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CH_4 and CO_2 fluxes at sites with different hydrological patterns in the polygonal tundra of Samoylov Island, Northeastern Siberia

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Introduction

It is vital to assess the amount of C that is mineralized as CO_2 and CH_4 in Arctic ecosystems, due to CH_4 higher global warming potential. Hydrology and vegetation are known as the most important controls of CH_4 emissions. The extensive Siberian tundra is currently underrepresented in international databases. We performed *in situ* chamber measurements in a polygon containing two sites with distinct hydrological features in Samoylov Island in the Lena River Delta, Northeastern Siberia, and calculated the CO_2:CH_4 production ratios from the measured CH_4 and heterotrophic respiration (R_h) fluxes.

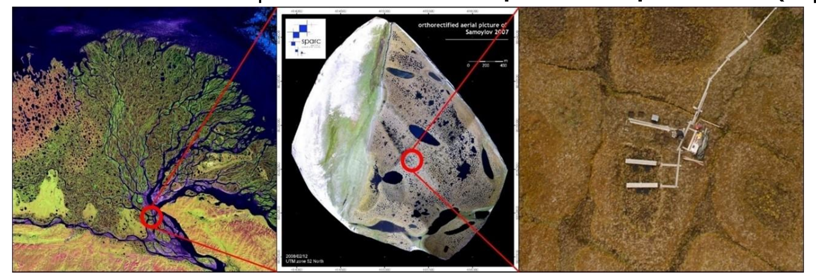

Figure 1 - Satellite images and aerial images of the study sites.

Material and Methods

Trenching experiment: Removal of tundra vegetation. Measurement of plant-mediated CH_4 transport and R_h.

Figure 2 - Boardwalk and measurement plots at the polygon center. Clipped plots at the left of the boardwalk and vegetated plots at the right.

Experiment design: Distribution of plots at the polygon water-saturated center and drained rim.

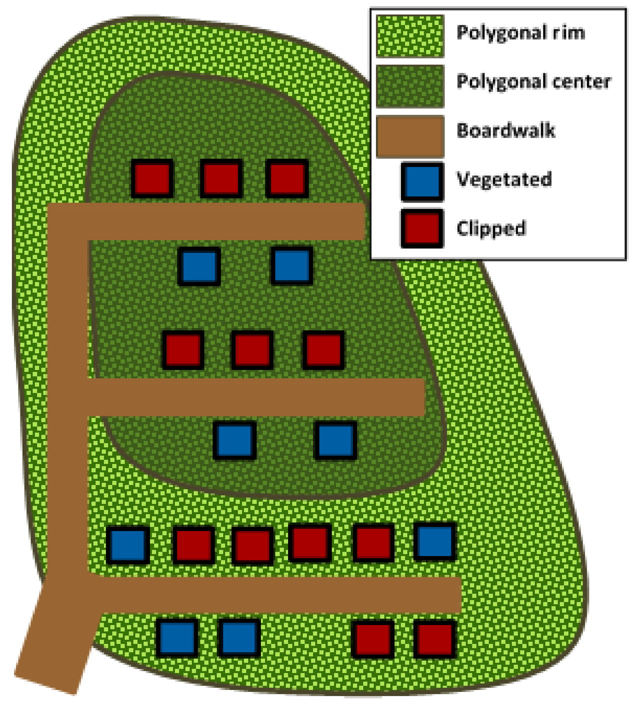

Figure 3 - Scheme of the study site and the installed measurement plots. From the total 20 PVC collars, 10 were installed at the center and 10 at the rim. From these 10 of each polygon part 6 were clipped and 4 remained with the original vegetation.

CH_4 Results

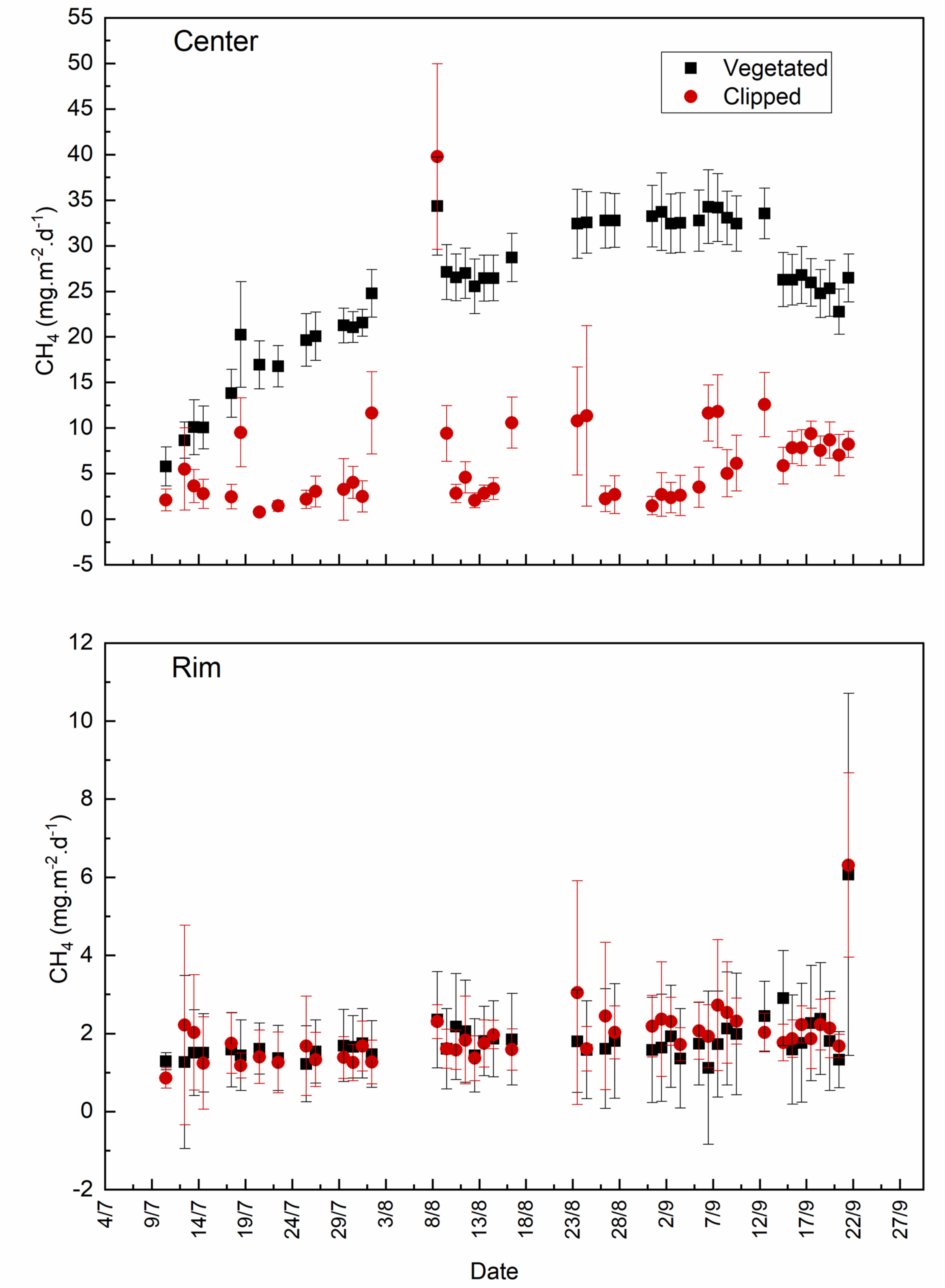

Figure 4 - CH_4 fluxes between July and September 2015 from a polygon on Samoylov Island at vegetated and clipped plots in the polygon center and polygon rim. Presented are daily means, error bars represent one standard deviation

Median CH_4 emission from vegetated plots at polygon center of 26 mg.m^{-2}.d^{-1}, and at the polygon rim 1.8 mg.m^{-2}.d^{-1}.

Distinct behavior of CH_4 emissions of wet and dry tundra during the growing season. Emissions at center showed seasonality, while at the rim not.

Importance of plant-mediated transport of CH_4 avoiding oxidation. Clipped plots emissions 80% lower than vegetated at the center, while virtually no difference at the rim (3%).

CO_2:CH_4 production ratios

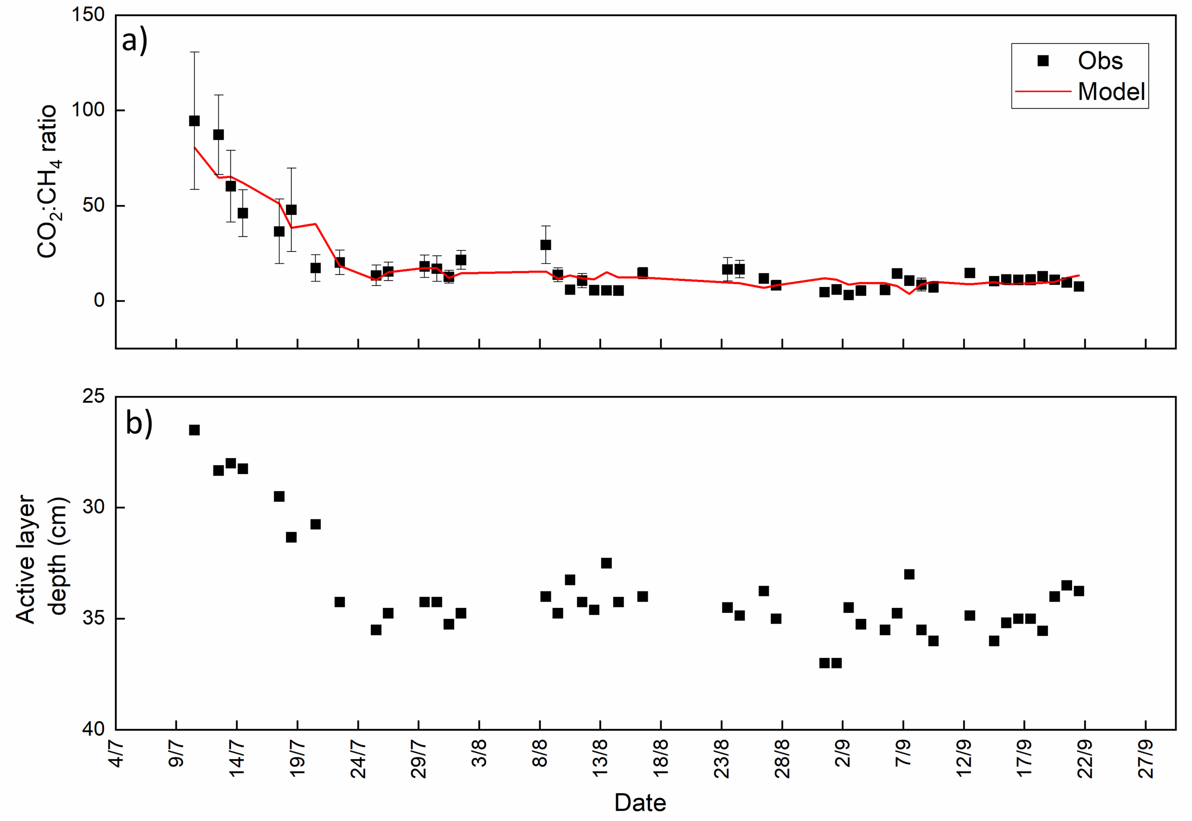

Figure 5 - In a), daily mean CO_2:CH_4 ratios in the polygon center during the growing season in 2015 and results from multivariate regression analysis with active layer depth and soil temperature at 40 cm as influence parameters. Error bars represent the standard deviation. In b), the daily mean active layer depth, which was the best predictor for CO_2:CH_4 at the center.

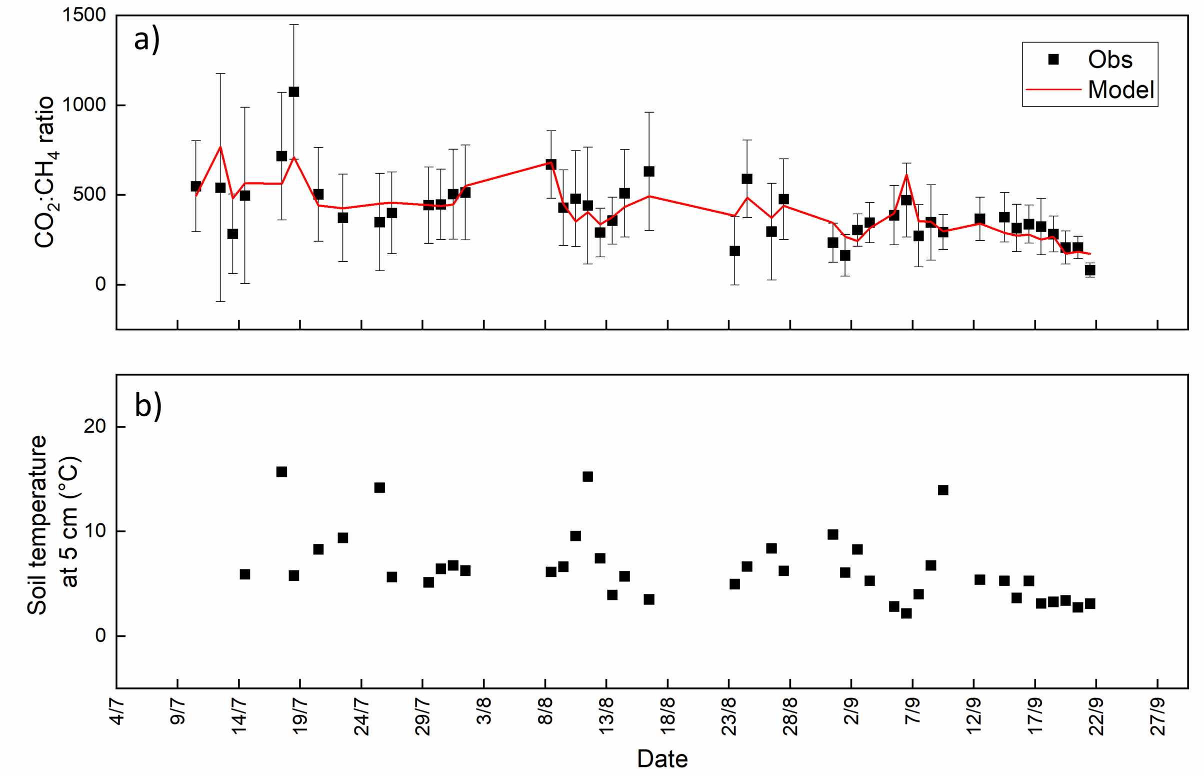

Figure 6 - In a), daily mean CO_2:CH_4 ratios in the polygon rim during the growing season in 2015 and results from multivariate regression analysis with active layer depth and soil temperature at 5 cm as influence parameters. Error bars represent the standard deviation. In b), the daily mean soil temperature at 5 cm, which was the best predictor for CO_2:CH_4 at the rim.

The CO_2:CH_4 ratios at the polygon center vary from around 3 to 100, while at the rim from around 100 to 1000

CO_2:CH_4 production ratios

CO_2:CH_4 ratios at the center that are more influenced by CH_4 production are related to soil temperature at 40 cm, while CO_2:CH_4 ratios at the rim that are more influenced by R_h are related to soil temperature at 5 cm.

CH_4 emissions are related to processes and changes happening at deeper soil layers, while the R_h are related to the soil surface and shallower layers.

Deep soil layers mostly anoxic, producing CH_4, while shallower soil layers mostly oxic, producing CO_2.

C budget

Table 1 – R_h (CO_2) and CH_4 emission budget of the polygonal tundra on Samoylov Island for the growing season in 2015

Gas	Unit	Wet tundra	Dry tundra
CO_2 (R_h)	$kg\ CO_2.ha^{-1}.d^{-1}$	10	20
CH_4	$kg\ CO_2\text{-}e.ha^{-1}.d^{-1}$	7	1
Total	$kg\ CO_2\text{-}e.ha^{-1}.d^{-1}$	17	20

Table 2 – Net ecosystem exchange (CO_2) and CH_4 emission budget of the polygonal tundra on Samoylov Island for the growing season in 2015

Gas	Unit	Wet tundra	Dry tundra
CO_2 (NEE)	$kg\ CO_2.ha^{-1}.d^{-1}$	-83	-25
CH_4	$kg\ CO_2\text{-}e.ha^{-1}.d^{-1}$	7	1
Total	$kg\ CO_2\text{-}e.ha^{-1}.d^{-1}$	-76	-24

The wet tundra, represented by the polygon center, has lower R_h and considerably higher CH_4 emission than the dry tundra. However, when both gases are accounted in CO_2 equivalent basis, their impact in the C budget is not so different.

Both tundra types are C sink during the growing season, with the wet tundra being the strongest one.

The CH_4 emissions offset 9% of the wet tundra C sink capacity, and 2% of the dry tundra C sink capacity. The relevance of CH_4 production and emission in the wet tundra is higher than in the dry tundra, despite of the dry tundra being the largest C source.

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