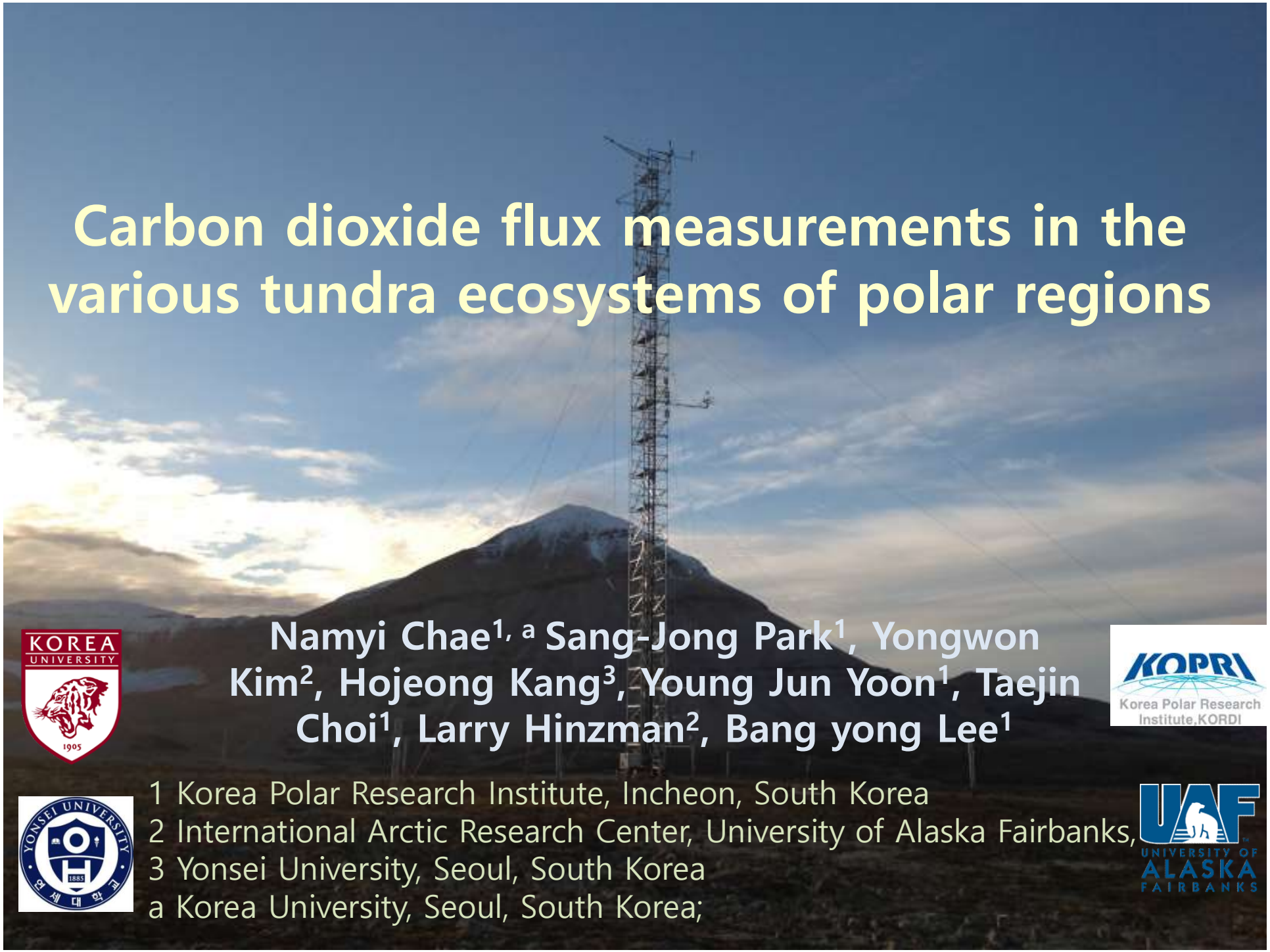
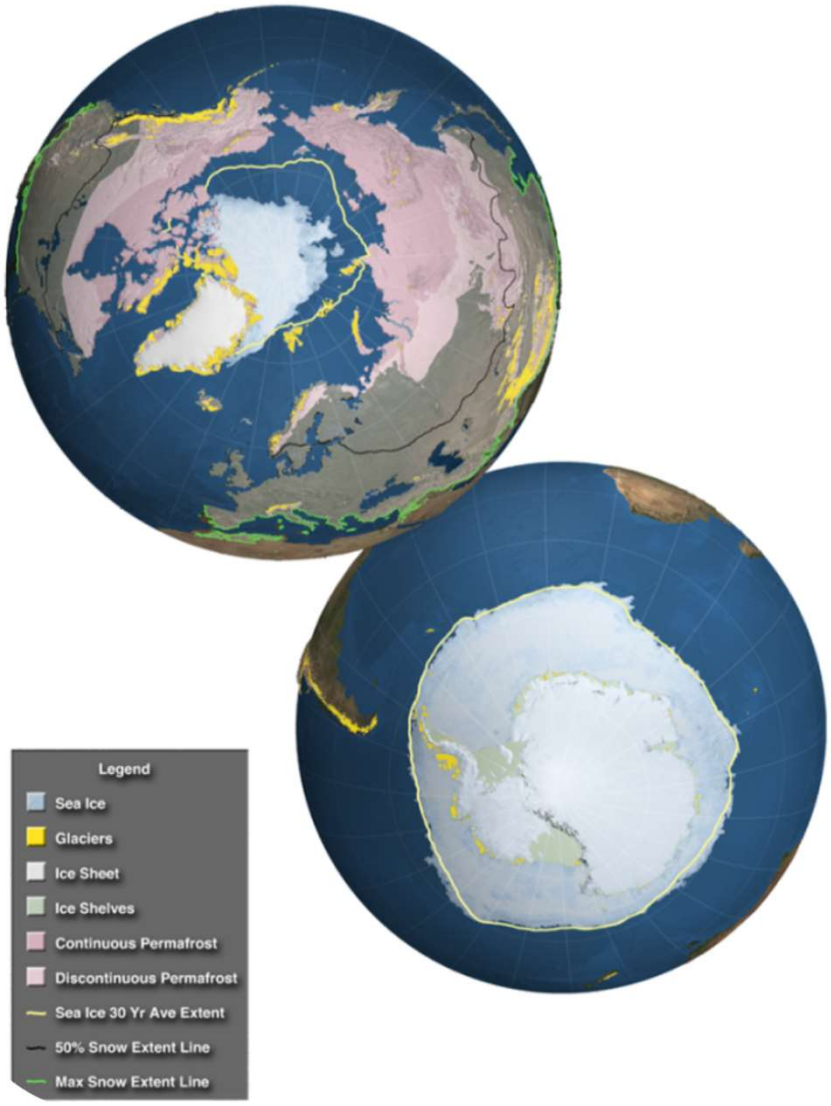


Carbon dioxide flux measurements in the various tundra ecosystems of polar regions

Namyi Chae[1, a] Sang-Jong Park[1], Yongwon Kim[2], Hojeong Kang[3], Young Jun Yoon[1], Taejin Choi[1], Larry Hinzman[2], Bang yong Lee[1]

1 Korea Polar Research Institute, Incheon, South Korea
2 International Arctic Research Center, University of Alaska Fairbanks,
3 Yonsei University, Seoul, South Korea
a Korea University, Seoul, South Korea;

Climate Change in Polar Regions



- **Increasing temperature ~0.6 °C / 10y**

➢ Decreasing snow cover area

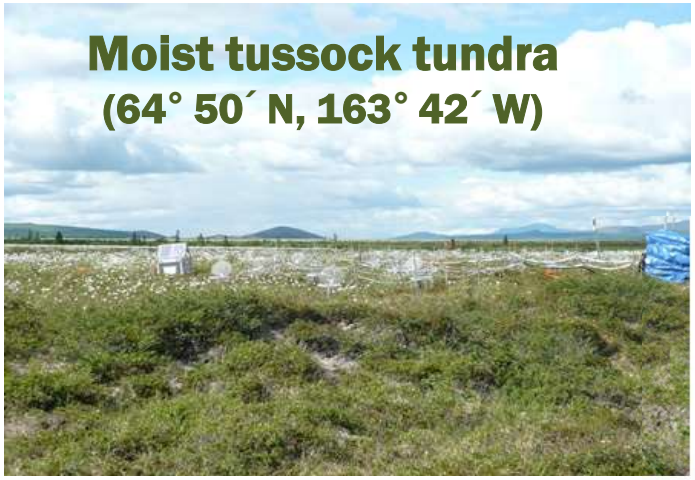
➢ Decreasing surface albedo

➢ Increasing depth of active layer thickness

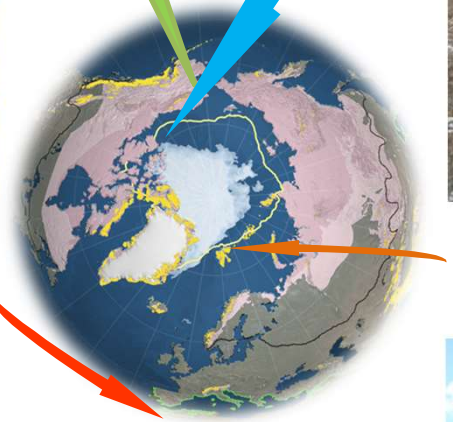
➢ Vegetation shift

Characters of Study Sites

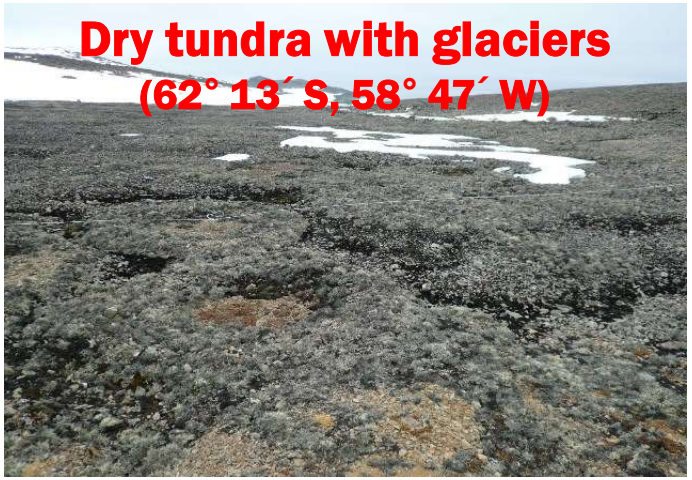
Council, Alaska



Cambridge Bay, Canada



King Sejong, Antarctic



Dasan, Svalbard

Council, Alaska

(64° 50´ N, 163° 42´ W)

Council, Alaska

Measurement site

	Council, Alaska
Site location	64° 50 ´ 38" N, 163° 42 ´ 38" W
Vegetation type	moist acidic tussock tundra - Vascular plants (Erophorum scheuchzeri and Betula nana), - Moss (Sphagnum lenese pohle and Sphagnum russowii Warnst) - Lichen (Cladonia stellaris)
Soil type	Histic Cryosols
Soil organic matter	0-20cm: SOC 35-40%
enzyme activities: ß-glucosidase (mmol g dry soil $^{-1}$ min^{-1})	- Shrub: 27(± 8), 12(± 2) - Moss: 8(± 1), 10(± 2) - Tussock: 24(± 6), 10(± 2) - Lichen: 15(± 5), 18(± 5)
Climate	2000 to 2012 - Temperature: -3.1ºC, (-30 ~20 ºC) Summer (June to August) : 11.2(±1.8) ° C , Winter (December to March): -14.8(±4.3) ° C - Precipitation(June to September): 258 mm yr^{-1} - Snow-free period: May to October - Wind speed: 3.5(± 0.2) ms^{-1} (2~6ms^{-1},maximum 12ms^{-1}), Winter: monthly 5 ~ 6ms^{-1} - Wind direction: northwest, south - Snow depth: October or November to March Maximum: 0.8m ~ 1m (March or April) - Soil temperature (-15 ~10ºC) - Active layer (~ 50cm, September)
Measurement	1. Automated closed-dynamic chamber - Plot :15 m x 20 m (15) - Surface: shrub + moss, moss, grass (tussock), lichen - Period: 2012, 2014, 2015 2. eddy covariance system - Eddy-covariance: CSAT3A, EC150 - Net radiometer: CNR4 3. soil temperature, water content, water table, PAR, thaw depth
Ecosystem CO_2 exchange (summer)	-0.4(daytime) ~ 0.2 (nighttime CO_2 mg m^{-2} s^{-1}
CO_2 efflux (mg m^{-2} s^{-1} (µmol m^{-2} s^{-1}))	- Shrub and Moss: 0.05-0.3(1.14-6.82) - Tussock: 0.03-0.2(0.68-4.55) - Lichen: 0-0.12(0-2.7)

Council, Alaska

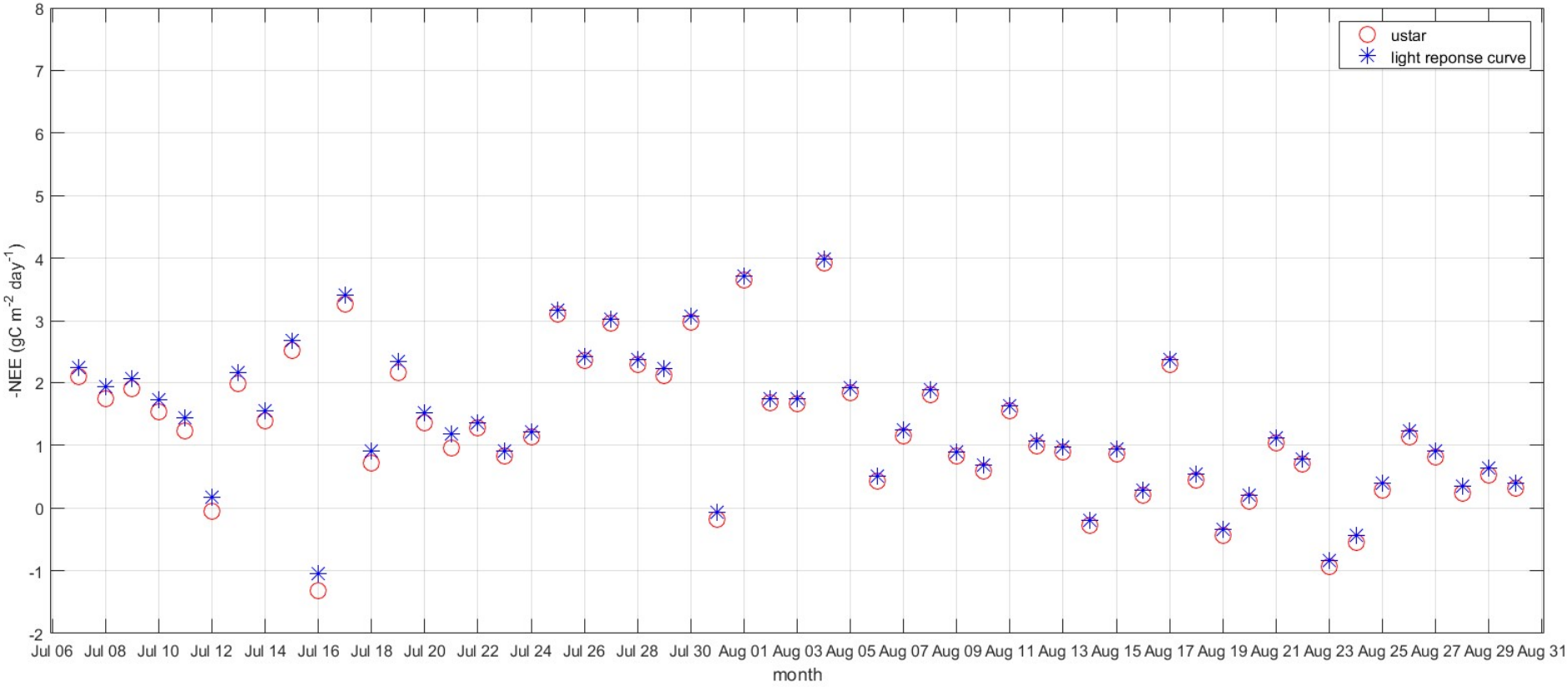
Eddy covariance instruments

- Eddy-covariance: CSAT3A+EC150
- Net radiometer: CNR4

- Since July 2012
- July - September

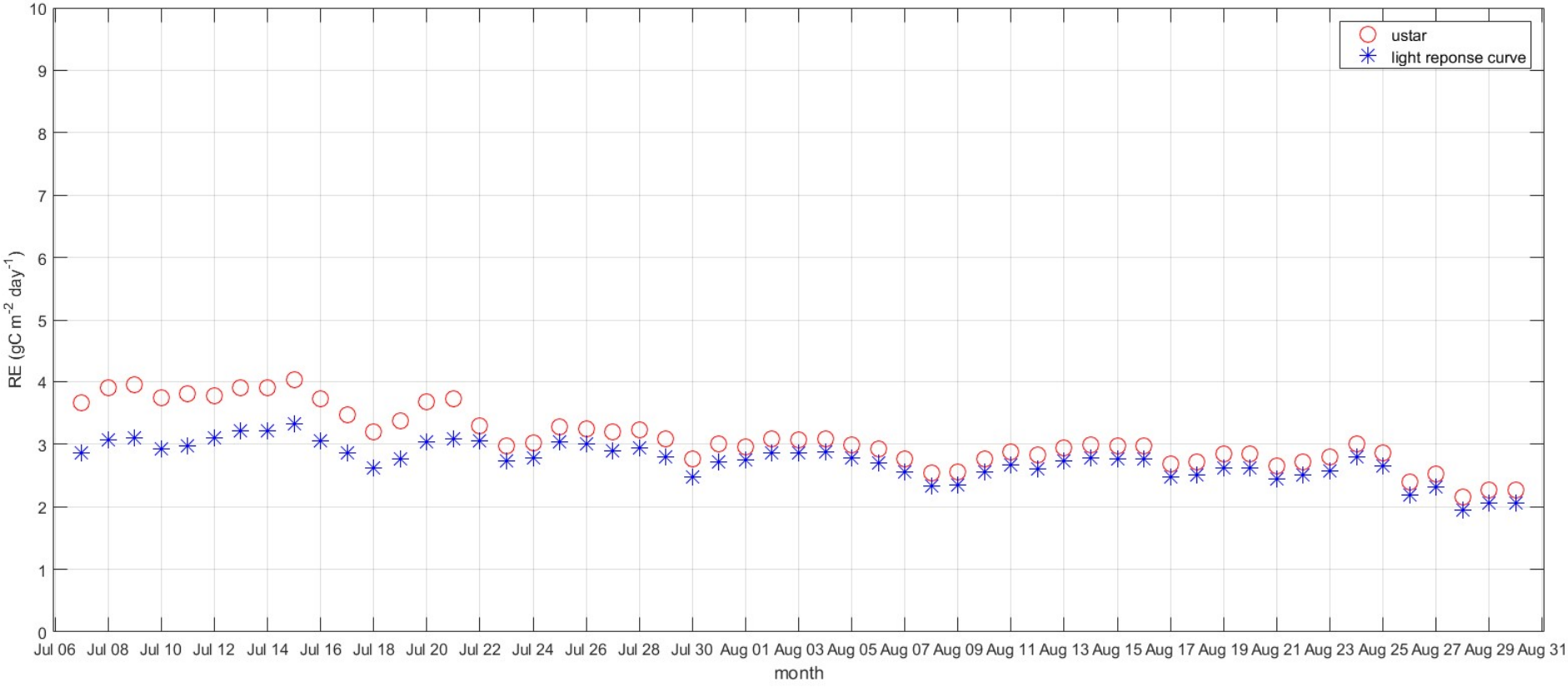
Council, Alaska

Daily NEE (Council, July-August 2015)



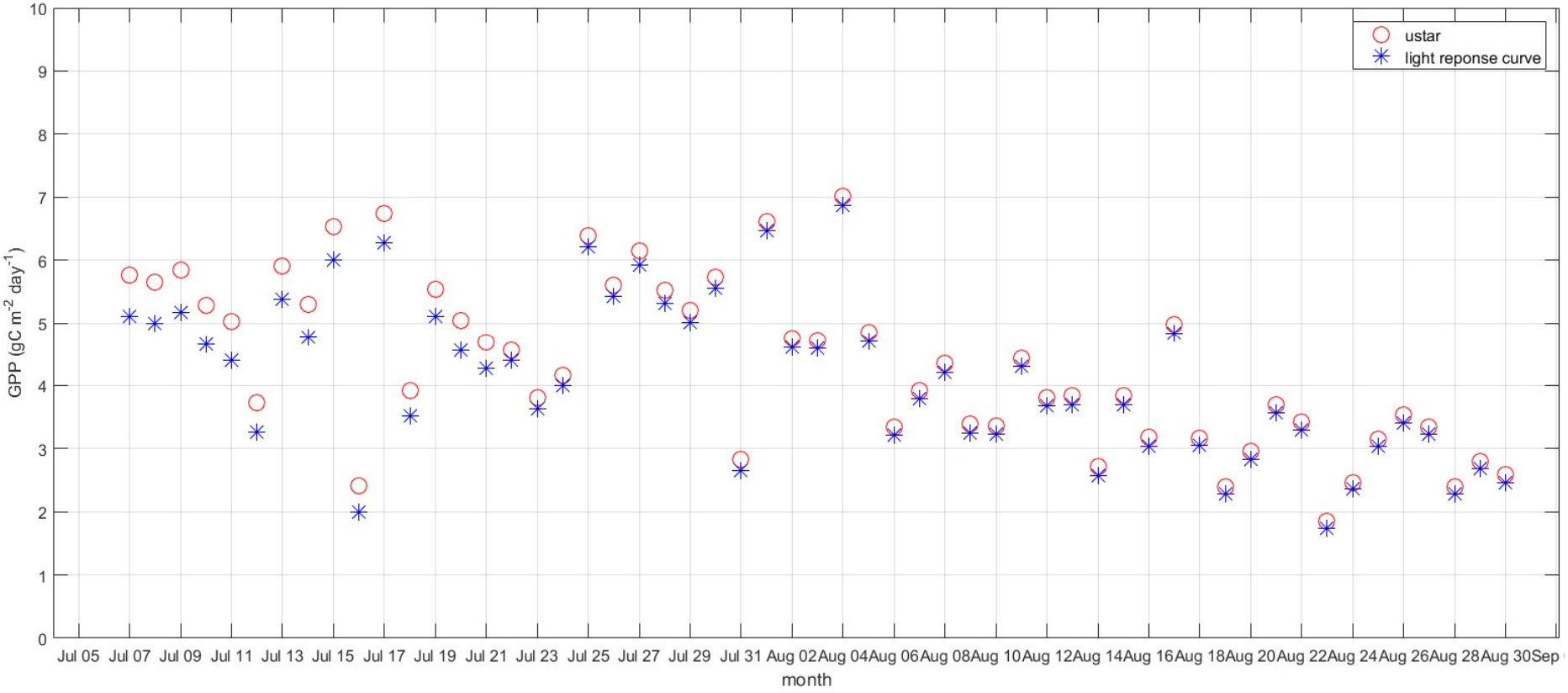
Council, Alaska

Daily RE (Council, June-August 2015)



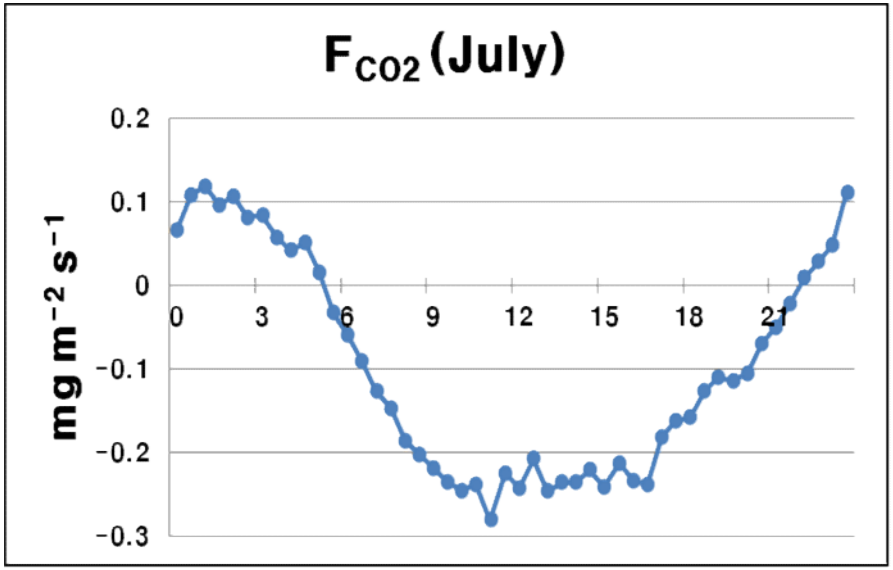
Council, Alaska

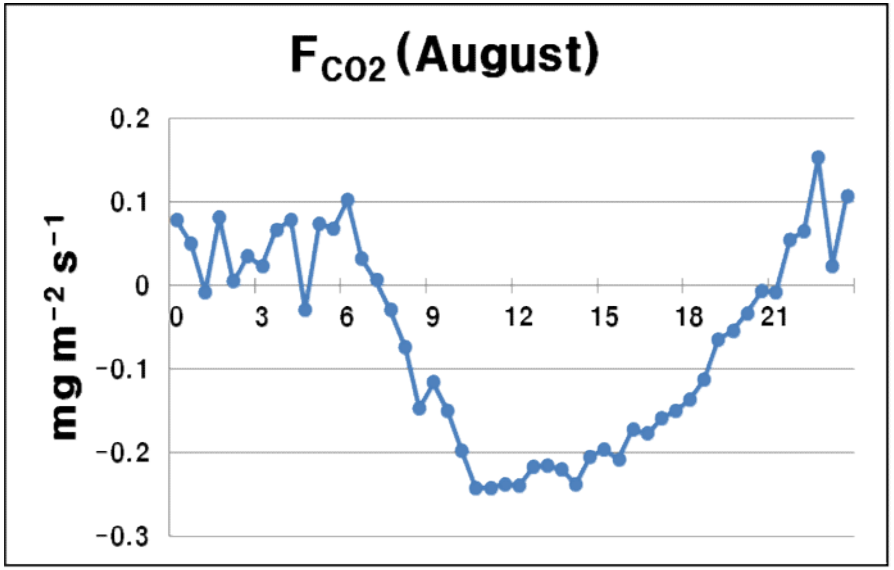
Daily GPP (Council, June-August 2015)

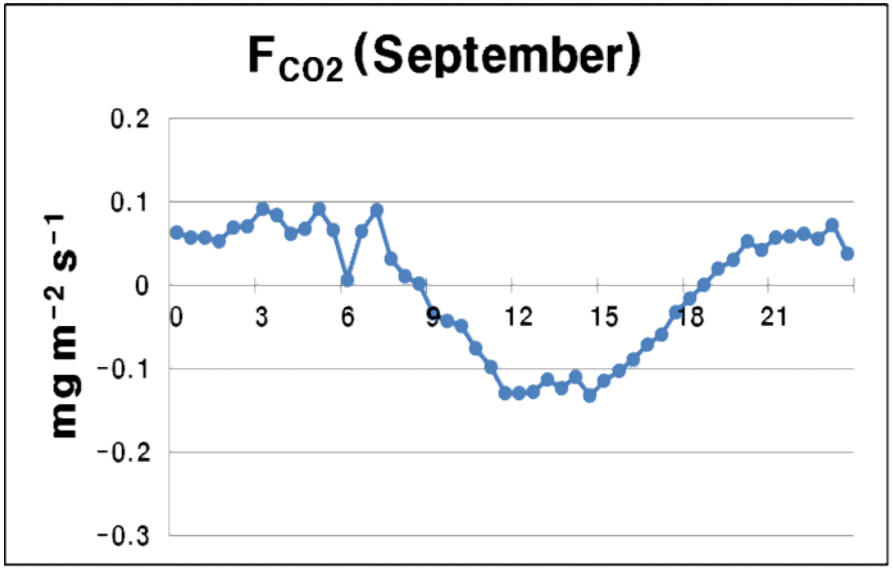


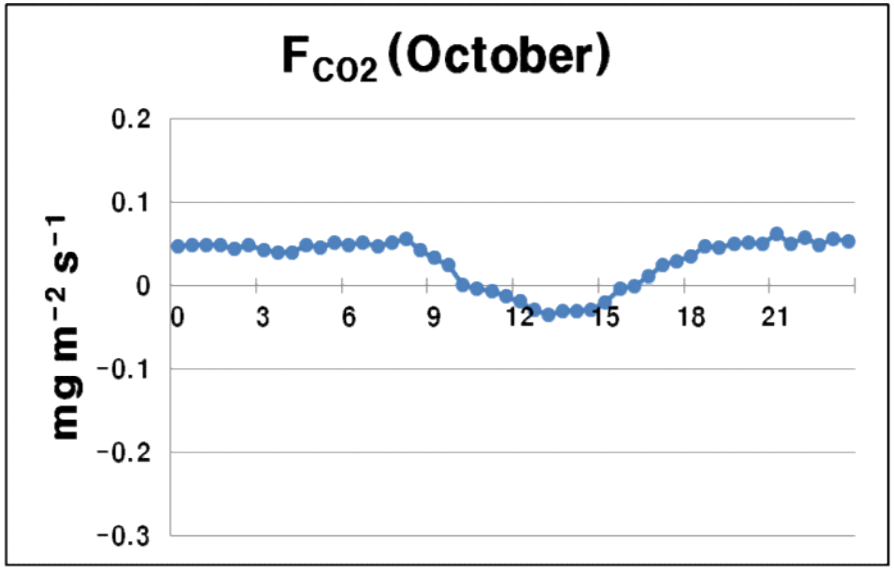
Council, Alaska

Mean Diurnal Variations of CO_2 Flux (2012 summer)







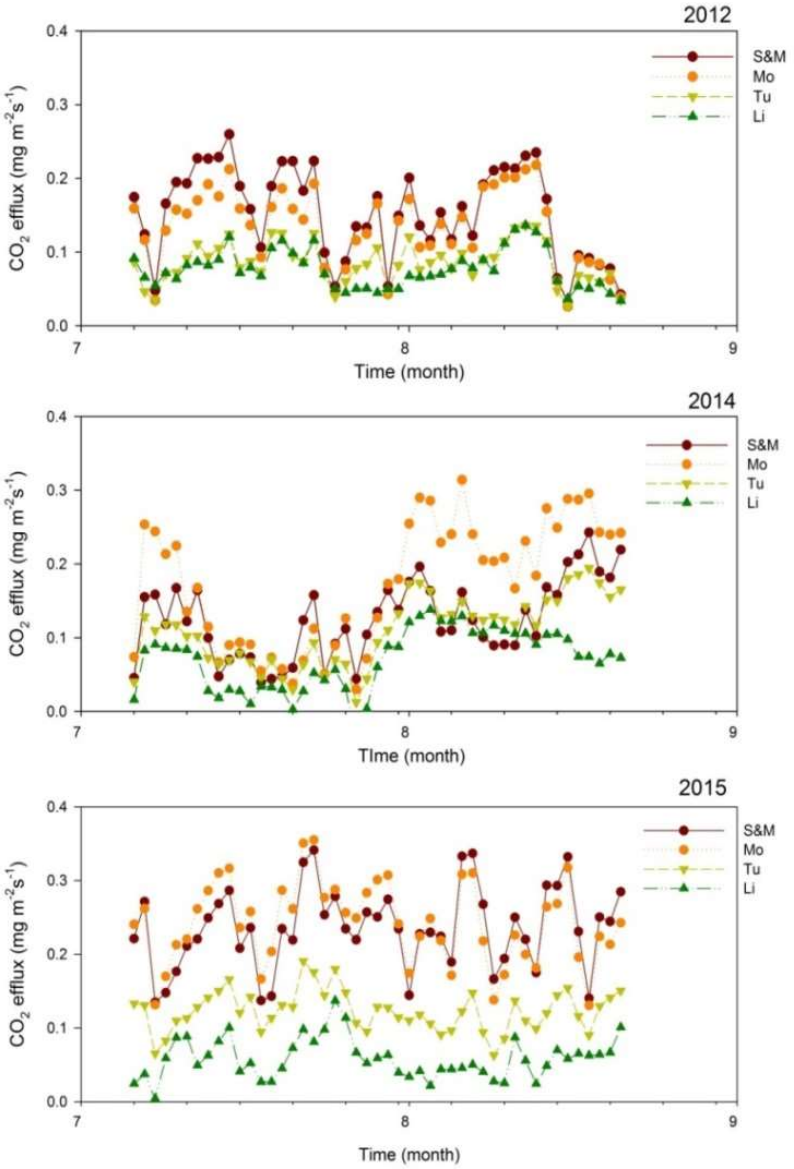


Council, Alaska

Automated chamber system

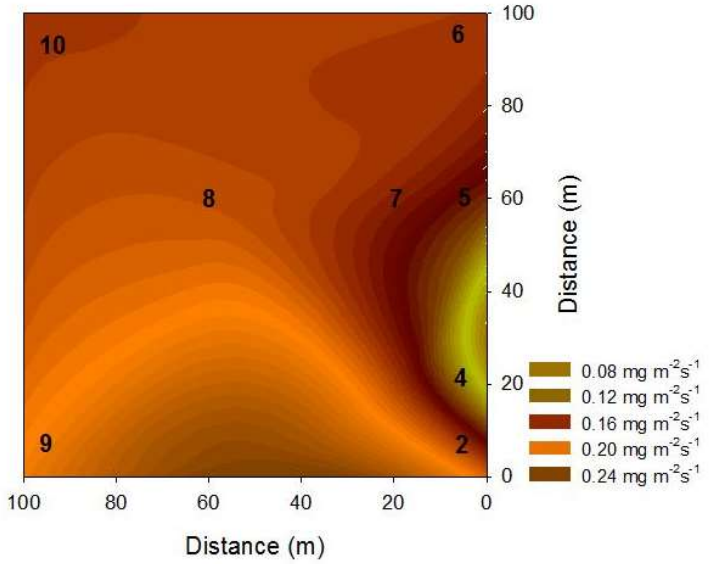
Council, Alaska

- **Soil CO_2 efflux (2012, 2014, 2015)**



(Chae et al., *in preparation*)

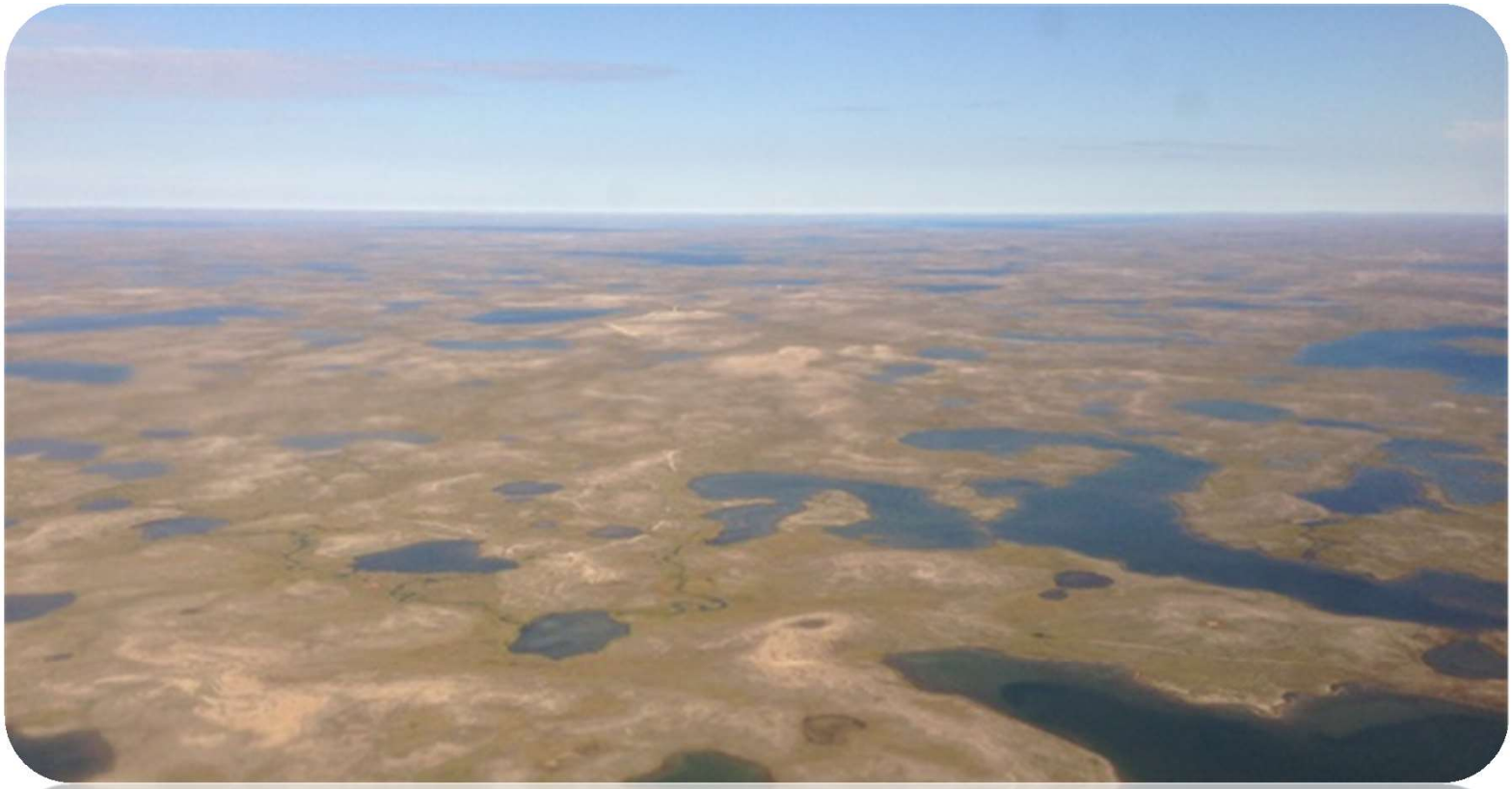
- **Prediction of soil CO_2 efflux (2013)**



(Chae et al., 2016, *Cold Region Sciences and Technology*)

Cambridge Bay, Canada

(69° 13´ S, 105° 06´ W)



Cambridge Bay, Canada

Position : N69° 07′ 46″ W105° 03′ 34″
Height : 5m (Main Direction 270°)

Eddy covariance instrument

- Sonic Anemometer (CSAT3)
- Open Path CO_2/H_2O analyzer (EC150)
- Open Path CH_4 analyzer (LI7700)

Meteorological instrument

- Radiometer (CNR4)
- Soil Heat Flux Plate (HFP01-L)
- Soil Temperature probe (TCAV-L)
- Soil water contents (CS655)

Data Status

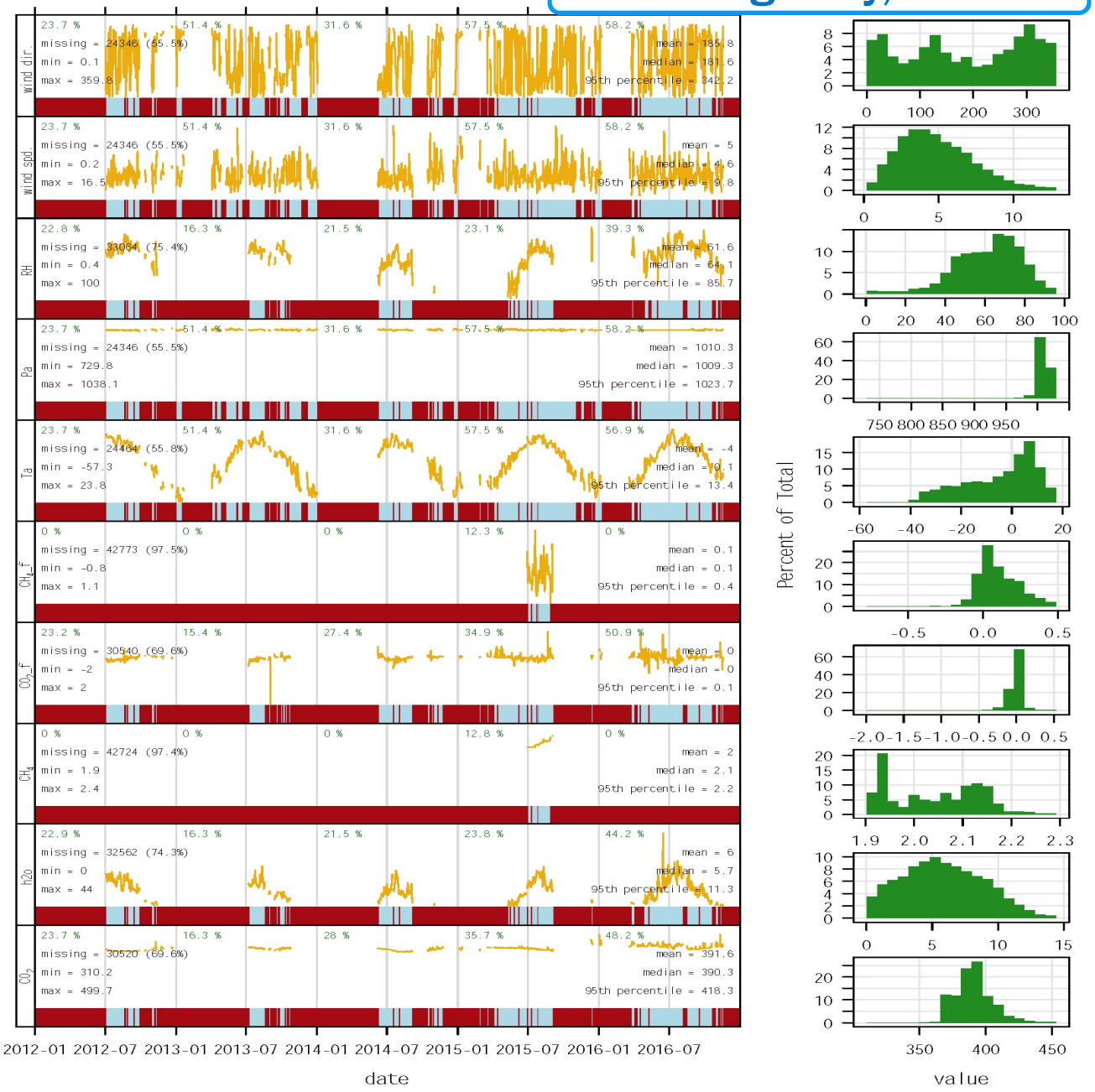
Mean Wind speed
: $5.0 \pm 2.6\ m/s$
min : $0.2\ m/s$
max : $16.5\ m/s$

Mean Air Temperature
: $-4.0 \pm 15.4℃$
min : $-57.3℃$
max : $23.8℃$

Mean Soil Temperature
: $-6.8 \pm 12.1℃$
min : $-27.1℃$
max : $25.3℃$

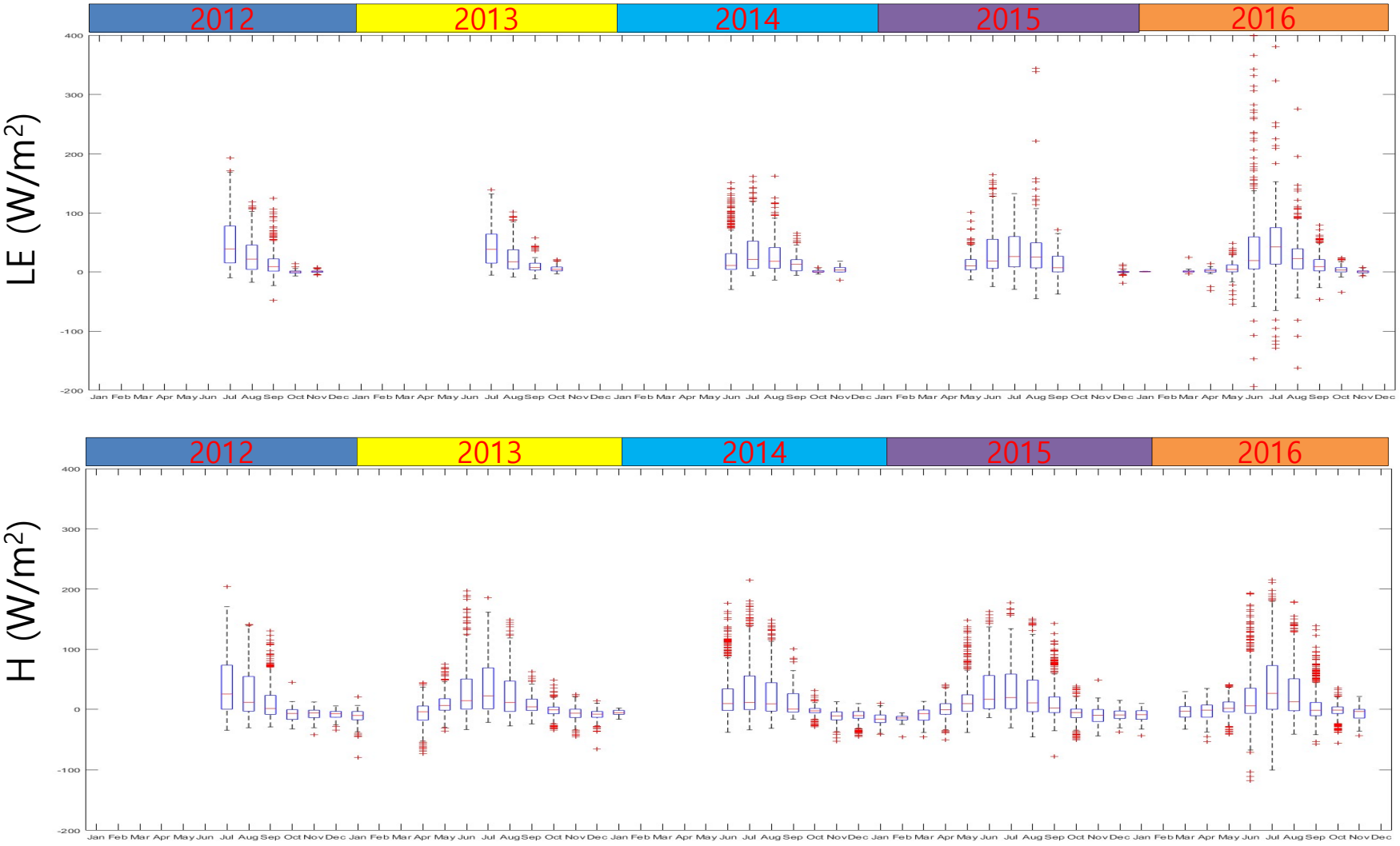
Mean Soil Water Contents
: 0.15 ± 0.10
min : 0.06
max : 0.35

Cambridge Bay, Canada



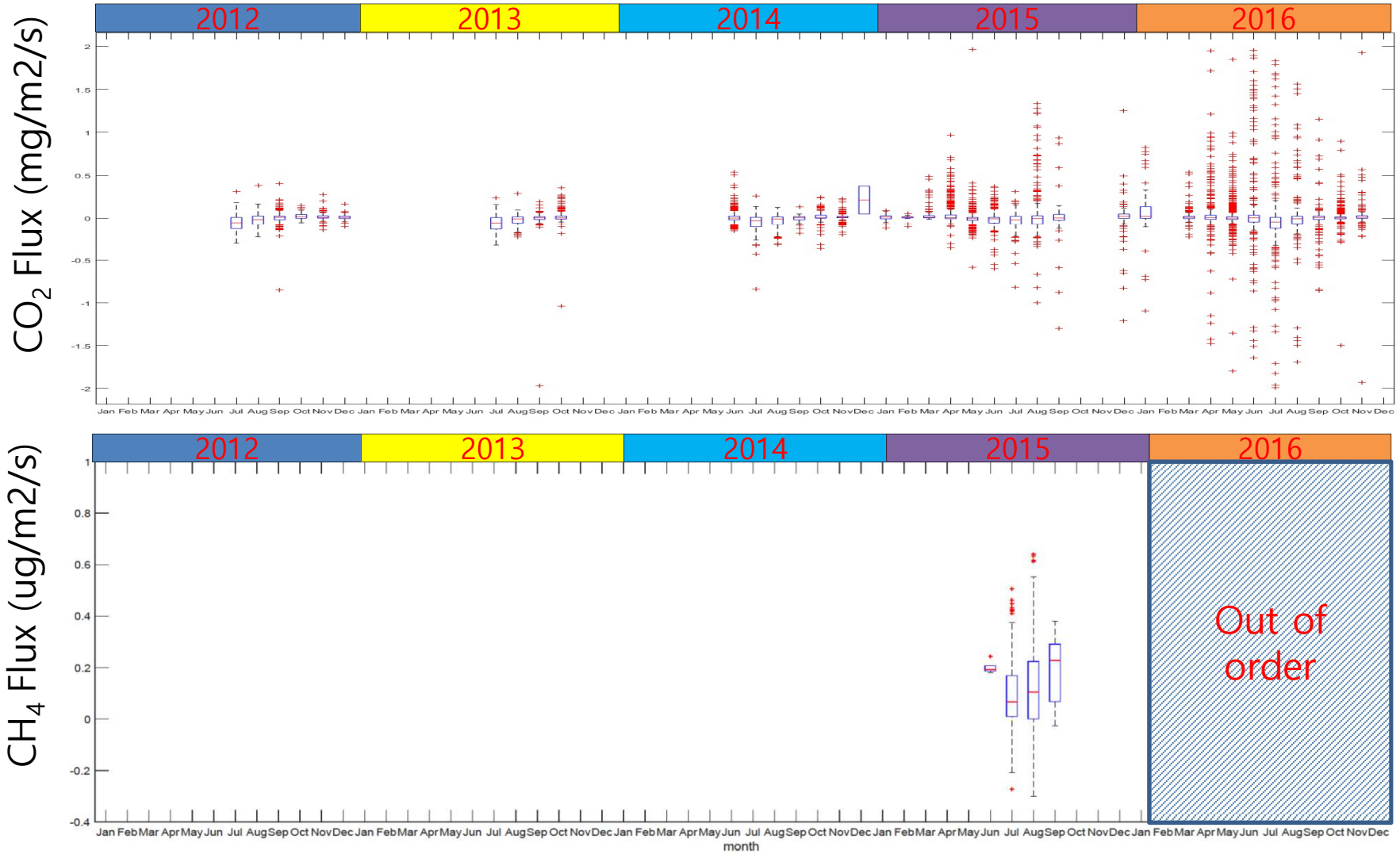
Cambridge Bay, Canada

Energy Flux



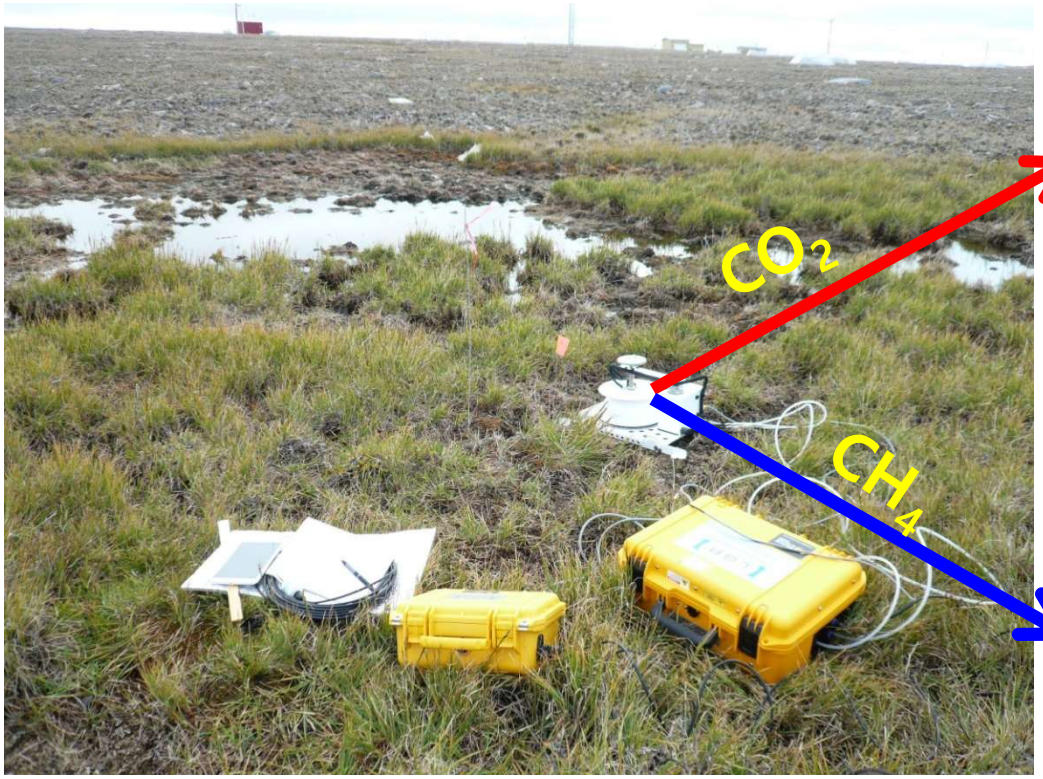
Cambridge Bay, Canada

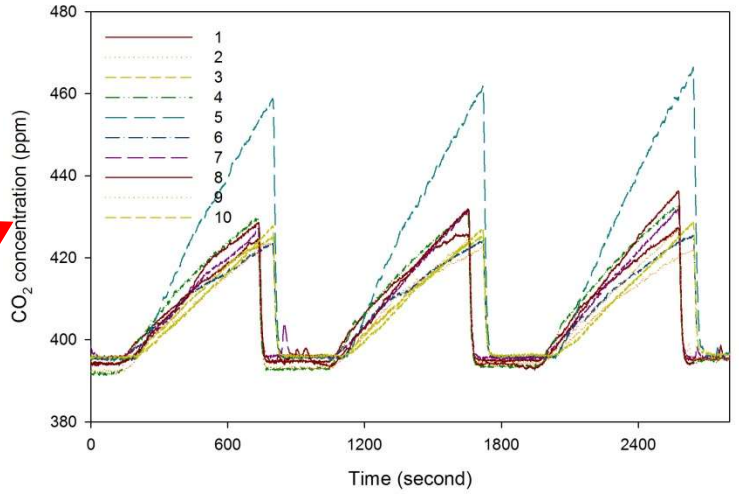
Carbon Flux

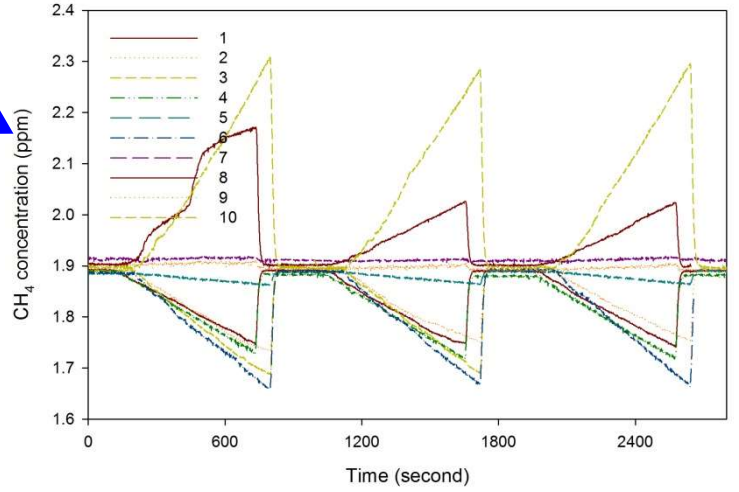


Cambridge Bay, Canada

Soil CO_2 and CH_4 measurement : Emission and uptake

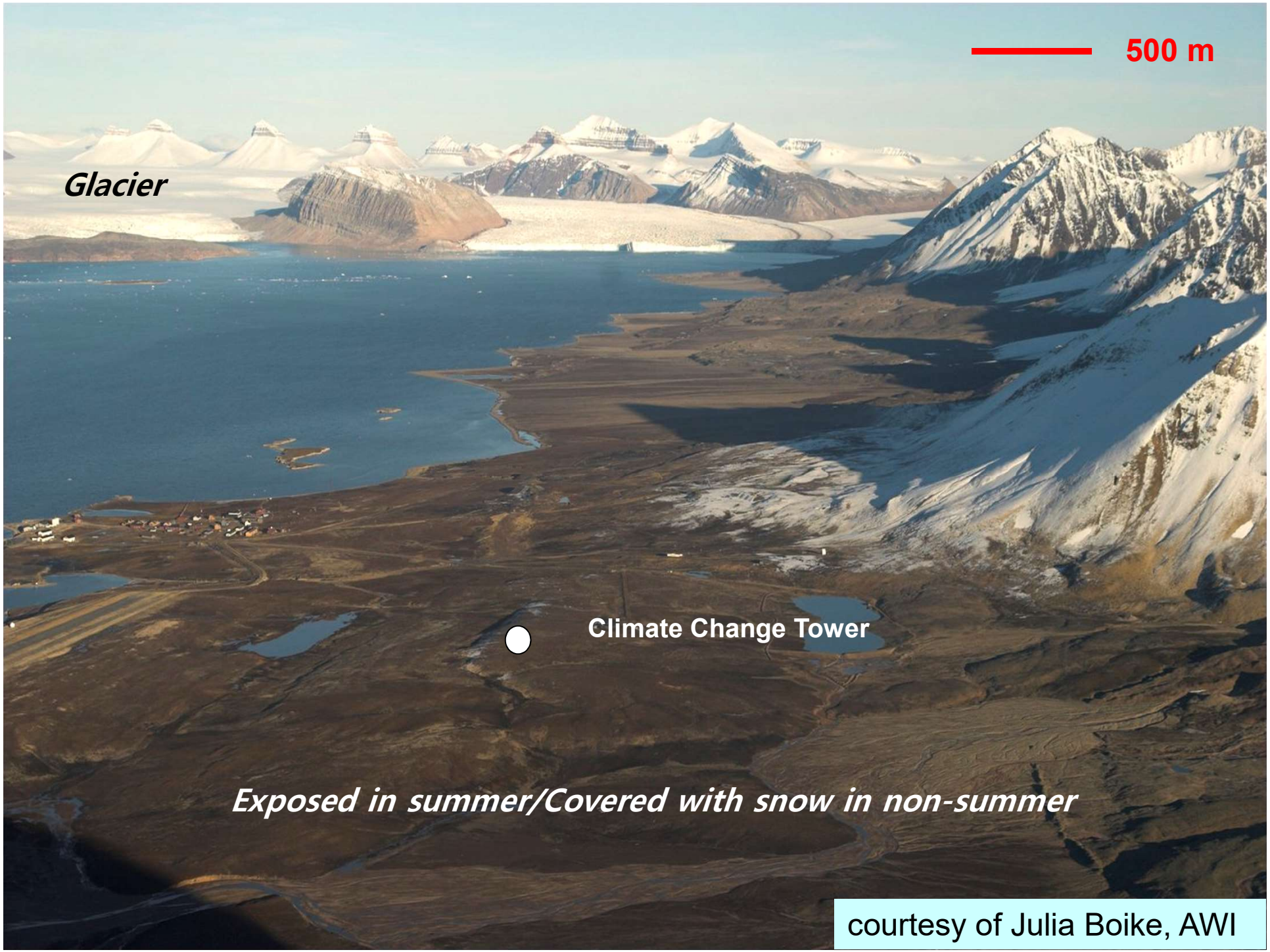




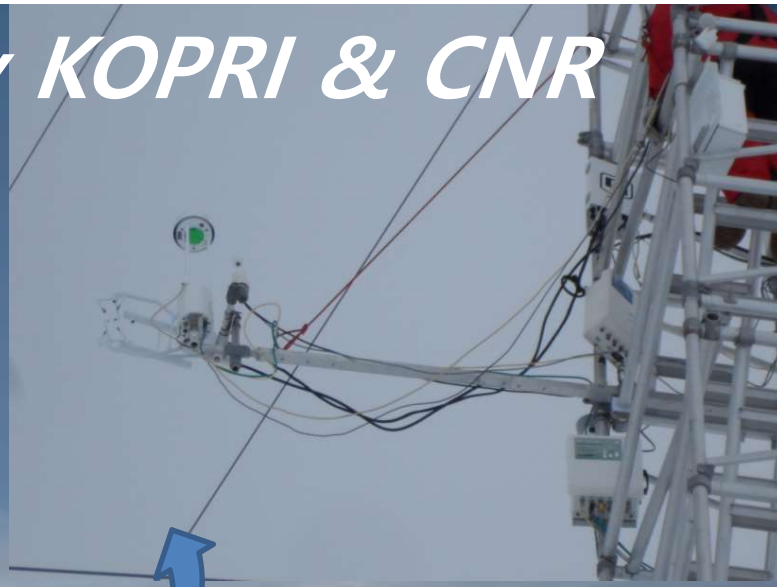


Ny-Alesund, Svalbard

(78° 55´ N, 11° 55´ E)


500 m
Glacier
Climate Change Tower
Exposed in summer/Covered with snow in non-summer
courtesy of Julia Boike, AWI

Flux and Profile systems by KOPRI & CNR at 32 m tower



21 m

Instruments operated by KOPRI

Dasan, Svalbard

Instrument	Model	Variables	Remark
Sonic Anemometer (2012 ~)	CSAT3A	Ux, Uy, Uz, Ts	Campbell Sci.
IRGA (2013 ~)	EC150	CO_2, H_2O, T, P	Campbell Sci.
IRGA (2012 ~)	LI7500	CO_2, H_2O, P	Li-Cor.
CRDS (2012 ~)*	G2301-f	CH_4, H_2O (CO_2)	Picarro
Methane Analyzer (2012 ~2013)	LI-7700	CH_4, T, P	Li-Cor
Platinum resistance thermometer		T	Heating correction
Wind Lidar (2016 ~)	WINDCUBE 100S	Vertical wind profile	Leosphere
Logger	CR3000	10 Hz	Campbell Sci.

* Sent to Manufacturer for repair and recalibration

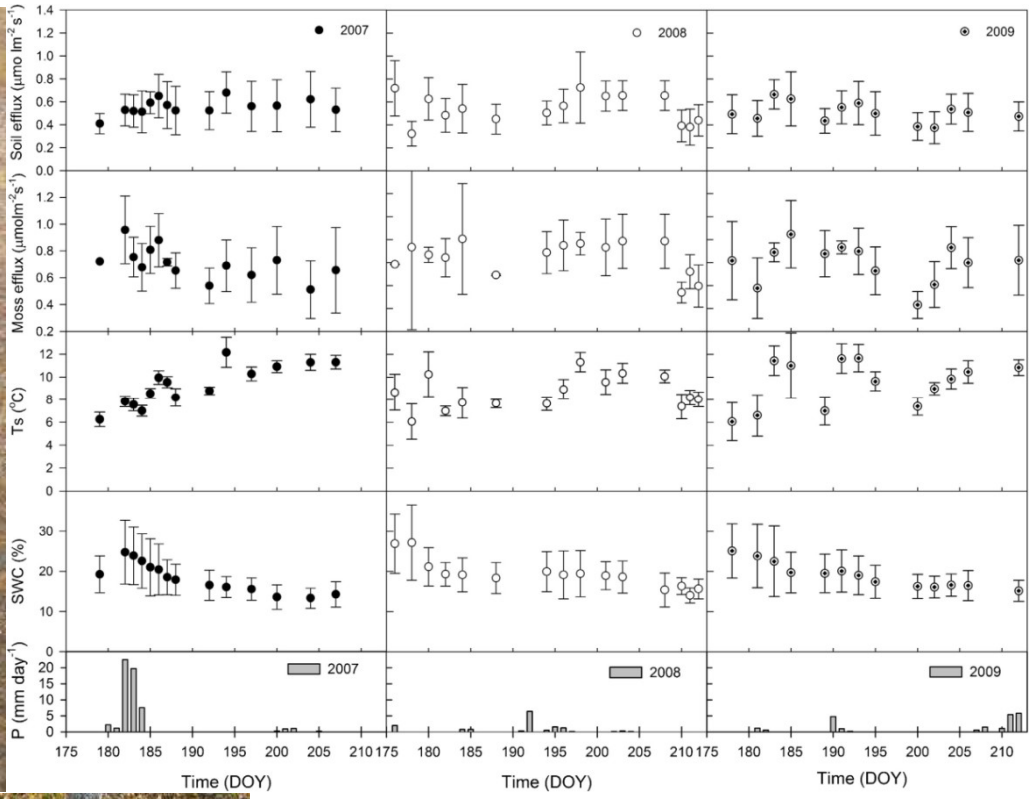
Dasan, Svalbard

Examples of turbulent fluxes in summer

Soil CO_2 Efflux

: On biological soil crust with black color

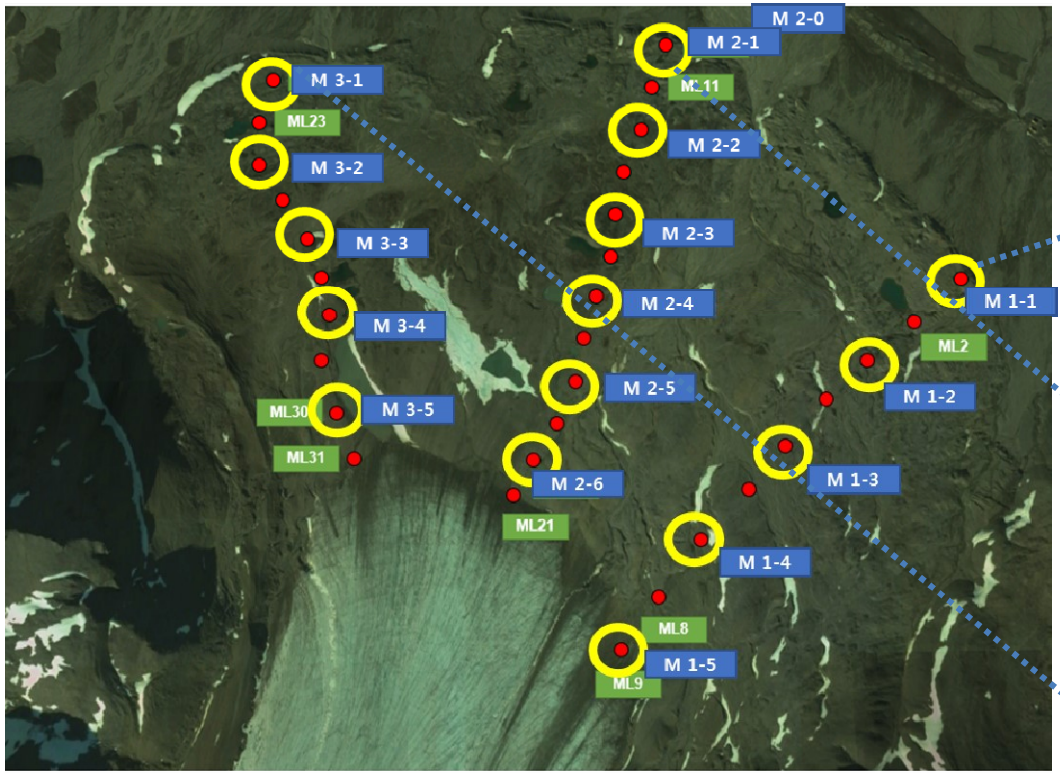
Dasan, Svalbard

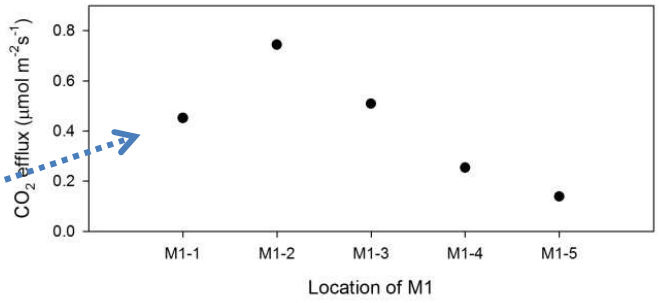


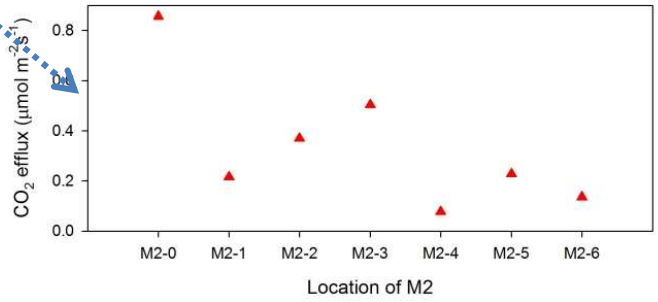
(Chae et al., 2016. *Applied Soil Ecology*)

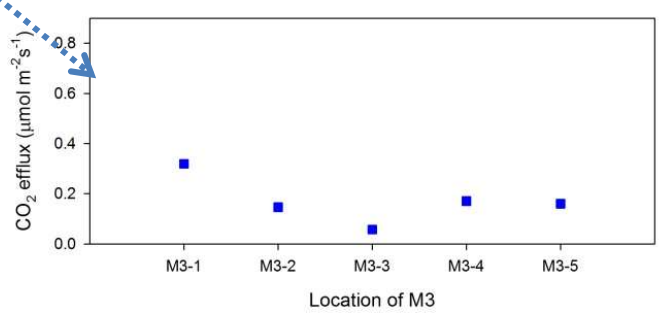
Dasan, Svalbard

Soil CO_2 Efflux
: On retreating glacier









King Sejong, Antarctic

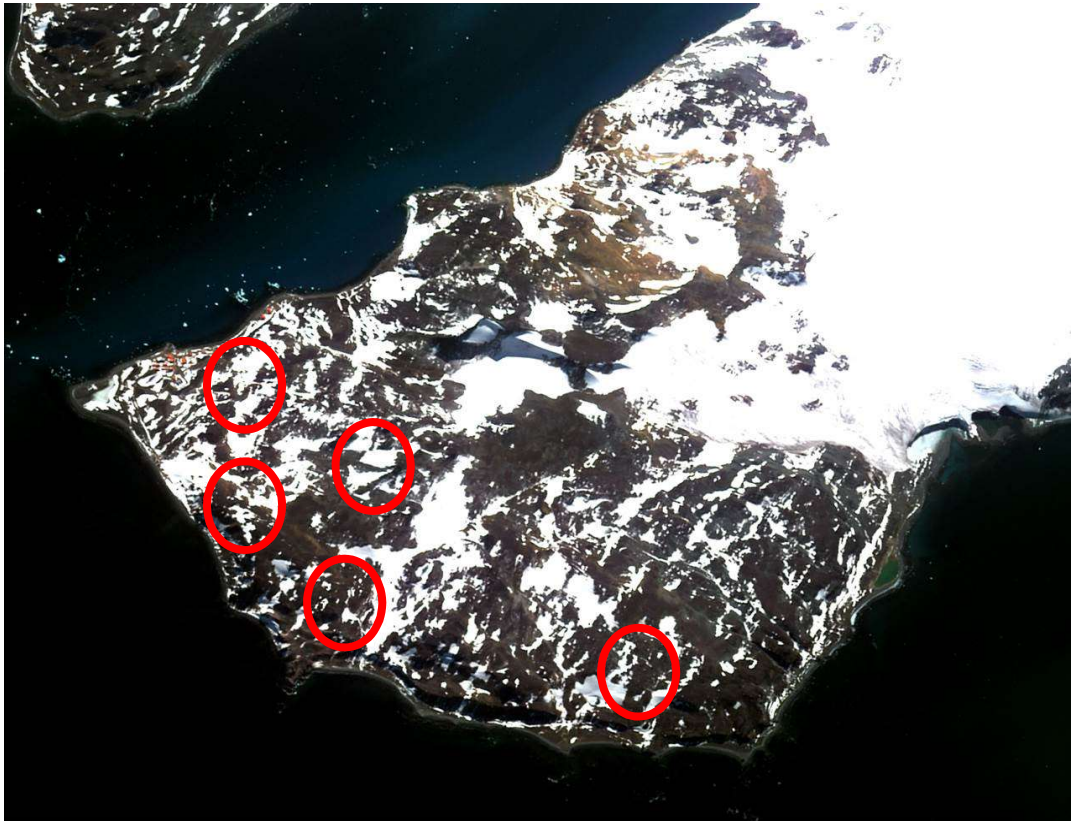
(62° 13´ S, 58° 47´ W)

King Sejong, Antarctic

King Sejong, Antarctic

Soil CO_2 Efflux

: On patterned ground and organic soil

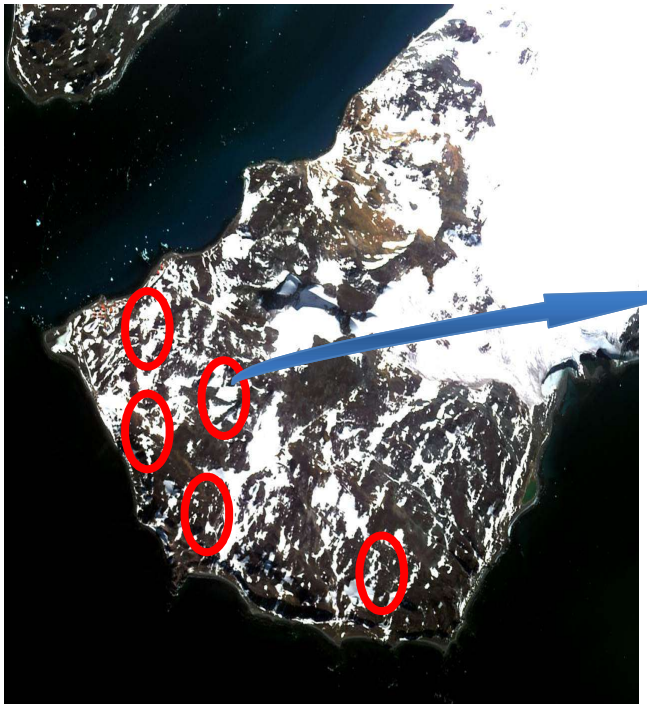


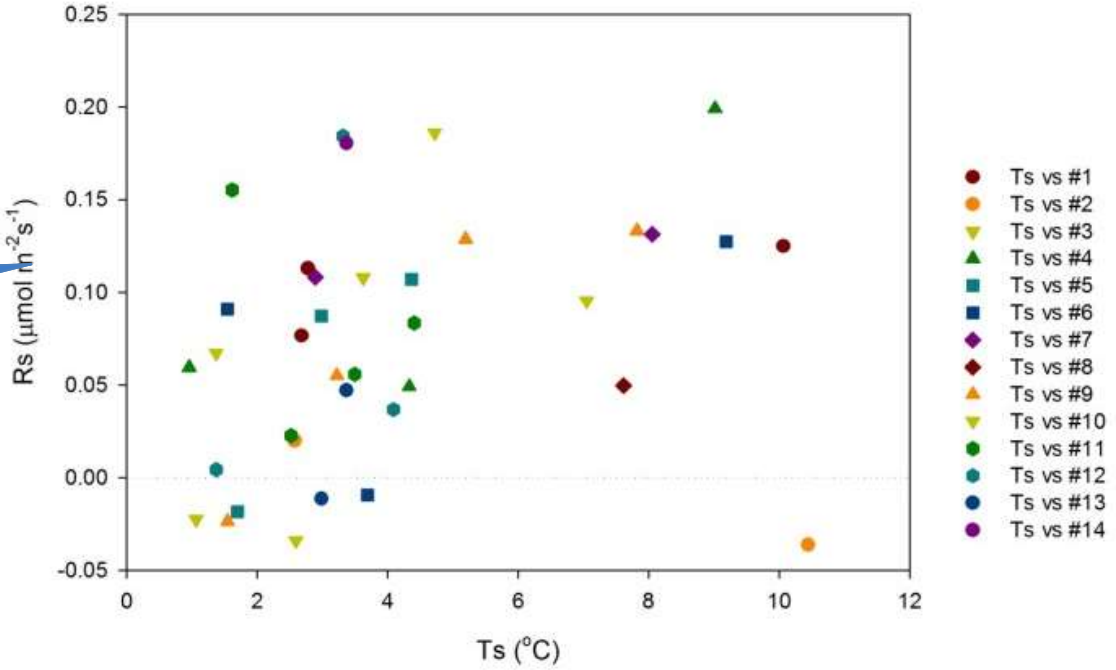
Measurement locations (o) in Barton peninsula

Portable chamber system

King Sejong, Antarctic

Soil CO_2 efflux on patterned ground in Barton Peninsula





Keep going……


Council, Alalska


Cambridge Bay, Canada


King Sejong Station


Ny-Alesund, Svalbard

Thank you for your attention!