CO_2 flux from tundra lichen, moss, and tussock, Council, Alaska: Assessment of spatial representativeness

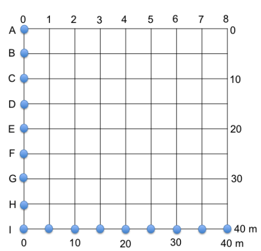
Yongwon Kim[1] (kimyw@iarc.uaf.edu), Namyi Chae[2], Youngjun Yoon[2], and Bangyong Lee[2]

1. International Arctic Research Center (IARC), University of Alaska Fairbanks (UAF), USA,
2. 2. Division of Polar Climate Research, Korean Polar Research Institute (KOPRI), Incheon 406-840, Korea

ABSTRACT

CO_2 flux-measurement in dominant tundra vegetation on the Seward Peninsula of Alaska was examined for spatial representativeness, using a manual chamber system. In order to assess the representativeness of CO_2 flux, a 40 m × 40 m (5-m interval; 81 total points) plot was used in June, August, and September of 2011. Average CO_2 fluxes in lichen, moss, and tussock tundra were 3.4 ± 2.7, 4.5 ± 2.9, and 7.2 ± 5.7 $mgCO_2/m^2/m$ during growing season, respectively, suggesting that tussock tundra is a significant CO_2 source, especially considering the wide distribution of tussock tundra in the circumpolar region. Further, soil temperature, rather than soil moisture, held the key role in regulating CO_2 flux at the study site: CO_2 flux from tussock increased linearly as soil temperature increased, while the flux from lichen and moss followed soil temperature nearly exponentially, reflecting differences in surface area covered by the chamber system. Regarding sample size, the 81 total sampling points over June, August, and September satisfy an experimental average that falls within ±10% of full sample average, with a 95% confidence level. However, the number of sampling points for each variety of vegetation during each month must provide at least ±20%, with an 80% confidence level. In order to overcome the logistical constraints, we were required to identify the site's characteristics with a manual chamber system over a 40 m × 40 m plot and to subsequently employ an automated chamber for spatiotemporal representativeness.

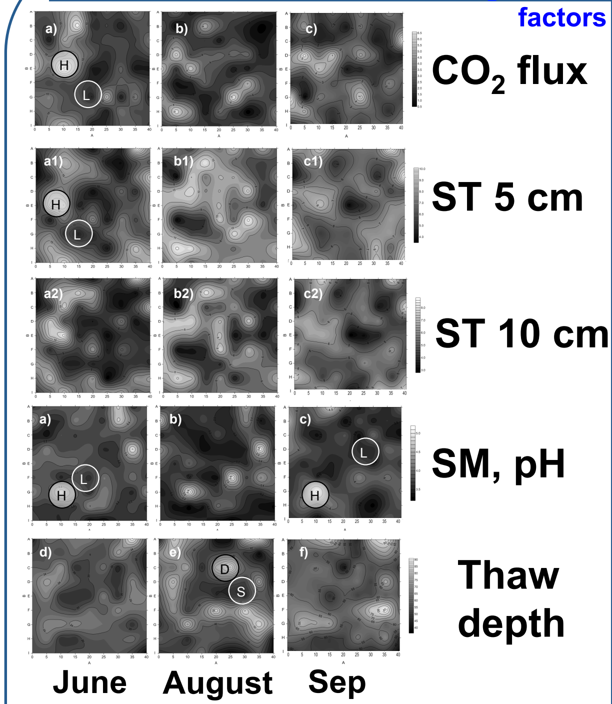
Experimental Method



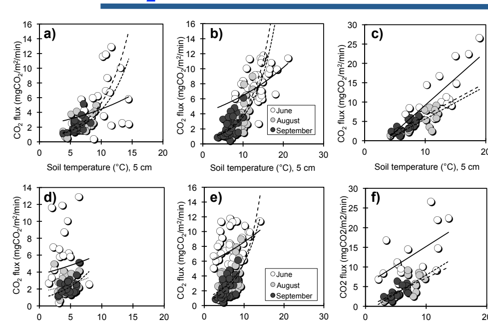
1. **Council: 64°51'38.3" N; 163°42'39.7" W; 45 m.a.s.l.,**
2. **Vegetation: lichen, tussock tundra, sphagnum and feather moss,**
3. **Portable CO_2 efflux-measurement system (NDIR analyzer, pump, laptop) within 81 point (40X40 m; 5-m interval),**
4. **Measurement of soil temperature at 5 and 10 cm, pH, thaw depth, and soil moisture,**

RESULTS AND DISCUSSION

1. Seasonal variations of CO_2 flux and factors



2. CO_2 flux vs environmental factors



3.Q10 and Representativeness

Table 2.Q_{10} values and correlation coefficient between CO_2 flux and soil temperature at 5 and 10 cm below the soil surface in lichen, moss, and tussock during the growing season based on a one-way ANOVA with a 95% confidence level

Vegetation	Month	5 cm			10 cm		
		Q_{10}	R^2	p	Q_{10}	R^2	p
Lichen	June	2.05	0.10	<0.001	1.68	0.01	0.018
	August	8.58	0.36	<0.001	2.47	0.04	<0.001
	September	10.59	0.43	<0.001	6.87	0.32	<0.001
	Total	4.97	0.34	<0.001	1.06	0.01	0.032
Moss	June	1.58	0.26	<0.001	1.54	0.15	0.073
	August	6.59	0.40	<0.001	5.88	0.41	<0.001
	September	7.54	0.28	<0.001	10.10	0.78	<0.001
	Total	5.05	0.62	<0.002	4.46	0.21	<0.001
Tussock	June	2.68	0.54	0.890	2.01	0.33	0.005
	August	8.66	0.68	<0.001	11.70	0.66	0.041
	September	10.74	0.58	<0.001	9.64	0.44	0.008
	Total	6.15	0.73	0.018	5.44	0.39	0.467

To estimate the number of sampling points required for each approach at various degrees of precision at a specific level, the equation $n = [ts/D]^2$ is used, where n is the sampling point requirement, t is the t-statistic for a given confidence level and degrees of freedom, s is the standard deviation of the full samples of measurement, and D is the desired interval about the full sample average in which a smaller sample average is expected to fall.

Table 3. Number of required sampling points for static chamber on different vegetation to achieve different degrees of precision (within±10% to 20% of full sample average) with 80 and 95% confidence level

Month, 2011	Vegetation	No. of actually measured points	CO_2 flux ($mgCO_2/m^2/m$) Average	S.D.	80% Within ±10%	80% Within ±20%	95% Within ±10%	95% Within ±20%
June	Lichen	22	5.7	3.6	70	17	173	43
	Moss	43	7.8	2.2	13	3	31	8
	Tussock	16	12.9	6.2	42	10	105	26
	Average	81	8.0	3.6	28	7	64	16
August	Lichen	24	2.5	1.2	40	10	99	25
	Moss	41	3.3	1.7	44	11	102	25
	Tussock	16	5.1	2.7	51	13	129	32
	Average	81	3.3	1.3	21	5	50	13
September	Lichen	23	2.3	0.9	27	7	66	16
	Moss	43	2.5	1.2	38	9	89	22
	Tussock	15	3.5	1.5	33	8	85	21
	Average	81	2.6	0.8	13	3	31	8

CONCLUSIONS

1) **The monthly average CO_2 flux in June, August, and September decreased 8.0 ± 3.6, 3.3 ± 1.3, and 2.6 ± 0.8 $mgCO_2/m^2/m$ and followed soil temperature's decrease over time, which is a more important factor in modulating the flux than soil moisture,**
2) **Tussock tundra is a greater atmospheric CO_2 source in the tundra ecosystem: surface area in tussock covered by the chamber was two-fold higher than in lichen and moss,**
3) **A total of 81 sampling points in June, August, and September are required for the manual chamber system to gain an experimentally spatial representativeness of the flux that falls within ±10% of full sample average with 95% confidence level**

ACKNOWLEDGEMENTS

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