B31D-0580 Continuous monitoring of soil gas efflux with Forced Diffusion (FD) chamber technique in a tundra ecosystem, Alaska

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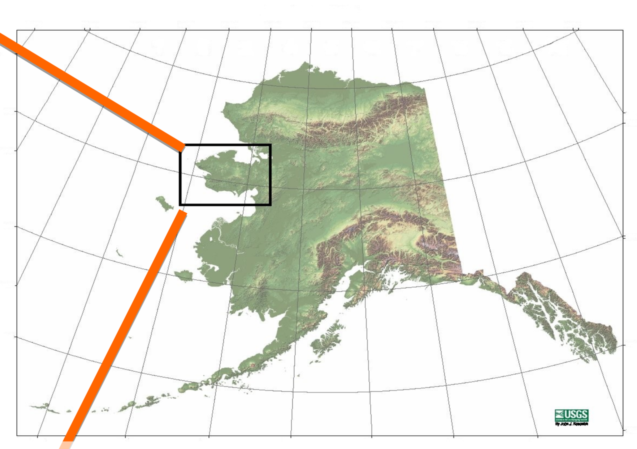
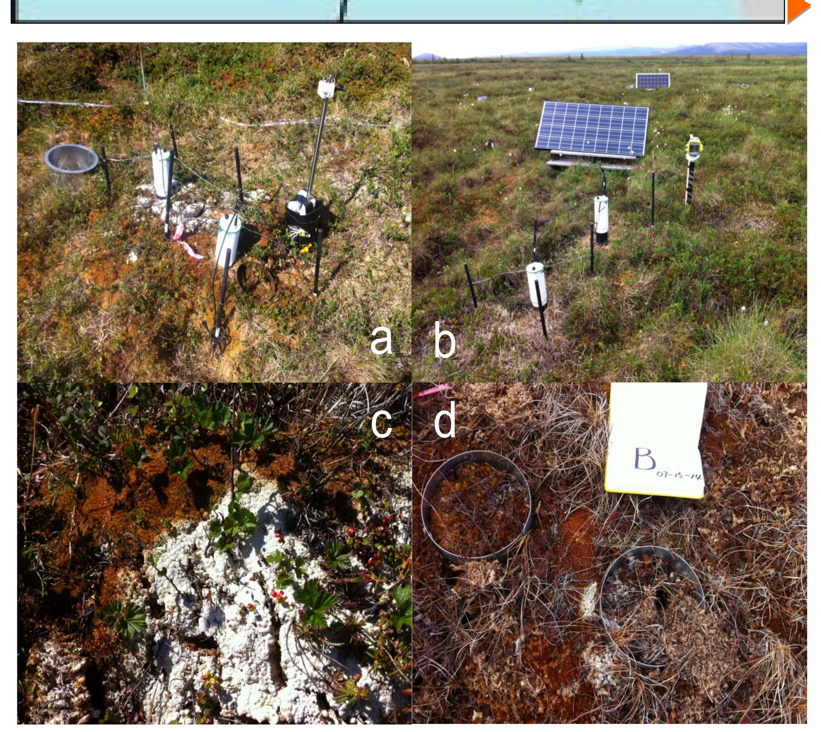
ABSTRACT

We deployed the FD chamber system in a tundra ecosystem over the discontinuous permafrost regime of Council, Alaska. The representative understory plants are tussock (17 %), lichen (32 %), and moss (51 %), within a 40 × 40 m plot at an interval of five meters (81 points total) for efflux-measurement by dynamic chamber. The FD chamber monitored soil CO_2 effluxes from moss, lichen, and tussock regimes at an interval of 30 min during the growing season of 2015. As the results, mean soil CO_2 effluxes in intact and infected sphagnum moss, lichen, and tussock were 0.42 ± 0.17, 0.39 ± 0.22, 0.76 ± 0.21, and 0.87 ± 0.41 μmol/m²/s during June 25 to September 21 2015, respectively. Mean simulated soil CO_2 efflux normalized by air temperature of 10°C were 0.40 ± 0.17, 0.36 ± 0.16, 0.77 ± 0.13, and 0.85 ± 0.30 μmol/m²/s from four plants, respectively, suggesting there are not significant differences between measured and simulated CO_2 effluxes.

During the measured air temperature from January 1 to October 3 2015, snow-covered (**Jan 1 to May 8**) and snow-free (**May 8 to October 3**) period carbon emission rates from intact and infected sphagnum, lichen, and tussock were **8.0, 6.9, 47.0**, and **22.6** gC/m²/period, and **59.4, 53.4, 115.0**, and **126.7** gC/m²/period. We found the snow-free period carbon contributes **88.1, 88.6, 71.0**, and **84.8%** of annual carbon emission rates from intact and infected sphagnum, lichen, and tussock, respectively.

SITE DESCRIPTION





Site Information

1. Council: 64°51'38.3" N; 163°42'39.7" W; 45 m.a.s.l.;
2. Vegetation: lichen, tussock tundra, and sphagnum moss;
3. Forced Diffusion (FD) CO_2 efflux system in dominant vegetation (a and b);
4. Summer CO2 exchange rates within 81 points (40X40m);
5. Sphagnum moss: Intact (d) and infected-lichen (c);
6. Environmental data: temperature of air and soil, soil moisture; thaw depth; snow depth, albedo and NDVI-b, and time-lapsed camera.

RESULTS AND DISCUSSION

1. Annual Variation of Thaw Depth

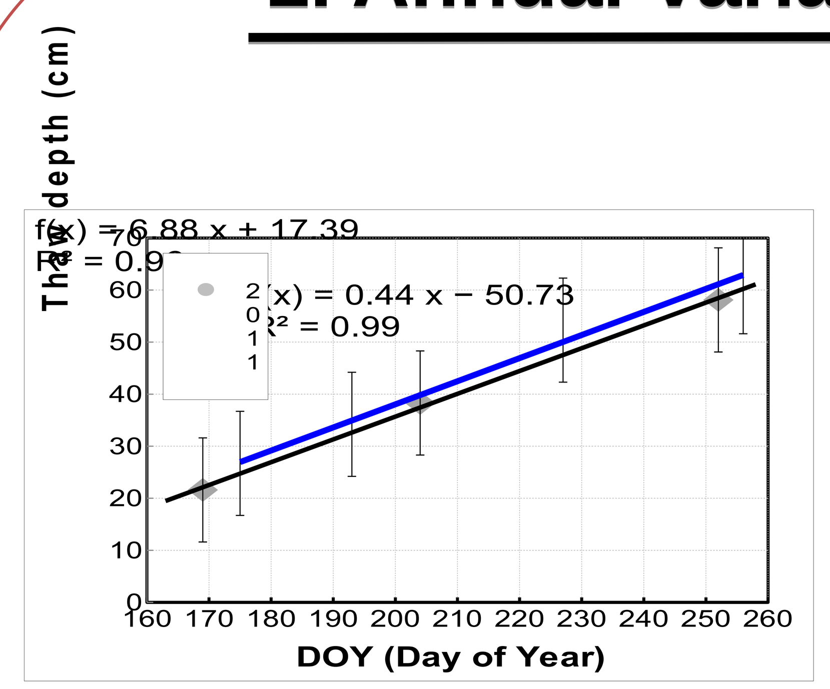


Fig 1. Annual variation of thaw depth in 81 points within a 40 m X 40 m plot in Council, Seward Peninsula, Alaska during the growing seasons of 2011-15. The gradient is from 0.429 cm/d in 2011 to 0.444 cm/d 2014; however, thawing rate in 2015 is much faster than others, suggesting there is a significant difference.

2.Temporal Variations of Data and CO_2

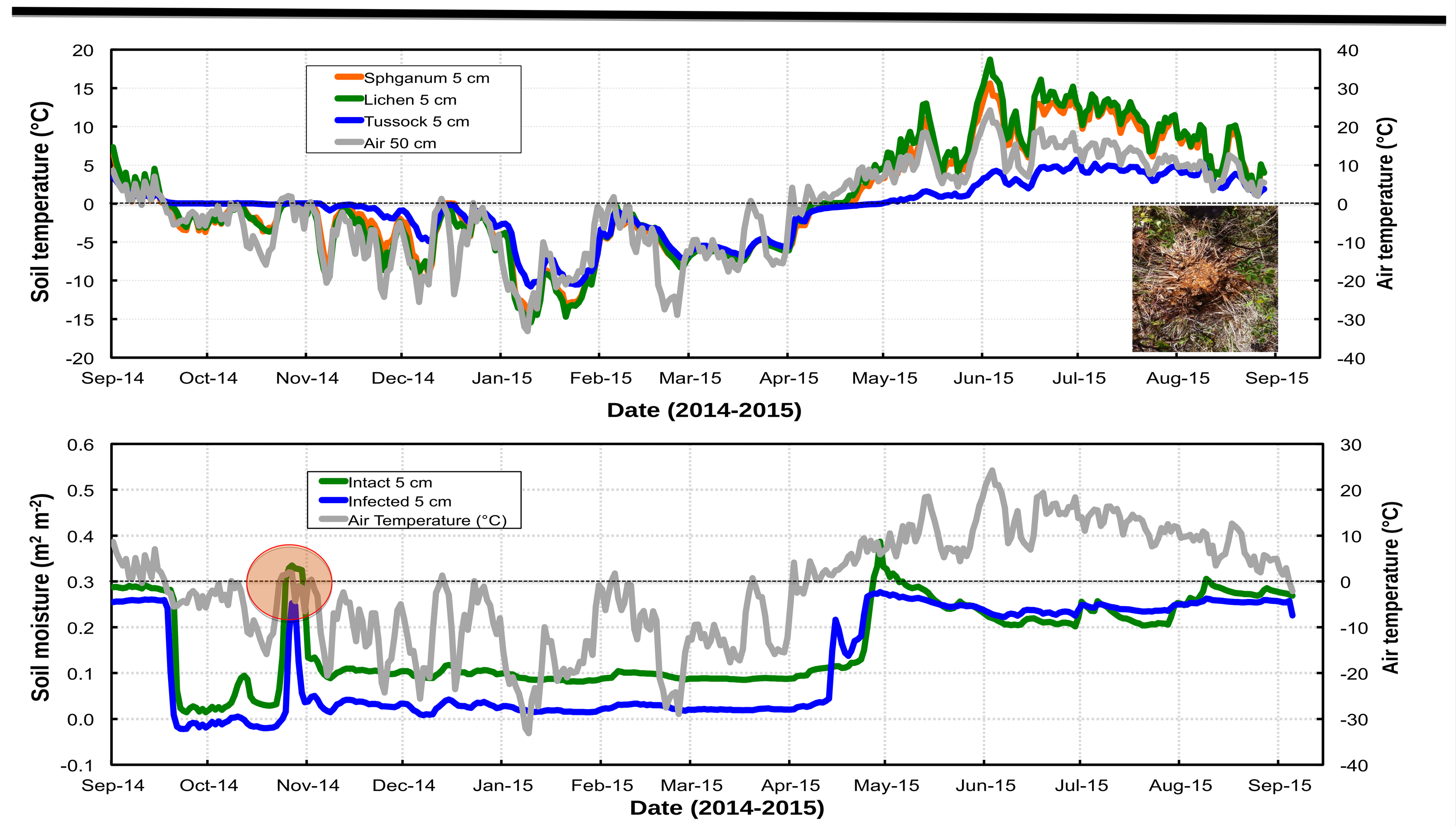


Fig 2. Temporal variations in (a) air temperature and soil temperature at 5 cm below the surface, and (b) soil moisture at 5 cm during 2014-15. Soil temperature and soil moisture sensitively depend on change in air temperature. Further, soil temperature in tussock is much slow response to air temperature, suggesting that the cotton grass (*Eriophorum*) is much dense, compact community during snow-free period.

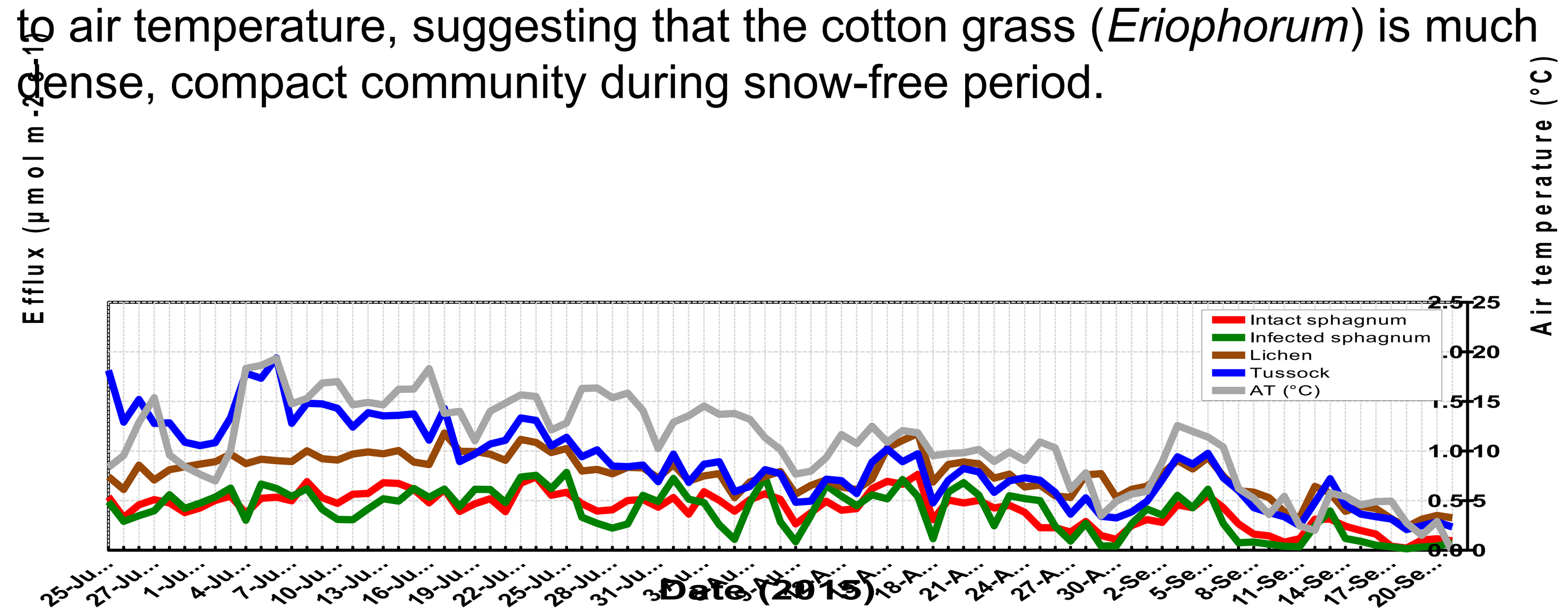


Fig 3. Temporal variations in soil CO_2 efflux from intact sphagnum, infected sphagnum, lichen, and tussock during vegetation growing period. The difference between intact and infected sphagnum is not significant. However, CO_2 efflux in tussock is greatly dependent on change in air temperature. Interestingly, CO_2 efflux in lichen is much higher than those in sphagnum regime (Kim et al., 2014).

3. CO_2 and Environmental factors

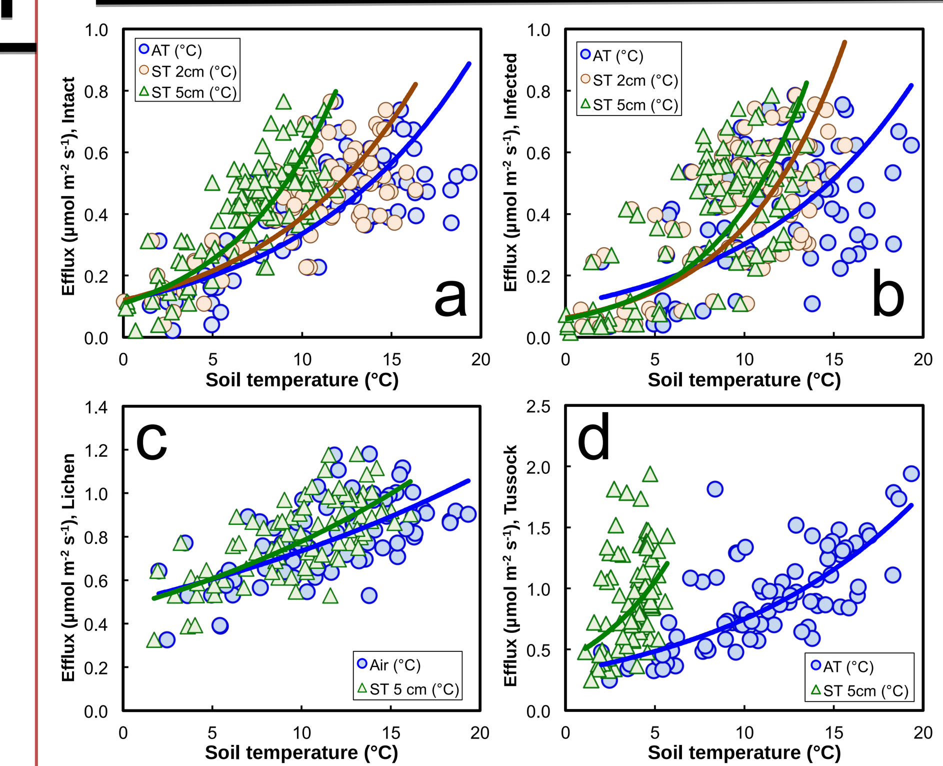


Table 2. Q_{10} values and correlation coefficient between CO_2 efflux and temperature at air, 5 and 10 cm below the soil surface in lichen, sphagnum, and tussock of tundra ecosystem, Seward Peninsula, Alaska from June 25 to September 22, 2015 based on a one-way ANOVA with 95% confidence level*

Dominant Plants		Temperature (°C)	b	Q_{10}	R^2 *
Intack sphagnum	a	Air	0.059	1.81	0.14
		Soil 2 cm	0.118	3.25	0.63
		Soil 5 cm	0.167	5.30	0.63
Infected sphagnum	b	Air	0.107	2.91	0.32
		Soil 2 cm	0.175	5.75	0.62
		Soil 5 cm	0.196	7.08	0.59
Lichen	c	Air	0.039	1.48	0.40
		Soil 5 cm	0.050	1.64	0.49
Tussock	d	Air	0.087	2.38	0.60
		Soil 5 cm	0.189	6.63	0.21

* $p < 0.05$

Fig 4. Responses from CO_2 effluxes to air temperature and soil temperature at 2 and 5 cm below the surface. Q_{10} value calculated by $Q_{10} = exp (b*10)$, where b is constant from each equations in sphagnum, lichen, and tussock.

Table 1. Hourly mean, standard deviation (stdev), and coefficient of variance (%) of CO_2 efflux (μmol m^{-2} s^{-1}), and temperature (°C) of ambient, soil 2 and 5 cm in sphagnum, lichen, and tussock of tundra ecosystem of Council, Seward Peninsula, Alaska

Month 2015	CO_2 efflux	Sphagnum (μmol m^{-2} s^{-1}) Intact	Infected	Temperature (°C) Ambient	Soil 2cm	Soil 5 cm	Lichen (μmol m^{-2} s^{-1})	Temperature (°C) Soil 5 cm	Tussock (μmol m^{-2} s^{-1})	Temperature (°C) Soil 5 cm
June 25 to 30	Mean	0.45	0.42	10.70	10.46	7.53	0.76	9.50	1.38	2.77
	Stdev *	0.23	0.26	5.00	4.51	2.01	0.17	3.19	0.36	0.55
	CV (%) **	52	62	47	43	27	23	34	26	20
July 1 to 31	Mean	0.53	0.51	14.58	12.95	9.59	0.93	12.65	1.22	4.39
	Stdev	0.28	0.28	5.62	4.59	2.39	0.23	3.79	0.40	1.03
	CV (%)	53	55	39	35	25	24	30	32	23
August 1 to 31	Mean	0.42	0.41	10.14	9.27	7.24	0.74	9.07	0.68	3.96
	Stdev	0.26	0.29	4.83	4.24	2.29	0.22	3.74	0.29	0.86
	CV (%)	60	70	48	46	32	30	41	43	22
September 1 to 22	Mean	0.23	0.19	5.43	3.68	3.08	0.53	5.63	0.49	2.40
	Stdev	0.20	0.22	5.38	4.18	2.49	0.24	3.87	0.28	0.93
	CV (%)	88	117	99	113	81	45	69	59	39
Total (n=2149)	Mean	0.41	0.39	10.58	9.28	7.07	0.76	9.87	0.87	3.77
	Stdev	0.27	0.30	6.29	5.60	3.41	0.27	4.50	0.47	1.18
	CV (%)	66	75	42	60	48	36	46	54	31

* denotes the standard deviation.
** indicates the coefficient of variance.

Normalization of air temperature 10°C as following equations;

$SR = b_0*exp (b_1*T)$, and

$R_i = R_{10}*Q_{10}^{[(T-10)/10]}$

where b_0 and b_1 are constants, R_{10} is normalized to a temperature of 10°C, and R_i is simulated CO_2 efflux (μmol/m²/s) at air temperature, T, (°C).

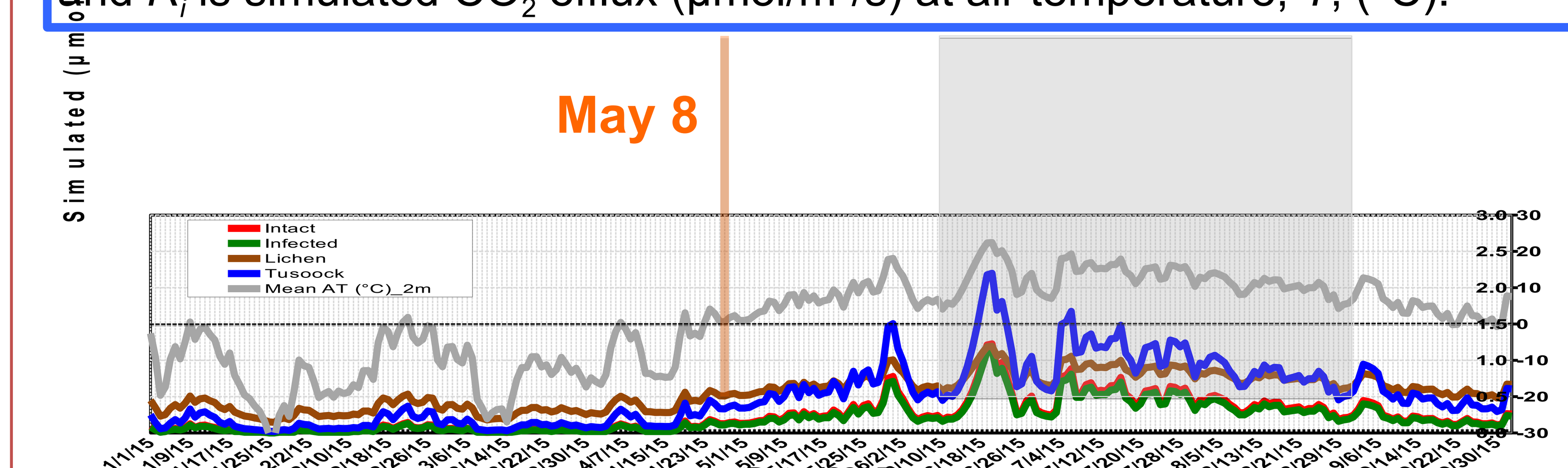


Fig 5. Temporal variations of simulated CO_2 effluxes from sphagnum, lichen, and tussock in tundra ecosystem, Council, Seward Peninsula, Alaska from January to September 2015. Shaded shows in-situ measuring period.

ACKNOWLEDGEMENTS

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