Linking Lateral Carbon Transport to Vertical Carbon Fluxes across the Terrestrial-Aquatic Interface in a Thawing Permafrost Peatland

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RESEARCH QUESTIONS

Overall Project Questions:

1) How does belowground carbon (C) quantity and quality change across the terrestrial-aquatic interface?
2) What is the importance of the lateral flow of this C to net CO_2 & methane (CH_4) emissions?
3) What role do CH_4 cycling microbes play in predicting CH_4 flux variability?

How do dissolved CH_4 concentrations affect CH_4 fluxes across a thaw gradient?

CONSEQUENCES OF A WARMING ARCTIC

- Permafrost thaw enhances the connectivity of terrestrial and aquatic environments by altering lateral flux of C due to active layer thickening and shifts in flow paths.[2]
- Although the importance of lateral C flux in the Arctic C cycle is increasingly recognized, **the proportions of different C species transported to streams is poorly quantified and are rarely linked to vertical fluxes across the landscape.**[3]

STUDY SITE: STORDALEN MIRE, SWEDEN

Study Site

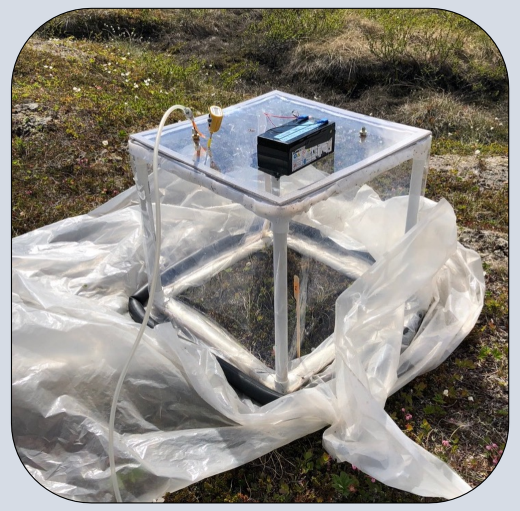
Stream Transect

Lake Transect

Location: Stordalen Mire is a subarctic catchment in northern Sweden (15 km², 68°21′ N 18°49′ E), characterized by patches of raised permafrost palsas (i.e., frozen peat mounds) and has experienced permafrost thaw for decades.[4]

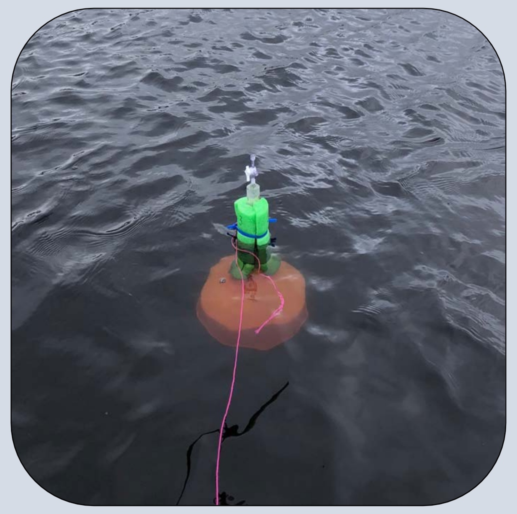
Sites: Three transects (~20 m in length, ~10 m apart) spanning a gradual thaw gradient from a palsa to a low-turbidity stream and three additional transects that span an abrupt thaw gradient from a palsa to a post-glacial lake.

METHODS



Flux Chamber

Stainless Steel Sipper



Bubble Trap

- Sampled transects weekly from June-August

Terrestrial

- CH_4 & CO_2 vertical fluxes → Static flux chamber
- Porewater (pCH_4, pCO_2, DOC, DIC, POC) → 60 ml polypropylene syringe with stopcock attached to stainless steel sipper (0.25" diameter), pulling 20cm below peat surface

Aquatic

- Diffusive fluxes → Wind-based flux model[5]
- Ebullitive fluxes → Bubble traps
- pCH_4, pCO_2, DOC, DIC, POC

CH_4 FLUXES AND DISSOLVED CH_4 CONCENTRATIONS VARY BY THAW STAGE

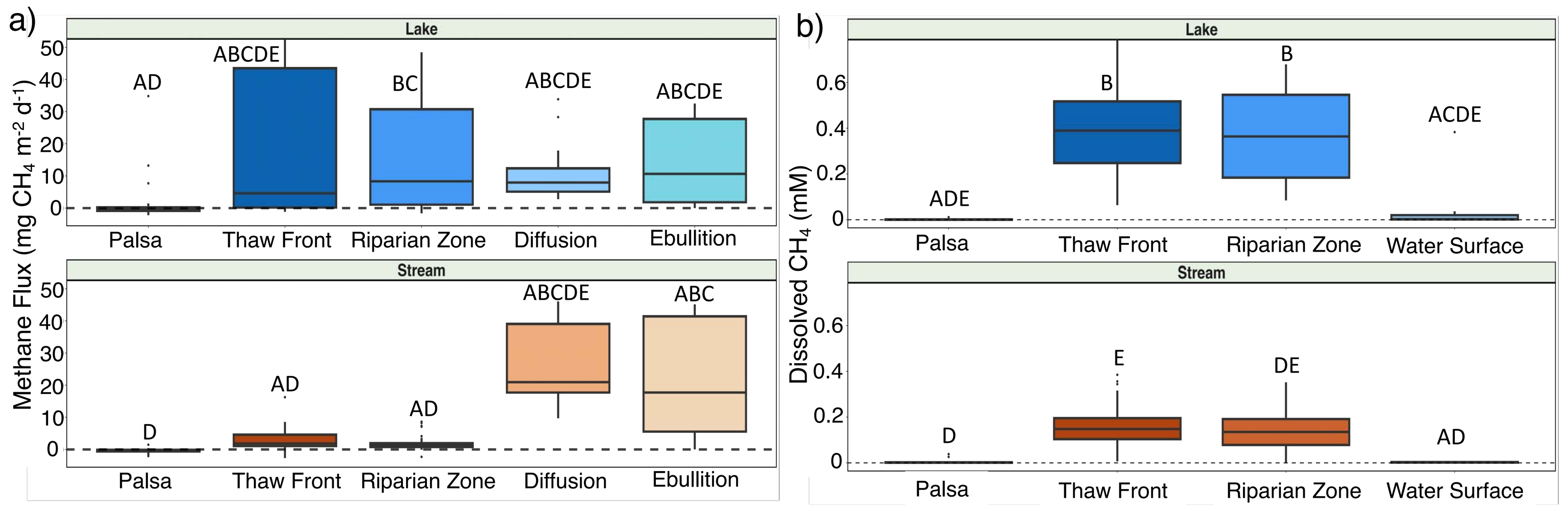


Fig 1. a) Methane fluxes (mg CH_4 m^{-2} d^{-1}) and **b)** dissolved CH_4 concentrations at three thaw stages, in the water surface (diffusive flux) and ebullitive fluxes. Top panel are fluxes from the transect leading to the lake, bottom panel are fluxes from the transect leading to the stream. Letters indicate statistical significance (p<0.05). Significance tested with-in and between sites.

CH_4 FLUXES POSITIVELY CORRELATED WITH DISSOLVED CH_4 CONCENTRATIONS

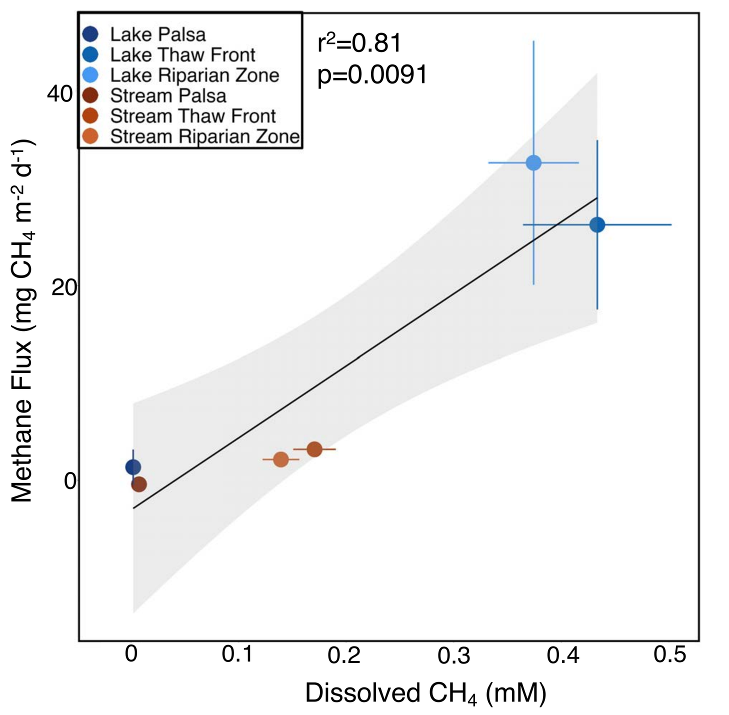
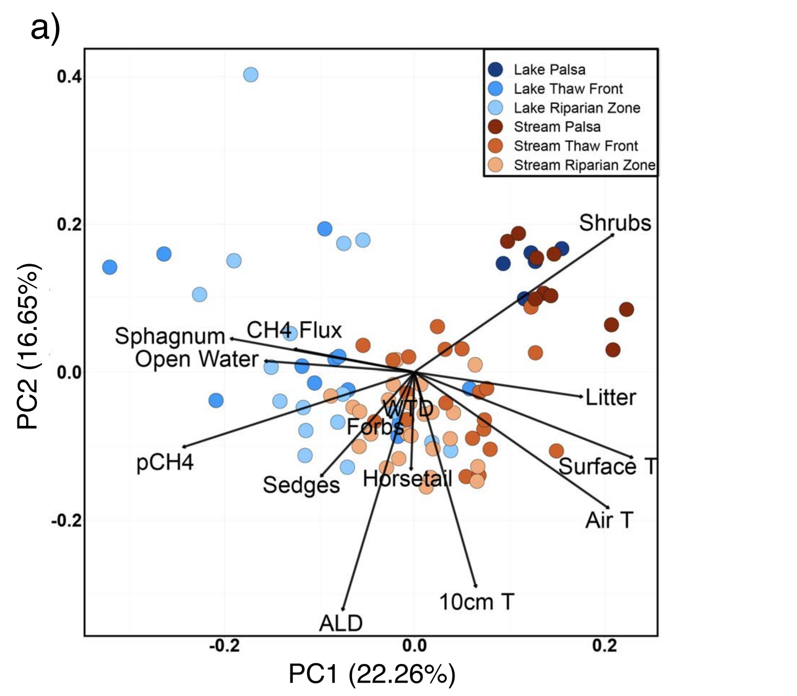


Fig 2. Linear regression of dissolved CH_4 concentrations (mM) and CH_4 fluxes (mg CH_4 m^{-2} d^{-1}) (r^2=0.81, p=0.0091). Colors represent site and thaw stage.

Porewater

Palsa | Thaw Front | Riparian Zone | Surface

FLUX DIFFERENCES DRIVEN BY VEGETATION, WATER CHEMISTRY



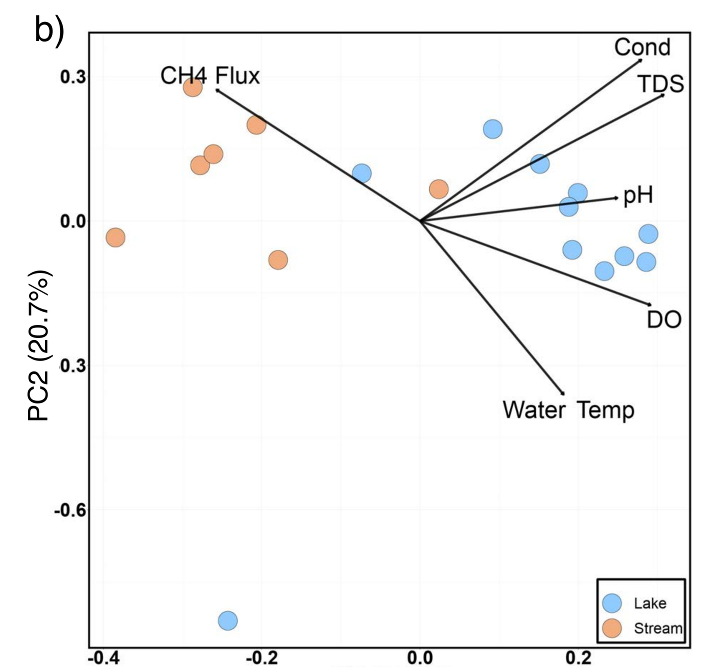
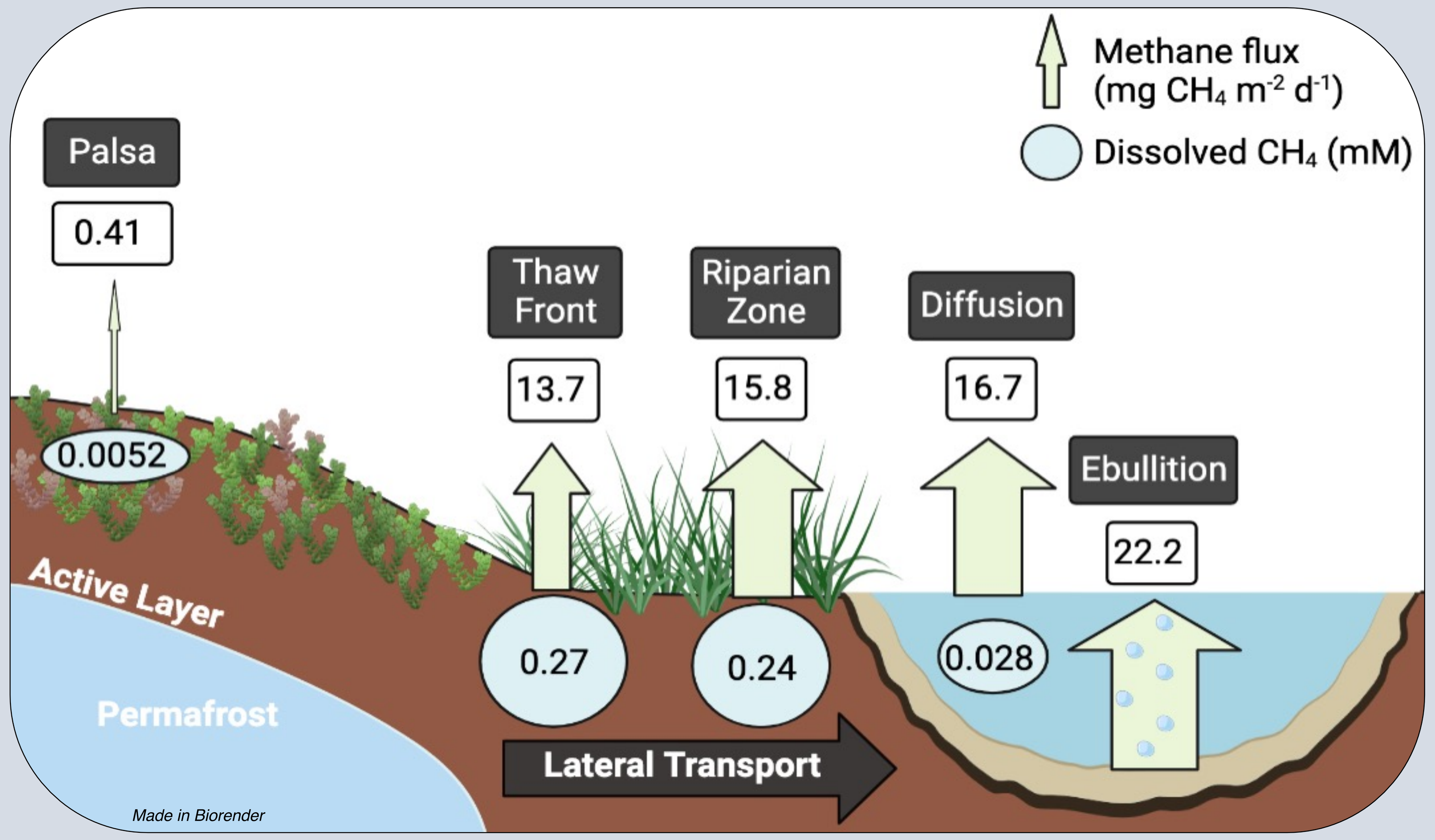


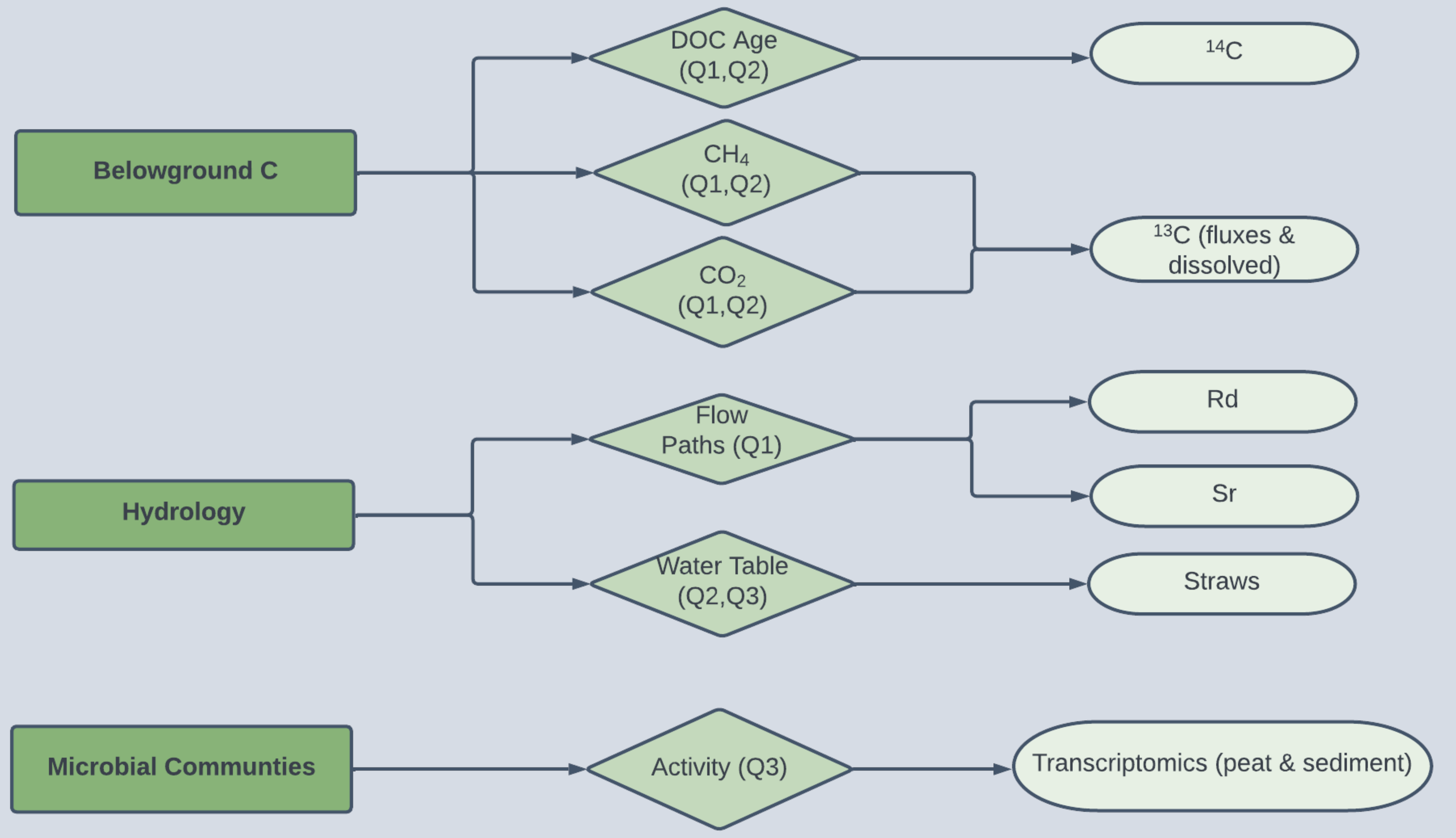
Fig 3. Principal component analysis between the **a)** transect leading into the lake (blue shaded circles) and stream (orange shaded circles) and **b)** water surface for the lake (blue) and stream (orange). Biplot vectors fit show the directions in which environmental measurements correlate most strongly with the ordination configuration. For environmental vectors: WTD = water table depth, ALD = active layer depth, DO= dissolved oxygen, Cond= conductivity, TDS= Total dissolved solids. All vegetation characteristics measured by percent cover.

MAIN CONCLUSION

As permafrost thaws, dissolved CH_4 could be getting flushed into streams and lakes, increasing methane emissions despite spatial heterogeneity in vertical CH_4 emissions



NEXT STEPS: BELOWGROUND PROCESSES



*Q refers to overall project questions and the associated question it assists in answering

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