The role of inland freshwaters in summer CO_2, CH_4 and N_2O emissions from north-eastern Siberian Arctic tundra

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Questions

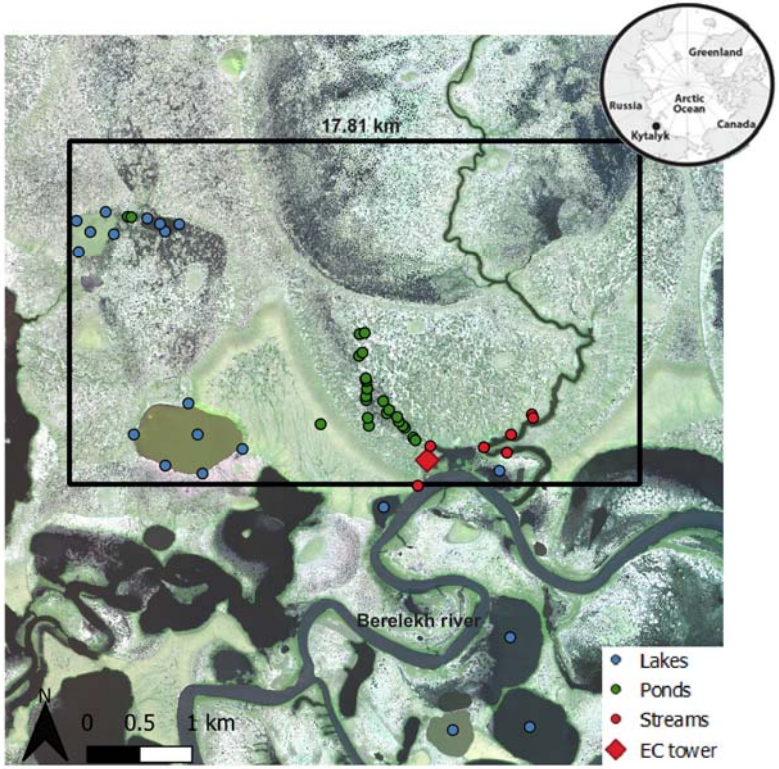
- How are the upscaled terrestrial carbon emissions in summer affected by including inland waters emissions?
- What role does N_2O play in Siberian Arctic freshwater systems?
- How does flooding affect the terrestrial carbon and N_2O emissions in summer?

Data

» Dissolved gas samples were collected in summers of 2015, 2016, 2017 to provide a ‘snapshot view’ of the vertical gas exchange

» In 2017 Berelekh river flooded the area around the EC tower, flood water samples were collected

NE Siberian lowland tundra



The box indicates the bounded area to which gas fluxes are upscaled

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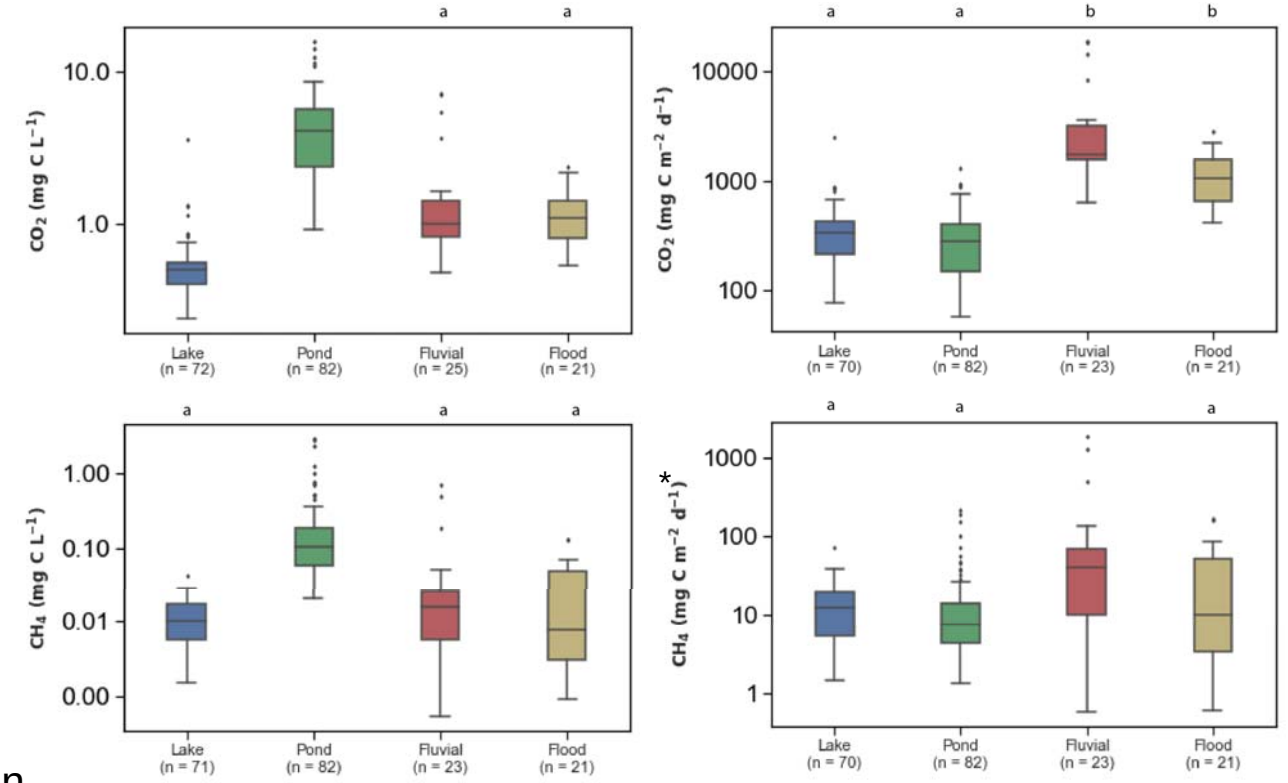
CO_2 and CH_4 concentrations and fluxes

- **Ponds** have the highest C gas concentrations
  - Only system with significantly different CH_4 concentrations
- **CO_2 concentrations** are significantly different in lakes, ponds and fluvial samples likely reflecting differences in CO_2 production, mainly:
  - Respiration in lake sediment and water column
  - External input to streams from large catchment area
  - High localized input to ponds due to high perimeter to volume ratio
- **Fluvial** systems have the highest emission rates due to a high gas exchange velocity (k = 2.59 ± 0.16)



Letters indicate medians that are not significantly different

***** Only CH_4 diffusive fluxes – lower bound to total CH_4 flux

$$Flux = k (c_{sur} - c_{eq})$$

k – gas exchange coefficient

c_{sur} – Surface water concentration

c_{eq} – Concentration in equilibrium with the atmosphere

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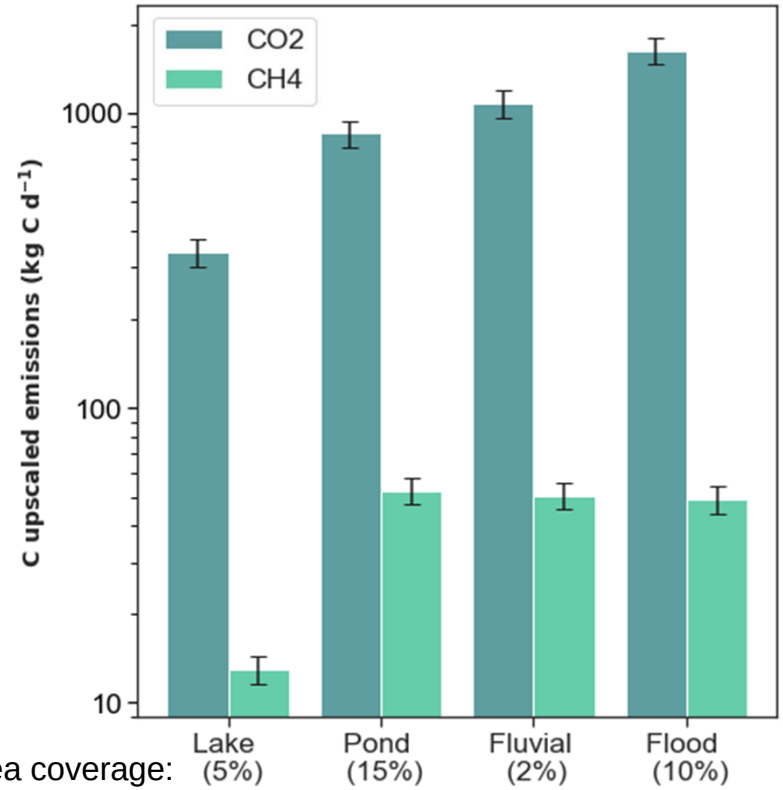
Upscaled vertical summer carbon fluxes to the bounded study area

- Vertical carbon balance of bounded area = -36.56 Mg C d^{-1}
  - **Inland waters reduce the terrestrial carbon sink by 27%**
  - The study area remains a vertical carbon sink
  - CO_2 dominates C emissions
  - Fluvial systems are the largest contributors due to high gas exchange coefficients followed by ponds due to a high surface area coverage
  - Fluvial CO_2 > Pond CO_2 but Pond CH_4 > Fluvial CH_4

- Assuming 10% of tundra becomes flooded
  - **Inland waters including the flooded area reduce terrestrial carbon sink by 38 %**



- EC tower measured tundra fluxes[1]:
  - CO_2: -2784 ± 349 mg C m^{-2} d^{-1}
  - CH_4: 42 ± 5 mg C m^{-2} d^{-1}

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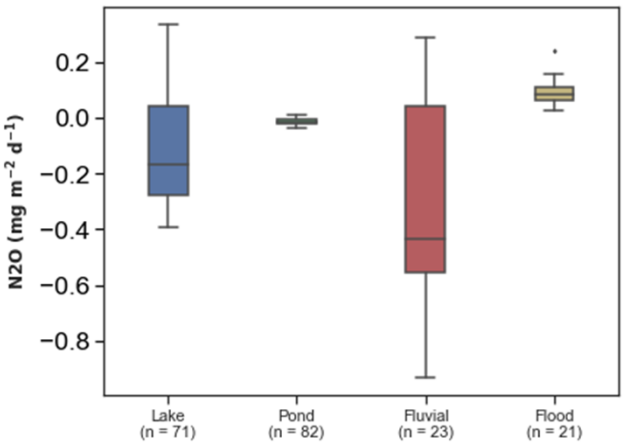
N_2O and Flooding

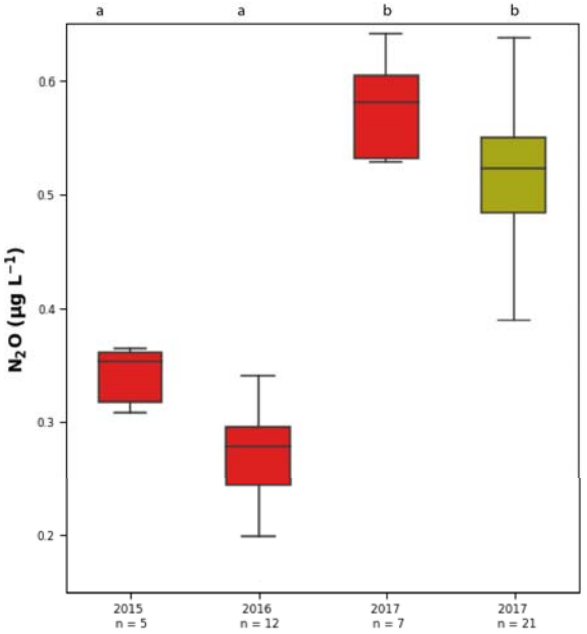
- Lake, pond and fluvial systems vary between **weak N_2O sources and sinks**
  - Likely due to shortage of mineral nitrogen (N) and low N deposition

- Higher N_2O concentrations were found in 2017 flood affected samples, resulting in **flood and fluvial** systems being **N_2O sources**
  - Probably snowmelt flood, caused by spring break-up ice jams release[2]
  - Inundation of floodplains liberates and flushes out N from plant litter and the floodplain soils making it available for mineralisation and subsequent denitrification or nitrification (or coupled denitrification-nitrification)[3]

N_2O fluxes



N_2O concentrations



Letters indicate medians that are not significantly different

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Questions

- How is the bounded areal terrestrial carbon emission in summer affected by including inland waters emissions?
- What role does N_2O play in Siberian Arctic freshwater systems?
- How does flooding affect the GHG emissions?

Answers

» Inland waters reduce the vertical terrestrial carbon sink of the north-eastern Siberian study area by 25%

» N_2O is negligible in the studied freshwater systems

» Flooding of lowland tundra areas further decreases the terrestrial carbon sink

Takeaway

- Carbon emissions from inland waters, especially with small surface areas (ponds and streams), need to be integrated into terrestrial carbon balances
- Flooding of arctic lowland floodplains requires more systematic processes investigation to determine controls on greenhouse gases

Thank you!

- First of all thank you for your time
- Secondly, the presented data is part of a manuscript in process so any feedback is greatly appreciated
- Comments or questions? Please email mmartynrosco@vu.nl

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References

1) Dean, J.F., Meisel, O.H., Martyn Rosco, M. *et al.* East Siberian Arctic inland waters emit mostly contemporary carbon. *Nat Commun* **11,** 1627 (2020). https://doi.org/10.1038/s41467-020-15511-6

2) Prowse, T.D., Wrona, F.J., Reist, J.D., Gibson, J.J., Hobbie, J.E., Lévesque, L.M. and Vincent, W.F., 2006. Climate change effects on hydroecology of Arctic freshwater ecosystems. *AMBIO: A Journal of the Human Environment*, *35*(7), pp.347-358 https://doi.org/10.1579/0044-7447(2006)35[347:CCEOHO]2.0.CO;2

3) Baldwin, D.S. and Mitchell, A.M., 2000. The effects of drying and re-flooding on the sediment and soil nutrient dynamics of lowland river–floodplain systems: a synthesis. *Regulated Rivers: Research & Management: An International Journal Devoted to River Research and Management*, *16*(5), pp.457-467

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