MAX PLANCK INSTITUTE
FOR BIOGEOCHEMISTRY

IN-SITU OBSERVATION OF CH_4 SIGNALS IN THE ARCTIC

CURRENT NETWORK STATUS, AND FUTURE CHALLENGES

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CORE OBSERVATION TECHNIQUES

Flux chambers

Plot scale
(0.2 – 4 m^2)

Eddy covariance towers

Local scale
(0.2 – 4 km^2)

Atmospheric tall towers

Regional scale
(up to 1000s km^2)

REPRESENTATIVENESS

RESOLUTION

PLOT SCALE: FLUX CHAMBER OBSERVATIONS

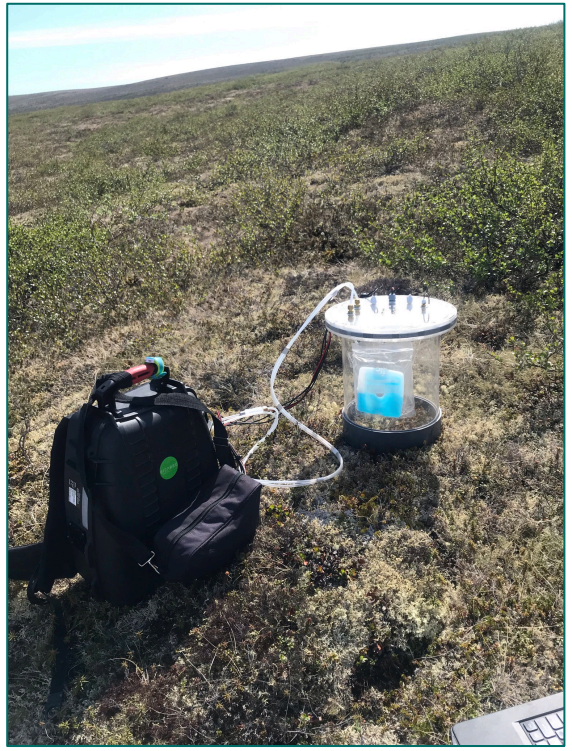
Small-scales: Footprints usually < 1 m²

- Strength: target homogeneous microsites in mixed terrain
- Limitation: Spatial representativeness of plots

Episodic measurements

- Most data from field campaigns
- Some automated systems with quasi-continuous measurements

dry — wet

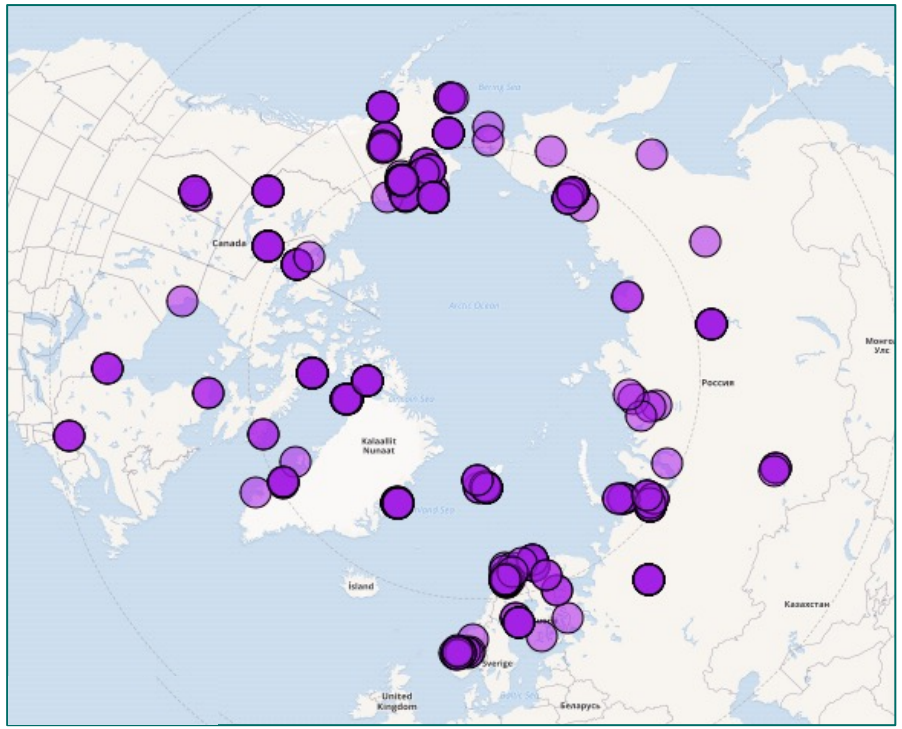


Photos
top: C. Voigt, Univ. Montreal
left: B. Lecavallier, Univ. Montreal

FLUX CHAMBER NETWORK COVERAGE

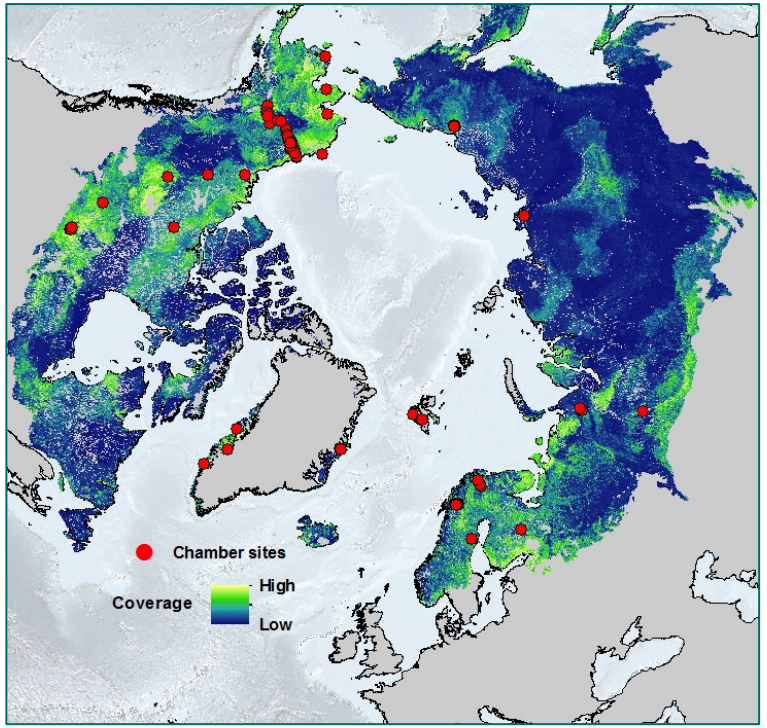
https://cosima.nceas.ucsb.edu/carbon-flux-sites/

Arctic flux site coverage



Database entries: 665 (not all CH_4)

Extrapolated representativeness map



Results: A. Virkkala, S. Natali, B. Rogers, J. Watts
Woodwell Climate Research Center

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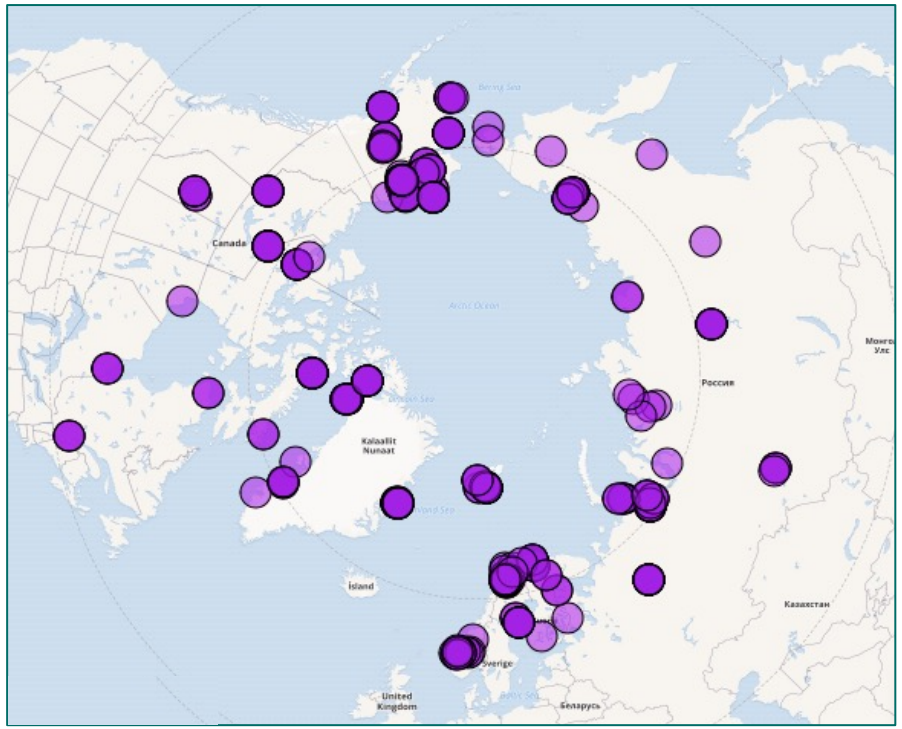

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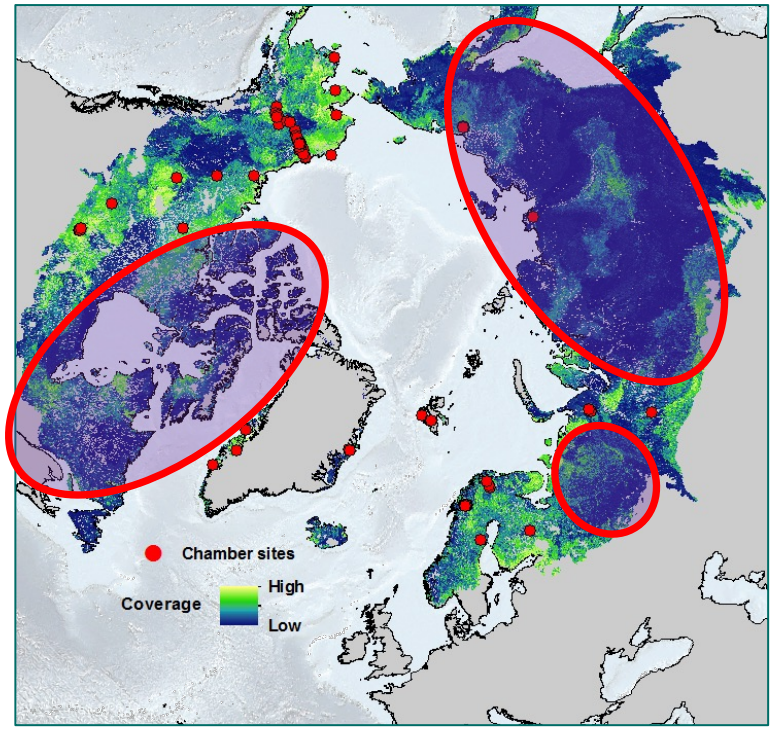

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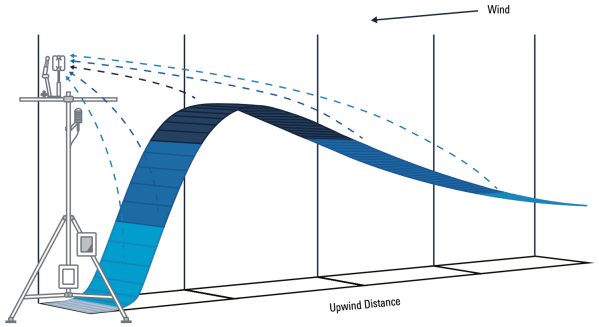
Database entries: 665 (not all CH_4)

MAJOR GAPS: **NE Canada**
most of Siberia, European Russia

LOCAL SCALE: EDDY COVARIANCE TOWERS

Photo: M. Hertel, MPI-BGC



Source: Burba (2022)

Landscape scale observations

- Strength: Field of view 100s – 1000s m^2
- Limitation: mixed signal from heterogeneous sources and sinks

Continuous measurements

year-round detection of flux signals at 30-minute resolution

Non-intrusive flux observations

No influence on detected signal, no disturbance to the ecosystem

LOCAL SCALE: EDDY COVARIANCE TOWERS

Arctic flux site coverage

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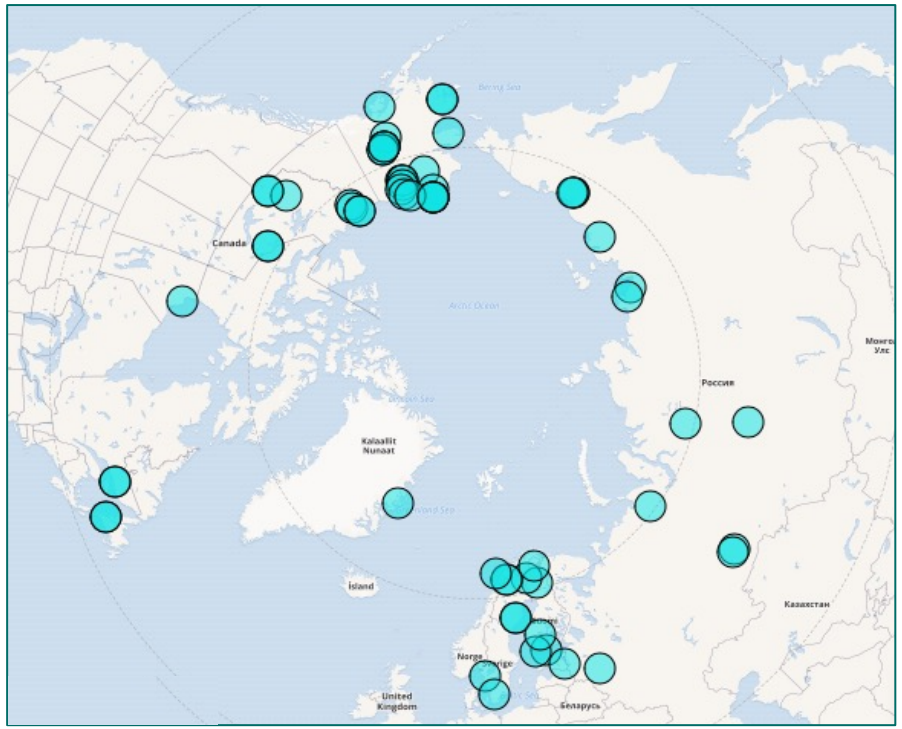
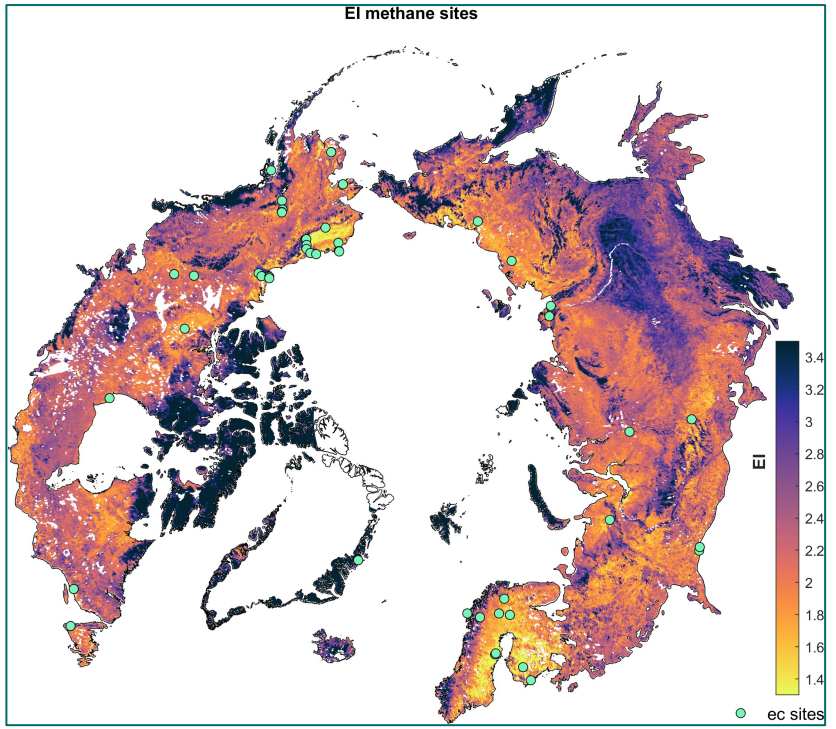


Database entries: 66

Extrapolated representativeness map



Analysis: M. Pallandt, MPI-BGC

LOCAL SCALE: EDDY COVARIANCE TOWERS

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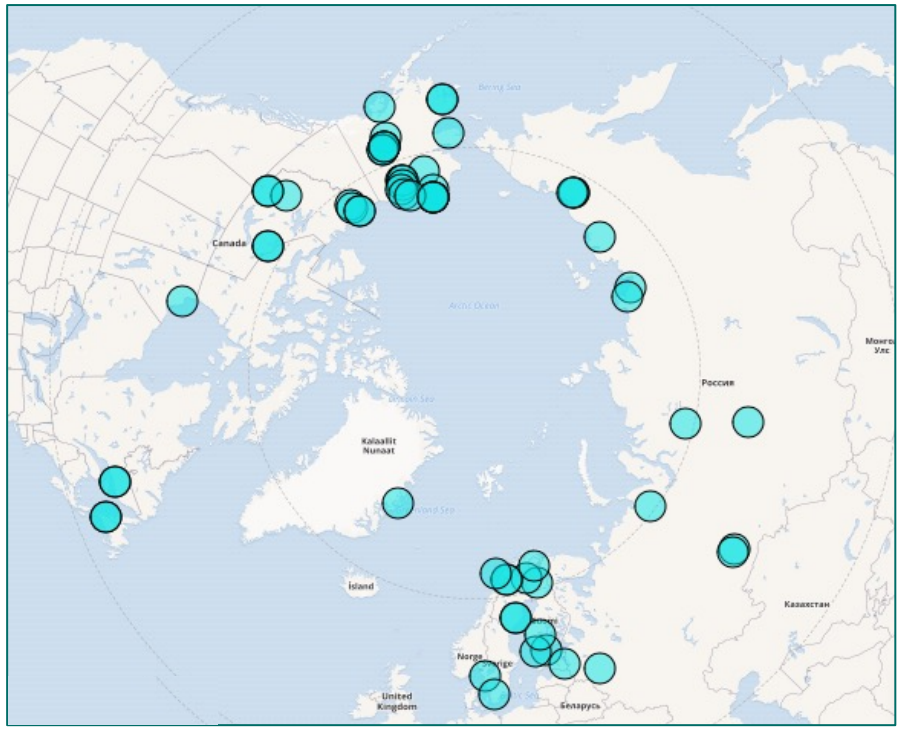

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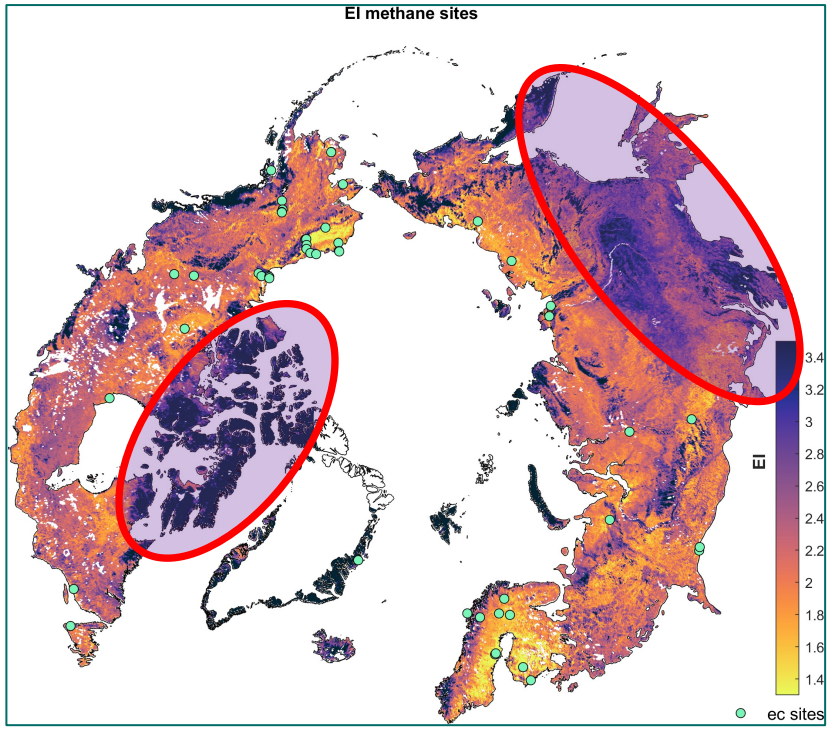


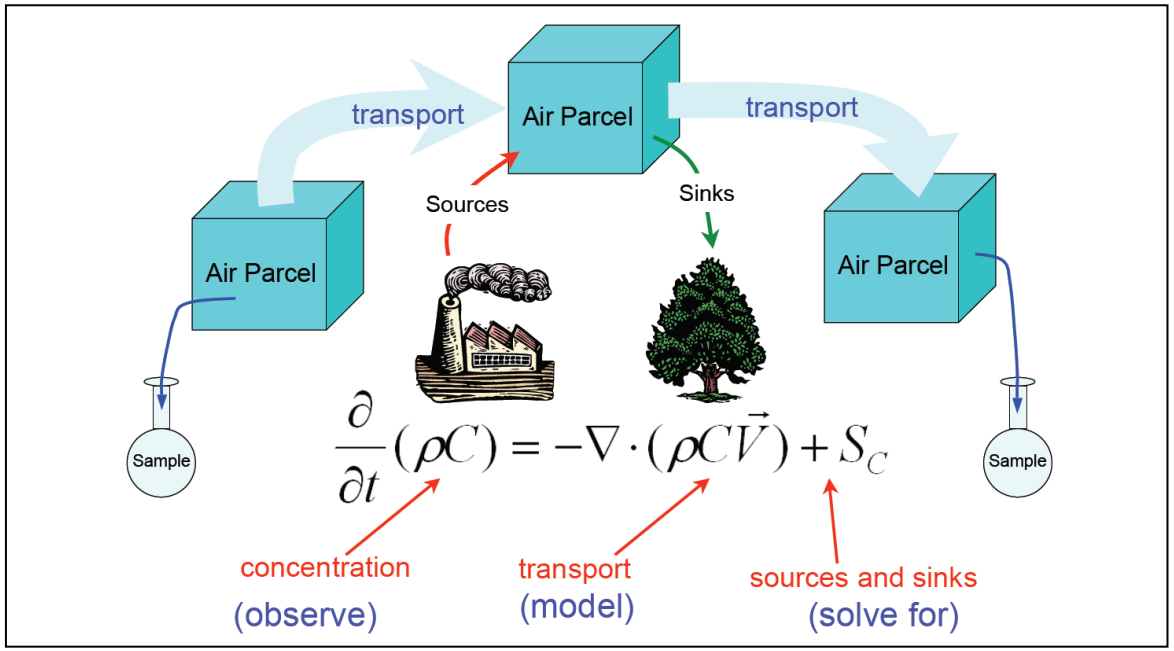
Analysis: M. Pallandt, MPI-BGC

MAJOR GAPS: **N Canada, Nunavut**
central South Siberia

TALL TOWERS FOR ATMOSPHERIC INVERSION

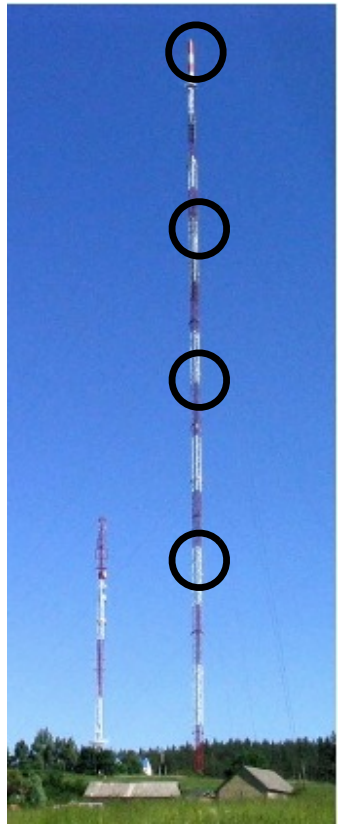
Atmospheric transport constitutes a natural integrator of surface-atmosphere fluxes

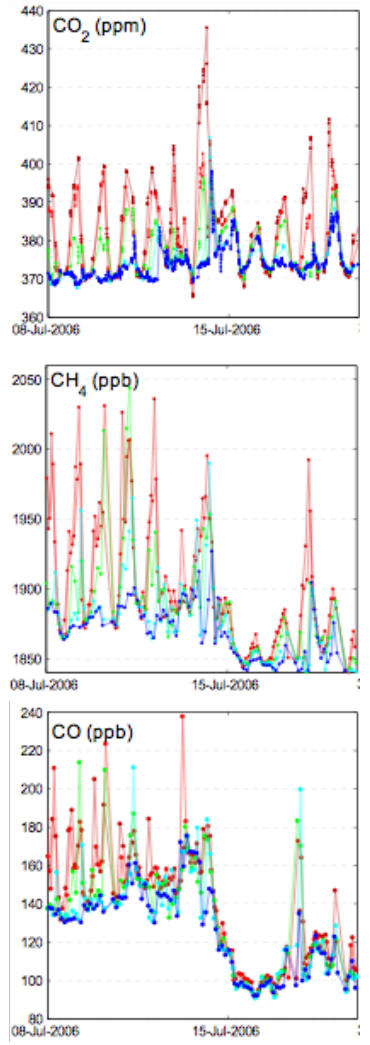
Atmospheric inverse modeling can be used to constrain regional to global scale surface-atmosphere exchange



Source: S. Denning, CSU

Bialystok tower (Eastern Poland) Trace gas concentration measurements





Source: Popa et al. (2010)

TALL TOWERS FOR ATMOSPHERIC INVERSION

Arctic tall tower coverage

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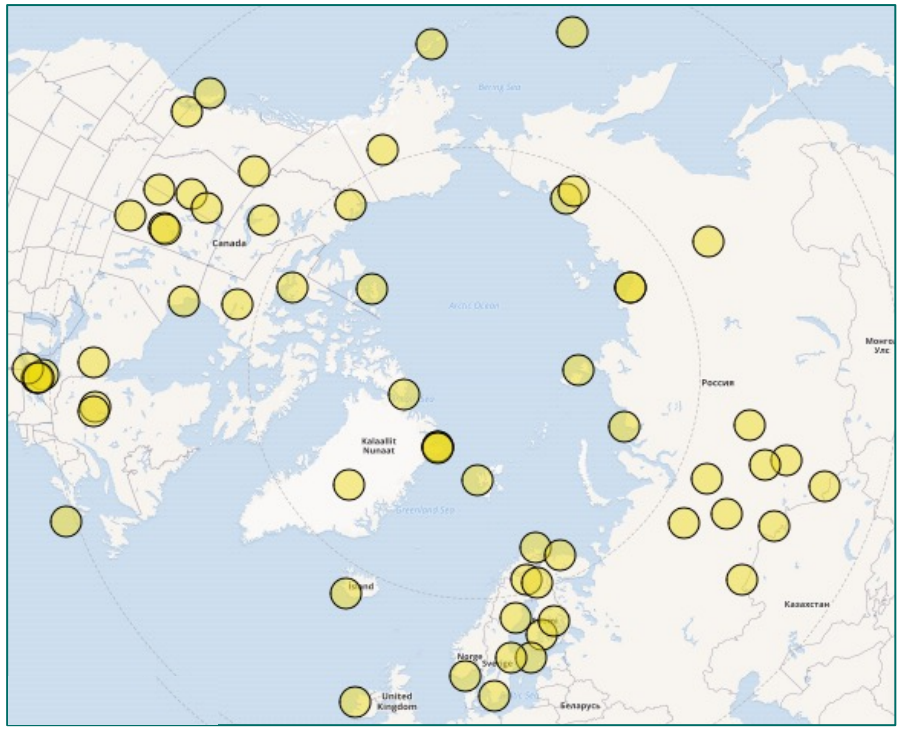
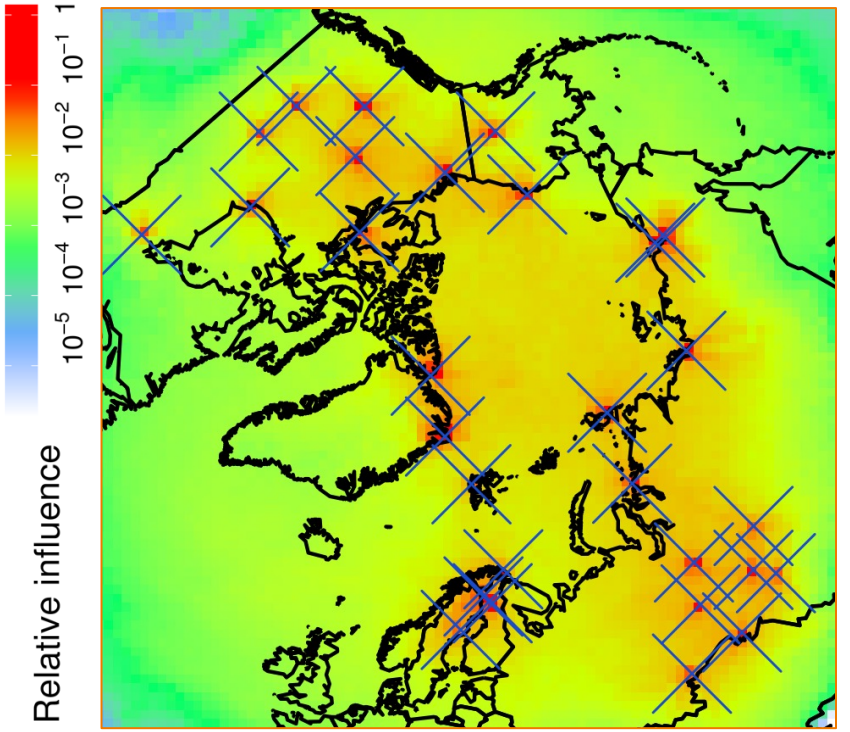


Database entries: 63

Pan-Arctic gridded footprints



Analysis: F. Reum, MPI-BGC

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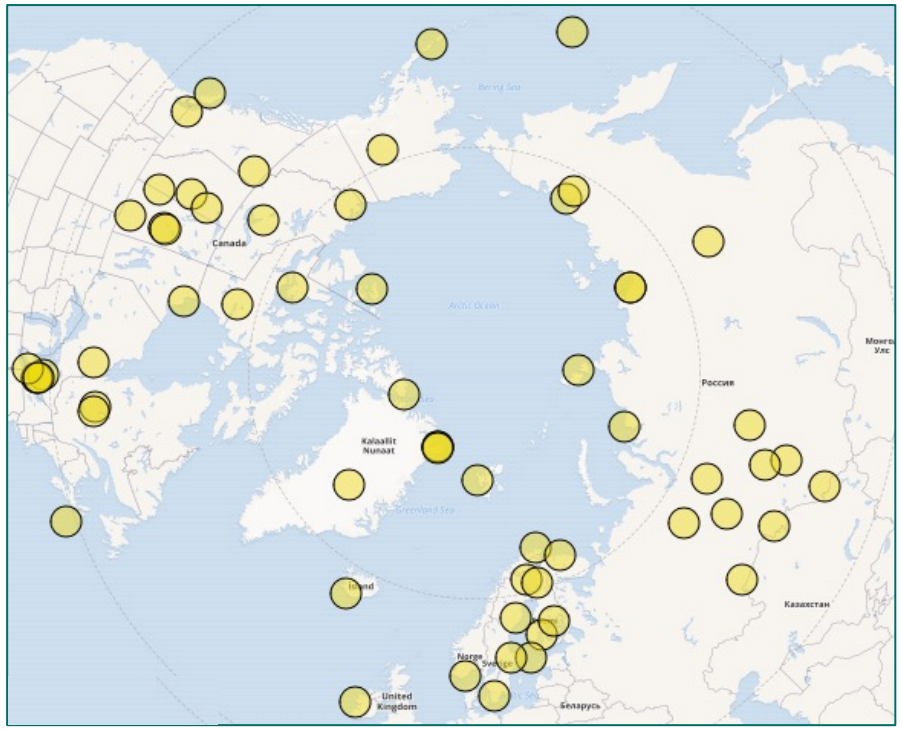

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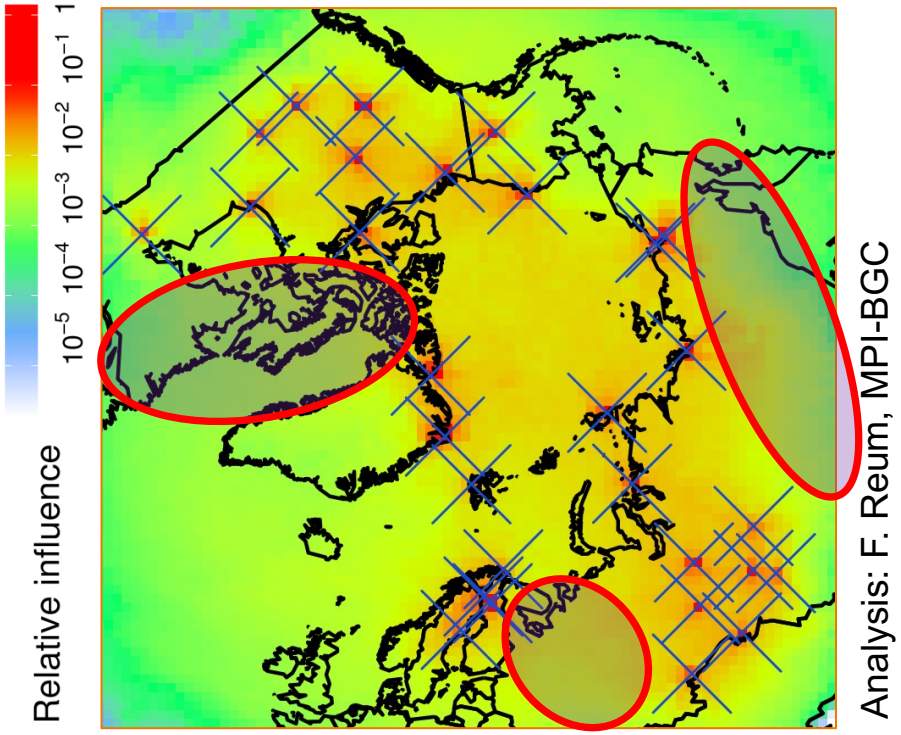
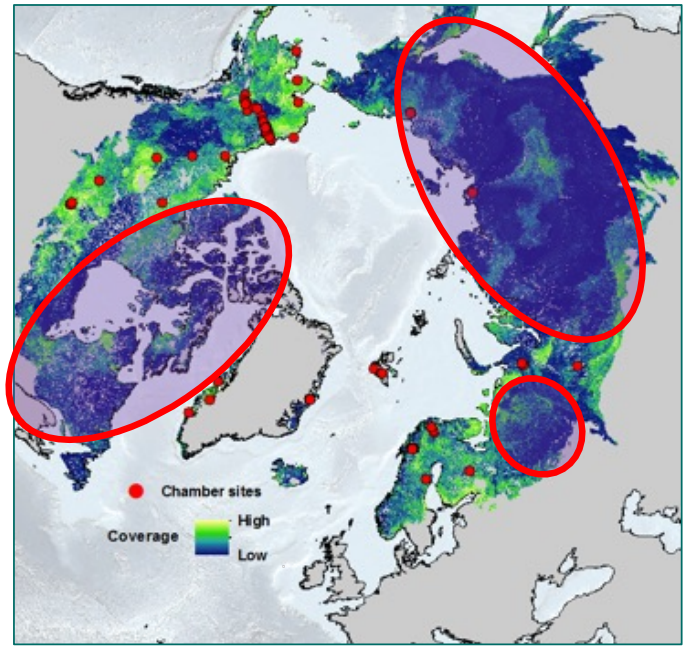


Analysis: F. Reum, MPI-BGC

MAJOR GAPS: **NE Canada**
SE Siberia, European Russia

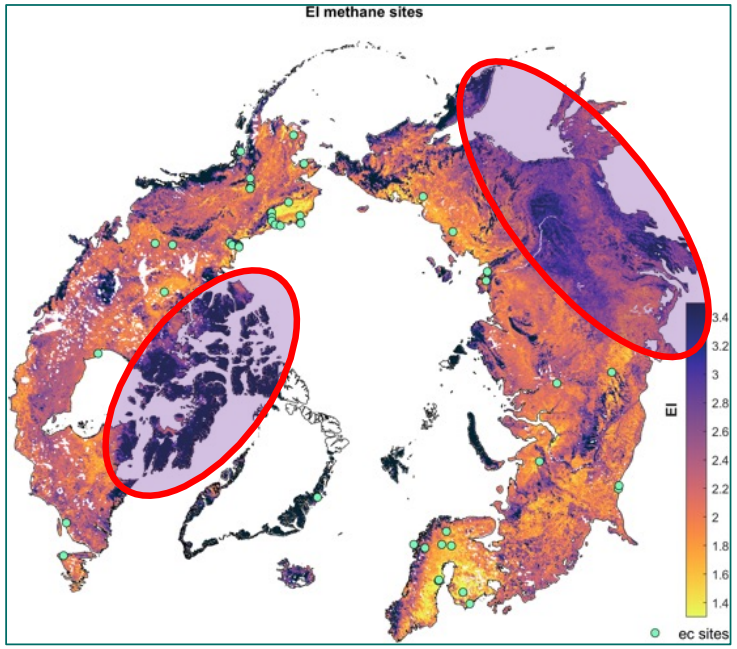
GAP SYNTHESIS

Flux chambers



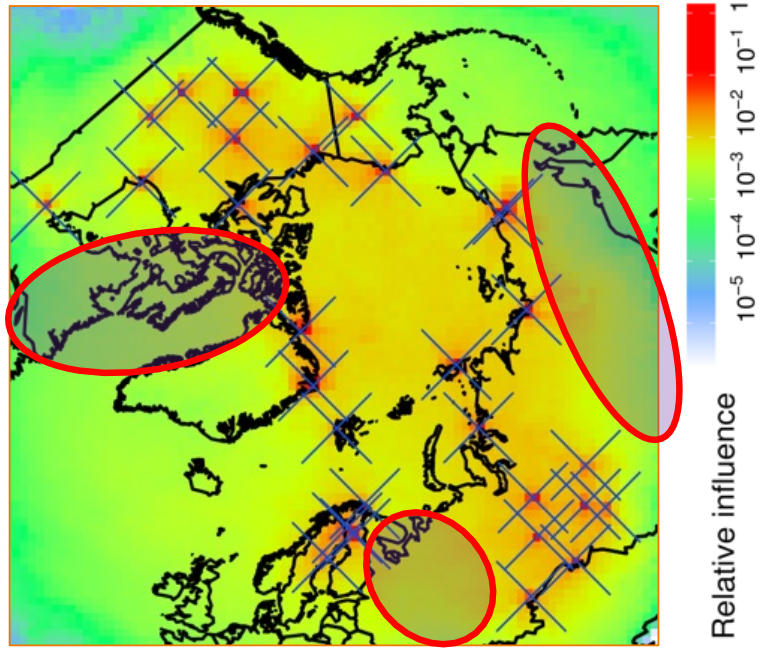
(665 chamber plots)

Eddy covariance towers



66 eddy towers

Tall atmospheric towers

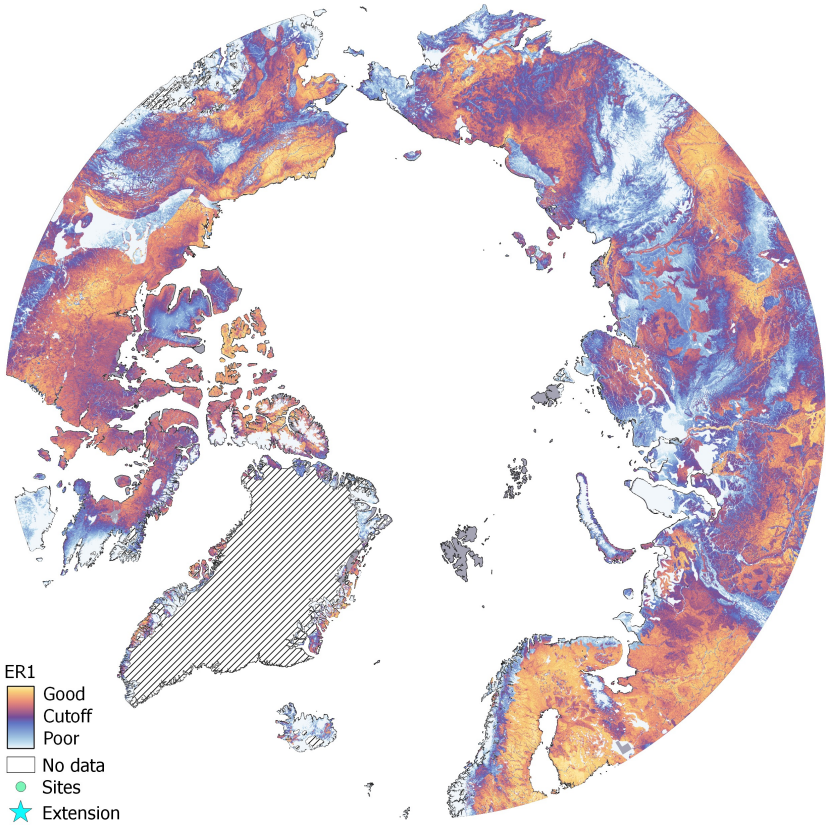


63 atmospheric towers

2 major areas with gaps: Eastern Canada, Canadian Archipelago
the largest parts of Central and Eastern Siberia, European Russia

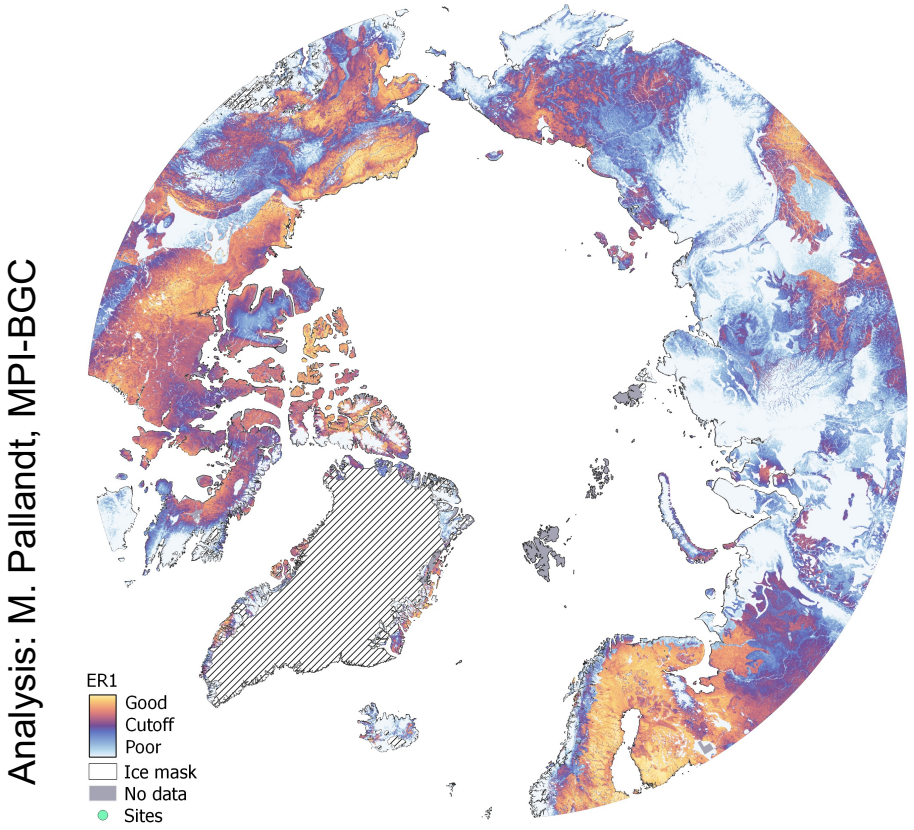
EFFECT OF CUTTING OFF RUSSIA FROM NETWORK

Active eddy covariance tower network



55% of domain with ‘good’ data coverage

Eddy covariance network without Russia



36% of domain with ‘good’ data coverage

SUMMARY 1:
AVAILABLE RESOURCES FOR IN-SITU CH_4 OBSERVATIONS

Large available database

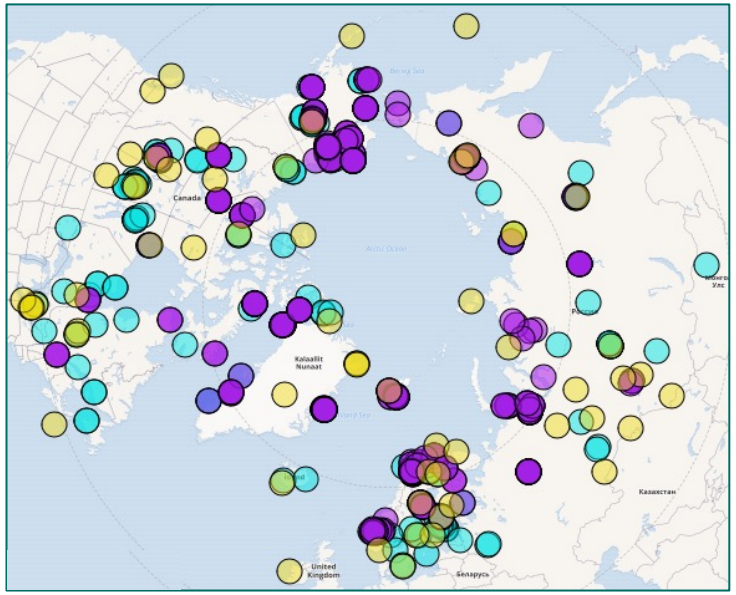
- 665 chamber flux plots (incl. non-CH_4)
- 66 eddy-covariance towers
- 63 atmospheric monitoring towers

Representative network coverage

- Some highly instrumented regions
- Decent observational coverage in many Arctic regions
- Growing number of observation sites

Good data availability

- Large fraction of the flux datasets freely available
- PIs willing to to share 98% of data (eventually ..)
- search aided by metadata tools



https://q-arctic.net

http://intaros.eu/

SUMMARY 2:
CHALLENGES FOR IN SITU CH_4 OBSERVATIONS

Technical hurdles
- no common database, or multiple options, for parts of the data
- part of the data (still) not open access
- formatting challenges, also related to methodologies

Gaps in network coverage
- 'White spots' remaining, mainly Siberia and NE Canada

→ Strategic selection of new locations underway

Methodological advances required
- winter-proofing of infrastructure for year-round data coverage
- special target on disturbance or heterogeneity, e.g. nested observatories

Russia situation seriously affects in-situ observation networks
- Major investments in new sites should ideally target Siberia
- Missing data streams from Russian sites cannot be compensated for!

APGC Arctic Permafrost Geospatial Centre

apgc.awi.de

PERMAFROST PATHWAYS

permafrost.woodwellclimate.org