Supplementary material to article 'Carbon dioxide balance of subarctic tundra from plot to regional scales'

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Supplementary methods

Auxiliary data

Local weather was monitored at the study site with two weather stations. As a default, data was taken from weather station I. When this data was missing, complementary data was obtained from weather station II. Weather data was collected to a data logger (CR23X, Campbell Scientific, UK/Hobo Micro Station H21-002, Onset, USA for weather station I/weather station II, respectively) on following parameters: air temperature (Hygromer MP100A, Rotronic, USA/S-THA-M006, Onset, USA), soil heat flux (HFP01, Hukseflux Thermal Sensors, the Netherlands/-), net radiation (NR LITE, Kipp & Zonen, the Netherlands/-), photosynthetically active radiation (PAR) (LI-190, LI-COR, USA/S-LIA-M003, Onset, USA), precipitation (7852 Rain Collector II, Davis, USA/7852 Rain Collector, Davis, USA) and wind speed (A100R, Vector Instruments, UK/ S-WSA-M003, Onset, USA). Data from the weather station II was normalized against the default data to account for the slightly different location (distance about 250 m) and different instrumentation. In addition, soil moisture, water table level (WT), active layer depth (AL; depth of the seasonal thaw) and soil temperature at a depth of 2 cm were monitored on different land cover classes by manual and continuous measurements as described by Marushchak *et al.* (2011).

The leaf area index of vascular plants (LAI; one-sided leaf area per unit ground surface area) was measured weekly from early June to early September 2008 at the chamber measurements plots and on thirteen 200-m transects starting at the EC mast (Fig. 1B) using a LAI 2000 Plant Canopy Analyzer (LiCor, NE USA). Additional LAI measurements were made fortnightly on a 1-km^2 grid around the EC mast. The total number of measurement points was 284. Missing weekly values were imputed by linear interpolation. Another interpolation method, a four parameter Gaussian fitting, was used to obtain daily LAI values for the chamber plots for modeling the C fluxes.

Supplementary figures and tables

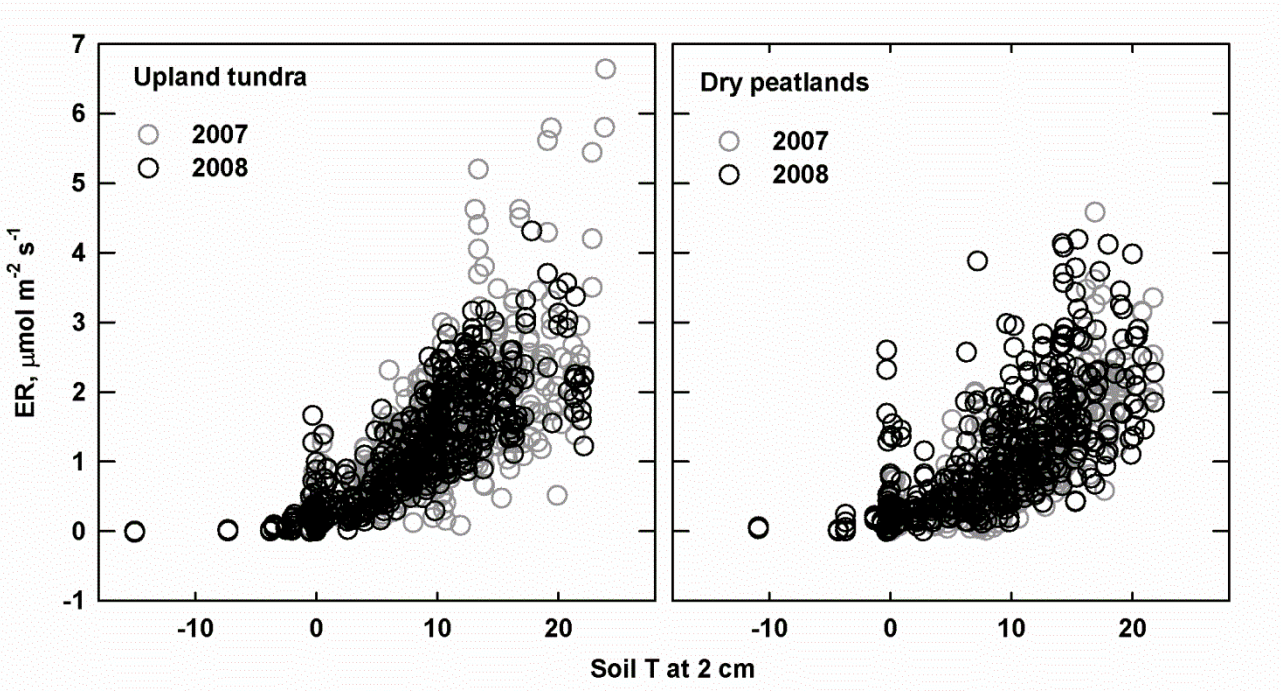

Figure S1. Temperature response of ecosystem respiration at the dry microsites in upland tundra and dry peatlands measured by chambers.

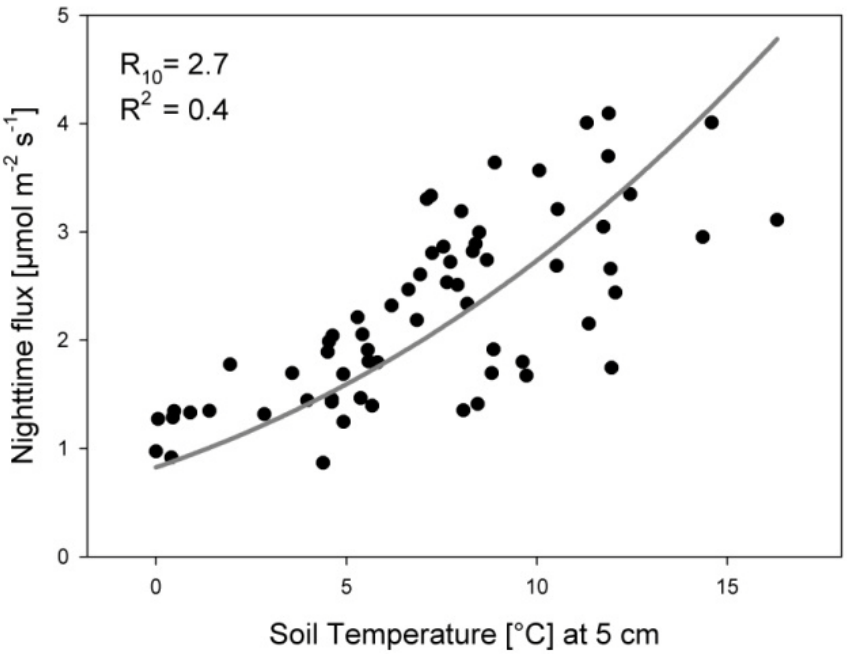

Figure S2. Temperature response of night-time ecosystem respiration measured by eddy covariance.

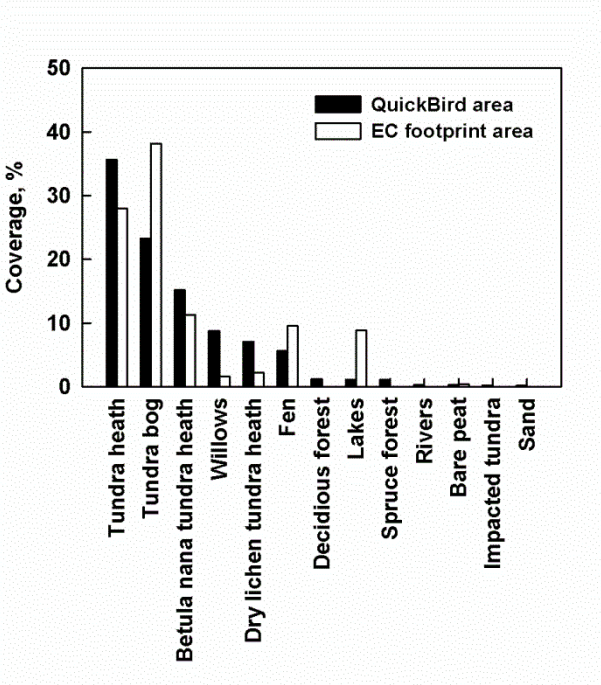

Figure S3. Coverage of different LCTs in the QuickBird image (98.6 km^2) and in the EC footprint area.

Table S1. Summary of ecosystem respiration (ER) models for microsites studied with chamber technique; R_{10} = ER at 10°C, E_0 = activation energy of ER.

Period	Land cover type	Microsite	R_{10}	E_0	df	r^2	RMSE
2007	Tundra heath	Shrub tundra heath, dry	1.34 ± 0.02	322.29 ± 23.71	32 – 33	0.573 – 0.731	0.54 – 0.64
		" , moist	1.42 ± 0.09	264.94 ± 17.56	32 – 34	0.447 – 0.623	0.66 – 0.80
		Betula nana tundra heath	1.45 ± 0.13	252.43 ± 14.26	32 – 37	0.433 – 0.549	0.55 – 0.87
		Dry lichen tundra heath	0.96 ± 0.05	244.32 ± 7.97	32 – 36	0.540 – 0.639	0.37 – 0.47
	Dry peatlands	Tundra bog, dry	0.88 ± 0.06	292.57 ± 15.24	34 – 35	0.434 – 0.560	0.51 – 0.64
		" , moist	1.00 ± 0.06	321.08 ± 10.26	34 – 37	0.643 – 0.724	0.43 – 0.51
		Bare peat	0.60 ± 0.03	391.63 ± 33.42	30 – 34	0.771 – 0.913	0.21 – 0.25
	Wetlands	Willow	1.59 ± 0.15	412.87 ± 9.71	30 – 31	0.540 – 0.642	0.84 – 1.26
		Fen, *Carex*	1.23 ± 0.14	388.41 ± 3.03	30 – 32	0.688 – 0.833	0.61 – 0.65
		" , *Eriophorum*	0.48 ± 0.25	380.85 ± 99.82	28 – 31	0.319 – 0.575	0.21 – 0.64
2008	Tundra heath	Shrub tundra heath, dry	1.24 ± 0.06	245.71 ± 30.52	34 – 37	0.622 – 0.793	0.38 – 0.46
		" , moist	1.30 ± 0.13	299.97 ± 24.57	35 – 36	0.764 – 0.848	0.37 – 0.48
		Betula nana tundra heath	1.04 ± 0.06	274.08 ± 24.73	35 – 36	0.704 – 0.820	0.27 – 0.54
		Dry lichen tundra heath	1.12 ± 0.09	225.17 ± 16.93	38 – 40	0.589 – 0.795	0.39 – 0.49
	Dry peatlands	Tundra bog, dry	0.77 ± 0.06	318.04 ± 29.35	38 – 40	0.733 – 0.740	0.35 – 0.39
		" , moist	1.57 ± 0.06	271.69 ± 32.96	36 – 37	0.598 – 0.845	0.55 – 0.67
		Bare peat	0.76 ± 0.03	372.61 ± 52.17	35 – 37	0.717 – 0.841	0.42 – 0.55
	Wetlands	Willow	1.72 ± 0.12	464.26 ± 21.73	32 – 33	0.766 – 0.814	0.95 – 1.05
		Fen, *Carex*	1.54 ± 0.26	427.80 ± 19.86	34 – 35	0.598 – 0.845	0.71 – 1.46
		" , *Eriophorum*	0.60 ± 0.07	314.07 ± 69.25	34	0.433 – 0.678	0.41 – 0.47

Table S2. Summary of gross photosynthesis (GP) models for microsites studied with chamber technique; Q = maximum GP, k = PAR level at which GP reaches half of Q, T_{opt} = temperature optimum of GP, T_{tol} = temperature tolerance of GP, a = correction term for LAI.

Period	Land cover	Microsite	Model type	Q	k	T_{opt}	T_{tol}	a	df	r^2	RMSE
2007	Tundra heath	Shrub tundra heath, dry	1	–17.09 ± 5.15	320 ± 96	19.5 ± 10.8	17.7 ± 11.5	0.0 ± 0.1	58	0.742	0.60
		” ,	1	–5.22 ± 0.66	453 ± 70	14.7 ± 0.5	9.5 ± 0.8	1.4 ± 0.3	95	0.887	0.85
		Betula nana tundra heath	1	–11.89 ± 4.74	297 ± 85	27.4 ± 13.2	16.8 ± 7.9	0.2 ± 0.1	84	0.735	0.98
		Dry lichen tundra heath	1	–6.02 ± 4.36	409 ± 104	16.2 ± 1.1	10.1 ± 1.8	0.8 ± 0.7	85	0.731	0.63
	Dry peatlands	Tundra bog, dry	1	–3.64 ± 0.71	353 ± 70	15.2 ± 1.0	10.8 ± 1.5	0.8 ± 0.4	90	0.832	0.67
		“ , moist	1	–3.20 ± 0.66	306 ± 47	17.4 ± 1.2	9.4 ± 1.2	2.6 ± 0.6	101	0.869	0.85
		Bare peat	4	–4.01 ± 10.24	335 ± 152	38.2 ± 133.3	25.6 ± 67.0	–	69	0.391	0.36
	Wetlands	Willow	2	–9.48 ± 2.50	465 ± 132	15.5 ± 1.1	8.4 ± 1.5	0.3 ± 0.6	82	0.731	2.43
		Fen, *Carex*	1	–3.76 ± 0.83	329 ± 59	16.4 ± 2.2	10.8 ± 2.4	3.2 ± 0.9	81	0.812	1.59
		“ , *Eriophorum*	1	–15.52 ± 5.17	148 ± 52	25.5 ± 10.3	13.3 ± 6.2	0.1 ± 0.0	82	0.763	0.62
May–Jul 2008	Tundra heath	Shrub tundra heath, dry	1	–3.61 ± 2.54	196 ± 98	16.2 ± 2.3	10.8 ± 2.5	1.0 ± 0.9	87	0.430	0.62
		” ,	1	–8.74 ± 1.24	286 ± 100	16.5 ± 1.5	10.0 ± 3.0	0.2 ± 0.1	77	0.860	0.99
		Betula nana tundra heath	1	–13.66 ± 2.84	441 ± 119	21.4 ± 7.1	15.9 ± 7.3	0.1 ± 0.0	77	0.835	0.59
		Dry lichen tundra heath	3	–1.89 ± 0.00	194 ± 0	–	–	0.0 ± 88.5	87	0.645	0.70
	Dry peatlands	Tundra bog, dry	3	–0.3 ± 0.05	428 ± 0	–	–	0.6 ± 119.0	87	0.827	0.69
		“ , moist	1	–5.01 ± 0.92	371 ± 78	17.5 ± 0.3	5.1 ± 0.4	2.3 ± 0.5	92	0.881	0.97
		Bare peat	4	–1.36 ± 0.31	133 ± 3	17.4 ± 139.3	7.7 ± 2.4	–	75	0.171	0.30
	Wetlands	Willow	2	–12.84 ± 1.49	383 ± 106	20.8 ± 5.0	13.0 ± 10.2	0.1 ± 0.1	35	0.909	2.38
		Fen, *Carex*	1	–7.24 ± 1.29	261 ± 102	19.0 ± 1.7	7.9 ± 2.7	0.8 ± 0.2	78	0.754	1.58
		“ , *Eriophorum*	1	–6.18 ± 2.15	110 ± 87	20.8 ± 0.7	4.3 ± 0.7	0.4 ± 0.2	74	0.652	0.50
Aug–Oct	Tundra heath	Shrub tundra heath, dry	1	–5.09 ± 1.58	353 ± 79	8.4 ± 0.7	6.1 ± 1.1	1.0 ± 0.3	67	0.747	1.19
		” ,	1	–3.86 ± 0.56	281 ± 55	9.8 ± 0.5	5.5 ± 1.5	1.3 ± 0.3	71	0.818	1.39
		Betula nana tundra heath	1	–8.07 ± 1.14	269 ± 52	7.6 ± 2.6	9.0 ± 3.9	0.3 ± 0.1	67	0.867	0.87
		Dry lichen tundra heath	1	–5.09 ± 4.11	297 ± 95	8.7 ± 0.4	3.4 ± 0.8	0.9 ± 0.8	58	0.669	0.78
	Dry peatlands	Tundra bog, dry	1	–3.47 ± 0.79	194 ± 50	15.3 ± 9.0	12.9 ± 11.9	0.5 ± 0.3	63	0.756	0.89
		“ , moist	1	–7.98 ± 1.58	565 ± 153	9.6 ± 0.2	3.1 ± 0.4	1.5 ± 0.4	74	0.875	1.24
		Bare peat	4	–4.49 ± 2.82	717 ± 621	11.9 ± 4.2	7.0 ± 3.9	–	48	0.293	0.37
	Wetlands	Willow	2	–29.73 ± 77.08	1749 ± 1423	24.0 ± 70.1	14.2 ± 35.4	1.0 ± 0.5	44	0.765	2.17
		Fen, *Carex*	1	–4.32 ± 1.14	461 ± 150	12.9 ± 1.8	5.7 ± 1.9	2.6 ± 0.9	66	0.753	2.45
		“ , *Eriophorum*	1	–12.48 ± 2.32	314 ± 11.1	11.1 ± 1.2	3.4 ± 1.8	0.1 ± 0.0	63	0.781	0.78