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*Supplement of*

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

**Anna-Maria Virkkala et al.**

*Correspondence to:* Anna-Maria Virkkala (avirkkala@woodwellclimate.org)

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**S1. 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.

**Table S1. The number of site-months in ABCFlux v2 for each individual flux variable.**

| Flux column | Number of site-months |
|---|---|
| nee | 14,913 |
| gpp | 11,623 |
| reco | 13,017 |
| co2_flux | 3,770 |
| ch4_flux_total | 8,094 |
| ch4_flux_diffusion | 3,560 |
| 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** | 56,139 |
| **Total concentration values** | 15,668 |

**Table S2. 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 |

**Table S3. 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 | | | | |

| 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-BEO_US-Beo_tower | Jan-13 | Nov-22 | 92 | Oct-13 | Nov-22 | 82 | |
| 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- | Jan-12 | Dec-15 | 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 |
|---|---|---|---|---|---|---|---|
| Eusk_cher1_tower | | | | | | | |
| Cherskii reference_RU-Ch2_tower | Jul-13 | Dec-21 | 102 | Jul-13 | Dec-21 | 102 | |
| Cherskii_RU-Che_tower | Aug-02 | Dec-21 | 134 | Jul-13 | Dec-21 | 102 | |
| 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 | |

| 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 |
|---|---|---|---|---|---|---|---|
| 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 | | | | |
| 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 | |

| 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 |
|---|---|---|---|---|---|---|---|
| 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 | | | | |
| 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 | |

| 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 |
|---|---|---|---|---|---|---|---|
| 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 | | | | |
| 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 | | | | |

| 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 |
|---|---|---|---|---|---|---|---|
| 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) Tundra_CA-Mtk_tower | Aug-24 | Nov-24 | 4 | Aug-24 | Sep-24 | 2 | |
| Mukhrino field station, Khanty-Mansiysk, Russia_RU-Muh_tower | May-15 | Sep-22 | 11 | | | | |
| 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 | |

| 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 |
|---|---|---|---|---|---|---|---|
| Norunda_SE-Nor_tower | Jan-99 | Dec-23 | 180 | | | | |
| Nuuk Fen_GL-NuF_tower | Jun-08 | Sep-22 | 49 | | | | |
| 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 | |

| 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 |
|---|---|---|---|---|---|---|---|
| Rosinedal-3_SE-Ros_tower | Aug-14 | Dec-20 | 77 | | | | |
| Rylekaerene_tower | Jun-08 | Oct-09 | 11 | Jun-08 | Oct-09 | 11 | |
| 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 | | | | |

| 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 |
|---|---|---|---|---|---|---|---|
| Saskatchewan - Western Boreal, Mature Black Spruce_CA-Obs_tower | May-99 | Dec-10 | 140 | | | | |
| Saskatchewan - Western Boreal, Mature Jack Pine_CA-Ojp_tower | Jan-00 | Dec-10 | 132 | | | | |
| 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 | |

| 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 |
|---|---|---|---|---|---|---|---|
| Stortjarn_SE-Srj_tower | Apr-20 | Dec-22 | 33 | Apr-20 | Dec-22 | 31 | |
| Svartberget_SE-Svb_tower | Jan-14 | Dec-23 | 108 | | | | |
| 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 | | | | |

| 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 |
|---|---|---|---|---|---|---|---|
| University of Alaska, Fairbanks_US-Uaf_tower | Jan-03 | Dec-23 | 252 | Apr-11 | Nov-23 | 95 | |
| 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 | Oct-20 | Dec-22 | 27 | Oct-20 | Dec-22 | 27 | |
| 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 | | | | |

**Table S4. 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 Wikipedia (https://en.wikipedia.org/wiki/List_of_countries_and_dependencies_by_area). We also included some data from Japan, Mongolia, and the UK but their country-level cover is not shown here.

| | 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 | 24.3 | 18.2 | 186 | 108.3 | 23.4 | 30.3 | 102 | 59.4 | 25.9 | 12.8 | 91 | 53.0 | 22.1 | 16.7 | 20.6 | 19.8 |
| Sweden | 0.450 | 201.0 | 23.3 | 239 | 530.8 | 14.7 | 9.5 | 32 | 71.1 | 32.5 | 29.6 | 211 | 468.6 | 18.3 | 24.9 | 21.4 | 9.1 |
| Canada | 9.985 | 19.2 | 14.1 | 144 | 14.4 | 20.3 | 25.8 | 87 | 8.7 | 17.6 | 8.6 | 61 | 6.1 | 20.8 | 12.3 | 17.4 | 13.5 |
| Finland | 0.338 | 17.4 | 24.4 | 250 | 739.3 | 20.5 | 7.4 | 25 | 73.9 | 11.5 | 31.6 | 225 | 665.4 | 19.1 | 28.0 | 20.3 | 36.4 |
| Russia | 17.098 | 11.2 | 14.3 | 146 | 8.5 | 11.9 | 14.8 | 50 | 2.9 | 9.9 | 14.7 | 105 | 6.1 | 12.0 | 13.1 | 10.1 | 15.8 |
| Norway | 0.386 | 3.0 | 2.3 | 24 | 62.1 | 3.8 | 5.0 | 17 | 44.0 | 1.3 | 1.1 | 8 | 20.7 | 2.8 | 1.9 | 5.9 | 2.3 |
| Greenland | 2.166 | 2.2 | 2.1 | 21 | 9.7 | 2.9 | 3.9 | 13 | 6.0 | 1.1 | 1.1 | 8 | 3.7 | 2.5 | 1.5 | 2.3 | 2.3 |
| Mongolia | 1.564 | 1.0 | 0.5 | 5 | 3.2 | 1.6 | 1.5 | 5 | 3.2 | | | | 0.0 | 1.5 | 0.6 | | |
| Estonia | 0.045 | 0.3 | 0.3 | 3 | 66.2 | 0.4 | 0.9 | 3 | 66.2 | | | | 0.0 | 0.4 | 0.3 | 0.9 | 0.3 |

**Table S5. 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) | -7.7 (-18.5 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) | -18.5 (-32.7 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 (-46.6 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) | -13.6 (-23.4 to -6.5) | -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) |

**Table S6. 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) | 4.1 (1 to 9.9) | 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) | 3.4 (0.5 to 7.5) | 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) | 2.9 (0.6 to 7.1) | 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) | 1.5 (0.3 to 6.4) | 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) | 3.7 (0.6 to 9.2) | 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) | -10.2 (-28.1 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) | -41.8 (-63.7 to -21) | -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) | -19.8 (-36.7 to -7.6) | -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) | 10.6 (0.2 to 19.1) | 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) | 9.9 (4.8 to 15.8) | 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) | 7.6 (4.3 to 12.4) | 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) | 6.2 (2.5 to 10.4) | 7.4 (3.3 to 10) | 5.6 (2.8 to 23.9) | 4.7 (2.3 to 9.2) | |

**Table S7. 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) | 6.7 (2 to 18) | 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) | 11.3 (3.2 to 27) | 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) | 22.1 (5.4 to 58.3) | 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) | 20.6 (6.5 to 37.1) | 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) |

**Table S8. Monthly median $CH_4$ flux (mg 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 | | 65.63 (-17.35 to 231.16) | | -1.69 (-6.43 to 0.21) | 325.1 (29.9 to 513.6) | 216.1 (117.4 to 310.6) |
| 2 | 1961.25 (979.03 to 2943.47) | -9.26 (-30.51 to 207.67) | | -1.2 (-7.6 to 2) | 91.9 (25.5 to 465.8) | 182 (85.7 to 245) |
| 3 | 358.26 (82.71 to 629.79) | 35.58(-9.38 to 153.14) | | 0.52 (0.1 to 1.87) | 73.7 (9.9 to 224.7) | 197.5 (126.8 to 255) |
| 4 | | 67.99 (-14.42 to 194.2) | -13.98 (-20.89 to -9.01) | 0 (-4.79 to 0.38) | 106.5 (26.2 to 291.2) | 328.2 (157.4 to 421.9) |
| 5 | 157.71 (-4.62 to 1067.12) | 37.38 (-26.38 to 302.54) | 0.17 (0.14 to 1.29) | 6.68 (-2.74 to 29.47) | 587.7 (127.4 to 1238.9) | 586.9 (205.1 to 907.6) |
| 6 | -12.73 (-18.4 to 456.35) | 0.67 (-22.15 to 284.75) | 4.46 (4.45 to 4.47) | 2.35 (-4.74 to 21.56) | 839.6 (155 to 1813.2) | 892.3 (448.8 to 1724) |
| 7 | -32.63 (-45.26 to -27.11) | -40.87 (-77.48 to -10.07) | 1.19 (-0.9 to 3.27) | -21.24 (-58.9 to -3.46) | 1037.9 (190.8 to 2459.3) | 1719.8 (505.5 to 3336.5) |
| 8 | 0.25 (-31.95 to 154.38) | -5.21 (-47.98 to 222.19) | 2.55 (2.18 to 3.22) | 0.55 (-12.65 to 102.81) | 1463.5 (320 to 2802.5) | 2059.9 (960.6 to 3147.8) |
| 9 | -35.09 (-62.36 to -23.57) | 0.91 (-77.58 to 147.41) | -0.37 (-3.49 to 2.74) | -2.38 (-13.87 to 46.54) | 761.4 (190 to 1719.2) | 1482.3 (776 to 2292) |
| 10 | 61.98 (61.98 to 61.98) | -24.52 (-55.36 to 292.5) | | 38.26 (-10.45 to 100.91) | 425.2 (178.9 to 796.6) | 718.8 (471.4 to 927.5) |
| 11 | | -1.43 | | 32.62 | 211.7 | 405.4 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | (-46.01 to 241.15) | | (-3.6 to 264.34) | (91.6 to 530.7) | (297.9 to 525.1) |
| 12 | | 29.69<br><br>(-20.15 to 252.9) | | -2.08<br><br>(-7.51 to 1.88) | 366.9<br><br>(52.8 to 505.6) | 309.5<br><br>(213.1 to 406.8) |

**Table S9. Monthly median $CH_4$ flux (mg 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 | 15.7 (5.1 to 57.3) | 122.9 (45 to 302) | 9.6 (9.6 to 9.6) | 68.05 (-1.05 to 143.86) | -1.81 (-6.75 to -0.7) | |
| 2 | 12.9 (0.7 to 48.8) | 103.4 (49.8 to 236.9) | 8.67 (8.67 to 8.67) | 135.22 (17.46 to 2458.96) | -0.45 (-2.1 to -0.22) | |
| 3 | 14 (0.4 to 23.6) | 86.6 (18.7 to 189.4) | -2.49 (-3.48 to 0.15) | 33.72 (7.15 to 50.77) | -1.2 (-1.82 to 0) | -249 (-249 to -249) |
| 4 | 4.7 (0 to 11.8) | 22.2 (1.5 to 138.4) | -4.04 (-20.46 to -0.8) | 43.27 (1.35 to 88.9) | 0.07 (-0.7 to 0.35) | -2219 (-2582 to -1856) |
| 5 | 8.4 (0 to 80.5) | 111.9 (29.2 to 317.3) | -19.26 (-58.37 to 20.85) | 281.7 (163.62 to 354.86) | -1.85 (-10.2 to 0.03) | 290 (-415 to 995) |
| 6 | 30.4 (1.2 to 265.7) | 376.3 (146 to 1023.6) | -16.18 (-53.48 to -1.18) | 7.17 (0 to 79.54) | -1.89 (-8.34 to 4.05) | |
| 7 | 142.2 (2.2 to 980.2) | 1008.2 (380.9 to 2518.1) | -31.96 (-69.14 to -7.94) | 2.89 (-9.2 to 145.47) | -19.56 (-47.47 to -1.92) | 9.56 (-1.33 to 26.49) |
| 8 | 158.1 (2.1 to 1579.5) | 947 (424 to 1825.3) | -24.39 (-46.71 to -8.17) | 8.93 (-4.83 to 375.68) | -8.9 (-24.35 to 5.87) | |
| 9 | 27.8 (0.2 to 308.9) | 452.9 (266.8 to 895.4) | -33 (-79.35 to -1.44) | 193.17 (9.04 to 746.65) | -10 (-28.96 to -5.3) | |
| 10 | 9.5 (-0.3 to 89.2) | 368.2 (205.4 to 619.9) | -17.71 (-34.16 to -5.17) | 105.58 (8.37 to 136.11) | -17.2 (-27.73 to -4.58) | |
| 11 | 26.8 (5.6 to 210.4) | 245.8 (143.4 to 367.5) | -23.93 (-38.3 to -9.36) | 52.96 (12.61 to 259.32) | -11.4 (-19.5 to -2.55) | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 12 | 26.9<br>(9 to 175.3) | 165.8<br>(106.5 to 353.1) | -11.84<br>(-24.66 to 5.68) | 83.47<br>(-1 to 1434.63) | -3.9<br>(-14.9 to -0.6) | |

**Table S10. 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 | 222.1 (210 to 227) | -2.3 (-26.5 to -1.8) | 78.8 (47.6 to 127.8) | | |
| 1 | diffusion | | 67.8 (57.9 to 77.7) | | 898.4 (688.5 to 1186.2) | 458 (212.2 to 1119.8) |
| 2 | total | 162.7 (154.7 to 169.1) | 2.1 (0 to 6.7) | 54.2 (25.6 to 119.2) | | |
| 2 | diffusion | | 122.8 (81.7 to 164) | | 983.5 (983.5 to 983.5) | |
| 3 | total | 206.1 (106.9 to 221) | 2.6 (-0.9 to 4) | 125.1 (64.8 to 161.6) | 2228.5 (2228.5 to 2228.5) | |
| 3 | ebullition | | | | 0 (0 to 0) | |
| 3 | diffusion | | 236 (146.1 to 357.5) | | 14.2 (3.7 to 97.4) | |
| 4 | total | 271.8 (76 to 446.1) | 4.9 (2.3 to 13.6) | 89 (26 to 158.3) | | |
| 4 | ebullition | 22.1 (14 to 114.6) | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 4 | diffusion | 49.8 (38.4 to 172.2) | 1378.7 (1378.7 to 1378.7) | 5 (4 to 6) | 43.3 (0 to 296.9) | |
| 5 | total | 587.9 (265.9 to 886.1) | 121.8 (36.8 to 1358.4) | 51.6 (22.7 to 156.5) | 6685.4 (5861.3 to 7509.5) | |
| 5 | ebullition | 629.9 (233.6 to 1070) | 38 (26.7 to 65.8) | 4.2 (4.2 to 4.2) | 510.7 (359.8 to 661.6) | |
| 5 | diffusion | 106.9 (26.1 to 756) | 19.1 (5.3 to 86.7) | 10.8 (2.5 to 49.6) | 60.2 (3.5 to 388.9) | 81.8 (11.2 to 280.2) |
| 6 | total | 432.2 (153.7 to 1173.6) | 400 (155.4 to 590) | 25.5 (18.7 to 314) | 1123.2 (603.6 to 7413.3) | |
| 6 | ebullition | 166.8 (39.4 to 519.9) | 104.5 (3.5 to 474.8) | 11.4 (6.1 to 16.8) | 0 (0 to 112.3) | |
| 6 | diffusion | 142 (40.8 to 548.8) | 27.1 (12.1 to 81.2) | 6.5 (5.4 to 15.7) | 220.9 (12.4 to 1700) | 94.8 (29.4 to 1057.5) |
| 7 | total | 670.4 (263.3 to 1274.4) | 776.1 (244.4 to 1405.2) | 141.2 (25.2 to 435.3) | 15814.9 (210.9 to 43241.8) | |
| 7 | ebullition | 362.4 (102 to 843.9) | 373.4 (27.1 to 1327.8) | 7.3 (5.1 to 9.4) | 14985.9 (317 to 41742.4) | |
| 7 | diffusion | 287.5 (105.7 to 674.9) | 221.5 (60.5 to 548) | 20 (4.4 to 82.3) | 40.7 (1.8 to 228.4) | 9.9 (2.6 to 45) |

| | | | | | | |
|---|---|---|---|---|---|---|
| 8 | total | 850.2 (343 to 1224.9) | 890 (357.1 to 1684.8) | 271.7 (93.8 to 474.5) | 5408.7 (1561.9 to 7476.8) | |
| 8 | ebullition | 331.4 (156.9 to 742.6) | 932 (10.2 to 1899) | 26.3 (18.8 to 33.8) | 613.6 (537.7 to 6673) | |
| 8 | diffusion | 290 (100 to 1370) | 67.8 (29.7 to 265.3) | 21.3 (10.1 to 80) | 129.4 (4.7 to 769.7) | 134 (16.9 to 1087.4) |
| 9 | total | 458.8 (257.9 to 780.9) | 404.8 (119.4 to 623.6) | 191.3 (179.2 to 322.7) | 100 (100 to 100) | |
| 9 | ebullition | 208.5 (71.6 to 418.9) | 281.7 (5.6 to 697) | | | |
| 9 | diffusion | 475 (103.8 to 2379.8) | 160.2 (52.6 to 518.1) | 30 (30 to 140) | 212.3 (17.3 to 674.1) | 283.1 (20.2 to 855.3) |
| 10 | total | 184.2 (127.5 to 446.7) | 198 (36.4 to 235) | 323.4 (159.2 to 338.2) | | |
| 10 | ebullition | 71.8 (63.7 to 84.4) | 48.4 (20.2 to 83.6) | 10.4 (10.4 to 10.4) | | |
| 10 | diffusion | 64.2 (22.3 to 317.2) | 17.5 (8.6 to 41.8) | 6 (3.3 to 15.3) | 38.7 (4.7 to 273.4) | 4.5 (1.6 to 392.7) |
| 11 | total | 180.7 (93.4 to 323.8) | 1.8 (-46.4 to 4.5) | 238.8 (207.8 to 289.3) | | |
| 11 | ebullition | 23.4 (23.4 to 23.4) | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 11 | diffusion | 77.8<br>(21.5 to 600) | 7<br>(5 to 17.8) | 9.5<br>(9.2 to 9.8) | 22.1<br>(3 to 206.2) | |
| 12 | total | 231.1<br>(180.8 to 260) | -2.5<br>(-5.8 to 2.2) | 268<br>(194 to 680.3) | | |
| 12 | diffusion | 13.3<br>(13.3 to 13.3) | 126<br>(6 to 247.9) | 6.5<br>(4.8 to 8.2) | 0.3<br>(-0.3 to 8.4) | |

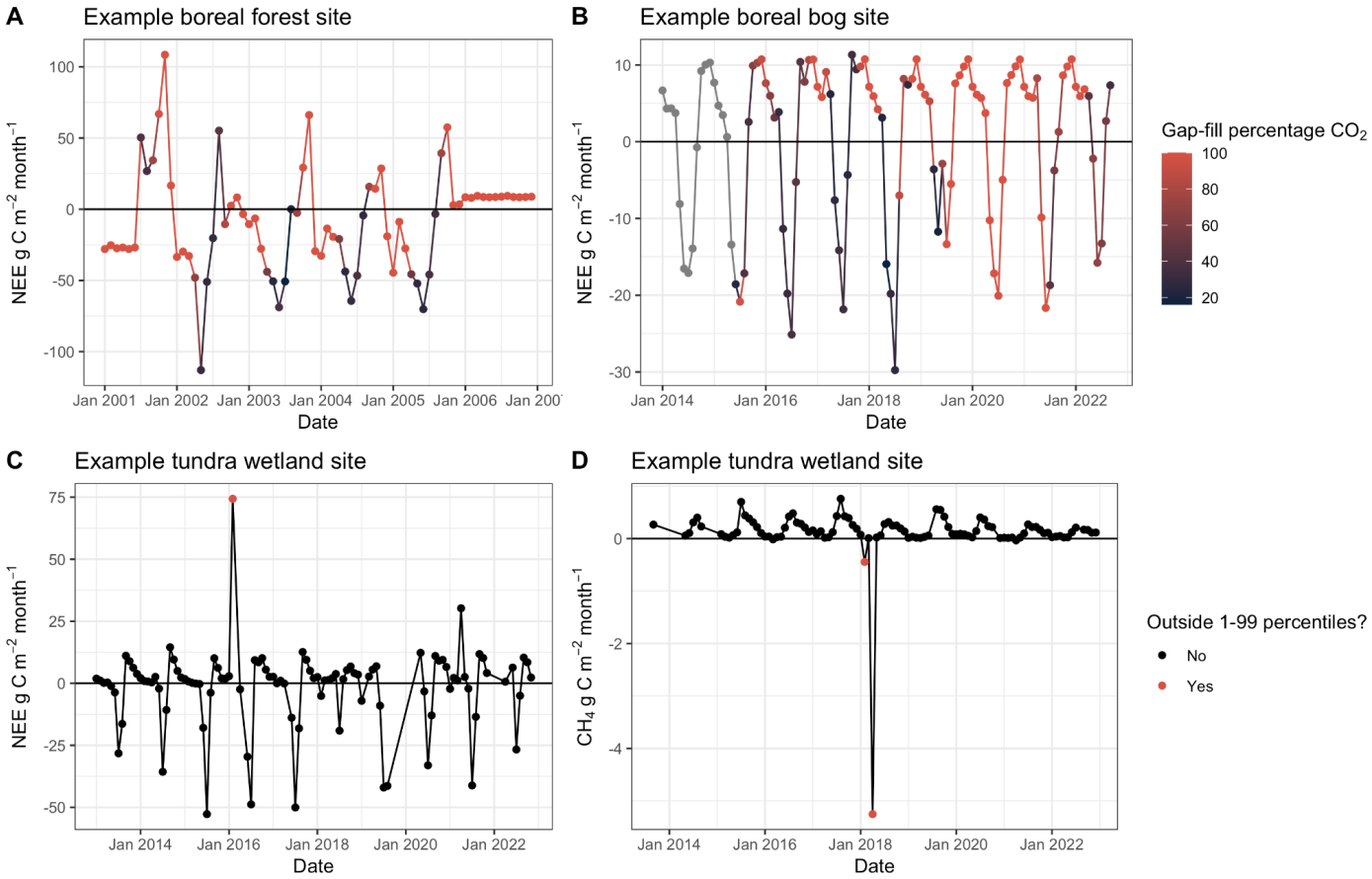



**Figure S1. Example of situations encountered in data cleaning A) site time series with "flat lines" based on entirely gap-filled data, B) heavy gap-filling across most winters and some years (grey points and lines indicate no gap-fill percentage was available), fluxes flagged as outside the 1-99th percentiles and visually identified as outliers that were removed for C) NEE and D) $CH_4$.**

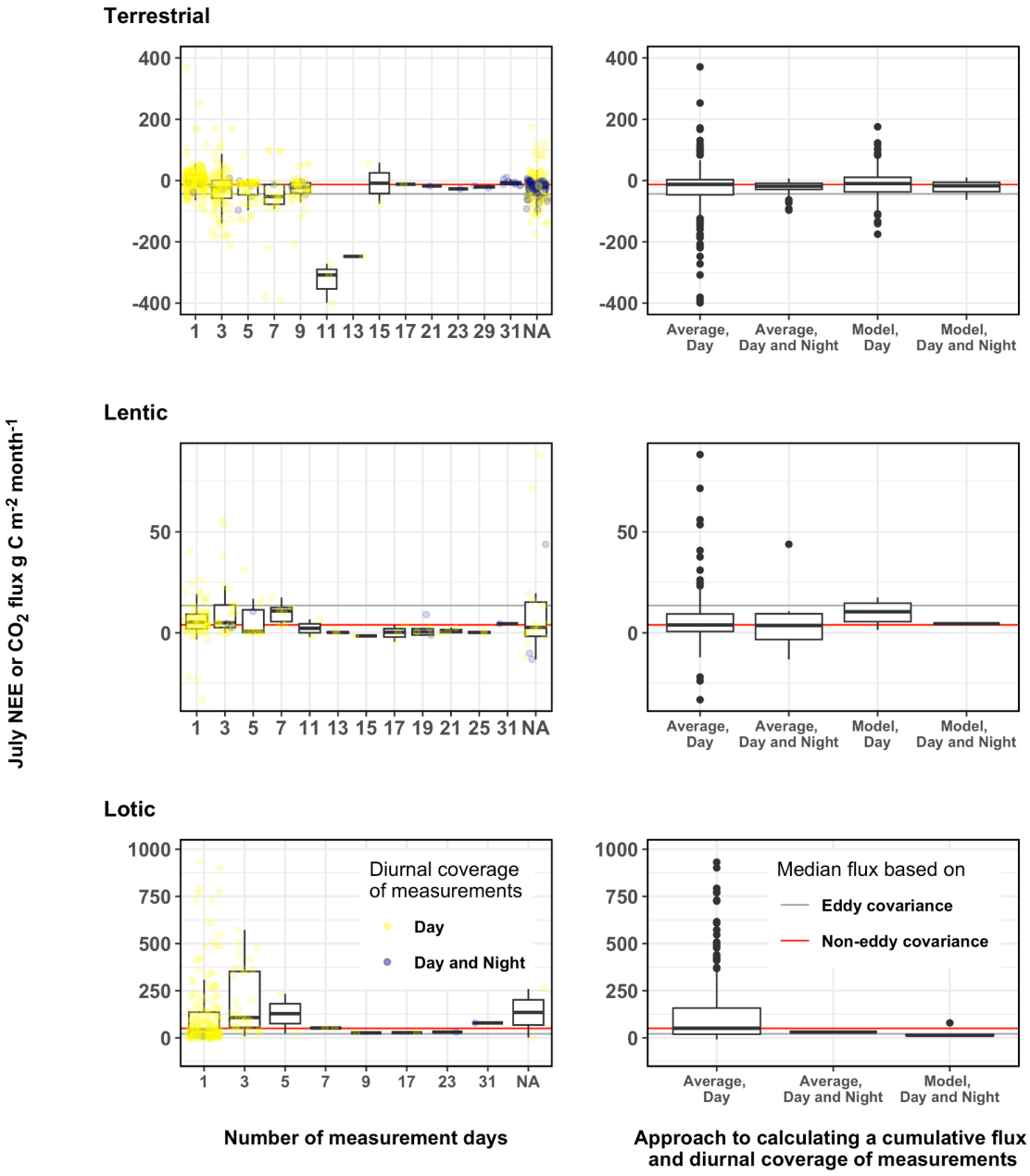



**Figure S2. The relationship between chamber-based net $CO_2$ flux for July and the number of measurement days, diurnal coverage, and the method used to calculate cumulative fluxes across key ecosystems.** "Terrestrial" refers only to treeless ecosystems. When information on diurnal coverage was unavailable, 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.

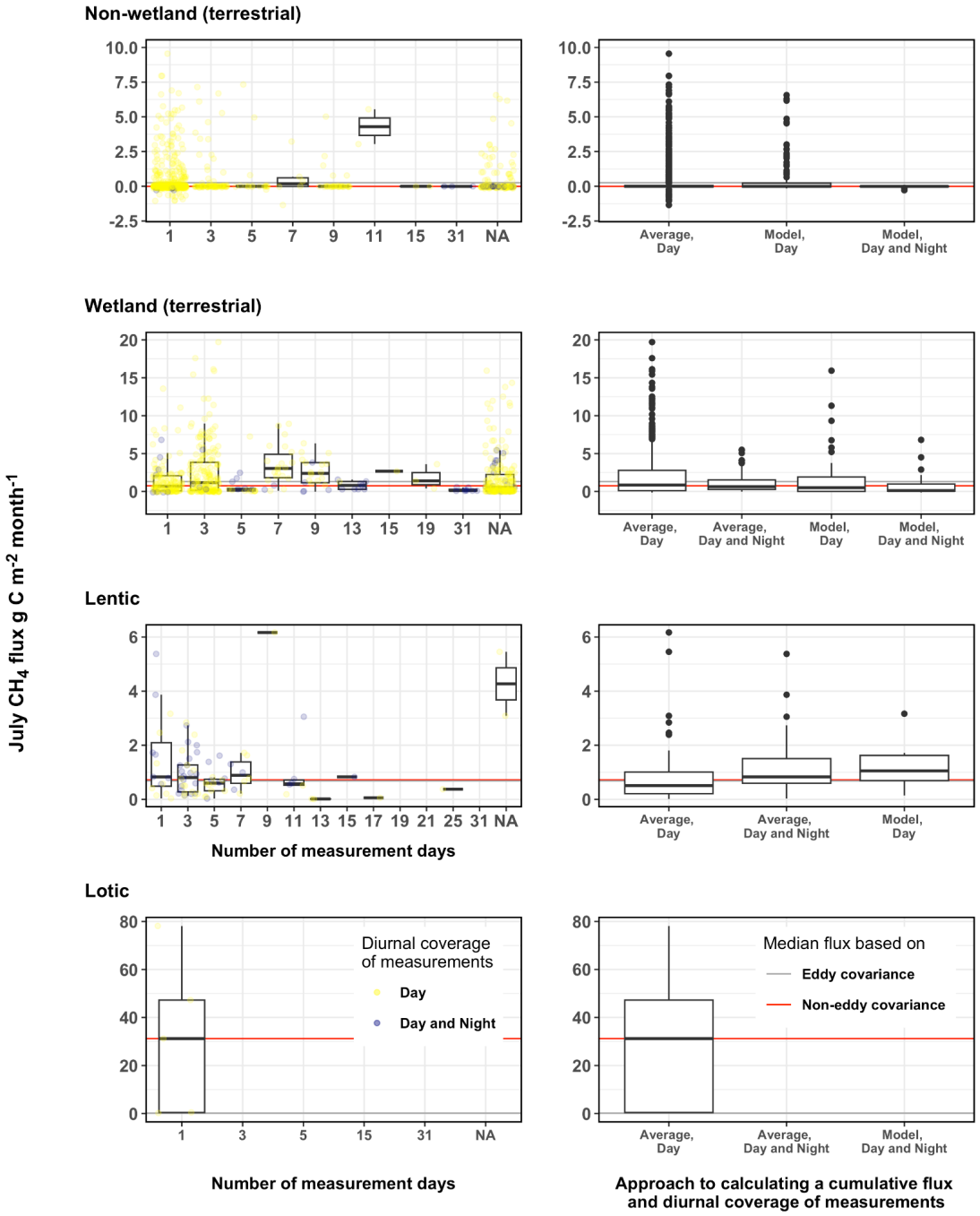



**Figure S3. The relationship between chamber-based net $CH_4$ flux for July and the number of measurement days, diurnal coverage, and the method used to calculate cumulative fluxes across key ecosystems.** When information on diurnal coverage was unavailable, we assumed daytime-only measurements for 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.

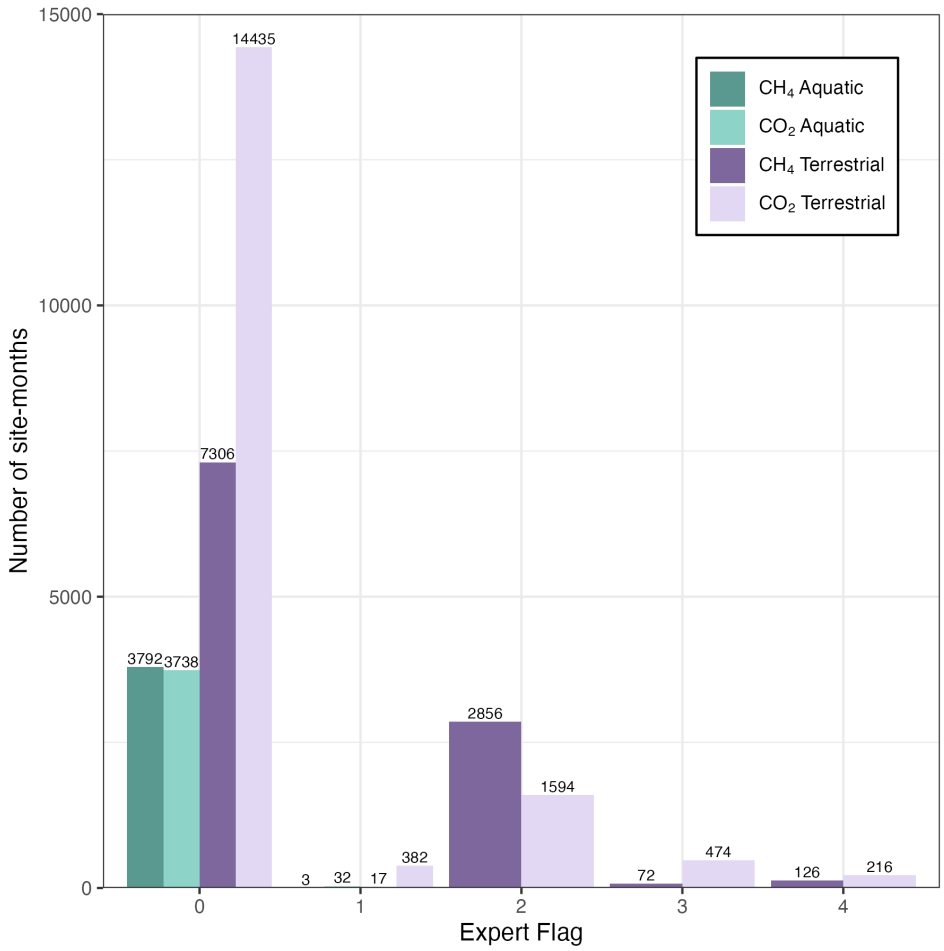



**Figure S4. The number of site-months flagged with the 4 different expert flags across $CO_2$ fluxes (NEE, GPP, Reco) and $CH_4$ fluxes (flag 0 = data was not flagged).** For $CO_2$, the flags considered fluxes outside the 1st and 99th percentiles for terrestrial, and outside the 99th percentile for 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).

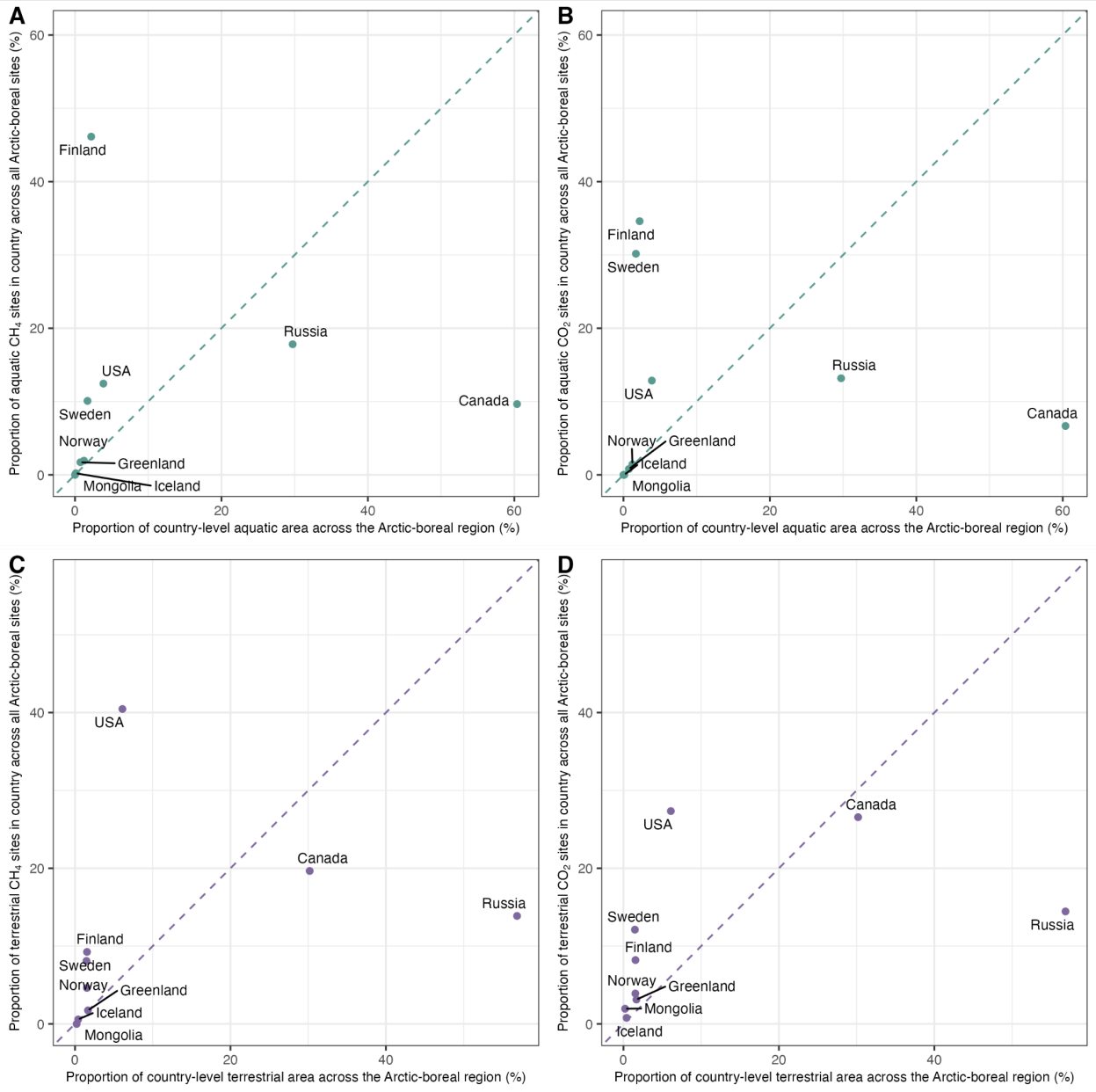



**Figure S5. Proportion of sites in each country across all Arctic-boreal sites relative to the proportion of total area (terrestrial or aquatic) occupied by countries in the ABCFlux v2 study region for A) aquatic $CH_4$ fluxes and concentration data, B) aquatic $CO_2$ fluxes and concentration data, 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).

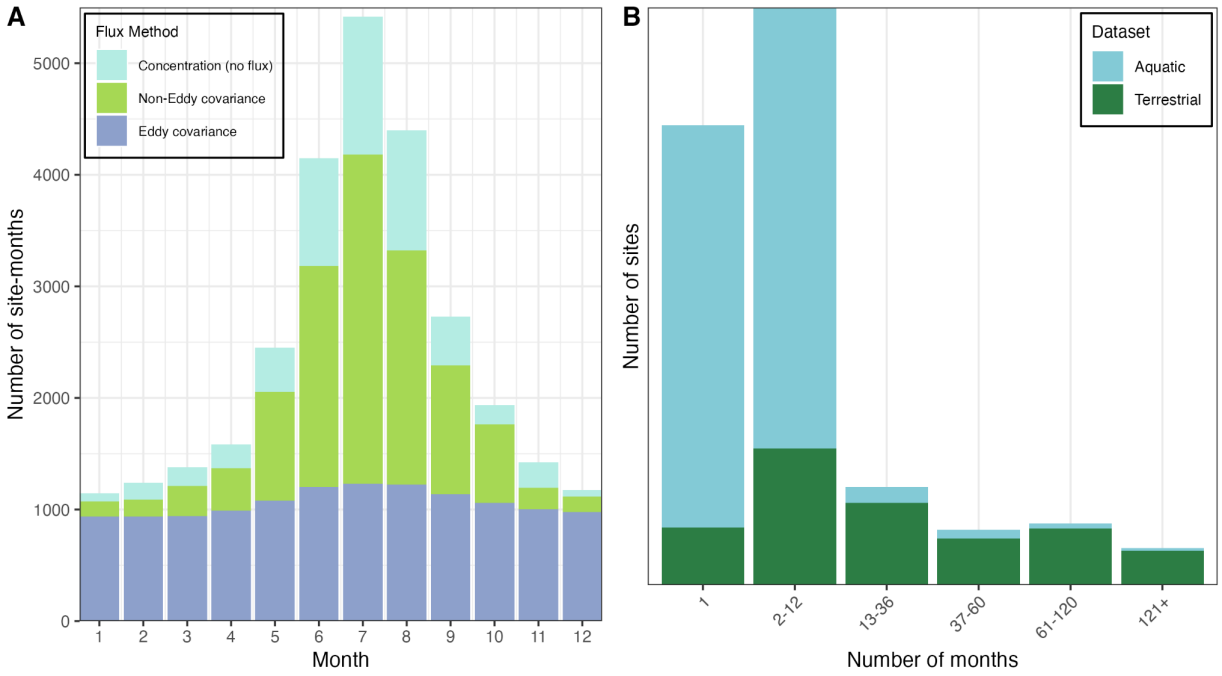



**Figure S6. A) The number of observations by measurement method distributed across months. B) The number of sites by the number of total site-month observations for each site separated by aquatic and terrestrial datasets.**

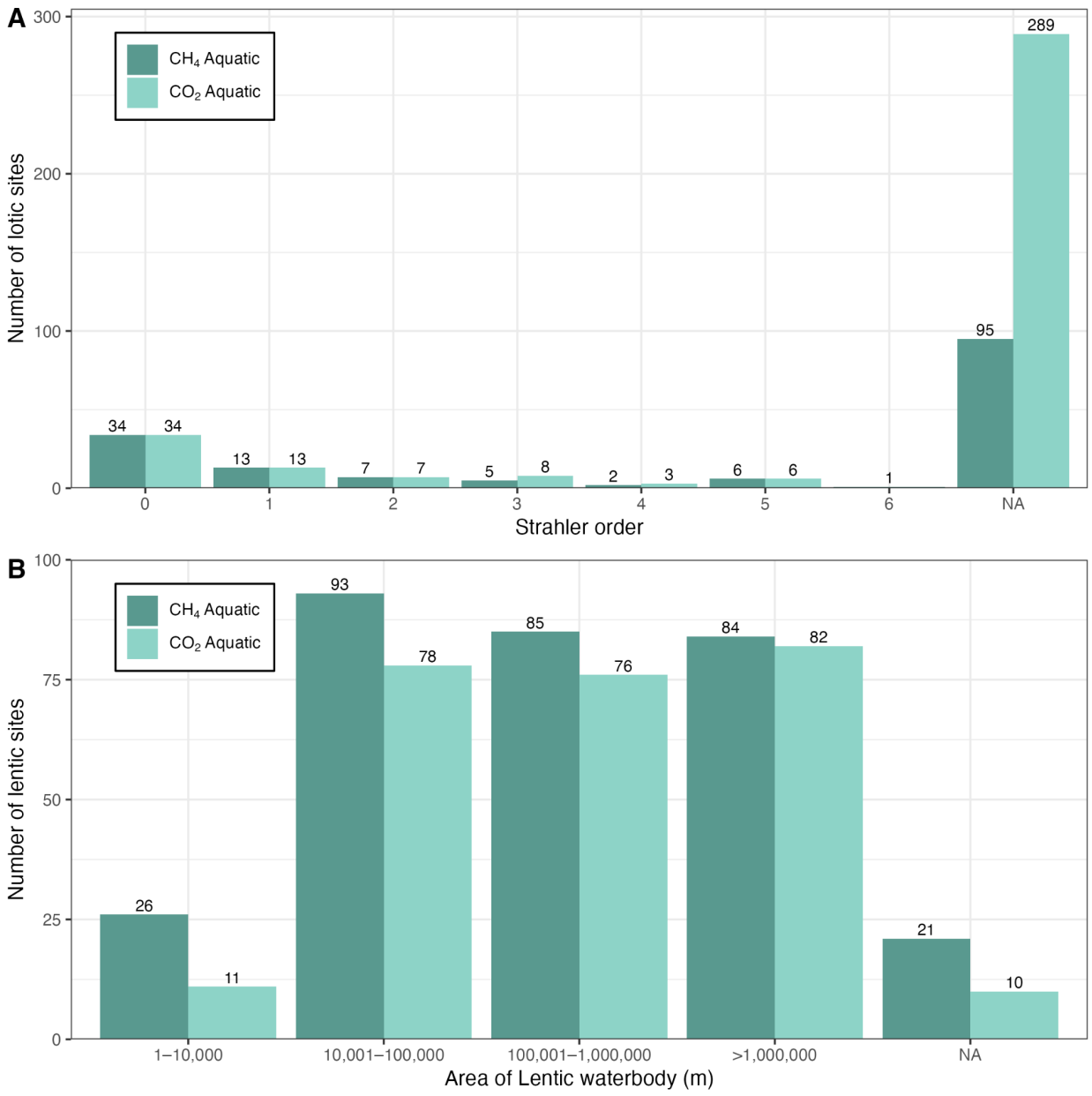



**Figure S7. Number of unique lotic sites for each Strahler order for $CO_2$ and $CH_4$**

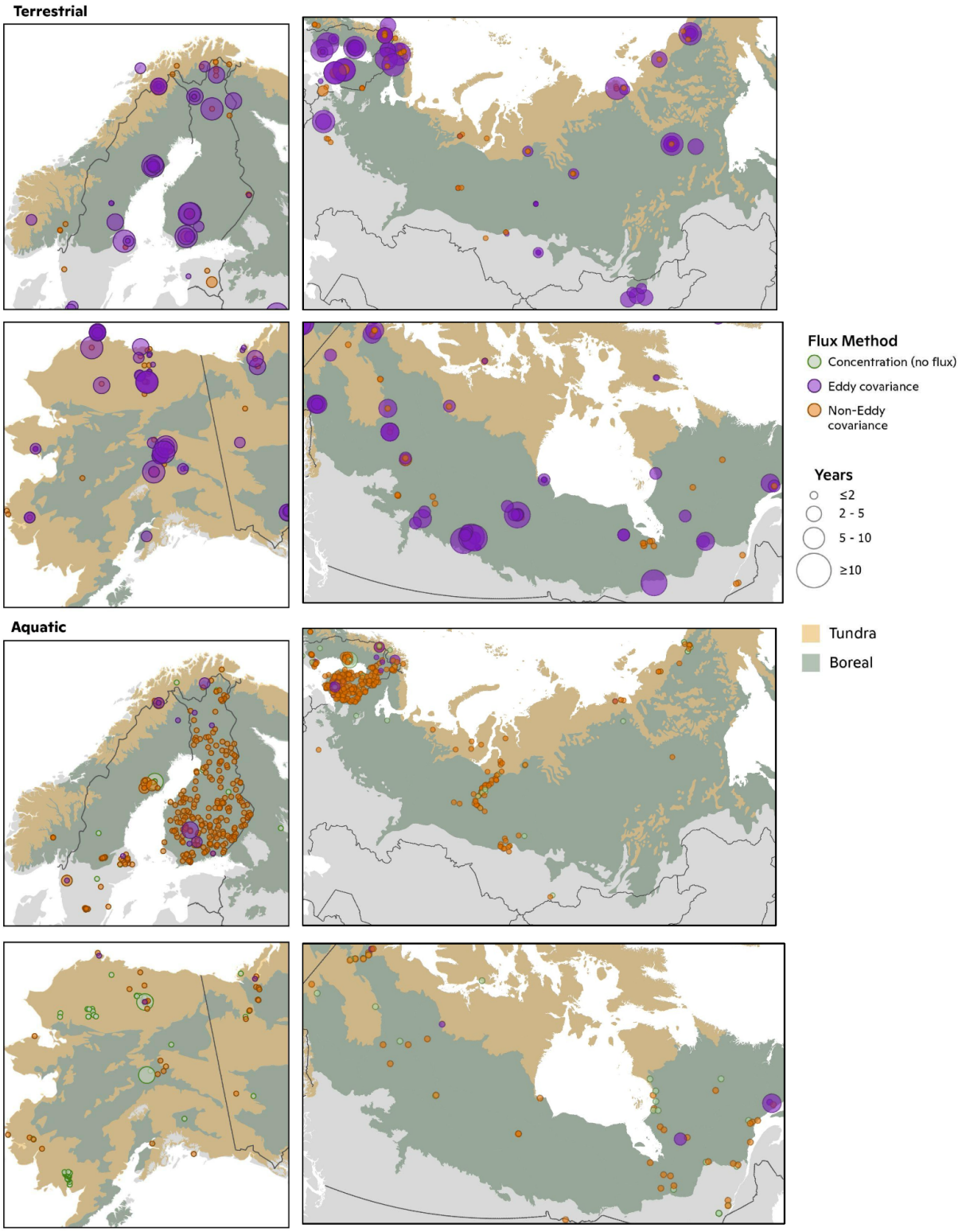



**Figure S8. Zoomed-in maps of regional flux sites.**

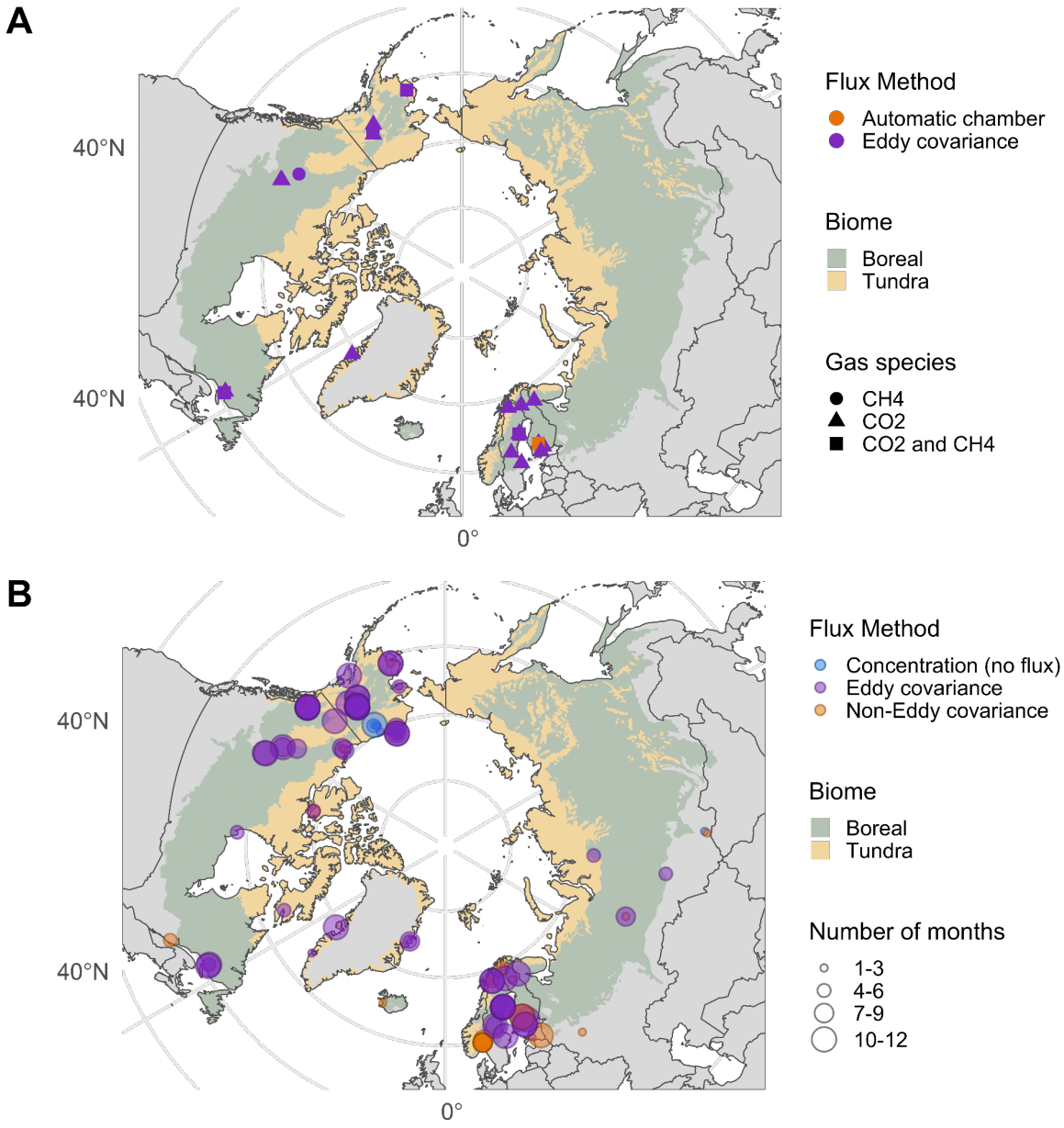



**Figure S9. Eddy covariance and automated chamber sites that provided (a) a full year of data (12 months of data, excluding months that are 100% gap-filled) and (b) some monthly data for year 2022 (representing the situation for sites actively sharing data).**

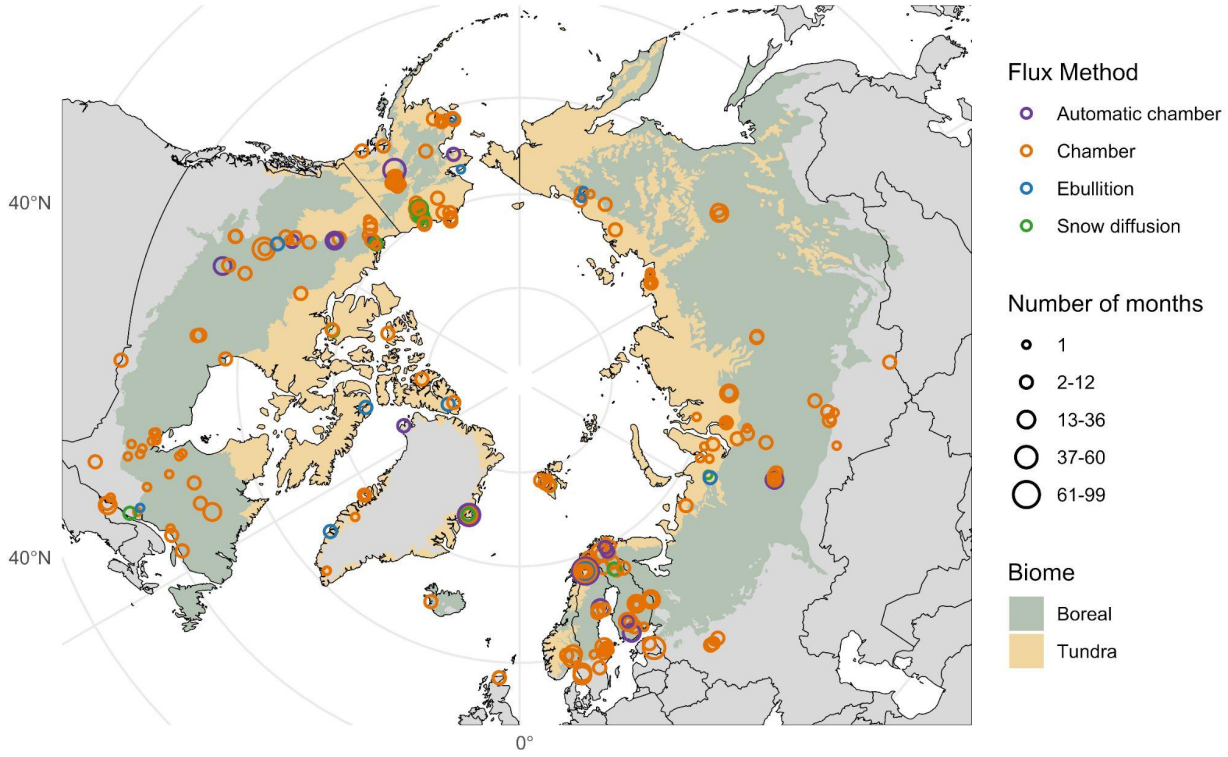



**Figure S10. Site-months of non-eddy covariance based measurement sites.**

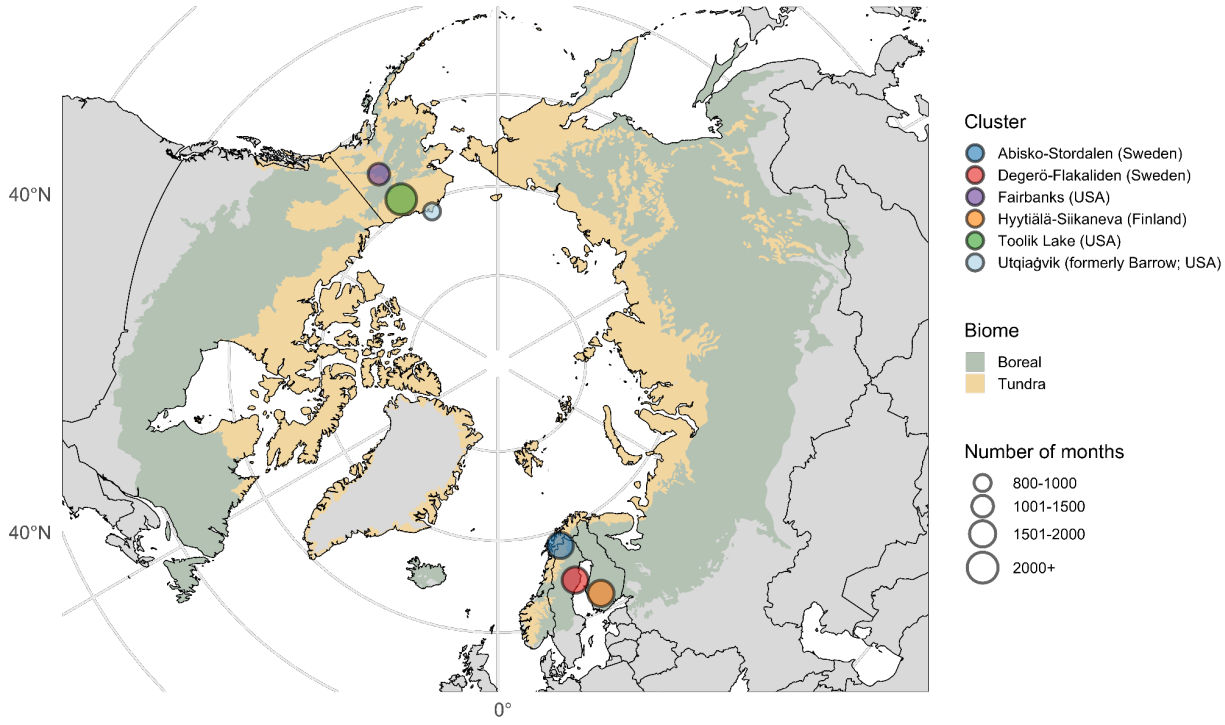



**Figure S11. Cluster sites identified by more than 800 site-months within 30km radius.**

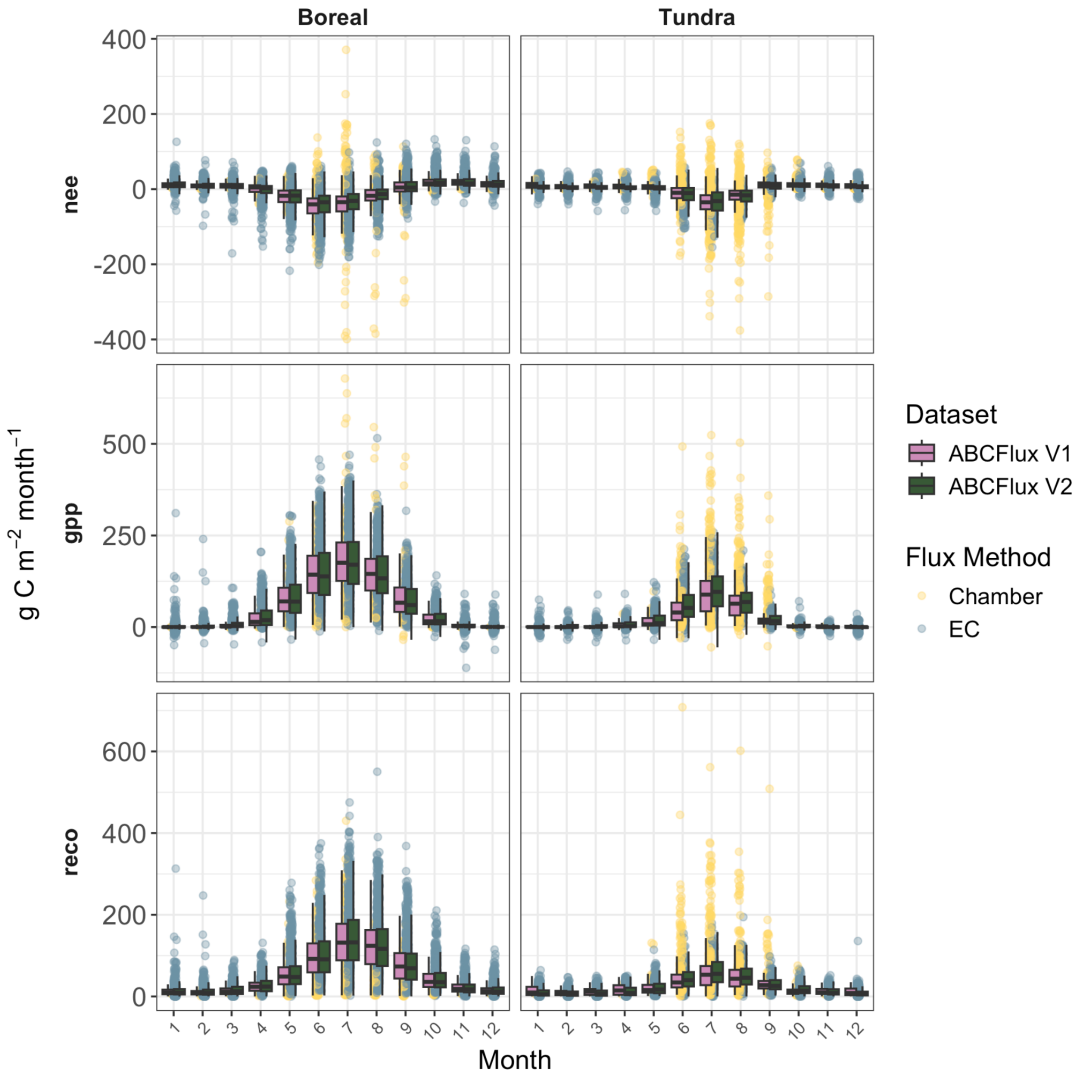



**Figure S12. Comparison of monthly terrestrial CO2 flux magnitudes in ABCFluxv1 vs. v2. GPP was presented as a negative flux in ABCFlux v1 but was converted to positive for the purpose of this comparison.**

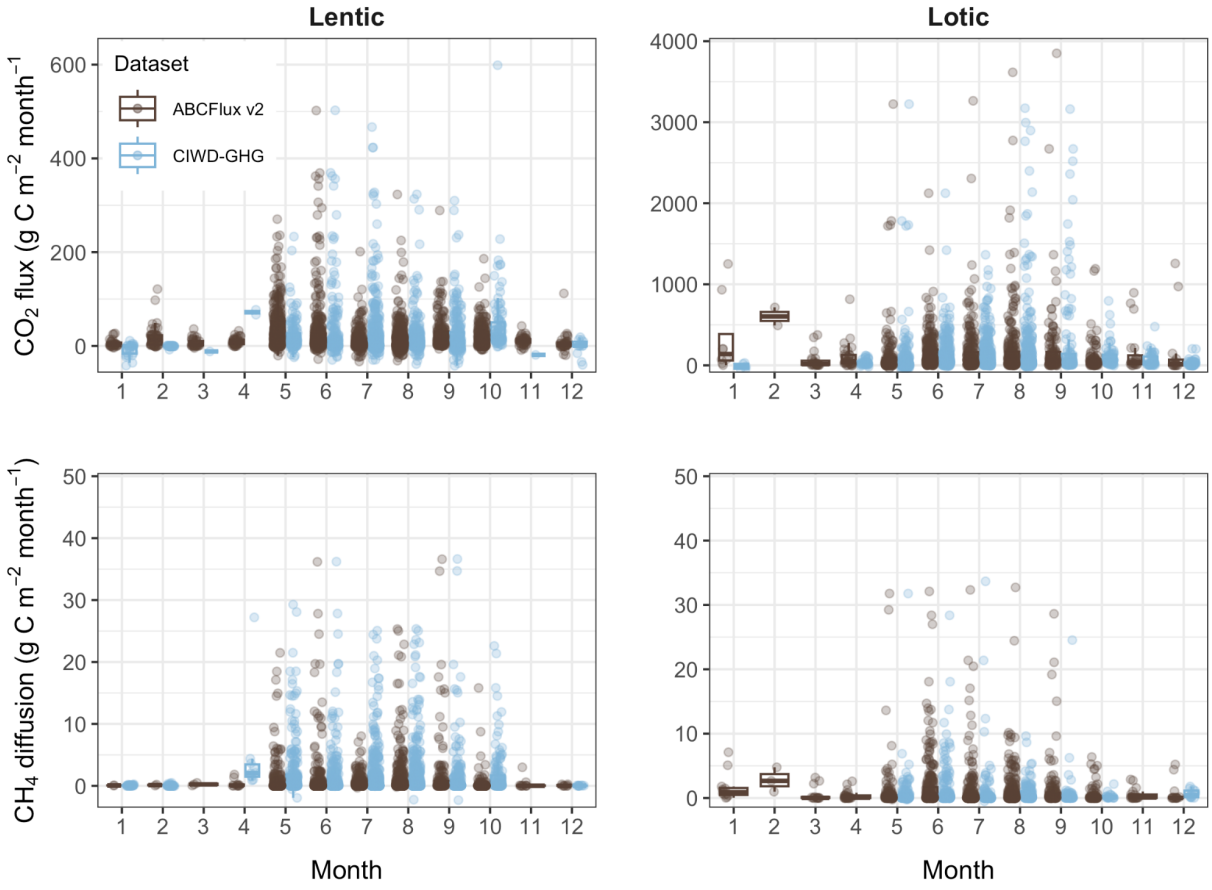



**Figure S13. Comparison of monthly cumulative carbon fluxes (CO2 and diffusive CH4 flux) for aquatic ecosystems between this study (ABCFlux v2, grey) and Song et al. (2024; CIWD-GHG, blue).**

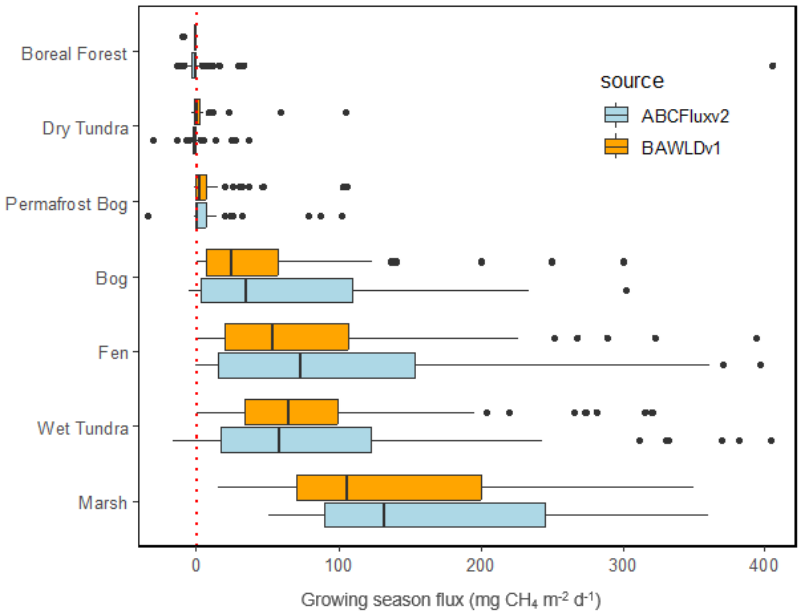



**Figure S14. Comparison of terrestrial CH4 fluxes in ABCFlux v2 vs BAWLD-CH4 v1**. Fluxes from ABCFlux v2 represent the average fluxes between June and August.