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Soil CO_2 efflux in the Arctic, Ny-Ålesund, Svalbard using chamber method

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Introduction

Northern ecosystems contain an estimated 25- 33% of the world's soil carbon (Oecechel and Vourlitis, 1995). Due to the large quantities of carbon (C) stored in tundra, the Arctic plays an important role in global C budgets. The Arctic soil will influence how northern ecosystems respond to global warming by acting as a carbon source or sink to the atmosphere, controlling energy balance at the earth's surface and serving as a source of nutrients for plant growth (Marion et al., 1997). The study of soil CO_2 emission has been widely investigated through artificial control of the environment in the laboratory and *in situ* measurements in Norway, Alaska, Canada and Greenland. Arctic soil will influence how northern ecosystems respond to global warming by acting as a carbon source or sink to the atmosphere, controlling energy balance at the earth's surface and serving as a source of nutrients for plant growth (Marion et al., 1997). To evaluate the role of soil carbon to the net ecosystem exchange of CO_2 in summer season, quantifying of CO_2 efflux from soil surface to atmosphere and its controlling factors were investigated in the Ny-Ålesund in Svalbard, Norway.

Materials and Method

The soil CO_2 efflux (R_s) using closed-dynamic chamber system and net ecosystem exchange CO_2 (NEE) using eddy covariance method were conducted in the Dasan station (78° 55′ N, 11° 56′E), Ny-Ålesund in Svalbard, Norway (Fig. 1, 2 & 3). R_s was measured at 16 sampling locations in the plot (30 m x 30 m) within the major footprint area of tower of NEE during July in 2007, 2008 and 2009 (Fig. 4).

The location of study plot was selected to be within the major footprint area for the tower CO_2 flux measurements. Measurement locations consisted of peat soil covered with lichen (～20%) and soil including small stones. R_s were measured using PVC collars (80 mm in height, 106 mm in diameter) to minimize disturbance. Soil temperature (LI-6000-09TC, LI-COR) at 0.1 m depth and soil water content (Hydro Sense, Campbell Scientific Australia) at 0-0.1 m depth were measured outside each measurement location using portable sensors. Additional sensors for soil temperature (TCAV, Campbell Scientific, Inc.) and soil water content (CS615, Campbell Scientific, Inc.) were also installed around the flux tower for continuous measurements.

The vegetation distribution of the plot is dominated moss *(e.g. Warnstrofia Sarmentosa)* by ～70% and the others consist of peat soil, lichen and various phanerogamous plant. R_s measurement was usually conducted on the peat soil due to the exclusion photosynthesis and dark respiration. Chemical physical soil properties were analyzed in 5 locations of the site using can core. C was 1.6%, N was 0.2%, total P was 605 mgkg^{-1}, bulk density was 0.77 gcm^{-3} and soil water content was 13% (Fig. 6).

Figure 1. Map of the Arctic.

Figure 2. The location of sampling site near Dasan Station in Ny-Ålesund , Norway.

Figure 3. Flux tower of NEE

Figure 4. Chamber measurement system of R_s

Figure 5. Measurement locations (i.e. organic layer, soil surface and moss layer) of Rs

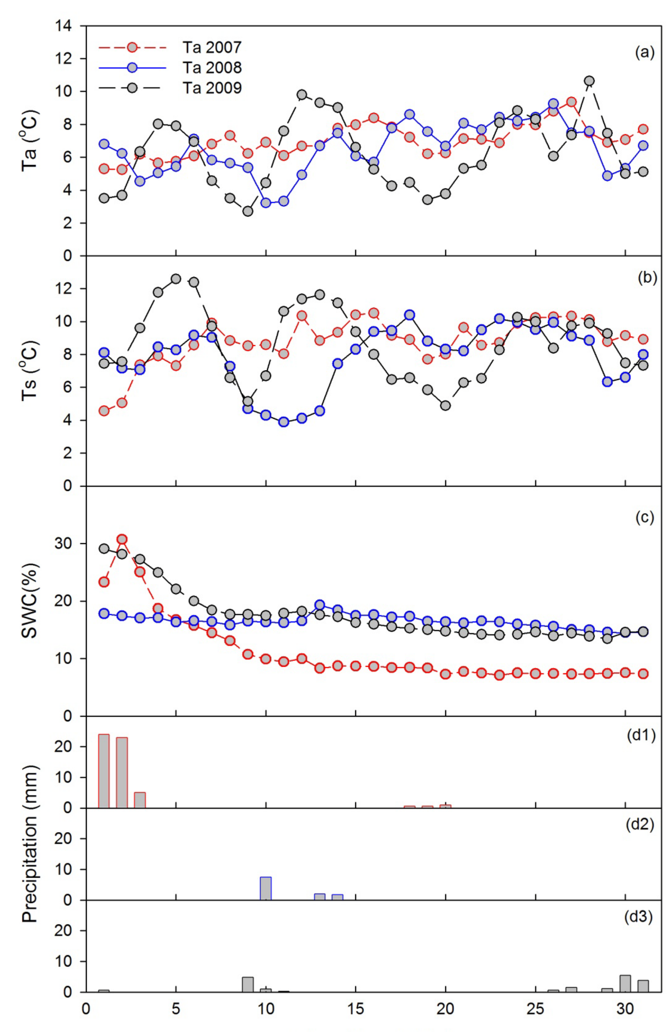

Figure 4. Temporal variations of air temperature, soil temperature, soil water content and precipitation during July, 2007 and 2008.

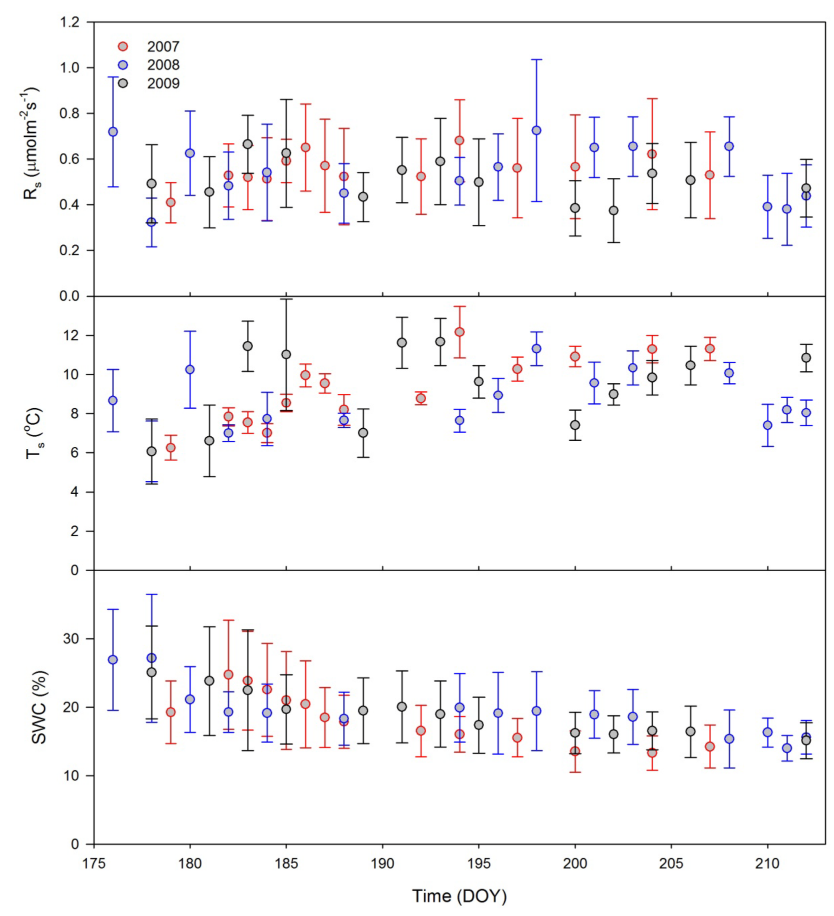

Figure 5. Temporal variation of soil CO_2 efflux, soil temperature and soil water content during measurement period in 2007 and 2008.

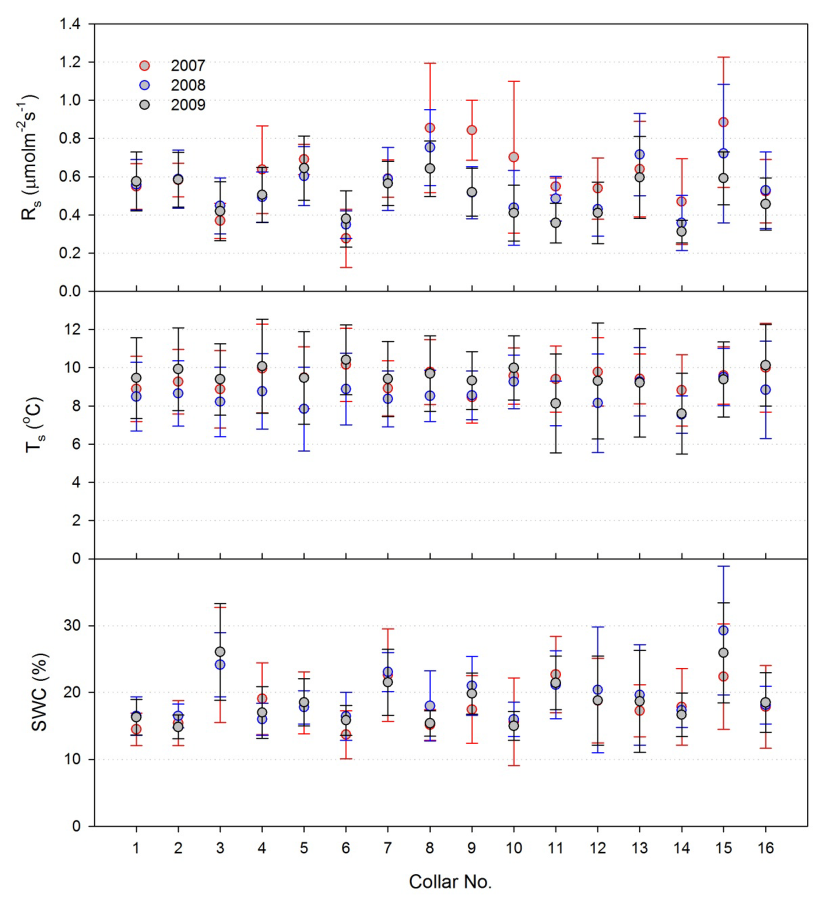

Figure 8. Spatially averaged soil CO_2 efflux, soil temperature and soil water content during measurement period.

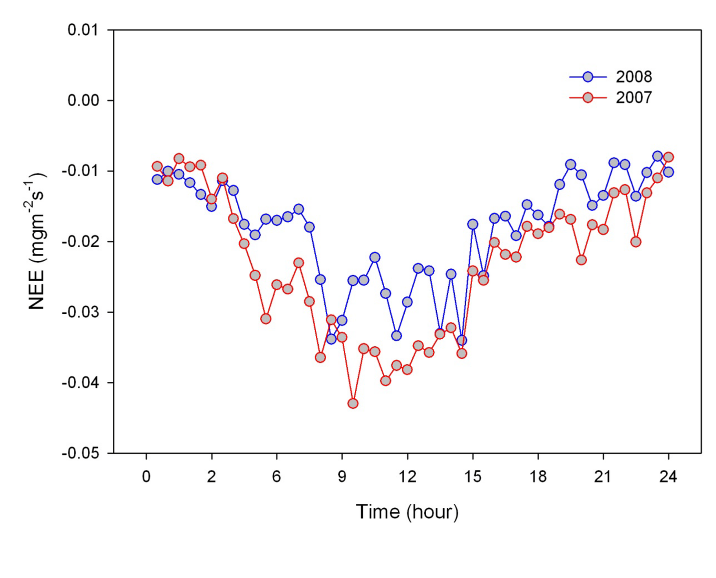

Figure 5. Diurnal variation of net ecosystem exchange(NEE) during July 2007 and 2008 (50 - 150°).

Results and discussion

The air temperature (3～10℃) during both months in 2007 and 2008 was near normal. The soil temperature was similar both yeas (around 8 ℃) and near normal. The mean soil water content in 2008 was higher than 2007 even lower precipitation. This results are assumed difference of thawing period both years. The amount of precipitation was above normal (23mm/month of July) in 2007(55mm), but below normal in 2008(12mm) in July (Fig.5).

Averaged R_s ranged from 0.2 to 1.0 μmol m^{-2} s^{-1} in July 2007 and 2008. Soil temperature ranged 5 ～ 14℃, 4～12℃ both year, respectively. Soil water content ranged 10～35 %, 10～40%, respectively. The R_s in both year was not different (Fig. 7 & 8). However, Rs in 2007 seasonally increased against decreased soil water content, while R_s in 2008 have not against relationship to the soil water content. Consequently, Rs of both years have positive relationship with soil temperature. Coefficient of variation (CV) of Rs was about 30% and soil temperature was within 10 %. CV of Rs is normal range.

Results

The mean R_s in the Arctic was 0.5(±0.16) during summer (July), 2007, 2008. The mean soil temperature and soil water content was 9 (±0.16) ℃ and 19(±4.6)%, respectively. R_s in both years was determined predominantly by soil temperature whereas soil water content less important under this period. These results indicate that the changes in global warming can significantly alter the carbon sink/source strength of tundra ecosystems in the Arctic.

Acknowledgements

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