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SUPPLEMENTARY INFORMATION

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Potential carbon emissions dominated by carbon dioxide from thawed permafrost soils

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Additional Results

Besides calculating the effect of a 10 °C increase in incubation temperature on total C release (sum of CO_2-C and CH_4-C), we also calculated the effect of increasing temperature on total C release when accounting for the higher GWP of CH_4, which resulted in an almost identical increase in C release of 2.06 (Table S5).

Additionally, we looked at the effect of a 10 °C increase in incubation temperature on CH_4-C release alone (anaerobic studies only). Over all studies the CH_4-C release was 4.26 times higher with a 10 °C increase in temperature and no effects of ecosystem, soil type or permafrost condition were found (Fig. S1, Table S6, Table S12). Given that CH_4 accounts for a small portion of the total C release under anaerobic incubation conditions the overall ratio of C release with a 10 °C increase in incubation temperature did not differ for aerobic or anaerobic incubation conditions.

Sensitivity analysis

We performed a sensitivity analysis that uses three different datasets to show that our conclusions about the low contribution of CH_4-C to total anaerobic C emissions from the given incubation studies are robust. We performed the aerobic to anaerobic meta-analyses using the following three different datasets:

a) The original dataset that includes all samples and studies as reported in the main text
b) Only those studies were included for which more than 60% of the samples had reached maximum CH_4 rate during the incubation (see Table 17)
c) Only those samples from individual incubation studies were included that had reached maximum CH_4 rate during the incubation (includes samples from all studies except for Diáková et al. (in revision). The difference to b) is that individual samples were explicitly excluded rather than studies, which are collections of individual samples.

Maximum CH_4 rate refers to the peak CH_4 rate and was determined based on daily rates over time. Table 18 shows the results from all three meta-analyses. The overall mean estimate (ratio of soil C release under aerobic versus anaerobic incubation conditions) is for a) 3.39 (95% CI from 2.22 to 5.18), for b) 3.65 (95% CI from 1.91 to 6.98) and for c) 3.81 (95% CI from 2.53 to 5.73) when using total C (sum of CO_2-C + CH_4-C). When also accounting for the higher Global Warming Potential of CH_4 (as CO_2-C equivalent) the overall mean estimate for a) is 2.3 (95% CI from 1.55 to 3.4), for b) 2.7 (95% CI from 1.62 to 4.49), and for c) 2.26 (95% CI from 1.44 to 3.54).

In addition, we have also calculated the contribution of CH_4-C to total anaerobic C release using the three different datasets. On average the contribution of CH_4-C to total C is for a) 5.73% (95% CI from 2.74 to 8.73), for b) 5.59 (95% CI from -1.97 to 13.16), and for c) 7.5% (95% CI from 3.83 to 16.84; Supplementary Figure S2). Ecosystem and Temperature are only significant moderators for the original analysis, which includes all samples and studies. This sensitivity analysis shows that for all three datasets C release under anaerobic conditions is dominated by anaerobic CO_2.

Figure S1| Ratio of CH_4-C release with a 10° C increase in temperature. Studies are split into different ecosystems, soil types and permafrost conditions (numbers in brackets represent number of observations for each subgroup). The arrow indicates that the confidence interval (CI) is wider than the space.

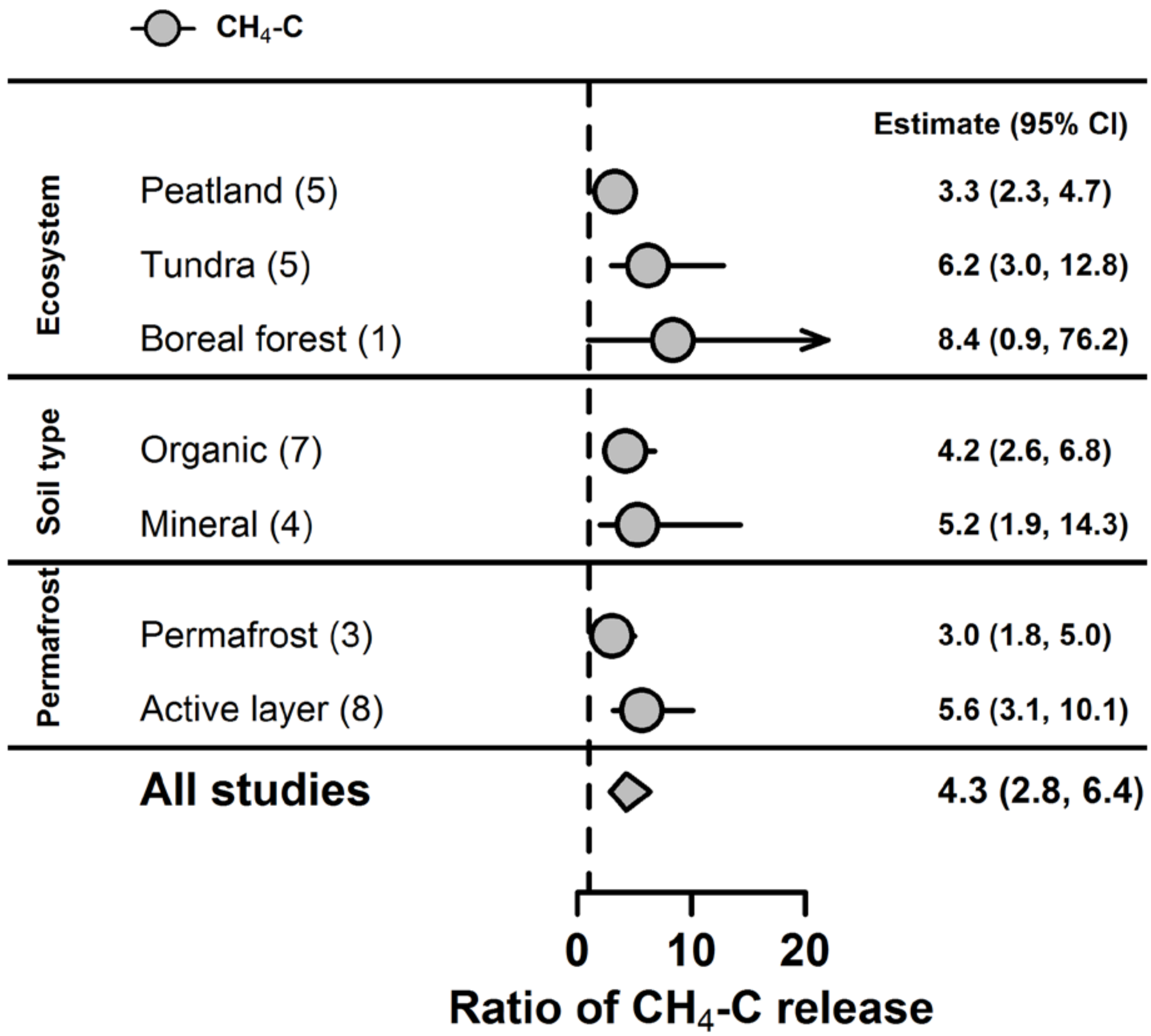
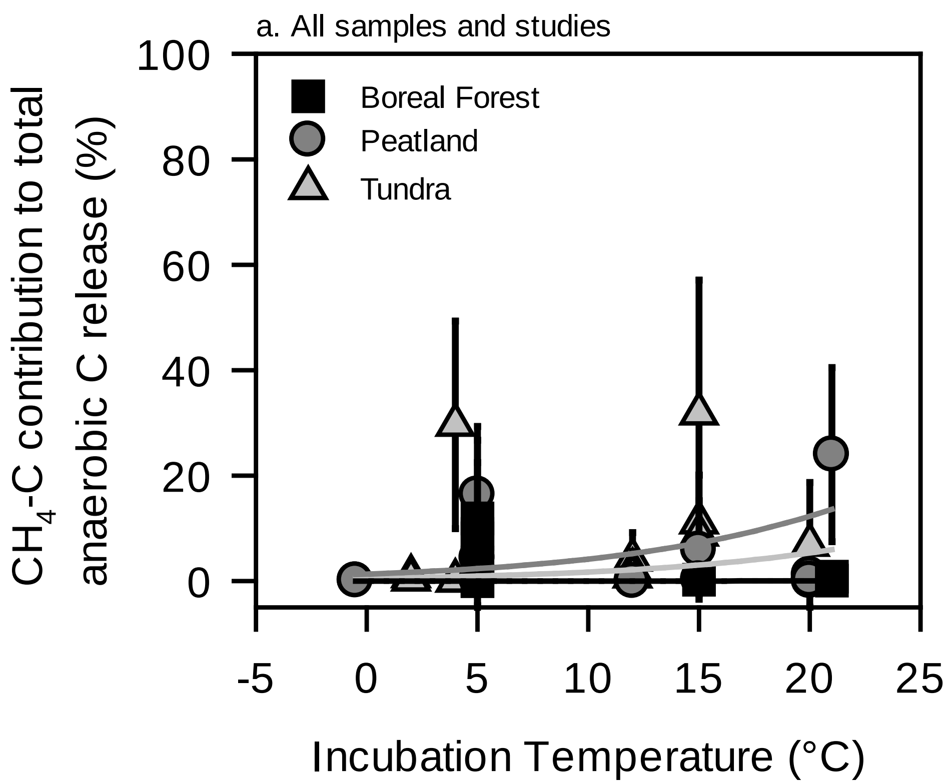
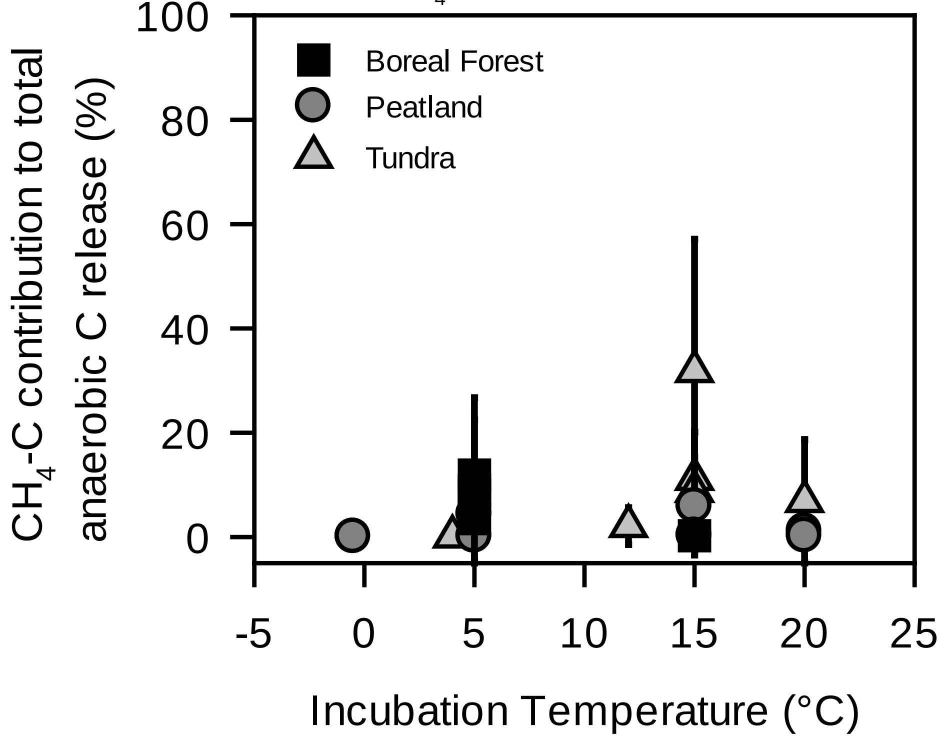


Figure S2| Contribution of CH_4-C to total anaerobic C release for the three datasets used in the sensitivity analysis. Black squares represent boreal forest, dark circles peatland and light grey triangles tundra ecosystems. Symbols represent observations from different observations and error bars show standard deviation within an observation. Figure S2a is the same as Fig. 3 in the main text. In a) lines represent the average predicted relationship between CH_4-C contributions to total anaerobic C release and incubation temperature for the three given ecosystems. For b) and c) neither ecosystem nor temperature were significant moderators. For a) mean over all observations = 5.73% (95% CI 2.74, to 8.73); for b) mean of all observations = 5.59 (95% CI -1.97 to 13.16); for c) mean over all observations = 7.5% (95% CI 3.83 to 16.84).



b. Studies with >60% of samples reaching maximum CH_4 rate



c. Only samples included that reached maximum CH_4 rate

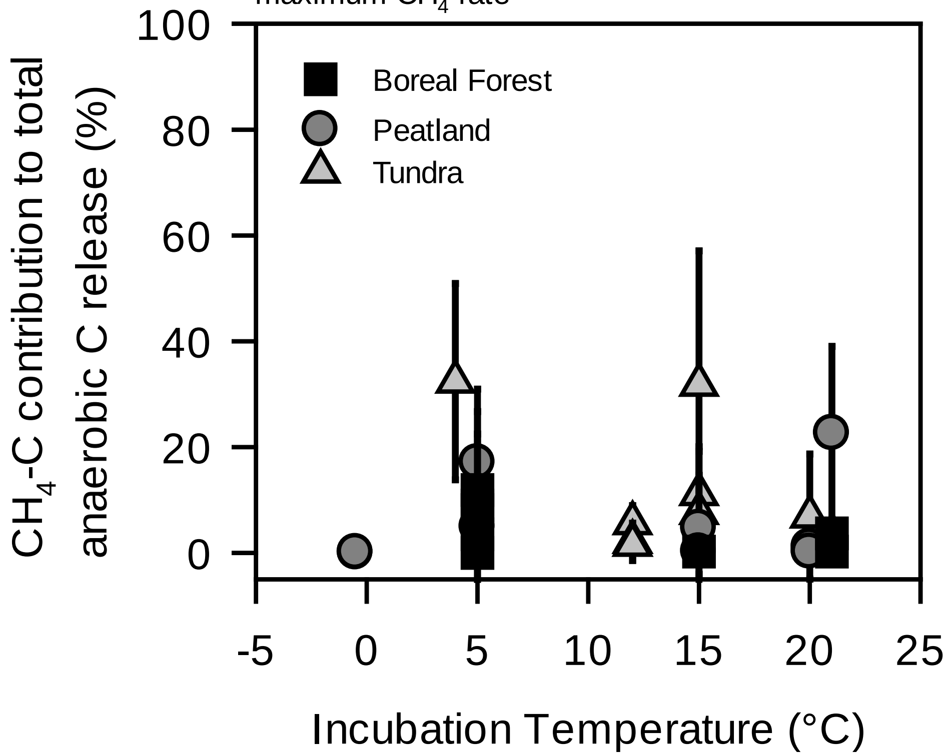


Table S1| Study details with treatment, incubation temperature used in the meta-analysis, ecosystem, permafrost, soil type, and incubation length.

Citation	Treatment[a]	Used incubation temperatures (°C)	Ecosystem[b]	Permafrost[c]	Soil type[d]	Incubation length (days)
Bracho et al. (2016)[1]	T	15, 25	tundra	al, p	min, org	365
Čapek et al. (2015)[2]	T + Ae/An	4, 20	tundra	al	min	133
Dai et al. (2002)[3]	T	4, 25	tundra	al, p	min, org	120
De Baets et al. (in revision)[4]	T	7, 17	tundra	al, p	min, org	469
Diáková et al. (in revision)[5]	T + Ae/An	4, 20	peat, tundra	al	min, org	162
Dutta et al. (2006)[6]	T	5, 15	boreal, tundra	al, p	min	390
Ernakovich et al. (2014)[7]	T	1, 15	tundra	p	min, org	91
Estop-Aragones et al. (in prep)	T + Ae/An	5, 15	boreal, peat	al, p	min, org	110, 230[i]
Hobbie et al. (2002[e])[8]	T	4, 15	tundra	al	org	216
Iversen et al. (2015a[f])[9]	T + Ae/An	2,12	tundra	al	min, org	28
Iversen et al. (2015b[f])	T	4,12	tundra	al	min, org	28
Kane et al. (2013)[10]	Ae/An	22	peat	al	org	38
Knoblauch et al. (2013)[11]	Ae/An	4	tundra	p	min	1242
Lee et al. (2012)[12]	Ae/An	15	boreal, tundra	al, p	min, org	493
Lavoie et al. (2011)[13]	T	5, 15	boreal, tundra	al, no	min, org	1086
Nadelhoffer et al. (1991[e])[14]	T	3, 15	tundra	al	min, org	91
Neff & Hooper (2002[e])[15]	T	10, 30	tundra	al	org	352
O'Donnell et al. (2009)[16]	T	2, 20	boreal	al	org	48
Oelbermann et al. (2008[e])[17]	T	14, 21	tundra	al	min, org	84
Roy Chowdhury et al. (2015)[18]	T	4,8 (10[g])	tundra	al, p	min, org	60
Shaver et al. (2006)[19]	T	7, 15	tundra	al	org	465
Treat et al. (2014)[20]	T + Ae/An	-0.5[h], 4, 20	peat	al, p	min, org	27
Waldrop et al. (2010)[21]	Ae/An	5	boreal	al, p	min, org	40
Waldrop et al. (in prep)	T + Ae/An	5, 21	boreal, peat	al, p	min, org	355
Wickland & Neff (2008[e])[22]	T	10, 20	boreal	al, no	org	57

[a]Treatment: T = temperature, Ae/An=aerobic and anaerobic

[b]Ecosystem: boreal=boreal forest, peat=peatland, tundra=tundra

[c]Permafrost: al=active layer, no= no permafrost, p=permafrost layer

[d]Soil type: min=mineral (% C<20), org=organic (% C>20)

[e]Data extracted from publication, for all other studies we used raw data

[f]Both Iversen et al. 2015 datasets fall under the same data citation but are independent data sets

[g]Twelve samples were incubated at 4 °C and 8 °C and eight samples were incubated at 4 °C and 10 °C

[h]Anaerobic incubations were performed at -0.5°C and 20°C, for aerobic incubations we used 4°C and 20°C

[i]Anaerobic incubations lasted 110 days (peatland), aerobic incubations lasted either 110 (peatland) or 230 days (boreal forest)

Table S2 | Effect size estimates (y_i, log ratio of the means) and corresponding variance (v_i) used for meta-analysis of the effect of a 10 °C increase in incubation temperature on total C release (CO_2-C+CH_4-C) and on total CO_2-C equivalent release by accounting for the Global Warming Potential of CO_2 (GWP=1) and CH_4 (GWP=34)[23]. Ecosystem, permafrost, soil type and oxygen are moderators used for multilevel meta-analysis. Nr is the number of observations per citation.

Citation	Ecosystem[a]	Permafrost[b]	Soil type[c]	Oxygen[d]	Total C		CO_2-C equivalent		Nr
					y_i	v_i	y_i	v_i	
Bracho et al. (2016)[1]	tundra	al	org	Ae	0.457	0.096	0.457	0.096	3
Bracho et al. (2016)	tundra	p	org	Ae	0.741	0.170	0.741	0.170	3
Bracho et al. (2016)	tundra	p	min	Ae	0.710	0.036	0.710	0.036	3
Čapek et al. (2015)[2]	tundra	al	min	Ae	0.986	0.807	0.986	0.807	2
Čapek et al. (2015)	tundra	al	min	An	0.807	0.240	0.993	0.210	2
Dai et al. (2002)[3]	tundra	al	min	Ae	0.562	0.115	0.562	0.115	1
De Baets et al. (in revision)[4]	tundra	al	org	Ae	0.820	0.003	0.820	0.003	3
De Baets et al. (in revision)	tundra	p	org	Ae	1.252	0.092	1.252	0.092	3
De Baets et al. (in revision)	tundra	p	min	Ae	1.464	0.212	1.464	0.212	3
Diáková et al. (in revision)[5]	peat	al	org	Ae	1.072	0.956	1.072	0.956	1
Dutta et al. (2006)[6]	tundra	p	min	Ae	0.173	0.056	0.173	0.056	3
Dutta et al. (2006)	boreal	al	min	Ae	0.583	0.165	0.583	0.165	3
Dutta et al. (2006)	boreal	p	min	Ae	0.272	0.040	0.272	0.04	3
Ernakovich et al. (2014)[7]	tundra	p	min	Ae	0.880	0.035	0.880	0.035	2
Ernakovich et al. (2014)	tundra	p	min	An	0.653	0.423	0.726	0.505	2
Estop-Aragones et al. (in prep)	peat	al	org	Ae	1.136	0.180	1.136	0.180	8
Estop-Aragones et al. (in prep)	peat	al	org	An	0.724	0.197	0.778	0.785	8
Estop-Aragones et al. (in prep)	peat	p	org	Ae	1.121	0.064	1.121	0.064	8
Estop-Aragones et al. (in prep)	peat	p	org	An	0.774	0.070	0.783	0.069	8
Estop-Aragones et al. (in prep)	boreal	al	org	Ae	0.917	0.088	0.917	0.088	8
Estop-Aragones et al. (in prep)	boreal	al	min	Ae	1.040	0.102	1.040	0.102	8
Estop-Aragones et al. (in prep)	boreal	p	org	Ae	1.013	0.378	1.013	0.378	8
Estop-Aragones et al. (in prep)	boreal	p	min	Ae	0.991	0.126	0.991	0.126	8
Hobbie et al. (2002)[8]	tundra	al	org	Ae	1.549	0.306	1.549	0.306	1
Iversen et al. (2015a)[9]	tundra	al	org	Ae	1.121	0.271	1.121	0.271	4
Iversen et al. (2015a)	tundra	al	org	An	0.581	0.305	1.204	0.315	4
Iversen et al. (2015a)	tundra	al	min	Ae	0.940	0.033	0.940	0.033	4
Iversen et al. (2015a)	tundra	al	min	An	0.599	0.010	0.688	0.013	4
Iversen et al. (2015b)	tundra	al	org	Ae	0.917	0.123	0.917	0.123	2
Iversen et al. (2015b)	tundra	al	min	Ae	0.925	0.038	0.925	0.038	2
Lavoie et al. (2011)[13]	tundra	al	org	Ae	0.334	0.115	0.334	0.115	4
Lavoie et al. (2011)	tundra	al	min	Ae	0.627	0.026	0.627	0.026	4
Lavoie et al. (2011)	boreal	no	org	Ae	0.714	0.126	0.714	0.126	4
Lavoie et al. (2011)	boreal	no	min	Ae	0.646	0.062	0.646	0.062	4

Nadelhoffer et al. (1991)[14]	tundra	al	org	Ae	0.447	0.128	0.447	0.128	2
Nadelhoffer et al. (1991)	tundra	al	min	Ae	0.426	0.203	0.426	0.203	2
Neff & Hooper (2002)[15]	tundra	al	org	Ae	0.383	0.067	0.383	0.067	1
O'Donnell et al. (2009)[16]	boreal	al	org	Ae	1.060	0.043	1.060	0.043	1
Oelbermann et al. (2008)[17]	tundra	al	org	Ae	0.980	0.082	0.980	0.082	2
Oelbermann et al. (2008)	tundra	al	min	Ae	1.296	0.780	1.296	0.780	2
Roy Chowdhury et al. (2015)[18]	tundra	al	org	An	0.936	0.494	1.549	0.617	1
Shaver et al. (2006)[19]	tundra	al	org	Ae	0.594	0.119	0.594	0.119	1
Treat et al. (2014)[20]	peat	al	org	Ae	0.969	0.036	0.969	0.036	5
Treat et al. (2014)	peat	al	org	An	0.820	0.024	0.886	0.017	5
Treat et al. (2014)	peat	p	org	Ae	0.690	0.020	0.690	0.020	5
Treat et al. (2014)	peat	p	org	An	0.520	0.054	0.529	0.050	5
Treat et al. (2014)	peat	p	min	Ae	0.821	0.082	0.821	0.082	5
Waldrop et al. (in prep)	peat	al	org	Ae	0.812	0.055	0.812	0.055	6
Waldrop et al. (in prep)	peat	al	org	An	0.617	0.126	0.848	0.050	6
Waldrop et al. (in prep)	boreal	al	min	Ae	0.579	0.161	0.579	0.161	6
Waldrop et al. (in prep)	boreal	al	min	An	0.475	0.290	0.483	0.294	6
Waldrop et al. (in prep)	boreal	p	min	Ae	0.293	0.052	0.293	0.052	6
Waldrop et al. (in prep)	boreal	p	min	An	0.456	0.187	0.456	0.187	6
Wickland & Neff (2008)[22]	boreal	al	org	Ae	0.500	0.000	0.500	0.000	1

[a]Ecosystem: boreal = boreal forest, peat=peatland, tundra=tundra
[b]Permafrost: al=active layer, no= no permafrost, p=permafrost layer
[c]Soil type: min=mineral (% C<20), org=organic (% C>20)
[d]Oxygen: Ae=aerobic incubation, An=anaerobic incubation

Table S3 | Effect size estimates (y_i, log ratio of the means) and corresponding variance (v_i) used for meta-analysis of the effect of a 10 °C increase in incubation temperature on CH_4-C release. Ecosystem, permafrost, and soil type are moderators used for meta-analysis with mixed effects models. Nr is the number of observations per citation.

Citation	Ecosystem[a]	Permafrost[b]	Soil type[c]	yi	vi	Nr
Čapek et al. (2015)[2]	tundra	al	min	3.142	1.117	1
Ernakovich et al. (2014)[7]	tundra	p	min	0.735	0.5155	1
Estop-Aragones et al. (in prep.)	peat	al	org	0.811	1.3675	2
Estop-Aragones et al. (in prep.)	peat	p	org	1.159	0.0841	2
Iversen et al. (2015a)[9]	tundra	al	org	2.296	0.3361	2
Iversen et al. (2015a)	tundra	al	min	1.492	0.6506	2
Roy-Chowdhury et al. (2015)[18]	tundra	al	org	1.832	0.757	1
Treat et al. (2014)[20]	peat	al	org	2.168	0.3172	2
Treat et al. (2014)	peat	p	org	1.131	0.7972	2
Waldrop (in prep.)	peat	al	org	1.006	0.0793	2
Waldrop (in prep.)	boreal	al	min	2.128	1.2665	2

[a]Ecosystem: boreal = boreal, peat=peat, tundra=tundra
[b]Permafrost: al=active layer, p=permafrost layer
[c]Soil type: min=mineral (% C<20), org=organic (% C>20)

Table S4 | Effect size estimates (y_i, log ratio of the means) and corresponding variance (v_i) used for meta-analysis of aerobic to anaerobic total C release (CO_2-C+CH_4-C) and total CO_2-C equivalent release. Ecosystem, permafrost, soil type and temperature are moderators used for meta-analysis with mixed effects models. Nr is the number of observations per citation.

Citation	Ecosystem[a]	Permafrost[b]	Soil type[c]	Temp[d]	Total C		CO_2-C equivalent		Nr
					yi	vi	yi	vi	
Čapek et al. (2015)[2]	tundra	al	min	4	0.411	0.574	0.397	0.575	3
Čapek et al. (2015)	tundra	al	min	12	0.884	0.456	0.607	0.558	3
Čapek et al. (2015)	tundra	al	min	20	0.636	0.543	0.165	0.511	3
Diáková et al. (in revision)[4]	peat	al	org	4	0.259	1.093	0.259	1.093	3
Diáková et al. (in revision)	peat	al	org	12	0.915	1.041	0.915	1.041	3
Diáková et al. (in revision)	peat	al	org	20	1.016	0.551	1.015	0.551	3
Estop-Aragones et al. (in prep.)	peat	al	org	5	1.477	0.168	0.552	0.447	4
Estop-Aragones et al. (in prep.)	peat	al	org	15	1.884	0.206	0.896	0.490	4
Estop-Aragones et al. (in prep.)	peat	p	org	5	1.468	0.080	1.447	0.079	4
Estop-Aragones et al. (in prep.)	peat	p	org	15	1.815	0.054	1.785	0.054	4
Iversen et al. (2015a)[9]	tundra	al	org	2	0.391	0.289	0.302	0.289	4
Iversen et al. (2015a)	tundra	al	org	12	1.302	0.130	0.860	0.143	4
Iversen et al. (2015a)	tundra	al	min	2	0.184	0.038	0.156	0.035	4
Iversen et al. (2015a)	tundra	al	min	12	0.526	0.029	0.430	0.030	4
Kane et al. (2013[e])[10]	peat	al	org	22	-0.700	0.008	-2.480	0.012	1
Knoblauch et al. (2013)[11]	tundra	p	min	4	1.387	0.016	-0.071	0.041	1
Lee et al. (2012)[12]	boreal	p	min	15	1.622	0.072	1.596	0.069	4
Lee et al. (2012)	tundra	al	org	15	2.401	0.045	1.575	0.068	4
Lee et al. (2012)	tundra	p	org	15	1.539	0.579	-0.298	0.727	4
Lee et al. (2012)	tundra	p	min	15	1.966	0.076	1.291	0.078	4
Treat et al. (2014)[20]	peat	al	org	-0.5	-0.102	0.157	-0.109	0.156	4
Treat et al. (2014)	peat	al	org	20	0.615	0.025	0.495	0.025	4
Treat et al. (2014)	peat	p	org	-0.5	-0.326	0.099	-0.339	0.100	4
Treat et al. (2014)	peat	p	org	20	0.546	0.018	0.519	0.018	4
Waldrop et al. (2010)[21]	boreal	al	org	5	1.487	0.164	0.566	0.394	4
Waldrop et al. (2010)	boreal	al	min	5	1.189	0.211	1.004	0.139	4
Waldrop et al. (2010)	boreal	p	org	5	1.940	0.056	1.605	0.048	4
Waldrop et al. (2010)	boreal	p	min	5	1.870	0.205	1.264	0.196	4
Waldrop et al. (in prep.)	boreal	al	min	5	1.142	0.244	1.140	0.244	6
Waldrop et al. (in prep.)	boreal	al	min	21	1.251	0.113	1.226	0.118	6
Waldrop et al. (in prep.)	boreal	p	min	5	1.775	0.082	1.774	0.082	6
Waldrop et al. (in prep.)	boreal	p	min	21	0.983	0.396	0.935	0.381	6
Waldrop et al. (in prep.)	peat	al	org	5	1.981	0.087	1.191	0.042	6
Waldrop et al. (in prep.)	peat	al	org	21	2.214	0.123	0.973	0.146	6

[a]Ecosystem: boreal = boreal forest, peat=peatland, tundra=tundra
[b]Permafrost: al=active layer, p=permafrost layer

[c]Soil type: min=mineral (% C<20), org=organic (% C>20)
[d]Temp= incubation temperature
[e]Kane et al. 2013 not included in final analysis, considered influential study

Table S5| Summary of the results of a meta-analysis of the effect of a 10°C increase in incubation temperature on total C release (CO_2-C + CH_4-C) and total C release as CO_2-C equivalent. See Material and methods for detailed description of the response metric and the meta-analysis performed. N is the number of observations per ecosystem, soil type or permafrost.

		Total C			Total CO_2-C equivalent		
	N	Estimate	95% CI		Estimate	95% CI	
			lower	upper		lower	upper
Ecosystem							
Boreal Forest	14	1.88	1.5	2.37	1.88	1.5	2.37
Tundra	28	2.05	1.84	2.28	2.1	1.89	2.33
Peatland	12	2.23	1.95	2.55	2.29	2.02	2.6
Soil Type							
Mineral	24	1.98	1.71	2.28	2.02	1.74	2.34
Organic	30	2.09	1.85	2.37	2.14	1.89	2.43
Permafrost							
No Permafrost	2	1.95	1.31	2.91	1.95	1.31	2.91
Permafrost	17	2.03	1.57	2.62	2.03	1.58	2.62
Active layer	35	2.07	1.87	2.3	2.13	1.91	2.37
Overall mean	**54**	**2.02**	**1.82**	**2.24**	**2.06**	**1.86**	**2.29**

[a] Sampling sites from the discontinuous permafrost zone where permafrost was not present[20]

Table S6 | Summary of the results of a meta-analysis of the effect of a 10°C increase in incubation temperature on CH_4-C from anaerobic incubations. N is the number of observations per ecosystem, soil type or permafrost. See Material and methods for detailed description of the response metric and meta-analysis performed

	CH_4-C			
	N	Estimate	95% CI	
			lower	upper
Ecosystem				
Peatland	5	3.29	2.3	4.72
Tundra	5	6.16	2.97	12.81
Boreal Forest	1	8.4	0.93	76.25
Soil Type				
Organic	7	5.25	1.93	14.29
Mineral	4	4.18	2.58	6.78
*Permafrost**				
Permafrost	3	3.01	1.82	4.99
Active layer	8	5.62	3.14	10.07
Overall mean	**11**	**4.26**	**2.84**	**6.38**

* Samples from anaerobic incubations only represented active layer and permafrost

Table S7 | Summary of the results of a meta-analysis of the ratio of aerobic to anaerobic incubation conditions on total C release (CO_2-C + CH_4-C) and on total C release as CO_2-C equivalent by accounting for the GWP of CO_2 (GWP=1) and CH_4 (GWP=34[23]). See Material and methods for detailed description of the response metric and meta-analysis. N is the number of observations per ecosystem, soil type or permafrost. Numbers in light grey are estimates and 95% CI for analyses when Kane et al. (2013[10]) is included.

		Total C			Total CO_2-C equivalent		
	N	Estimate	95% CI lower	95% CI upper	Estimate	95% CI lower	95% CI upper
Ecosystem							
Tundra	11	3.32	1.57	7.03	1.68	0.9	3.12
Peatland	13	3.46	1.54	7.77	2.48	1.4	4.41
Boreal Forest	9	5.0	3.99	6.27	4.17	3.34	5.21
Soil Type							
Mineral	14	3.34	2.11	5.28	2.18	1.27	3.72
Organic	19	4.23	2.44	7.34	2.63	1.79	3.87
Permafrost							
Active layer	21	3.29	1.99	5.45	2.2	1.56	3.09
Permafrost	12	4.15	2.53	6.8	2.76	1.53	4.95
Overall mean	**33**	**3.39**	**2.22**	**5.18**	**2.3**	**1.55**	**3.4**
Overall mean with Kane et al. 2013[8]	34	2.77	1.63	4.7	1.61	0.77	3.39

Table S8 | Multiple regression results for logit transformed ratio of CH_4-C to total anaerobic C release.

Coefficients	Estimate	SE	DF	t value	P value
Intercept	-5.20	1.64	20	-3.18	<0.01
Peatland	0.91	1.43	20	0.63	0.53
Boreal Forest	-4.53	1.18	20	-3.84	<0.01
Temperature	0.12	0.03	20	3.61	<0.01

Table S9| Information on the amount of heterogeneity in each meta-analysis. All final models were fitted with restricted maximum likelihood.

Meta-Analysis	
Temperature, total C (CO_2-C + CH_4-C)	
Q-test	Q(df = 53) = 98.306, p-val < 0 .001
tau^2	0.025
Temperature, CO_2-C equivalent	
Q-test	Q(df = 53) = 106.108, p-val < 0.001
tau^2	0.026
Temperature, CH_4-C	
Q-test	Q(df = 10) = 11.395, p-val = 0.328
tau^2	0.096
Ae/Anaerobic, total C (CO_2-C + CH_4-C)	
Q-test	Q(df = 32) = 206.373, p-val < 0.001
tau^2	0.409
Ae/Anaerobic, CO_2-C equivalent	
Q-test	Q(df = 32) = 142.343, p-val < .001
tau^2	0.334

Table S10 | Models, their corresponding Akaike Information Criterion corrected for finite sample sizes (AICc), and Akaike weights for meta-analysis of the effect of a 10 °C increase in temperature on total C release (CO_2-C + CH_4-C). Bolded model is the final model. yi=effect size estimate, soiltype = soil type, water.treat = oxygen availability, permafrost = permafrost, ecosystem = ecosystem, doi = day of incubation

Model	AICc	Akaike weights
yi ~ 1	**27.72**	**0.19**
yi ~ 1 + water.treat	28.36	0.14
yi ~ 1 + doi	29.07	0.1
yi ~ 1 + water.treat + doi	29.24	0.09
yi ~ 1 + soiltype	29.72	0.07
yi ~ 1 + ecosystem + water.treat	30.26	0.05
yi ~ 1 + ecosystem	30.39	0.05
yi ~ 1 + soiltype + water.treat	30.5	0.05
yi ~ 1 + soiltype + doi	31.3	0.03
yi ~ 1 + soiltype + water.treat + doi	31.62	0.03
yi ~ 1 + ecosystem + water.treat + doi	31.74	0.03
yi ~ 1 + permafrost	32.01	0.02
yi ~ 1 + ecosystem + doi	32.32	0.02
yi ~ 1 + permafrost + water.treat	32.66	0.02
yi ~ 1 + ecosystem + soiltype	32.79	0.02
yi ~ 1 + ecosystem + soiltype + water.treat	32.89	0.01
yi ~ 1 + permafrost + doi	33.29	0.01
yi ~ 1 + permafrost + water.treat + doi	33.35	0.01
yi ~ 1 + ecosystem + permafrost + water.treat	34.37	0.01
yi ~ 1 + permafrost + soiltype	34.39	0.01
yi ~ 1 + ecosystem + soiltype + water.treat + doi	34.51	0.01
yi ~ 1 + ecosystem + permafrost	34.66	0.01
yi ~ 1 + ecosystem + soiltype + doi	34.87	0.01
yi ~ 1 + ecosystem + permafrost + water.treat + doi	35.15	0
yi ~ 1 + permafrost + soiltype + water.treat	35.21	0
yi ~ 1 + permafrost + soiltype + doi	35.88	0
yi ~ 1 + permafrost + soiltype + water.treat + doi	36.11	0
yi ~ 1 + ecosystem + permafrost + doi	36.27	0
yi ~ 1 + ecosystem + permafrost + soiltype + water.treat	37.19	0
yi ~ 1 + ecosystem + permafrost + soiltype	37.42	0
yi ~ 1 + ecosystem + permafrost + soiltype + water.treat + doi	38.07	0
yi ~ 1 + ecosystem + permafrost + soiltype + doi	39.16	0

Table S11 | Models, their corresponding Akaike Information Criterion corrected for finite sample sizes (AICc), and Akaike weights for weighted meta-analysis of the effect of a 10 °C increase in temperature on total C release calculated as CO_2-C equivalent. Bolded model is the final model. yi = effect size, soiltype = soil type, water.treat = oxygen availability, permafrost =permafrost, ecosystem = ecosystem, doi = day of incubation

Model	AICc	Akaike weights
yi ~ 1	**30.18**	**0.2**
yi ~ 1 + doi	31.09	0.13
yi ~ 1 + ecosystem	31.53	0.1
yi ~ 1 + soiltype	31.92	0.08
yi ~ 1 + water.treat	32.51	0.06
yi ~ 1 + ecosystem + doi	33.1	0.05
yi ~ 1 + soiltype + doi	33.12	0.05
yi ~ 1 + water.treat + doi	33.46	0.04
yi ~ 1 + permafrost	33.73	0.03
yi ~ 1 + ecosystem + water.treat	33.82	0.03
yi ~ 1 + ecosystem + soiltype	33.91	0.03
yi ~ 1 + soiltype + water.treat	34.35	0.03
yi ~ 1 + permafrost + doi	34.49	0.02
yi ~ 1 + ecosystem + permafrost	34.97	0.02
yi ~ 1 + ecosystem + water.treat + doi	35.32	0.02
yi ~ 1 + soiltype + water.treat + doi	35.59	0.01
yi ~ 1 + ecosystem + soiltype + doi	35.63	0.01
yi ~ 1 + ecosystem + permafrost + doi	35.91	0.01
yi ~ 1 + permafrost + soiltype	36.06	0.01
yi ~ 1 + permafrost + water.treat	36.23	0.01
yi ~ 1 + ecosystem + soiltype + water.treat	36.36	0.01
yi ~ 1 + permafrost + water.treat + doi	36.95	0.01
yi ~ 1 + permafrost + soiltype + doi	37.06	0.01
yi ~ 1 + ecosystem + permafrost + water.treat	37.25	0.01
yi ~ 1 + ecosystem + permafrost + soiltype	37.74	0
yi ~ 1 + ecosystem + permafrost + water.treat + doi	37.91	0
yi ~ 1 + ecosystem + soiltype + water.treat + doi	38.01	0
yi ~ 1 + permafrost + soiltype + water.treat	38.67	0
yi ~ 1 + ecosystem + permafrost + soiltype + doi	38.79	0
yi ~ 1 + permafrost + soiltype + water.treat + doi	39.64	0
yi ~ 1 + ecosystem + permafrost + soiltype + water.treat	40.11	0
yi ~ 1 + ecosystem + permafrost + soiltype + water.treat + doi	40.87	0

Table S12 | Models, their corresponding Akaike Information Criterion corrected for finite sample sizes (AICc), and Akaike weights for meta-analysis of the effect of a 10 °C increase in temperature on CH_4-C release. Bolded model is the final model. yi = effect size, soiltype = soil type,p ermafrost = permafrost, ecosystem = ecosystem, doi = day of incubation

Model	AICc	Akaike weights
yi ~ 1	**32.78**	**0.63**
yi ~ 1 + doi	35.64	0.15
yi ~ 1 + permafrost	36.23	0.11
yi ~ 1 + soiltype	37.74	0.05
yi ~ 1 + permafrost + doi	38.6	0.03
yi ~ 1 + ecosystem	42.28	0.01
yi ~ 1 + soiltype + doi	42.84	0
yi ~ 1 + permafrost + soiltype	43.35	0
yi ~ 1 + permafrost + soiltype + doi	49.57	0
yi ~ 1 + ecosystem + doi	52.02	0
yi ~ 1 + ecosystem + soiltype	52.34	0
yi ~ 1 + ecosystem + permafrost	52.53	0
yi ~ 1 + ecosystem + permafrost + doi	67.04	0
yi ~ 1 + ecosystem + soiltype + doi	69.57	0
yi ~ 1 + ecosystem + permafrost + soiltype	70.23	0
yi ~ 1 + ecosystem + permafrost + soiltype + doi	103.6	0

Table S13 | All possible model subsets, their corresponding Akaike Information Criterion corrected for finite sample sizes (AICc), and Akaike weights for meta-analysis of the effect of aerobic to anaerobic total C release (CO_2-C+CH_4-C). Bolded model is the final model. yi = effect size, soiltype = soil type, temp = temperature, permafrost = permafrost, ecosystem = ecosystem, doi = day of incubation

Model	AICc	Akaike weights
yi ~ 1 + soiltype + temp	53.97	0.35
yi ~ 1 + soiltype + temp + doi	54.02	0.34
yi ~ 1 + permafrost + soiltype + temp	56.67	0.09
yi ~ 1 + permafrost + soiltype + temp + doi	57.05	0.07
yi ~ 1 + soiltype	58.87	0.03
yi ~ 1 + soiltype + doi	59.08	0.03
yi ~ 1 + ecosystem + soiltype + temp	59.37	0.02
yi ~ 1 + ecosystem + soiltype + temp + doi	60.48	0.01
yi ~ 1 + permafrost + soiltype	61.47	0.01
yi ~ 1 + temp	61.62	0.01
yi ~ 1 + permafrost + soiltype + doi	61.98	0.01
yi ~ 1 + ecosystem + permafrost + soiltype + temp	62.37	0.01
yi ~ 1 + temp + doi	62.9	0
yi ~ 1 + ecosystem + temp	63.11	0
yi ~ 1	**63.89**	**0**
yi ~ 1 + ecosystem + soiltype	64	0
yi ~ 1 + ecosystem + permafrost + soiltype + temp + doi	64.02	0
yi ~ 1 + permafrost + temp	64.39	0
yi ~ 1 + ecosystem + soiltype + doi	65.12	0
yi ~ 1 + doi	65.29	0
yi ~ 1 + ecosystem + temp + doi	65.4	0
yi ~ 1 + permafrost + temp + doi	65.83	0
yi ~ 1 + ecosystem + permafrost + temp	66.3	0
yi ~ 1 + permafrost	66.48	0
yi ~ 1 + ecosystem + permafrost + soiltype	66.94	0
yi ~ 1 + ecosystem	67.09	0
yi ~ 1 + permafrost + doi	68.01	0
yi ~ 1 + ecosystem + permafrost + soiltype + doi	68.5	0
yi ~ 1 + ecosystem + permafrost + temp + doi	68.9	0
yi ~ 1 + ecosystem + doi	69.14	0
yi ~ 1 + ecosystem + permafrost	70.06	0
yi ~ 1 + ecosystem + permafrost + doi	72.39	0

Table S14 All possible model subsets, their corresponding Akaike Information Criterion corrected for finite sample sizes (AICc), and Akaike weights for meta-analysis of the effect of aerobic to anaerobic C release calculated as CO_2-C equivalent. Bolded model is the final model. yi = effect size, soiltype = soil type, temp = temperature, permafrost = permafrost, ecosystem = ecosystem, doi = day of incubation

Model	AICc	Akaike weights
yi ~ 1 + temp	60.55	0.14
yi ~ 1 + permafrost + temp	60.8	0.12
yi ~ 1 + ecosystem + soiltype + temp	61.65	0.08
yi ~ 1 + ecosystem + temp	62.4	0.06
yi ~ 1	**62.43**	**0.06**
yi ~ 1 + permafrost + soiltype + temp	62.49	0.05
yi ~ 1 + temp + doi	62.59	0.05
yi ~ 1 + permafrost + temp + doi	62.63	0.05
yi ~ 1 + soiltype + temp	62.82	0.05
yi ~ 1 + permafrost	63.2	0.04
yi ~ 1 + ecosystem + soiltype	63.63	0.03
yi ~ 1 + ecosystem	63.66	0.03
yi ~ 1 + ecosystem + permafrost + soiltype + temp	63.71	0.03
yi ~ 1 + doi	64.19	0.02
yi ~ 1 + ecosystem + permafrost + temp	64.52	0.02
yi ~ 1 + permafrost + doi	64.58	0.02
yi ~ 1 + soiltype	64.73	0.02
yi ~ 1 + permafrost + soiltype + temp + doi	64.83	0.02
yi ~ 1 + ecosystem + soiltype + temp + doi	65.05	0.01
yi ~ 1 + permafrost + soiltype	65.11	0.01
yi ~ 1 + soiltype + temp + doi	65.22	0.01
yi ~ 1 + ecosystem + temp + doi	65.26	0.01
yi ~ 1 + ecosystem + permafrost + soiltype	65.79	0.01
yi ~ 1 + ecosystem + permafrost	66	0.01
yi ~ 1 + ecosystem + doi	66.32	0.01
yi ~ 1 + ecosystem + soiltype + doi	66.62	0.01
yi ~ 1 + soiltype + doi	66.81	0.01
yi ~ 1 + permafrost + soiltype + doi	66.93	0.01
yi ~ 1 + ecosystem + permafrost + soiltype + temp + doi	67.2	0.01
yi ~ 1 + ecosystem + permafrost + temp + doi	67.39	0
yi ~ 1 + ecosystem + permafrost + doi	68.58	0
yi ~ 1 + ecosystem + permafrost + soiltype + doi	68.76	0

Table S15 | All possible model subsets, their corresponding Akaike Information Criterion corrected for finite sample sizes (AICc), and Akaike weights for regression analysis of logit transformed ratio of CH_4-C to total anaerobic C release. Bolded model is the final model. yi = effect size, soiltype = soil type, temp = temperature, permafrost = permafrost, ecosystem = ecosystem, doi = day of incubation

Model	AICc	Akaike weights
logit.ratio ~ 1 + ecosystem + temp	**146.45**	**0.41**
logit.ratio ~ 1 + ecosystem + permafrost + temp	148.00	0.19
logit.ratio ~ 1 + ecosystem + temp + doi	148.87	0.12
logit.ratio ~ 1 + ecosystem + soiltype + temp	149.01	0.11
logit.ratio ~ 1 + ecosystem + permafrost + temp + doi	150.47	0.05
logit.ratio ~ 1 + ecosystem + permafrost + soiltype + temp	151.08	0.04
logit.ratio ~ 1 + ecosystem + soiltype + temp + doi	151.53	0.03
logit.ratio ~ 1 + ecosystem	153.71	0.01
logit.ratio ~ 1 + ecosystem + permafrost + soiltype + temp + doi	153.72	0.01
logit.ratio ~ 1 + ecosystem + doi	156.00	0.00
logit.ratio ~ 1 + ecosystem + permafrost	156.00	0.00
logit.ratio ~ 1 + ecosystem + soiltype	156.31	0.00
logit.ratio ~ 1 + ecosystem + permafrost + doi	158.28	0.00
logit.ratio ~ 1 + ecosystem + soiltype + doi	158.62	0.00
logit.ratio ~ 1 + soiltype + temp	158.84	0.00
logit.ratio ~ 1 + ecosystem + permafrost + soiltype	159.02	0.00
logit.ratio ~ 1 + soiltype + temp + doi	159.18	0.00
logit.ratio ~ 1 + soiltype	160.27	0.00
logit.ratio ~ 1 + soiltype + doi	160.31	0.00
logit.ratio ~ 1 + permafrost + soiltype + temp	160.38	0.00
logit.ratio ~ 1 + permafrost + soiltype + temp + doi	160.54	0.00
logit.ratio ~ 1	161.39	0.00
logit.ratio ~ 1 + ecosystem + permafrost + soiltype + doi	161.40	0.00
logit.ratio ~ 1 + permafrost + soiltype + doi	162.05	0.00
logit.ratio ~ 1 + doi	162.17	0.00
logit.ratio ~ 1 + permafrost + soiltype	162.26	0.00
logit.ratio ~ 1 + temp	162.27	0.00
logit.ratio ~ 1 + permafrost	163.30	0.00
logit.ratio ~ 1 + temp + doi	163.32	0.00
logit.ratio ~ 1 + permafrost + temp	163.58	0.00
logit.ratio ~ 1 + permafrost + doi	163.63	0.00
logit.ratio ~ 1 + permafrost + temp + doi	164.18	0.00

Table S16| Variable importance values for each Meta-Analysis

Meta-Analysis	Moderators	Variance importance value
Temperature, total C (CO_2-C + CH_4-C)		
	Ecosystem	0.22
	Permafrost	0.09
	Soil type	0.24
	Water treatment	0.45
	Day of incubation	0.34
Temperature, CO_2-C equivalent		
	Ecosystem	0.29
	Permafrost	0.13
	Soil type	0.24
	Water treatment	0.23
	Day of incubation	0.36
Temperature, CH_4-C (CH_4-C)		
	Ecosystem	0.01
	Permafrost	0.15
	Soil type	0.06
	Day of incubation	0.19
Ae/Anaerobic, total C (CO_2-C + CH_4-C)		
	Ecosystem	0.04
	Permafrost	0.19
	Soil type	0.97
	Temperature	0.9
	Day of incubation	0.46
Ae/Anaerobic, total CO_2-C equivalent		
	Ecosystem	0.32
	Permafrost	0.4
	Soil type	0.36
	Temperature	0.71
	Day of incubation	0.24
Regression analysis, CH_4-C to total C		
	Ecosystem	1.0
	Permafrost	0.3
	Soil type	0.21
	Temperature	0.97
	Day of incubation	0.23

Table S17: Number (Nr) of samples used in meta-analysis for ratio of aerobic to anaerobic C release.

Citation	Total Nr of sample pairs[a]	Nr of anaerobic samples reaching max. CH_4 rate	Percentage (%) of samples that reached max. CH_4 rate
Čapek et al. (2015)[2]	9	6	67
Diáková et al. (in revision)[5]	9	0	0
Estop-Aragones et al. (in prep)	48	31	65
Iversen et al. (2015a)[9]	41	11	27
Kane et al. (2013)[10]	48	27	56
Knoblauch et al. (2013)[11]	25	13	52
Lee et al. (2012)[12]	28	26	93
Treat et al. (2014)[20]	29	19	66
Waldrop et al. (2010)[21]	16	16	100
Waldrop et al. (in prep)	60	31	52

[a] One sample pair is a set of soil that has been incubated under aerobic and anaerobic conditions

Table S18: Summary of the results of the sensitivity analysis. meta-analyses of the ratio of aerobic to anaerobic incubation conditions on total C release (CO_2-C + CH_4-C) and on total C release as CO_2-C equivalent by accounting for the GWP of CO_2 (GWP=1) and CH_4 (GWP=34[23]). N are numbers of observations (not equal to number of samples as multiple samples could be grouped into one observation). Letters a-c in the headers refer to the three analyses performed as part of the sensitivity analysis.

	a) All studies and samples				b) Studies with > 60% of samples reaching max. CH_4 rate				c) Only samples included that reached maximum CH_4 rate			
	N	Estimate	95% CI		N	Estimate	95% CI		N	Estimate	95% CI	
			lower	upper			lower	upper			lower	upper
						Total C						
Ecosystem												
Tundra	11	3.32	1.57	7.03	6	4.34	0.98	19.24	8	3.82	2.07	7.03
Peatland	13	3.46	1.54	7.77	8	2.69	0.73	9.95	9	4.1	1.52	11.06
Boreal Forest	9	5.0	3.99	6.27	5	5.52	4.15	7.33	8	5.1	3.89	6.69
Soil Type												
Mineral	14	3.34	2.11	5.28	7	4.09	2.21	7.6	11	3.36	2.35	4.8
Organic	19	4.23	2.44	7.34	12	4.47	1.95	10.23	14	5.04	2.91	8.71
Permafrost												
Active layer	21	3.29	1.99	5.45	10	3.76	1.86	7.6	15	3.9	2.33	6.53
Permafrost	12	4.15	2.53	6.8	9	4.03	1.88	8.62	10	3.9	2.38	6.41
Overall mean	**33**	**3.39**	**2.22**	**5.18**	**19**	**3.65**	**1.91**	**6.98**	**25**	**3.81**	**2.53**	**5.73**
						CO_2-C equivalent						
Ecosystem												
Tundra	11	1.68	0.9	3.12	6	2.58	1.0	6.64	8	1.68	0.79	3.6
Peatland	13	2.48	1.4	4.41	8	2.28	0.72	7.23	9	2.53	1.28	4.99
Boreal Forest	9	4.17	3.34	5.21	5	4.17	3.16	5.5	8	3.71	2.74	5.02
Soil Type												
Mineral	14	2.18	1.27	3.72	7	2.95	1.69	5.14	11	1.93	1.08	3.43
Organic	19	2.63	1.79	3.87	12	2.67	1.46	4.87	14	2.63	1.75	3.96
Permafrost												
Active layer	21	2.2	1.56	3.09	10	2.25	1.39	3.63	15	2.36	1.68	3.3
Permafrost	12	2.76	1.53	4.95	9	3.15	1.66	5.99	10	2.32	1.2	4.48
Overall mean	**33**	**2.3**	**1.55**	**3.4**	**19**	**2.7**	**1.62**	**4.49**	**25**	**2.26**	**1.44**	**3.54**

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