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LATERAL CARBON EXPORT FROM POLYGONAL TUNDRA CATCHMENTS ON SAMOYLOV ISLAND, LENA RIVER DELTA

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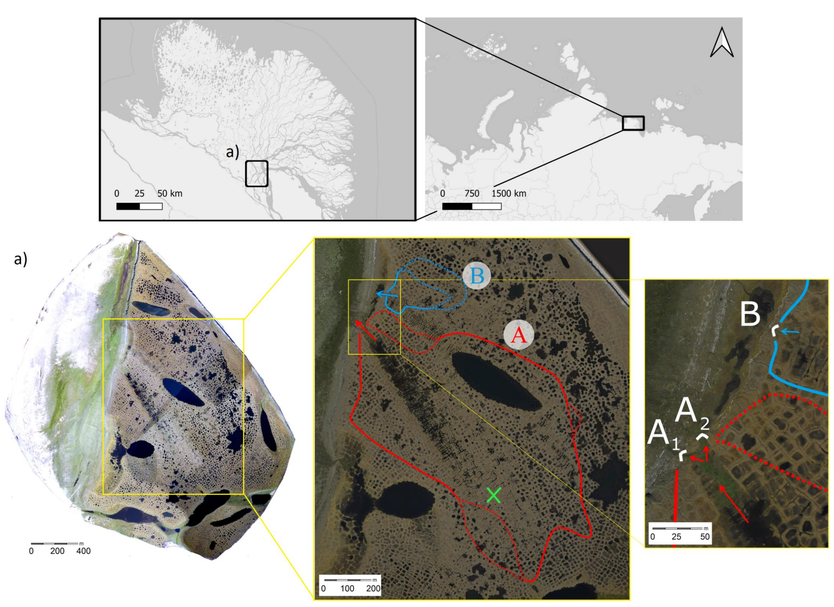
OBJECTIVE

ESTIMATE NET ECOSYSTEM CARBON BALANCE OF THE POLYGONAL TUNDRA USING LATERAL CARBON EXPORT AND VERTICAL CARBON FLUX MEASUREMENTS OVER ONE GROWING SEASON

STUDY SITE

The study site lays within the Lena River Delta, northern Russia, and is characterized by polygonal tundra. Water runoff and carbon (C) content measurements were conducted at three weirs, and the vertical C flux was observed at an eddy covariance tower.



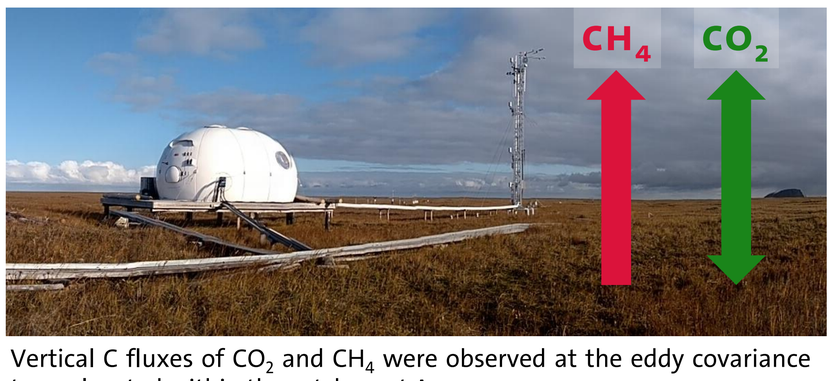
Top: Maps of northern Russia and the Lena River Delta. Bottom: Map of Samoylov Island with the catchment A (red) and B (blue). The outer and inner dotted lines mark the maximum and minimum assumed catchment size in areas with an uncertain watershed. The **green cross** marks the location of the **eddy covariance tower**. The right side shows the locations of weirs A1, A2 and B. Map data from OpenStreetMap contributors, under OpenDatabase License (top) and modified after Boike et al. 2012 (bottom).

METHODS

LATERAL CARBON EXPORT

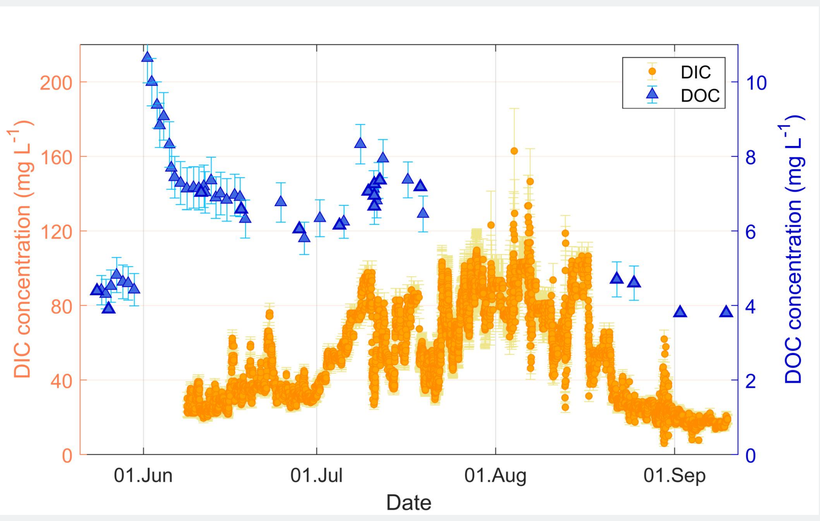
We observed the continuous water runoff rate at three weirs during the growing season of 2014. From frequent measurements of the concentration of dissolved organic carbon (C_{DOC}) and dissolved inorganic carbon (C_{DIC}, calculated from dissolved CO_2 (dCO_2)), we could estimate the lateral C export rate.

VERTICAL CARBON FLUX



Vertical C fluxes of CO_2 and CH_4 were observed at the eddy covariance tower located within the catchment A.

RESULTS



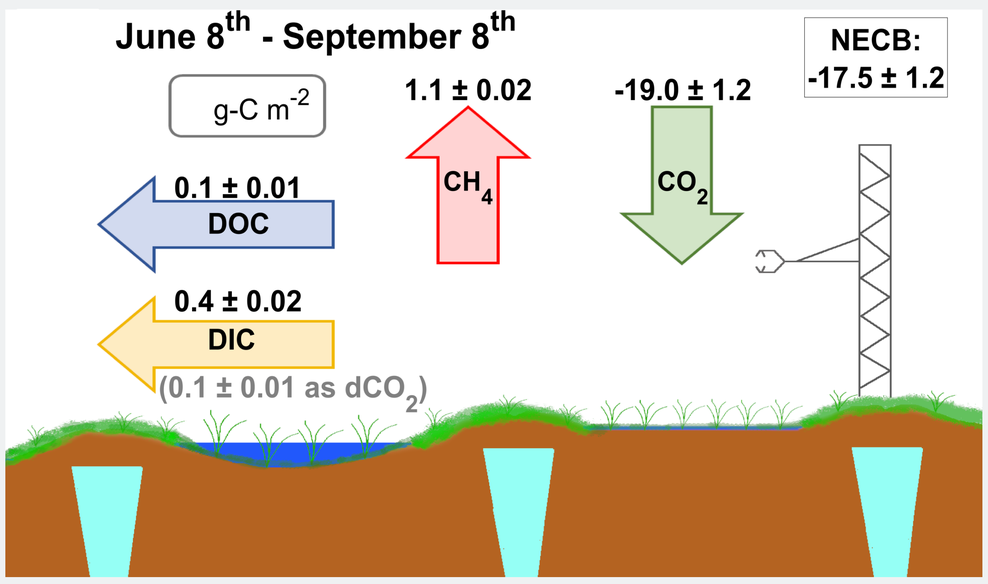
LEFT:

The concentration of DIC (C_{DIC}) mainly dominates the C content of water discharging the ecosystem (orange dots, left y-axis). The concentration of DOC (C_{DOC}) only rises up to 10.5 mg L^{-1} during the growing season (blue triangles, right y-axis). The peak in C_{DOC} at the beginning of June can be attributed to the high flood of the Lena River resulting in river water discharging through the weirs.

With values of up to 163 mg L^{-1}, C_{DIC} is up to 11 times higher compared to C_{DOC} . The two concentration time series do not follow a similar pattern throughout the growing season of 2014.

RIGHT:

Here, the cumulative fluxes of all net ecosystem carbon balance (NECB) components between June 8th and September 8th are summarized. During these three months, the NECB accumulated to -17.5 ± 1.2 g-C m^{-2}. The vertical fluxes of F_{CO2} and F_{CH4} and the lateral fluxes of F_{DOC} and F_{DIC} contributed with -19.0 ± 1.2, 1.1 ± 0.02, 0.1 ± 0.01 and 0.4 ± 0.02 g-C m^{-2}, respectively, to the NECB.



DISCUSSION

Our results show up to 11 times higher DIC concentration compared to DOC concentration in the polygonal tundra discharge water. This is in contrast to other studies reporting a C_{DIC}/C_{DOC}-ratio of smaller than 1 from an Alaskan permafrost-affected watershed (Kling et al. 2000) and a ratio of 0.24 - 1.30 in Canadian boreal bioms (Hutchins et al. 2019). However, at the northern outlet of Samoylov Island, C_{DIC} of 40.3 - 43.2 mg L^{-1} and C_{DOC} of 2.6 - 6.5 mg L^{-1} were observed in September 2008, leading to a C_{DIC}/C_{DOC}-ratio of close to 10 (Abnizova et al. 2012). Therefore, we are confident that our results of C_{DOC} and C_{DIC} are reliable.

The results of the NECB indicate that the vertical CO_2 uptake dominates the carbon balance during the growing season, even after the inclusion of lateral C export rate. However, the inclusion of this lateral carbon export leads to a decrease of 3% in the seasonal ecosystem carbon balance.

VERTICAL CO_2 FLUX DOMINATES THE NECB
➢ HOWEVER, LATERAL C FLUX DECREASES C-UPTAKE BY 3% DURING GROWING SEASON

Please note: a comparison of DOC export rates from catchment A and B will be provided in the upcoming paper.

Biblography:
Abnizova, A., Siemens, J., Langer, M., & Boike, J. (2012). Small ponds with major impact: The relevance of ponds and lakes in permafrost landscapes to carbon dioxide emissions. *Global Biogeochemical Cycles*, *26*(2).
Boike, J., Grüber, M., Langer, M., Piel, K., & Scheritz, M. (2012). Orthomosaic Samoylov Island, Lena Delta, Siberia.
Hutchins, R. H., Prairie, Y. T., & del Giorgio, P. A. (2019). Large-Scale Landscape Drivers of CO2, CH4, DOC, and DIC in Boreal River Networks. *Global Biogeochemical Cycles*, *33*(2), 125-142.
Kling, G. W., Kipphut, G. W., Miller, M. M., & O'Brien, W. J. (2000). Integration of lakes and streams in a landscape perspective: the importance of material processing on spatial patterns and temporal coherence. *Freshwater Biology*, *43*(3), 477-497.

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