

**Supporting Information for:**

# **Thermokarst and Microtopography Enhance Carbon Fluxes from an Arctic Tussock Tundra Site**

Kelcy Kent\* [1], Kyle A Arndt\* [1], Danielle Trangmoe [1], Patrick Murphy [1], Sigrid Dengel [3], Margaret Torn [3], Oriana Chafe [4], Marco Montemayor [2], and Susan Natali [1]

[1] Woodwell Climate Research Center, Falmouth, MA, USA

[2] Department of Earth and Planetary Science, University of California Santa Cruz, California, USA

[3] Lawrence Berkeley National Laboratory, Berkeley, CA, USA

[4] Environmental Studies Program - Department of Biology, University of Oregon, Eugene, OR, USA

\* Authors contributed equally to this work

*Correspondence to: Kelcy Kent (kck7bw@virginia.edu)*

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## **Introduction**

This supporting information includes additional figures showing the EC tower, the mean average EC tower footprint for the entire study period, the mean EC tower footprint for each season, ERA5 predictor variable agreement with measured predictors, and monthly means of predictor variables. Also included are additional figures depicting temperature and carbon flux models showing poor winter agreement, seasonal time series of carbon budgets and predictor variables, stepwise reduced models for variable importance for carbon variables, final model variable importance (%IncMSE) for carbon fluxes, significant relationships between daily means of measured carbon fluxes and environmental predictor variables, carbon fluxes by cardinal wind direction, and means of predictor variables from the lowland, upland, and slope soil chamber landscape positions. Tables reflect the percent gap-filled for carbon and environmental variables, calendar year means of carbon and environmental predictor variables, and a comparison of winter carbon budgets from random forest versus the proportionate winter budgets calculated based on daily mean growing season fluxes.

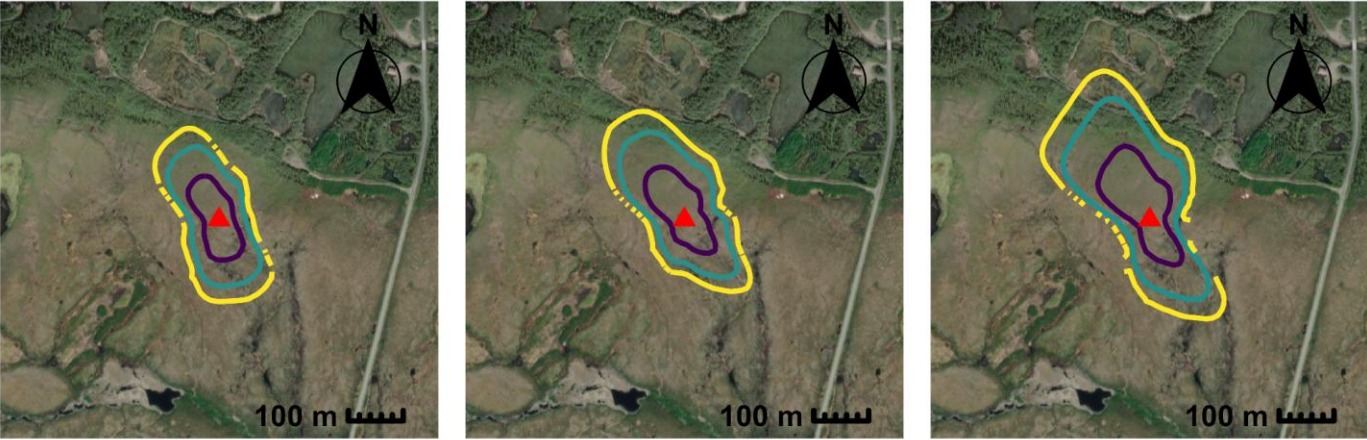


**Figure S1. The Ngee Arctic eddy-covariance flux tower at the Council Road Site MM-71 on the Seward Peninsula near Council, Alaska (AMF site US-NGC).**

**Growing Season**

**Fall**

**Winter**



**Footprint**    █ 90%    █ 60%    █ 30%

Figure S2. The mean flux footprint for growing season, fall, and winter at the Council eddy covariance site. The tower is represented by a red triangle. Colored contour lines delineate the distances from the tower where the surface contributions to the measured carbon fluxes cumulate to 30%, 60% and 90% from closest to the tower to furthest away, respectively. (Basemap: Tiles © Esri - Source: Esri, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGN, IGP, UPR-EGP, and the GIS User Community | Powered by Esri.)

## Mean Footprint for Study Period

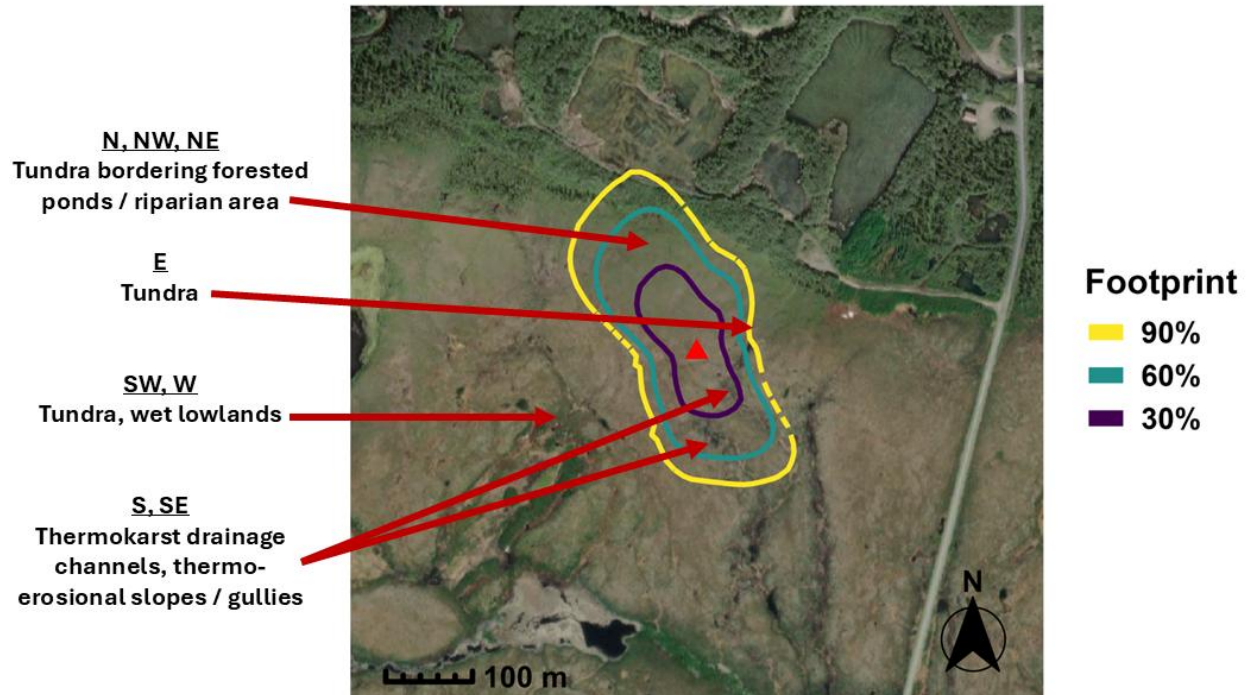
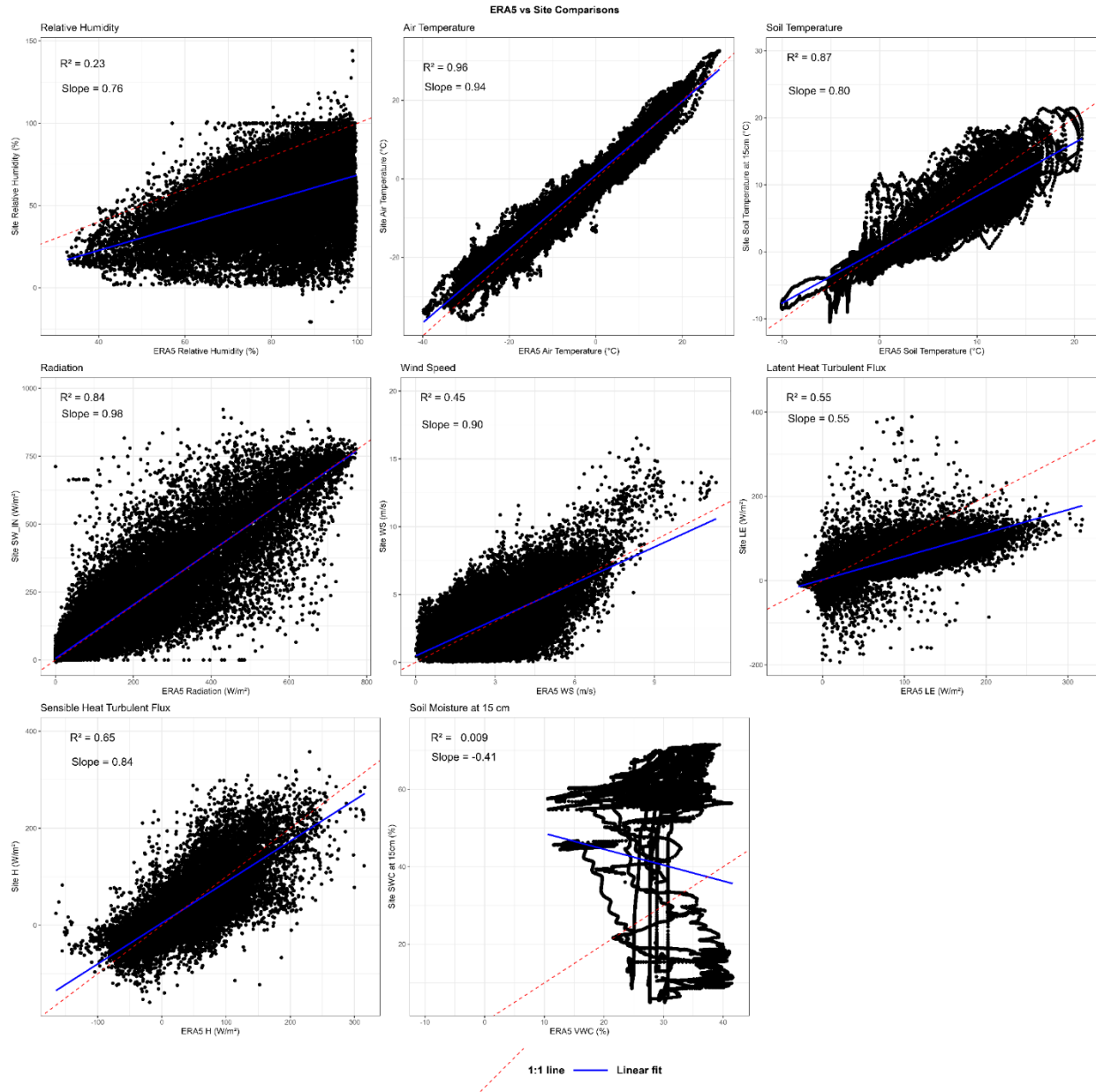
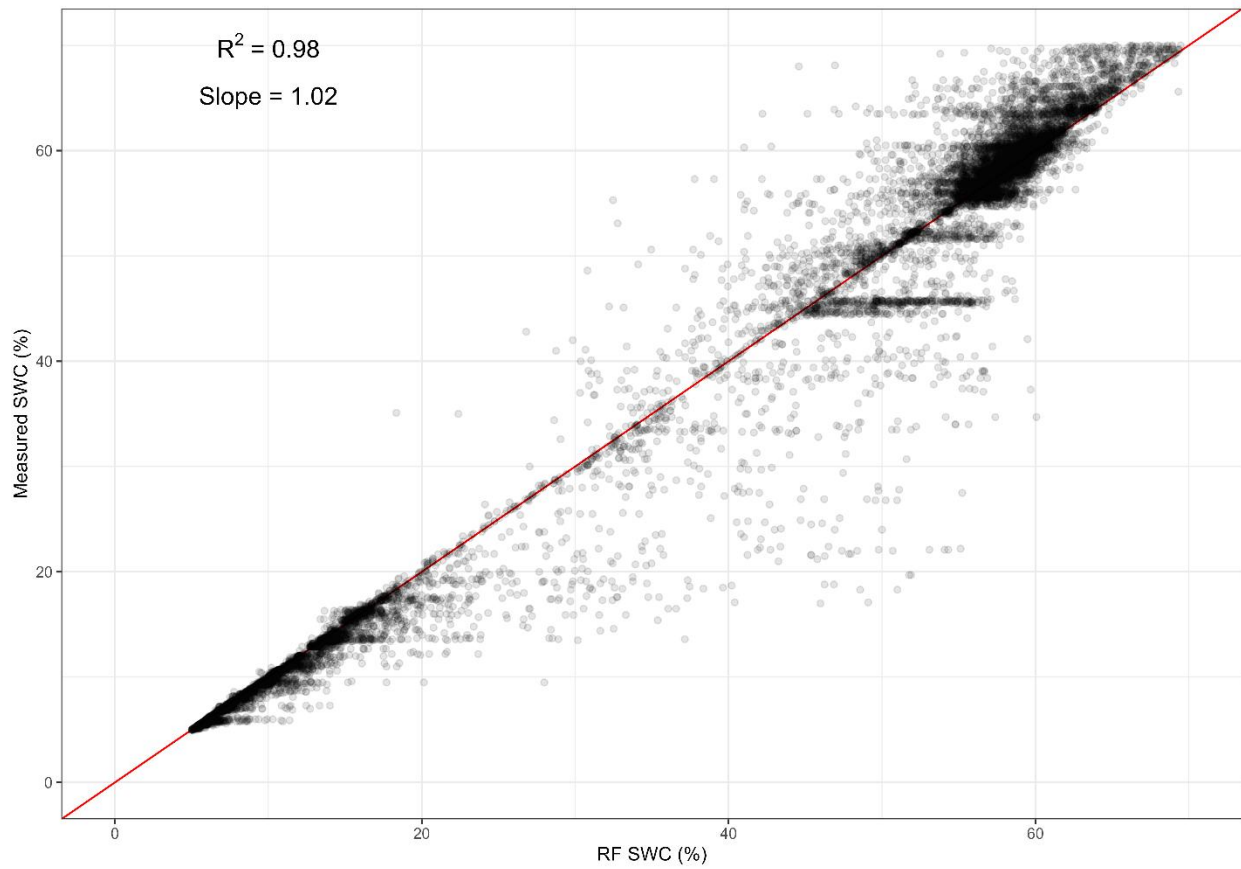


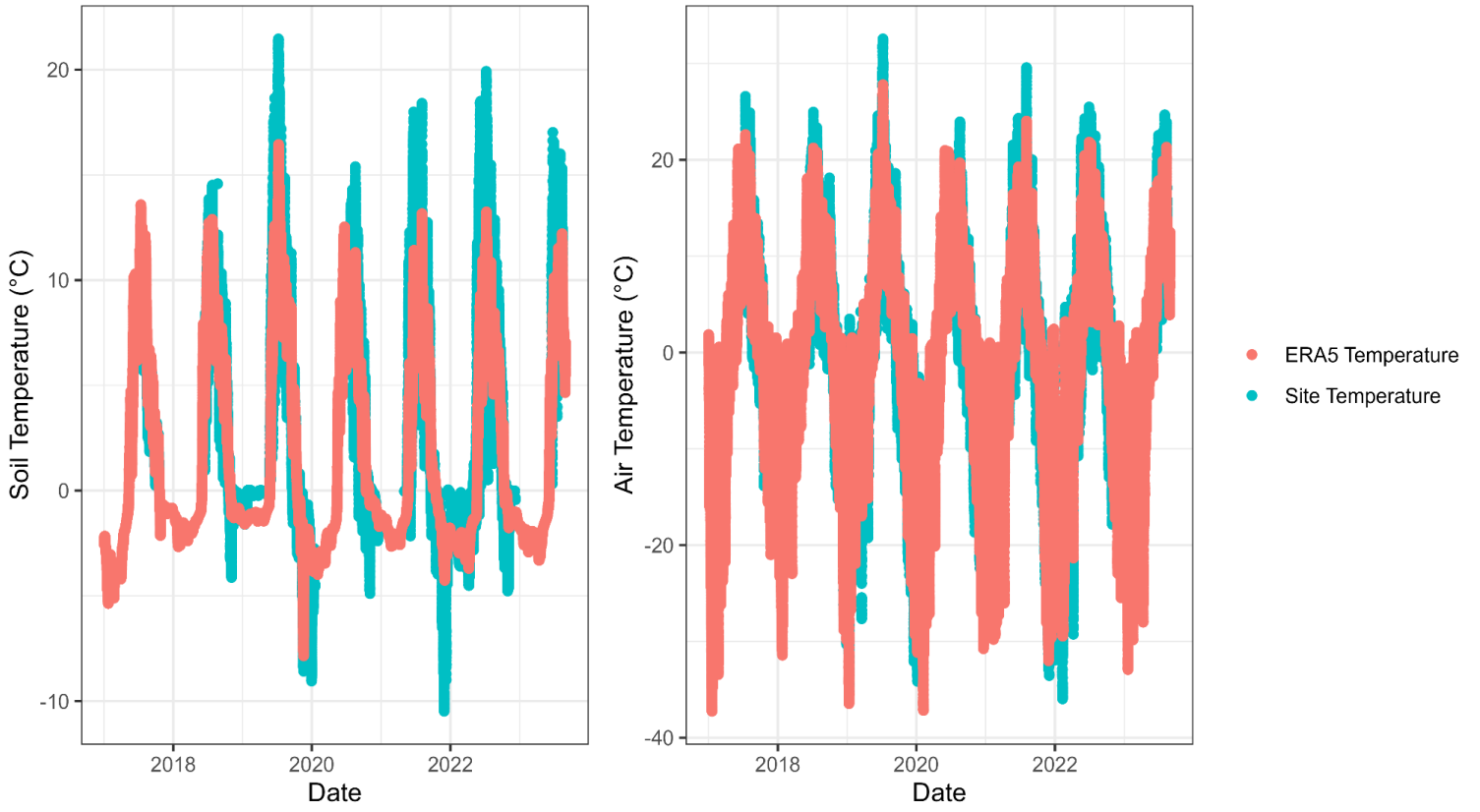
Figure S3. The mean flux footprint for the study period at the Council eddy covariance site. The tower is represented by a red triangle. Cells are colored by their mean contribution to the flux during that season. Colored contour lines delineate the distances from the tower where the surface contributions to the measured carbon fluxes cumulate to 30%, 60% and 90% from closest to the tower to furthest away, respectively. (Basemap: Tiles © Esri - Source: Esri, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGN, IGP, UPR-EGP, and the GIS User Community | Powered by Esri.)



**Figure S4.** Comparison of site-measured meteorological variables and ERA5 meteorological variables to demonstrate agreement for the purpose of training random forest model and gap-filling air and soil temperature.



**Figure S5. Comparison of site-measured soil moisture content (% SWC) at 15 cm (tussock probe) and random forest-modeled soil moisture content to demonstrate agreement for the purpose of training random forest model to gap-fill carbon fluxes.**



**Figure S6. Time series of measured half-hourly site soil and air temperature compared to ERA5 soil and air temperature.**

**Table S1. Calendar year mean ( $\pm$  SE) daily net ecosystem exchange (NEE) and methane (CH<sub>4</sub>) flux by season, seasonal and annual net CO<sub>2</sub>, CH<sub>4</sub>, and total carbon budgets, as well as mean seasonal and annual gap-filled air and soil temperature, soil moisture, and number of days within season across years. Percents represent percent gap-filled. Winter CO<sub>2</sub> and CH<sub>4</sub> emissions were calculated as a proportion of the daily average growing season flux (0.473 and 0.445, respectively) – as determined by the measurements from 2019, which had the best winter coverage among calendar years – multiplied by the number of days within each year’s respective winter season.**

Year	Season	Adjusted Daily NEE Flux ( $\mu\text{molC m}^{-2} \text{s}^{-1}$ )	Adjusted Daily CH <sub>4</sub> Flux ( $\text{nmolC m}^{-2} \text{s}^{-1}$ )	Adjusted Net CO <sub>2</sub> Budget ( $\text{gC m}^{-2}$ )	Adjusted Net CH <sub>4</sub> Budget ( $\text{gC m}^{-2}$ )	Total Net C Budget ( $\text{gC m}^{-2}$ )	ERA5-Gapfilled Air Temperature ( $^{\circ}\text{C}$ )	ERA5-Gapfilled Soil Temperature ( $^{\circ}\text{C}$ )	SWC (%)	Season Length (days)
<b>2017</b>	Winter	0.42 $\pm$ 0.03	3.48 $\pm$ 0.11	88.51	0.74	89.25	-9.75 $\pm$ 0.67 (98.1%)	-2.37 $\pm$ 1.47 (98.1%)	-	206
	Growing Season	-0.88 $\pm$ 0.06	7.83 $\pm$ 0.25	-116.17	1.03	-115.14	10.29 $\pm$ 0.36 (60.2%)	6.33 $\pm$ 2.82 (63.4%)	59.79 $\pm$ 0.17	127
	Fall Senescence	0.44 $\pm$ 0.04	2.82 $\pm$ 0.23	14.50	0.09	14.59	3.85 $\pm$ 0.38 (0%)	2.30 $\pm$ 0.90 (0%)	59.96 $\pm$ 0.10	32
	<b>Annual</b>	-	-	<b>-13.16</b>	<b>1.86</b>	<b>-11.30</b>	<b>-1.58 <math>\pm</math> 0.63 (76.3%)</b>	<b>1.07 <math>\pm</math> 4.53 (77.5%)</b>	-	365
<b>2018</b>	Winter	0.48 $\pm$ 0.04	4.35 $\pm$ 0.16	108.10	0.97	109.07	-7.69 $\pm$ 0.57 (69.4%)	-1.35 $\pm$ 0.73 (69.4%)	-	216
	Growing Season	-1.02 $\pm$ 0.07	9.77 $\pm$ 0.37	-112.11	1.07	-111.04	11.32 $\pm$ 0.28 (11.9%)	7.56 $\pm$ 2.44 (37.4%)	55.68 $\pm$ 0.95	106
	Fall Senescence	0.60 $\pm$ 0.04	9.61 $\pm$ 0.48	26.83	0.43	27.26	5.46 $\pm$ 0.52 (0.5%)	3.66 $\pm$ 2.43 (0.5%)	65.72 $\pm$ 0.26	43
	<b>Annual</b>	-	-	<b>22.81</b>	<b>2.47</b>	<b>25.29</b>	<b>-0.62 <math>\pm</math> 0.58 (44.6%)</b>	<b>1.83 <math>\pm</math> 4.32 (52%)</b>	-	365
<b>2019</b>	Winter	0.53 $\pm$ 0.02	6.78 $\pm$ 0.39	124.44	1.58	126.02	-7.05 $\pm$ 0.54 (0.5%)	-0.97 $\pm$ 1.60 (0.5%)	-	225
	Growing Season	-1.12 $\pm$ 0.09	15.22 $\pm$ 0.65	-114.86	1.56	-113.29	12.64 $\pm$ 0.35 (0%)	9.77 $\pm$ 3.29 (0%)	55.83 $\pm$ 1.25	99
	Fall Senescence	0.68 $\pm$ 0.06	15.98 $\pm$ 0.64	29.01	0.68	29.69	6.67 $\pm$ 0.66 (0%)	5.24 $\pm$ 3.35 (0%)	67.16 $\pm$ 0.45	41
	<b>Annual</b>	-	-	<b>38.59</b>	<b>3.82</b>	<b>42.41</b>	<b>-0.17 <math>\pm</math> 0.59 (0.3%)</b>	<b>2.64 <math>\pm</math> 5.32 (0.3%)</b>	-	365
<b>2020</b>	Winter	0.41 $\pm$ 0.03	4.15 $\pm$ 0.12	84.81	0.87	85.68	-11.49 $\pm$ 0.69 (72.2%)	-2.24 $\pm$ 1.28 (72.1%)	-	201
	Growing Season	-0.86 $\pm$ 0.06	9.33 $\pm$ 0.27	-101.86	1.10	-100.76	10.90 $\pm$ 0.26 (62.6%)	7.70 $\pm$ 2.39 (62.6%)	58.72 $\pm$ 0.19	114
	Fall Senescence	0.35 $\pm$ 0.04	7.80 $\pm$ 0.46	18.46	0.41	18.87	3.50 $\pm$ 0.48 (0%)	2.45 $\pm$ 2.53 (0%)	60.21 $\pm$ 0.35	51
	<b>Annual</b>	-	-	<b>1.41</b>	<b>2.38</b>	<b>3.79</b>	<b>-2.43 <math>\pm</math> 0.66 (59.1%)</b>	<b>1.51 <math>\pm</math> 4.84 (59.1%)</b>	-	365
<b>2021</b>	Winter	0.36 $\pm$ 0.03	4.69 $\pm$ 0.16	85.00	1.09	86.09	-11.97 $\pm$ 0.64 (55%)	-1.99 $\pm$ 1.66 (57.5%)	-	225
	Growing Season	-0.77 $\pm$ 0.07	10.53 $\pm$ 0.37	-89.89	1.23	-88.66	9.93 $\pm$ 0.36 (0%)	7.38 $\pm$ 2.59 (05)	52.37 $\pm$ 1.46	113
	Fall Senescence	0.28 $\pm$ 0.03	6.79 $\pm$ 0.43	7.91	0.19	8.10	1.87 $\pm$ 0.61 (0%)	1.41 $\pm$ 2.38 (05)	60.02 $\pm$ 0.41	27
	<b>Annual</b>	-	-	<b>3.02</b>	<b>2.52</b>	<b>5.54</b>	<b>-4.16 <math>\pm</math> 0.67 (33.9%)</b>	<b>1.16 <math>\pm</math> 4.73 (35.5%)</b>	-	365
<b>2022</b>	Winter	0.39 $\pm$ 0.03	2.46 $\pm$ 0.12	91.33	0.58	91.90	-9.38 $\pm$ 0.62 (20.6%)	-1.36 $\pm$ 1.39 (20.5%)	-	227
	Growing Season	-0.82 $\pm$ 0.06	5.52 $\pm$ 0.27	-91.43	0.61	-90.82	10.65 $\pm$ 0.32 (0%)	8.14 $\pm$ 2.38 (0%)	47.42 $\pm$ 1.11	107
	Fall Senescence	0.27 $\pm$ 0.06	6.74 $\pm$ 0.53	8.81	0.22	9.02	5.72 $\pm$ 0.46 (2.2%)	4.37 $\pm$ 2.34 (2.2%)	59.53 $\pm$ 0.39	31
	<b>Annual</b>	-	-	<b>8.70</b>	<b>1.41</b>	<b>10.11</b>	<b>-2.22 <math>\pm</math> 0.63 (13%)</b>	<b>1.91 <math>\pm</math> 4.68 (12.9%)</b>	-	365

Table S2. Percent gap-filled of variable means presented in Table 1.

Year	Season	Adjusted Daily NEE Flux ( $\mu\text{molC m}^{-2} \text{s}^{-1}$ )	Adjusted Daily FCH4 Flux ( $\text{nmolC m}^{-2} \text{s}^{-1}$ )	ERA5-Gapfilled Air Temperature ( $^{\circ}\text{C}$ )	ERA5-Gapfilled Soil Temperature ( $^{\circ}\text{C}$ )
2017	Growing Season	66.10%	74%	60.60%	63.80%
	Fall Senescence	21.90%	31.20%	0%	0%
	Winter of 2017 - 2018 *	98.7%*	98.7%*	98.20%	98.20%
	<b>Annual Mean</b>	-	-	76.40%	77.50%
	<b>2017 - 2018 Carbon Budget</b>	-	-	-	-
2018	Growing Season	15.10%	31.10%	12.30%	37.70%
	Fall Senescence	20.90%	44.20%	0%	0%
	Winter of 2018 - 2019*	68.9%*	61.2%*	0%	0%
	<b>Annual Mean</b>	-	-	44.70%	52.10%
	<b>2018 - 2019 Carbon Budget</b>	-	-	-	-
2019	Growing Season	4%	20.20%	0%	0%
	Fall Senescence	34.10%	68.30%	0%	0%
	Winter of 2019 - 2020 *	71.8% *	70.8% *	55.10%	55.10%
	<b>Annual Mean</b>	-	-	0.30%	0.30%
	<b>2019 - 2020 Carbon Budget</b>	-	-	-	-
2020	Growing Season	66.70%	79.80%	62.30%	62.30%
	Fall Senescence	25.50%	84.30%	0%	0%
	Winter of 2020 - 2021 *	90.90%	98.1% *	73.10%	73.10%
	<b>Annual Mean</b>	-	-	59.30%	59.30%
	<b>2020 - 2021 Carbon Budget</b>	-	-	-	-
2021	Growing Season	31%	61.90%	0%	0%
	Fall Senescence	59.30%	74.10%	0%	0%
	Winter of 2021 - 2022 *	95.10%	95.1%*	0%	2.20%
	<b>Annual Mean</b>	-	-	34%	35.30%
	<b>2021 - 2022 Carbon Budget</b>	-	-	-	-
2022	Growing Season	9.30%	17.80%	0%	0%
	Fall Senescence	35.50%	87.10%	3.20%	3.20%
	Winter of 2022 - 2023 *	91.7% *	100% *	84.20%	84.20%
	<b>Annual Mean</b>	-	-	13.20%	13.20%
	<b>2022 - 2023 Carbon Budget</b>	-	-	-	-

## All-Season Nighttime CO<sub>2</sub> Model Applied to Winter Data

*Demonstrating poor model performance in winter*

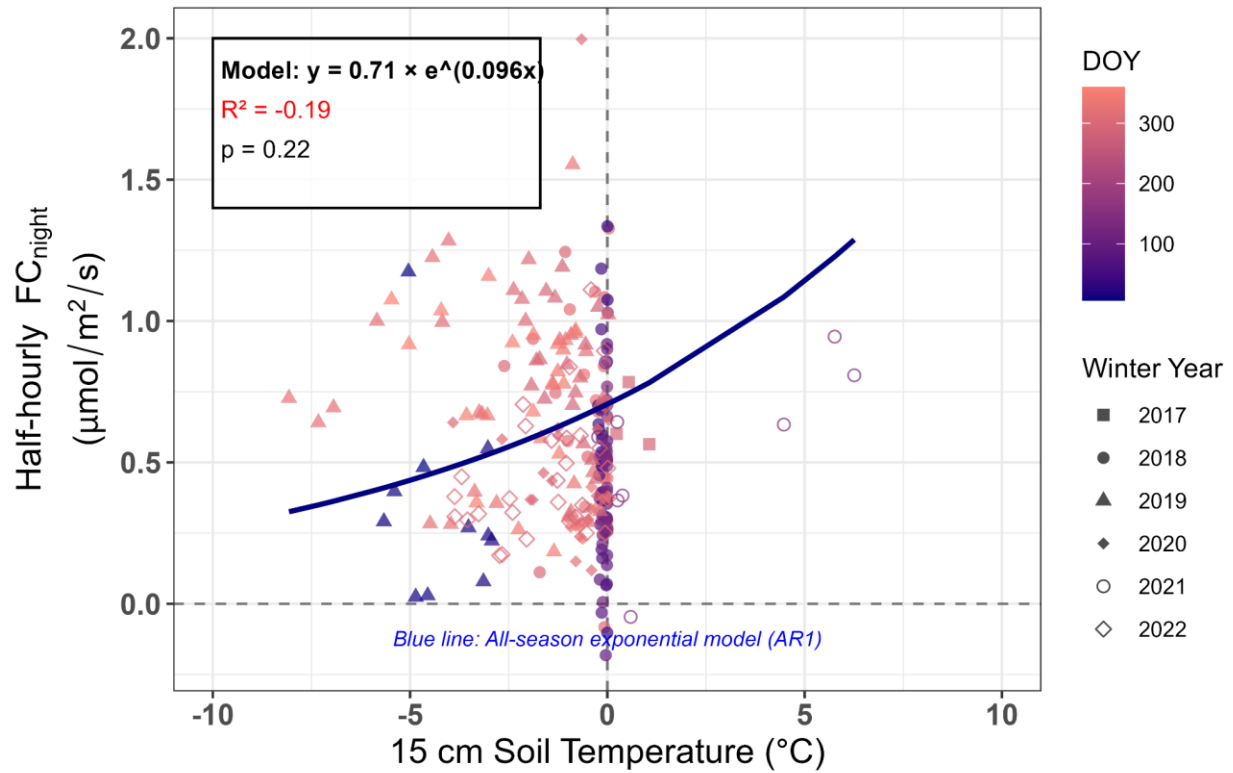


Figure S7. Demonstrating the poor fit of the nighttime CO<sub>2</sub> - temperature model utilizing the full time-series when applied to winter-only data.

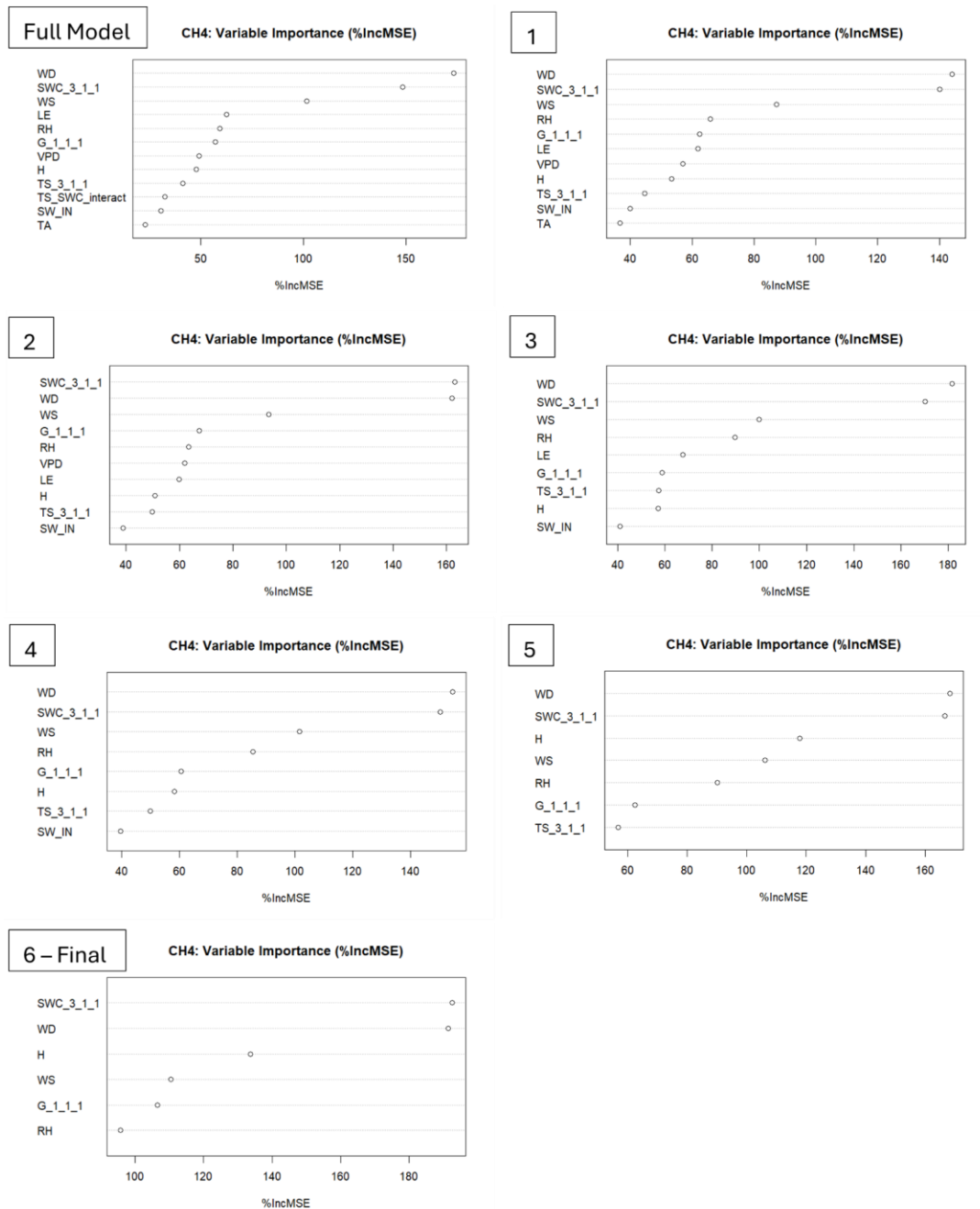


Figure S8. Stepwise approach for reduced random forest model assessing important meteorological variables for CH<sub>4</sub> fluxes using %IncMSE. Collinear variables were determined via a spearman correlation matrix and variable inflation factor (VIF) analysis. Variables with the highest VIF values in the random forest model were removed one by one in subsequent models until all VIF values were below 2. Predictors used included: WD (wind direction), SWC\_3\_1\_1 (soil moisture integrated over 0 - 15 cm), WS (windspeed), LE (latent heat flux), RH (relative humidity), G\_1\_1\_1 (ground heat flux at 7 cm), VPD (vapor pressure deficit), H (sensible heat flux), TS\_3\_1\_1 (soil temperature integrated over 0 - 15 cm), TS\_SWC\_interact (calculated interaction term for soil temperature and soil moisture), SW\_IN (incoming shortwave radiation), TA (air temperature).

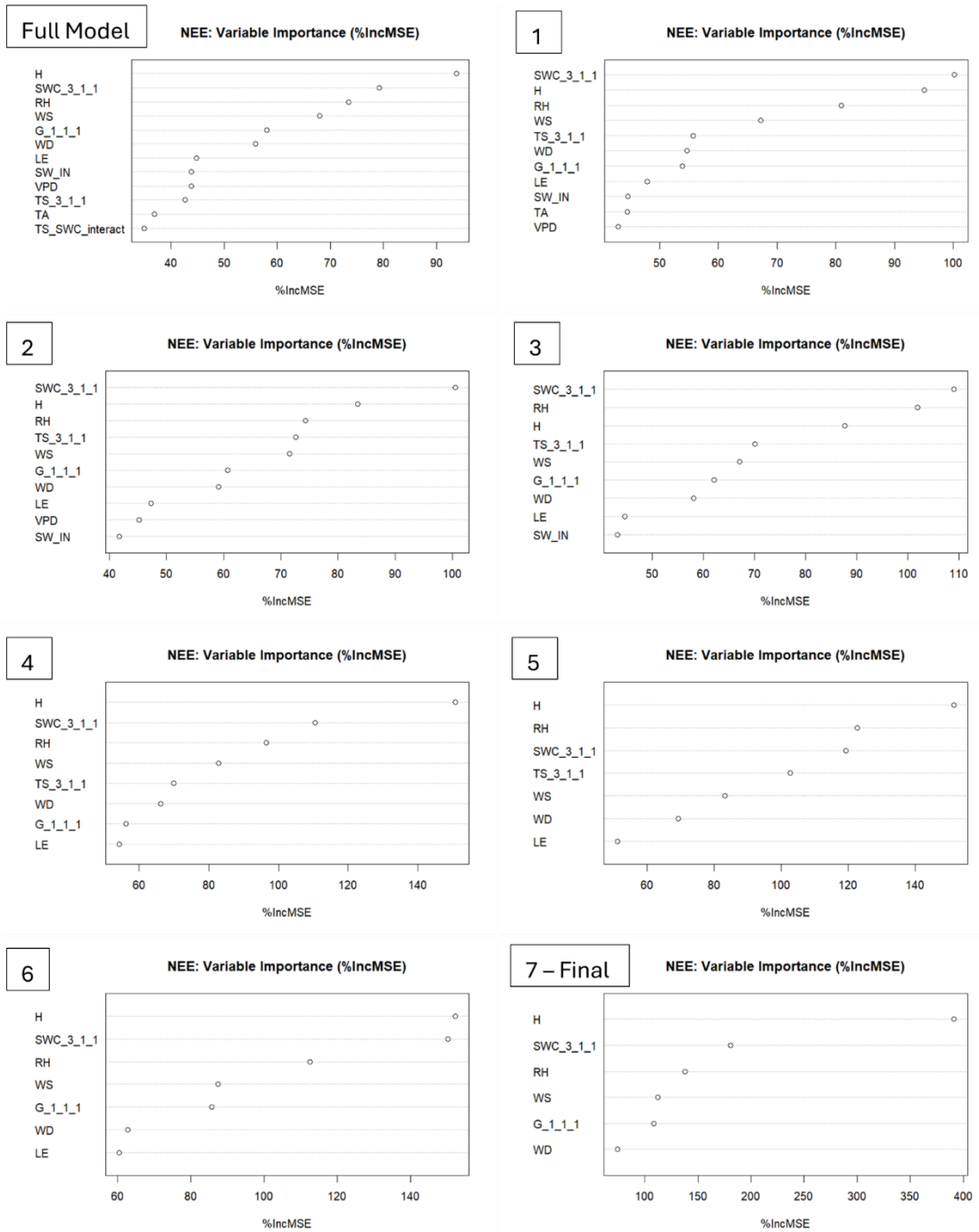


Figure S9. Stepwise approach for reduced random forest model assessing important meteorological variables for NEE (CO<sub>2</sub>) fluxes using %IncMSE. Collinear variables were determined via a spearman correlation matrix and variable inflation factor (VIF) analysis. Variables with the highest VIF values in the random forest model were removed one by one in subsequent models until all VIF values were below 2. Predictors used included: WD (wind direction), SWC\_3\_1\_1 (soil moisture integrated over 0 - 15 cm), WS (windspeed), LE (latent heat flux), RH (relative humidity), G\_1\_1\_1 (ground heat flux at 7 cm), VPD (vapor pressure deficit), H (sensible heat flux), TS\_3\_1\_1 (soil temperature integrated from 0 - 15 cm), TS\_SWC\_interact (calculated interaction term for soil temperature and soil moisture), SW\_IN (incoming shortwave radiation), TA (air temperature).

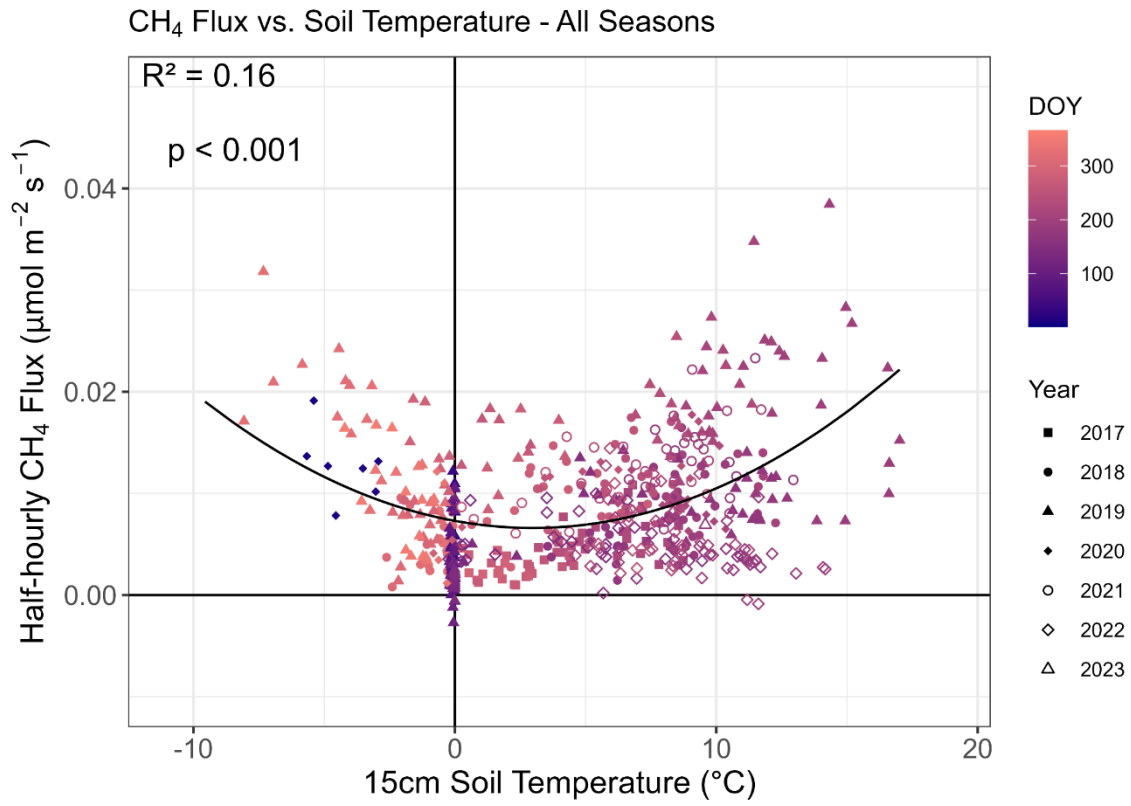


Figure S10. Quadratic model of mean daily CH<sub>4</sub> fluxes and soil temperature across all years and seasons to show “U” shape of trendline when temperatures below 0 °C are included.

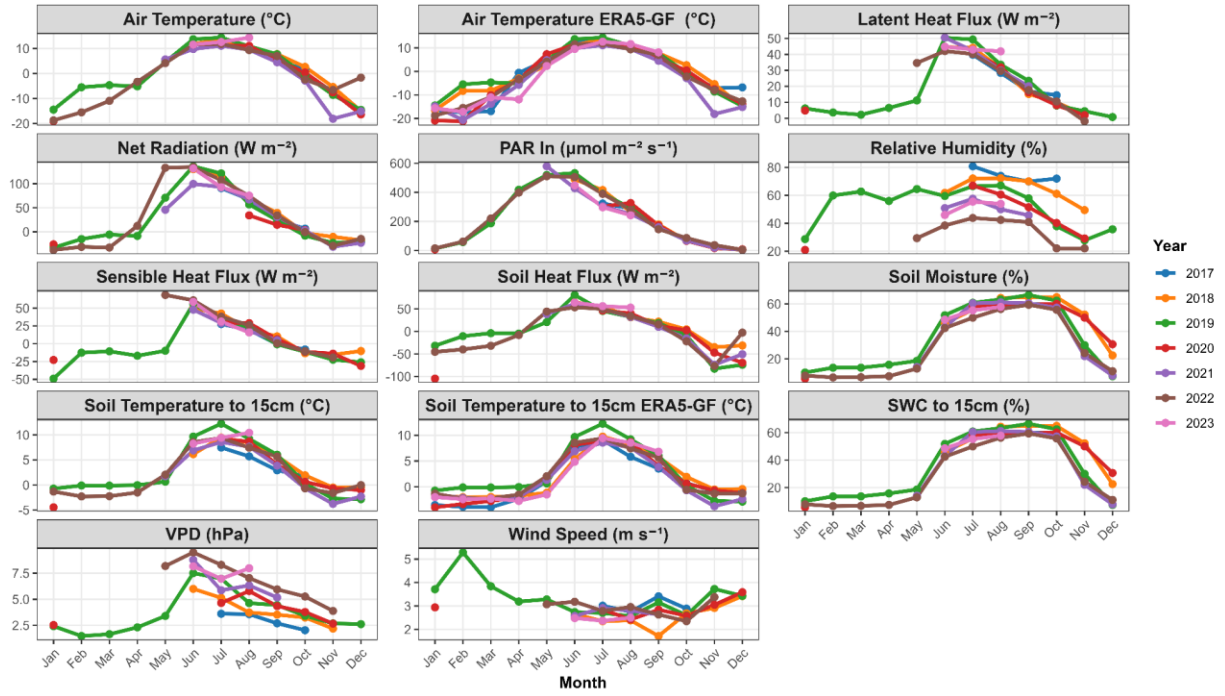


Figure S11. Monthly averages of environmental variables of interest.

GPP, Respiration, NEE, and Methane Fluxes (2017-2022)

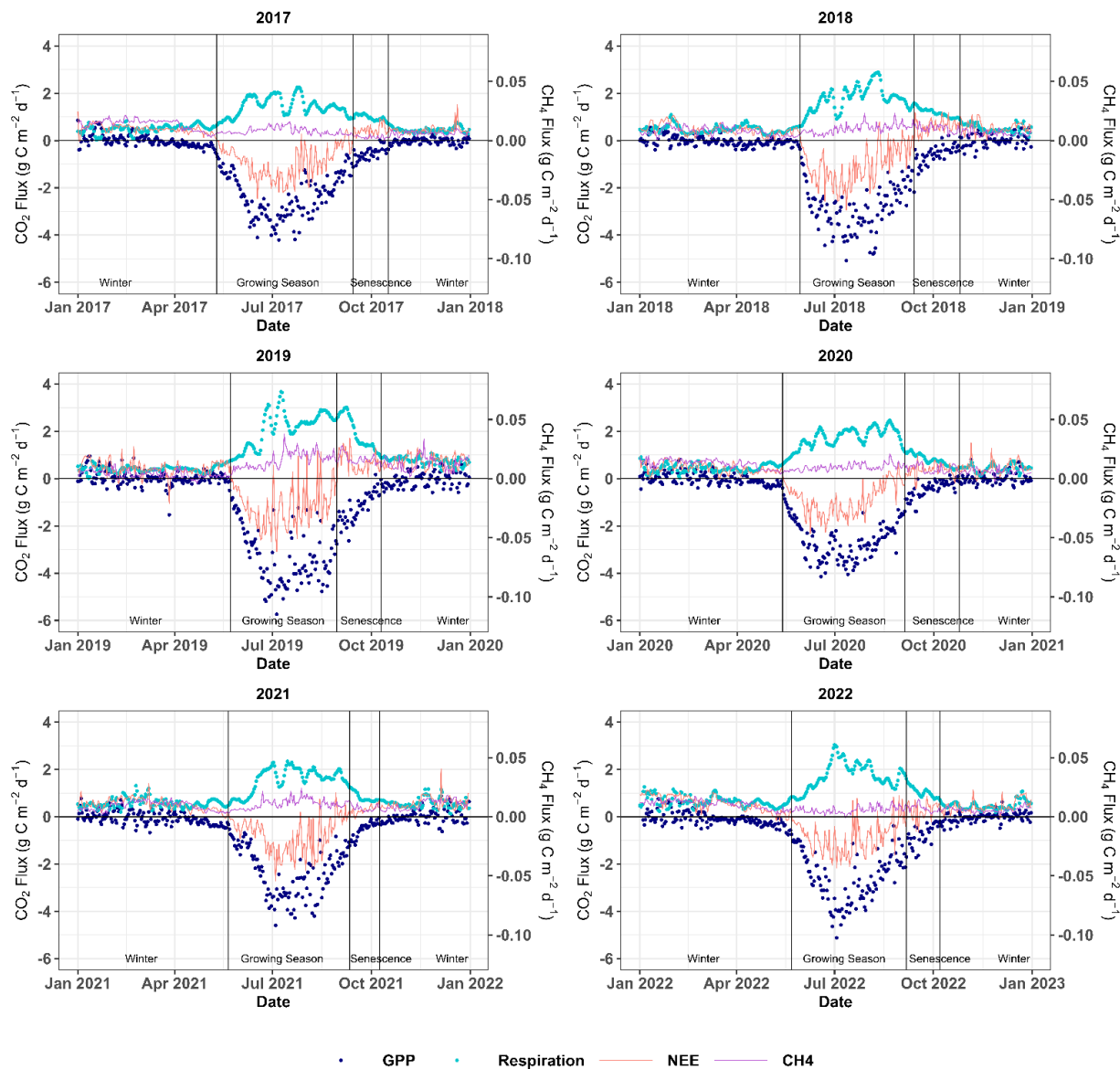


Figure S12. Seasonal trends of daily means of gross primary production (GPP), ecosystem respiration (R<sub>ECO</sub>), net ecosystem exchange (NEE), and CH<sub>4</sub> fluxes for the years 2017 - 2022 from the eddy covariance tower near Council, Alaska. Vertical lines denote seasonal delineations (winter, growing season, fall senescence).

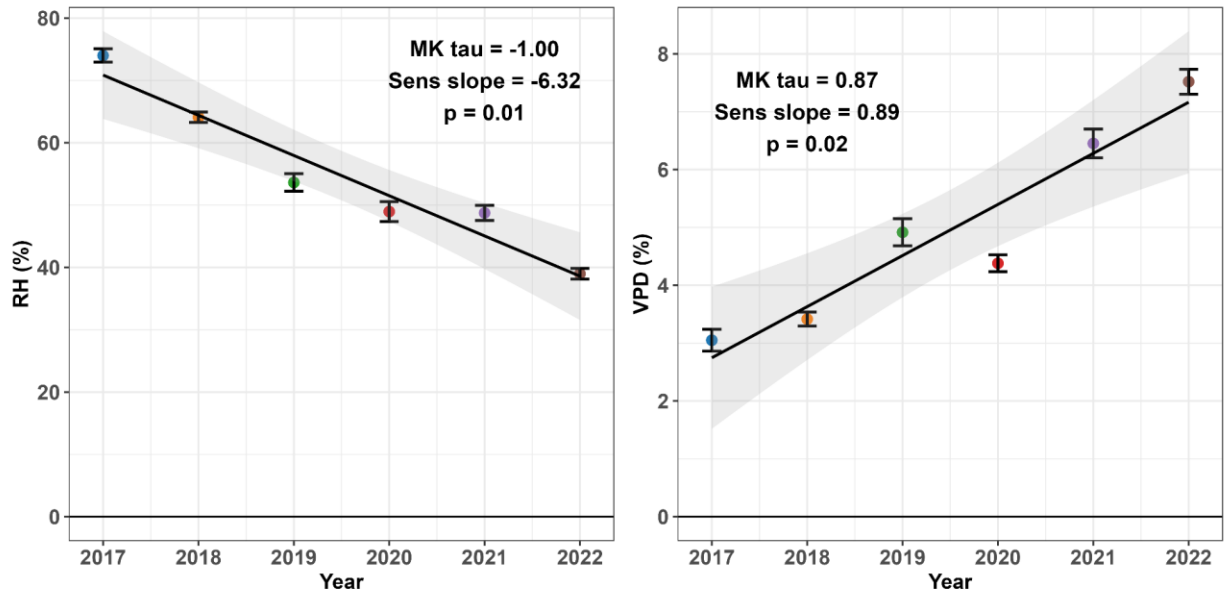


Figure S13. Significant Mann-Kendall time series of mean annual relative humidity (RH) and mean annual vapor pressure deficit (VPD) across years. Grey shading and error bars represent SE.

### Seasonal Environmental Trends (2017-2022)

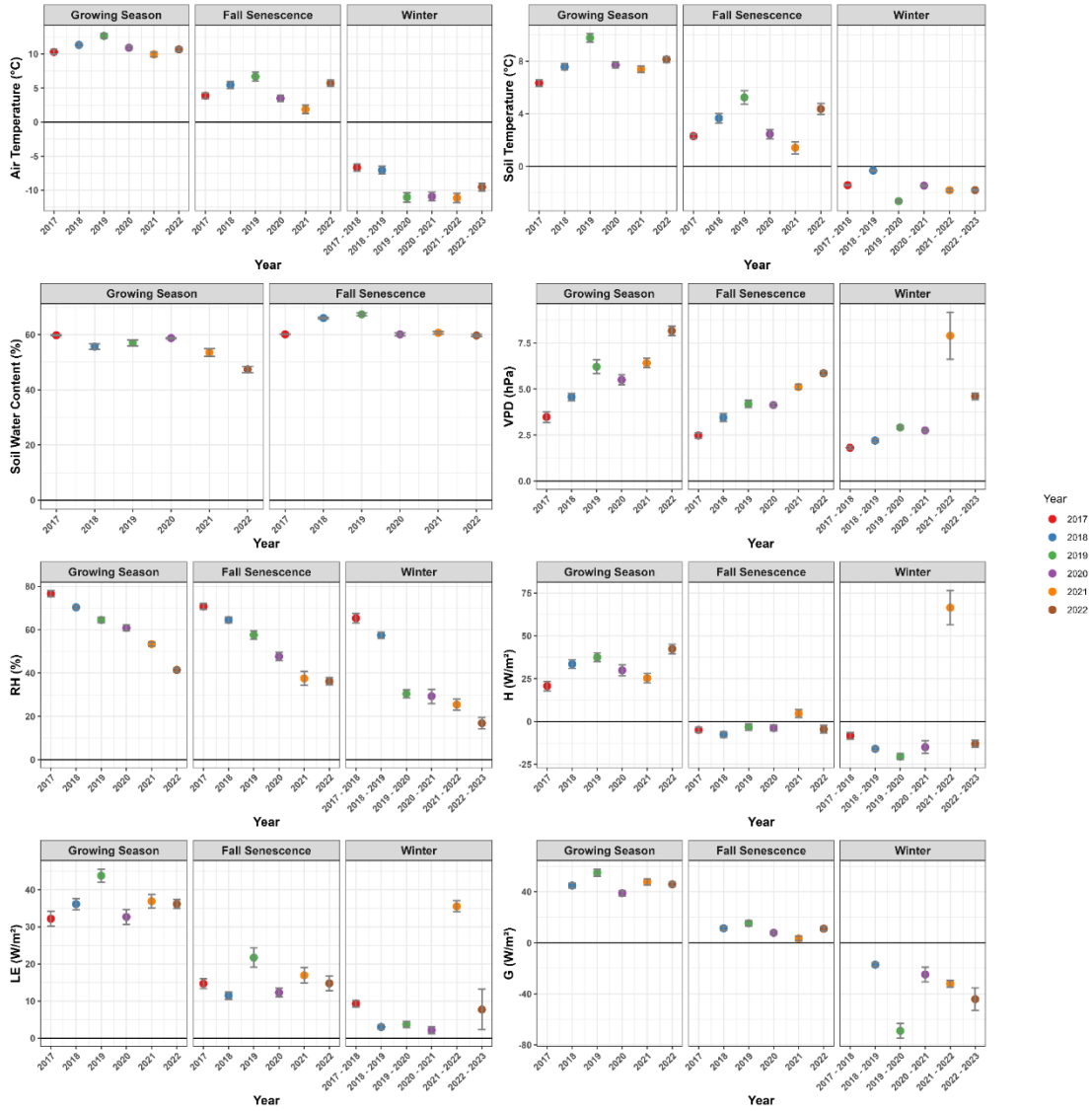


Figure S14. Seasonal means ( $\pm$  SE) of gap-filled air temperature, gap-filled soil temperature, soil water content, vapor pressure deficit (VPD), and relative humidity (RH) by year.

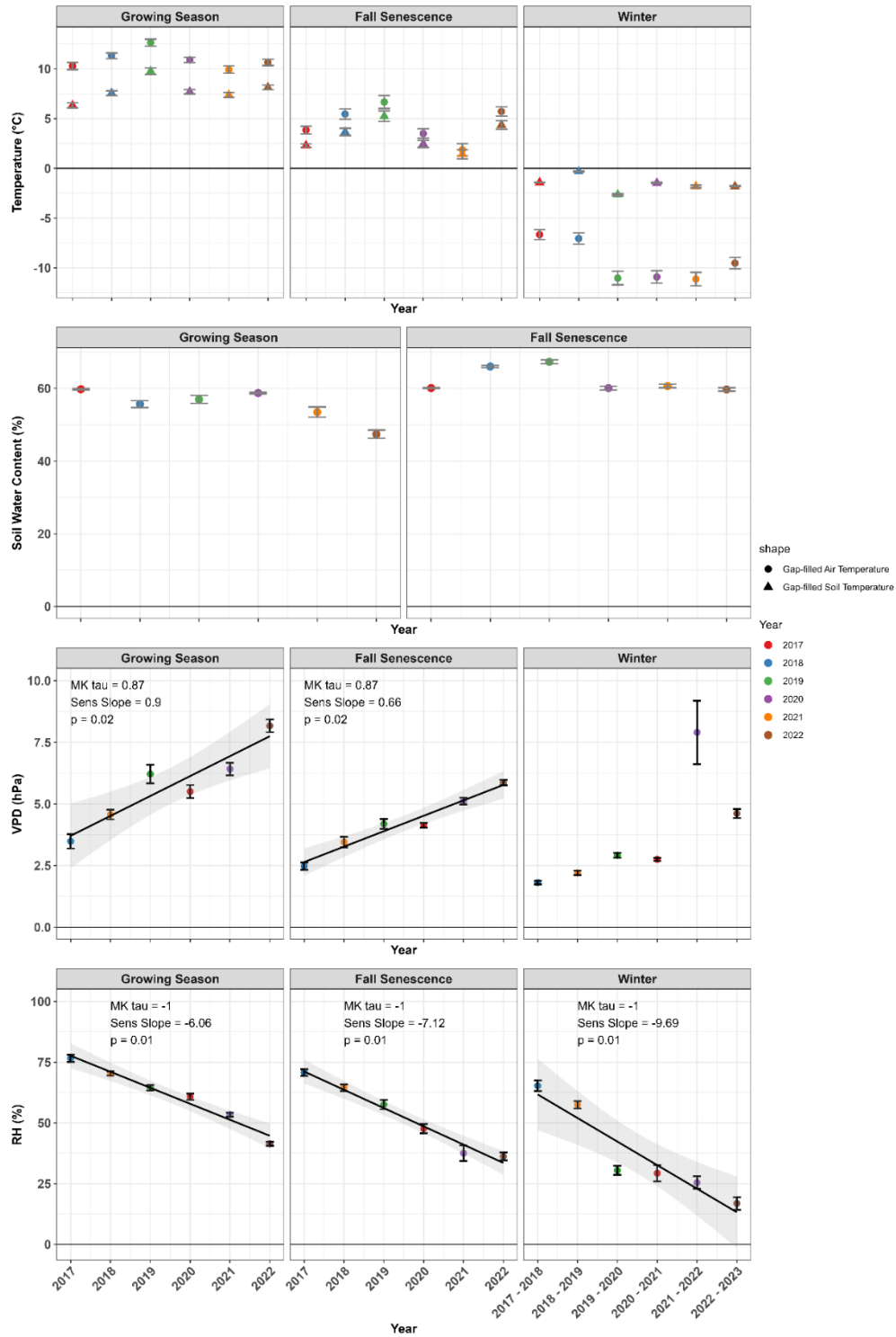


Figure S15. Seasonal means of gap-filled air temperature, gap-filled soil temperature, unfrozen soil water content and variables with statistically significant Mann-Kendall time series trends across years including vapor pressure deficit (VPD) and relative humidity (RH). Grey shading and error bars represent SE.

**Table S3. Seasonal means ( $\pm$  SE) of meteorological variables of interest with percent of measured data (% data coverage).**

Year	Season	Total Days	SWC (unfrozen)	VPD (hPa)	RH (%)	H (W/m <sup>2</sup> )	LE (W/m <sup>2</sup> )	G (W/m <sup>2</sup> )
2017	Growing Season	127	59.79 $\pm$ 0.17 (36.2%)	3.48 $\pm$ 0.29 (37.0%)	76.59 $\pm$ 1.45 (37.0%)	20.70 $\pm$ 2.77 (35.4%)	32.16 $\pm$ 2.03 (36.2%)	-
2017	Fall Senescence	32	60.11 $\pm$ 0.09 (62.5%)	2.48 $\pm$ 0.15 (90.6%)	70.69 $\pm$ 1.41 (90.6%)	-4.91 $\pm$ 1.49 (100.0%)	14.70 $\pm$ 1.31 (96.9%)	-
2017	Winter of 2017 - 2018 *	226	-	1.81 $\pm$ 0.08 (1.3%)	65.30 $\pm$ 2.24 (1.3%)	-8.36 $\pm$ 2.05 (1.3%)	9.28 $\pm$ 0.85 (1.3%)	-
2018	Growing Season	106	55.68 $\pm$ 0.95 (62.3%)	4.57 $\pm$ 0.20 (86.8%)	70.35 $\pm$ 0.87 (86.8%)	33.53 $\pm$ 2.57 (86.8%)	36.11 $\pm$ 1.54 (86.8%)	44.83 $\pm$ 1.89 (87.7%)
2018	Fall Senescence	43	66.01 $\pm$ 0.31 (76.7%)	3.45 $\pm$ 0.22 (100.0%)	64.46 $\pm$ 1.39 (100.0%)	-7.64 $\pm$ 1.72 (95.3%)	11.49 $\pm$ 0.97 (93.0%)	11.43 $\pm$ 1.78 (100.0%)
2018	Winter of 2018 - 2019 *	209	-	2.20 $\pm$ 0.09 (42.6%)	57.43 $\pm$ 1.50 (42.6%)	-15.98 $\pm$ 1.02 (65.6%)	3.01 $\pm$ 0.62 (37.8%)	-17.18 $\pm$ 1.54 (100.0%)
2019	Growing Season	99	56.98 $\pm$ 1.10 (97.0%)	6.22 $\pm$ 0.38 (100.0%)	64.46 $\pm$ 1.19 (100.0%)	37.46 $\pm$ 2.54 (100.0%)	43.76 $\pm$ 1.76 (100.0%)	54.86 $\pm$ 2.84 (100.0%)
2019	Fall Senescence	41	67.33 $\pm$ 0.51 (78.0%)	4.19 $\pm$ 0.20 (82.9%)	57.55 $\pm$ 1.92 (82.9%)	-3.28 $\pm$ 1.94 (100.0%)	21.70 $\pm$ 2.60 (73.2%)	15.34 $\pm$ 2.14 (100.0%)
2019	Winter of 2019 - 2020 *	216	-	2.92 $\pm$ 0.10 (24.1%)	30.41 $\pm$ 1.88 (24.1%)	-20.52 $\pm$ 1.74 (35.2%)	3.70 $\pm$ 0.80 (21.3%)	-69.01 $\pm$ 5.69 (44.9%)
2020	Growing Season	114	58.72 $\pm$ 0.19 (37.7%)	5.50 $\pm$ 0.27 (36.8%)	60.78 $\pm$ 1.32 (36.8%)	29.85 $\pm$ 3.16 (36.8%)	32.66 $\pm$ 2.03 (36.0%)	38.81 $\pm$ 2.21 (37.7%)
2020	Fall Senescence	51	60.10 $\pm$ 0.52 (52.9%)	4.14 $\pm$ 0.10 (92.2%)	47.61 $\pm$ 1.93 (92.2%)	-3.77 $\pm$ 1.79 (96.1%)	12.29 $\pm$ 1.23 (82.4%)	7.85 $\pm$ 1.49 (100.0%)
2020	Winter of 2020 - 2021 *	208	-	2.75 $\pm$ 0.06 (10.6%)	29.26 $\pm$ 3.32 (10.6%)	-14.99 $\pm$ 3.74 (15.4%)	2.15 $\pm$ 0.96 (6.7%)	-24.80 $\pm$ 5.77 (26.9%)
2021	Growing Season	113	53.50 $\pm$ 1.40 (96.5%)	6.42 $\pm$ 0.25 (77.0%)	53.37 $\pm$ 0.87 (77.0%)	25.30 $\pm$ 2.74 (76.1%)	36.88 $\pm$ 1.81 (75.2%)	47.67 $\pm$ 2.37 (100.0%)
2021	Fall Senescence	27	60.67 $\pm$ 0.48 (29.6%)	5.12 $\pm$ 0.14 (40.7%)	37.50 $\pm$ 3.22 (40.7%)	4.70 $\pm$ 2.35 (37.0%)	16.91 $\pm$ 2.11 (37.0%)	3.40 $\pm$ 1.74 (100.0%)
2021	Winter of 2021 - 2022 *	226	-	7.90 $\pm$ 1.29 (5.3%)	25.41 $\pm$ 2.58 (5.3%)	66.42 $\pm$ 9.96 (4.9%)	35.50 $\pm$ 1.50 (4.9%)	-32.04 $\pm$ 2.58 (100.0%)
2022	Growing Season	107	47.42 $\pm$ 1.11 (100.0%)	8.17 $\pm$ 0.26 (100.0%)	41.40 $\pm$ 0.85 (100.0%)	42.34 $\pm$ 2.79 (99.1%)	36.14 $\pm$ 1.23 (97.2%)	45.85 $\pm$ 1.72 (100.0%)
2022	Fall Senescence	31	59.71 $\pm$ 0.45 (80.6%)	5.87 $\pm$ 0.11 (90.3%)	36.18 $\pm$ 1.63 (93.5%)	-4.51 $\pm$ 2.31 (93.5%)	14.76 $\pm$ 2.04 (80.6%)	11.07 $\pm$ 1.68 (96.8%)
2022	Winter of 2022 - 2023 *	241	-	4.61 $\pm$ 0.18 (3.3%)	16.83 $\pm$ 2.61 (3.3%)	-13.05 $\pm$ 2.12 (12.9%)	7.70 $\pm$ 5.45 (1.7%)	-44.16 $\pm$ 8.85 (15.8%)

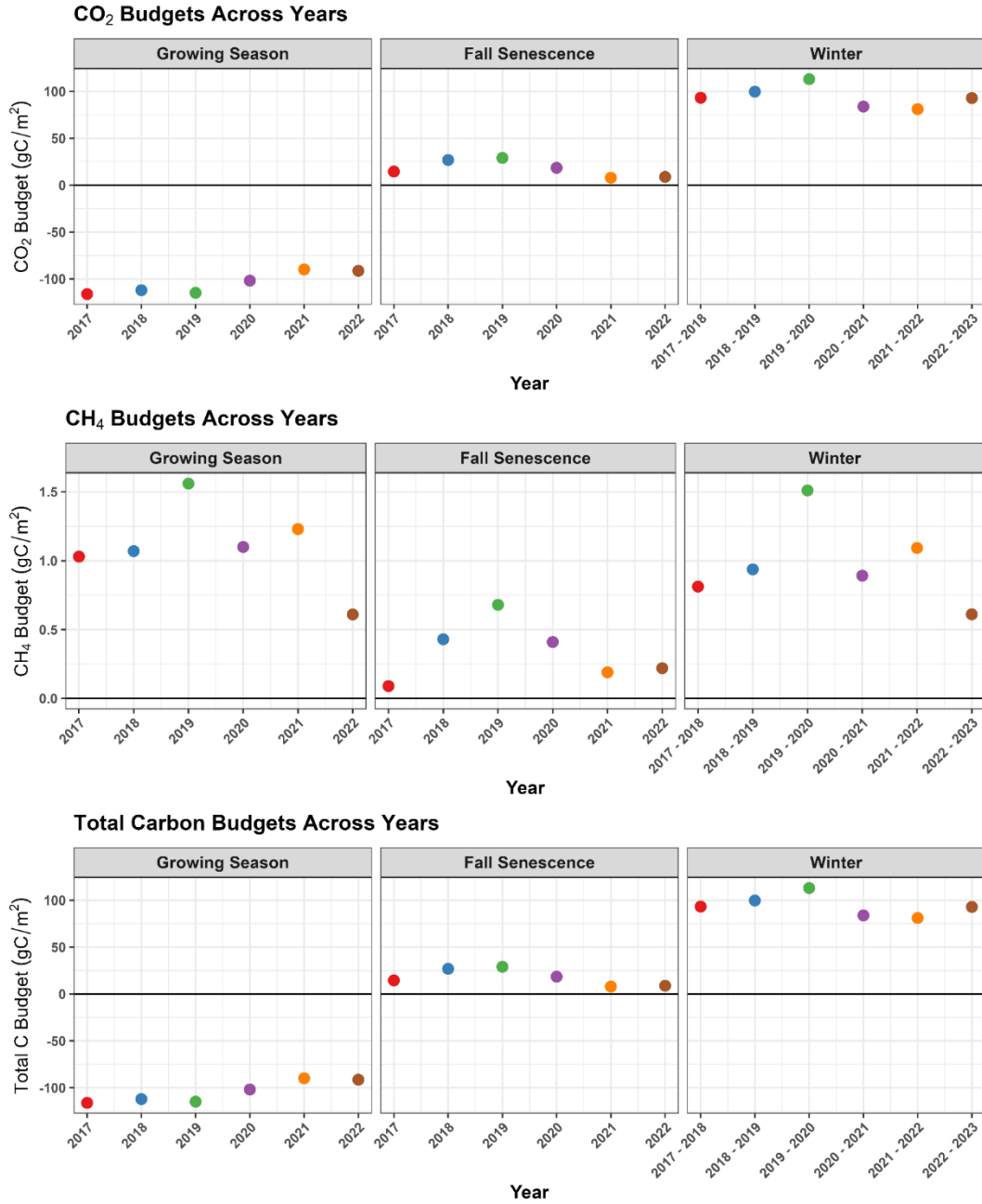


Figure S16. Seasonal CO<sub>2</sub>, CH<sub>4</sub>, and total carbon budgets across years. Linear regression and Mann-Kendall time series tests found no significant increasing or decreasing trends in carbon fluxes across years.

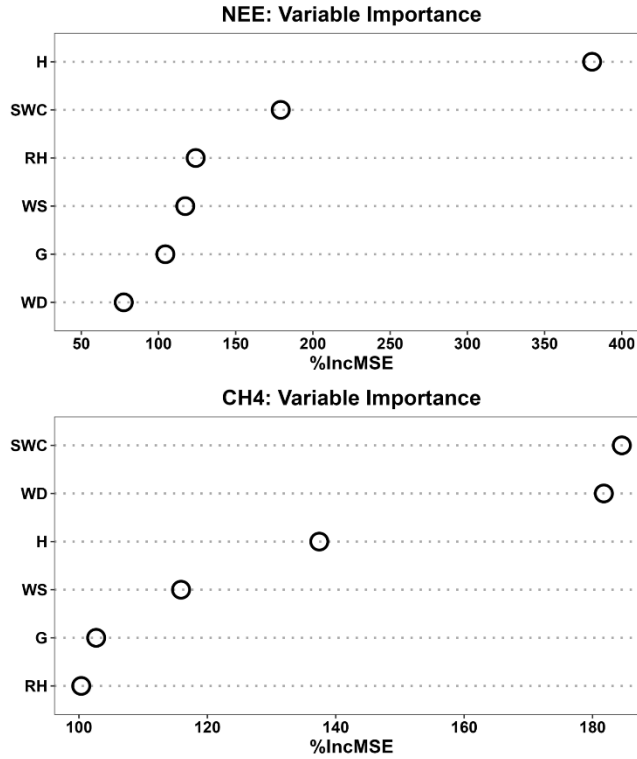


Figure S17. Variable importance (%IncMSE) for NEE (CO<sub>2</sub>) and CH<sub>4</sub> per a reduced random forest regression model (ntree = 850 and 950, respectively). Variables tested consisted of the half-hourly measurements of C fluxes, soil moisture (SWC), wind direction (WD), soil temperature (TS), air temperature (TA), shortwave-in (SW\_IN), relative humidity (RH), latent heat flux (LE), sensible heat flux (H), ground heat flux (G), wind speed (WS), calculated vapor pressure deficit (VPD), as well as a calculated soil temperature-soil moisture interaction term (TS\_SWC\_Interact).

### Growing Season: RH vs Carbon Budgets

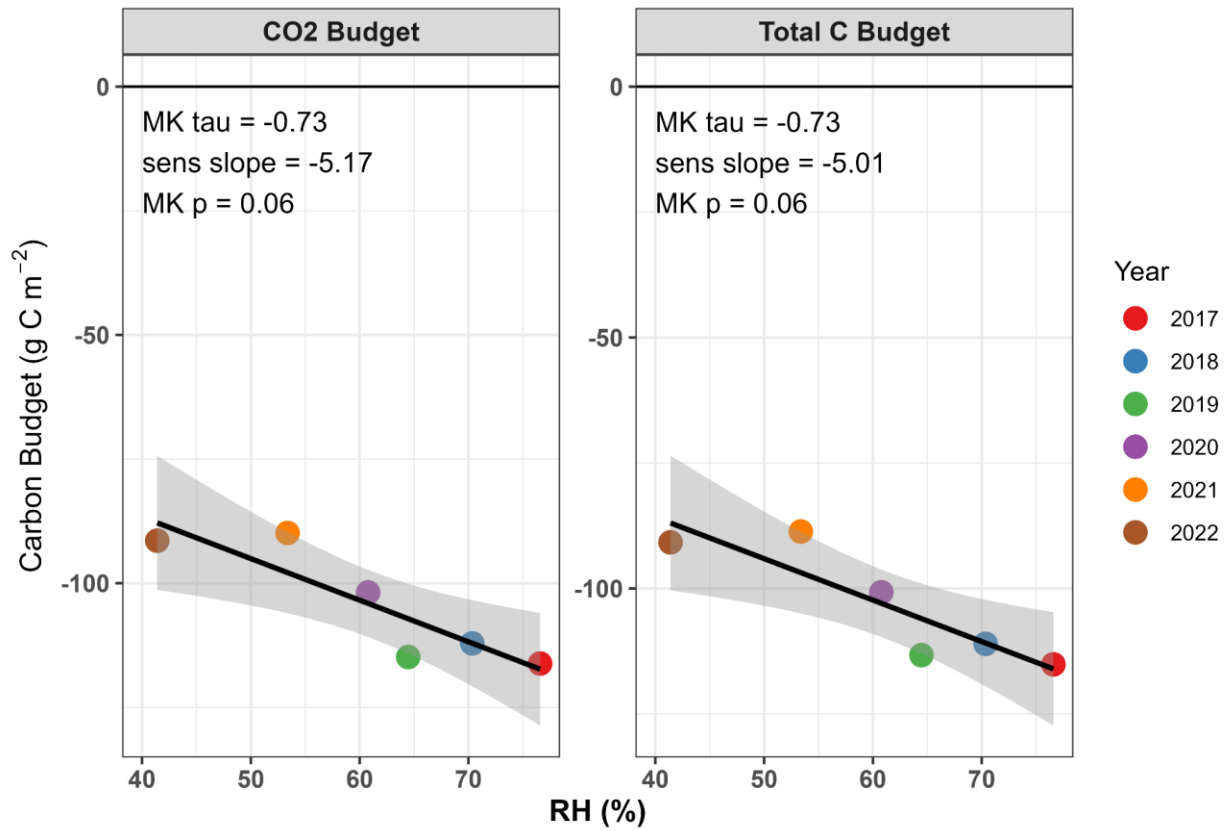


Figure S18. Kendall's tau tests of growing season mean RH vs growing season CO<sub>2</sub> and total carbon budgets with borderline significance. Shaded area represents SE.

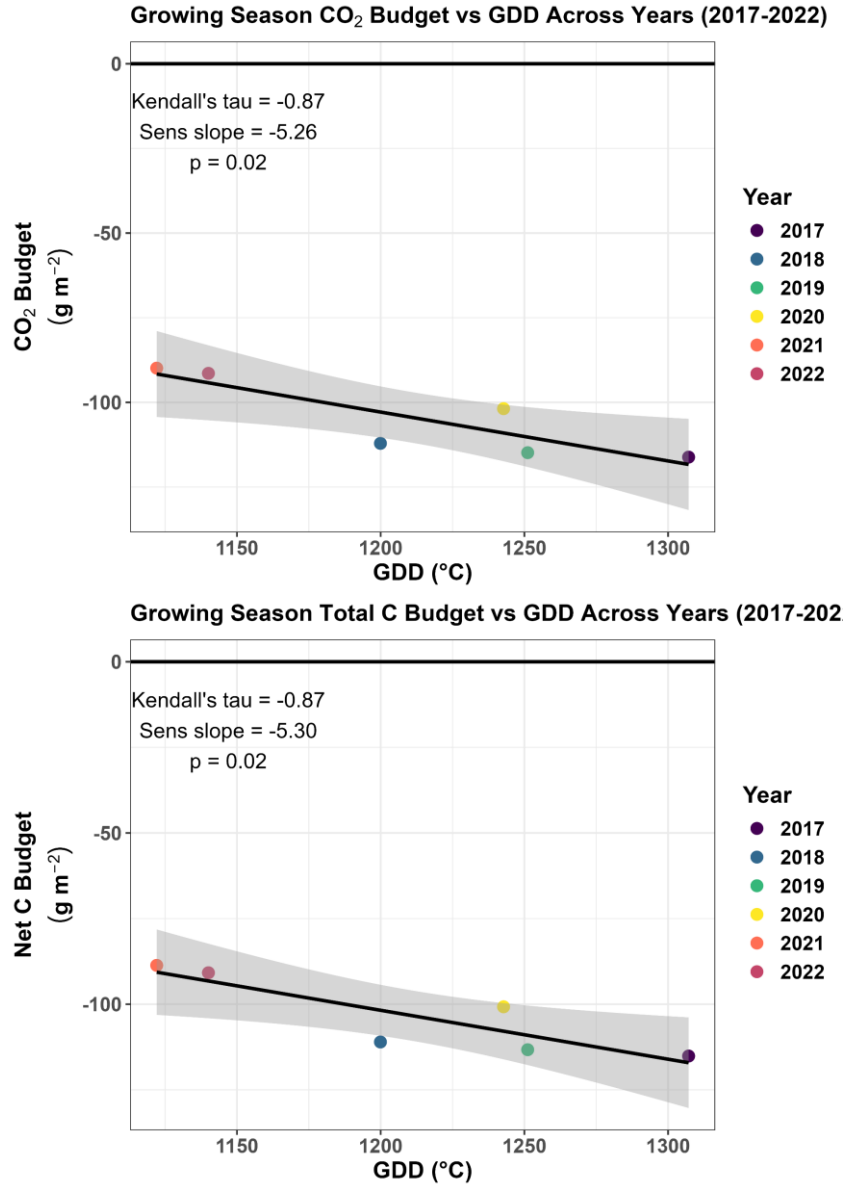


Figure S19. Kendall's tau tests of growing season annual growing degree days (GDD) vs CO<sub>2</sub> and total carbon budgets showing significant increases in carbon uptake with increasing GDD. Shaded area represents SE.

### CO<sub>2</sub> Flux - Growing Season: Significant Relationships

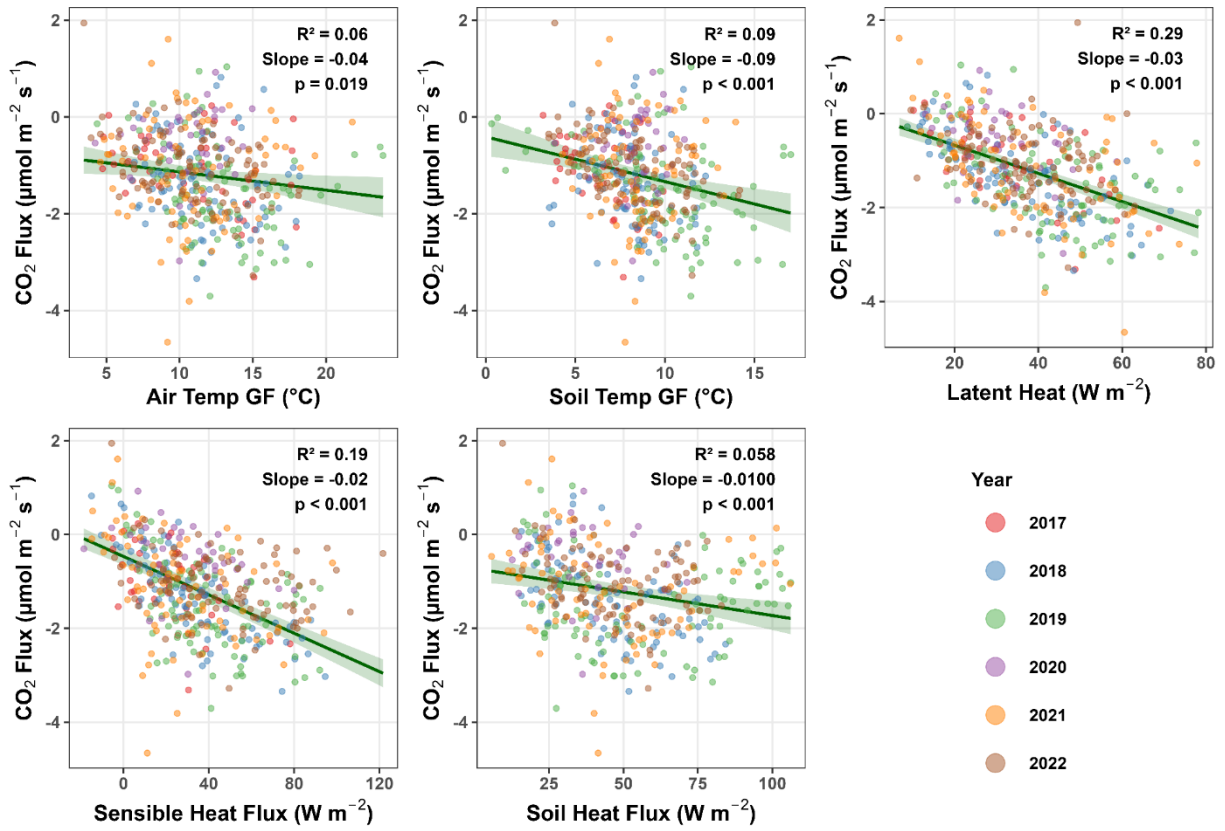
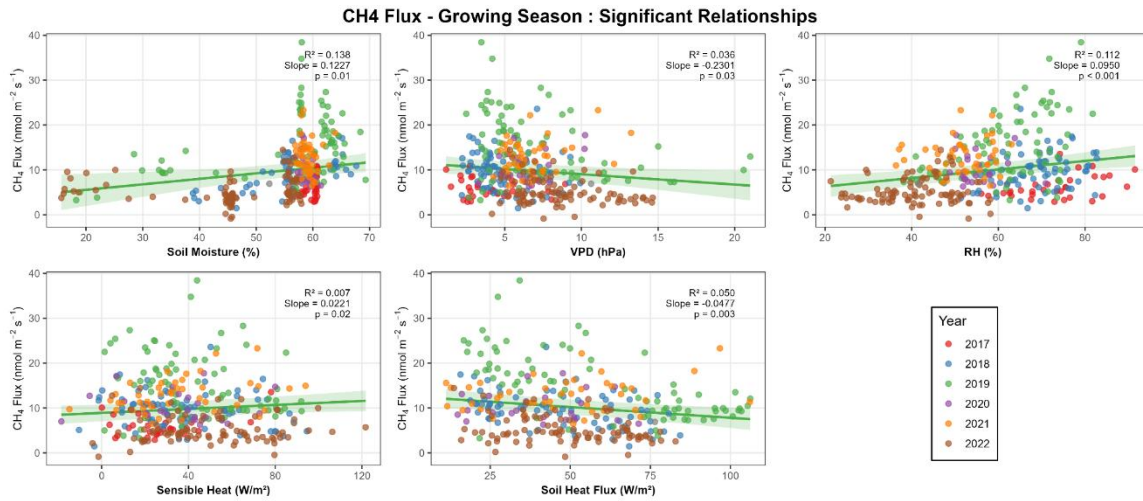
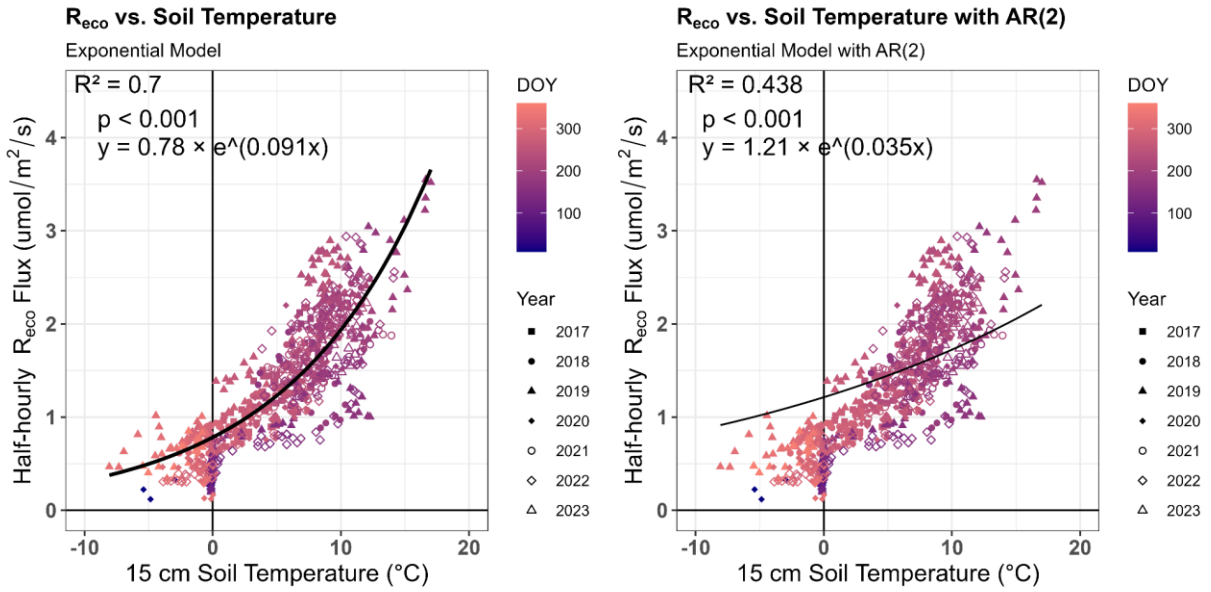


Figure S20. Measured growing season daily means of half-hourly CO<sub>2</sub> fluxes regressed against daily means of meteorological variables. Only regressions with significant slopes are depicted. Shaded areas represent SE.



**Figure S21. Growing season daily means of half-hourly CH<sub>4</sub> fluxes regressed against daily means of meteorological variables. Only regressions with significant slopes are depicted. Shaded areas represent SE.**



**Figure S22.** Exponential model of mean daily R<sub>ECO</sub> and soil temperature across all years and seasons (left). There was heavy autocorrelation that was resolved with an AR(2) structure (right). Both models are presented for comparison.

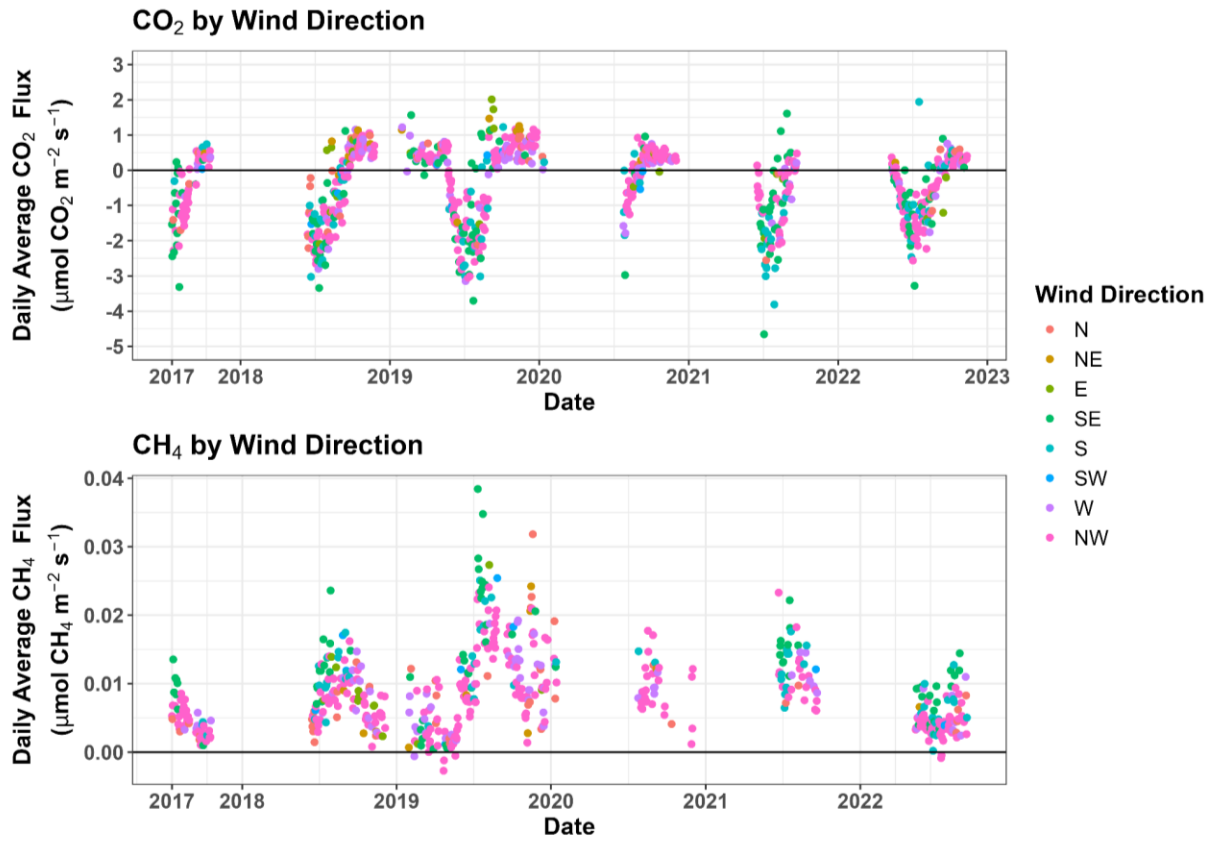
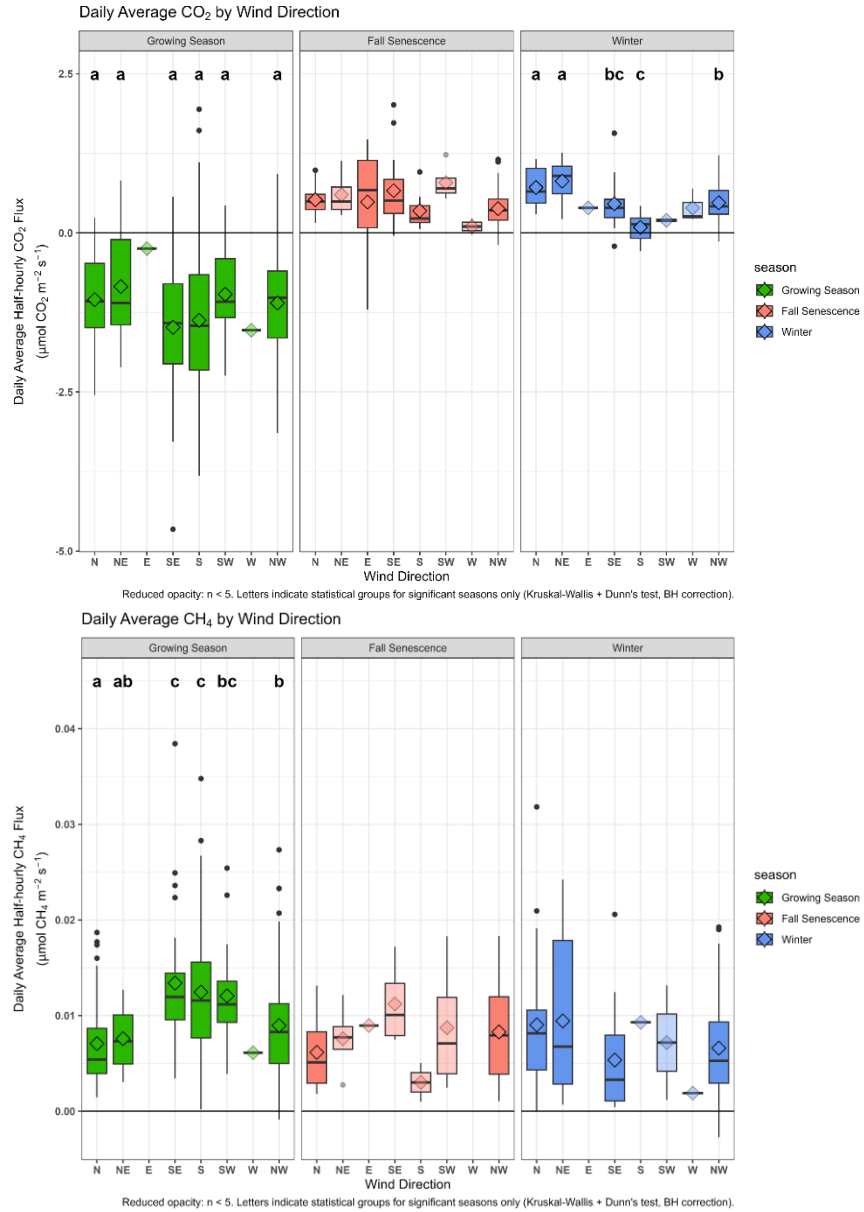


Figure S23. Daily mean CO<sub>2</sub> flux (top) and daily mean CH<sub>4</sub> flux (bottom) in by wind direction.



**Figure S24. Daily mean ( $\pm$ SE) CO<sub>2</sub> flux (top) and daily mean CH<sub>4</sub> flux (bottom) in by wind direction during growing season, fall senescence, and winter (2017 – 2022). Reduced opacity indicates wind directions with less than five wind observations, which were therefore not included in the statistical analyses. Letters represent wind directions within each season with statistically significant differences in C fluxes at  $p < 0.05$ .**

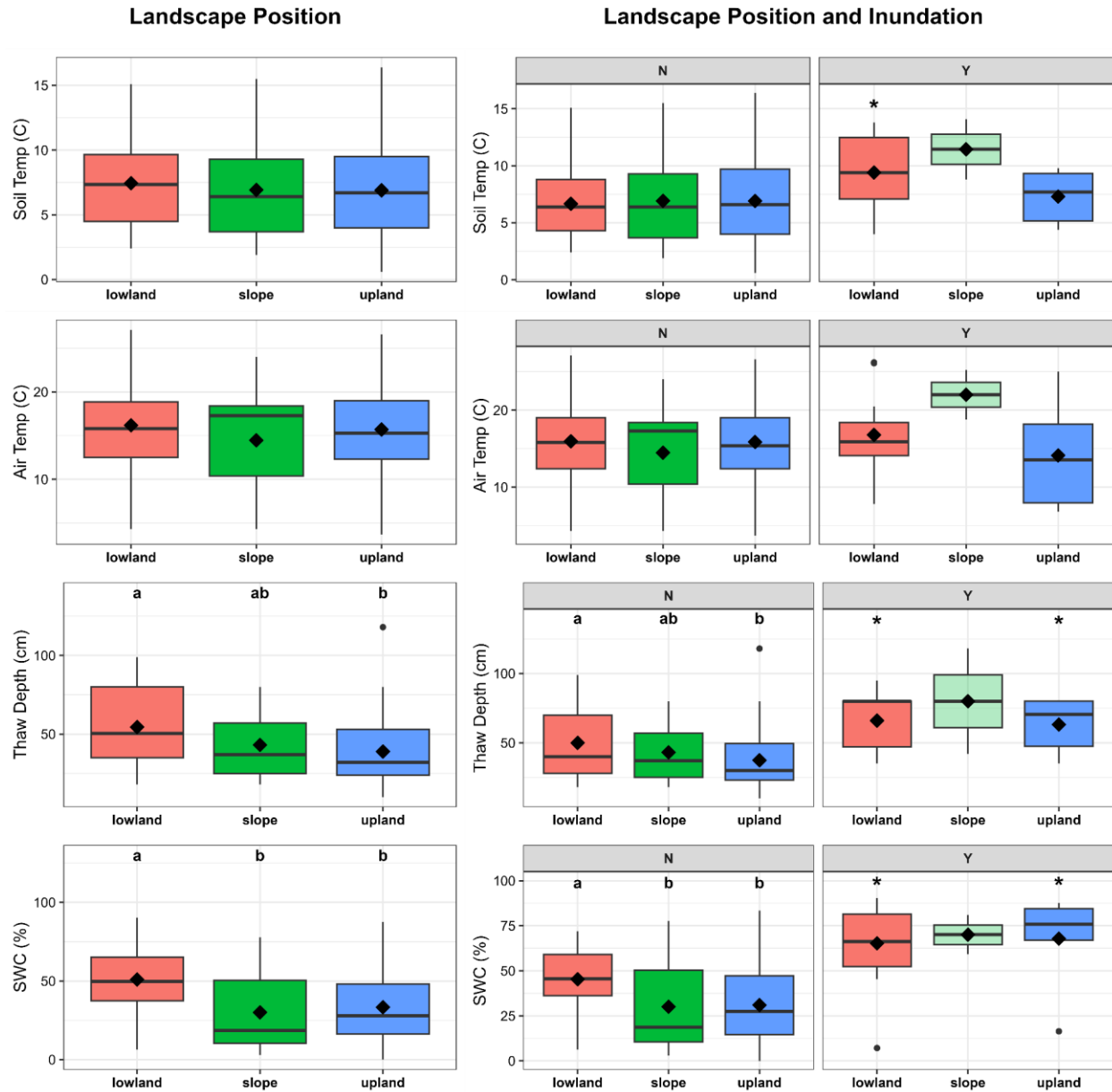


Figure S25. Mean ( $\pm$  SE) environmental variables by landscape position, and landscape position and inundation, as measured flux chambers. Due to low sample size ( $n = 2$ ), inundated slope measurements were excluded from the landscape position figures in the far left panel. The diamond shape represents the mean across the study period. Differing letters represent significant differences in environmental variable means among landscape positions at  $p < 0.05$ , and a “\*” signifies a significant difference between landscape positions that are inundated compared to their non-inundated counterparts.

**Table S4. Comparison of random forest-generated winter budgets and winter budgets calculated based on the growing season daily fluxes.**

<b>Winter-year</b>	<b>RF Winter-year Net C Budget (gC m<sup>-2</sup>)</b>	<b>Adjusted Winter Net C Budget (gC m<sup>-2</sup>)</b>
<b>2017</b>	102.97	94.05
<b>2018 *</b>	<b>101.5</b>	<b>100.63</b>
<b>2019</b>	121.59	114.53
<b>2020</b>	105.33	84.71
<b>2021</b>	130.93	82.17
<b>2022</b>	119.91	93.49