Permafrost Carbon

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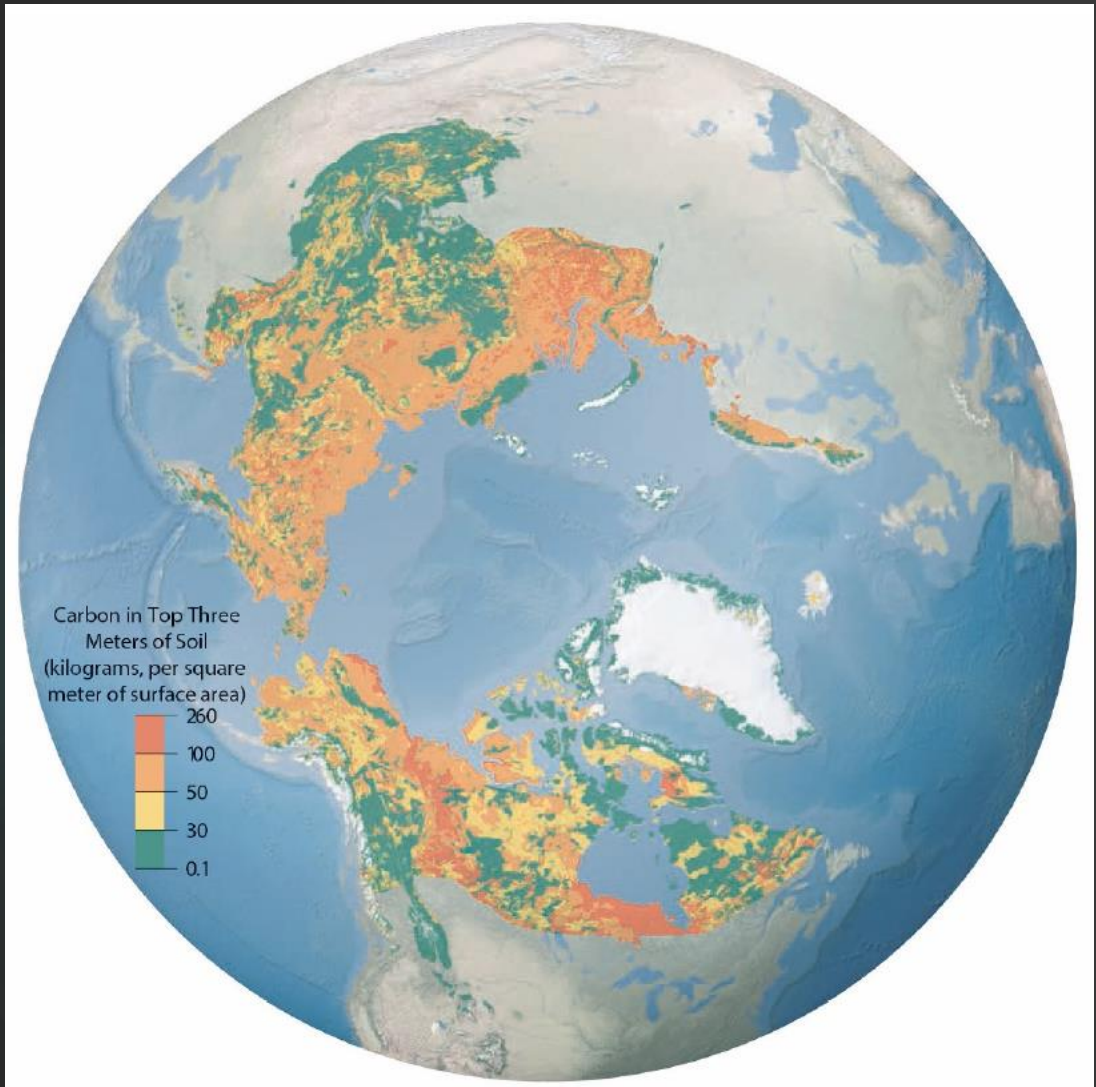
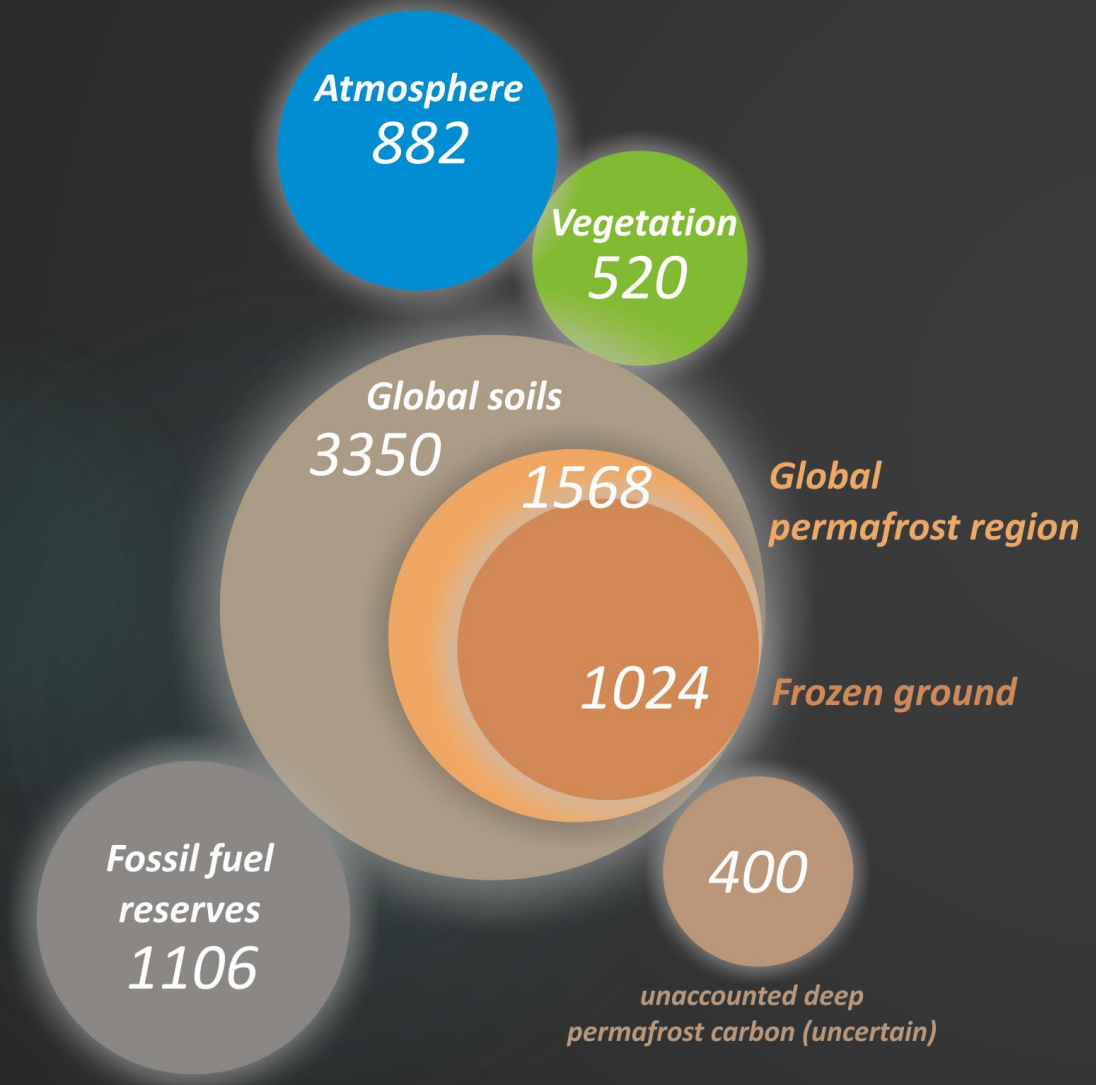
What and where is permafrost?



- 2+ years frozen
- Common across northern high latitudes
- Formed during Pleistocene and Holocene during colder climate
- Protects SOM from decomposition
- Large C stocks have accumulated

Schuur et al. (*in press*) ARER

Permafrost C stocks



- Permafrost region stores nearly 50% of global soil C
- 2/3 in frozen ground
- Larger than stocks in atmosphere and vegetation

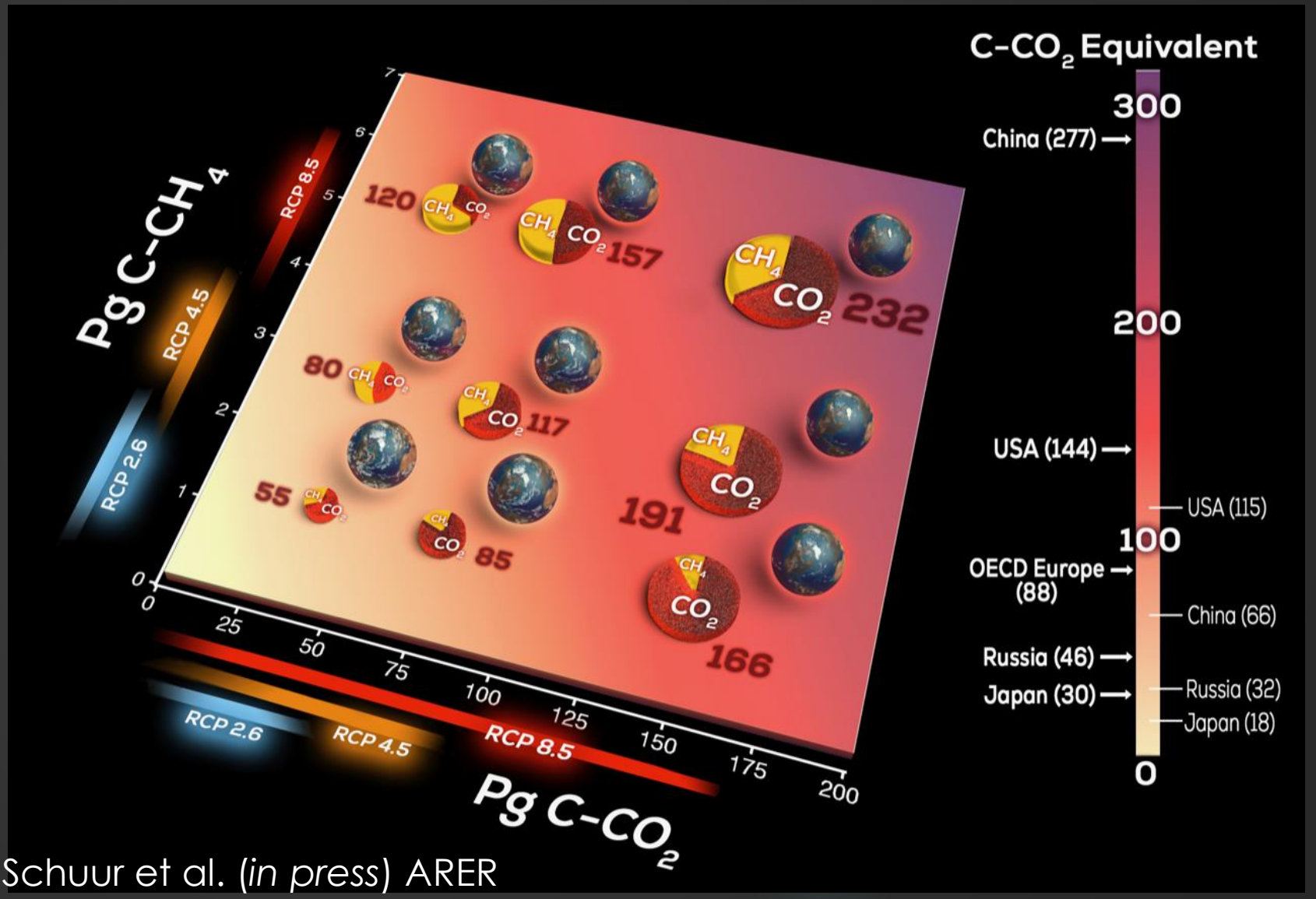
Strauss et al. (2021) FAO

Permafrost Carbon – climate feedback

- Formerly frozen carbon can be decomposed
- Often old C! deposits range from Holocene to Pleistocene age
- Emitted as CO_2 or CH_4

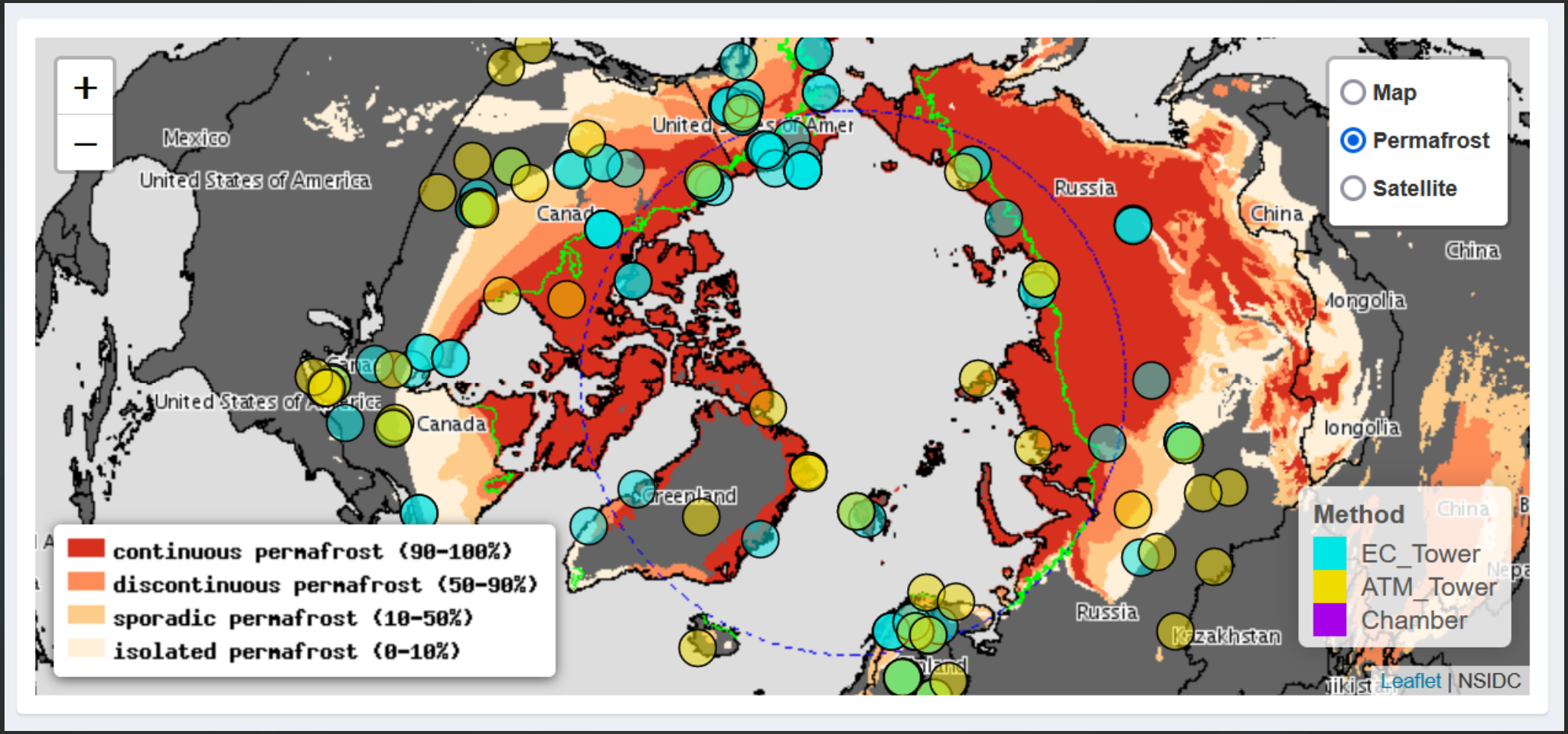
Permafrost Carbon - climate feedback

- ESM MIP from Permafrost Carbon Network
- Projections to 2100
- Country-like level of emissions
- Broad spatial distribution, limited sampling : how to detect?



Schuur et al. (*in press*) ARER

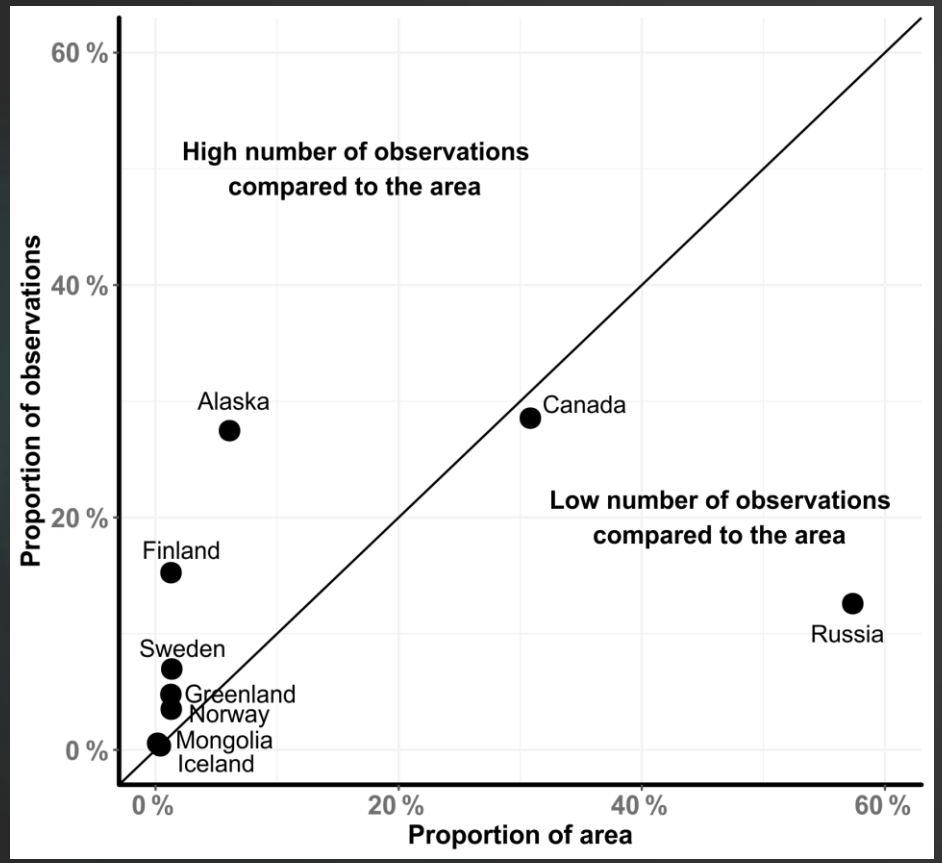
188 Active CO_2 flux measurement sites: not all with permafrost



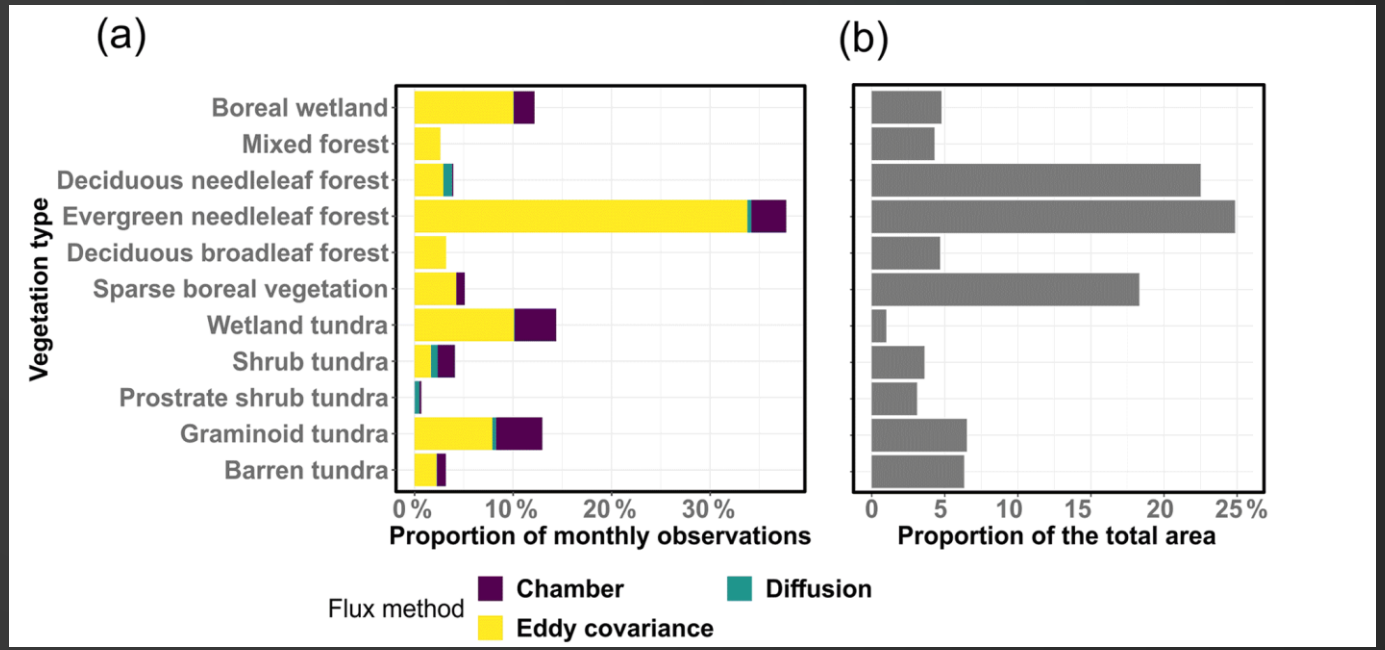
https://cosima.nceas.ucsb.edu/carbon-flux-sites/

Current CO_2 flux network doesn't capture spatial dimensions

Area



Vegetation Type



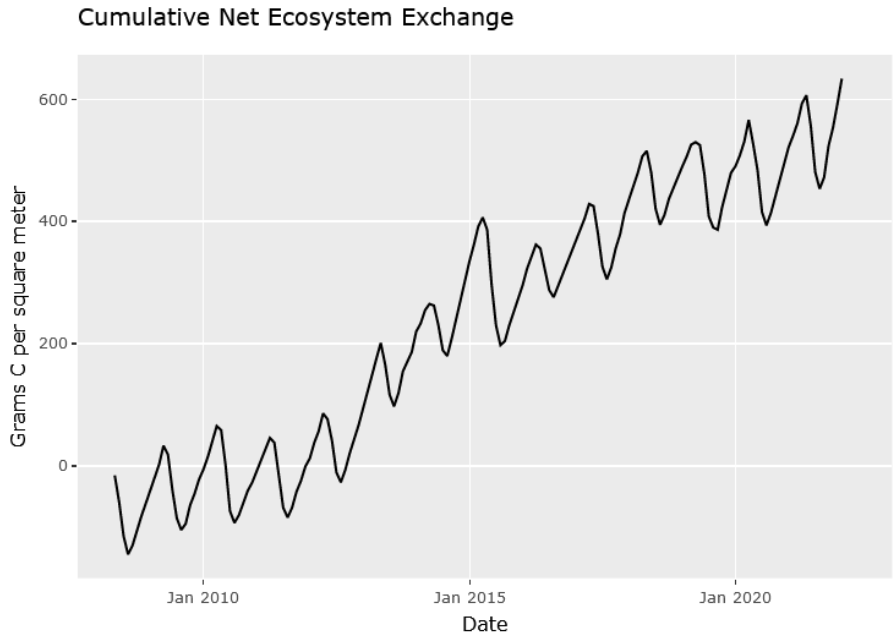
Virkkala et al. (2021)m

Observing Temporal Changes: CO_2

Cumulative Net Ecosystem Exchange (NEE)

This plot shows the cumulative flux of carbon (as carbon dioxide) to the atmosphere since eddy covariance measurements at Eight Mile Lake began in May 2008. Scroll over the time series to see the data. Values below zero represent cumulative net carbon uptake into the ecosystem; above zero is cumulative net carbon release into the atmosphere.

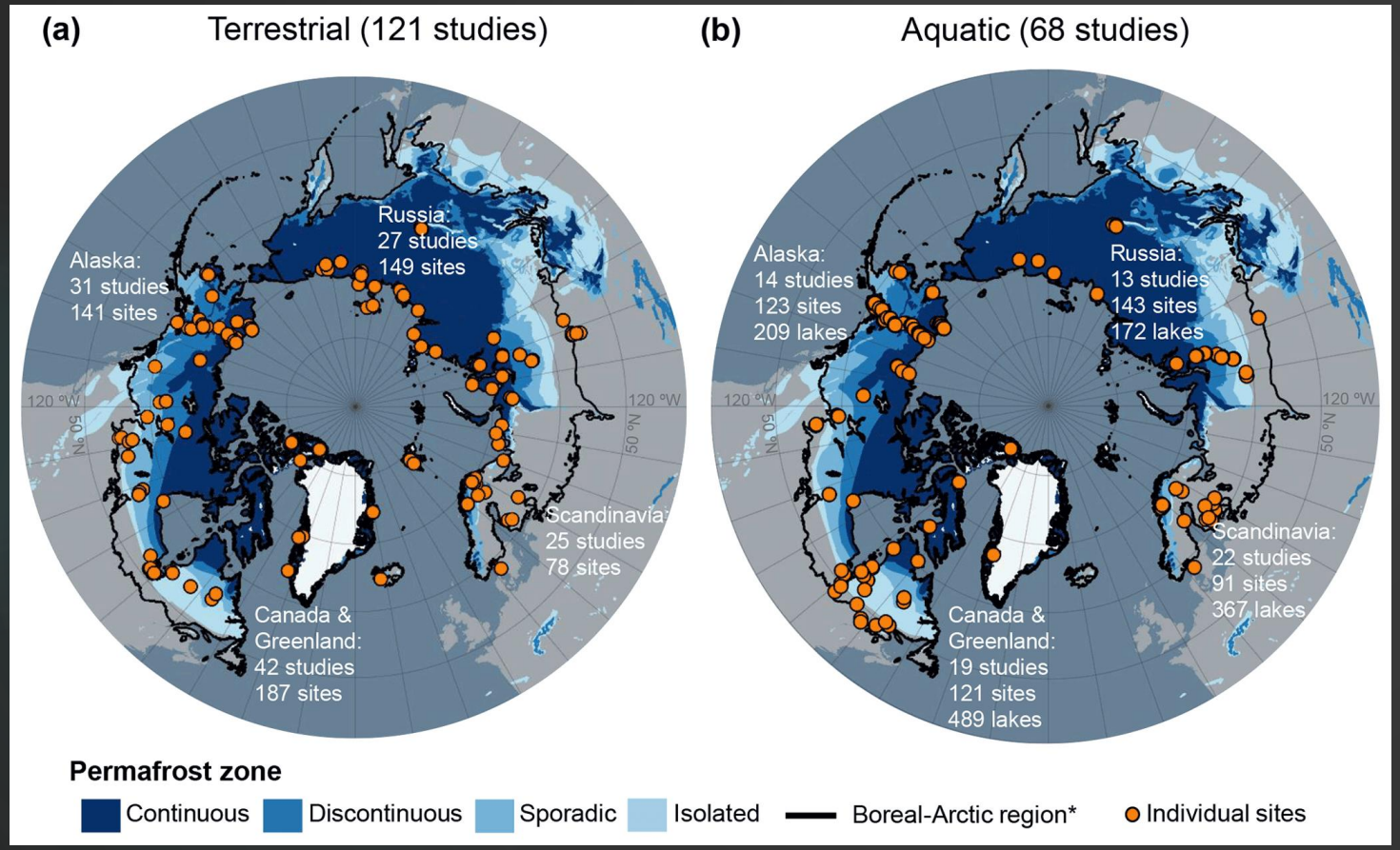
The full site carbon flux time series starts in 2004 combining clear flux chamber measurements with eddy covariance. The latest analysis is published here: Schuur et al. 2021. Tundra underlain by thawing permafrost persistently emits carbon to the atmosphere over 15 years of measurements. Journal of Geophysical Research: Biogeosciences, 126, e2020JG006044. https://doi.org/10.1029/2020JG006044



- System that can give near real time measurements
- Gridded + temporally resolved product for modeling comparison
- Question of C sink/source still open

https://eightmilelake.neocities.org/Monthly-Eddy-Updates.html

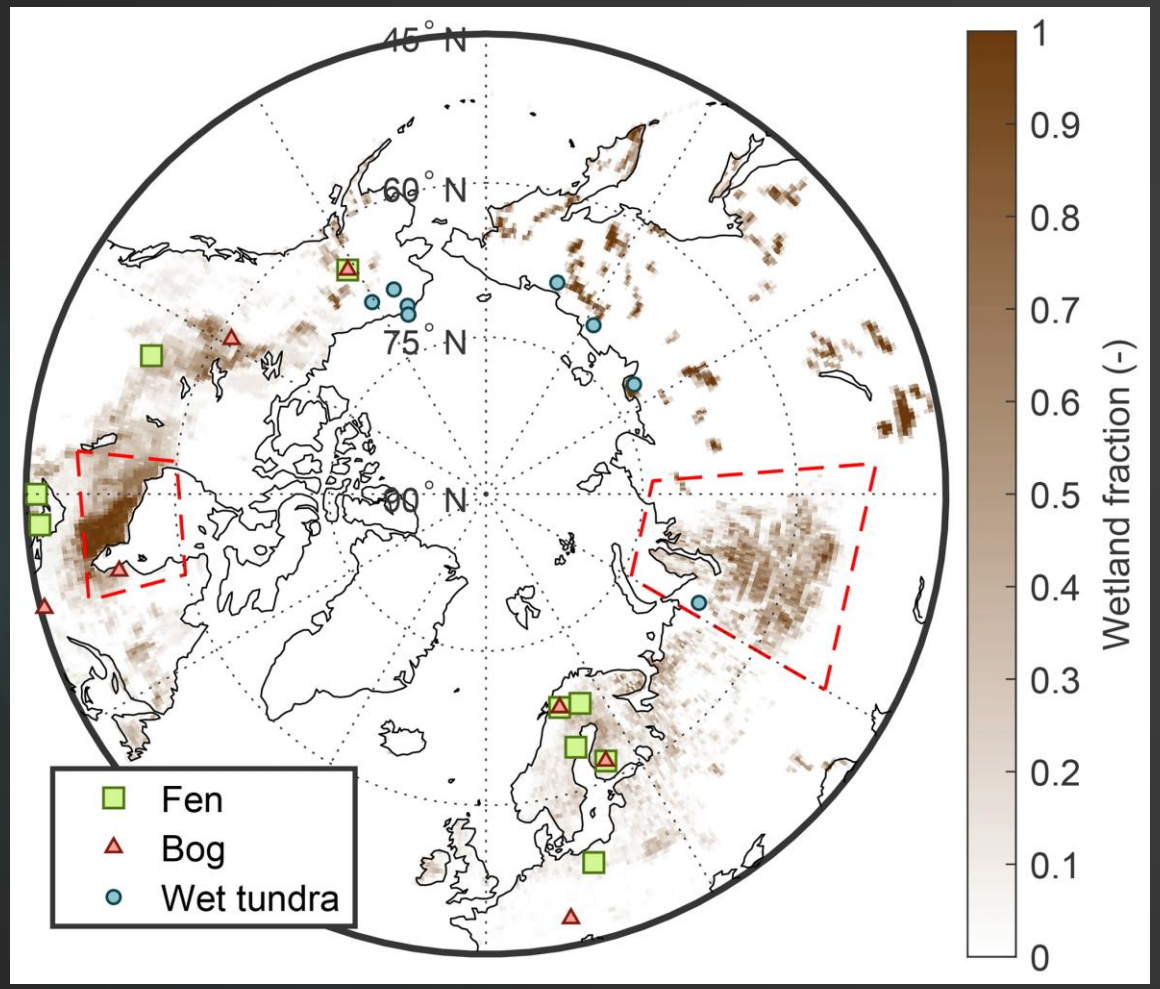
Permafrost region CH_4 emissions



- Several recent synthesis efforts
  - Kuhn et al. (2021) ESSD
  - Knox et al. (2019) BAMS
  - Treat et al. (2018) GCB
- 25 – 32 Tg CH4 per year (Treat et al. 2018)

Kuhn et al. (2022) ESSD

Methane gridded products: data limited!



- Large wetland regions
- few long term or current measurements!
- Lots of additional chamber data, but patchy in space and time

Peltola et al. (2019) ESSD

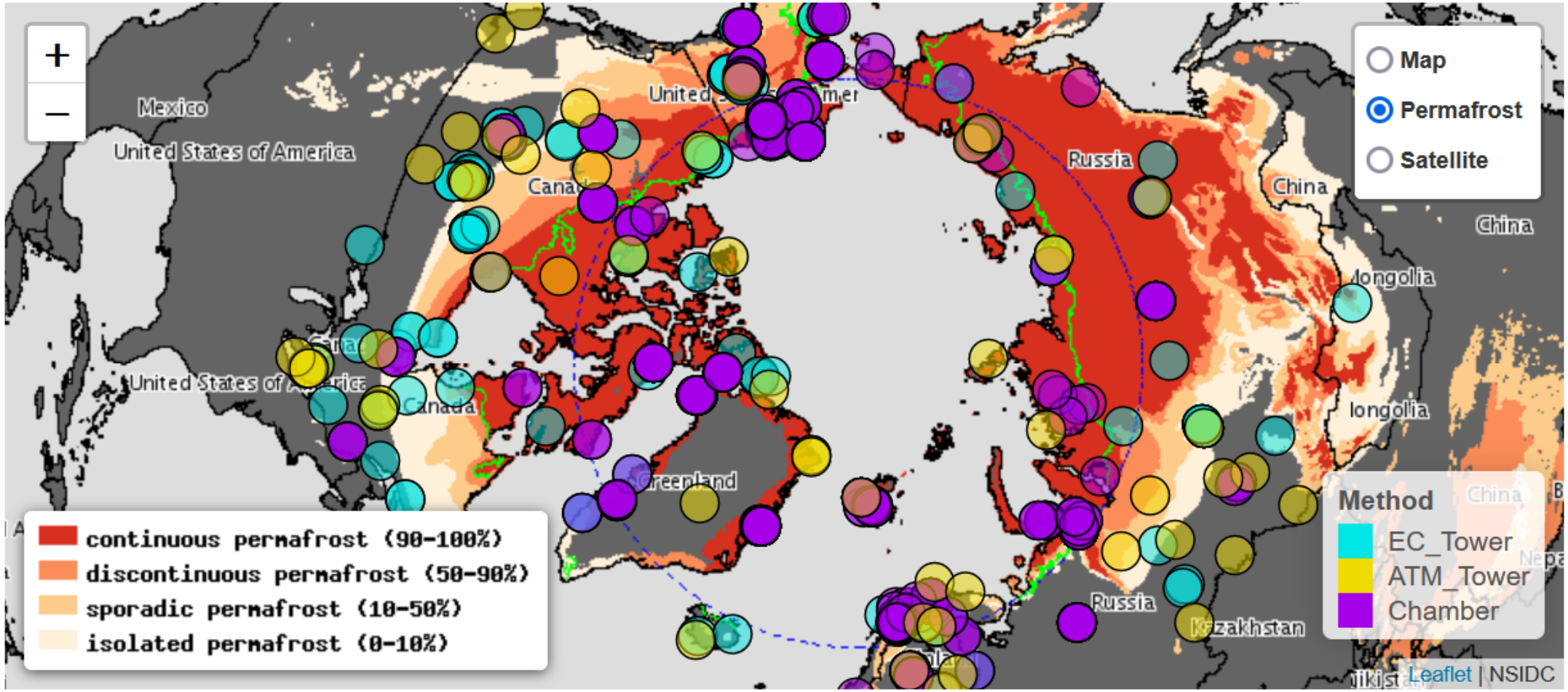
Challenges: Permafrost C & Arctic-boreal zone

- Access: Remote areas
  - Remote
  - Little to no infrastructure across wide areas
    - Power ??
  - Russia
- Difficult environmental conditions
  - Cold, dark, snowy, windy
- Sparse observation networks
  - Can we afford to be picky?
  - Current synthesis products are really data limited
- Chambers measurements
  - Large role historically
  - Captures high spatial variability in tundra
  - Often vegetation is low enough to get everything inside

Sue Natali's recent TED Talk

- https://youtu.be/r9lDDetKMi4
- Permafrost Pathways Project:
  - US-based, was large Russian component
  - $41 M Project
  - Establish new EC tower sites

Historic & current CO_2 flux measurements in permafrost region



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