ASSESSMENT OF WINTER FLUXES OF CO_2 AND CH_4 IN BLACK SPRUCE FOREST SOILS OF CENTRAL ALASKA ESTIMATED BY THE PROFILE METHOD AND CHAMBER METHOD

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ABSTRACT

This research was carried out to estimate the winter fluxes of CO_2 and CH_4 by the concentration profile method (indirect) and the chamber method (direct) at black spruce forest soils of central Alaska during the winter 2004/5. The average winter fluxes of CO_2 and CH_4 by the indirect and direct methods were 0.24±0.06 (SE; standard error) and 0.21±0.06 $gCO_2\text{-}C/m^2/d$, and 21.4±5.6 and 21.4±14 $\mu gCH_4\text{-}C/m^2/h$, respectively. The fluxes estimated by two methods are not a significant difference based on a one-way ANOVA with a 95% confidence level. The winter CO_2 flux corresponds to 30% of the annual CO_2 emitted from Alaskan black spruce forest soils. The average winter emissions of CO_2 and CH_4 were 49±13 $gCO_2\text{-}C/m^2$ and 4.5±3.0 $mgCH_4\text{-}C/m^2$, respectively. This suggests that the winter emissions of CO_2 and CH_4 are an important part of the annual carbon budget in seasonally snow-covered terrain.

Although the black spruce forest of central Alaska is aerated soils, the CH_4 plays a significant source role in emitting through the snowpack to the atmosphere in central Alaska based on the inter-comparison of CH_4-flux between tower and chamber observations during 24-hour observation during the early winter.

INTRODUCTION

CO_2 and CH_4 are significantly major gases for global warming and climate change in the Arctic. The sink and source of these gases are well known in terrestrial ecosystem; however, the winter fluxes of CO_2 and CH_4 was rarely observed in boreal forest of Northern Hemisphere. Generally, atmospheric CH_4 was oxidized to aerated soil; however, the research on the production and/or oxidation of CH_4 during the winter was poorly understood. The reasons are that 1) is CH_4 produced due to the deficiency of oxygen supply by the frozen surface soil, 2) is CH_4 produced from the decomposition of acetic acid and/or the permafrost. In order to answer questions, we have analyzed O_2/N_2 ratio and the stable isotope C-13 of CH_4 from soil / snowpack air samples and tower (2 and 8 m high). If CH_4 is produced by the acetic acid, C-13 value of CH_4 will be increased. Or if CH_4 is originated by the permafrost, C-13 value of CH_4 will be decreased.

This flux-measurement was conducted in tower flux site within the UAF (University of Alaska Fairbanks) in typical black spruce forest of central Alaska. The forest ground vegetations are tussock and sphagnum/feather mosses. The sampling tubes (stainless steel; 60 cm long; 3 mm OD and 1 mm ID) for concentration profiles of CO_2 and CH_4 on the ground were set at tussock and moss areas before the snow falls. The tubes under soil are also built at moss layers. The sampling depths were 0, 10, 20, 30, 40, and 50 cm above soil surface and 5, 10, 20, 30, and 40 cm below the surface. The sampling period was at an interval of 10 days with snow pit-wall observation that is examined the snow crystals, snow density and snow temperature. The monitoring of soil temperature and moisture has carried out since June 2004 at sphagnum moss regime.

RESULTS AND DISCUSSION

CH_4-flux measurements form tower and chamber methods during 24-hour observation were compared in black spruce forest on October 2004 (Fig. 1). The frequency of CH_4 flux has a similar pattern between both methods; however, the strength of CH_4 flux is quite different. This is suggests that higher CH_4 flux depend strongly on CH_4 concentration gradient at 2 and 8 m levels due to the CH_4 flux gradient calculation method of tower at two levels.

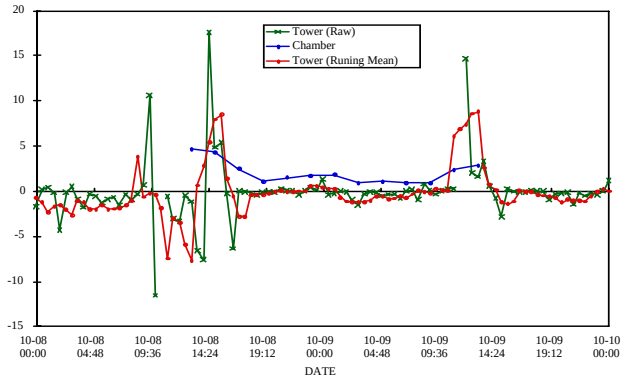

Fig. 1 Comparision of 24-hour CH_4 flux measurements between from tower data and static chamber data in October, 2004.

Temporal variations of CO_2 and CH_4 concentrations in UAF tower site in boreal forest of central Alaska during the winter of 2004 to 2005 are shown by using Ocean Data View software of Schlizer (2004). The data above ground and below surface are described the concentrations of CO_2 and CH_4 from tussock and sphagnum moss layer, respectively. The empty columns on the ground in each Figure denote long period between before and after observation. Also, the empty below the surface show no collecting samples by the frozen soil. The height of tussock is approximately 20 cm. During the mid-winter, higher CH_4 (>5 ppm) appeared in top of tussock, suggesting that the higher CH_4 concentration results from the decomposition of acetic acid from the tussock. We cannot exactly explain the origin of higher CH_4 concentration at top of tussock during the winter. However, we have analyzed the stable isotope C-13 of CH_4 for the identification of higher CH_4 concentration.

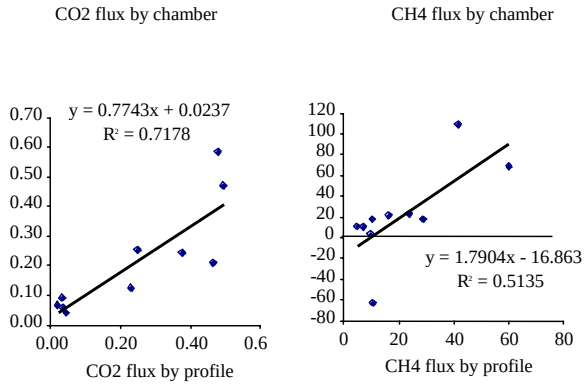

Fig 2. Comparison between the profile and static chamber methods for the winter
fluxes of CO_2 (left) and CH_4 (right) in typical boreal forest of central Alaska during winter of 2004/5

The average winter fluxes of CO_2 and CH_4 by the indirect and direct methods were 0.24±0.06 (SE; standard error) and 0.21±0.06 gCO_2-C/m^2/d, and 21.4±5.6 and 21.4±14 μgCH_4-C/m^2/h, respectively. The fluxes estimated by two methods are not a significant difference based on a one-way ANOVA with a 95% confidence level (Fig. 2). The winter CO_2 flux corresponds to 30% of the annual CO_2 emitted from Alaskan black spruce forest soils. Except for the winter CH_4 emission to the atmosphere through the snowpack in boreal forest, most of atmospheric CH_4 are oxidized to the aerated boreal forest soils. The average winter emissions of CO_2 and CH_4 were 49±13 gCO_2-C/m^2 and 4.5±3.0 $mgCH_4$-C/m^2, respectively. This suggests that the winter emissions of CO_2 and CH_4 are an important part of the annual carbon budget in seasonally snow-covered terrain.

REFERENCE

Schlizer, R. (2004), Ocean Data View, http://www.awi-bremerhaven.de/GEO/ODV.