Title: ABCFlux v2: Arctic–boreal CO_2 and CH_4 monthly flux observations and ancillary information across terrestrial and freshwater ecosystems

Supplement

Supplementary Text 1. Description of the ESA CCI, BAWLD and biome classes and datasets used in figures

For figures 4, 5, 7, 8 and 9, we used the classes “Boreal forest”, “Tundra”, “Wetland”, “Lentic”, and “Lotic” which were formed utilizing the column “bawld_class” for terrestrial (Wetland=bog, fen, marsh, permafrost bog, and wet tundra, Tundra=dry and moist tundra, Boreal forest=Boreal forest) and waterbody_type for lentic and lotic.

For figure 6, we used the terrestrial BAWLD (column “bawld_class”) wetland classes (bog, fen, marsh, permafrost bog, and wet tundra) for calculating the proportion of flux data in the dataset for each class. We also calculated their aerial extents in the gridded product (Olefeldt et al., 2021b). Boreal forest class in column “bawld_class” was split to classes deciduous broadleaf forest, evergreen needleleaf forest, deciduous needleleaf forest and mixed forest based on ESA CCI column “land_cover_ecosystem”; aerial extents of these classes within the original BAWLD boreal forest domain were calculated based on ESA CCI gridded data (ESA CCI 2016). The dry and moist tundra classes in column “bawld_class” were split to shrub, graminoid and barren classes based on column “land_cover_ecosystem”; aerial extents of these classes in the gridded ESA CCI product within the original dry tundra class in BAWLD product were also calculated. Sparse vegetation types were found in boreal forests and dry tundra class in the BAWLD gridded product and their aerial extents in both biomes were calculated and then summed together. For the aquatic classes, we regrouped lotic and lentic classes by their size (Large lentic=Large Lake; Midsize lentic=Midsize Glacial Lake, Midsize Peatland Lake, Midsize Yedoma Lake; Small lentic=Small Glacial Lake, Small Peatland Lake, Small Yedoma Lake; Large lotic=Large river; Small lotic=Small Organic-Rich River, Small Organic-Poor River) and calculated their aerial extents.

Supplementary Table 1. The number of site-months in ABCFlux v2 for each individual flux variable.

Flux column	Number of site-months
nee	14,796
gpp	11,502
reco	12,896
co2_flux	3,713
ch4_flux_total	8,005
ch4_flux_diffusion	3,486
co2_flux_ebullition	33
ch4_flux_ebullition	474
co2_flux_storage	3
ch4_flux_storage	367
nee_seasonal	27
ch4_flux_total_seasonal	179
ch4_flux_diffusion_seasonal	4
ch4_flux_ebullition_seasonal	19
water_co2	7,923
water_ch4	7,745
Total Fluxes	55,504
Total concentration values	15,668

Supplementary Table 2. The 1st and 99th percentiles of terrestrial flux variables separated by measurement methods (EC= eddy covariance, Non-EC= manual and automatic chambers and snow pack diffusion) used to identify outlier measurements.

Month	Biome	Flux method	1st nee	99th nee	1st gpp	99th gpp	1st reco	99th reco	1st CH_4	99th CH_4
1	Boreal	EC	-13.007	50.131	0.000	68.664	-19.618	51.634	-0.040	5.599
2	Boreal	EC	-12.817	42.354	0.001	59.237	-10.343	42.103	-0.826	3.979
3	Boreal	EC	-44.080	39.233	0.219	67.651	-7.305	65.854	-0.130	3.320
4	Boreal	EC	-85.205	36.783	1.724	99.452	-1.746	140.242	-0.077	2.490
5	Boreal	EC	-108.804	48.295	8.333	231.916	3.296	249.231	-0.153	4.942
6	Boreal	EC	-160.174	36.586	16.534	314.340	12.362	360.195	-0.204	2.761
7	Boreal	EC	-138.957	38.031	22.589	366.238	24.167	398.710	-0.185	4.041
8	Boreal	EC	-99.772	66.841	17.773	331.058	20.292	311.961	-0.201	4.359
9	Boreal	EC	-45.720	86.208	11.374	257.750	6.529	197.074	-0.184	2.360
10	Boreal	EC	-12.087	86.766	1.262	160.611	-0.992	88.286	-0.115	2.372
11	Boreal	EC	-0.805	81.776	0.292	95.468	-17.586	35.166	-0.078	4.213
12	Boreal	EC	-11.880	62.902	0.007	74.486	-14.161	38.070	-0.044	5.291
1	Tundra	EC	-23.280	39.765	0.000	50.422	-24.024	48.183	-0.134	0.856
2	Tundra	EC	-28.065	34.041	0.000	40.317	-16.837	41.167	-0.125	0.539
3	Tundra	EC	-26.299	33.138	0.000	45.050	-23.175	36.740	-0.135	0.494
4	Tundra	EC	-25.386	34.025	0.000	47.901	-11.355	46.164	-0.096	0.564
5	Tundra	EC	-38.250	30.536	1.059	76.125	-8.633	106.578	-0.057	1.109
6	Tundra	EC	-95.447	31.338	3.393	119.604	-0.040	186.357	-0.135	2.736
7	Tundra	EC	-120.362	-2.450	3.451	140.281	19.598	226.331	-0.090	4.181
8	Tundra	EC	-72.763	14.205	7.108	123.961	10.956	155.444	-0.003	4.048
9	Tundra	EC	-21.758	33.556	3.017	75.252	-1.959	61.033	0.003	2.550
10	Tundra	EC	-13.271	42.063	0.354	60.809	-9.346	25.889	-0.065	1.149
11	Tundra	EC	-12.782	39.046	0.168	37.806	-13.594	15.096	-0.144	0.572
12	Tundra	EC	-21.244	39.304	0.000	39.167	-18.752	19.320	-0.134	0.614
1	Boreal	Non-EC	0.913	8.149	3.515	8.164	0.000	0.000	-0.030	1.337
2	Boreal	Non-EC	0.015	15.936	1.183	16.327	0.000	0.000	-0.026	4.026
3	Boreal	Non-EC	0.320	19.406	1.416	19.310	0.000	0.000	-0.041	1.157
4	Boreal	Non-EC	-33.851	21.189	-0.146	26.236	0.000	55.314	-0.163	1.169
5	Boreal	Non-EC	-63.068	37.251	0.981	177.796	2.598	507.675	-0.106	8.510
6	Boreal	Non-EC	-176.048	93.987	1.615	250.548	3.525	670.628	-0.180	6.591
7	Boreal	Non-EC	-361.110	173.791	1.281	366.409	13.849	793.996	-0.191	11.537
8	Boreal	Non-EC	-424.430	79.618	1.038	168.134	21.858	819.444	-0.172	9.504
9	Boreal	Non-EC	-259.839	61.962	0.317	136.952	-27.942	445.003	-0.266	6.190

10	Boreal	Non-EC	-9.606	25.935	0.556	39.045	0.000	31.389	-0.075	4.357
11	Boreal	Non-EC	-0.080	13.290	0.754	10.182	-0.036	0.653	-0.106	4.463
12	Boreal	Non-EC	0.020	19.408	2.237	8.285	0.000	0.000	-0.069	1.254
1	Tundra	Non-EC	0.107	23.231	4.906	4.906			0.001	0.557
2	Tundra	Non-EC	-0.083	10.373					0.003	0.892
3	Tundra	Non-EC	0.000	12.816	8.716	10.676			-0.846	0.291
4	Tundra	Non-EC	-0.023	29.433	-3.076	28.918	3.748	36.016	-1.826	0.466
5	Tundra	Non-EC	-9.080	49.132	1.504	130.650	7.145	92.611	-1.513	1.534
6	Tundra	Non-EC	-77.834	109.158	1.247	425.724	-0.676	219.060	-0.137	11.808
7	Tundra	Non-EC	-175.583	117.286	5.840	628.680	0.000	402.490	-0.716	28.216
8	Tundra	Non-EC	-146.325	92.193	4.068	293.761	0.000	318.983	-0.632	42.387
9	Tundra	Non-EC	-95.418	67.054	4.273	529.057	-7.269	196.348	-0.050	36.320
10	Tundra	Non-EC	1.351	76.742	1.291	71.069	-2.318	4.864	-0.004	4.290
11	Tundra	Non-EC	1.051	19.168	4.629	6.678	2.621	2.621	0.008	1.559
12	Tundra	Non-EC	0.116	13.061	8.292	8.292			-0.002	1.190

Supplementary Table 3. The start and end dates (month-year) of data collection and number of site-months for all eddy covariance flux data in ABCFlux v2 separated by gases. Footprint_Partitioned refers to datasets where fluxes have been isolated to different ecosystems within the footprint and thus there are multiple datasets across the different ecosystems for a single site.

site_reference	Start CO_2 data collection (Month-Year)	End CO_2 data collection (Month-Year)	Number of CO_2 site-months	Start CH_4 data collection (Month-Year)	End CH_4 data collection (Month-Year)	Number of CH_4 site-months	Footprint_ Partitioned
Abisko Stordalen birch forest_tower	May-21	Oct-23	30				
Adventdalen_SJ-Adv_tower	Jan-12	Dec-15	48				
Alberta - Western Peatland - LaBiche River,Black Spruce,Larch Fen_CA-WP1_tower	Sep-03	Sep-09	73				
Alberta - Western Peatland - Poor Fen (Sphagnum moss)_CA-WP2_tower	May-04	Dec-06	32				
Alberta - Western Peatland - Rich Fen (Carex)_CA-WP3_tower	May-04	Dec-06	32				
Anaktuvuk River Moderate Burn_US-An2_tower	Jun-08	Aug-23	47				
Anaktuvuk River Severe Burn_US-An1_tower	Jun-08	Aug-23	47				
Anaktuvuk River Unburned_US-An3_tower	Jun-08	Aug-23	47				
Andoya_NO-And_tower	Jul-08	Nov-14	77				
ARM-NSA-Barrow_US-A10_tower	Nov-11	Dec-20	109	Feb-14	Oct-19	58	
ARM-NSA-Oliktok_US-A03_tower	Sep-14	Jun-21	80	Jan-18	Jan-18	1	
Atqasuk_US-Atq_tower	Jan-03	Nov-22	173	Sep-13	Nov-22	93	
Attawapiskat River Bog_CA-ARB_tower	May-11	Dec-15	56				
Attawapiskat River Fen_CA-ARF_tower	Apr-11	Dec-15	57				
Barrow_Medium lake_tower	Jun-11	Aug-11	Seasonal flux				
Barrow_Old lake_tower	Jun-11	Aug-11	Seasonal flux				
Barrow_Young lake_tower	Jun-11	Aug-11	Seasonal flux				
Barrow-BEO_US-Beo_tower	Jan-13	Nov-22	92	Oct-13	Nov-22	82	

site_reference	Start CO_2 data collection (Month-Year)	End CO_2 data collection (Month-Year)	Number of CO_2 site-months	Start CH_4 data collection (Month-Year)	End CH_4 data collection (Month-Year)	Number of CH_4 site-months	Footprint_ Partitioned
Barrow-BES_US-Bes_tower	Jul-05	Nov-22	104	Aug-13	Nov-22	74	
Barrow-CMDL_US-Brw_tower	Sep-13	Dec-22	107	Sep-13	Dec-22	96	
Bayelva, Spitsbergen_SJ-Blv_tower	Jan-08	Dec-15	28				
Bernard Lake_tower	Jul-22	Jan-24	19	Jul-22	Jan-24	19	
Bernard spruce-moss valley_tower	Nov-18	Jan-24	63	Jul-21	Jan-24	29	
Bibai bog_JP-Bby_tower	Jan-15	Feb-21	74	Jan-15	Feb-21	74	
Bonanza Creek Black Spruce_US-BZS_tower	Jun-10	Dec-21	115	May-15	Sep-16	11	
Bonanza Creek Old Thermokarst Bog_US-BZo_tower	Apr-18	Dec-21	45				
Bonanza Creek Rich Fen_US-BZF_tower	May-11	Dec-21	116	May-14	Oct-16	16	
Bonanza Creek Thermokarst Bog_US-BZB_tower	Jan-11	Dec-21	120	May-14	Oct-16	18	
Bouleau peatland_CA-BOU_tower	Jun-18	Oct-20	29	Jun-18	Oct-20	13	
Cambridge Bay - Mesic_CB-mesic_tower	May-22	Sep-22	5				
Cape Bounty_CA-CB_tower	Jun-08	Jul-18	12				
Cascaden Ridge Fire Scar_US-Fcr_tower	Jan-11	Dec-14	48				
Central Marsh_US-Cms_tower	Jan-99	Aug-05	80	Jun-99	Aug-00	5	
Cherskii disturbed forest_RU-Eusk_cher2_tower	Mar-13	Nov-15	31				
Cherskii ecotone_RU-Eusk_cher1_tower	Jan-12	Dec-15	36				
Cherskii reference_RU-Ch2_tower	Jul-13	Dec-21	102	Jul-13	Dec-21	102	

site_reference	Start CO_2 data collection (Month-Year)	End CO_2 data collection (Month-Year)	Number of CO_2 site-months	Start CH_4 data collection (Month-Year)	End CH_4 data collection (Month-Year)	Number of CH_4 site-months	Footprint_Partitioned
Churchill Fen 3_CA-CF3_tower	Sep-22	Dec-24	28	Sep-22	Dec-24	28	
Churchill Fen Site 2_CA-CF2_tower				Jul-08	Nov-11	18	
Churchill Fen Site 1_CA-CF1_tower	Jan-07	Dec-08	24				
Council Alaska Tundra_US-CAK_tower	Sep-24	Sep-24	1	Sep-24	Sep-24	1	
Council, Alaska_US-KOC_tower	Jul-14	Aug-23	26				
Daring Lake_CA-DL1_tower	May-04	Aug-15	54				
Daring Lake_CA-DL3_tower	May-10	Aug-15	24				
Daring Lake_CA-DL4_tower	May-10	Aug-15	21				
Daring Lake_tower	May-06	Aug-06	4				
Degero_SE-Deg_tower	Jan-01	Dec-23	276	Jan-14	Dec-18	50	
Delta Junction evergreen conifer forest_US-Bn2_tower	Apr-02	Apr-04	3				
Delta Junction deciduous broadleaf forest_US-Bn1_tower	Apr-02	Apr-04	3				
Disko_GL-Dsk_tower	Dec-12	Dec-23	107				
Eastmain Reservoir_tower	Jan-08	Sep-12	45				
Eight Mile Lake_US-EML_tower	May-08	Mar-24	188	Jul-15	Mar-24	67	
Elgeeii forest station_RU-Ege_tower	Jan-10	Dec-18	108				
Faejemyr_SE-Faj_tower	Jul-05	Dec-09	53				
Finse west_NO-Fns_tower	Jan-19	Dec-21	36				

site_reference	Start CO_2 data collection (Month-Year)	End CO_2 data collection (Month-Year)	Number of CO_2 site-months	Start CH_4 data collection (Month-Year)	End CH_4 data collection (Month-Year)	Number of CH_4 site-months	Footprint_Partitioned
Fish Island_FI-NWT_tower	Jul-17	Aug-17	2	Jul-17	Aug-17	2	
Flakaliden_SE-Fla_tower	Jun-96	Dec-09	103				
Flux Observations of Carbon from an Airborne Laboratory (FOCAL) Campaign Site 1_US-Fo1_tower	Jul-13	Sep-24	9	Jul-13	Sep-24	9	
Flux Observations of Carbon from an Airborne Laboratory (FOCAL) Campaign Site 2_US-Fo2_tower	Jun-23	Sep-24	9	Jun-23	Sep-24	9	
Fyodorovskoye_RU-Fyo_tower	May-98	Dec-20	272				
Fyodorovskoye2_RU-Fy2_tower	May-15	Dec-20	68	Jun-15	Dec-18	43	
Gunnarsholt_IS-Gun_tower	Jul-96	Dec-98	22				
Hakasia 10 yr_RU-Ha3_tower	Apr-04	Nov-04	8				
Hakasia 5yr_RU-Ha2_tower	Jul-02	Jul-03	9				
Hakasia Steppe_RU-Ha1_tower	Jul-02	Dec-04	30				
Halmyran_SE-Hmr_tower	Apr-20	Dec-22	33	Apr-20	Dec-22	33	
Halsingfors mire_SE-HfM_tower	Apr-20	Dec-22	33	Jun-20	Dec-22	31	
Happy Valley Wet Sedge Tundra_US-HVs_tower	May-95	Sep-95	5				
Happy Valley_US-HVa_tower	Jun-94	Sep-95	7	Jun-95	Aug-95	3	
Havikpak Creek_CA-HPC_tower	Apr-13	Sep-22	114	Jan-18	Sep-22	57	
HJP02 Jack Pine_CA-HJP02_tower	Jan-04	Dec-05	24				
HJP75 Jack Pine_CA-HJP75_tower	Apr-04	Dec-05	21				

site_reference	Start CO_2 data collection (Month-Year)	End CO_2 data collection (Month-Year)	Number of CO_2 site-months	Start CH_4 data collection (Month-Year)	End CH_4 data collection (Month-Year)	Number of CH_4 site-months	Footprint_ Partitioned
HJP94 Jack Pine_CA-HJP94_tower	Jan-04	Dec-05	24				
Hustai grassland_MN-Hst_tower	Jan-15	Dec-20	72				
Hyltemossa_SE-Htm_tower	Jan-15	Dec-20	71				
Hyytiala_FI-Hyy_tower	Jul-96	Dec-23	330	Jan-12	Dec-16	21	
Igarka_RU-Iga_tower	Jun-16	Aug-23	26				
Illisarvik_IL-NWT_tower	Jul-16	Aug-16	Seasonal flux	Jul-16	Aug-16	Seasonal flux	
Imnavait Creek Watershed Heath Tundra_US-ICh_tower	Sep-07	Dec-21	172				
Imnavait Creek Watershed Tussock Tundra_US-ICt_tower	Jul-07	Dec-21	174				
Imnavait Creek Watershed Wet Sedge Tundra_US-ICs_tower	Sep-07	Dec-21	160	Jun-14	Nov-21	22	
Iqaluit Tundra_CA-IQ1_tower	May-22	Oct-23	11				
Iqaluit_CA-Iqa_tower	Jul-08	Jul-08	1				
Iskoras_NO-Isk_tower	Apr-19	Feb-22	35	Apr-19	Feb-22	31	
Iskoras_NO-Isk-fen_tower	Apr-19	Feb-22	35	Apr-19	Feb-22	31	Yes
Iskoras_NO-Isk-palsa_tower	Apr-19	Feb-22	35	Apr-19	Feb-22	31	Yes
Iskoras_NO-Isk-pond_tower	Apr-19	Feb-22	35	Apr-19	Feb-22	31	Yes
Ivotuk_US-Ivo_tower	Oct-03	Nov-18	119	Jul-13	Jul-18	49	
Kaamanen_FI-Kaa_tower	Jan-97	Dec-08	143				
Kalevansuo_FI-Kns_tower	Sep-04	Apr-09	56				
Kenttarova_FI-Ken_tower	Jan-12	Dec-23	84				

site_reference	Start CO_2 data collection (Month-Year)	End CO_2 data collection (Month-Year)	Number of CO_2 site-months	Start CH_4 data collection (Month-Year)	End CH_4 data collection (Month-Year)	Number of CH_4 site-months	Footprint_ Partitioned
Kherlenbayan Ulaan_MN-Kbu_tower	Jan-03	Dec-08	72				
Kitinen_tower	Jun-18	Sep-18	4	Jun-18	Sep-18	4	
Knottasen_SE-Kno_tower	Jan-06	Dec-17	139				
Kuivajaervi_FI-Kvr_tower	Aug-10	Mar-22	113	Sep-12	Sep-15	31	
Kymijoki_tower	Jun-09	Jul-09	2				
Kytalyk, Russia_RU-Cok_tower	May-03	Sep-21	80	Jul-08	Aug-21	21	
Lac Le Caron peatland, an ombrotrophic bog_CA-LLC_tower	Jan-08	Sep-12	45				
Lake Hazen, Ellesmere Island_CA-LHazen1-semidesert_tower	Jun-09	Sep-12	9				
Lake Hazen, Ellesmere Island_CA-LHazen2-meadow wetland_tower	Jun-11	Sep-12	6				
Lettosuo_FI-Let_tower	Sep-09	Dec-24	183				
Lily Lake Fen_US-KPL_tower	Apr-21	Oct-23	31	Mar-21	Oct-23	20	
Ljusdal_HY_tower	Aug-19	Oct-22	23				
Ljusdal_SLM_tower	Jun-20	Dec-22	25				
Lompolojankka_FI-Lom_tower	Jan-06	Dec-12	72	Jan-06	Dec-10	60	
Lutose_CA-LUT_tower	Jun-21	Oct-23	29				
Manitoba - Northern Old Black Spruce (former BOREAS Northern Study Area)_CA-Man_tower	Apr-94	Dec-08	149				
Merasjaervi_tower	Jun-05	Oct-05	5				
Mittimatalik (Pond Inlet)	Aug-24	Nov-24	4	Aug-24	Sep-24	2	

site_reference	Start CO_2 data collection (Month-Year)	End CO_2 data collection (Month-Year)	Number of CO_2 site-months	Start CH_4 data collection (Month-Year)	End CH_4 data collection (Month-Year)	Number of CH_4 site-months	Footprint_Partitioned
Tundra_CA-Mtk_tower							
Mukhrino field station, Khanty-Mansiysk, Russia_RU-Muh_tower	May-15	Sep-22	15				
Mukhrino_Mukhrino_RHC_tower	May-15	Aug-15	4				
Nalaikh grassland_MN-Nkh_tower	Jan-15	Dec-20	72				
Nelegel_RU-Nel_tower	Jun-00	Aug-06	30				
Neleger Burnt Forest_RU-NeB_tower	Jan-99	Dec-00	24				
Neleger Cutover_RU-NeC_tower	Jan-01	Dec-06	72				
Neleger larch forest_RU-NeF_tower	Jan-00	Dec-06	84				
NEON Barrow Environmental Observatory (BARR)_US-xBA_tower	Jun-19	Oct-22	37				
NEON Caribou Creek - Poker Flats Watershed (BONA)_US-xBN_tower	Nov-17	Nov-22	56				
NEON Delta Junction (DEJU)_US-xDJ_tower	Oct-17	Nov-22	54				
NEON Healy (HEAL)_US-xHE_tower	Jan-18	Nov-22	48				
NGEE Arctic Barrow_US-NGB_tower	Sep-12	Dec-19	88	Jun-13	Aug-23	35	
NGEE Arctic Council_US-NGC_tower	Aug-17	Dec-19	29	Jul-17	Jul-23	24	
North Star Yedoma_US-NSY_tower	May-21	Apr-23	24	May-21	Apr-23	24	
Norunda_SE-Nor_tower	Jan-99	Dec-23	180				
Nuuk Fen_GL-NuF_tower	Jun-08	Sep-22	49				

site_reference	Start CO_2 data collection (Month-Year)	End CO_2 data collection (Month-Year)	Number of CO_2 site-months	Start CH_4 data collection (Month-Year)	End CH_4 data collection (Month-Year)	Number of CH_4 site-months	Footprint_ Partitioned
Ontario - Groundhog River, Boreal Mixedwood Forest_CA-Gro_tower	Aug-03	Dec-13	125				
Pallasjaervi_tower	Jul-13	Oct-13	4				
Pitsalu_tower	Oct-22	Oct-23	13	Oct-22	Oct-23	13	
Plotnikovo field station, Tomsk, Rusia_RU-Plt_tower	May-22	Oct-22	6				
Poker Flat Research Range Black Spruce Forest_US-Prr_tower	Jan-11	Dec-22	144				
Poker Flat Research Range: Succession from fire scar to deciduous forest_US-Rpf_tower	Sep-08	Dec-22	172				
Pond Inlet_CA-Pin_tower	Jul-08	Jul-08	1				
Quebec - 1975 Harvested Black Spruce_CA-Qc2_tower	Jan-08	Dec-10	36				
Quebec - Eastern Boreal, Mature Black Spruce_CA-Qfo_tower	Sep-03	Dec-10	88				
Ranskalankorpi_FI-Ran forestry treatment_tower	Oct-19	Jul-23	46				Yes
Ranskalankorpi_FI-Ran_tower	Oct-19	Jul-23	46				Yes
Resolute Bay Polar Desert_CA-RSB_tower	Aug-24	Sep-24	2	Sep-24	Sep-24	1	
Romaine-2 reservoir_raft+shore_tower	Jul-18	Jan-24	67	Jul-18	Jan-24	64	
Rosinedal-3_SE-Ros_tower	Aug-14	Dec-20	77				
Rylekaerene_tower	Jun-08	Oct-09	11	Jun-08	Oct-09	11	

site_reference	Start CO_2 data collection (Month-Year)	End CO_2 data collection (Month-Year)	Number of CO_2 site-months	Start CH_4 data collection (Month-Year)	End CH_4 data collection (Month-Year)	Number of CH_4 site-months	Footprint_ Partitioned
Sag River_US-Sag_tower	Jun-96	Aug-96	3	Jun-96	Aug-96	3	
Salmisuo_FI-Salm_tower	Jan-06	Dec-07	24				
Sammaltunturi fell_FI-SamFell_tower	Jan-12	Dec-12	12				
Samoylov Island_Merged polygonal pond_tower	Jul-19	Sep-19	Seasonal flux				
Samoylov Island_RU-Sam (closed)_tower	Sep-10	Aug-17	31				
Samoylov Island_RU-Sam (open)_tower	Aug-09	Sep-17	66				
Samoylov Island_RU-Sam_tower	Jan-02	Dec-14	106				
Saskatchewan - Western Boreal, forest burned in 1977_CA-SF1_tower	Aug-03	Dec-06	41				
Saskatchewan - Western Boreal, forest burned in 1989_CA-SF2_tower	Jul-01	Dec-05	48				
Saskatchewan - Western Boreal, forest burned in 1998_CA-SF3_tower	May-01	Sep-06	59				
Saskatchewan - Western Boreal, Jack Pine harvested in 1975_CA-SJ3_tower	Dec-03	Dec-06	37				
Saskatchewan - Western Boreal, Jack Pine harvested in 2002_CA-SJ2_tower	Jan-04	Dec-07	48				
Saskatchewan - Western Boreal, Mature Aspen_CA-Oas_tower	May-96	Dec-10	176				
Saskatchewan - Western Boreal, Mature Black Spruce_CA-Obs_tower	May-99	Dec-10	140				
Saskatchewan - Western Boreal, Mature Jack	Jan-00	Dec-10	132				

site_reference	Start CO_2 data collection (Month-Year)	End CO_2 data collection (Month-Year)	Number of CO_2 site-months	Start CH_4 data collection (Month-Year)	End CH_4 data collection (Month-Year)	Number of CH_4 site-months	Footprint_ Partitioned
Pine_CA-Ojp_tower							
Scotty Creek Bog_CA-SCB_tower	Jan-14	Sep-22	105	May-14	Sep-22	94	
Scotty Creek Landscape_CA-SCC_tower	Jan-13	Dec-22	108	May-13	Dec-22	104	
Seida_RU-Vrk_tower	Jan-08	Dec-08	12	Jun-08	Sep-08	4	
Siikaneva_FI-Sii_tower	Jan-05	Dec-23	225	Feb-08	Dec-20	134	
Siikaneva2_FI-Si2_tower	Jan-12	Dec-16	60	Apr-12	Sep-16	36	
Skogaryd_Lake Erssjoen_tower				Apr-13	Dec-13	7	
Skyttorp 1_SE-Sk1_tower	Jan-05	Dec-08	48				
Skyttorp 2_SE-Sk2_tower	Jan-04	Jul-05	12				
Smith Creek_CA-SMC_tower	Jul-17	Sep-22	63	Jul-17	Sep-22	63	
Sodankyla_FI-Sod_tower	Jan-01	Dec-14	168				
Southern Khentei Taiga_MN-Skt_tower	Jan-03	Dec-06	48				
Steen River_CA-STR_tower	Jun-20	Jun-23	37				
Stordalen Fen_Lake Villasjoen_SE-St1_tower				Jun-12	Aug-19	42	Yes
Stordalen Fen_SE-St1_tower	Jun-12	Sep-19	81	Jun-12	Aug-19	73	Yes
Stordalen Palsa Bog_SE-Sto_tower	Jan-14	Aug-23	104	Jan-14	Dec-19	48	
Stordalen_Harrsjoen_Lake Harrsjoen_L1_tower	Jun-09	Sep-09	4				
Stordalen, Sweden_Stordalen_tower				May-96	Jul-96	3	
Stortjarn_SE-Srj_tower	Apr-20	Dec-22	33	Apr-20	Dec-22	31	
Svartberget_SE-Svb_tower	Jan-14	Dec-23	108				

site_reference	Start CO_2 data collection (Month-Year)	End CO_2 data collection (Month-Year)	Number of CO_2 site-months	Start CH_4 data collection (Month-Year)	End CH_4 data collection (Month-Year)	Number of CH_4 site-months	Footprint_Partitioned
Taemnaren_tower	Sep-10	Sep-12	18	Sep-10	Sep-12	18	
Tervalamminsuo_Dry_tower	Jul-12	Dec-22	126				
Tervalamminsuo_Wet_tower	Jul-12	Dec-22	126				
Tiksi_RU-Tks_tower	Jul-10	Dec-14	54				
Tombstone_slavin_CA-TWOSL_tower	Jan-20	Nov-22	35				
Toolik Lake_US-TOL_tower	Jun-10	Aug-15	18	Jun-10	Aug-15	18	
Trail Valley Creek_Big Bear Lake_tower	Feb-23	Sep-23	8	Mar-23	Aug-23	6	
Trail Valley Creek_CA-TVC_tower	Jan-13	Sep-22	117	Jan-13	Sep-22	117	
Tura_RU-Tur_tower	Jan-04	Aug-23	33				
UCI-1850 burn site_CA-NS1_tower	Jun-02	Sep-05	40				
UCI-1930 burn site_CA-NS2_tower	Aug-01	Sep-05	50				
UCI-1964 burn site wet_CA-NS4_tower	Jan-03	Sep-05	33				
UCI-1964 burn site_CA-NS3_tower	Aug-01	Sep-05	50				
UCI-1981 burn site_CA-NS5_tower	Aug-01	Sep-05	50				
UCI-1989 burn site_CA-NS6_tower	Oct-01	Sep-05	48				
UCI-1998 burn site_CA-NS7_tower	May-02	Sep-05	41				
Udleg practice forest_MN-Udg_tower	Jan-10	Dec-12	36				
Umiujaq_tower	Jun-17	Apr-20	35				
University of Alaska, Fairbanks_US-Uaf_tower	Jan-03	Dec-23	252	Apr-11	Nov-23	95	

site_reference	Start CO_2 data collection (Month-Year)	End CO_2 data collection (Month-Year)	Number of CO_2 site-months	Start CH_4 data collection (Month-Year)	End CH_4 data collection (Month-Year)	Number of CH_4 site-months	Footprint_ Partitioned
Vaenajavesi_tower	Jan-16	Jan-17	13				
Valkea-Kotinen_tower	Apr-03	Jun-09	52				
Varrio_FI-Var_tower	Jan-12	Dec-23	144				
Wolf_creek_Buckbrush_CA-WCBB_tower	Jan-15	Dec-22	96				
Wolf_creek_forest_CA-WCF_tower	Jan-17	Nov-22	71				
Wolf_creek_SparseShrub_CA-WCPLT_tower	Jan-15	Dec-22	96				
Wolf_creek_upper_forest_CA-WCUF_tower	Jan-20	Nov-22	35				
Yakutsk Spasskaya Pad larch_RU-SkP_tower	Jul-00	Sep-14	132				
Yakutsk Spasskaya Pad Pine_RU-Sk2_tower	Jan-04	Dec-08	48				
YKD (burned)_US-YK1_tower	Sep-19	Dec-22	40	Sep-19	Dec-22	40	
YKD (unburned)_US-YK2_tower	Jul-19	Dec-22	42	Jul-19	Dec-22	42	
Zackenberg Fen_GL-ZaF_tower	May-08	Sep-22	80				
Zackenberg Heath_GL-ZaH_tower	Jun-97	Sep-22	88				
Zotino_RU-Zot_tower	Mar-02	Sep-04	23				
Zotino; Central Siberia_RU-Zfw 1_tower	Apr-99	Apr-00	3				
Zotino; Central Siberia_RU-Zfw 2_tower	Apr-99	Jul-00	3				
ZOTTO Bog_RU-Zo1_tower	May-13	Jun-16	11				
ZOTTO Forest_RU-Zo2_tower	Apr-13	Jun-17	15				

Supplementary Table 3. The start and end dates (month-year) of data collection and number of site-months for all eddy covariance flux data in ABCFlux v2 separated by gases. Footprint_Partitioned refers to datasets where fluxes have been isolated to different ecosystems within the footprint and thus there are multiple datasets across the different ecosystems for a single site.

Supplementary Table 4. The distribution of site-months and sites for the whole dataset as well as separately for the terrestrial and aquatic ecosystems, and CO_2 and CH_4 flux and concentration datasets across Arctic-boreal countries. Country-level areal estimates from

	Area	Overall dataset				Terrestrial				Aquatic				CO_2		CH_4	
	Million km2	**% of site-months**	**% of sites**	**# of sites**	**# of sites per million km2**	**% of site-months**	**% of sites**	**# of sites**	**# of sites per million km2**	**% of site-months**	**% of sites**	**# of sites**	**# of sites per million km2**	**% of site-months**	**% of sites**	**% of site-months**	**% of sites**
Alaska (USA)	1.718	24.5	18.2	186	108.3	23.6	30.3	102	59.4	26.1	12.8	91	53.0	26.4	16.7	25.2	19.8
Sweden	0.450	20.9	23.3	239	530.8	14.8	9.5	32	71.1	32.0	29.5	210	466.4	21.5	24.9	26.0	9.1
Canada	9.985	19.3	14.1	144	14.4	20.4	25.8	87	8.7	17.8	8.6	61	6.1	19.9	12.3	17.4	13.5
Finland	0.338	17.5	24.4	250	739.3	20.6	7.4	25	73.9	11.6	31.6	225	665.4	15.6	28.0	15.8	36.4
Russia	17.098	10.9	14.3	146	8.5	11.3	14.8	50	2.9	10.0	14.8	105	6.1	10.0	13.1	9.3	15.8
Norway	0.386	3.0	2.3	24	62.1	3.9	5.0	17	44.0	1.3	1.1	8	20.7	2.4	1.9	3.5	2.3
Greenland	2.166	2.3	2.1	21	9.7	2.9	3.9	13	6.0	1.1	1.1	8	3.7	2.4	1.5	1.8	2.3
Mongolia	1.564	1.0	0.5	5	3.2	1.6	1.5	5	3.2				0.0	1.2	0.6		
Estonia	0.045	0.3	0.3	3	66.2	0.4	0.9	3	66.2				0.0	0.3	0.1	0.4	0.3

Wikipedia (https://en.wikipedia.org/wiki/List_of_countries_and_dependencies_by_area). We also included some data from Japan, Mongolia, and UK but their country-level cover is not shown here.

Supplementary Table 5. Monthly median NEE (g C m^{-2} $month^{-1}$) across key boreal terrestrial ecosystems, with 25th–75th quantiles in parentheses.

Month	Deciduous Broadleaf Forest	Evergreen Needleleaf Forest	Deciduous Needleleaf Forest	Mixed Forest	Bog	Fen
1	13.2 (11 to 18)	12.5 (6.6 to 20.7)	13.7 (10.6 to 16.2)	11.4 (4.1 to 15)	7.2 (4.3 to 11.8)	4.5 (2.9 to 7.3)
2	12.8 (9.4 to 16)	10.1 (5.1 to 16.5)	15.9 (8.8 to 20)	4.2 (2.1 to 12.3)	5.9 (2.9 to 8.7)	3.7 (2.2 to 6.1)
3	17.2 (12 to 20.4)	8.7 (3.1 to 14.5)	12.6 (7.4 to 14)	1.0 (0.5 to 3)	5.0 (1.9 to 8)	3.7 (1.6 to 6.8)
4	16 (8.8 to 33.3)	-3.1 (-22.6 to 8.6)	9.0 (-3.8 to 10.9)	2.5 (-1.5 to 5.3)	1.1 (-0.9 to 6.5)	4.4 (2.2 to 6.3)
5	2.3 (-18.7 to 28.8)	-32.7 (-54.9 to -17.1)	-2.0 (-8.8 to 6.1)	-20.0 (-30.2 to -9.4)	-7.8 (-18.6 to -2.3)	-0.8 (-7.5 to 5.6)
6	-44.5 (-122.8 to -23.5)	-48.4 (-69.6 to -30.5)	-58.2 (-87.9 to -28.3)	-51.9 (-73.8 to -39.4)	-18.6 (-32.9 to -6.2)	-25.3 (-39.1 to -14.9)
7	-65.5 (-110.2 to -21.4)	-31.5 (-55.2 to -14.6)	-41.1 (-59.5 to -27.4)	-48.8 (-63.9 to -38.4)	-22.1 (-46.7 to -8.6)	-40.8 (-74.3 to -27.6)
8	-25.9 (-78.3 to 0.6)	-7.6 (-28.2 to 10.3)	-19.9 (-30.7 to -11.4)	-25.8 (-39.3 to -12.7)	-13.7 (-23.3 to -6.6)	-20.1 (-35.5 to -12.1)
9	16.6 (-0.8 to 24.3)	10.0 (-6.4 to 26.5)	15.0 (8.7 to 24.4)	7.3 (-3.5 to 17.9)	-2.8 (-6.6 to 2.6)	4.4 (-3.1 to 11.7)
10	30.8 (22 to 52.7)	19.4 (11.7 to 34.5)	20.5 (14.5 to 26.1)	18.3 (12.2 to 25.1)	8.7 (2.3 to 16.8)	9.9 (7.2 to 15.7)
11	25.4 (16.5 to 30.9)	19.8 (12 to 30.2)	17.3 (15.9 to 24.2)	17.9 (11.4 to 20.7)	10.3 (6.8 to 15)	7.5 (4.8 to 10.4)
12	14.9 (10 to 20.4)	15.4 (7.6 to 25.7)	17 (10.5 to 18.6)	12.8 (7.5 to 20.8)	9.5 (6.3 to 13.9)	5.7 (3.7 to 9)

Supplementary Table 6. Monthly median NEE (g C m^{-2} $month^{-1}$) across key tundra terrestrial ecosystems, with 25th–75th quantiles in parentheses.

Month	Permafrost Bog	Wet Tundra	Shrub	Graminoid	Sparse Vegetation	Barren
1	4.5 (2.8 to 6.5)	4.0 (1 to 10.1)	5.8 (3.1 to 8.4)	5.0 (1.6 to 15.6)	1.5 (1.2 to 5.6)	
2	4.3 (1.8 to 5.6)	3.1 (0.4 to 8)	4.8 (2 to 8.1)	1.9 (-0.1 to 10.8)	1.5 (-0.2 to 7.4)	
3	2.6 (1 to 5.2)	3.0 (0.5 to 7.2)	3.6 (1 to 8.5)	2.4 (0.3 to 7.5)	1.0 (0.2 to 4.5)	
4	1.7 (-1.2 to 5)	1.4 (0.3 to 5.7)	3.1 (1 to 7.7)	1.9 (0.6 to 4.2)	0.5 (0.2 to 1.1)	
5	-4.6 (-25.4 to 1.4)	2.9 (0.2 to 8.2)	3.9 (0.8 to 8.9)	0.2 (-6.6 to 3.5)	12.0 (8.8 to 15)	
6	-14.9 (-31.7 to -4.1)	-10.3 (-27.9 to 3.7)	-11.9 (-27.7 to 5.7)	-13.5 (-40.8 to 1.4)	-4.2 (-19.2 to 6.6)	
7	-27.7 (-56.9 to -7.2)	-41.3 (-62.3 to -20.9)	-17.4 (-46.8 to 4)	-28.7 (-57.2 to -10.7)	-15.4 (-31.7 to -0.9)	7.3 (-29.4 to 61.3)
8	-20.1 (-41 to -4.8)	-19.5 (-36 to -7.3)	-7.3 (-26.1 to -0.4)	-17.6 (-33.9 to -4.1)	-5.8 (-13.7 to 0.1)	-1.0 (-3.8 to -0.2)
9	1.7 (-8.9 to 17.2)	9.3 (-0.5 to 17.1)	12.0 (6.4 to 17.9)	9.7 (3.8 to 16.8)	12.7 (10.7 to 18.2)	-7.6 (-14.5 to -7.2)
10	8.8 (5.1 to 11.7)	9.5 (4.4 to 15.4)	11.5 (8.6 to 15.3)	9.8 (6.2 to 21.4)	12.9 (8.7 to 14.6)	
11	6.1 (3.4 to 7.7)	7.2 (4.1 to 13.1)	8.8 (5.6 to 11.7)	9.2 (3 to 19.6)	10.3 (7.3 to 13.5)	
12	4.9 (2.6 to 6.8)	6.0 (2.3 to 11.4)	7.4 (3.3 to 10)	5.6 (2.8 to 23.9)	4.7 (2.3 to 9.2)	

Supplementary Table 7. Monthly median NEE (g C m^{-2} $month^{-1}$) across key aquatic ecosystems, with 25th–75th quantiles in parentheses.

Month	Large Lentic	Midsize Lentic	Small Lentic	Large Lotic	Small Lotic
1	2.1 (-0.7 to 3.4)	2.1 (1.5 to 5.1)	25.3 (25 to 26.1)	74.7 (35.3 to 170.4)	
2	3.3 (2.2 to 5.7)	1.2 (0.2 to 2.7)	22 (15.8 to 23.1)		
3	3.5 (1.2 to 7.9)	2.2 (0.9 to 3.5)	21.8 (10.8 to 22)		29.8 (9.5 to 67.5)
4	6.6 (4.0 to 9.4)	5.2 (2.5 to 11.8)	12.1 (6.1 to 21.4)		51.0 (25.8 to 115.8)
5	14.5 (9.1 to 32.2)	36.1 (15.1 to 60.7)	18.8 (5.8 to 57.7)	22.8 (16.9 to 63.3)	58.0 (26.5 to 126.2)
6	9.6 (4.8 to 14.9)	10.3 (4.2 to 19.5)	11.7 (4.7 to 30.7)	52.1 (13.1 to 152.3)	78.4 (35.6 to 195.6)
7	6.1 (0.4 to 14.0)	3.9 (0.8 to 9.3)	5.3 (1.8 to 15)	30.7 (10.6 to 75.6)	50.5 (17.4 to 159.3)
8	8.3 (2.7 to 14.5)	6.3 (1.0 to 16.1)	10.2 (2.8 to 25.2)	58.0 (28.6 to 86.3)	67.4 (29.8 to 180.1)
9	14.5 (9.4 to 21.2)	13.1 (4.7 to 30.1)	17.1 (4.6 to 39.9)	95.9 (35.4 to 154.1)	63.2 (25.5 to 164.6)
10	8.9 (5.1 to 13.2)	14.6 (5.0 to 23.1)	19.3 (5.9 to 33.9)	20.1 (9.8 to 30.4)	42.3 (20.9 to 77.8)
11	10.1 (2.0 to 14.1)	8.1 (3.6 to 11.5)	13.1 (10.8 to 19.1)		34.0 (10 to 75.6)
12	0.5 (-1 to 4.5)	2.6 (0.9 to 5.0)	21.6 (7.4 to 24.6)		0 (0 to 20.2)

Supplementary Table 8. Monthly median CH_4 flux (g C m^{-2} $month^{-1}$) across key boreal terrestrial ecosystems, with 25th–75th quantiles in parentheses.

Month	Deciduous Broadleaf Forest	Evergreen Needleleaf Forest	Deciduous Needleleaf Forest	Mixed Forest	Bog	Fen
1		0.07 (-0.02 to 0.23)		0 (-0.01 to 0)	0.3 (0 to 0.5)	0.2 (0.1 to 0.3)
2	1.96 (0.98 to 2.94)	-0.01 (-0.03 to 0.21)		0 (-0.01 to 0)	0.1 (0 to 0.5)	0.2 (0.1 to 0.2)
3	0.36 (0.08 to 0.63)	0.04 (-0.01 to 0.15)		0 (0 to 0)	0.1 (0 to 0.2)	0.2 (0.1 to 0.3)
4		0.07 (-0.01 to 0.19)	-0.01 (-0.02 to -0.01)	0 (0 to 0)	0.1 (0 to 0.3)	0.3 (0.2 to 0.4)
5	0.16 (0 to 1.07)	0.04 (-0.03 to 0.3)	0 (0 to 0)	0.01 (0 to 0.03)	0.6 (0.1 to 1.2)	0.6 (0.2 to 0.9)
6	-0.01 (-0.02 to 0.46)	0 (-0.02 to 0.28)	0 (0 to 0)	0 (0 to 0.02)	0.8 (0.2 to 1.8)	0.9 (0.4 to 1.7)
7	-0.03 (-0.05 to -0.03)	-0.04 (-0.08 to -0.01)	0 (0 to 0)	-0.02 (-0.06 to 0)	1.0 (0.2 to 2.5)	1.7 (0.5 to 3.3)
8	0 (-0.03 to 0.15)	-0.01 (-0.05 to 0.22)	0 (0 to 0)	0 (-0.01 to 0.1)	1.5 (0.3 to 2.8)	2.1 (1.0 to 3.1)
9	-0.04 (-0.06 to -0.02)	0 (-0.08 to 0.15)	0 (0 to 0)	0 (-0.01 to 0.05)	0.8 (0.2 to 1.7)	1.5 (0.8 to 2.3)
10	0.06 (0.06 to 0.06)	-0.02 (-0.06 to 0.29)		0.04 (-0.01 to 0.1)	0.4 (0.2 to 0.8)	0.7 (0.5 to 0.9)
11		0 (-0.05 to 0.24)		0.03 (0 to 0.26)	0.2 (0.1 to 0.5)	0.4 (0.3 to 0.5)
12		0.03 (-0.02 to 0.25)		0 (-0.01 to 0)	0.4 (0.1 to 0.5)	0.3 (0.2 to 0.4)

Supplementary Table 9. Monthly median CH_4 flux (g C m^{-2} $month^{-1}$) across key tundra terrestrial ecosystems, with 25th–75th quantiles in parentheses.

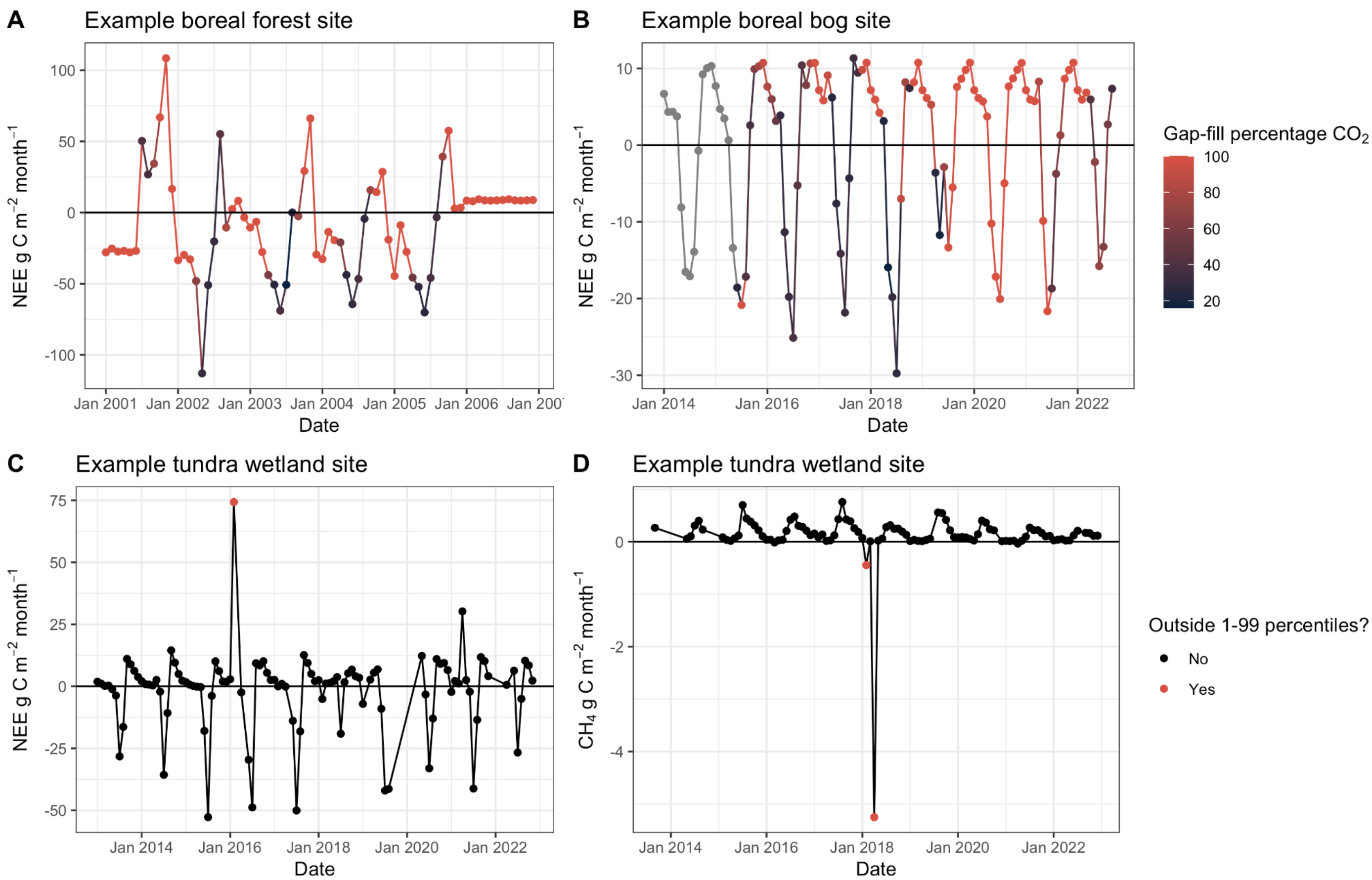
Month	Permafrost Bog	Wet Tundra	Shrub	Graminoid	Sparse	Barren
1	0 (0 to 0)	0.1 (0 to 0.4)	0.01 (0.01 to 0.01)	0.07 (0 to 0.14)	0 (-0.01 to 0)	
2	0 (0 to 0)	0.1 (0 to 0.3)	0.01 (0.01 to 0.01)	0.14 (0.02 to 2.46)	0 (0 to 0)	
3	0 (0 to 0)	0.1 (0 to 0.3)	0 (0 to 0)	0.03 (0.01 to 0.05)	0 (0 to 0)	-0.25 (-0.25 to -0.25)
4	0 (0 to 0)	0 (0 to 0.1)	0 (-0.02 to 0)	0.04 (0 to 0.09)	0 (0 to 0)	-2.22 (-2.58 to -1.86)
5	0 (0 to 0)	0.1 (0 to 0.3)	-0.02 (-0.06 to 0.02)	0.28 (0.16 to 0.35)	0 (-0.01 to 0)	0.29 (-0.42 to 0.99)
6	0 (0 to 0.2)	0.4 (0.1 to 1)	-0.02 (-0.05 to 0)	0.01 (0 to 0.08)	0 (-0.01 to 0)	
7	0.1 (0 to 1)	1.1 (0.4 to 2.7)	-0.03 (-0.07 to -0.01)	0 (-0.01 to 0.15)	-0.02 (-0.05 to 0)	0.01 (0 to 0.03)
8	0.1 (0 to 1.6)	1.0 (0.4 to 1.9)	-0.02 (-0.05 to -0.01)	0.01 (0 to 0.38)	-0.01 (-0.02 to 0.01)	
9	0 (0 to 0.3)	0.5 (0.2 to 0.9)	-0.03 (-0.08 to 0)	0.19 (0.01 to 0.75)	-0.01 (-0.03 to -0.01)	
10	0 (0 to 0)	0.4 (0.2 to 0.6)	-0.02 (-0.03 to -0.01)	0.11 (0.01 to 0.14)	-0.02 (-0.03 to 0)	
11	0 (0 to 0)	0.2 (0.1 to 0.4)	-0.02 (-0.04 to -0.01)	0.05 (0.01 to 0.26)	-0.01 (-0.02 to 0)	
12	0 (0 to 0)	0.2 (0.1 to 0.4)	-0.01 (-0.02 to 0.01)	0.08 (0 to 1.43)	0 (-0.01 to 0)	

Supplementary Table 10. Monthly median total, ebullitive, and diffusive CH_4 flux (g C m^{-2} month^{-1}) across key aquatic ecosystems, with 25th–75th quantiles in parentheses. Total flux estimates came from eddy covariance sites or sites where both ebullitive and diffusive fluxes were measured. Ebullitive fluxes are not presented for December–February, as the number of available measurements (<6) was insufficient for estimates.

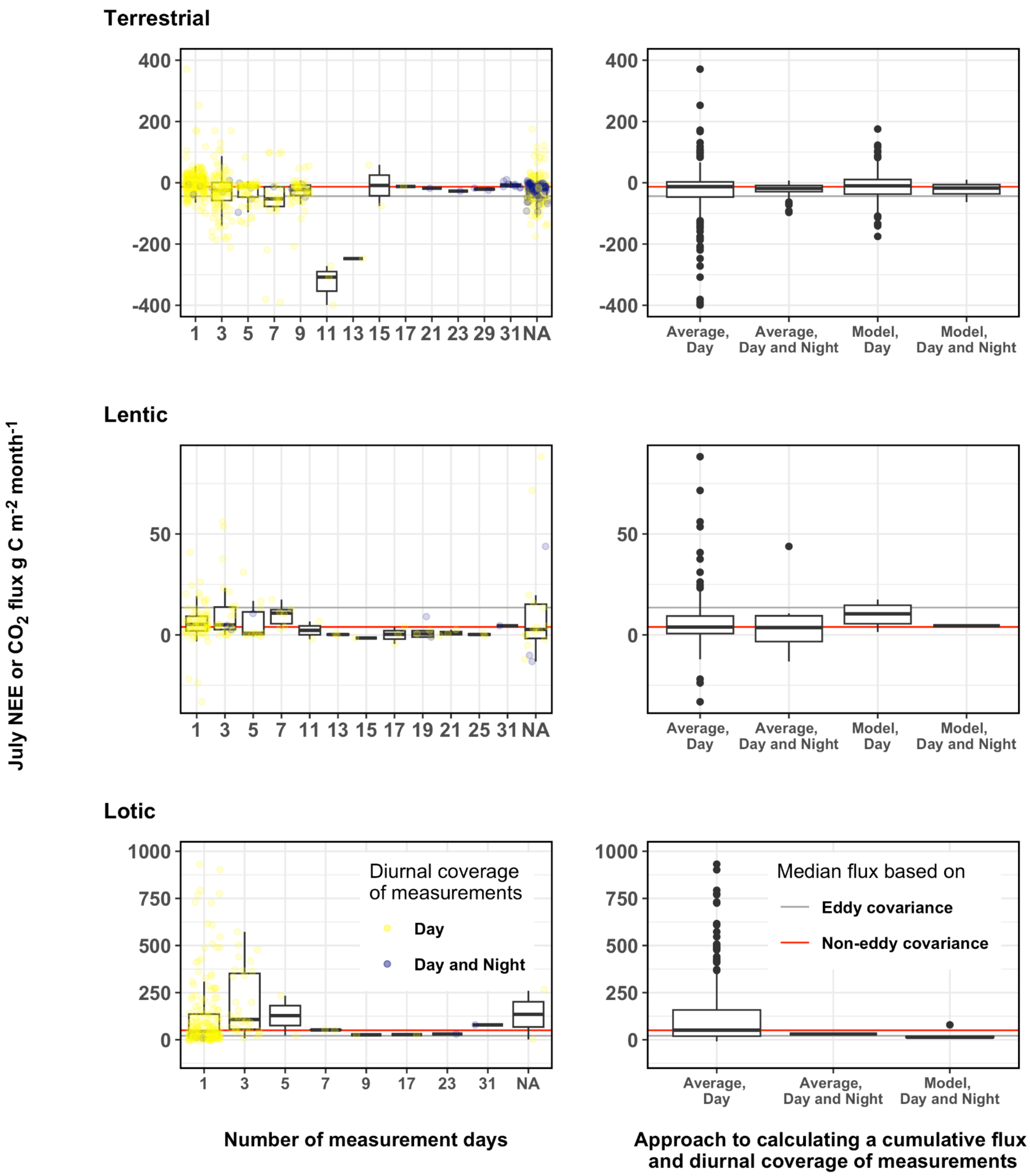
Month	Flux pathway	Small Lentic	Midsize Lentic	Large Lentic	Small Lotic	Large Lotic
1	total	0.2 (0.2 to 0.2)	0 (0 to 0)	0.1 (0 to 0.1)		
1	diffusion		0.07 (0.06 to 0.08)		0.9 (0.69 to 1.19)	0.46 (0.21 to 1.12)
2	total	0.2 (0.2 to 0.2)	0 (0 to 0)	0.1 (0 to 0.1)		
2	diffusion		0.12 (0.08 to 0.16)		0.98 (0.98 to 0.98)	
3	total	0.2 (0.1 to 0.2)	0 (0 to 0)	0.1 (0.1 to 0.2)	2.2 (2.2 to 2.2)	
3	ebullition				0 (0 to 0)	
3	diffusion		0.24 (0.15 to 0.36)		0.01 (0 to 0.1)	
4	total	0.3 (0.1 to 0.4)	0 (0 to 0)	0.1 (0 to 0.2)		
4	ebullition	0.02 (0.01 to 0.11)				
4	diffusion	0.05 (0.04 to 0.17)	1.38 (1.38 to 1.38)	0 (0 to 0.01)	0.04 (0 to 0.3)	

5	total	0.6 (0.3 to 0.9)	0.1 (0 to 1.4)	0.1 (0 to 0.2)	6.7 (5.9 to 7.5)	
5	ebullition	0.63 (0.23 to 1.07)	0.04 (0.03 to 0.07)	0 (0 to 0)	0.51 (0.36 to 0.66)	
5	diffusion	0.11 (0.03 to 0.76)	0.02 (0.01 to 0.09)	0.01 (0 to 0.05)	0.06 (0 to 0.39)	0.08 (0.01 to 0.28)
6	total	0.4 (0.2 to 1.2)	0.4 (0.2 to 0.6)	0 (0 to 0.3)	1.1 (0.6 to 7.4)	
6	ebullition	0.17 (0.04 to 0.52)	0.1 (0 to 0.47)	0.01 (0.01 to 0.02)	0 (0 to 0.11)	
6	diffusion	0.12 (0.04 to 0.41)	0.03 (0.01 to 0.08)	0.01 (0.01 to 0.02)	0.22 (0.01 to 1.7)	0.09 (0.03 to 1.06)
7	total	0.7 (0.3 to 1.3)	0.8 (0.2 to 1.4)	0.1 (0 to 0.4)	15.8 (0.2 to 43.2)	
7	ebullition	0.36 (0.1 to 0.84)	0.37 (0.03 to 1.33)	0.01 (0.01 to 0.01)	14.99 (0.32 to 41.74)	
7	diffusion	0.28 (0.1 to 0.61)	0.22 (0.06 to 0.55)	0.02 (0 to 0.08)	0.04 (0 to 0.23)	0.01 (0 to 0.05)
8	total	0.9 (0.3 to 1.2)	0.9 (0.4 to 1.7)	0.3 (0.1 to 0.5)	5.4 (1.6 to 7.5)	
8	ebullition	0.33 (0.16 to 0.74)	0.93 (0.01 to 1.9)	0.03 (0.02 to 0.03)	0.61 (0.54 to 6.67)	
8	diffusion	0.26 (0.09 to 0.93)	0.07 (0.03 to 0.27)	0.02 (0.01 to 0.08)	0.13 (0 to 0.77)	0.13 (0.02 to 1.09)

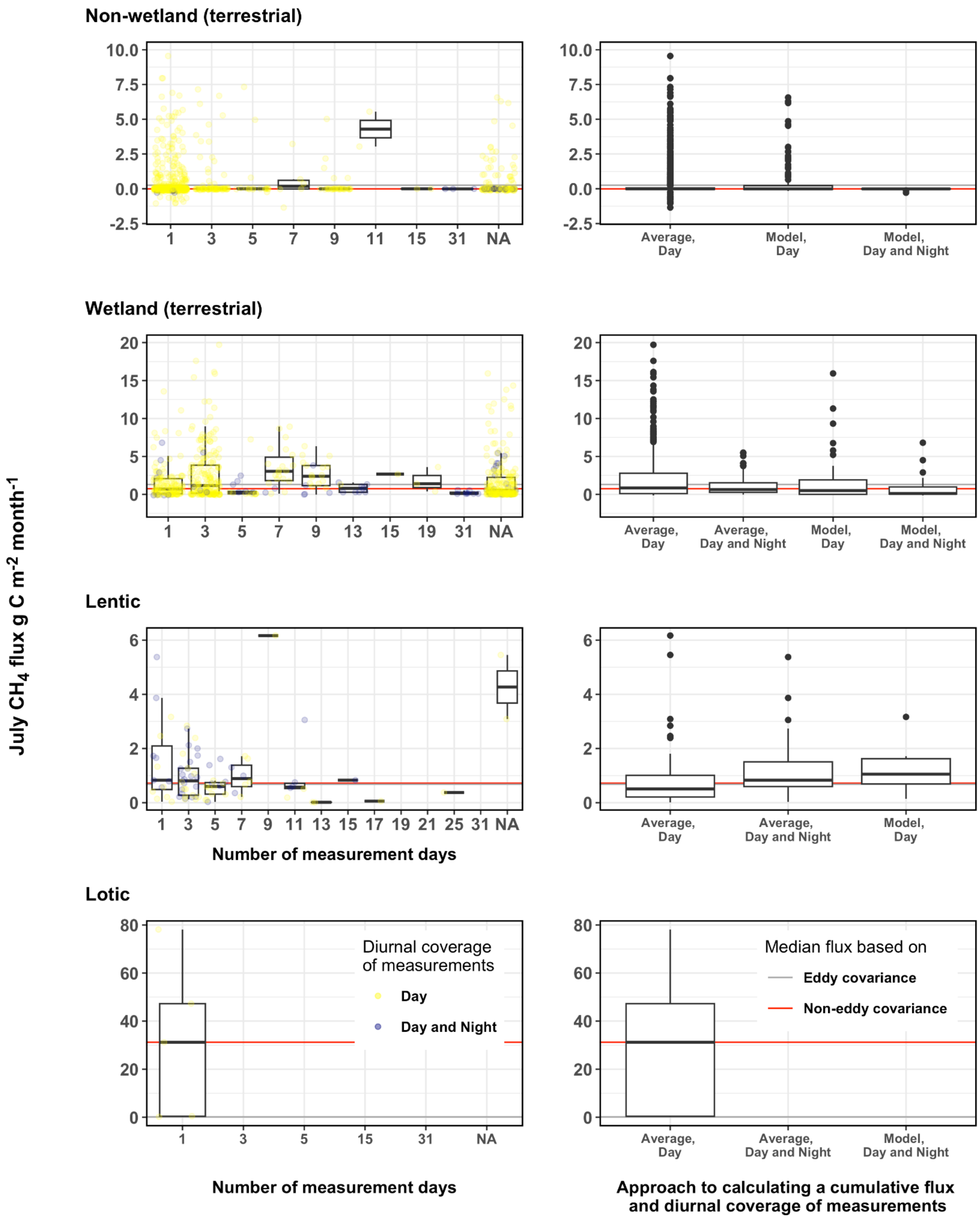
9	total	0.5 (0.3 to 0.8)	0.4 (0.1 to 0.6)	0.2 (0.2 to 0.3)	0.1 (0.1 to 0.1)	
9	ebullition	0.21 (0.07 to 0.42)	0.28 (0.01 to 0.7)			
9	diffusion	0.34 (0.09 to 1.36)	0.16 (0.05 to 0.52)	0.03 (0.03 to 0.14)	0.21 (0.02 to 0.67)	0.28 (0.02 to 0.86)
10	total	0.2 (0.1 to 0.4)	0.2 (0 to 0.2)	0.3 (0.2 to 0.3)		
10	ebullition	0.07 (0.06 to 0.08)	0.05 (0.02 to 0.08)	0.01 (0.01 to 0.01)		
10	diffusion	0.04 (0.02 to 0.14)	0.02 (0.01 to 0.04)	0.01 (0 to 0.02)	0.04 (0 to 0.27)	0 (0 to 0.39)
11	total	0.2 (0.1 to 0.3)	0 (0 to 0)	0.2 (0.2 to 0.3)		
11	ebullition	0.02 (0.02 to 0.02)				
11	diffusion	0.08 (0.02 to 0.6)	0.01 (0 to 0.02)	0.01 (0.01 to 0.01)	0.02 (0 to 0.21)	
12	total	0.2 (0.2 to 0.3)	0 (0 to 0)	0.3 (0.2 to 0.7)		
12	diffusion	0.01 (0.01 to 0.01)	0.13 (0.01 to 0.25)	0.01 (0 to 0.01)	0 (0 to 0.01)	



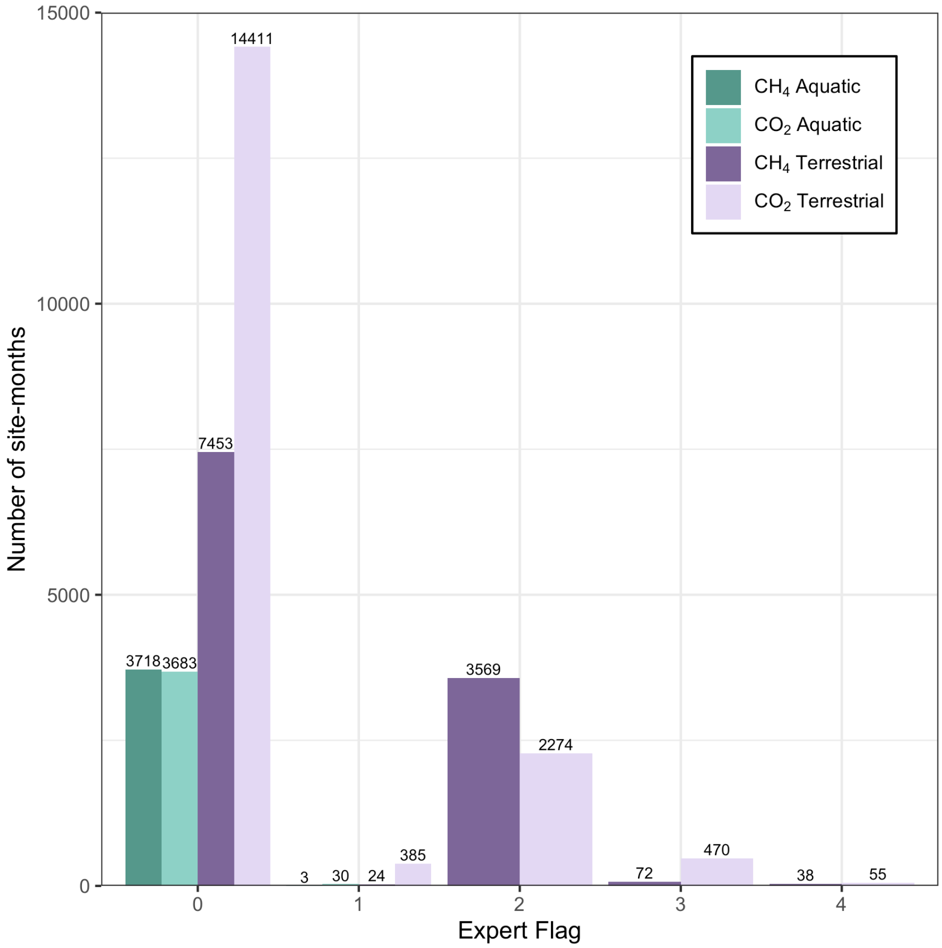
Supplementary Fig. 1. Example of situations encountered in data cleaning A) site time series with “flat lines” based on entirely gap-filled data, B) heavy gap-filling across most winters and some years (grey points and lines indicate no gap-fill percentage was available), fluxes flagged as outside the 1-99th percentiles and visually identified as outliers that were removed for C) NEE and D) CH_4.



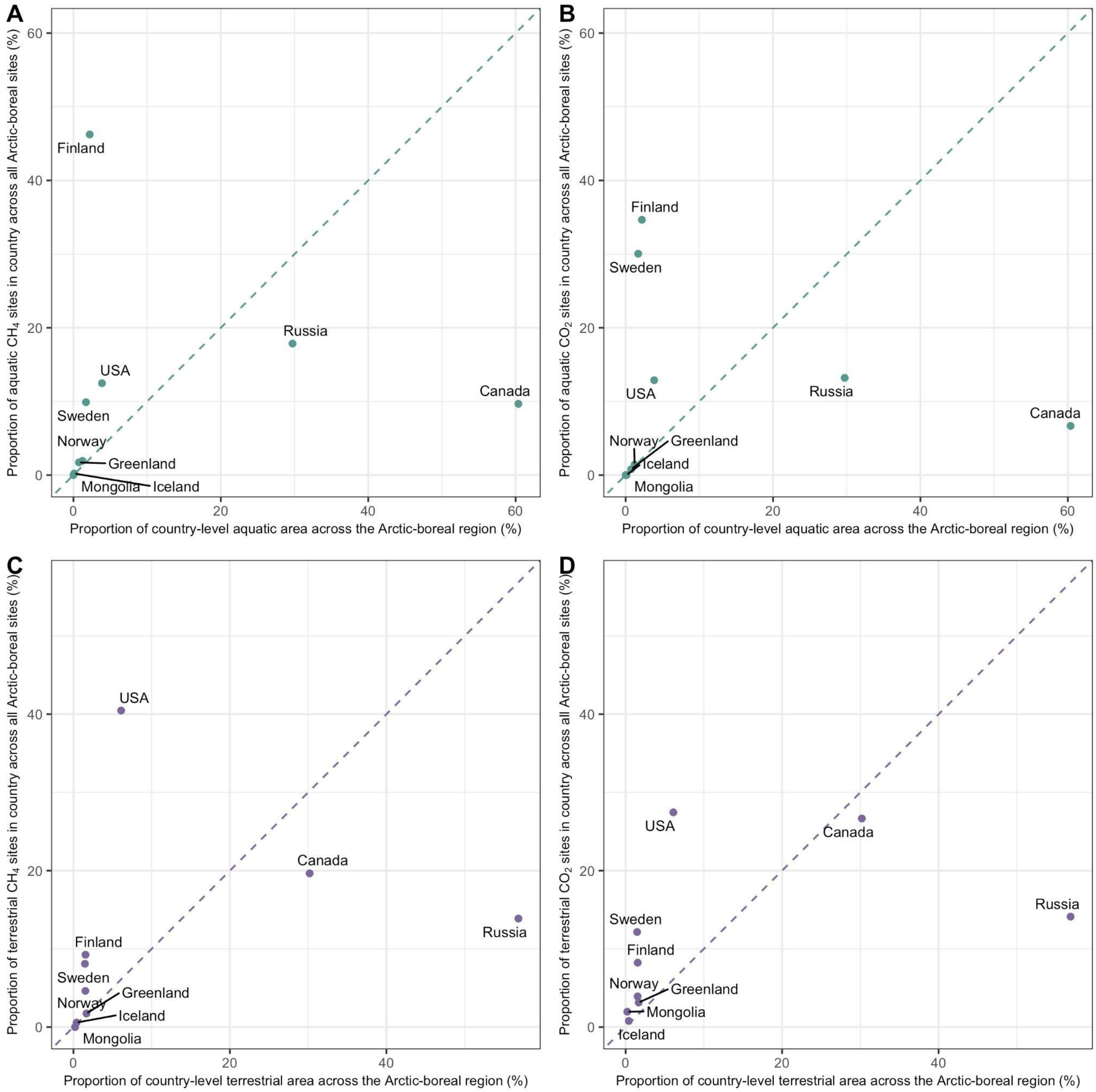
Supplementary Fig. 2. The relationship between chamber-based net CO_2 flux for July and the number of measurement days, diurnal coverage, and the method used to calculate cumulative fluxes across key ecosystems. "Terrestrial" refers only to treeless ecosystems. When information on diurnal coverage was unavailable, we assumed daytime-only measurements for this visualization. Similarly, in the absence of details on the aggregation approach, we assumed a simple average was used—that is, the mean measured flux multiplied by the number of days, rather than modeled using light and temperature response functions.



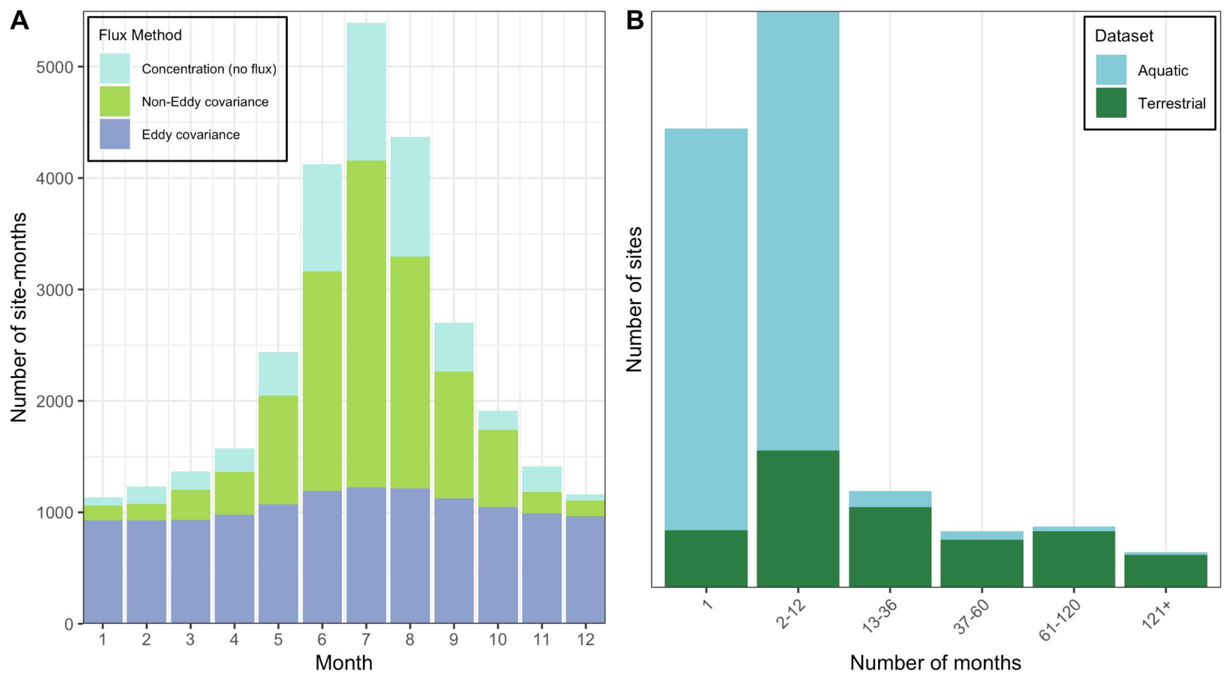
Supplementary Fig. 3. The relationship between chamber-based net CH_4 flux for July and the number of measurement days, diurnal coverage, and the method used to calculate cumulative fluxes across key ecosystems. When information on diurnal coverage was unavailable, we assumed daytime-only measurements for this visualization. Similarly, in the absence of details on the aggregation approach, we assumed a simple average was used—that is, the mean measured flux multiplied by the number of days, rather than modeled using environmental response functions.



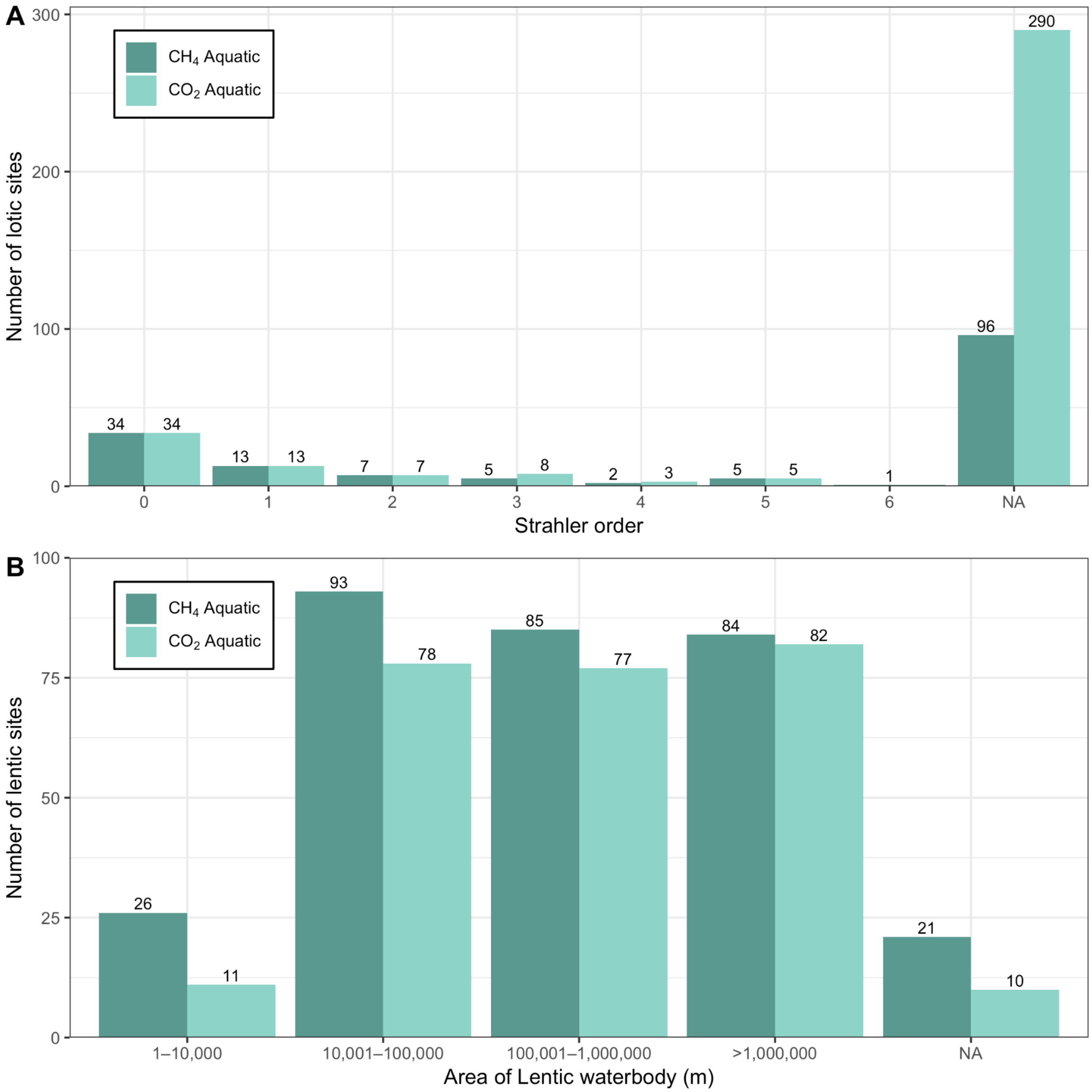
Supplementary Fig. 4. The number of site-months flagged with the 4 different expert flags across CO_2 fluxes (NEE, GPP, Reco) and CH_4 fluxes (flag 0 = data was not flagged). For CO_2, the flags considered fluxes outside the 1st and 99th percentiles for terrestrial, and outside the 99th percentile for aquatic data (flag 1). For CH_4, flag 1 points to terrestrial sites with fluxes higher than 30 g C m^{-2} $month^{-1}$, and to lentic sites with higher CH_4 diffusion fluxes. Flags 2 to 4 refer to both gas species and only terrestrial sites. Monthly fluxes based on sporadic non-eddy covariance measurements were marked with flag 2, eddy covariance data with long periods of entirely gap-filled data with flag 3, and sites that do not represent typical conditions across the Arctic-boreal region with flag 4 (Table 4).



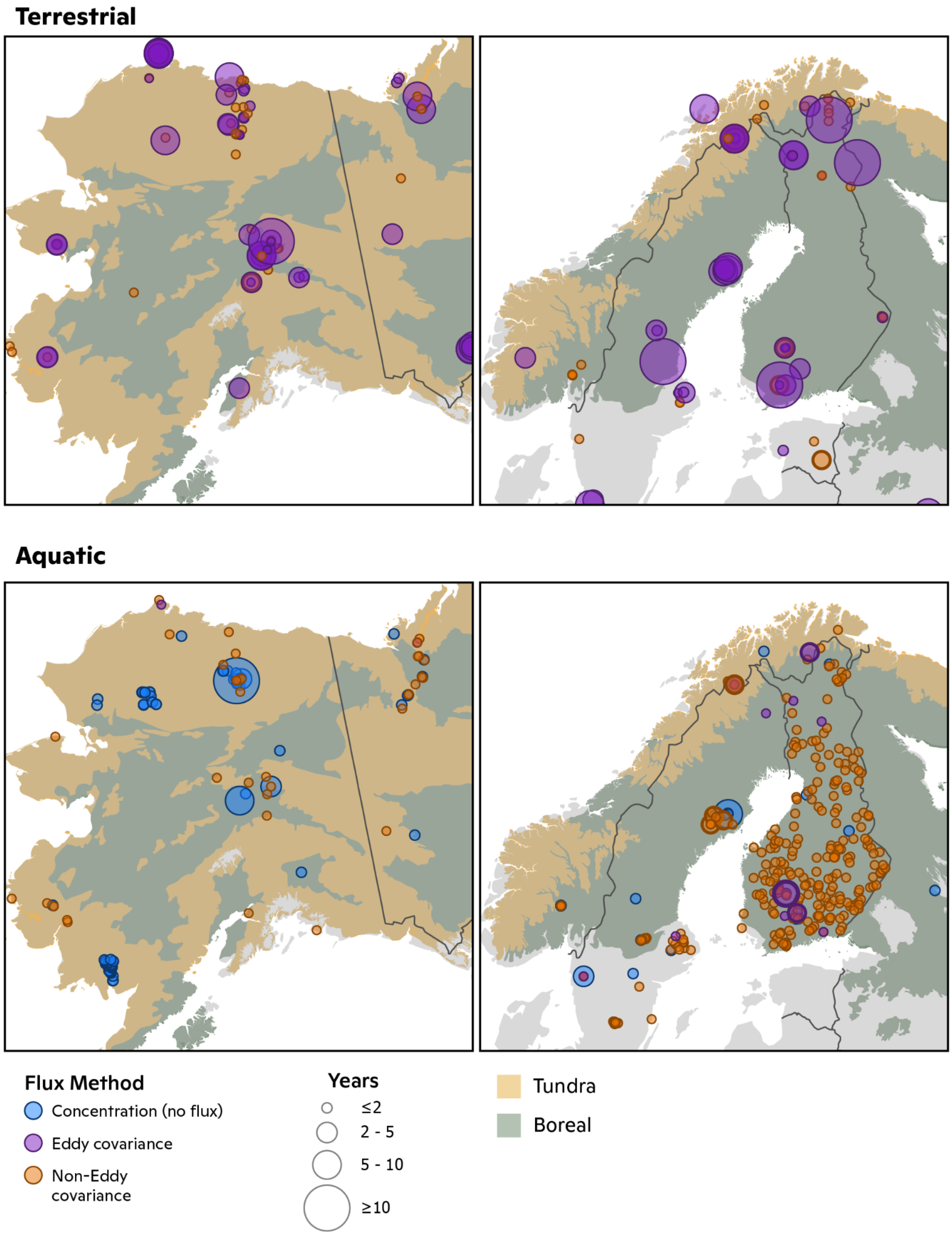
Supplementary Fig. 5. Proportion of sites in each country across all Arctic-boreal sites relative to the proportion of total area (terrestrial or aquatic) occupied by countries in the ABCFlux v2 study region for A) aquatic CH_4 fluxes and concentration data, B) aquatic CO_2 fluxes and concentration data, C) terrestrial CH_4 fluxes and concentration data, D) terrestrial CO_2 fluxes and concentration data. Area estimates from BAWLD land cover product were used (terrestrial area includes rocklands, boreal forest, dry tundra, and all wetland classes; aquatic area includes all lentic and lotic classes).



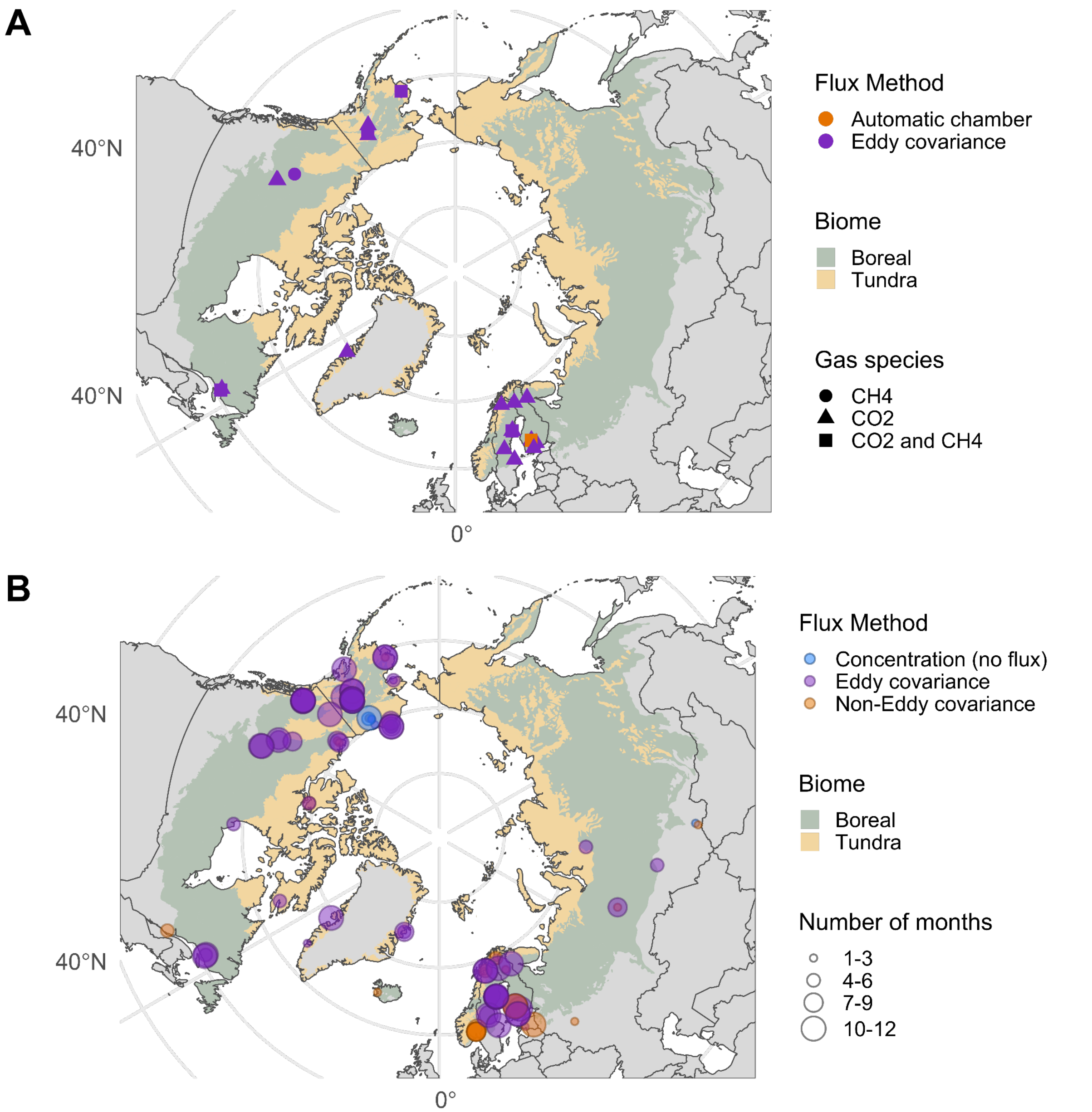
Supplementary Fig. 6. A) The number of observations by measurement method distributed across months. B) The number of sites by the number of total site-month observations for each site separated by aquatic and terrestrial datasets.



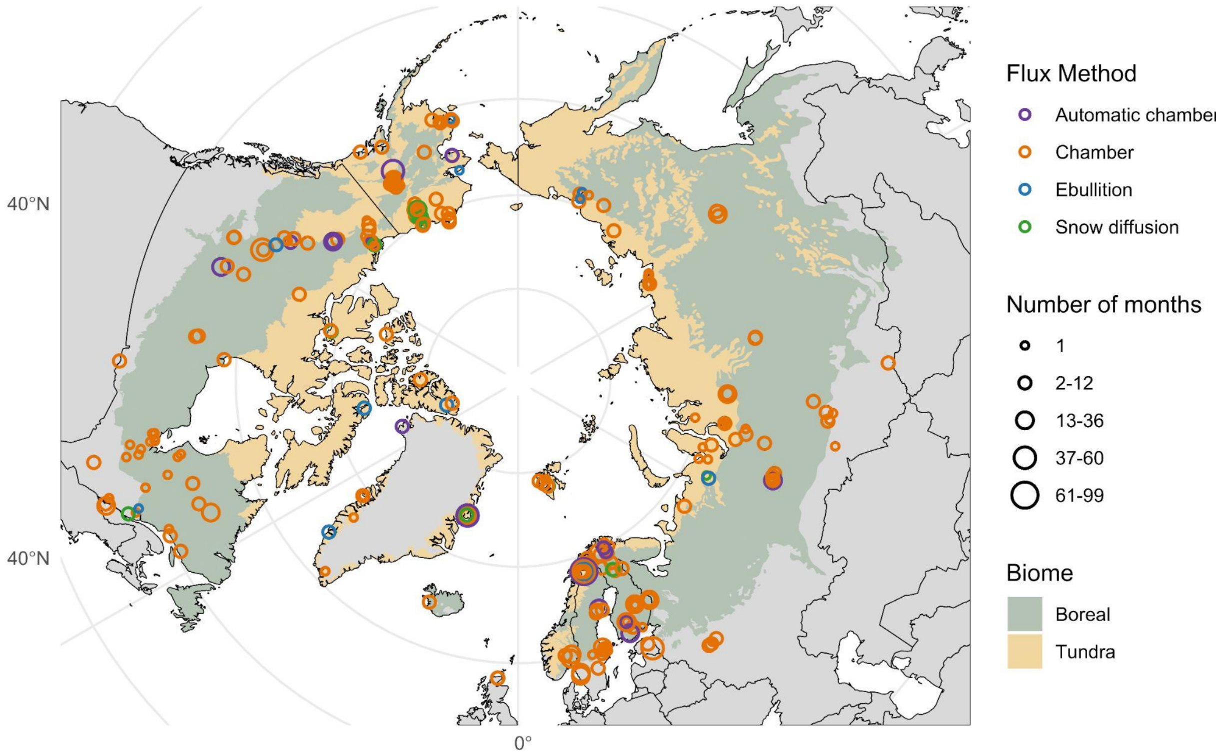
Supplementary Fig. 7. Number of unique lotic sites for each Strahler order for CO_2 and CH_4



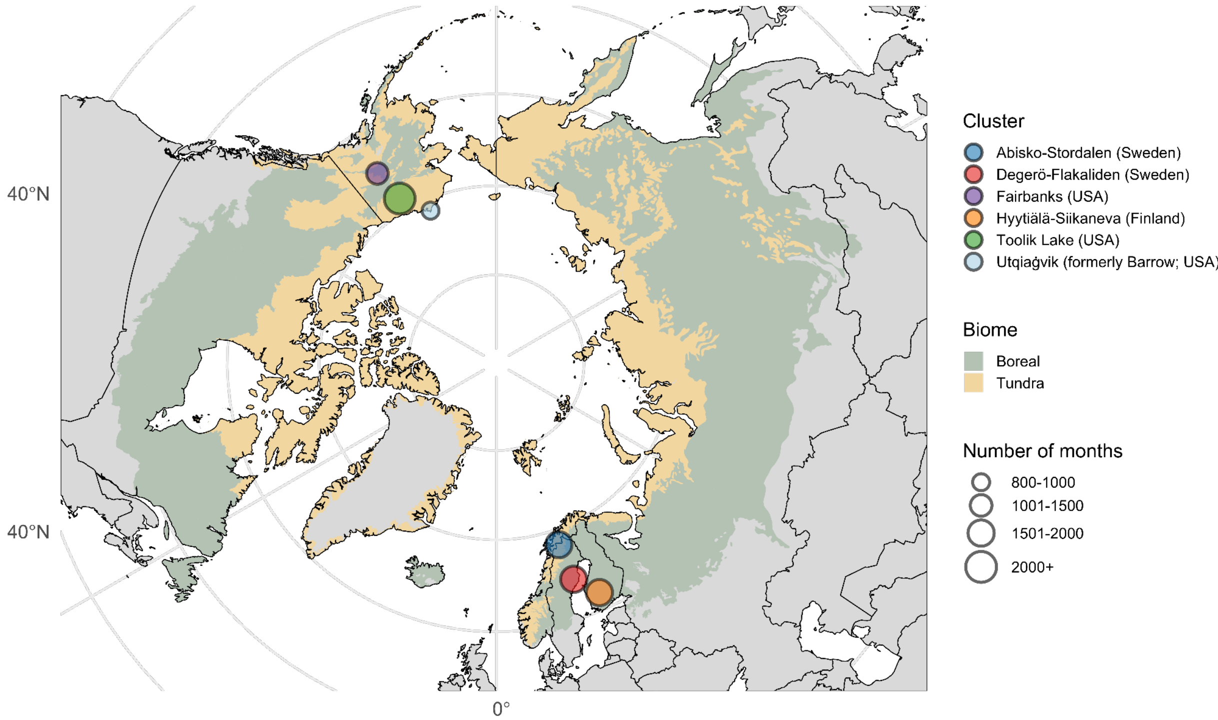
Supplementary Fig. 8. Zoomed-in maps of flux sites for the densely measured areas.



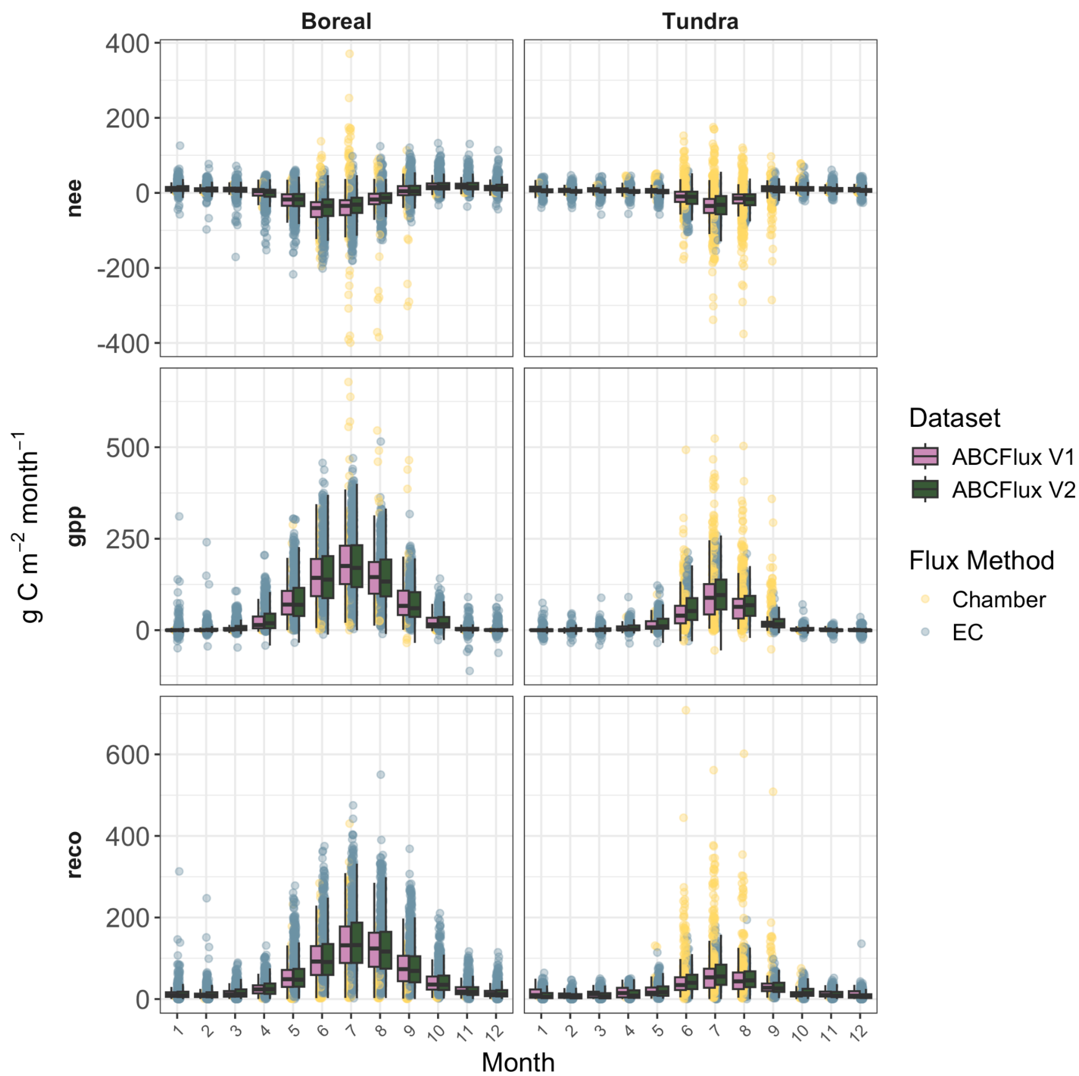
Supplementary Fig. 9. Eddy covariance and automated chamber sites that provided (a) a full year of data (12 months of data, excluding months that are 100% gap-filled) and (b) some monthly data for year 2022 (representing the situation for sites actively sharing data).



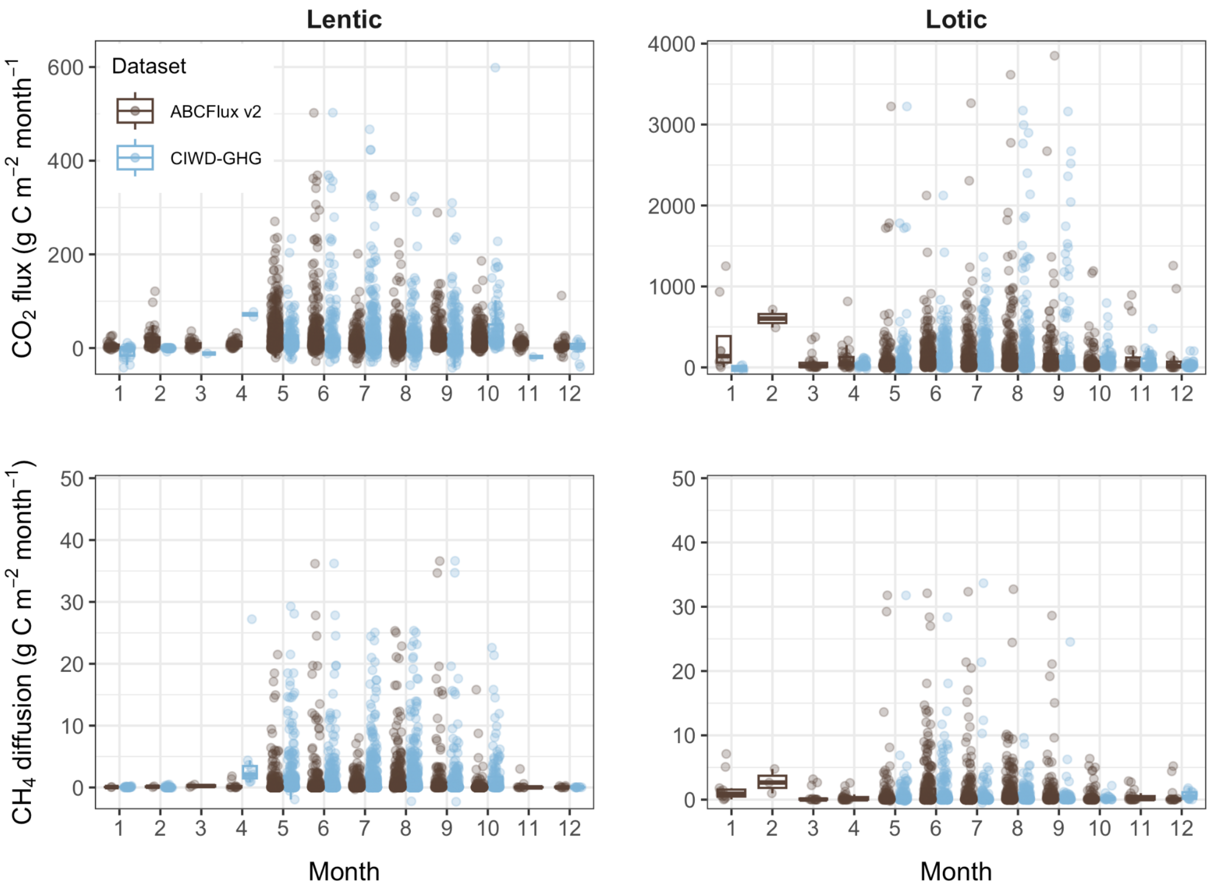
Supplementary Fig. 10. Site-months of non-eddy covariance based measurement sites.



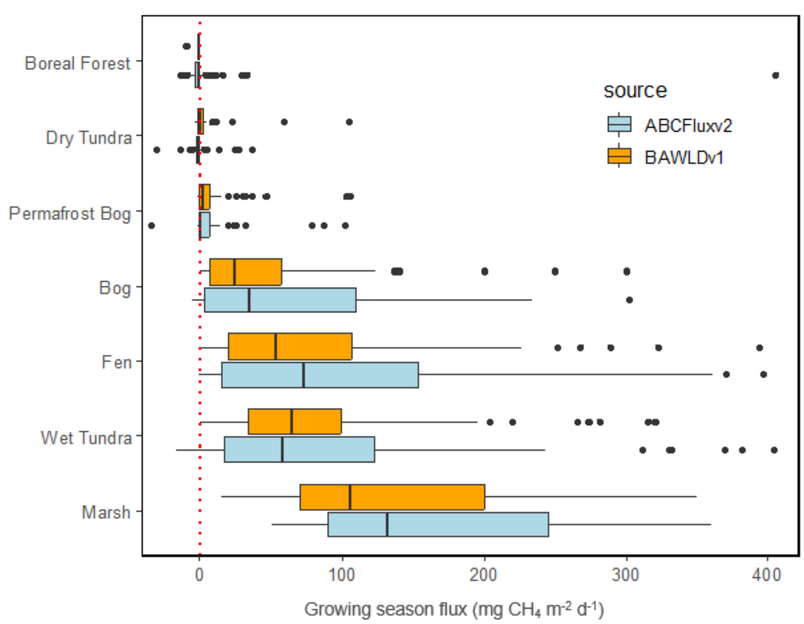
Supplementary Fig 11. Cluster sites identified by more than 800 site-months within 30km radius.



Supplementary Fig. 12. Comparison of monthly terrestrial CO_2 flux magnitudes in ABCFluxv1 vs. v2. GPP was presented as a negative flux in ABCFlux v1 but was converted to positive for the purpose of this comparison.



Supplementary Fig. 13. Comparison of monthly cumulative carbon fluxes (CO_2 and diffusive CH_4 flux) for aquatic ecosystems between this study (ABCFlux v2, grey) and Song et al. (2024; CIWD-GHG, blue).



Supplementary Fig. 14. Comparison of terrestrial CH_4 fluxes in ABCFlux v2 vs BAWLD-CH4 v1. Fluxes from ABCFlux v2 represent the average fluxes between June and August.