Winter and spring soil CO_2 efflux along trans-Alaska pipeline, Alaska

Yongwon Kim

International Arctic Research Center, University of Alaska Fairbanks, USA

ABSTRACT

3-year winter and spring soil CO_2 efflux was conducted in several sites along the trans-Alaska pipeline, Alaska during winter and spring seasons of 2010 to 2012. During the spring, the snow was disappeared mostly fast in the surrounding of tree such as white spruce (*Picea glauca*) and black spruce (*Picea mariana*) in boreal forest of Alaska. On the other hand, in tundra, the snow-covered tussock tundra was firstly exposed due to the topography. In white spruce forest, 4-directional soil CO_2 efflux is higher east, south, west, and north in turn. Soil temperature is a crucial role in determining soil CO_2 efflux, indicating a exponential curve. The CO_2 efflux is related to with and without snow cluster that formed by sublimation. However, the efflux has much lower relation to snow depth. In exposed soil in spring of 2011, the CO_2 efflux is similar to the growing season CO_2 efflux. 3-yr spring CO_2 efflux corresponds to 22-46% of annual CO_2 efflux along the trans-Alaska pipeline, Alaska during the spring seasons.

Methodology

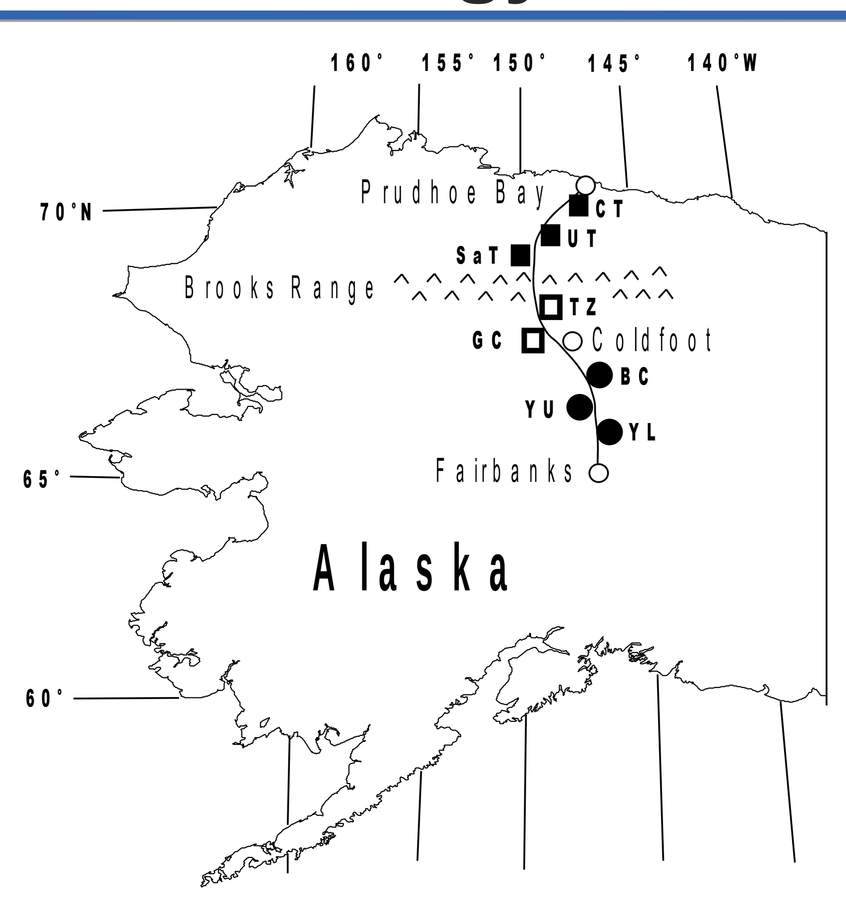

Fig. 1. Site locations along the trans-Alaska pipeline, during spring seasons of 2010 to 2012. Solid circles are black spruce forest sites, open squares are white spruce forest sites, and solid squares denote tundra sites.

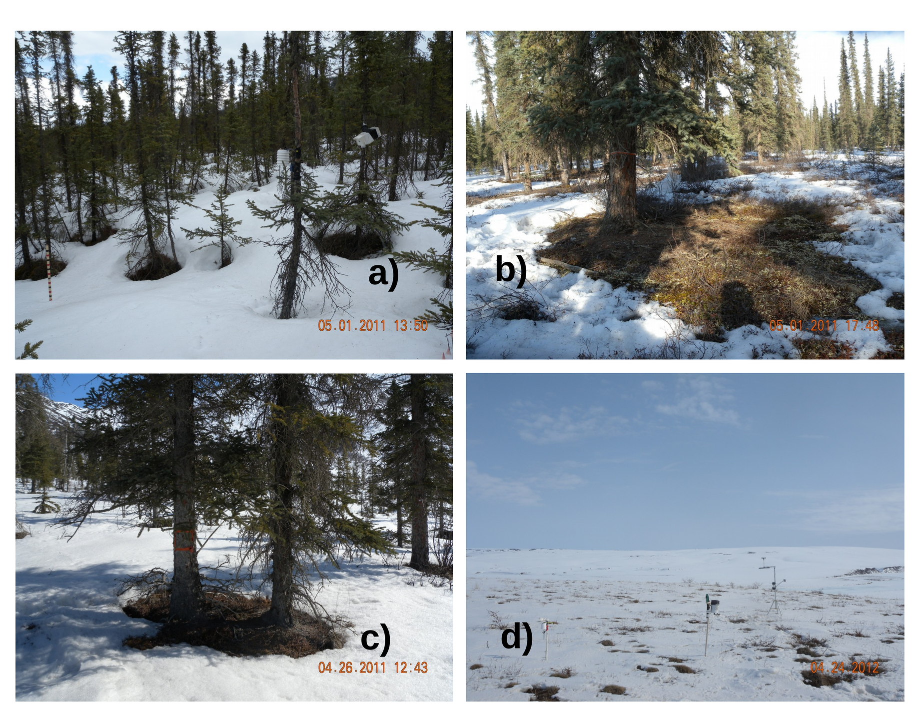

Fig. 2. Figure 2. Site views in a) black spruce forest site (BC), b) and c) white spruce sites (GC and TZ), and d) tundra site (UT) during spring of 2011. Exposed soils were found in surrounding stems and tree well (a to c) and in tussock (d) due to fast snow-melting by long wave radiation for nighttime.

Black spruce (Picea mariana) site: YL, YU, and BC,
White spruce (Picea glauca) site: GC and TZ,
Tundra site: SaT, UT, and CT
Observation period: winter/spring seasons of 2010 to 2012

Results and Discussion

1. Temperature

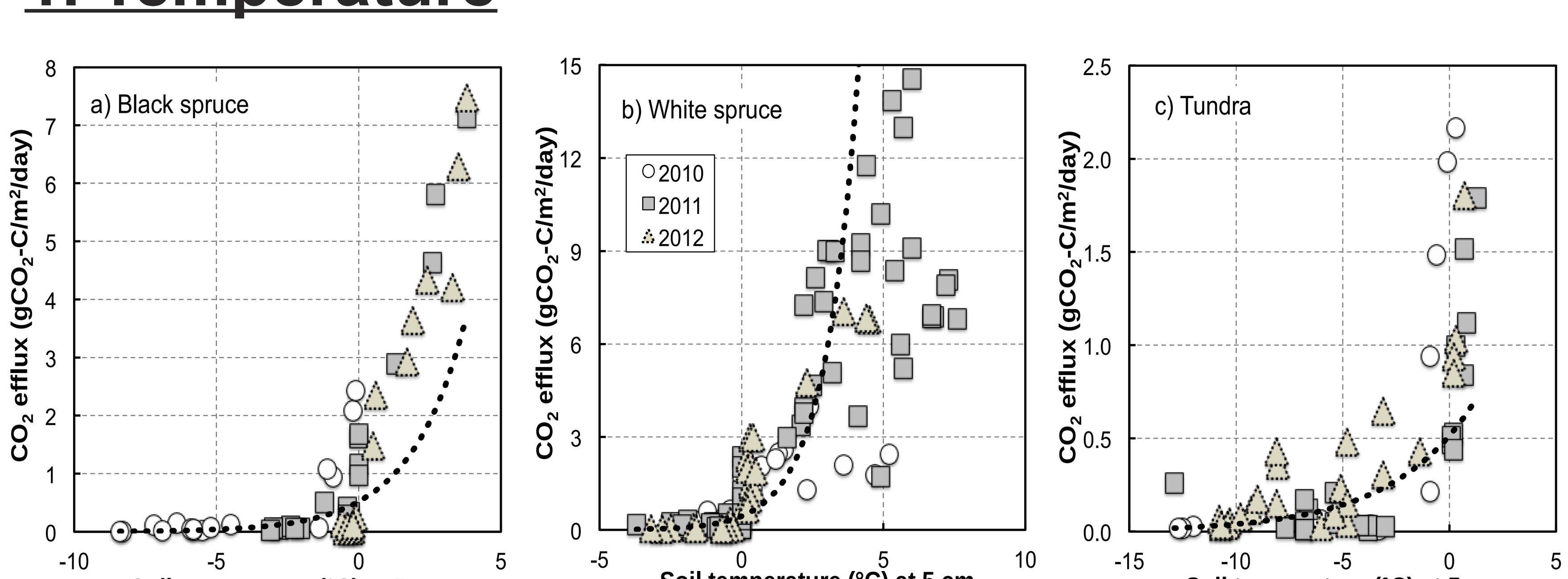

Fig. 3. Responses of spring CO_2 efflux on soil temperature at 5 cm below the surface in a) black spruce forest sites, b) white spruce forest sites, and tundra sites during the spring of 2010 to 2012. The dotted curves denote the 3-year exponential relationship between spring CO_2 efflux and soil temperature.

2. Four direction in white spruce

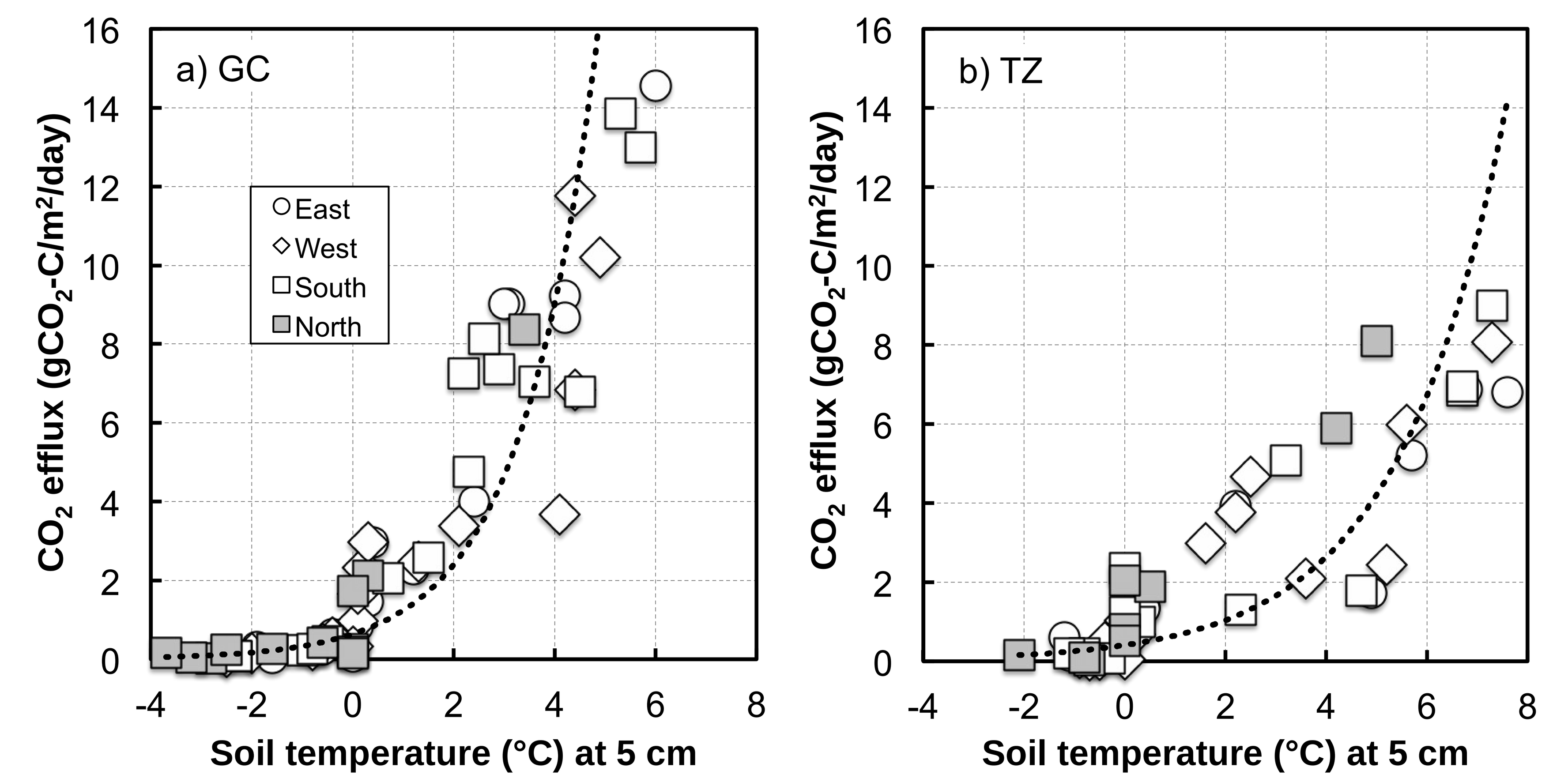

Fig. 4. Responses of spring CO_2 efflux on soil temperature at 5 cm below the surface measured in four-direction from the stem of white spruce in a) GC and b) TZ sites during the spring. The dotted curves denote the 3-year exponential relationship between spring CO_2 efflux and soil temperature.

3. Snow depth and cluster

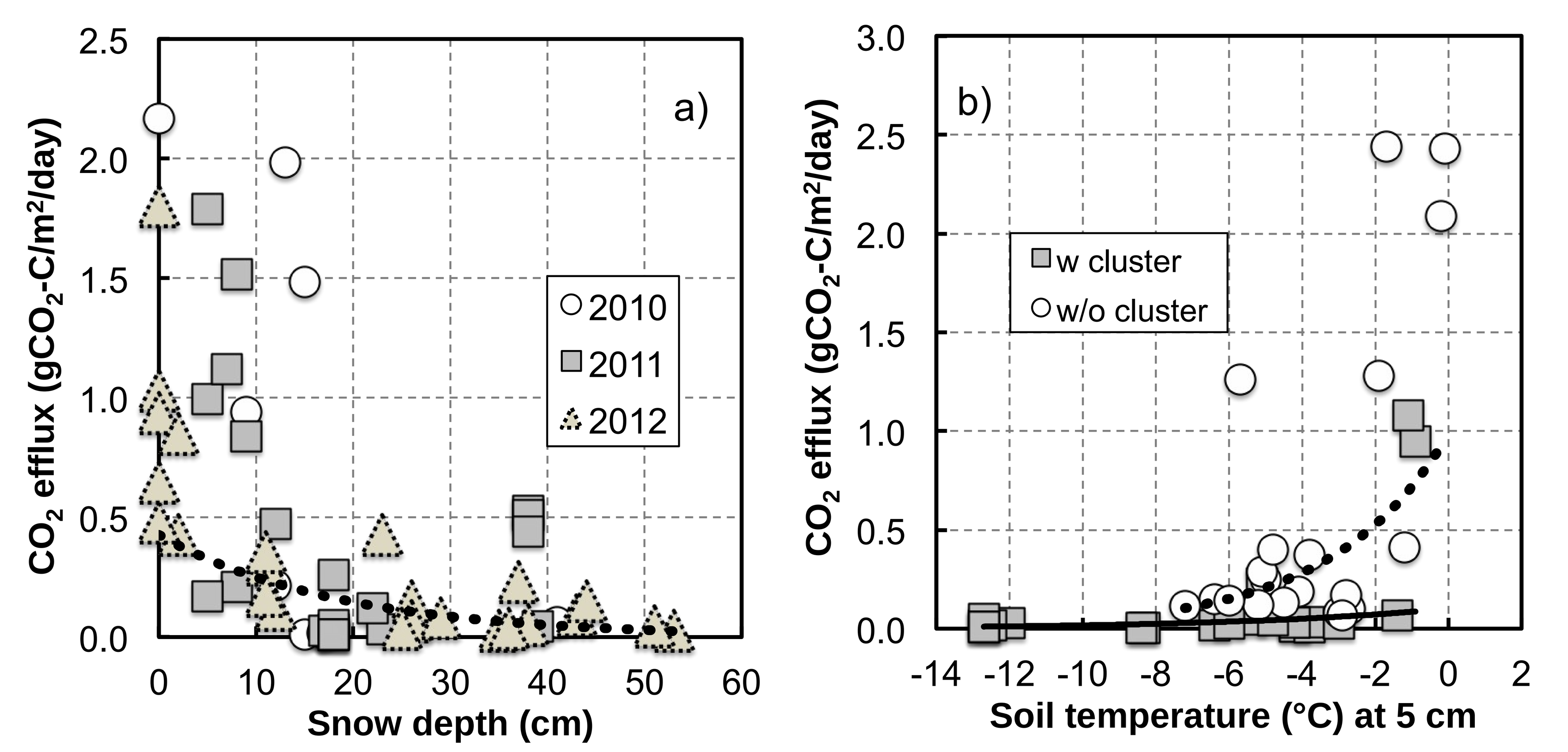

Fig. 5. Responses of spring CO_2 efflux on a) snow depth and b) soil temperature at 5 cm below the surface with and without cluster in tundra sites during the spring. The dotted curves denote the 3-year exponential relationship between spring CO_2 efflux and a) snow depth and b) soil temperature after the removal of cluster, and the line in b) shows the relationship between the efflux and soil temperature

4. Annual soil CO_2 efflux vs soil temperature

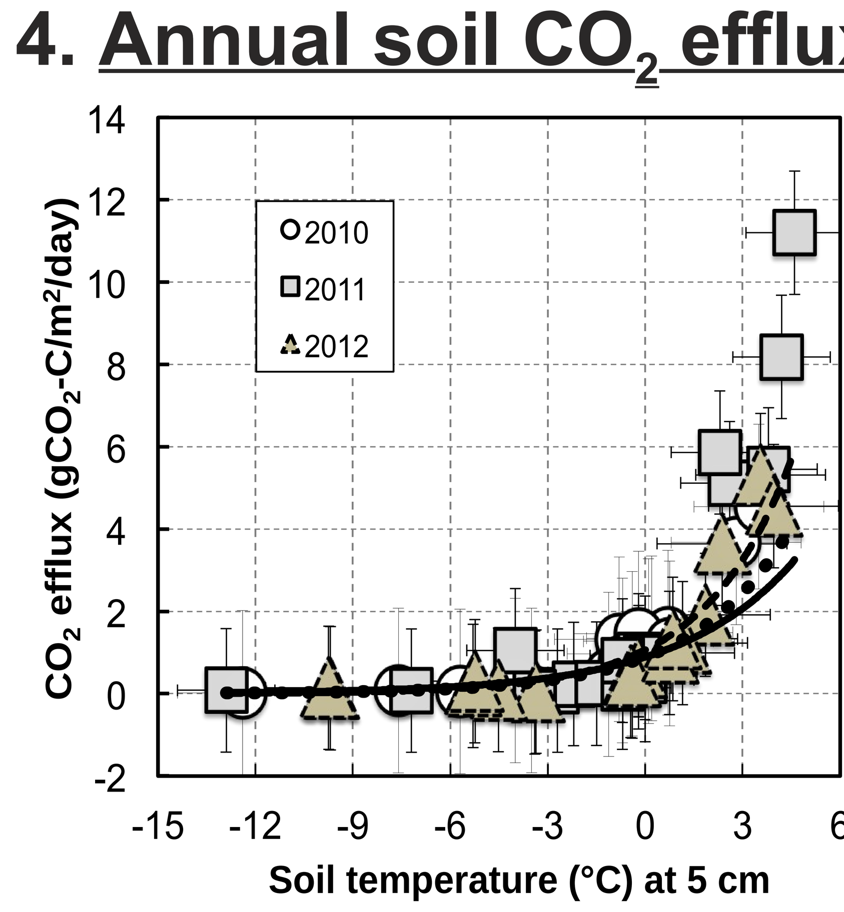

Fig. 6. Responses of spring CO_2 efflux on soil temperature at 5 cm below the surface in whole sites during the spring seasons of 2010 and 2012. The dashed, dotted and linear curves shows 2010, 2011 and 2012, respectively.

Table 2 Constants and correlation coefficients in exponential equation of soil CO_2 efflux on soil temperature at 5 cm below the surface in white spruce, black spruce and tundra sites across haul road of Alaska during spring seasons of 2010 to 2012, which the equation is as $CO_2 = a \exp(b\, ST_5)$, based on a one-way ANOVA at the 95% confidence level

Year	number	Whole					White spruce					Black spruce					Tundra				
		a	b	R^2	Q_{10}*	*p*	a	b	R^2	Q_{10}*	*p*	a	b	R^2	Q_{10}*	*p*	a	b	R^2	Q_{10}*	*p*
2010	49	1.064	0.373	0.90	41.7	<0.001	0.766	0.343	0.53	31	0.075	1.414	0.588	0.77	358	0.0125	0.588	0.310	0.59	22.2	0.0030
2011	100	0.890	0.337	0.61	29.1	<0.001	0.530	0.506	0.73	158	0.002	0.664	0.841	0.90	4492	0.0083	0.379	0.290	0.40	18.2	<0.001
2012	67	0.889	0.282	0.72	16.8	0.0015	0.448	0.851	0.66	4964	0.007	0.143	1.248	0.77	263024	<0.001	0.793	0.254	0.62	12.7	<0.001
Total	216	0.937	0.328	0.72	26.6	<0.001	0.525	0.531	0.67	202	<0.001	0.522	0.512	0.72	167	<0.001	0.515	0.256	0.45	12.9	<0.001

* Q_{10} is calculated from the equation (3).

ACKNOWLEDGEMENTS

This research was conducted under the IARC-JAXA Information System (IJIS) project with funding by the Japan Aerospace Exploration Agency (JAXA), and under the JAMSTEC-IARC Collaboration Study (JICS) with funding provided by the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), through a grant to the International Arctic Research Center (IARC). We thank Mr. Nate Bauer of IARC, University of Alaska Fairbanks (UAF) for constructive editorial revisions of the manuscript.