



Supplement of

Content of soil organic carbon and labile fractions depend on local combinations of mineral-phase characteristics

Malte Ortner et al.

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Table S1. Ranges (min to max) of analyzed parameters for the entire dataset and identified clusters.

Dataset	DCS	LBS	DLS	PSS	Sandy soils	Loamy soils	Silty soils	Arable	Grassland
	(n=199)	(n=50)	(n=50)	(n=49)	(n=54)	(n=98)	(n=42)	(n=150)	(n=49)
SOC [%]	0.38-5.23	1.38-5.23	0.54-2.69	0.38-3.15	0.65-2.11	0.65-2.35	0.38-4.52	0.38-4.07	0.54-5.23
N [%]	0.06-0.55	0.14-0.55	0.06-0.24	0.09-0.30	0.07-0.26	0.07-0.20	0.06-0.49	0.06-0.47	0.06-0.55
H [%]	0.12-1.51	0.36-1.51	0.12-0.49	0.24-0.92	0.13-0.63	0.16-0.51	0.16-1.22	0.12-1.51	0.16-1.29
O [%]	0.91-14.60	4.59-9.72	1.39-4.56	0.91-14.60	1.61-4.37	1.39-4.40	0.91-14.60	0.91-14.60	1.38-9.72
HWEC [$\mu\text{g g}^{-1}$]	237-1889	438-1889	447-1146	386-1202	237-1711	263-1146	386-1631	237-1304	317-1889
HWEN [$\mu\text{g g}^{-1}$]	6.08-237	53.9-221	18.5-146	35.5-220	6.08-237	13.5-144	35.5-220	6.08-237	26.0-221
MBC [$\mu\text{g g}^{-1}$]	52.4-810	126-798	52.4-242	177-810	59.8-599	52.4-344	135-629	52.4-558	114-810
MBN [$\mu\text{g g}^{-1}$]	3.60-139	10.4-117	3.60-43.3	18.2-139	12.6-87.1	3.60-54.5	20.02-99.7	3.60-99.7	16.26-139
Respiration [$\mu\text{g CO}_2/\text{g}^{-1}$ dry matter h^{-1}]	0.08-0.71	0.10-0.71	0.10-0.34	0.12-0.70	0.08-0.43	0.10-0.43	0.12-0.50	0.08-0.51	0.10-0.71
MBC/SOC	0.40-5.47	0.53-1.81	0.40-4.44	1.03-5.47	0.53-3.37	0.40-2.66	0.67-5.47	0.40-5.47	0.84-3.37
SOC/N	4.21-18.7	8.50-13.2	9.93-18.7	4.21-16.4	8.06-13.0	8.06-18.7	4.21-15.6	4.21-18.7	9.47-18.2
HWE-C/N	2.22-45.5	4.20-18.7	6.31-28.2	2.86-17.8	2.22-45.4	3.28-32.8	2.87-15.0	2.22-45.5	4.61-27.44
MB-C/N	2.86-23.3	4.12-19.2	3.22-23.3	4.98-13.5	2.86-10.1	2.86-23.3	4.41-13.5	2.86-23.3	4.49-13.5
IC [%]	0.00-6.80	-	-	0.00-6.80	-	-	0.00-6.80	0.00-6.80	0.00-4.50
pH	3.81-7.43	4.10-6.41	3.81-6.71	5.03-7.43	4.78-7.09	3.81-6.68	4.92-7.43	3.81-7.43	4.22-7.41
ECEC [mmolc kg^{-1}]	14.0-147	28.8-110	14.0-86.4	46.9-147	34.9-108	14.0-61.4	27.9-147	14.0-147	20.2-142
Ca + MgECEC [mmolc kg^{-1}]	6.27-134	18.0-107	6.27-81.6	34.5-134	28.1-91.0	6.27-57.8	22.41-134	6.27-134	12.21-132
Feo [g kg^{-1}]	0.54-6.43	2.34-6.43	0.54-2.29	1.37-5.22	0.80-4.54	0.54-2.01	1.37-5.22	0.54-5.29	0.84-6.43
Fed-Feo [g kg^{-1}]	0.15-11.7	2.02-11.7	1.40-7.63	1.12-8.70	0.15-8.45	0.55-6.26	1.12-11.7	0.15-11.7	0.55-9.70
Alo [g kg^{-1}]	0.11-5.23	1.25-5.23	0.21-1.98	0.11-1.53	0.23-1.10	0.23-1.98	0.13-3.71	0.13-5.01	0.11-5.23
Sand [%]	12.7-91.9	13.4-39.8	33.4-91.9	12.7-42.9	31.2-82.8	52.4-91.9	12.7-35.0	12.7-91.9	12.9-86.9
cSilt+ mSilt [%]	0.32-57.8	20.8-39.3	0.32-44.7	31.9-57.8	7.87-40.9	0.32-33.8	29.9-57.8	0.32-55.8	5.33-57.8
fSilt + clay [%]	6.27-53.3	33.4-53.3	6.27-23.0	16.7-44.8	8.51-40.6	6.27-20.9	16.7-47.1	6.27-53.3	7.78-51.0
Stones [%]	0.00-45.9	7.44-45.0	0.60-41.4	0.00-45.9	0.52-43.5	0.60-20.2	0.93-45.9	0.53-45.9	0.00-41.4

Table S2 Intercepts and regression coefficient of selected mixed effect models for the content SOC, HWEC and MBC as response variable for the complete dataset as well as for the cluster of DCS, sandy soils and arable soils (n according to Table 1).

Response variable	Random factor	Intercept				Parameters and multipliers						
		Fe ₀	Fe _d -Fe ₀	Al ₀	Sand	cSilt+mSilt	fSilt+Clay	(Ca+Mg) _{CEC}	pH	stones		
SOC	Parent material	A:2.41	B: 2.29	C: 2.37	D: 1.86	-0.07	0.51	0.02	0.02	0.02	-0.25	-0.01
	Land use	E: 1.17	F: 1.30			-0.06	0.52	0.01	0.02	0.01	-0.26	
HWEC	Texture	G: 2.26	H: 2.26	I: 2.26	J: 2.26	-0.06	0.55	0	-0.01	0.02	-0.31	-0.01
	Parent material*	A:42.9	B: 42.2	C: 41.3	D: 39.8	0.96	1.86	0.16	0.16	0.16	-4.23	-0.07
MBC	Land use*	E: 35.1	F: 38.2			1.02	1.92	0.12	0.12	0.12	-3.16	
	Texture*	G: 42.4	H: 42.5	I: 42.6	J: 42.6	0.80	2.39	0.16	0.16	0.16	-4.59	-0.06
SOC	Parent material	A: 20.4	B: 20.3	C: 20.4	D: 20.4	-0.53	0.45	0.01	0.02	0.11	-2.45	-0.05
	Land use*	E: 7.24	F: 11.5			-0.30	0.50	0.04	0.03	0.04	-0.36	-0.01
HWEC	Texture*	G: 20.2	H: 20.4	I: 20.6	J:20.5	-0.53	1.26	0.06	0.06	0.11	-2.43	-0.05
	Parent material	A: 0.77	B: 0.81	C: 0.84	D: 0.34		1.14	0.06	0.06	0.06	-0.63	-0.01
MBC	Texture	G: 2.44	H: 2.44	I: 2.44	J: 2.44		1.26	0.06	0.06	0.06	-0.63	-0.01
	Parent material	A: 32.0	B: 32.4	C: 31.2	D: 28.9	0.94	1.26	0.10	0.10	0.10	-2.17	
SOC	Texture	G:1221	H: 1222	I: 1227	J: 1223	-19.6	114	6.56	6.56	6.56	-167	
	Parent material	A: 17.2	B: 17.2	C: 17.2	D: 17.2		-0.07	0.06	0.06	0.06	-0.63	
HWEC	Texture	G: 17.1	H: 17.1	I: 17.2	J: 17.1		-0.07	0.06	0.06	0.06	-0.63	
	Parent material	E: 1.13	F: 1.90			0.32	0.31	0.02	0.02	0.02	-0.72	
MBC	Texture	H: 4.03	I: 3.98	J: 4.45		0.30	0.32	8.30	14.2	14.2	-320	-9.2
	Land use	E: 1568	F: 2094			141	59.4	5.29	5.29	5.29	-464	-5.10
SOC	Texture	H: 2779	I: 2834	J: 3086		133	-26.5	0.24	0.02	0.01	-0.02	
	Land use	E: 26.0	F: 315			56.8		0.24	0.02	0.01	-0.02	
HWEC	Texture	H: 948	I: 959	J: 1115		52.2	-26.5	0.24	0.02	0.01	-0.02	
	Parent material	B: -0.43	D: -1.09			0.39		0.24	0.02	0.01	-0.02	
MBC	Texture	E: 1.22	F: 1.22			0.59		0.59	0.02	0.01	-0.02	
	Land use	B: 1413	D: 1264			195		111	11	11	-217	-9.95
SOC	Texture	E: 1481	F: 1481			207		207	10.6	10.6	-214	-10.4
	Parent material	B: 28.9	D: 28.9			2.68		1.23	0.11	0.11	-1.31	
HWEC	Texture	E: 16.9	D: 19.9			2.68		1.23	0.11	0.11	-1.31	
	Land use	B: 28.9	D: 28.9			2.68		1.23	0.11	0.11	-1.31	

*Response variable was square root transformed; Intercepts of Random effect factors: a = DCS, b = LBS, c = DLS, d = PSS, e = arable, f = grassland, g = sand, h = silt, I = loam, j = clay.

Table S13. RMSE of the bivariate linear regressions for parameters explaining the variance of SOC [%], HWEC and MBC [mg g^{-1}] respectively, for soils groups of different parent material, major textural class and land use

Dataset	SOC	HWEC	MBC	Fe _o		Fe _d -Fe _o		Al _o		Sand		cSilt + mSilt		fSilt + clay		Stones		ECEC		(Ca+Mg) _{FCEC}		pH		
				RMSE	RMSE	RMSE	RMSE	RMSE	RMSE	RMSE	RMSE	RMSE	RMSE	RMSE	RMSE	RMSE	RMSE	RMSE	RMSE	RMSE	RMSE	RMSE	RMSE	RMSE
All samples																								
Land use																								
Arable n = 150	SOC	0.64	0.18	0.09	0.52	0.22	0.09	0.46	0.18	0.09	0.64	0.21	0.07	0.72	0.23	0.07	0.62	0.21	0.09	0.7	0.21	0.06	0.73	0.23
Grassland n = 49	SOC	1.06	0.24	0.18	0.58	0.4	0.18	0.57	0.26	0.16	0.96	0.37	1.11	0.41	0.3	0.83	0.34	0.17	1.11	0.41	0.18	1.12	0.4	
DCS n = 50	SOC	0.59	0.31	0.14	0.67	0.32	0.15	0.57	0.32	0.15	0.78	0.35	0.16	0.76	0.35	0.16	0.78	0.35	0.16	0.78	0.35	0.16	0.77	0.35
LBS n = 50	SOC	0.39	0.16	0.04	0.37	0.16	0.04	0.35	0.16	0.04	0.37	0.16	0.04	0.37	0.16	0.04	0.39	0.16	0.04	0.41	0.16	0.04	0.41	0.16
DLS n = 50	SOC	0.48	0.21	0.12	0.48	0.21	0.12	0.49	0.21	0.12	0.48	0.21	0.12	0.49	0.21	0.12	0.44	0.21	0.11	0.44	0.21	0.11	0.48	0.21
PSS n = 49	SOC	0.27	0.25	0.1	0.33	0.23	0.12	0.28	0.23	0.1	0.27	0.22	0.12	0.29	0.22	0.1	0.33	0.24	0.12	0.28	0.24	0.11	0.33	0.24
Sandy n = 54	SOC	0.45	0.19	0.04	0.45	0.2	0.04	0.35	0.17	0.05	0.41	0.19	0.04	0.41	0.19	0.05	0.45	0.2	0.05	0.45	0.2	0.05	0.44	0.19
Silty n = 42	SOC	0.75	0.25	0.12	0.67	0.28	0.12	0.62	0.26	0.11	0.76	0.28	0.12	0.67	0.26	0.12	0.76	0.27	0.12	0.75	0.27	0.11	0.75	0.27
Loamy n = 89	SOC	0.52	0.26	0.13	0.79	0.32	0.13	0.48	0.26	0.13	0.67	0.29	0.13	0.87	0.32	0.13	0.69	0.3	0.13	0.85	0.32	0.12	0.82	0.32
	HWEC	0.26	0.13	0.04	0.32	0.13	0.04	0.26	0.13	0.04	0.29	0.13	0.04	0.28	0.13	0.04	0.3	0.13	0.04	0.32	0.13	0.04	0.32	0.13
	MBC	0.13	0.04	0.04	0.13	0.04	0.04	0.13	0.04	0.04	0.13	0.04	0.04	0.13	0.04	0.04	0.13	0.04	0.04	0.12	0.04	0.04	0.12	0.04

Table S4. R² and RMSE [mg g⁻¹] for implementation of the global dataset to local clusters for HWEC and MBC.

		HWEC					
		Parent material		Land use		Texture	
Sample subgroups		Cluster specific model	total model to local cluster	Cluster specific model	total model to local cluster	Cluster specific model	total model to local cluster
Dataset	R ²	0.63		0.68		0.61	
	RMSE	0.19		0.18		0.20	
DCS	R ²			0.78	0.66	0.62	0.47
	RMSE			0.17	0.20	0.22	0.26
LBS	R ²			0.27	0.21	0.29	0.15
	RMSE			0.14	0.16	0.14	0.17
DLS	R ²			0.36	0.37	0.37	0.37
	RMSE			0.17	0.18	0.17	0.17
PSS	R ²			0.62	0.54	0.56	0.54
	RMSE			0.16	0.18	0.16	0.18
Sandy soils	R ²	0.61	0.52	0.51	0.40		
	RMSE	0.12	0.14	0.14	0.15		
Silty soils	R ²	0.75	0.58	0.66	0.54		
	RMSE	0.14	0.18	0.16	0.19		
Loamy soils	R ²	0.59	0.57	0.66	0.63		
	RMSE	0.20	0.21	0.19	0.19		
Arable	R ²	0.59	0.58			0.53	0.53
	RMSE	0.15	0.16			0.16	0.17
Grassland	R ²	0.78	0.73			0.67	0.71
	RMSE	0.19	0.26			0.24	0.26

		MBC					
		Parent material		Land use		Texture	
Sample subgroups		Cluster specific model	total model to local cluster	Cluster specific model	total model to local cluster	Cluster specific model	total model to local cluster
Dataset	R ²	0.55		0.71		0.56	
	RMSE	0.10		0.08		0.10	
DCS	R ²			0.79	0.73	0.55	0.41
	RMSE			0.07	0.09	0.11	0.13
LBS	R ²			0.48	0.43	0.41	0.24
	RMSE			0.03	0.05	0.03	0.04
DLS	R ²			0.32	0.35	0.26	0.24
	RMSE			0.10	0.10	0.10	0.11
PSS	R ²			0.74	0.71	0.60	0.53
	RMSE			0.06	0.06	0.07	0.08
Sandy soils	R ²	0.28	0.13	0.58	0.38		
	RMSE	0.04	0.05	0.03	0.04		
Silty soils	R ²	0.48	0.46	0.50	0.43		
	RMSE	0.09	0.09	0.08	0.09		
Loamy soils	R ²	0.41	0.36	0.64	0.59		
	RMSE	0.10	0.11	0.08	0.08		
Arable	R ²	0.70	0.60			0.71	0.61
	RMSE	0.05	0.07			0.05	0.07
Grassland	R ²	0.76	0.61			0.76	0.61
	RMSE	0.09	0.15			0.09	0.15

Figure S1. Clustering of the dataset according to land use along the first two principal components.

