16th ICMGP Cape Town 2024

ICMGP 2024

CAPE TOWN • SOUTH AFRICA • 21 - 26 JULY

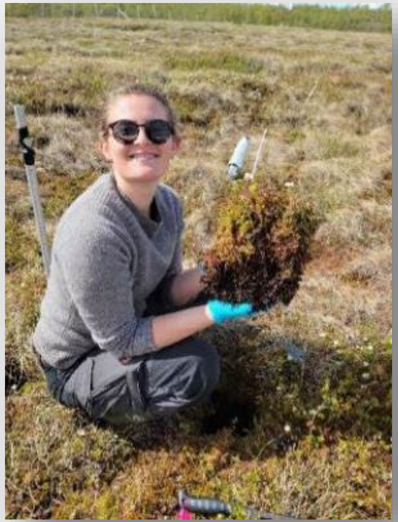
Mercury Mobility in Permafrost Peatlands of northern Scandinavia

Charlotte Haugk

charlotte.Haugk@aces.su.se

Co-authors:

Alyssa Azaroff, Margareta Johansson, Mingyue Li, Lauren Thompson, Maria Camilla Urrea & Sofi Jonsson



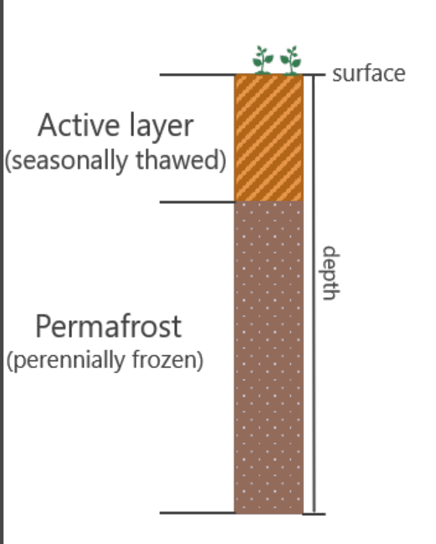
WWW.MERCURYCAPETOWN.COM

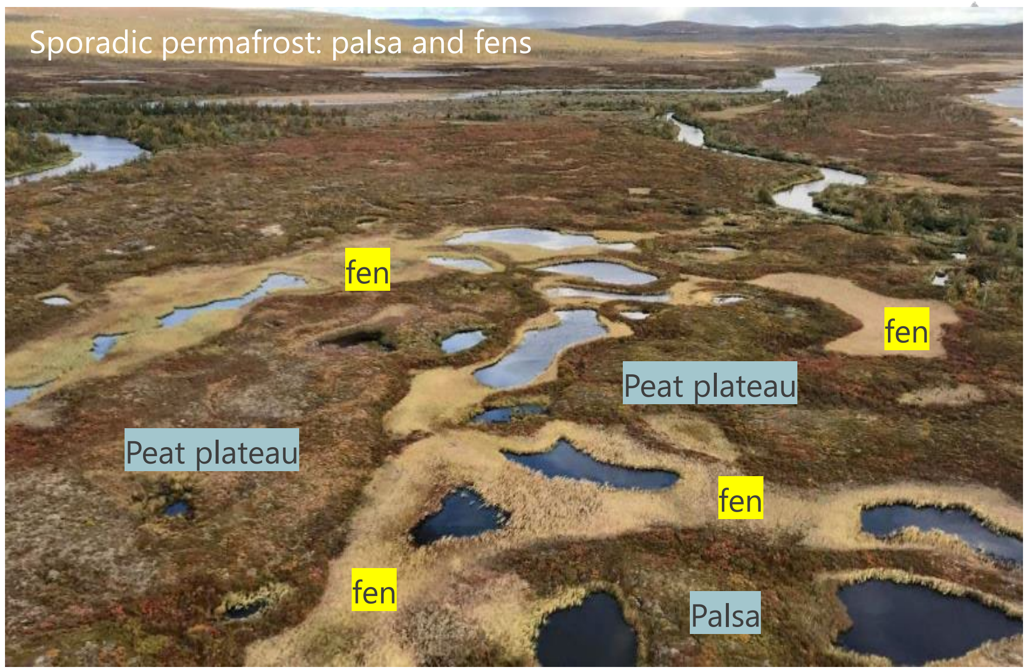
Permafrost in the Arctic

What is it?

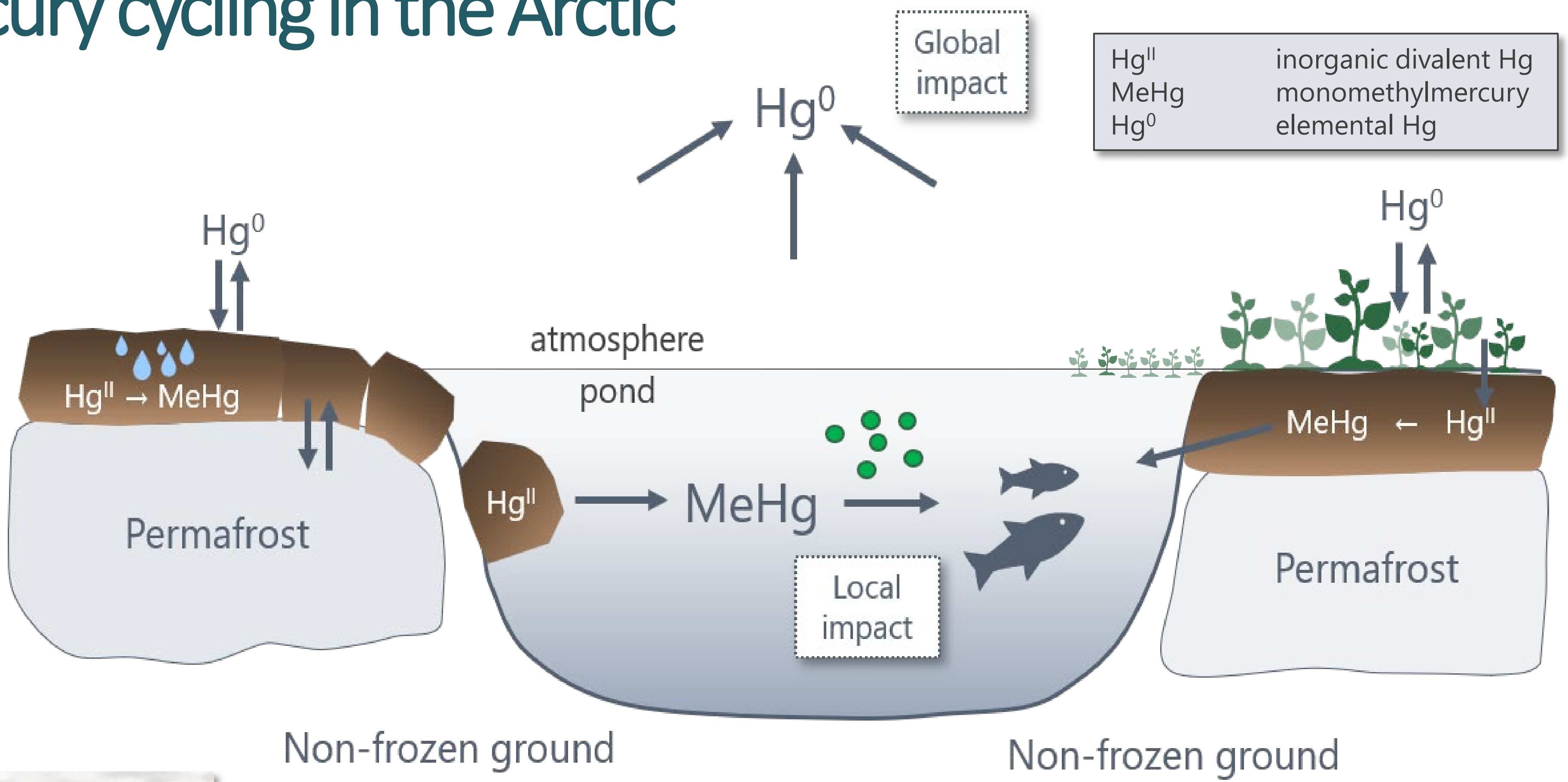
<u>Permafrost</u> is defined as ground (soil, rock, including ice or organic material) that remains at or below 0°C for at least two consecutive years.

Where is it and how much do we have?



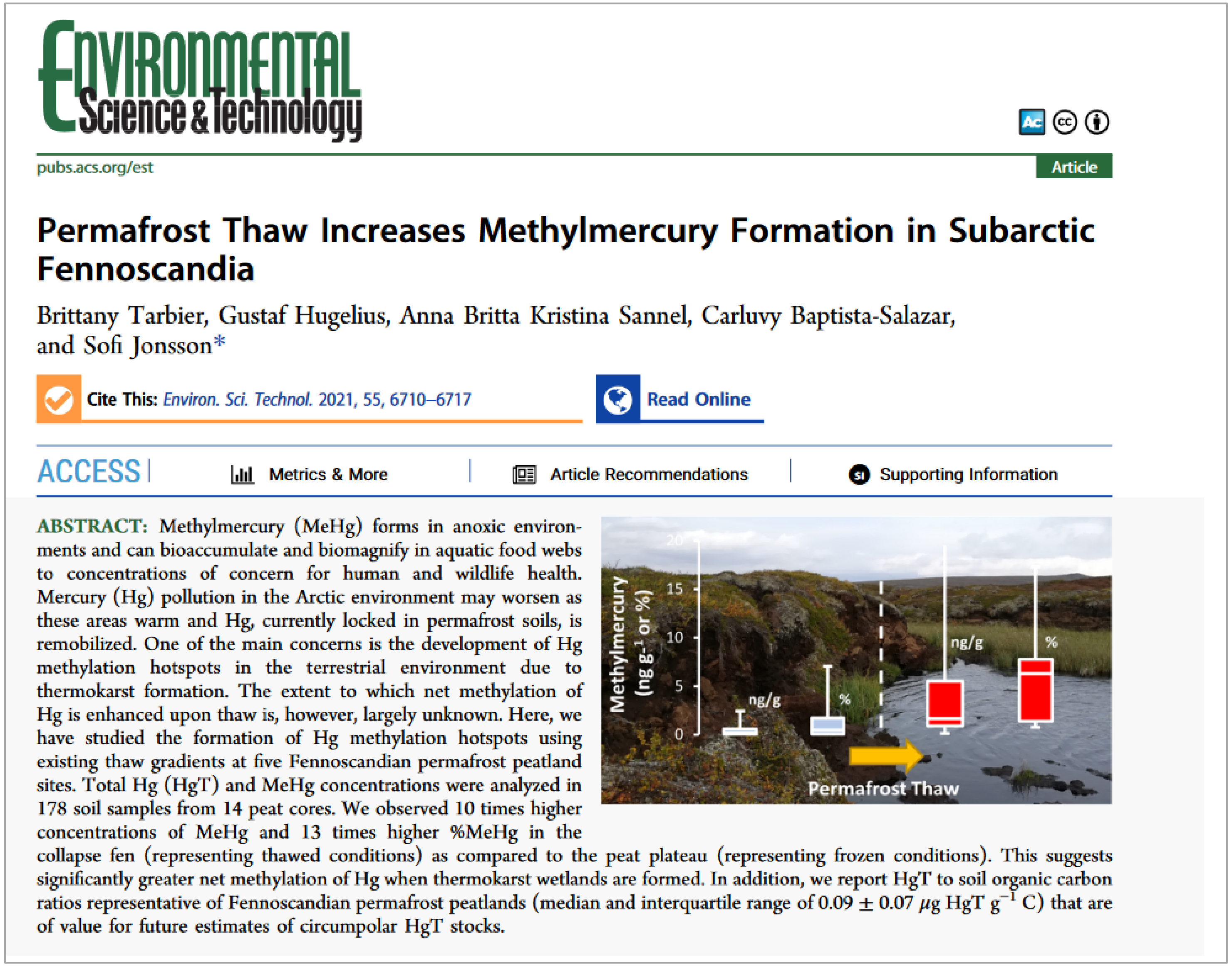


Mercury cycling in the Arctic



- 600 Gt Hg estimated to be stored in permafrost (Lim et al. 2020)
- Permafrost thaw: organic rich material alongside Hg is being remobilized and available for potential methylation
- Two main concerns:
  Export of mercury and formation of MeHg hotspots

Mercury mobility along natural thaw gradients



pubs.acs.org/est

Article

Permafrost Thaw Increases Methylmercury Formation in Subarctic Fennoscandia

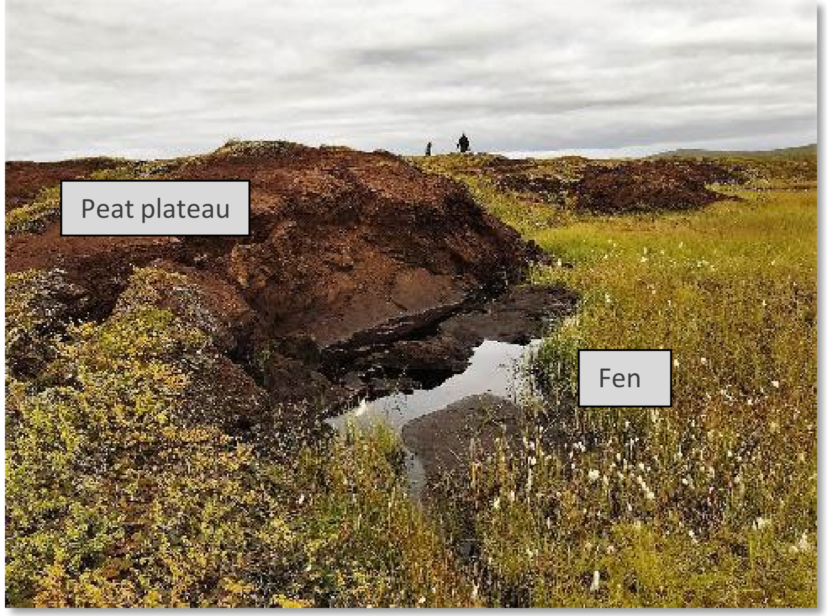
Brittany Tarbier, Gustaf Hugelius, Anna Britta Kristina Sannel, Carluvy Baptista-Salazar, and Sofi Jonsson*

Cite This: *Environ. Sci. Technol.* 2021, 55, 6710–6717

Read Online

ACCESS | Metrics & More | Article Recommendations | Supporting Information

ABSTRACT: Methylmercury (MeHg) forms in anoxic environments and can bioaccumulate and biomagnify in aquatic food webs to concentrations of concern for human and wildlife health. Mercury (Hg) pollution in the Arctic environment may worsen as these areas warm and Hg, currently locked in permafrost soils, is remobilized. One of the main concerns is the development of Hg methylation hotspots in the terrestrial environment due to thermokarst formation. The extent to which net methylation of Hg is enhanced upon thaw is, however, largely unknown. Here, we have studied the formation of Hg methylation hotspots using existing thaw gradients at five Fennoscandian permafrost peatland sites. Total Hg (HgT) and MeHg concentrations were analyzed in 178 soil samples from 14 peat cores. We observed 10 times higher concentrations of MeHg and 13 times higher %MeHg in the collapse fen (representing thawed conditions) as compared to the peat plateau (representing frozen conditions). This suggests significantly greater net methylation of Hg when thermokarst wetlands are formed. In addition, we report HgT to soil organic carbon ratios representative of Fennoscandian permafrost peatlands (median and interquartile range of 0.09 ± 0.07 μg HgT g^{-1} C) that are of value for future estimates of circumpolar HgT stocks.

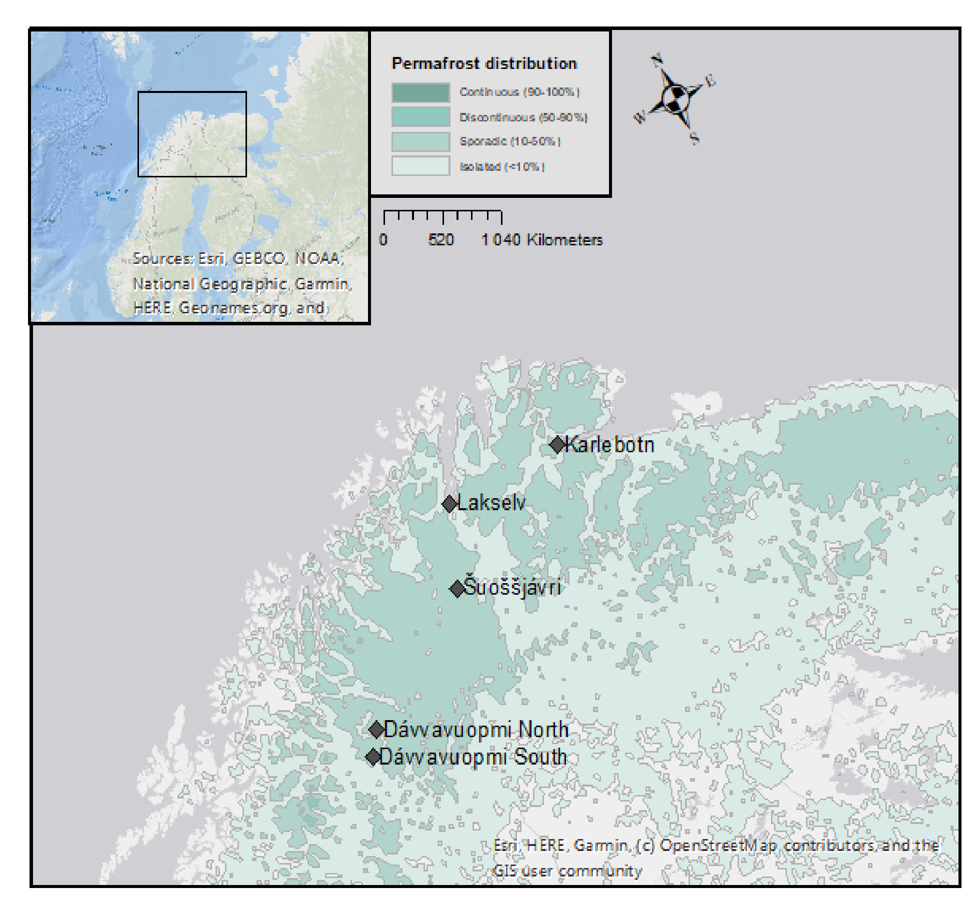


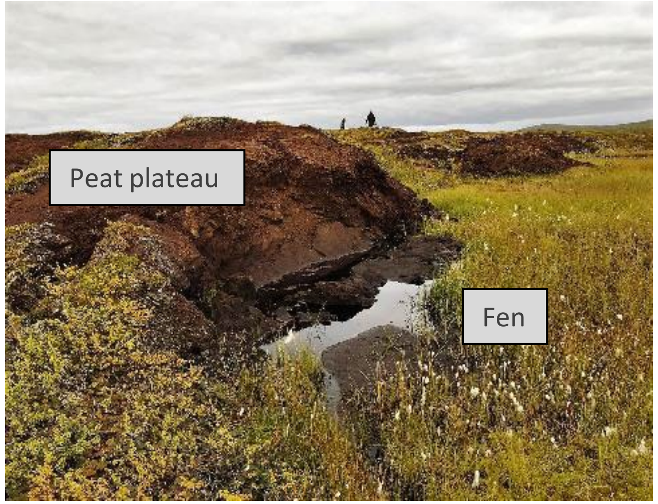
Earlier study observed thawing permafrost leads to **increased methylation in thermokarst** (fen) compared to intact permafrost (peat plateau)

Mercury mobility of northern Scandinavia

4 locations, 94 cores, 47 transects

>1000 samples analysed for THg
Subset for MeHg

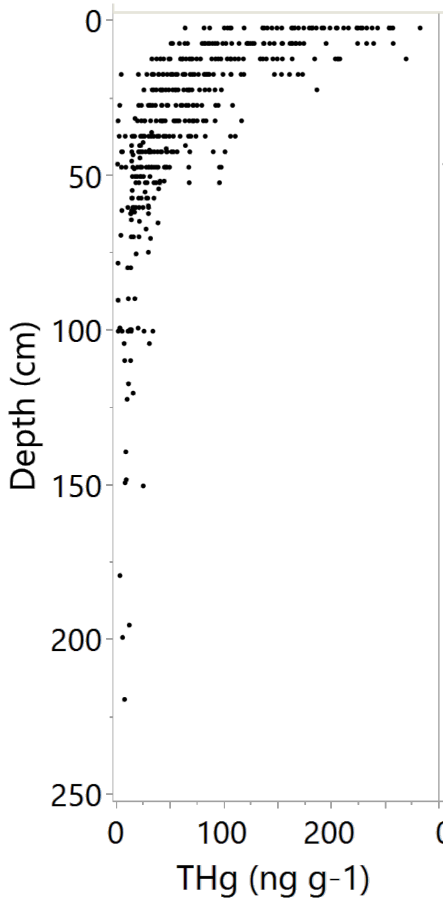


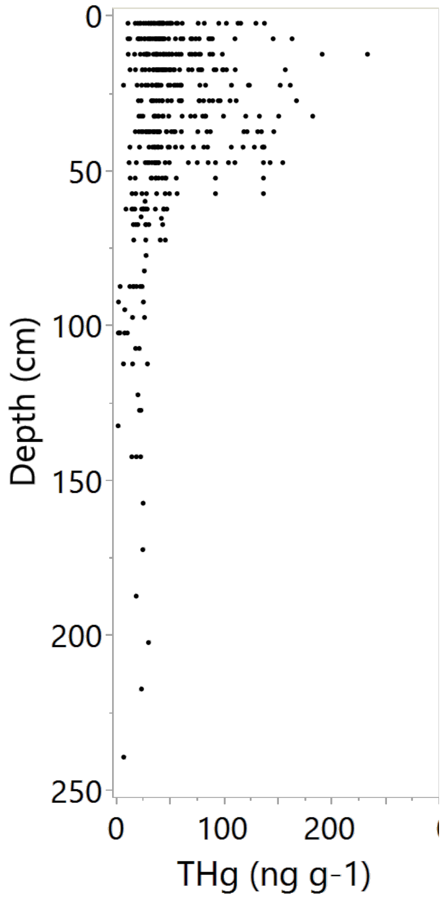


Mercury mobility along natural thaw gradients

Peat plateau
(intact permafrost conditions)

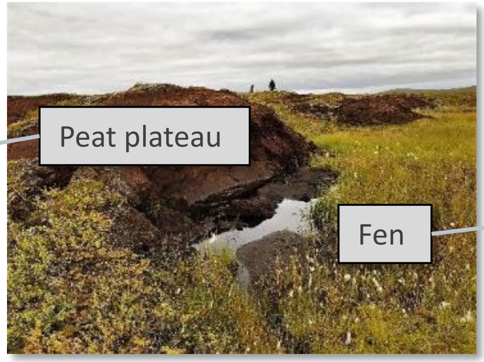
Fen/thermokarst
(thawed conditions)



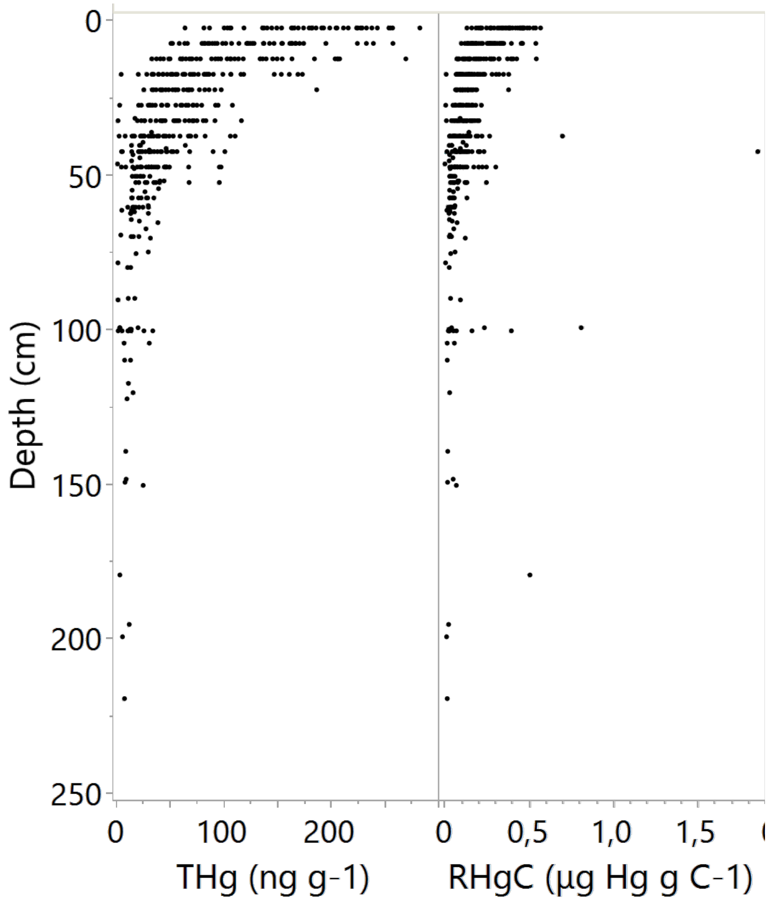


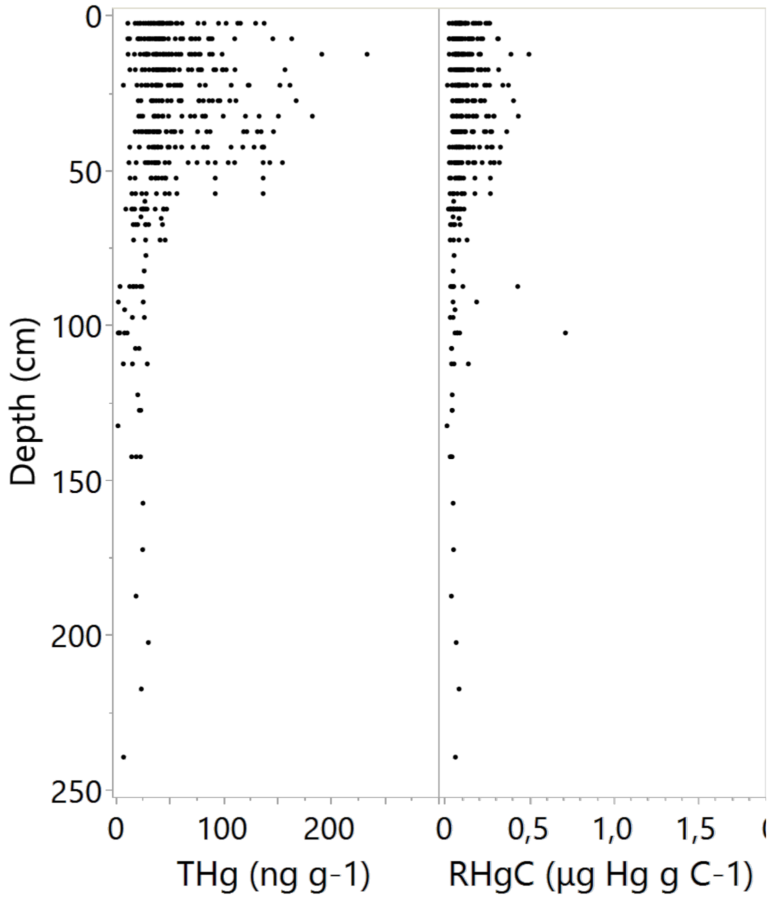
Mercury mobility along natural thaw gradients

Peat plateau
(intact permafrost conditions)



Fen/thermokarst
(thawed conditions)

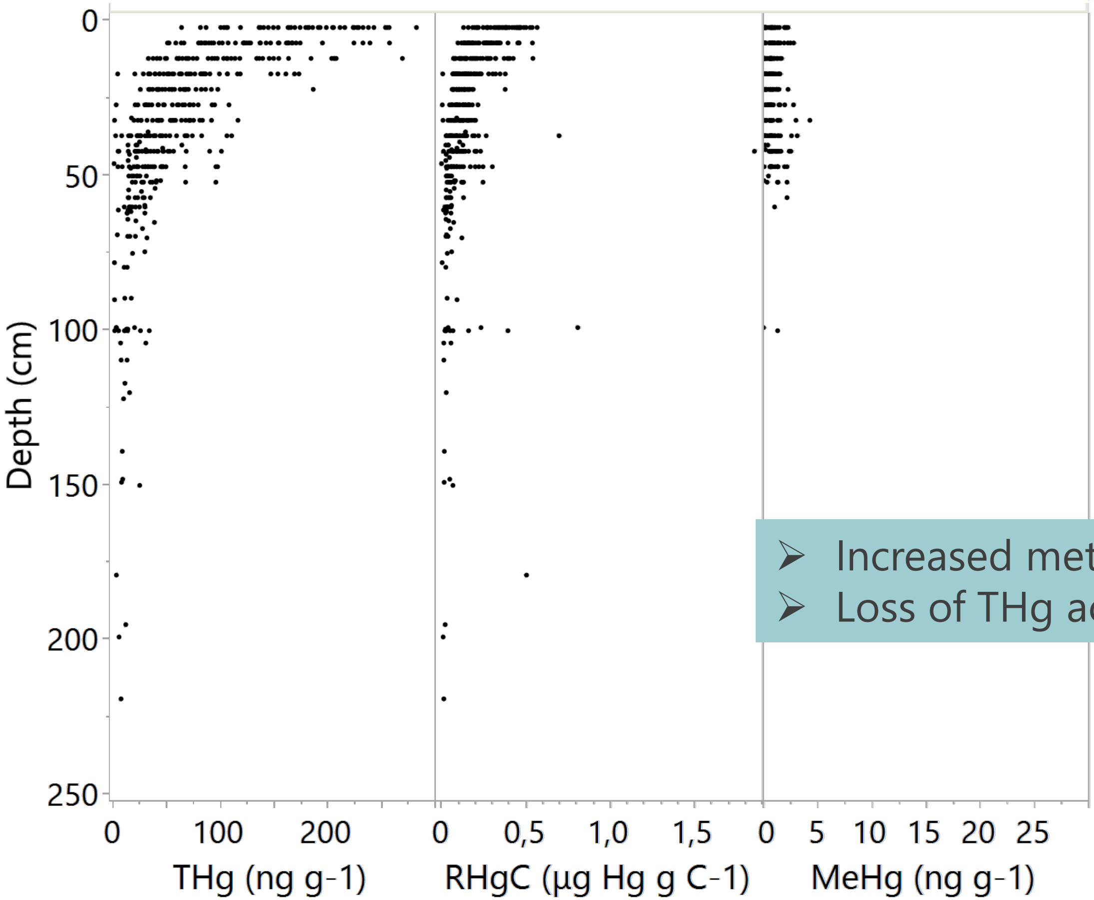


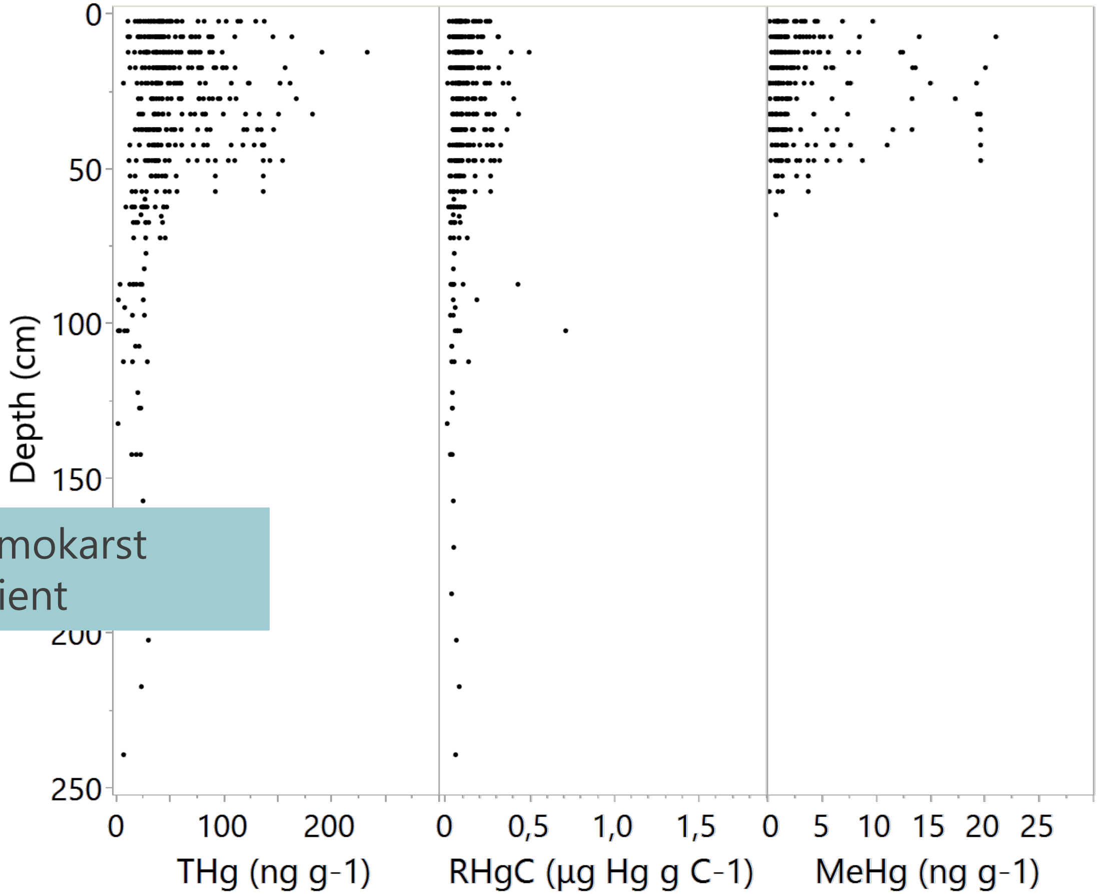


Mercury mobility along natural thaw gradients

Peat plateau
(intact permafrost conditions)

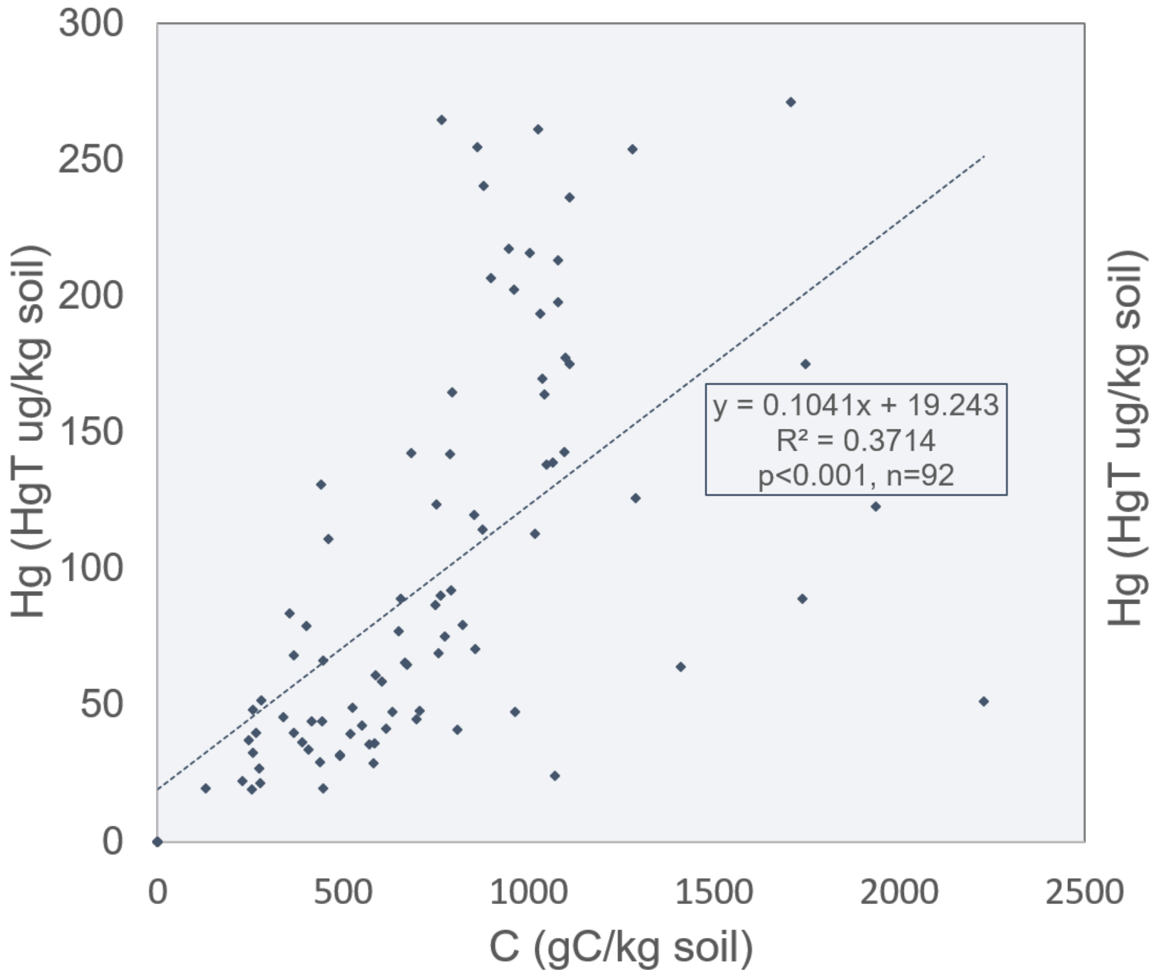
Fen/thermokarst
(thawed conditions)

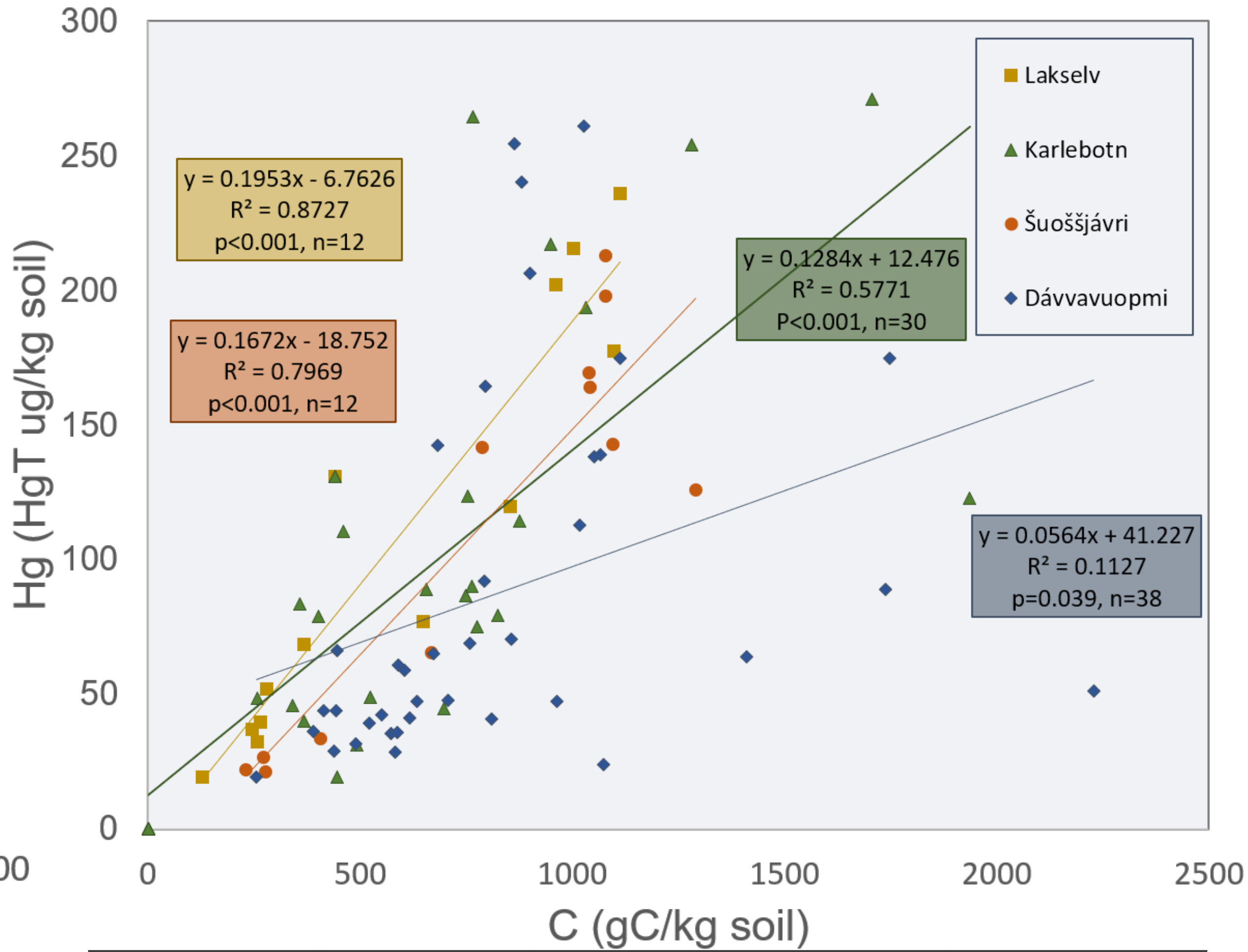




- ➢ Increased methylation in thermokarst
- ➢ Loss of THg across thaw gradient

Mercury mobility along natural thaw gradients - Hg-C ratio (R_{HgC})





- Hg follows carbon trend
- Variability within and between sites

RHgC	Lakselv	Karlebotn	Šuoššjávri	Dávvavuopmi
µg Hg g C^{-1}	0.17±0.09	0.15±0.1	0.13±0.08	0.12±0.1

Pan Arctic organic and mineral Hg-C ratio (R_{HgC})

	R_{HgC} – mineral	R_{HgC} – organic	
Schuster et al. (2018)	1.6±0.9 µg Hg g C^{-1}		Alaska mainly
Olsson et al. (2018)	0.62 Gg Pg^{-1} (30-100 cm)	0.12 Gg Pg^{-1} (0-30cm)	+ literature
Lim et al. (2020)	0.64 Gg Pg^{-1}	0.15 Gg Pg^{-1}	+ West Siberian Lowlands Excl. Alaska
This study	**0.24±0.02 µg Hg g C^{-1} (<17%SOC)**	**0.14±0.004 µg Hg g C^{-1} (>17%SOC)**	**Northern Scandinavia (94 cores)**
Kirkwood in prep.	0.08 µg Hg g C^{-1}		Hudson Bay Lowlands (50 cores)

Organic: compares well
Mineral: 7x lower in this study than Schuster et al.
2.5 x lower in this study than Lim et al.

Peat plateau (permafrost)

Fen (thermokarst)

0.13±0.1 µg Hg g C^{-1}

0.09±0.08 µg Hg g C^{-1}

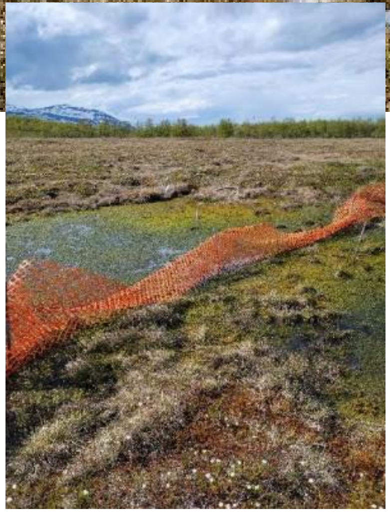
- More Hg stored in peat plateaus compared to fens
- THg loss across thaw gradient (av. 37%)
- Increased methylation in thermokarst
- Timeline of thaw?

Exploring Mercury Responses to Winter Warming: A Snow Fence Field Experiment in a Swedish Sub-Arctic Peatland

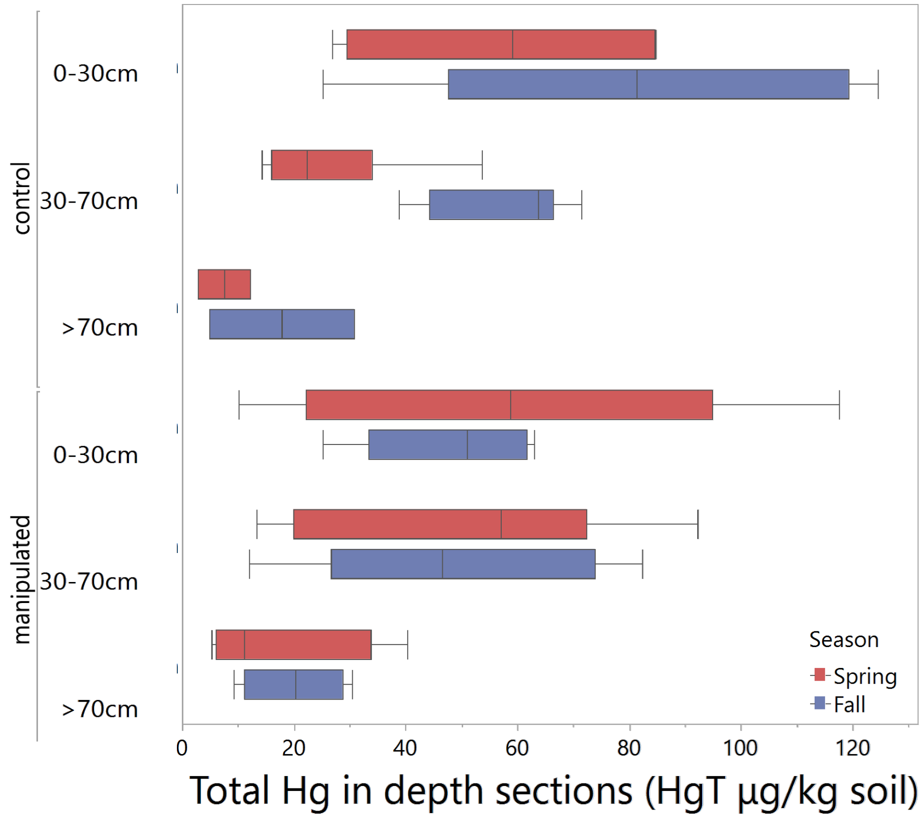
Charlotte Haugk[1], Alyssa Azaroff[1], Bertilsson, Stefan[2], Margareta Johansson[3], Mingyue Li[4], Tong Liu[2], Lauren Thompson[5,6] & Sofi Jonsson[1]

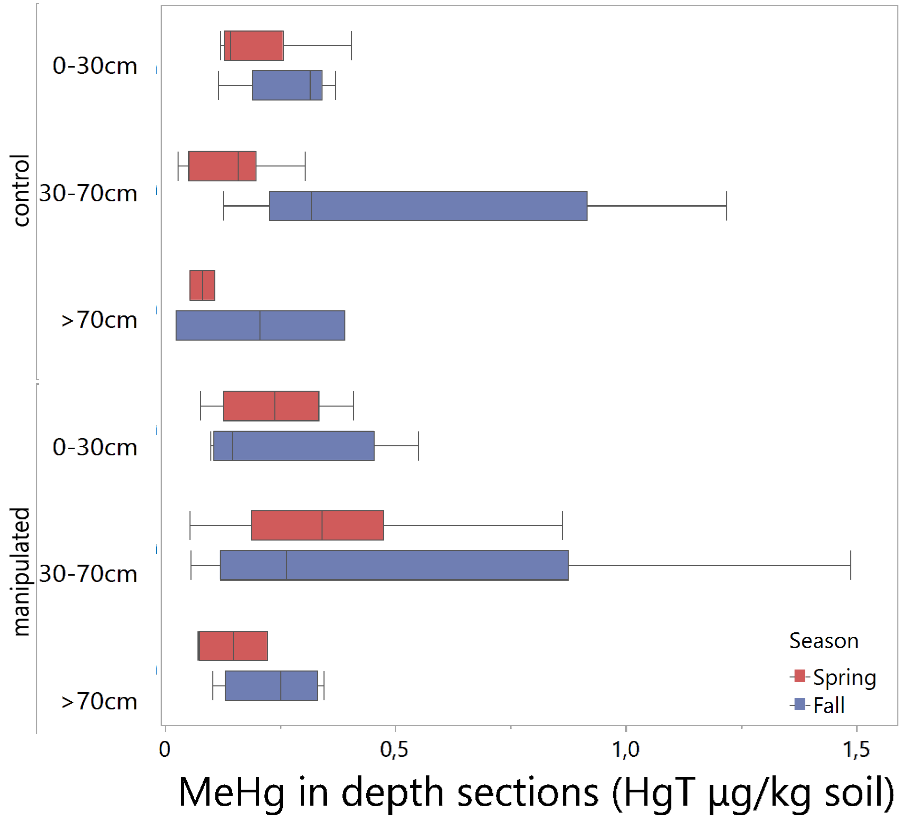
[1]Department of Environmental Science (ACES), Stockholm University, Stockholm, Sweden, [2]Department of Aquatic Sciences and Assessment, Swedish University of Agricultural Sciences, Uppsala, Sweden, [3] Department of Physical Geography and Ecosystem Science, Lund University, Sweden, [4] Institute of Tibetan Plateau Research, University of Chinese Academy of Sciences, Beijing, China, [5]Department of Renewable Resources, University of Alberta, Edmonton, Alberta, Canada, [6]Hatfield Consultants, Calgary, Alberta, Canada

Does increased permafrost thaw have an impact on the Hg pools in this controlled experiment?



Exploring Mercury Responses to Winter Warming: A Snow Fence Field Experiment in a Swedish Sub-Arctic Peatland





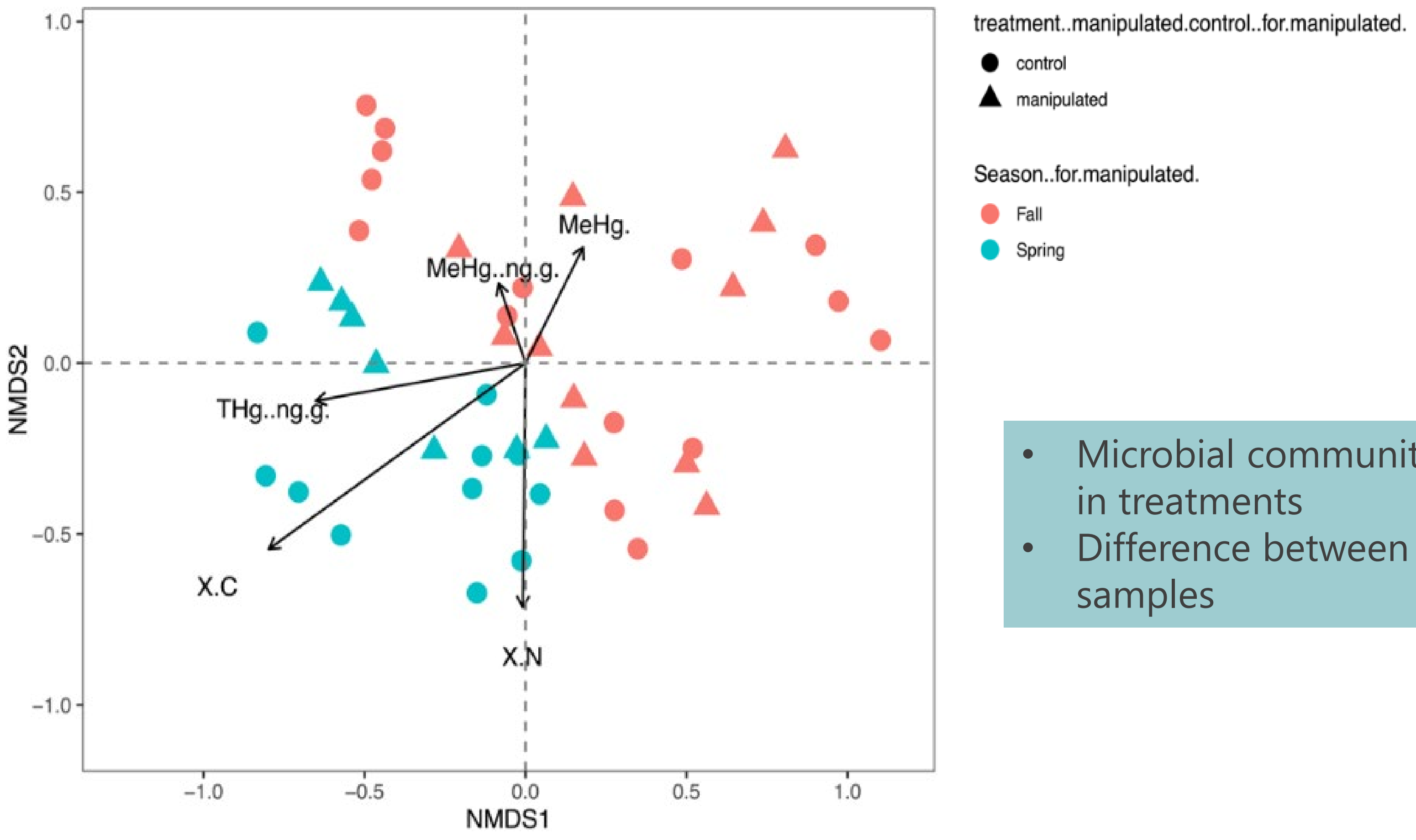
Active layer deepness (cm)

	Spring	*Fall*
control	28	70
manipulated	47	not detectable

Depth sections
0-30 cm (shallow active layer),
30-70 cm (intermediate active layer)
>70cm (permafrost)

Exploring Mercury Responses to Winter Warming:
A Snow Fence Field Experiment in a Swedish Sub-Arctic Peatland

Non-metric Multidimensional Scaling (NMDS) of amplicon sequence variants (ASVs) of the 16S rRNA genes



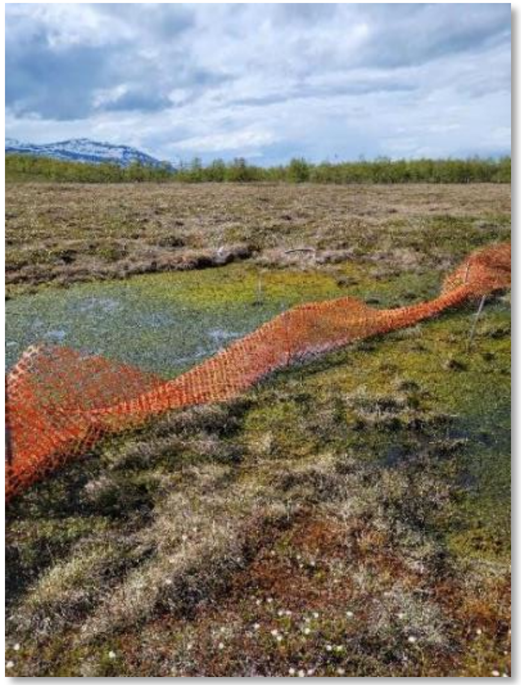
Swedish University of Agricultural Sciences
SLU

- Microbial community structure similar in treatments
- Difference between fall and spring samples

Mercury mobility of northern Scandinavia

Conclusion:

- **Increased methylation in thermokarst** across thaw gradient
- **THg loss along thaw gradient**
- **Hg stocks driven by carbon content**
- **Variability within and between sites** of Hg stored in different landscape features
- R_{HgC} of northern Scandinavian permafrost is **lower than previously estimated**
- In climate scenario: Winter Warming has no effect on Hg species, but **microbial community structure and abundance depends on seasons**

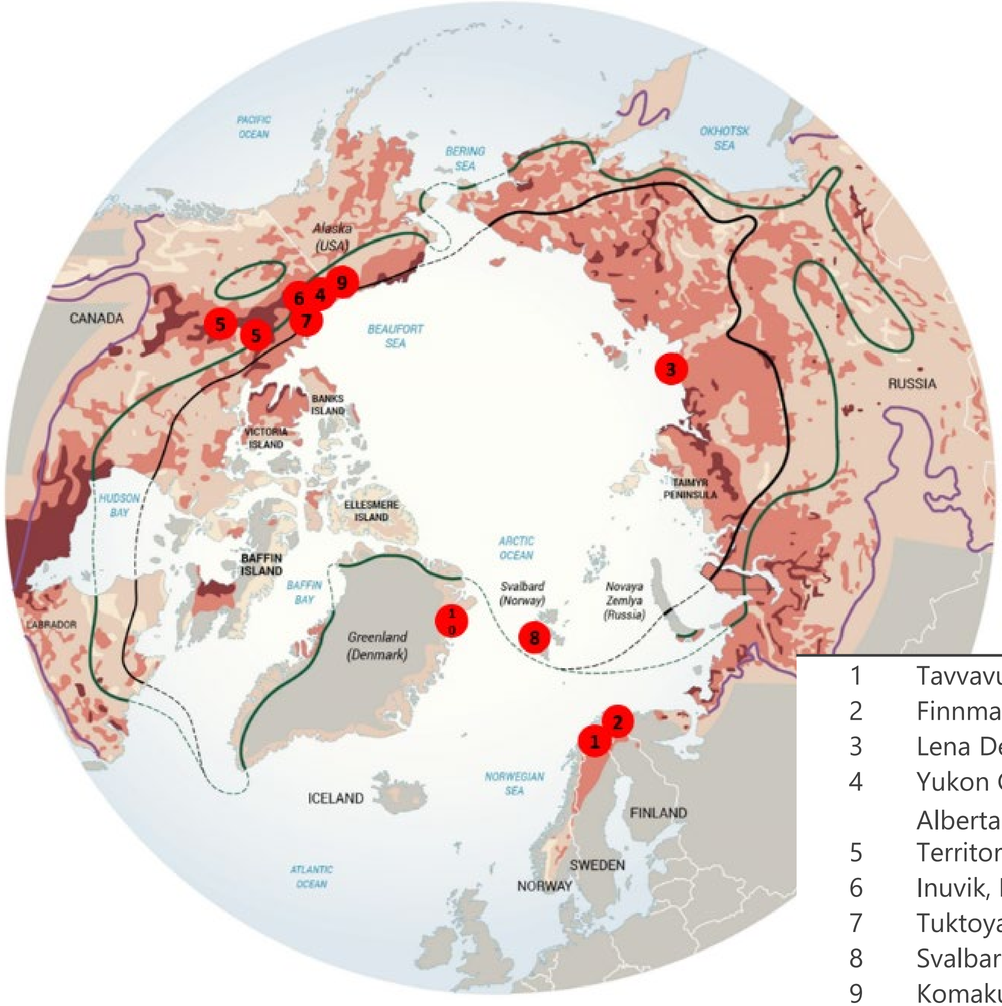


MerPerA - Database for MeHg distribution in Arctic Permafrost

1. Pan-Arctic mapping of terrestrial MeHg distribution
2. MeHg stock estimates

Data collection through:
fieldwork, collaborations, INTERACT Access, literature review

Classification:
- Landscape features/thaw stages
- Permafrost distribution



Modified after:
https://www.grida.no/resources/13344

1	Tavvavuoma
2	Finnmark
3	Lena Delta, Siberia
4	Yukon Coast, NWT
5	Alberta and North-Western Territories
6	Inuvik, Dempster Highway, NWT
7	Tuktoyaktuk, NWT
8	Svalbard, Hornsund/Ny-Ålesund
9	Komakuk Beach, Yukon Coast
10	Zackenberg Station, Greenland
…	…

ICMGP 2024
CAPE TOWN • SOUTH AFRICA • 21 - 26 JULY
CAPE TOWN INTERNATIONAL CONVENTION CENTRE

THANK YOU!

2020

2021

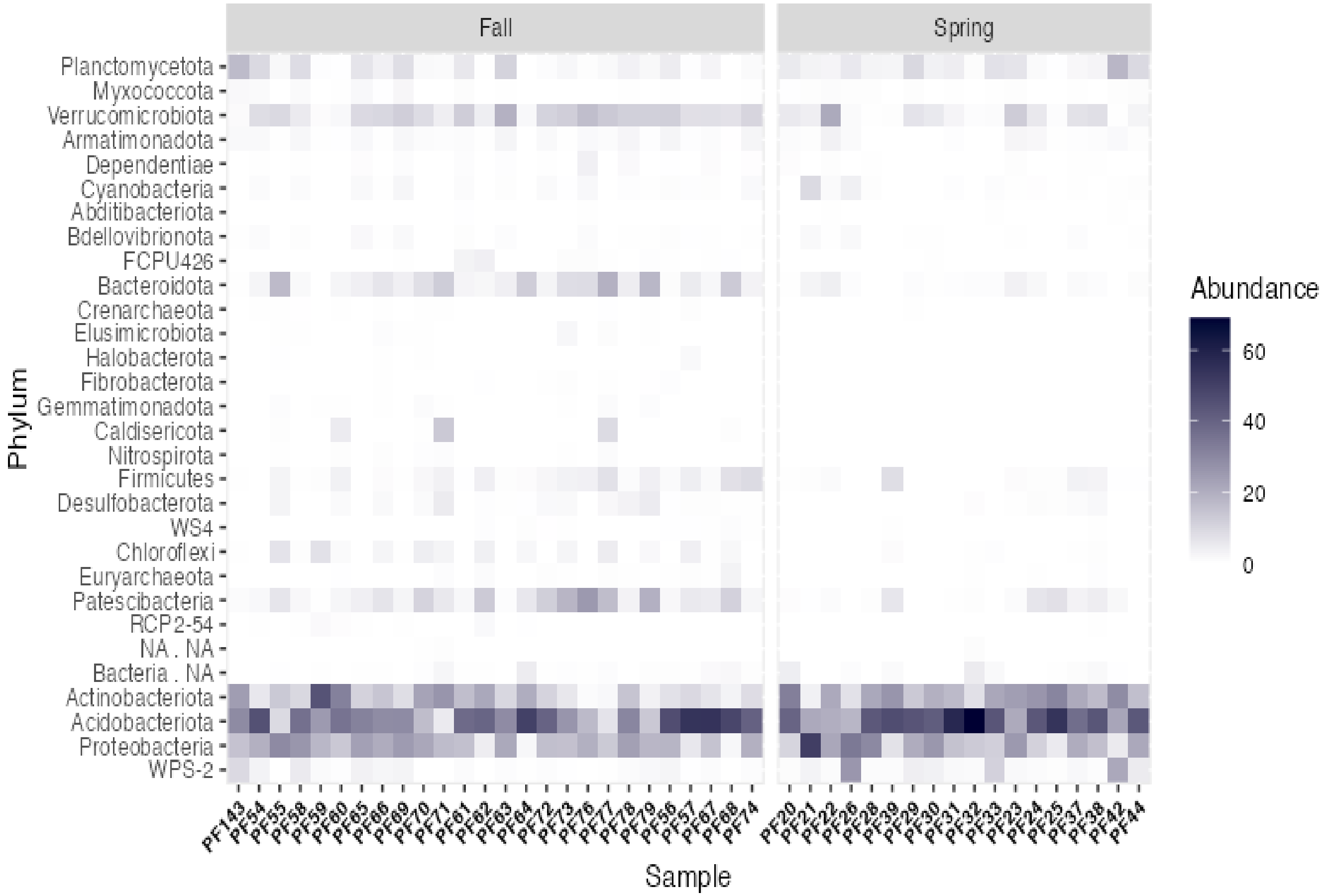
2022

2022

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement no. 860497.

Exploring Mercury Responses to Winter Warming: A Snow Fence Field Experiment in a Swedish Sub-Arctic Peatland

(B) Heatmap visualizing rel. abundance of microbial community in phyla level
(left to right: samples ordered by sampling depth



Swedish University of Agricultural Sciences
SLU