.672	0.054	11387	-12.362	<0.0001
MAP.c:MAT.c	-0.001	0.000	594	-4.794	<0.0001
MAP.c:SPEI	-0.046	0.003	11387	-14.495	<0.0001
MAT.c:SPEI	1.141	0.132	11387	8.629	<0.0001
Forests.mean:Forests.an	-619.545	135.886	11387	-4.559	<0.0001
cdioxide:Crops.an	-4.959	1.550	11387	-3.199	0.0014

Table S11: Northern Hemisphere, latitudes between 15 and 35° – MACC-II (R^2_m=0.10; R^2_c=0.48)

	Value	SE	DF	*t*	*P*
(Intercept)	-79.616	30.449	8352	-2.615	0.0089
cdioxide	0.044	0.071	8352	0.618	0.5369
MAP.an	-0.025	0.010	8352	-2.656	0.0079
MAP.c	-0.069	0.040	435	-1.736	0.0832
MAT.c	2.611	0.590	435	4.428	<0.0001
Forests.mean	2127.100	425.131	435	5.003	<0.0001
Forests.an	434.725	226.387	8352	1.920	0.0549
Crops.an	-710.036	92.556	8352	-7.671	<0.0001
cdioxide:MAP.c	0.000	0.000	8352	5.377	<0.0001
MAP.an:MAP.c	0.000	0.000	8352	3.176	0.0015
MAP.c:MAT.c	-0.006	0.001	435	-7.328	<0.0001
cdioxide:Forests.mean	-5.519	1.1213	8352	-4.922	<0.0001
Forests.mean:Forests.an	-3856.659	779.0509	8352	-4.950	<0.0001

Table S12: Northern Hemisphere, latitudes between 15 and 35° – Jena CarboScope (R^2_m=0.40; R^2_c=0.88)

	Value	SE	DF	*t*	*P*
(Intercept)	-43.864	48.290	3395	-0.908	0.3638
cdioxide	0.016	0.082	3395	0.189	0.8498
MAP.an	-0.016	0.004	3395	-4.081	<0.0001
MAP.c	0.145	0.046	173	3.120	0.0021
MAT.an	-171.208	49.580	3395	-3.453	0.0006
MAT.c	1.611	1.526	173	1.055	0.2928
Forests.mean	-2000.599	121.655	173	-16.445	<0.0001
Crops.mean	-561.718	134.866	173	-4.165	<0.0001
cdioxide:MAT.an	0.433	0.131	3395	3.313	0.0009
MAP.c:MAT.c	-0.007	0.002	173	-3.810	0.0002
cdioxide:Forests.mean	6.019	0.305	3395	19.751	<0.0001
cdioxide:Crops.mean	1.794	0.343	3395	5.223	<0.0001

Table S13: Northern Hemisphere, latitudes between 15 and 35° – TRENDY ensemble (R^2_m=0.30; R^2_c=0.35)

	Value	SE	DF	*t*	*P*
(Intercept)	-68.340	7.518	7456	-9.090	<0.0001
cdioxide	0.198	0.020	7456	10.124	<0.0001
MAP.an	0.170	0.005	7456	37.363	<0.0001
MAP.c	0.008	0.001	389	12.135	<0.0001
MAT.an	-1.954	1.747	7456	-1.119	0.2633
MAT.c	-0.194	0.061	389	-3.195	0.0015
SPEI	-3.494	1.050	7456	-3.327	0.0009
Forests.mean	-4.296	2.422	389	-1.773	0.0770
Forests.an	-553.870	69.076	7456	-8.018	<0.0001
Crops.an	7186.625	953.175	7456	7.540	<0.0001
MAP.an:MAP.c	0.000	0.000	7456	-30.362	<0.0001
MAT.an:MAT.c	-0.470	0.081	7456	-5.788	<0.0001
MAP.c:SPEI	0.008	0.002	7456	4.898	<0.0001
Forests.mean:Forests.an	1533.238	146.520	7456	10.464	<0.0001
cdioxide:Crops.an	-19.228	2.502	7456	-7.686	<0.0001

Table S14: Equatorial belt, latitudes between 15°S and 15°N – MACC-II (R^2_m=0.15; R^2_c=0.48)

	Value	SE	DF	*t*	*P*
(Intercept)	183.608	47.826	9755	3.839	0.0001
cdioxide	0.107	0.081	9755	1.321	0.1867
MAP.an	-0.362	0.062	9755	-5.805	<0.0001
MAP.c	-0.134	0.031	508	-4.390	<0.0001
MAT.an	-673.146	57.219	9755	-11.764	<0.0001
MAT.c	-8.489	1.417	508	-5.993	<0.0001
Forests.mean	-773.117	73.978	508	-10.451	<0.0001
Forests.an	5470.146	1507.142	9755	3.629	0.0003
Crops.mean	-1426.739	189.017	508	-7.548	<0.0001
Crops.an	13000.868	1276.836	9755	10.182	<0.0001
cdioxide:MAP.an	0.001	0.000	9755	5.862	<0.0001
cdioxide:MAT.an	1.727	0.152	9755	11.397	<0.0001
MAP.c:MAT.c	0.005	0.001	508	4.541	<0.0001
cdioxide:Forests.mean	1.833	0.194	9755	9.445	<0.0001
cdioxide:Forests.an	-14.186	3.980	9755	-3.564	0.0004
cdioxide:Crops.mean	3.844	0.497	9755	7.739	<0.0001
cdioxide:Crops.an	-34.276	3.343	9755	-10.255	<0.0001

Table S15: Equatorial belt, latitudes between 15°S and 15°N – Jena CarboScope (R^2_m=0.07; R^2_c=0.78)

	Value	SE	DF	*t*	*P*
(Intercept)	-231.111	61.688	4056	-3.746	0.0002
cdioxide	0.576	0.159	4056	3.628	0.0003
MAT.an	-916.973	111.309	4056	-8.238	<0.0001
Forests.mean	-1654.001	183.348	211	-9.021	<0.0001
Forests.an	922.283	165.588	4056	5.570	<0.0001
Urban.an	-3932.951	1345.514	4056	-2.923	0.0035
Crops.mean	-71.310	61.180	211	-1.166	0.2451
Crops.an	9437.141	1957.146	4056	4.822	<0.0001
cdioxide:MAT.an	2.324	0.295	4056	7.875	<0.0001
cdioxide:Forests.mean	4.236	0.478	4056	8.870	<0.0001
Forests.mean:Forests.an	-2347.530	460.780	4056	-5.095	<0.0001
cdioxide:Crops.an	-26.660	5.086	4056	-5.242	<0.0001
Crops.mean:Crops.an	2293.997	497.158	4056	4.614	<0.0001

Table S16: Equatorial belt, latitudes between 15°S and 15°N – TRENDY ensemble (R^2_m=0.39; R^2_c=0.60)

	Value	SE	DF	*t*	*P*
(Intercept)	490.827	140.772	8061	3.487	0.0005
cdioxide	-1.569	0.367	8061	-4.278	<0.0001
MAP.an	0.147	0.007	8061	22.211	<0.0001
MAP.c	0.131	0.019	419	7.042	<0.0001
MAT.an	10.027	9.465	8061	1.059	0.2895
MAT.c	-26.543	5.550	419	-4.783	<0.0001
SPEI	64.166	12.534	8061	5.120	<0.0001
Forests.mean	29.681	5.594	419	5.306	<0.0001
Forests.an	4054.263	916.317	8061	4.425	<0.0001
Urban.an	-1831.333	493.907	8061	-3.708	0.0002
Crops.mean	-106.331	9.997	419	-10.636	<0.0001
Crops.an	-167.024	26.050	8061	-6.412	<0.0001
MAP.an:MAP.c	0.000	0.000	8061	-20.128	<0.0001
cdioxide:MAT.c	0.083	0.015	8061	5.743	<0.0001
MAT.an:MAT.c	-2.361	0.374	8061	-6.308	<0.0001
MAP.c:MAT.c	-0.005	0.001	419	-7.071	<0.0001
MAP.c:SPEI	0.009	0.003	8061	3.482	0.0005
MAT.c:SPEI	-2.052	0.494	8061	-4.151	<0.0001
cdioxide:Forests.an	-10.149	2.418	8061	-4.197	<0.0001
Forests.mean:Forests.an	-610.824	134.759	8061	-4.533	<0.0001

Table S17: Southern Hemisphere, latitudes between 15 and 35° – MACC-II (R^2_m=0.09; R^2_c=0.58)

	Value	SE	DF	*t*	*P*
(Intercept)	-242.440	82.133	5081	-2.952	0.0032
cdioxide	0.660	0.212	5081	3.126	0.0018
MAP.an	0.380	0.097	5081	3.907	0.0001
MAP.c	-0.100	0.031	262	-3.280	0.0012
MAT.an	-4.550	1.104	5081	-4.116	<0.0001
MAT.c	11.390	3.814	262	2.986	0.0031
Forests.mean	-572.320	192.578	262	-2.972	0.0032
Forests.an	-825.520	86.080	5081	-9.590	<0.0001
Urban.mean	735.440	315.200	262	2.333	0.0204
Urban.an	-4607.060	680.517	5081	-6.770	<0.0001
Crops.an	284.940	40.948	5081	6.958	<0.0001
cdioxide:MAP.an	0.000	0.000	5081	-3.806	0.0001
cdioxide:MAT.c	-0.030	0.010	5081	-3.038	0.0024
MAP.c:MAT.c	0.000	0.001	262	3.389	0.0008
cdioxide:Forests.mean	1.530	0.504	5081	3.026	0.0025
Forests.mean:Forests.an	2305.430	391.332	5081	5.891	<0.0001
Urban.mean:Urban.an	81024.440	14792.053	5081	5.478	<0.0001

Table S18: Southern Hemisphere, latitudes between 15 and 35° – Jena CarboScope (R^2_m=0.15; R^2_c=0.95)

	Value	SE	DF	*t*	*P*
(Intercept)	-19.308	19.218	2066	-1.005	0.3152
cdioxide	0.063	0.042	2066	1.502	0.1332
MAT.an	-183.420	32.543	2066	-5.636	<0.0001
Forests.mean	-1077.137	124.092	106	-8.680	<0.0001
Crops.mean	-384.891	89.924	106	-4.280	<0.0001
Crops.an	213.558	34.207	2066	6.243	<0.0001
cdioxide:MAT.an	0.457	0.086	2066	5.336	<0.0001
cdioxide:Forests.mean	2.798	0.283	2066	9.882	<0.0001

Table S19: Southern Hemisphere, latitudes between 15 and 35° – TRENDY ensemble (R^2_m=0.55; R^2_c=0.60)

	Value	SE	DF	*t*	*P*
(Intercept)	-45.408	17.113	4816	-2.653	0.0080
cdioxide	0.174	0.043	4816	4.088	<0.0001
MAP.an	0.346	0.009	4816	39.371	<0.0001
MAP.c	-0.041	0.011	248	-3.612	0.0004
MAT.an	-22.058	0.997	4816	-22.129	<0.0001
MAT.c	-0.640	0.289	248	-2.211	0.0280
SPEI	-23.135	3.024	4816	-7.651	<0.0001
Forests.mean	-649.653	162.990	248	-3.986	0.0001
Forests.an	-7245.744	1048.986	4816	-6.907	<0.0001
Urban.an	-1210.500	308.180	4816	-3.928	0.0001
Crops.mean	-38.742	10.446	248	-3.709	0.0003
MAP.an:MAP.c	0.000	0.000	4816	-28.136	<0.0001
MAP.c:MAT.c	0.002	0.001	248	3.365	0.0009
MAP.c:SPEI	0.043	0.004	4816	10.075	<0.0001
cdioxide:Forests.mean	1.755	0.429	4816	4.089	<0.0001
cdioxide:Forests.an	20.440	2.740	4816	7.460	<0.0001

Table S20: Southern Hemisphere, latitudes between 35 and 55° – MACC-II (R^2_m=0.16; R^2_c=0.29)

	Value	SE	DF	*t*	*P*
(Intercept)	841.089	175.678	1664	4.788	<0.0001
cdioxide	-2.235	0.463	1664	-4.828	<0.0001
MAT.an	20.909	7.317	1664	2.858	0.0043
MAT.c	-67.293	15.352	84	-4.383	<0.0001
Forests.mean	118.721	23.271	84	5.102	<0.0001
Forests.an	-12027.914	2731.858	1664	-4.403	<0.0001
Crops.mean	-1729.768	445.845	84	-3.880	0.0002
Crops.an	267.144	68.516	1664	3.899	0.0001
cdioxide:MAT.c	0.181	0.041	1664	4.472	<0.0001
MAT.an:MAT.c	-2.178	0.630	1664	-3.455	0.0006
cdioxide:Forests.an	30.931	7.120	1664	4.344	<0.0001
cdioxide:Crops.mean	4.530	1.175	1664	3.855	0.0001

Table S21: Southern Hemisphere, latitudes between 35 and 55° – Jena CarboScope (R^2_m=0.003; R^2_c=0.95)

	Value	SE	DF	*t*	*P*
(Intercept)	-39.683	8.216	834	-4.830	<0.0001
cdioxide	0.097	0.019	834	5.180	<0.0001
Crops.an	68.632	11.319	834	6.063	<0.0001

Table S22: Southern Hemisphere, latitudes between 35 and 55° – TRENDY ensemble (R^2_m=0.46; R^2_c=0.58)

	Value	SE	DF	*t*	*P*
(Intercept)	350.908	67.256	1206	5.218	<0.0001
cdioxide	-0.925	0.177	1206	-5.243	<0.0001
MAP.an	0.037	0.012	1206	2.955	0.0032
MAP.c	0.012	0.002	60	5.191	<0.0001
MAT.an	37.053	5.352	1206	6.924	<0.0001
MAT.c	-31.635	5.807	60	-5.448	<0.0001
SPEI	-18.042	7.769	1206	-2.322	0.0204
Crops.mean	-35.806	12.237	60	-2.926	0.0048
Crops.an	-7670.795	829.101	1206	-9.252	<0.0001
cdioxide:MAT.c	0.084	0.015	1206	5.483	<0.0001
MAT.an:MAT.c	-3.921	0.450	1206	-8.712	<0.0001
MAP.c:SPEI	-0.042	0.006	1206	-7.507	<0.0001
MAT.c:SPEI	6.182	0.592	1206	10.445	<0.0001
cdioxide:Crops.an	19.649	2.153	1206	9.126	<0.0001

3 Europe and the USA (analyses of atmospheric deposition)

Additional abbreviations: N_{OX}.mean, oxidised nitrogen deposition averaged per pixel; N_{OX}.an, N_{OX} interannual deviation from the mean; N_{RED}.mean, reduced nitrogen deposition averaged per pixel; N_{RED}.an, N_{RED} interannual deviation from the mean; S.mean, mean S deposition per pixel; and S.an, S interannual deviation from the mean.

Table S23: Model using atmospheric deposition for Europe and the US – MACC-II (R^2_m=0.22; R^2_c=0.49)

	Value	SE	DF	*t*	*P*
(Intercept)	-40.893	35.980	12635	-1.137	0.2558
cdioxide	0.044	0.094	12635	0.468	0.6396
N_{OX}.mean	33.048	6.284	656	5.259	<0.0001
N_{OX}.an	481.225	82.496	12635	5.833	<0.0001
N_{RED}.mean	-299.383	28.774	656	-10.405	<0.0001
N_{RED}.an	15.835	2.507	12635	6.316	<0.0001
S.mean	183.977	15.764	656	11.671	<0.0001
S.an	-0.005	1.149	12635	-0.004	0.9965
MAP.c	-0.008	0.008	656	-0.980	0.3274
MAT.an	-118.061	22.241	12635	-5.308	<0.0001
MAT.c	0.396	0.255	656	1.551	0.1214
SPEI	-7.308	1.844	12635	-3.963	0.0001
Forests.mean	55.145	9.435	656	5.845	<0.0001
Forests.an	-16349.819	4977.417	12635	-3.285	0.001
Urban.mean	299.800	90.998	12635	3.295	0.001
Urban.an	476.701	612.090	12635	0.779	0.4361
Crops.mean	-3.279	16.432	656	-0.200	0.8419
Crops.an	1094.763	159.344	12635	6.870	<0.0001
cdioxide:N_{OX}.an	-1.329	0.220	12635	-6.037	<0.0001
cdioxide:N_{RED}.mean	0.836	0.075	12635	11.114	<0.0001
cdioxide:S.mean	-0.440	0.041	12635	-10.710	<0.0001
N_{OX}.an:S.an	4.108	1.204	12635	3.412	0.0006
N_{OX}.mean:S.mean	-7.487	0.887	656	-8.444	<0.0001
cdioxide:MAT.an	0.297	0.059	12635	5.066	<0.0001
MAP.c:MAT.c	-0.005	0.000	656	-9.135	<0.0001
cdioxide:Forests.an	49.106	13.067	12635	3.758	0.0002
Forests.mean:Forests.an	-4423.097	705.891	12635	-6.266	<0.0001
Urban.mean:Urban.an	-17270.851	5511.130	12635	-3.134	0.0017
Crops.mean:Crops.an	-3545.647	350.347	12635	-10.120	<0.0001

Table S24: Model using atmospheric deposition for Europe and the US – Jena CarboScope (R^2_m=0.33; R^2_c=0.73)

	Value	SE	DF	*t*	*P*
(Intercept)	94.055	57.772	4539	1.628	0.1036
cdioxide	-0.088	0.149	4539	-0.592	0.5536
N_{OX}.mean	36.936	11.080	232	3.334	0.0010
N_{OX}.an	-824.383	139.292	4539	-5.918	<0.0001
N_{RED}.mean	-321.085	31.616	232	-10.156	<0.0001
N_{RED}.an	403.022	119.088	4539	3.384	0.0007
S.mean	-16.923	3.351	232	-5.050	<0.0001
S.an	250.057	45.066	4539	5.549	<0.0001
MAP.an	0.068	0.015	4539	4.688	<0.0001
MAP.c	0.227	0.080	232	2.850	0.0048
MAT.an	-97.148	28.983	4539	-3.352	0.0008
MAT.c	-1.785	0.601	232	-2.970	0.0033
SPEI	0.618	4.212	4539	0.147	0.8833
Forests.mean	-25.323	24.202	232	-1.046	0.2965
Forests.an	27919.339	5827.135	4539	4.791	<0.0001
Crops.mean	-94.767	31.392	232	-3.019	0.0028
Crops.an	516.327	84.094	4539	6.140	<0.0001
cdioxide:N_{OX}.an	2.206	0.373	4539	5.911	<0.0001
cdioxide:N_{RED}.mean	0.924	0.081	4539	11.430	<0.0001
cdioxide:N_{RED}.an	-1.131	0.313	4539	-3.607	0.0003
N_{RED}.mean:N_{RED}.an	5.735	1.741	4539	3.295	0.001
cdioxide:S.an	-0.659	0.121	4539	-5.457	<0.0001
N_{OX}.an:N_{RED}.an	49.57	6.295	4539	7.875	<0.0001
N_{RED}.an:S.an	-13.216	3.089	4539	-4.279	<0.0001
cdioxide:MAP.c	-0.001	0.000	4539	-3.456	0.0006
cdioxide:MAT.an	0.26	0.076	4539	3.403	0.0007
MAP.c:SPEI	-0.027	0.009	4539	-3.107	0.0019
cdioxide:Forests.an	-77.124	15.423	4539	-5.000	<0.0001
Forests.mean:Forests.an	2464.264	776.224	4539	3.175	0.0015

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