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Supplement of

TundraFlux: a database of ecosystem respiration with biotic and abiotic metadata from Arctic and alpine tundra warming experiments

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Supplementary information

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Contributors and Reference lists

Table S1: Comparison of the TundraFlux Database with related databases and synthesis initiatives relevant to carbon fluxes and tundra ecosystem research. The table highlights the primary scope of each resource and illustrates how TundraFlux complements existing databases by providing harmonized ecosystem respiration (R_{eco}) observations from both ambient and warming experiments in Arctic and alpine tundra ecosystems.

Database	Reference	Primary scope / distinction
Tundra Trait Team	Bjorkman *et al.* 2018, *Glob. Ecol. Biogeogr;* https://doi.org/10.1111/geb.12821	Plant trait database for tundra species. Contains vegetation trait information but no ecosystem carbon flux measurements.
COSORE	Bond-Lamberty *et al.* 2020, *Glob. Change Biol*; https://doi.org/10.1111/gcb.15353	Global compilation of continuous/automated soil respiration and soil greenhouse gas flux measurements. Emphasizes high-frequency temporal observations rather than tundra-specific ecosystem respiration syntheses.
ABCFlux	Virkkala *et al.* 2022, *Earth Syst. Sci. Data;* https://doi.org/10.5194/essd-14-179-2022	Arctic–boreal carbon flux database containing multiple carbon flux components across ecosystems, primarily under ambient conditions. Not specifically focused on tundra ecosystem respiration or experimental warming manipulations.
Manipulation Experiments Synthesis Initiative (MESI)	Van Sundert *et al.* 2023, *Glob. Change Biol;* https://doi.org/10.1111/gcb.16585	Global compilation of terrestrial climate-change experiments (e.g., warming, nutrient addition, CO_2 enrichment). Documents experimental manipulations and associated metadata rather than harmonized tundra Reco measurements.
TundraFlux	Schwieger et al., 2026, DOI: 10.5281/zenodo.17976235	Tundra-specific ecosystem respiration database integrating ambient and experimental warming (e.g., open-top chambers) across studies with standardized environmental and experimental metadata.

Table S2. List of the contributors to the TundraFlux Database including site identifiers (site_id), related site names, year when the warming treatments with open-top chambers started, and references or data repository links. End years are not included because all warming experiments are still ongoing at the time of publication.

Site_id	Site_name	Start warming	PI_contact	Additional contacts	References and Links
ALA_1	CiPEHR	2008	Ted Schuur	Heidi Rodenhizer	unfiltered data from CiPEHR can be accessed via: https://www2.nau.edu/schuurlab-p/data.html
ALA_2	Toolik_2015	2015	Tom Parker	Ned Fetcher	
ALA_3	Toolik_2016	2016	Tom Parker	Ned Fetcher	
ALA_4	Ice Cut	2016	Ellen Dorrepaal	Josefine Walz, Konstantin Gavazov	
ALA_9	Barrow Dry	NA	Paulo Olivas	Steven Oberbauer	
ALA_10	Barrow Wet	NA	Paulo Olivas	Steven Oberbauer	
ALA_11	Atqasuk Dry	NA	Paulo Olivas	Steven Oberbauer	
ALA_12	Atqasuk Wet	NA	Paulo Olivas	Steven Oberbauer	
ALA_13	Toolik MAT	1994	Jeffrey M Welker	Gus Jespersen	
AUS_1	Silver Plains	2014	Mark Hovenden	Marion Nyberg	Nyberg and Hovenden 2020, *Biogeosciences;* https://doi.org/10.5194/bg-17-4405-2020
CAN_2	Control (Pristine)	2011	Tariq Munir	Maria Strack	Munir *et al.* 2015, *Biogeosciences*; https://github.com/TariqMunir/Wandering-River-Wetland-WT_TM-MS.pdf
CAN_3	Experimental (Short-term drained)	2011	Tariq Munir	Maria Strack	
CAN_4	Drained (old drained)	2011	Tariq Munir	Maria Strack	
CAN_5	Cambridge Bay OTC	2012	Ji Young Jung	Mats Björkman	Kim et al., 2025, *Environ. Res*; https://doi.org/10.1016/j.envres.2025.122320
CHI_1	Haibei_1	2014	Jin-Sheng He	Zhen-huan Guan	
CHI_2	Haibei_2	2015	Jin-Sheng He	Zhen-huan Guan	
CHI_3	Haibei_3	2014	Jin-Sheng He	Zhen-huan Guan	
CHI_4	Gangca	2013	Yuanhe Yang		
FIN_1	Kilpisjärvi	1994	Anne Tolvanen	Sari Stark, Henni Ylänne	Ylänne *et al.* 2015, *Global Change Biology*; https://doi.org/10.1111/gcb.12964
GRE_1	Blæsedalen, Dry heath	2012	Anders Michelsen	Bo Elberling, Nynne R. Ravn, Ludovia D'Imperio	Ravn, Elberling, and Michelsen 2020 *Soil Biology & Biochemistry;*

Site_id	Site_name	Start warming	PI_contact	Additional contacts	References and Links
					https://doi.org/10.1016/j.soilbio.2019.107698
GRE_2	Blæsedalen, Wet tundra	2013	Anders Michelsen	Bo Elberling, Cecilie Skov Nielsen, NA	Nielsen *et al.* 2017, *JGR Biogeosciences*; https://doi.org/10.1002/2016JG003511
GRE_4	Zackenberg, Cassiope heath tundra	2007	Anders Michelsen	Riikka Rinnan, Niels Martin Schmidt, Ingvild Ryde	Jeanbille *et al.* 2021, *Arctic Science*; https://doi.org/10.1139/as-2020-0053
GRE_5	Zackenberg, Salix heath tundra	2007	Anders Michelsen	Riikka Rinnan, Niels Martin Schmidt, Ingvild Ryde	
GRE_6	Kobbefjord	2007	Katrine Raundrup		https://data.g-e-m.dk/
ICE_1	ITEX Audkuluheidi	2008	Ingibjörg Svala Jónsdóttir	Jón Guðmundsson, Hlynur Óskarsson	
ICE_3	CRUST	1997	Alejandro Salazar	Emmanuel Pierre Pagneux	Salazar *et al.*, 2024, *Plant and Soil*; https://doi.org/10.1007/s11104-024-06900-7
ITA_1	G1_1	2008	Michele Carbognani	Alessandro Petraglia, T'ai GW Forte, Giorgio Chiari	
ITA_2	G1_2	2008	Michele Carbognani	Alessandro Petraglia, T'ai GW Forte, Giorgio Chiari	
ITA_3	G2_1	2012	Alessandro Petraglia	Michele Carbognani, T'ai GW Forte, Giorgio Chiari	
ITA_4	G2_2	2012	Alessandro Petraglia	Michele Carbognani, T'ai GW Forte, Giorgio Chiari	
ITA_5	G3	2018	T'ai GW Forte	Michele Carbognani, Alessandro Petraglia, Giorgio Chiari	
NOR_1	Raisduoddar	2010	Sari Stark	Maria Väisänen, Henni Ylänne, Elina Kaarlejärvi	Väisänen *et al.* 2014, *Nature Climate Change*; https://doi.org/10.1038/nclimate2147; https://data.g-e-m.dk/
NOR_6	Iskoras vegetated palsa	2017	Hanna Lee	Inge H.J. Althuizen, Casper T. Christiansen	
NOR_7	Iskoras bare soil palsa	2017	Hanna Lee	Inge H.J. Althuizen, Casper T. Christiansen	
NOR_8	Iskoras thaw slump	2017	Hanna Lee	Inge H.J. Althuizen, Casper T. Christiansen	
NOR_9	INCLINE_Lavisdalen	2018	Vigdis Vandvik	Joseph Gaudard	Gya R. Disentangling effects and context dependencies of climate change on alpine plants [Doctoral thesis]. The University of Bergen, 2022;
NOR_10	INCLINE_Ulvhaugen	2018	Vigdis Vandvik	Joseph Gaudard	

Site_id	Site_name	Start warming	PI_contact	Additional contacts	References and Links
NOR_11	INCLINE_Gudmesdalen	2018	Vigdis Vandvik	Joseph Gaudard	https://bora.uib.no/bora-xmlui/handle/11250/3038854
NOR_12	INCLINE_Skjellingahaugen	2018	Vigdis Vandvik	Joseph Gaudard	
RUS_1	Seida mineral	2011	Christina Biasi	Maija Marushchak, Carolina Voigt, Richard Lamprecht	Voigt *et al.,* 2017, *Global Change Biology*; https://doi.org/10.1111/gcb.13563
RUS_2	Seida peat shrubs	2011	Christina Biasi	Maija Marushchak, Carolina Voigt, Richard Lamprecht	
RUS_3	Seida peat barren	2011	Christina Biasi	Maija Marushchak, Carolina Voigt, Richard Lamprecht	
SVA_1	HERBWARTUNDRA project_1	2016	Matteo Petit Bon	Ingibjörg Svala Jónsdóttir, Hanna Böhner	Petit Bon *et al.,* 2025, *Ecology;* https://doi.org/10.1002/ecy.4498
SVA_2	HERBWARTUNDRA project_2	2016	Matteo Petit Bon	Ingibjörg Svala Jónsdóttir, Hanna Böhner	
SVA_3	HERBWARTUNDRA project_3	2016	Matteo Petit Bon	Ingibjörg Svala Jónsdóttir, Hanna Böhner	
SVA_4	INSYNC project	2016	Brage Bremset Hansen	Mathilde Le Moullec, Matteo Petit Bon	Petit Bon et al., 2026, *Plant and Soil ;* https://doi.org/10.1007/s11104-026-08690-6
SVA_5	Adventdalen Wet	2003	Elisabeth J. Cooper	Bo Elberling, Sofie Sjögersten	Jeanbille *et al.* 2021, *Arctic Science*; https://doi.org/10.1139/as-2020-0053
SVA_6	Adventdalen Mesic	2003	Elisabeth J. Cooper	Bo Elberling, Sofie Sjögersten	
SVA_7	ITEX Svalbard_1	2002	Ingibjörg Svala Jónsdóttir	Inge H.J. Althuizen, Casper T. Christiansen, Siri V. Haugum	Vandvik *et al.,* 2023, Scientific Data; https://doi.org/10.1038/s41597-023-02467-7 Jónsdóttir *et al.* 2023, Ecological Monographs; https://doi.org/10.1002/ecm.1555 Jeanbille *et al.,* 2021, Arctic Science; https://doi.org/10.1139/as-2020-0053
SVA_8	ITEX Svalbard_2	2002	Ingibjörg Svala Jónsdóttir	Inge H.J. Althuizen, Casper T. Christiansen, Siri V. Haugum	
SVA_9	ITEX Svalbard_3	2002	Ingibjörg Svala Jónsdóttir	Inge H.J. Althuizen, Casper T. Christiansen, Siri V. Haugum	
SVA_10	Kongsfjordneset	2014	Birgitte Kortegaard Danielsen	Kevin Newsham, Bo Elberling	Newsham *et al.,* 2022, *Biology*; https://doi.org/10.3390/biology11121819
SWE_1	LATNJA TUSSOCK_TUNDRA	1995	Mats Björkman	Robert Björk	

Site_id	Site_name	Start warming	PI_contact	Additional contacts	References and Links
SWE_2	LATNJA DRY_HEATH	1995	Mats Björkman	Robert Björk	
SWE_3	LATNJA MESIC_MEADOW	1994	Mats Björkman	Robert Björk	
SWE_4	LATNJA DRY_MEADOW	1994	Mats Björkman	Robert Björk	
SWE_5	LATNJA WET_MEADOW	1994	Mats Björkman	Robert Björk	
SWE_6	Multe	1999	Anders Michelsen	Riikka Rinnan, Emily Pickering Pedersen, Patrick Faubert	Pedersen *et al.,* 2017, *JGR Biogesciences*, https://doi.org/10.1002/2017JG003782; Pedersen *et al.,* 2018, *Biogeochemistry*, https://doi.org/10.1007/s10533-018-0441-2
SWE_7	Paddus_1	1989	Anders Michelsen	Riikka Rinnan, Nynne R. Ravn	Jeanbille *et al.* 2021, *Arctic Science;* https://doi.org/10.1139/as-2020-0053
SWE_12	Paddus_DART_ Upper Tundra	1998	Sofie Sjögersten	Johan Olofsson, Sari Stark	2018 data: Sari Stark, Eero Myrsky 2001/1999 data: Sofie Sjögersten; Myrsky *et al.,* 2024, *Functional Ecology; https://doi.org/10.1111/1365-2435.14466*
SWE_14	Paddus_DART_ Lower Tundra	1998	Sofie Sjögersten	Johan Olofsson, Elina Kaarlejärvi, Olga Khitun	
SWE_15	Paddus_DART_ Lower Forest	1998	Sofie Sjögersten	Johan Olofsson, Sari Stark, Minna Mannisto, Eero Myrsky, Elina Kaarlejärvi	2018 data: Sari Stark , Eero Myrsky 2001/1999 data: Sofie Sjögersten; Jeanbille *et al.* 2021, *Arctic Science*; https://doi.org/10.1139/as-2020-0053
SWE_16	Abisko bog	2000	Hans Cornelissen	Ellen Dorrepaal, Richard Van Logtestijn, Caithlin Hicks Pries, Sylvia Toet, Simone I. Lang	

Database Structure

Table S3. Annual ecosystem CO_2 respiration (R_{eco}, g C-CO_2 m^{-2} d^{-1}) summarised by site (site_id) and measurement year (flux_year) across 219 site-years. The table presents the mean, standard deviation, minimum (min), maximum (max), and the daily observation count per year (N Daily Obs.) based on the daily averages. The dataset includes occasional negative and exact-zero R_{eco} values. Negative values can result from instrument noise or brief net CO_2 uptake, while exact zeros may reflect contributor preprocessing (e.g., rounding or thresholding small fluxes). Both are retained to preserve original measurements; users may apply their preferred filtering criteria. Measurement frequency estimated from the mean interval between consecutive daily averaged observations per site-year: Daily (≤1.5 days), Weekly (2–8.5 days), Bi-weekly (8.5–16 days), Monthly (16–35 days), or Irregular (>35 days). Raw observations (N Raw Obs.) before daily averaging.

Site ID	Year	Median R_{eco}[1]	Mean R_{eco}[1]	SD R_{eco}[1]	Min R_{eco}[1]	Max R_{eco}[1]	N Daily Obs.	Frequency	N Raw Obs.
ALA_1	2009	1.410	1.466	0.625	-0.187	6.796	1112	Daily	2566
ALA_1	2010	1.803	1.819	0.847	-0.222	8.090	1578	Daily	3250
ALA_1	2011	1.508	1.547	0.830	0.058	4.383	1579	Daily	4495
ALA_1	2012	1.841	1.842	0.960	0.006	5.015	1219	Daily	2400
ALA_1	2013	2.023	2.209	1.033	0.366	8.233	1100	Daily	2179
ALA_1	2014	1.876	2.018	1.095	0.035	6.777	1435	Daily	2874
ALA_1	2015	2.094	2.283	1.358	0.016	9.993	1367	Daily	2727
ALA_1	2016	2.240	2.483	1.416	0.065	11.218	1306	Daily	2528
ALA_1	2017	2.091	2.346	1.639	-1.309	12.230	1384	Daily	2623
ALA_1	2018	2.079	2.306	1.388	-1.371	8.114	1179	Daily	2219
ALA_1	2019	1.814	1.889	1.291	-0.190	9.217	313	Daily	636
ALA_2	2015	1.935	2.097	1.151	0.378	7.051	141	Weekly	141
ALA_3	2016	1.510	1.628	1.019	0.310	6.149	36	Weekly	36
ALA_4	2017	2.547	2.964	1.554	0.791	6.929	43	Weekly	47
ALA_4	2019	4.191	5.151	3.722	0.225	26.700	142	Weekly	144
ALA_9	2000	5.865	9.524	6.236	3.491	17.423	10	Irregular	10
ALA_9	2001	4.505	4.895	2.089	2.846	9.754	10	Irregular	10
ALA_9	2002	4.729	5.524	2.152	3.195	9.934	9	Irregular	9
ALA_9	2005	5.194	6.970	4.619	2.405	18.187	10	Irregular	10
ALA_9	2006	3.729	3.817	0.627	3.178	5.132	10	Irregular	10
ALA_9	2007	5.087	5.589	2.266	2.897	9.376	10	Irregular	10
ALA_9	2009	6.091	7.517	3.415	3.851	13.731	10	Irregular	10
ALA_9	2010	8.661	9.984	4.122	5.394	16.482	10	Irregular	10
ALA_9	2011	6.453	7.978	3.528	4.301	14.206	10	Irregular	10
ALA_9	2012	6.702	8.464	3.997	3.866	16.258	10	Irregular	10
ALA_9	2013	6.431	6.933	2.457	3.697	10.511	10	Irregular	10
ALA_9	2014	4.750	5.367	2.270	2.803	10.145	10	Irregular	10
ALA_9	2015	7.061	8.133	3.822	3.782	15.638	10	Irregular	10
ALA_9	2016	5.938	6.383	3.355	2.385	12.605	10	Irregular	10
ALA_9	2017	10.432	11.392	4.352	6.364	18.016	10	Irregular	10
ALA_9	2018	13.418	13.876	4.513	8.499	21.792	10	Irregular	10
ALA_10	2000	6.622	6.588	1.309	5.019	8.504	10	Irregular	10
ALA_10	2001	5.700	5.282	1.166	3.331	6.825	10	Irregular	10
ALA_10	2002	8.434	8.554	2.128	5.135	11.953	10	Irregular	10
ALA_10	2005	9.220	8.860	1.794	6.304	11.477	10	Irregular	10
ALA_10	2006	8.772	9.519	4.235	5.380	15.481	10	Irregular	10
ALA_10	2007	10.798	10.511	3.559	4.792	15.061	10	Irregular	10
ALA_10	2009	11.448	11.539	2.933	7.606	17.364	10	Irregular	10

Site ID	Year	Median R_{eco}[1]	Mean R_{eco}[1]	SD R_{eco}[1]	Min R_{eco}[1]	Max R_{eco}[1]	N Daily Obs.	Frequency	N Raw Obs.
ALA_10	2010	10.995	11.058	2.168	7.091	15.235	10	Irregular	10
ALA_10	2011	8.527	8.363	1.357	5.664	10.244	10	Irregular	10
ALA_10	2012	8.821	9.013	1.744	5.684	12.066	10	Irregular	10
ALA_10	2013	9.264	9.225	2.186	6.122	13.274	10	Irregular	10
ALA_10	2014	5.872	6.027	1.113	4.488	8.005	10	Irregular	10
ALA_10	2015	7.709	7.859	1.028	6.590	9.749	10	Irregular	10
ALA_10	2016	5.645	5.609	0.945	4.464	7.056	10	Irregular	10
ALA_10	2017	11.019	11.046	1.783	9.207	14.342	10	Irregular	10
ALA_10	2018	12.443	12.257	1.250	10.104	13.952	10	Irregular	10
ALA_11	2000	-0.193	-0.196	0.060	-0.293	-0.102	10	Irregular	10
ALA_11	2001	3.105	3.210	0.777	1.823	4.560	10	Irregular	10
ALA_11	2002	6.104	6.315	1.375	4.023	8.272	10	Irregular	10
ALA_11	2005	3.146	3.128	0.957	1.822	4.468	10	Irregular	10
ALA_11	2007	3.305	3.990	1.742	2.270	6.732	10	Weekly	10
ALA_11	2010	7.128	7.259	1.354	5.483	9.490	10	Irregular	10
ALA_11	2011	4.554	4.599	0.788	3.510	5.854	10	Irregular	10
ALA_11	2012	5.420	5.727	1.110	4.203	7.518	10	Irregular	10
ALA_11	2013	7.269	7.633	1.263	6.096	10.098	10	Irregular	10
ALA_11	2014	4.828	5.128	1.017	4.013	7.195	10	Irregular	10
ALA_11	2015	4.409	4.196	1.329	2.186	6.900	10	Irregular	10
ALA_11	2016	3.202	3.499	0.746	2.805	5.033	10	Irregular	10
ALA_11	2017	5.520	6.269	1.511	4.916	8.726	10	Irregular	10
ALA_11	2018	6.552	6.742	1.224	5.333	9.365	10	Irregular	10
ALA_12	2000	3.540	3.340	0.938	1.707	4.308	10	Irregular	10
ALA_12	2001	4.531	4.455	0.814	3.358	5.487	10	Irregular	10
ALA_12	2002	7.715	8.566	1.989	5.909	12.280	9	Irregular	9
ALA_12	2005	5.379	5.132	0.935	3.522	6.328	10	Irregular	10
ALA_12	2007	5.356	5.114	0.914	3.473	6.302	10	Irregular	10
ALA_12	2010	6.894	7.022	1.083	5.548	8.498	10	Irregular	10
ALA_12	2011	6.331	6.194	0.982	4.805	7.581	10	Irregular	10
ALA_12	2012	5.512	5.671	0.901	4.480	7.070	10	Irregular	10
ALA_12	2013	6.231	6.147	0.531	5.343	6.965	10	Irregular	10
ALA_12	2014	4.748	4.603	0.790	3.425	5.602	10	Irregular	10
ALA_12	2015	5.959	5.953	0.912	4.572	7.783	10	Irregular	10
ALA_12	2016	2.828	2.830	0.283	2.436	3.209	10	Irregular	10
ALA_12	2017	5.538	5.476	0.551	4.616	6.122	10	Irregular	10
ALA_12	2018	5.526	5.372	0.768	4.106	6.290	10	Irregular	10
ALA_13	2021	4.008	4.617	2.373	0.873	13.882	86	Weekly	86
AUS_1	2016	7.463	8.706	5.667	1.407	23.661	47	Irregular	47
AUS_1	2017	5.988	6.684	4.613	1.106	14.308	28	Irregular	28
AUS_1	2018	6.839	7.531	4.316	1.038	18.870	92	Monthly	93
CAN_2	2011	3.520	3.586	1.411	0.990	7.176	138	Weekly	138
CAN_2	2012	3.287	3.545	1.609	0.780	8.953	178	Bi-weekly	180
CAN_2	2013	4.192	4.481	1.742	1.771	11.562	100	Bi-weekly	169
CAN_3	2011	3.625	3.823	2.182	0.750	10.306	118	Weekly	120
CAN_3	2012	3.774	4.319	2.335	0.315	14.889	178	Bi-weekly	180

Site ID	Year	Median R_{eco}[1]	Mean R_{eco}[1]	SD R_{eco}[1]	Min R_{eco}[1]	Max R_{eco}[1]	N Daily Obs.	Frequency	N Raw Obs.
CAN_3	2013	4.351	4.554	2.096	1.200	10.998	97	Bi-weekly	150
CAN_4	2011	4.045	4.340	2.512	0.446	11.920	111	Weekly	122
CAN_4	2012	4.326	4.758	2.810	0.542	14.417	156	Bi-weekly	192
CAN_4	2013	4.447	4.435	2.224	0.298	9.465	88	Bi-weekly	135
CAN_5	2018	1.130	1.172	0.397	0.659	1.906	16	Monthly	16
CAN_5	2019	0.001	0.447	0.600	0.001	1.552	26	Bi-weekly	26
CHI_1	2019	7.030	7.351	1.883	4.386	12.753	32	Monthly	32
CHI_1	2020	5.801	6.023	1.301	4.282	11.218	32	Monthly	32
CHI_2	2019	5.179	5.816	2.778	3.152	15.479	24	Bi-weekly	24
CHI_2	2020	4.121	4.783	2.169	2.136	11.882	32	Monthly	32
CHI_3	2019	5.708	5.730	1.548	2.602	8.688	24	Bi-weekly	24
CHI_3	2020	4.453	4.263	2.238	0.332	8.543	32	Monthly	32
CHI_4	2014	6.602	7.286	4.351	0.231	28.062	320	Bi-weekly	320
CHI_4	2015	5.310	6.098	3.330	1.156	18.970	320	Bi-weekly	320
CHI_4	2016	6.051	6.910	3.310	2.104	20.731	320	Bi-weekly	320
FIN_1	2013	1.018	1.191	0.797	0.128	5.103	130	Weekly	138
GRE_1	2013	1.074	1.235	0.716	0.018	3.327	139	Bi-weekly	139
GRE_1	2014	1.751	1.788	0.953	0.078	4.937	142	Bi-weekly	142
GRE_2	2014	1.175	1.382	0.941	0.000	4.374	105	Bi-weekly	105
GRE_4	2012	0.710	0.787	0.820	0.000	3.064	70	Monthly	70
GRE_4	2015	0.928	1.034	0.536	0.121	2.048	40	Bi-weekly	40
GRE_5	2012	1.270	1.444	1.344	0.000	6.230	80	Bi-weekly	80
GRE_5	2015	1.194	1.235	0.695	0.070	2.761	37	Bi-weekly	37
GRE_6	2009	1.223	1.461	0.933	-0.329	5.017	169	Weekly	169
GRE_6	2010	1.740	1.892	0.942	0.356	5.440	206	Weekly	206
GRE_6	2011	1.542	1.518	0.704	0.298	5.139	152	Weekly	152
GRE_6	2012	2.652	2.715	1.171	0.244	8.603	185	Weekly	185
GRE_6	2013	2.263	2.566	1.609	0.083	8.182	187	Weekly	187
GRE_6	2014	2.834	2.884	1.670	0.224	8.349	164	Bi-weekly	164
GRE_6	2015	2.434	2.762	1.412	0.913	7.627	132	Bi-weekly	132
GRE_6	2016	1.816	2.202	1.324	0.239	6.703	209	Weekly	211
GRE_6	2017	2.680	2.952	1.348	0.344	7.391	125	Weekly	126
GRE_6	2018	2.290	2.863	1.781	0.679	12.424	153	Weekly	153
GRE_6	2019	2.453	2.849	1.686	0.584	11.293	148	Bi-weekly	148
GRE_6	2021	2.019	1.903	1.180	-0.067	4.647	48	Monthly	48
GRE_6	2022	2.309	2.643	1.504	0.395	9.343	155	Weekly	155
ICE_1	2007	0.632	0.703	0.509	0.105	2.490	24	Irregular	24
ICE_3	2023	0.064	0.103	0.104	0.001	0.442	16	Irregular	16
ICE_3	2024	0.165	0.202	0.147	0.031	0.607	17	Daily	20
ITA_1	2020	5.966	6.143	2.150	2.178	12.201	60	Bi-weekly	60
ITA_1	2021	4.016	4.415	1.973	1.000	8.557	50	Bi-weekly	50
ITA_2	2020	4.809	5.135	1.954	2.158	9.593	59	Bi-weekly	60
ITA_2	2021	3.221	3.571	2.144	0.671	8.264	50	Bi-weekly	50
ITA_3	2020	4.422	4.598	1.940	1.469	7.961	30	Bi-weekly	30
ITA_3	2021	4.170	4.569	1.876	2.009	8.297	15	Bi-weekly	15
ITA_4	2020	3.990	3.745	1.422	1.455	7.059	30	Bi-weekly	30

Site ID	Year	Median R_{eco}[1]	Mean R_{eco}[1]	SD R_{eco}[1]	Min R_{eco}[1]	Max R_{eco}[1]	N Daily Obs.	Frequency	N Raw Obs.
ITA_4	2021	2.512	2.520	1.067	1.024	4.124	15	Bi-weekly	15
ITA_5	2020	8.491	8.959	2.537	4.720	15.820	50	Bi-weekly	50
ITA_5	2021	8.559	8.996	3.488	3.534	22.262	60	Bi-weekly	60
ITA_5	2022	6.885	7.529	3.118	2.844	17.009	60	Monthly	60
NOR_1	2011	1.949	2.088	1.572	0.067	7.965	216	Weekly	216
NOR_1	2012	1.105	1.388	1.120	0.049	4.954	115	Bi-weekly	115
NOR_6	2019	0.028	0.029	0.014	0.011	0.054	12	Irregular	12
NOR_6	2020	2.173	2.385	1.508	0.250	6.245	58	Bi-weekly	58
NOR_7	2019	0.025	0.027	0.016	0.004	0.054	12	Irregular	12
NOR_7	2020	0.657	0.895	0.777	0.092	3.114	57	Bi-weekly	59
NOR_8	2019	0.031	0.036	0.029	0.001	0.109	11	Irregular	11
NOR_8	2020	1.779	2.358	1.976	0.134	9.783	47	Bi-weekly	47
NOR_9	2020	3.878	4.962	3.227	1.522	14.369	28	Monthly	28
NOR_9	2022	4.558	5.102	3.202	0.000	13.031	25	Irregular	26
NOR_10	2020	5.175	5.708	3.856	1.403	18.815	29	Monthly	29
NOR_10	2022	5.260	5.385	3.407	-0.081	11.468	40	Monthly	41
NOR_11	2020	4.404	4.539	0.981	3.220	6.006	6	Monthly	30
NOR_11	2022	5.781	5.470	3.371	-3.366	12.335	36	Monthly	38
NOR_12	2020	2.866	4.270	5.447	1.292	29.850	27	Bi-weekly	27
NOR_12	2022	5.333	6.051	3.906	0.000	18.506	29	Monthly	29
RUS_1	2012	3.922	4.262	2.154	1.253	15.707	70	Weekly	70
RUS_1	2013	3.584	3.643	1.953	0.154	8.905	99	Bi-weekly	99
RUS_1	2014	4.069	4.137	1.495	1.884	7.483	20	Weekly	20
RUS_2	2012	3.073	3.171	1.491	0.107	8.401	60	Weekly	60
RUS_2	2013	3.582	3.559	2.130	0.060	9.703	99	Bi-weekly	99
RUS_2	2014	2.703	3.201	1.642	1.141	6.371	17	Weekly	17
RUS_3	2012	0.940	1.017	0.472	0.263	2.740	60	Weekly	60
RUS_3	2013	1.195	1.170	0.584	0.000	2.527	99	Bi-weekly	99
RUS_3	2014	0.833	0.987	0.567	0.200	2.035	18	Weekly	18
SVA_1	2016	3.315	3.697	2.259	0.213	11.874	118	Weekly	118
SVA_1	2017	3.808	4.464	3.063	0.782	20.935	97	Weekly	97
SVA_2	2016	2.599	3.093	2.785	0.460	26.498	115	Weekly	115
SVA_2	2017	2.891	3.685	2.862	0.904	22.563	98	Weekly	98
SVA_3	2016	2.712	2.993	1.692	0.197	8.017	104	Weekly	104
SVA_3	2017	2.875	3.168	1.678	0.790	6.816	84	Weekly	84
SVA_4	2018	3.564	4.111	2.661	0.772	15.595	169	Weekly	169
SVA_4	2019	3.650	5.454	6.007	0.282	44.811	90	Monthly	90
SVA_5	2003	1.878	1.541	0.910	0.302	3.280	18	Monthly	18
SVA_5	2004	1.504	1.445	1.035	0.084	3.957	30	Monthly	30
SVA_5	2005	2.244	2.148	0.844	0.572	3.965	50	Daily	50
SVA_5	2007	0.710	0.929	0.711	0.018	3.941	98	Bi-weekly	98
SVA_6	2003	1.836	2.010	0.929	0.437	4.768	20	Monthly	20
SVA_6	2004	2.288	2.618	1.691	0.605	7.691	30	Monthly	30
SVA_6	2005	1.997	2.285	1.212	0.027	5.716	49	Daily	49
SVA_6	2007	0.699	0.842	0.660	0.025	3.957	101	Bi-weekly	101
SVA_7	2018	4.874	5.429	2.708	1.822	13.021	18	Weekly	18

Site ID	Year	Median R_{eco}[1]	Mean R_{eco}[1]	SD R_{eco}[1]	Min R_{eco}[1]	Max R_{eco}[1]	N Daily Obs.	Frequency	N Raw Obs.
SVA_8	2018	2.364	2.986	2.325	0.724	7.868	10	Weekly	10
SVA_9	2018	2.877	3.766	2.836	0.642	11.955	17	Weekly	17
SVA_10	2018	0.357	0.353	0.136	0.046	0.644	48	Weekly	48
SWE_1	2017	1.151	1.262	0.623	0.342	2.848	50	Bi-weekly	50
SWE_1	2018	0.963	1.114	0.587	0.246	3.266	60	Bi-weekly	60
SWE_1	2019	1.478	1.497	0.438	0.724	2.319	10	Daily	10
SWE_2	2017	1.464	1.630	0.666	0.529	3.301	48	Bi-weekly	48
SWE_2	2018	1.401	1.618	0.949	0.381	4.732	40	Bi-weekly	40
SWE_2	2019	1.389	1.802	0.815	1.127	3.319	8	Daily	8
SWE_3	2017	2.788	2.954	1.124	0.684	5.727	60	Bi-weekly	60
SWE_3	2018	2.491	2.937	1.731	0.349	7.888	50	Bi-weekly	50
SWE_3	2019	3.330	3.287	0.949	1.703	4.635	10	Weekly	10
SWE_4	2017	3.593	3.789	1.500	1.194	7.176	44	Bi-weekly	44
SWE_4	2018	3.022	3.740	2.494	1.298	12.629	50	Bi-weekly	50
SWE_4	2019	4.256	4.654	1.294	3.190	7.340	10	Daily	10
SWE_5	2017	3.946	4.304	2.388	1.214	9.368	30	Monthly	30
SWE_5	2018	3.314	3.747	1.776	0.798	8.206	59	Bi-weekly	59
SWE_5	2019	5.513	5.506	1.349	3.106	7.713	8	Irregular	8
SWE_6	2006	4.136	4.019	1.336	1.314	6.705	36	Bi-weekly	36
SWE_6	2007	4.004	5.064	3.346	0.987	16.001	44	Monthly	44
SWE_6	2015	2.311	2.629	1.605	0.222	7.545	166	Bi-weekly	166
SWE_7	2011	4.355	5.061	3.269	0.266	16.444	228	Weekly	228
SWE_12	2001	4.509	4.889	1.807	1.307	9.457	60	Weekly	70
SWE_12	2018	0.240	0.294	0.285	-0.357	0.975	96	Bi-weekly	96
SWE_14	2001	4.735	4.928	1.997	0.859	9.789	60	Weekly	60
SWE_15	2001	3.829	4.521	2.375	1.571	12.175	30	Daily	30
SWE_15	2018	0.300	0.378	0.357	-0.398	1.516	84	Bi-weekly	84
SWE_16	2003	0.701	1.021	1.124	0.000	5.951	188	Weekly	188
SWE_16	2005	3.674	3.667	1.954	0.626	7.369	58	Bi-weekly	58
SWE_16	2006	2.548	2.658	1.702	0.187	9.355	130	Bi-weekly	130
SWE_16	2007	2.424	2.663	1.653	0.116	7.440	105	Weekly	105
SWE_16	2011	3.376	3.811	2.123	1.077	9.335	36	Weekly	36

[1] Unit: g C-CO_2 m^{-2} d^{-1}

Table S4. Overview of the variables in the TundraFlux database including description. The TundraFlux Database contains 74 variables grouped into carbon flux data, site, vegetation, soil and method metadata.

1. Carbon Flux Data (plot-level)			
Variable	**Description**	**Unit**	**Data type**
site_id	Unique identifier for each site	-	factor
flux_date	Calendar date of the flux measurement	YYYY-MM-DD	date
flux_year	Year in which the flux measurement was taken	year	integer
flux_doy	Day of year of the measurement (1–365/366)	-	integer
reco	CO_2 ecosystem respiration, aggregated to day	daily, g C-CO_2 m^{-2} d^{-1}	numeric
treatment	Experimental treatment category (i.e., OTC, control)	-	factor
plot_id	Plot identifier within a site	-	character
par	Photosynthetic active radiation at the time of flux measurement	µmol m^{-2} s^{-1}	numeric
air_temperature	Air temperature at time of flux measurement	°C	numeric
soil_temperature	Soil temperature in 0-10 cm depth at time of flux measurement	°C	numeric
soil_moisture	Volumetric soil moisture in 0-10 cm depth at time of flux measurement	%	numeric
water_table	Depth of water table	cm	numeric
thaw_depth	Maximum thaw depth	cm	numeric
2. Metadata			
2a. Site Metadata (site-level)			
Variable	**Description**	**Unit**	**Data type**
site_name	Full site name	-	character
country	Country of the site	-	character
country_code	Country code of the site	-	factor
latitude	Latitude in decimal degrees	decimal degrees	numeric
longitude	Longitude in decimal degrees	decimal degrees	numeric
altitude	Elevation above sea level	mm yr^{-1}	numeric
mean_annual_temperature	Site mean annual air temperature	°C	numeric
mean_annual_precipitation	Site mean annual precipitation	mm yr^{-1}	numeric
active_layer_depth	Active layer depth	cm	numeric

parent_material	Parent material classification (i.e., Till, Silt, Clay, Sand, Unknown, Bedrock, Glacial-fluvial, Other)	-	factor
vegetation_type	Vegetation type following Walker et al. 2005; https://doi.org/10.1111/j.1654-1103.2005.tb02365.x	-	factor
PI_contact	Principal Investigator (lead scientist)	-	character
add_contact	Additional contributor contact(s)	-	character
2b. Vegetation Cover and Plant Traits (plot-level)			
Variable	**Description**	**Unit**	**Data type**
total_vascular_plant_cover	Cover of vascular plants (graminoids, forbs, shrubs)	%	numeric
deciduous_shrubs_cover	Cover of deciduous shrubs	%	numeric
evergreen_shrubs_cover	Cover of evergreen shrubs	%	numeric
forbs_cover	Cover of forbs	%	numeric
graminoids_cover	Cover of graminoids	%	numeric
lichen_cover	Cover of lichen	%	numeric
mosses_cover	Cover of mosses	%	numeric
vegetation_method	Method used to estimate vegetation cover (i.e., Cover/Abundance, Point frame)	-	factor
plant_height	Community mean plant height	cm	numeric
plant_height_method	Protocol used to measure plant height (i.e., ITEX 2020*, Other protocol)	-	factor
biomass	Aboveground biomass	g m^{-2}	numeric
biomass_method	Biomass estimation method (i.e., Calculated, Harvested)	-	factor
2c. Soil Properties (plot-level)			
Variable	**Description**	**Unit**	**Data type**
organic_layer_depth	Thickness of the organic soil layer	cm	numeric
bulk_density_organic	Bulk density of organic soil	g dwt cm^{-3}	numeric
bulk_density_mineral	Bulk density of mineral soil	g dwt cm^{-3}	numeric
bulk_density_mixture	Bulk density of mixed soil	g dwt cm^{-3}	numeric
c_n_organic	Carbon-to-nitrogen ratio in the organic soil layer	-	numeric
c_n_mineral	Carbon-to-nitrogen ratio in the mineral soil layer	-	numeric
soc_organic	Soil organic carbon in organic layer	g C kg^{-1} soil	numeric
soc_mineral	Soil organic carbon in mineral layer	g C kg^{-1} soil	numeric

soc_mixture	Soil organic carbon in mixed soil	g C kg^{-1} soil	numeric
son_organic	Soil organic nitrogen in organic layer	g N kg^{-1} soil	numeric
son_mineral	Soil organic nitrogen in mineral layer	g N kg^{-1} soil	numeric
son_mixture	Soil organic nitrogen in mixed soil	g N kg^{-1} soil	numeric
som_organic	Soil organic matter in organic layer	%	numeric
som_mineral	Soil organic matter in mineral layer	%	numeric
som_mixture	Soil organic matter in mixed soil	%	numeric
ph_h2o_organic	Soil pH measured in H_2O (organic layer)	-	numeric
ph_h2o_mineral	Soil pH measured in H_2O (mineral layer)	-	numeric
ph_h2o_mixture	Soil pH measured in H_2O (mixed soil)	-	numeric
soil_moisture_plot	Plot-level soil moisture	%	numeric
soil_moisture_plot_type	Soil moisture measurement type (i.e., gravimetric, volumetric)	-	factor
3. Method Metadata (site-level)			
Variable	**Description**	**Unit**	**Data type**
measurement_method	Flux measurement method (i.e., "Automated closed/static/non-steady state chamber", "Manual closed static/non-steady state chamber", "Manual open/dynamic/steady-state chamber")	-	character
machine	Instrument or brand used for flux measurement ("GC", "LGR", "LICOR", "other", "PP-system", "Vaisala")	-	character
machine_type	"GC", "IR", "Laser", "other"	year	character
flux_measurement_start_year	First year of flux measurements at the site	year	integer
warming_start_year	First year of the warming treatment	year	integer
plot_size	Total plot area	m^2	numeric
flux_plot_size	Area of the flux measurement subplot	m^2	numeric
otc_height	Height of the OTC	cm	numeric
chamber_temperature	Temperature inside the flux chamber during measurement	°C	numeric

*Plant height was measured using a standardized protocol developed by Sybryn Maes to ensure consistent data collection across sites. In case the standardized protocol was not followed, the metadata mentions “Other protocol”.

Table S5. Number of years R_{eco} was measured and number and percentages of total summed daily observations, by site and region.

Site_id	Site_name	N_flux years	Daily _obs	Daily_%
ALA_1	CiPEHR	11	13572	52.5
ALA_2	Toolik_2015	1	141	0.5
ALA_3	Toolik_2016	1	36	0.1
ALA_4	Ice Cut	2	185	0.7
ALA_9	Barrow Dry	16	169	0.7
ALA_10	Barrow Wet	16	170	0.7
ALA_11	Atqasuk Dry	14	150	0.6
ALA_12	Atqasuk Wet	14	149	0.6
ALA_13	Toolik MAT	1	86	0.3
CAN_2	Control (Pristine)	3	416	1.6
CAN_3	Experimental (Short-term drained)	3	393	1.5
CAN_4	Drained (old drained)	3	355	1.4
CAN_5	Cambridge Bay OTC	2	84	0.3
High-latitude North American				**61.6**
GRE_1	Blæsedalen, Dry heath	2	281	1.1
GRE_2	Blæsedalen, Wet tundra	1	105	0.4
GRE_4	Zackenberg, Cassiope heath tundra	2	110	0.4
GRE_5	Zackenberg, Salix heath tundra	2	117	0.5
GRE_6	Kobbefjord	13	2198	8.5
ICE_1	ITEX Audkuluheidi	1	72	0.3
ICE_3	CRUST	2	33	0.1
AUS_1	Silver Plains	3	167	0.6
Oceanic				**11.9**
NOR_1	Raisduoddar	2	331	1.3
NOR_6	Iskoras vegetated palsa	2	70	0.3
NOR_7	Iskoras bare soil palsa	2	69	0.3
NOR_8	Iskoras thaw slump	2	58	0.2
NOR_9	INCLINE_Lavisdalen	2	53	0.2
NOR_10	INCLINE_Ulvhaugen	2	69	0.3
NOR_11	INCLINE_Gudmesdalen	2	42	0.2
NOR_12	INCLINE_Skjellingahaugen	2	56	0.2
SVA_1	HERBWARTUNDRA project_1	2	215	0.8
SVA_2	HERBWARTUNDRA project_2	2	213	0.8
SVA_3	HERBWARTUNDRA project_3	2	188	0.7
SVA_4	INSYNC project	2	259	1.0
SVA_5	Adventdalen Wet	4	196	0.8
SVA_6	Adventdalen Mesic	4	200	0.8
SVA_7	ITEX Svalbard_1	1	18	0.1
SVA_8	ITEX Svalbard_2	1	10	0.0

Site_id	Site_name	N_flux years	Daily _obs	Daily_%
SVA_9	ITEX Svalbard_3	1	17	0.1
SVA_10	Kongsfjordneset	1	48	0.2
SWE_1	LATNJA TUSSOCK_TUNDRA	3	120	0.5
SWE_2	LATNJA DRY_HEATH	3	96	0.4
SWE_3	LATNJA MESIC_MEADOW	3	120	0.5
SWE_4	LATNJA DRY_MEADOW	3	104	0.4
SWE_5	LATNJA WET_MEADOW	3	97	0.4
SWE_6	Multe	3	246	1.0
SWE_7	Paddus_1	1	228	0.9
SWE_12	Paddus_DART_Upper Tundra	2	624	2.4
SWE_14	Paddus_DART_ Lower Tundra	1	60	0.2
SWE_15	Paddus_DART_Lower Forest	2	228	0.9
SWE_16	Abisko bog	5	517	2.0
FIN_1	Kilpisjärvi	1	130	0.5
High-latitude European				**18.1**
ITA_1	G1_1	2	110	0.4
ITA_2	G1_2	2	109	0.4
ITA_3	G2_1	2	45	0.2
ITA_4	G2_2	2	45	0.2
ITA_5	G3	3	170	0.7
Alpine European				**1.9**
RUS_1	Seida mineral	3	189	0.7
RUS_2	Seida peat shrubs	3	176	0.7
RUS_3	Seida peat barren	3	177	0.7
High-latitude Asian				**2.1**
CHI_1	Haibei_1	2	64	0.2
CHI_2	Haibei_2	2	56	0.2
CHI_3	Haibei_3	2	56	0.2
CHI_4	Gangca	3	960	3.7
Alpine Asian				**4.4**

Outlier Detection and Removal

To ensure the robustness of further data analysis and to mitigate the influence of anomalous measurements, we developed a site- and year-specific outlier detection and removal procedure for R_{eco} data. This approach accounts for the inherent variability in carbon fluxes across different sites and over time.

First, we calculated the median and the Median Absolute Deviation (MAD) of the R_{eco} values. The MAD is defined as:

$$\mathrm{MAD} = 1.4826 \times \mathrm{median}(|\, x_i - \mathrm{median}(x)\, |)$$

where x_i represents each Reco value. Using these values, we computed the modified z-score for each observation as:

$$z_i = 0.6745 \times \frac{(x_i - \mathrm{median}(x))}{\mathrm{MAD}}$$

The modified z-score measures how far each data point deviates from the median, expressed in units of the Median Absolute Deviation (MAD). This approach is more robust to extreme values than the traditional z-score, which relies on the mean and standard deviation.

Each individual R_{eco} observation in the dataset was compared against its site- and year-specific modified z-score thresholds ($|z_i| > 2.5$), suggested by Leys et al. (2013). Observations with modified z-scores exceeding these thresholds, either above the upper or below the lower limit, were flagged as outliers. This process identified values that strongly deviated from the central trend, allowing the creation of a cleaner dataset for further analysis. Applying this procedure would result in 285 observations being identified as outliers (0.71% of the original 40,160 data points).

We chose not to automatically remove these outliers from the daily-aggregated dataset. Instead, we provide a non-aggregated version that indicates the flagged observations, allowing data users to decide whether to filter out these outliers or apply an alternative outlier treatment approach depending on their specific analytical goals.

References

Leys, C., Ley, C., Klein, O., Bernard, P., and Licata, L.: Detecting outliers: Do not use standard deviation around the mean, use absolute deviation around the median, Journal of Experimental Social Psychology, 49, 764–766, https://doi.org/10.1016/j.jesp.2013.03.013, 2013.

Spatio-temporal resolution of the TundraFlux Database

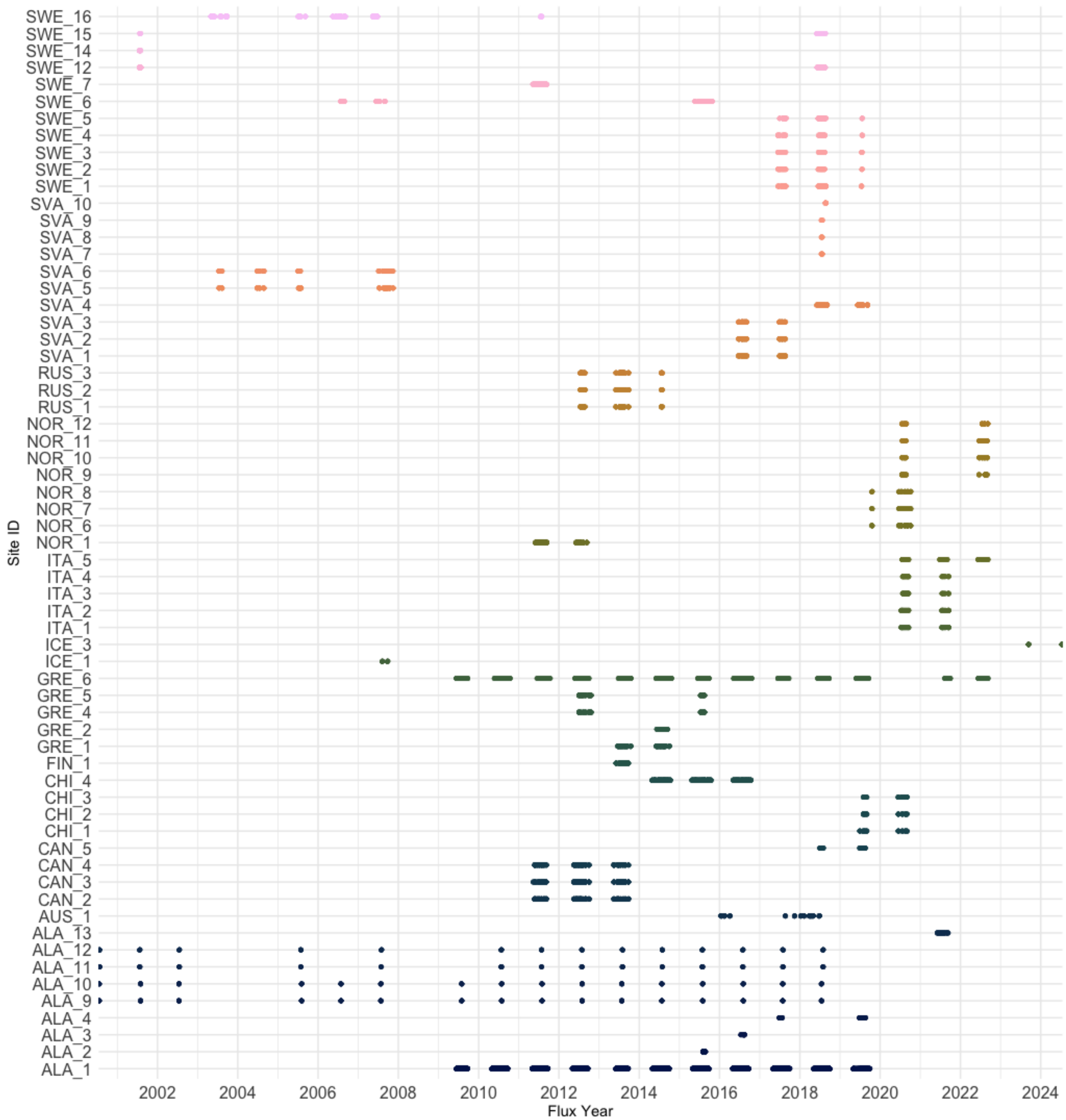

Figure S1. Overview of the temporal resolution of the R_{eco} measurement dates for each of the 64 site_ids.