Supplement of Geosci. Model Dev., 17, 6725–6744, 2024
https://doi.org/10.5194/gmd-17-6725-2024-supplement

Geoscientific
Model Development

Supplement of

Impacts of land-use change on biospheric carbon: an oriented benchmark using the ORCHIDEE land surface model

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Supplementary Material

S1. Idealised land-use change (LUC) simulations using realistic land-use transition matrices

We performed additional simulations to account for transition years specific to each site. These simulations are similar to the idealised LUC simulations presented in Sect. 2.3.2, involving two main processes: (1) the spin-up simulation FG1 to establish the equilibrium state for each land cover type, and (2) the historical simulation FG2. In the second step, we conducted FG2 using land-use transition matrices instead of a fixed 1950 transition year. The land-use transition matrix is constructed based on the land cover change and transition year information. For example, to perform the LUC from forest to crop (e.g. Temperate needleleaf evergreen forest (TeNE) to C_3 crop (C_3C)), the land cover is initially set to 100 % TeNE for all grid cells across Europe. Then, we adjusted this map to carry out the LUC by setting the land cover at the respective grid cell to 100 % C_3C at the corresponding transition year. This grid cell is then kept constant for the remainder of the simulation time. The simulation stops at the observed experiment year.

The land-use transition matrices depend on the observed transition information. However, this information may not always be provided in the meta-analyses (Tab. 2). Only 53 of the 102 study sites have a specific LUC year reported. Therefore, sites without transition year information are excluded. Additionally, within one study or one observation field, observation sites are often very close to each other. On the other hand, the ORCHIDEE model has a spatial resolution of 0.5° × 0.5°. Therefore, if multiple observation sites are located in the same grid cell, only one sample is chosen. The final number of selected samples for each LUC transition case is shown in Fig. S5. Due to the limited number of samples, we do not conduct additional fitted carbon response functions (CRFs, see Sect. 2.4.2).

The comparisons of observed and simulated SOC changes for different LUC transitions are shown in Fig. S5. Here, we directly compared the observed absolute change in SOC with the corresponding simulated change for each selected site. The observed and simulated CRFs (see Tab. S6) that are based on available observation sites and the assumed LUC year 1950 are presented for comparison.

The simulated responses in both cases — with the individually reported transition years (Fig. S5) and the idealised transition year in 1950 (Fig. 6) — show similarities: the model aligns with the observed changes but underestimates the amount of carbon gained or lost. The improvement is not significant for several reasons. One major factor could be the absence of site historical information. Although the exact transition year is known, accurately reconstructing the land use history of a particular site is impossible. Additionally, most experiments utilise paired plots or chronosequences to compare two adjacent sites: one with the original land cover and the other with new land cover following LUC. On the other hand, our simulations consider only a single site within a grid cell, analysing its behaviour before and after the LUC. This approach is used to accommodate the current European scope of the analysis and to minimise computational costs. More realistic simulations incorporating detailed information on land use history at a site-specific scale would provide more precise and reliable results.

Table S1: Net primary production (NPP) sites from Luyssaert et al. (2007).

ID	**Site**	**Latitude (° N)**	**Longitude (° E)**	**Ecosystem type**
1	Aheden	64.20	19.50	Forest
2	Aubure (F)	48.20	7.18	Forest
3	Aubure (P)	48.20	7.18	Forest
4	Belgium	51.20	5.00	Forest
5	Bornhoved Alder	54.10	10.20	Forest
6	Bornhoved Beech	54.10	10.20	Forest
7	Brasschaat Oak	51.30	4.52	Forest
8	Brasschaat Pine	51.30	4.52	Forest
9	Collelongo	41.80	13.60	Forest
10	Dooary	53.00	-7.30	Forest
11	Finland 1	60.50	23.90	Forest
12	Finland 2	60.50	23.90	Forest
13	Flakaliden C	64.10	19.50	Forest
14	Flakaliden I + F	64.10	19.50	Forest
15	France	48.40	2.70	Forest
16	Gribskov	56.00	12.30	Forest
17	Hainich	51.10	10.40	Forest
18	Hesse	48.70	7.07	Forest
19	Hestehaven	56.30	10.50	Forest
20	Hungary	47.90	20.50	Forest
21	Ilomantsi 1	62.80	31.00	Forest
22	Ilomantsi 2	62.80	31.00	Forest
23	Ilomantsi 3	62.80	31.00	Forest
24	Ilomantsi 4	62.80	31.00	Forest
25	Ispina Krakow	50.10	20.40	Forest
26	Jädraas C	60.80	16.50	Forest
27	Jädraas I + F	60.80	16.50	Forest
28	Jezeri	50.50	13.50	Forest
29	Kannenbruch Alder/Ash	53.80	10.60	Forest
30	Kannenbruch Beech	53.80	10.60	Forest
31	Kannenbruch Oak	53.80	10.60	Forest
32	Karelia_1	62.00	34.00	Forest
33	Karelia_10	62.00	34.00	Forest
34	Karelia_11	62.00	34.00	Forest
35	Karelia_12	62.00	34.00	Forest
36	Karelia_13	62.00	34.00	Forest
37	Karelia_14	62.00	34.00	Forest
38	Karelia_15	62.00	34.00	Forest
39	Karelia_16	62.00	34.00	Forest
40	Karelia_17	62.00	34.00	Forest
41	Karelia_2	62.00	34.00	Forest
42	Karelia_3	62.00	34.00	Forest
43	Karelia_4	62.00	34.00	Forest
44	Karelia_5	62.00	34.00	Forest
45	Karelia_6	62.00	34.00	Forest
46	Karelia_7	62.00	34.00	Forest
47	Karelia_8	62.00	34.00	Forest

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Table S1 – continued from previous page

ID	Site	Latitude (° N)	Longitude (° E)	Ecosystem type
48	Karelia_9	62.00	34.00	Forest
49	Klosterhede	56.50	8.40	Forest
50	Kongalund B	56.00	13.20	Forest
51	Kongalund S	56.00	13.20	Forest
52	Kuusamo	66.40	29.30	Forest
53	Langarod	55.80	13.90	Forest
54	Lei-135+15	51.30	10.40	Forest
55	Lei-30	51.30	10.40	Forest
56	Lei-62	51.30	10.40	Forest
57	Lei-T-111	51.30	10.40	Forest
58	Linnebjer	55.70	13.30	Forest
59	Loobos	52.20	5.74	Forest
60	Meathop	54.20	-2.90	Forest
61	Monte di Mezzo	41.80	14.90	Forest
62	Nacetin	50.60	13.30	Forest
63	Oved	55.70	13.60	Forest
64	Popface alba	42.40	11.80	Forest
65	Popface euamericana	42.40	11.80	Forest
66	Popface nigra	42.40	11.80	Forest
67	Schacht	50.10	11.80	Forest
68	Skogaby	56.50	13.20	Forest
69	Solling	51.80	9.58	Forest
70	Soroe	55.50	11.60	Forest
71	Tharandt	51.00	13.60	Forest
72	Tharandt 24	50.90	13.50	Forest
73	Tharandt 42	50.90	13.50	Forest
74	Tharandt 5	50.90	13.50	Forest
75	Tharandt 97	50.90	13.50	Forest
76	Virelles	50.10	4.35	Forest
77	Waldstein	50.20	11.90	Forest
78	Wet-T-57	50.50	11.50	Forest
79	Wytham Woods	51.50	-1.30	Forest

Table S2: Gross primary production (GPP) sites from Luyssaert et al. (2007).

ID	**Site**	**Latitude (° N)**	**Longitude (° E)**	**Ecosystem type**
1	Aberfeldy/Griffins	56.60	-3.78	Forest
2	Bayreuth/Weiden Brunnen	50.15	11.87	Forest
3	Bilos	44.49	-0.96	Forest
4	Bilos Clear	44.48	0.87	Forest
5	Bily Kriz Forest	49.50	18.54	Forest
6	Bornhoved Alder	54.10	10.23	Forest
7	Bornhoved Beech	54.10	10.23	Forest
8	Brasschaat	51.31	4.52	Forest
9	Castelporziano	41.71	12.38	Forest
10	Collelongo	41.85	13.59	Forest
11	Dooary	52.95	-7.25	Forest
12	El Saler	39.35	-0.32	Forest
13	Espirra	38.64	-8.60	Forest
14	Flakaliden C	64.12	19.45	Forest
15	Fyedorovskoye	56.45	32.92	Forest
16	Hainich	51.08	10.45	Forest
17	Hampshire	51.12	-0.86	Forest
18	Hardwood	55.10	-2.05	Forest
19	Hardwood Clear	55.10	-2.05	Forest
20	Hardwood_21	55.10	-2.05	Forest
21	Hardwood_7	55.10	-2.05	Forest
22	Hesse	48.67	7.07	Forest
23	Hyytiala	61.85	24.30	Forest
24	Hyytiala 12	61.85	24.30	Forest
25	Hyytiala 75	61.85	24.30	Forest
26	Hyytiala Clear	61.85	24.30	Forest
27	Ilomantsi Mekrijärvi	62.78	30.97	Forest
28	Kannenbruch Alder/Ash	53.78	10.60	Forest
29	Kannenbruch Beech	53.78	10.60	Forest
30	Kannenbruch Oak	53.78	10.60	Forest
31	La Majadas del Tietar	39.94	-5.77	Forest
32	La Mandria	45.58	7.15	Forest
33	Lavarone	45.96	11.28	Forest
34	Le Bray	44.72	-0.77	Forest
35	Loobos	52.17	5.74	Forest
36	Mehrstedt	51.28	10.66	Forest
37	Mitra	38.54	-8.00	Forest
38	Nonantola	44.69	11.09	Forest
39	Norunda	60.09	17.48	Forest
40	Parco Ticino	45.20	9.06	Forest
41	Popface alba	42.36	11.80	Forest
42	Popface euamericana	42.36	11.80	Forest
43	Popface nigra	42.36	11.80	Forest
44	Puechabon	43.72	3.58	Forest
45	Renon	46.59	11.43	Forest
46	Roccarespampami 1	42.41	11.93	Forest
47	San Rossore	43.73	10.28	Forest

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Table S2 – continued from previous page

ID	Site	Latitude (° N)	Longitude (° E)	Ecosystem type
48	Skyttorp1	60.13	17.92	Forest
49	Skyttorp2	60.13	17.84	Forest
50	Sodankylä	67.36	26.64	Forest
51	Solling	51.82	9.58	Forest
52	Soroe	55.49	11.65	Forest
53	Tharandt	50.96	13.57	Forest
54	Vielsalm	50.31	6.00	Forest
55	Wet-T-57	50.45	11.46	Forest
56	Wytham Woods	51.46	-1.32	Forest

Table S3: Gross primary production (GPP) sites from FLUXNET and ICOS (Pastorello et al., 2020).

ID	Site	Latitude (° N)	Longitude (° E)	Ecosystem type	Source
1	Sodankyla	67.36	26.64	Forest	FLUXNET
2	Degero	64.18	19.56	Grassland	ICOS
3	Hyytiala	61.85	24.29	Forest	FLUXNET
4	Jokioinen	60.90	23.51	Cropland	FLUXNET
5	Lettosuo	60.64	23.96	Forest	FLUXNET
6	Norunda	60.09	17.48	Forest	ICOS
7	Foulum	56.48	9.59	Cropland	FLUXNET
8	Fyodorovskoye	56.46	32.92	Forest	FLUXNET
9	Hyltemossa	56.10	13.42	Forest	ICOS
10	Voulundgaard	56.04	9.16	Cropland	ICOS
11	Enghave	55.69	12.19	Grassland	FLUXNET
12	Soroe	55.49	11.64	Forest	FLUXNET, ICOS
13	Horstermeer	52.24	5.07	Grassland	FLUXNET
14	Loobos	52.17	5.74	Forest	FLUXNET
15	Hohes Holz	52.09	11.22	Forest	ICOS
16	Leinefelde	51.33	10.37	Forest	FLUXNET
17	Brasschaat	51.31	4.52	Forest	FLUXNET, ICOS
18	Gebesee	51.10	10.91	Cropland	FLUXNET, ICOS
19	Hainich	51.08	10.45	Forest	FLUXNET
20	Tharandt	50.96	13.57	Forest	FLUXNET, ICOS
21	Grillenburg	50.95	13.51	Grassland	FLUXNET
22	Klingenberg	50.89	13.52	Cropland	FLUXNET
23	Selhausen Juelich	50.87	6.45	Cropland	FLUXNET, ICOS
24	Selhausen	50.87	6.45	Cropland	FLUXNET
25	Oberb„renburg	50.79	13.72	Forest	FLUXNET
26	Rollesbroich	50.62	6.30	Grassland	FLUXNET
27	Lonzee	50.55	4.75	Cropland	FLUXNET, ICOS
28	Vielsalm	50.30	6.00	Forest	FLUXNET, ICOS
29	Bily Kriz forest	49.50	18.54	Forest	FLUXNET, ICOS
30	Bily Kriz grassland	49.49	18.54	Grassland	FLUXNET
31	Lackenberg	49.10	13.30	Forest	FLUXNET
32	Grignon	48.84	1.95	Cropland	FLUXNET, ICOS
33	Lanzhot	48.68	16.95	Forest	ICOS
34	Fontainebleau-Barbeau	48.48	2.78	Forest	FLUXNET, ICOS
35	Laegern	47.48	8.36	Forest	FLUXNET
36	Oensingen crop	47.29	7.73	Cropland	FLUXNET
37	Oensingen grassland	47.29	7.73	Grassland	FLUXNET
38	Chamau	47.21	8.41	Grassland	FLUXNET
39	Frebel	47.12	8.54	Grassland	FLUXNET
40	Davos	46.82	9.86	Forest	FLUXNET
41	Renon	46.59	11.43	Forest	FLUXNET, ICOS
42	Monte Bondone	46.01	11.05	Grassland	FLUXNET
43	Lavarone	45.96	11.28	Forest	FLUXNET
44	Lavarone2	45.95	11.29	Forest	FLUXNET
45	Torgnon	45.84	7.58	Grassland	FLUXNET
46	Ispra ABC-IS	45.81	8.63	Forest	FLUXNET

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Table S3 – continued from previous page

ID	Site	Latitude (° N)	Longitude (° E)	Ecosystem type	Source
47	Parco Ticino forest	45.20	9.06	Forest	FLUXNET
48	Le Bray	44.72	-0.77	Forest	FLUXNET
49	Bilos	44.49	-0.96	Forest	ICOS
50	Puechabon	43.74	3.60	Forest	FLUXNET, ICOS
51	San Rossore 2	43.73	10.29	Forest	FLUXNET
52	San Rossore	43.73	10.28	Forest	FLUXNET
53	Lamasquere	43.50	1.24	Cropland	ICOS
54	Roccarespampani 1	42.41	11.93	Forest	FLUXNET
55	Roccarespampani 2	42.39	11.92	Forest	FLUXNET
56	Castel d'Asso2	42.38	12.03	Cropland	FLUXNET
57	Castel d'Asso1	42.38	12.03	Forest	FLUXNET
58	Castel d'Asso3	42.38	12.02	Forest	FLUXNET
59	Collelongo	41.85	13.59	Forest	FLUXNET
60	Castelporziano	41.71	12.38	Forest	FLUXNET
61	Castelporziano2	41.70	12.36	Forest	FLUXNET, ICOS
62	Borgo Cioffi	40.52	14.96	Cropland	FLUXNET

Table S4: Gross primary production (GPP) sites from Campioli et al. (2015).

ID	Site	Latitude (° N)	Longitude (° E)	Ecosystem type
1	Aurade	43.55	1.11	Cropland
2	Lamasquere	43.50	1.24	Cropland
3	Grignon	48.84	1.95	Cropland
4	Lonzee_winter_wheat	50.55	4.74	Cropland
5	Lonzee_sugar_beet	50.55	4.74	Cropland
6	Lonzee_potato	50.55	4.74	Cropland
7	Avignon	43.92	4.88	Cropland
8	Lutjewad	53.40	6.36	Cropland
9	Oensingen	47.29	7.73	Cropland
10	Gebesee	51.10	10.91	Cropland
11	Risbyholm	55.53	12.10	Cropland
12	Beano1	46.00	13.02	Cropland
13	Klingenberg	50.89	13.52	Cropland
14	Dooary	52.95	-7.25	Forest
15	Wytham_Woods	51.46	-1.32	Forest
16	Puechabon	43.74	3.60	Forest
17	Lochristi	51.11	3.85	Forest
18	Hesse	48.67	7.07	Forest
19	Bornhoved_Alder	54.10	10.23	Forest
20	Bornhoved_Beech	54.10	10.23	Forest
21	Hainich	51.08	10.45	Forest
22	Kannenbruch_AlderAsh	53.78	10.60	Forest
23	Kannenbruch_Beech	53.78	10.60	Forest
24	Kannenbruch_Oak	53.78	10.60	Forest
25	Caldaro	46.35	11.27	Forest
26	Soroe	55.49	11.64	Forest
27	Popface_alba	42.36	11.80	Forest
28	Popface_euamericana	42.36	11.80	Forest
29	Popface_nigra	42.36	11.80	Forest
30	Tharandt	50.96	13.57	Forest
31	Collelongo	41.85	13.59	Forest
32	Flakaliden_C	64.11	19.46	Forest
33	Beano2	46.00	13.02	Grassland
34	Grillenburg	50.95	13.51	Grassland
35	Kursk	51.67	36.50	Grassland

Table S5: List of studies included in the meta-analysis for different land-use change (LUC) transitions: cropland-to-grassland (C-to-G), grassland-to-cropland (G-to-C), cropland-to-forest (C-to-F), grassland-to-forest (G-to-F), and forest-to-cropland (F-to-C). Three designs include P—paired plots, C—chronosequences, or M—mono-site samplings; N is the number of samples.

ID	**Country**	**Design**	**N**	**Depth (cm)**	**LUC transitions**	**Reference**
1	Italy	P	5	30	G-to-F, C-to-F	Alberti et al. (2011)
2	Italy	C	10	30	G-to-F	Alberti et al. (2008)
3	Crete	C	2	15	C-to-G	Apostolakis et al. (2017)
4	France	P	14	50	F-to-C	Arrouays and Pelissier (1994)
5	England	C	12	40	G-to-F, C-to-F	Ashwood et al. (2019)
6	Italy	C	8	30	C-to-F	Badalamenti et al. (2019)
7	Denmark	C	30	25	C-to-G, C-to-F	Bárcena et al. (2014)
8	Ireland	C	5	30	G-to-F	Black et al. (2009)
9	Germany	C	7	20	C-to-G	Breuer et al. (2006)
10	Turkey	P	1	20	G-to-C	Celik (2005)
11	Germany	P	12	20	C-to-G	Chen et al. (2009)
12	Italy	C	20	30	G-to-F, C-to-G, C-to-F	Tommaso et al. (2018)
13	Russia	C	4	20	C-to-G	lopes de Gerenyu et al. (2008)
14	Italy	M	2	30	G-to-C, C-to-F	Del Galdo et al. (2003)
15	Germany	P	2	50	C-to-G	Don et al. (2009)
16	Turkey	P	1	70	F-to-G	Gol and Dengiz (2008)
17	Russia	M	1	60	F-to-G	Heikkinen et al. (2014)
18	Germany	M	3	60	G-to-C, F-to-G	John et al. (2005)
19	France	M	6	25	F-to-C	Jolivet et al. (1997)
20	France	M	13	20	F-to-C	Jolivet et al. (2003)
21	Germany	M	3	30	C-to-G	Hofmann-Schielle et al. (1999)
22	Sweden	C	9	20	G-to-C, C-to-G	Kätterer et al. (2008)
23	Russia	M	3	20	C-to-G	Larionova et al. (2003)
24	Germany	P	4	30	G-to-C, C-to-G	Leifeld and Kögel-Knabner (2005)
25	Italy	P	3	40	G-to-C	Papini et al. (2011)
26	Ireland	P	2	30	G-to-F	Peichl et al. (2012)
27	Austria, Denmark, Germany, Ireland, Italy, Lithuania, Netherlands, Scotland, Sweden, Switzerland	P	24	80	C-to-G, G-to-C, G-to-F, C-to-F	Poeplau and Don (2013)
28	England	P	7	69	C-to-F, C-to-G	Poulton et al. (2003)
29	Spain	M	12	30	C-to-F	Romanyà et al. (2000)

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ID	Country	Design	N	Depth (cm)	LUC transitions	Reference
30	Germany	C	7	29	G-to-C	Springob et al. (2001)
31	Italy, Germany	C	26	50	G-to-C	Thuille and Schulze (2006)
32	Sweden, Denmark, Netherlands	C	60	25	C-to-F	Vesterdal et al. (2007)
33	Ireland	P	42	30	G-to-F	Wellock et al. (2011)
34	England	C	4	10	F-to-F	Zerva et al. (2005)

Table S6: The observed carbon response function (CRF) and the leave-one-out coefficient of determination (R^2) measure for each land-use change (LUC) scenario in meta-analyses. (R^2 values range from 0 to 1, where values closer to 1 indicate better predictive performance of the model.)

LUC	ID	Model	R^2
Cropland-to-grassland	C-to-G	$0.85 \times age + 11.75$	0.57
Grassland-to-cropland	G-to-C	$-13.92 \times e^{age/133.80}$	0.62
Grassland-to-forest (mineral soil or without forest floor)	G-to-F_{woFF}	$-0.10 \times age + 3.54$	0.89
Grassland to forest (with forest floor)	G-to-F_{wFF}	$0.03 \times age + 2.24$	0.58
Cropland-to-forest (mineral soil)	C-to-F_{woFF}	$0.74 \times age - 5.78$	0.99
Cropland-to-forest (with forest floor)	C-to-F_{wFF}	$1.09 \times age + 3.54$	0.52
Forest-to-cropland (mineral soil)	F-to-C_{woFF}	$-1.10 \times age - 16.03$	0.98

Table S7: The leave-one-out coefficient of determination (R^2) and root mean square error (RMSE in $kg\ m^{-2}$) between the random forest regression and model bias for each land-use change (LUC) scenario. Results with negative R^2, indicating poor regression, are not shown. Two distinct forest types, namely temperate broadleaf summergreen (TeBS) and temperate needleleaf evergreen (TeNE), are considered for the forest sites.

Forest type	LUC	ID	R^2	RMSE
	Cropland-to-grassland	C-to-G	0.13	1.25
	Grassland-to-cropland	G-to-C	0.44	1.08
TeBS	Grassland to forest (mineral soil or without forest floor)	G-to-F_{woFF}	0.19	3.59
	Grassland-to-forest (with forest floor)	G-to-F_{wFF}	-	-
	Cropland-to-forest (mineral soil)	C-to-F_{woFF}	0.26	1.92
	Cropland-to-forest (with forest floor)	C-to-F_{wFF}	-	-
	Forest-to-cropland (mineral soil)	F-to-C_{woFF}	0.11	3.03
TeNE	Grassland to forest (mineral soil or without forest floor)	G-to-F_{woFF}	0.18	3.58
	Grassland-to-forest (with forest floor)	G-to-F_{wFF}	-	-
	Cropland-to-forest (mineral soil)	C-to-F_{woFF}	0.19	2.03
	Cropland-to-forest (with forest floor)	C-to-F_{wFF}	-	-
	Forest-to-cropland (mineral soil)	F-to-C_{woFF}	0.18	3.14

Table S8: Correlation (COR) and root mean square error (RMSE in $kg\ m^{-2}$) between observed and simulated soil organic carbons ($SOC_{LUCAS\ topsoil}$ and $SOC_{derived\ ORC}$) at different grid scales (from 0.5° × 0.5° to 3° × 3° cells), for three groups of vegetation (forest, grass, and crop).

Grid scale	Forest			Grass			Crop		
	COR	RMSE ($kg\ m^{-2}$)	rRMSE (%)	COR	RMSE ($kg\ m^{-2}$)	rRMSE (%)	COR	RMSE ($kg\ m^{-2}$)	rRMSE (%)
0.5° × 0.5°	0.17	2.82	59.15	0.53	1.57	39.38	0.42	1.18	35.98
1° × 1°	0.26	2.57	52.87	0.56	1.43	35.41	0.47	1.04	30.78
2° × 2°	0.39	2.48	48.21	0.52	1.31	31.77	0.54	0.91	26.6
3° × 3°	0.45	2.36	45.59	0.68	1.14	27.43	0.59	0.88	25.39

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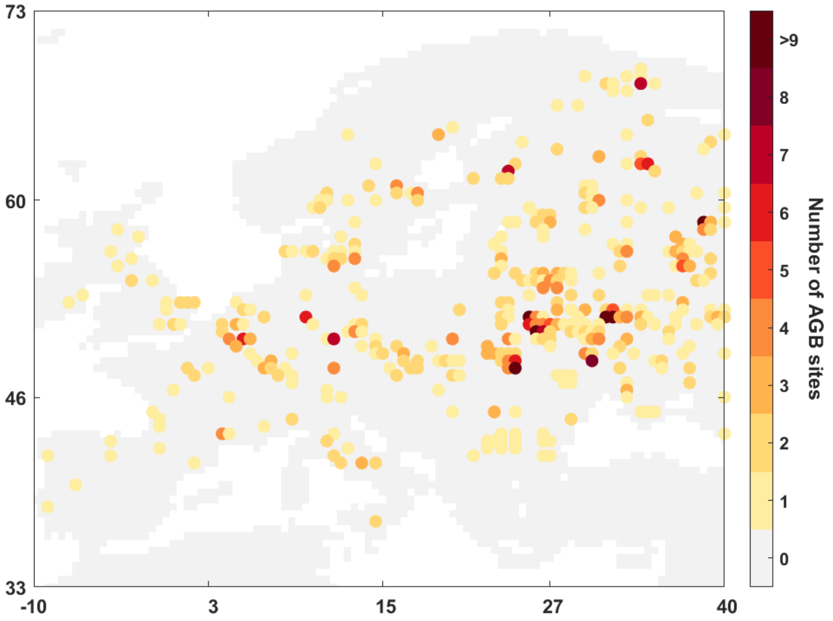

Figure S1: Map showing the observed above-ground biomass (AGB) sites included in the study.

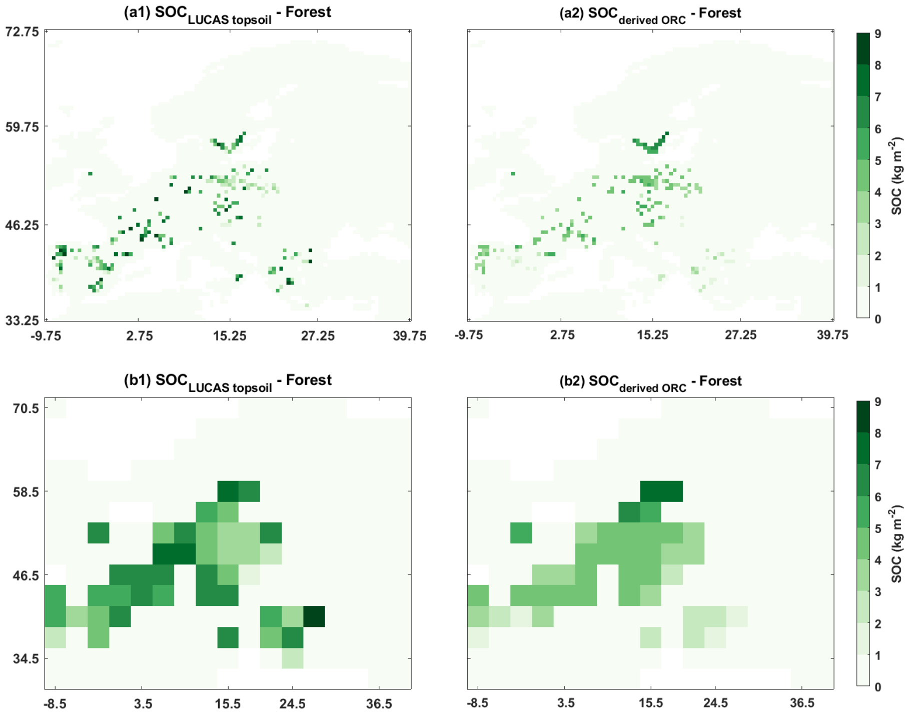

Figure S2: Maps showing the comparison between soil organic carbon of LUCAS topsoil and corresponding ORCHIDEE values (SOC$_{LUCAS\ topsoil}$ (a1,b1) and SOC$_{derived\ ORC}$ (a2,b2), in $kg\ m^{-2}$) at different grid scales (0.5° × 0.5° (a1, a2) and 3° × 3° (b1,b2)) for forest sites.

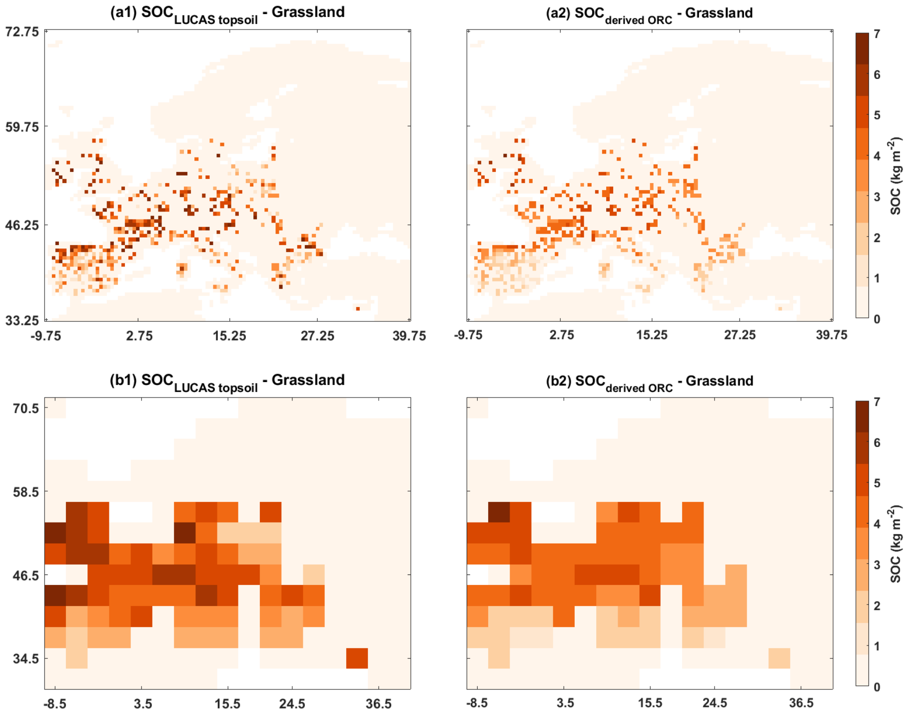

Figure S3: Same as Fig. S2, but for grassland sites.

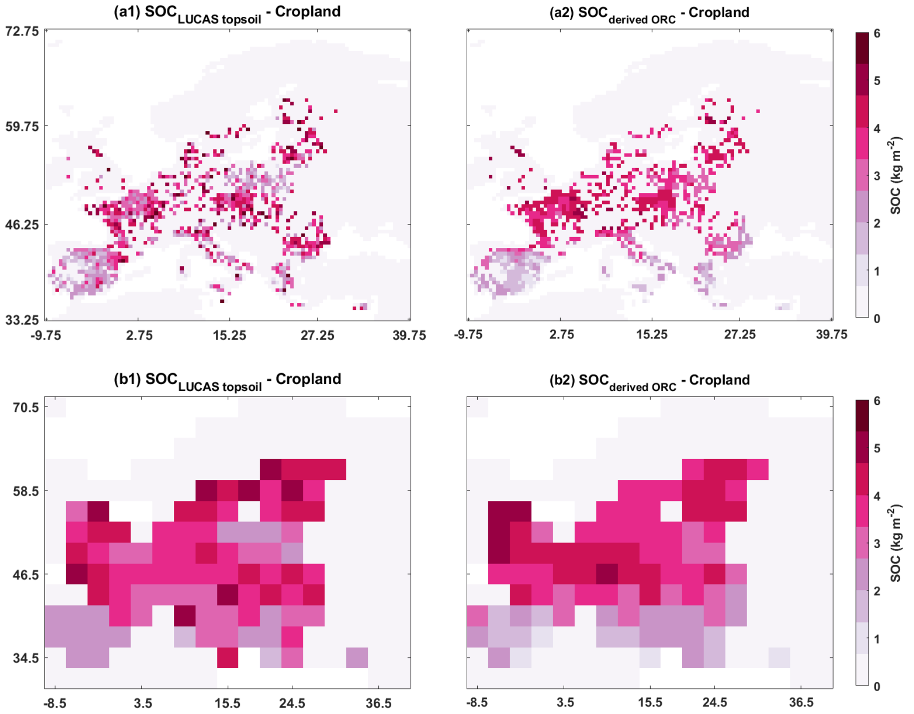

Figure S4: Same as Fig. S2, but for cropland sites.

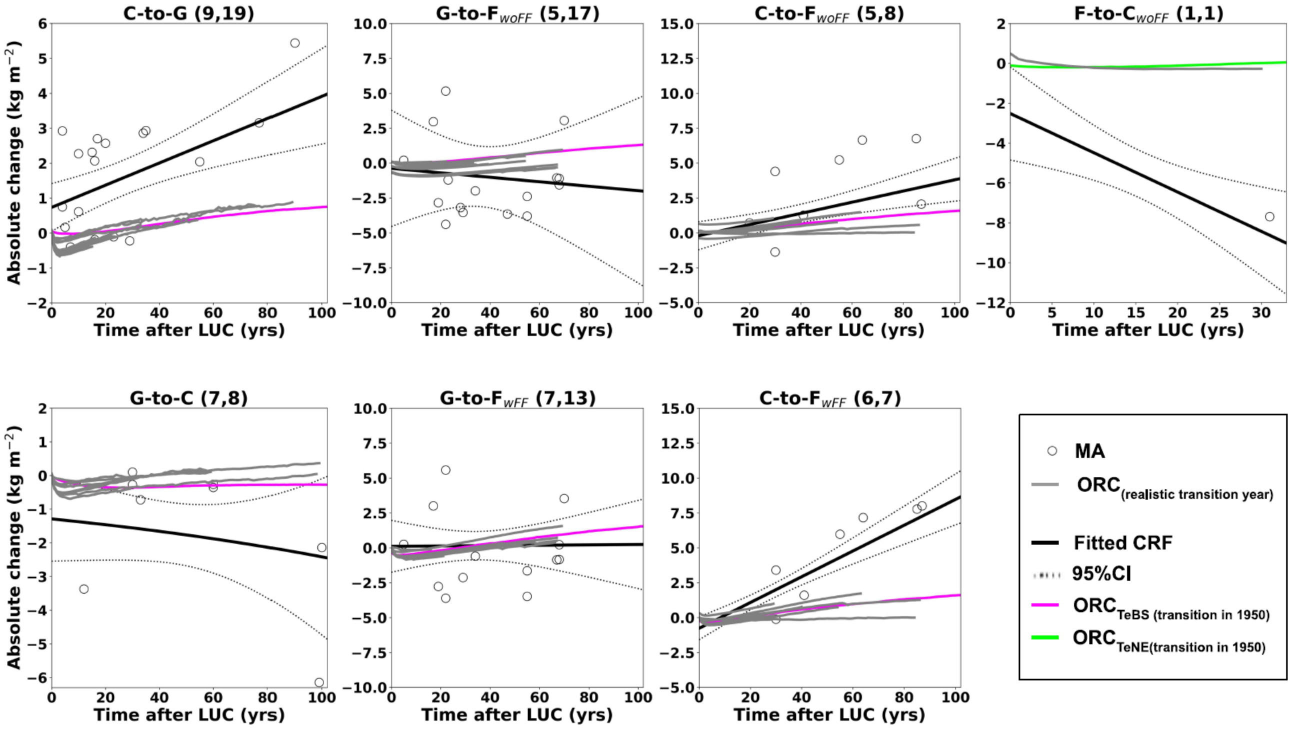

Figure S5: The absolute soil organic carbon changes (in $kg\ m^{-2}$) from site observations in meta-analyses (black circles) compared to corresponding ORCHIDEE simulated data (grey lines) for different land-use changes (LUCs: cropland-to-grassland ($C-to-G$), grassland-to-cropland ($G-to-C$), grassland-to-forest (without and with forest floor $G-to-F_{woFF}$, $G-to-F_{wFF}$), cropland-to-forest ($C-to-F_{woFF}$ and $C-to-F_{wFF}$), and forest-to-cropland ($F-to-C_{woFF}$). The first number in the parenthesis indicates the number of study sites, and the second is the number of samples in the meta-analyses. Here, temperate broadleaf summergreen (ORC$_{TeBS}$) is considered for the forest sites in all ORCHIDEE simulations, except for $F-to-C_{woFF}$ in which temperate needleleaf evergreen (ORC$_{TeNE}$) is considered. The fitted carbon response functions (CRFs, black lines) ± 95 % confidence interval (black dotted lines) and simulated CRFs (magenta and green line) corresponding to all observation samples (Tab. S6, Fig. 6) are included here for comparison.