Sue Natali
Woods Hole Research Center (WHRC)

Winter respiration in the Arctic

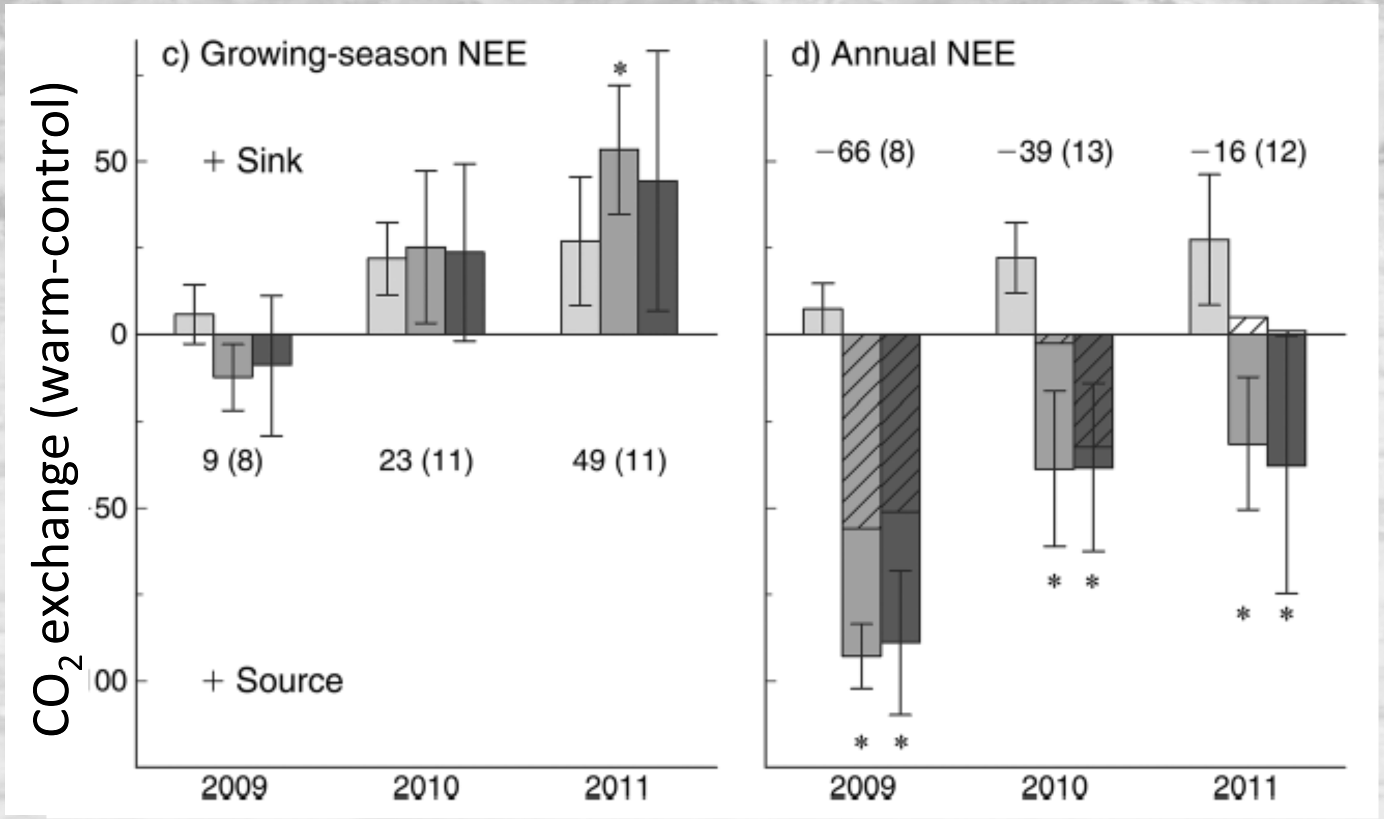
***Co-Investigator:* Scott Goetz**, WHRC

Collaborators:

Torre Jorgenson, EcoScience, Fairbanks AK
Dave Risk, St. Francis Xavier University
Julie Jastrow, Argonne National Lab

Context (and, but, therefore)

- Winter CO_2 emissions can shift ecosystems from a growing season C sink to annual source



Natali et al. 2014

Context (and, but, therefore)

- Winter CO_2 emissions can shift ecosystems from a growing season C sink to annual source
- **AND** greatest warming is occurring in the Arctic during the winter months
- **BUT** there is large uncertainty in estimates of winter CO_2 emissions
- **THEREFORE** we propose a winter respiration monitoring network to investigate drivers of winter respiration & improve estimates of CO_2 emissions

Science Questions & Objectives

- Science Question: *How are the magnitudes, fates, and land-atmosphere exchanges of* ***carbon pools*** *responding to environmental change, and what are the* ***biogeochemical*** *mechanisms driving these changes?*

Science Questions & Objectives

- Science Question: *How are the magnitudes, fates, and land-atmosphere exchanges of **carbon pools** responding to environmental change, and what are the **biogeochemical** mechanisms driving these changes?*
- Tier 2 Science Objectives, Ecosystem Dynamics
  - O4: *Quantify how changes in the spatial and temporal distribution of snow impacts ecosystem structure and function*
  - O6: *Elucidate how climate change and disturbance interact with above-and belowground communities and processes to alter carbon biogeochemistry, including release to surface water and the atmosphere.*

Research Objectives

- Collect **ground-based measurements of surface & subsurface properties**, with an emphasis on areas undergoing permafrost degradation

- Establish **network of automated soil respiration sensors** to determine winter CO2 emissions & relevant drivers

- **Map surface properties** of permafrost landscapes using various remote sensing and gridded data products

- **Extend field measurements spatially and temporally** using satellite-derived data sets of drivers of winter respiration

Research Overview

Organic matter quality

Plant inputs: NDVI; Organic matter: Soil C:N, mid-IR

Plant inputs: MODIS Terra& Aqua, Landsat reflectance & veg indices

Soil Temperature

Soil & air temp., snow depth

Snow Cover (MOD10A1)

Snow water equiv. (AMSR-E)

Surface temp (MOD11A2)

Winter respiration

Soil Moisture

CS616 moisture probe

Freeze thaw & soil moisture:

SMAP, PALSAR L-band

Organic matter quantity

Organic & active layer depths, %C, bulk density

NCSCD soil carbon map (Hugelius et al. 2013)

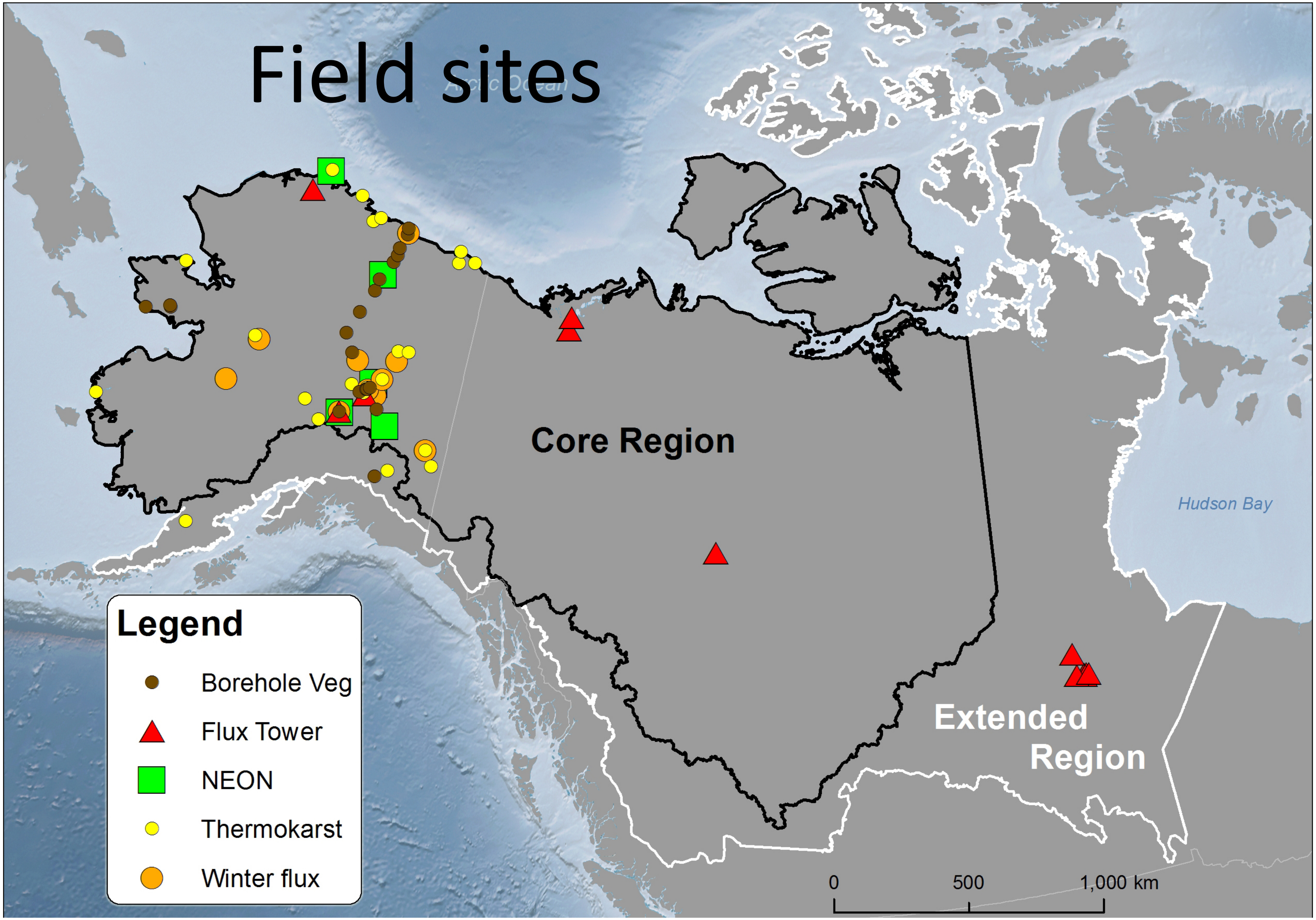
Field Studies

- Forced diffusion sensors
  - ‘continuous’ CO_2 flux thru winter
  - passively regulate diffusive flow (e.g., Risk et al. 2011)
  - chamber fluxes & 2 soil [CO2] sensors to solve for Q_{10} and production depth (Latimer & Risk 2015)
- Continuous soil & air temp, moisture, snow depth
- Soil sampling for organic matter quantity & quality (C, N, FTIR)

Field Studies-Timeline

- 2015-2016: Construct FD systems
- 2015-2016: Winter respiration synthesis
- 2016 spring & fall: Install FD systems at disturbance sites
- 2016: Soil sampling, all sites
- 2016-2018: Sensors at disturbance sites
- 2018-2019: Co-locate sensors with eddy towers for data calibration

Field sites


Core Region
Extended Region
Hudson Bay
Legend
Borehole Veg
Flux Tower
NEON
Thermokarst
Winter flux
0
500
1,000 km

Field sites

Site	Latitude	Longitude	Region	Site Description
Taylor Highway	63.46	-142.49	Taiga	Rocky uplands; burn chronosequence
Innoko Flats	63.57	-157.73	Taiga	Peaty silty lowlands; young and intermediate bogs, old forest with permafrost
Eielson-Horseshoe	64.76	-147.05	Taiga	Uplands; yedoma
Creamer Field	64.87	-147.73	Taiga	Birch forest with ice wedge degradation
Koyukuk	65.19	-156.64	Taiga	Peaty silty lowlands; young and intermediate bogs, old forest with permafrost
Nome Creek	65.35	-146.92	Taiga	Upland; young burns & old forests
Hess Creek	65.70	-149.14	Taiga	Upland boreal; burn chronosequence
Boot Lake	66.06	-146.26	Taiga	Yedoma, paired degradation transects
Imnavait	68.61	-149.30	Tundra	Tussock and heath tundra
Prudhoe Bay	70.23	-148.42	Tundra	Ice wedge degradation

Spaceborne Remote Sensing

Organic matter quality

Plant inputs: NDVI; Organic matter: Soil C:N, mid-IR

Plant inputs: MODIS Terra& Aqua, Landsat reflectance & veg indices

Soil Temperature

Soil & air temp., snow depth

Snow Cover (MOD10A1)

Snow water equiv. (AMSR-E)

Surface temp (MOD11A2)

Winter respiration

Soil Moisture

CS616 moisture probe

Freeze thaw & soil moisture:

SMAP, PALSAR L-band

Organic matter quantity

Organic & active layer depths, %C, bulk density

NCSCD soil carbon map (Hugelius et al. 2013)

Expected products / outcomes

- Maps of surface properties of permafrost landscapes
- Multi-scale freeze-thaw products
- **Winter CO_2 flux data & data synthesis: mechanisms and drivers of winter respiration**
    - **Scaling spatially and temporally**
    - **Data for model benchmarking & calibration**

Questions

Natali et l. 2014