Carbon Dynamics Working Group

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Kim **Wickland** -- United States Geological Survey
Emily **Wilson** -- NASA GSFC
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Carbon Dynamics Working Group

- Fisher-01 (*Modeling*)
- Gamon-01
- Kimball-04
- Mack-01 (*Fire*)
- Meyer-01
- Miller-C-01, 02, 03
- Moghaddam-03
- Munger-03
- Natali-01
- Rogers-01 (*Fire*)
- Striegl-01 (*Hydrology*)
- Wilson-01

Institutional Collaborations

Federal & State Agencies

- Environment Canada
- National Park Service
- USDA
- USGS
- US Fish & Wildlife Service
- DOE/NGEE-Arctic
- DOE/ARM NSA & ARM Airborne Facility
- NOAA
- Natural Resources Canada
- NWT Geoscience
- Alaska DNR Division of Geological and Geophysical Surveys

Other Stakeholder Organizations

- Alberta Biodiversity Monitoring Institute
- Alaska Ecoscience
- Atmospheric and Environmental Research

Overarching 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

- What processes are contributing to changes in **disturbance regimes and what are the impacts of these changes**?
- What processes are controlling changes in the distribution and properties of **permafrost and what are the impacts of these changes**?
- What are the causes and **consequences of changes in the hydrologic system**, specifically the amount, temporal distribution, and discharge of surface and subsurface water?
- How are **flora** and fauna responding to changes in biotic and abiotic conditions, and what are the **impacts on ecosystem structure and function**?

Research Themes

Determine carbon cycling consequences of:

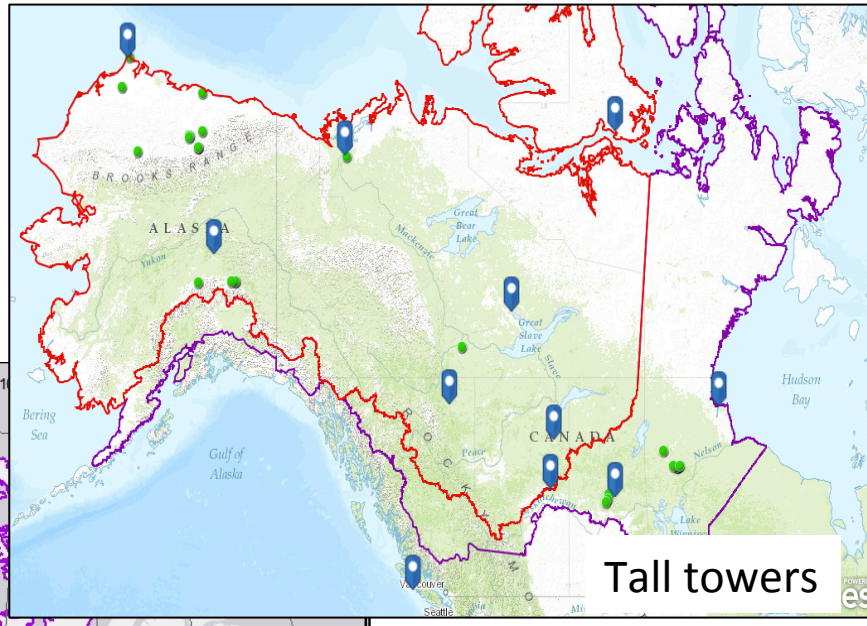
1) Disturbance
2) Permafrost thaw
3) Hydrologic changes
4) Vegetation changes

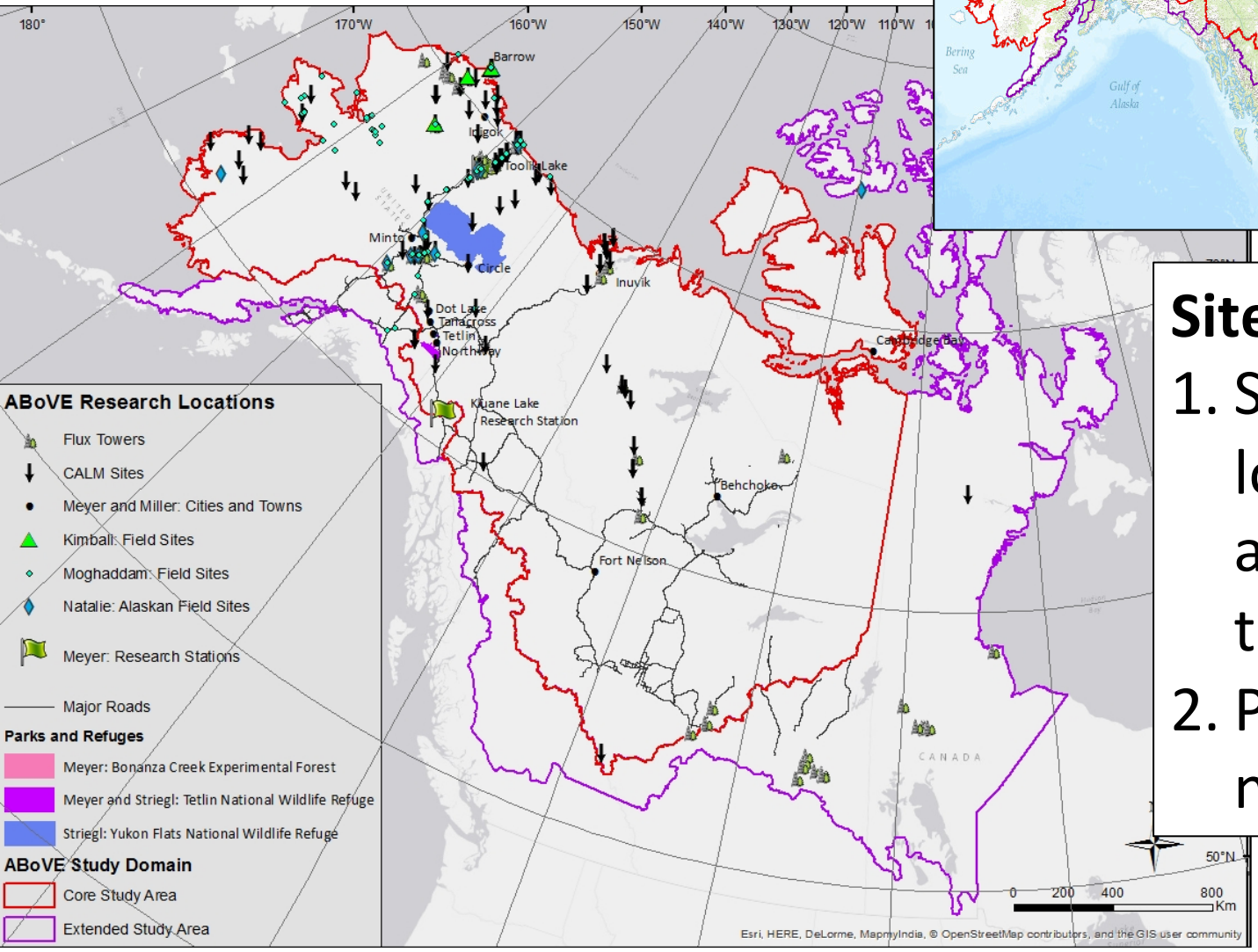
5) Determine spatiotemporal patterns & variability in carbon fluxes
6) Assess terrestrial feedbacks and associated uncertainties to climate (model-data integration)

Science Objectives

- ***Elucidate how climate change and disturbances interact with above- and belowground communities and processes to alter carbon biogeochemistry, including release to surface waters and the atmosphere (Objective 2)***
  - impacts of snow distribution on carbon biogeochemistry (Objective 4)
  - greening and browning trends and their impacts on ecosystem form and function (Objective 5)

Field Site Locations





Site Selection

1. Strategic locations to address science themes
2. Pre-existing networks

Field Measurements, overview

1. Carbon fluxes from terrestrial and aquatic sites
2. Soil & water carbon pools and OM composition
3. Meteorology
4. Water environ. parameters (e.g., temp, pH)
5. Optical phenology
6. Soil biophysical data (e.g., active layer & water table depth, soil moisture and temperature)
7. Streamflow & hydrological measurements.

Field Measurements
Pre-existing Networks

CO_2 and CH_4 fluxes, Eddy covariance towers
Atmospheric trace gasses: CO2, CH4, CO from tall towers
Optical phenology, Eddy tower sites
Active Layer Depth, CALM Network and tower sites
Active layer and permafrost temperatures, TSP Borehole network
Meteorology and environmental parameters, tower and other sites

Field Measurements
New Ground Measurements

Active layer temperature and moisture, sensors
CH_4 ebullition from lakes Radiocarbon dating of CH_4 and soil organic carbon
Automated CO_2 chambers to measure CO_2 emissions from soils Soil temperature and moisture, sensors Snow depth, sensors Soil organic matter depth and chemical characterization Active layer depth

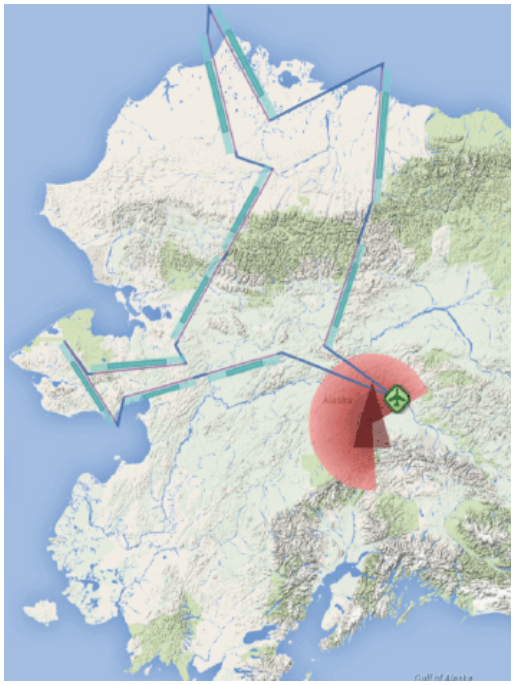
Spaceborne Remote Sensing

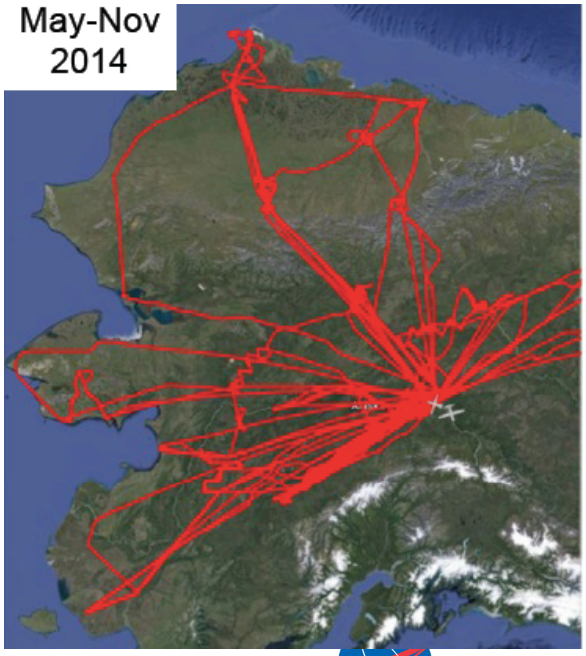
- Land cover
- Vegetation indices (NDVI, EVI)
- Plant productivity
- Snow cover
- Surface temperature
- Ground freeze-thaw state
- Soil moisture
- Albedo
- Surface reflectance
- Atmospheric CO_2 and CH_4

Airborne Remote Sensing

- AirMOSS: permafrost soil properties – active layer moisture, freeze-thaw, active layer depth, organic layer thickness, and depth to water table (Moghaddam)

- CARVE: Atmospheric CO_2 and CH_4 concentrations and flux estimates (Miller)





Modeling efforts

Modeling goal: Quantify patterns and variations in carbon exchange across ABoVE region

- Assess processes within local-scale models
- Use models to scale up field measurements to the larger region
- Integrate field data & remote sensing w/ global terrestrial biosphere models (Fisher)

Modeling efforts

Type of Model	**Expected Predictions**
Light-use efficiency model	Changes in **plant phenology & productivity** (Gamon)
Satellite-driven carbon model	**CO_2 & CH_4 fluxes and environmental controls** on the net ecosystem carbon budget (Kimball)
Talik, regression & GIS models	**permafrost thaw effects on CH_4** release from lakes (Meyer)
Community Land Model, w/ meteorology & sea ice:	I**mpacts of a seasonally sea ice-free Arctic** on permafrost, snow cover, biogeochemical cycling (Miller)
Geostatistical inverse modeling	**Net ecosystem exchange** and parameters that explain **variability in carbon fluxes** (Miller)
Lagrangian particle dispersion modeling	**CO_2 & CH_4 flux** for the Mackenzie basin (Miller)
CO2 flux models w/ map of active layer properties	Impact of **permafrost soil dynamics and surface hydrology on carbon flux** (Moghaddam)
Ecosystem model of greenhouse gases	assess whether **changes in climate and vegetation are leading to detectable large scale changes in carbon exchange** (Munger)
Regression, inverse model	**Drivers of winter CO_2 emissions,** response functions (Natali)

Geospatial Data Products

Gamon:

- Carbon flux & optical data from core sites
- Maps (MODIS, OCO-2): for vegetation type, photosynthetic productivity, season length (2000-2015, ABoVE domain-wide)

Kimball

- 1 km maps of daily CO2 fluxes (GPP, NPP, Reco, NEE), wetland CH4 emissions, Net Ecosystem Carbon Balance; annual surface SOC stocks (2003 to > 2016 for towers sites and the ABoVE domain)
- Tower Eddy Covariance CO_2 & CH_4 fluxes
- Ecosystem metrics/indicators including in situ soil temperature & moisture data

Meyer:

- Multi-temporal layers of geocoded remote sensing imagery for project region
- Historical hydro - multi-temporal historical lake boundaries
- Lake-bound CH_4 ebullition emission maps – all lakes within project region
- Regional SOC stock and CH_4 emission vulnerability maps – regions around selected active thermokarst margins of lakes
- Present-day regional-scale net lake CH_4 emission budget – project region
- Ebullition flux data from bubble traps – for field study lakes
- Bubble CH_4 content and isotopes – for field study lakes
- Soil carbon data – for field study lakes

Geospatial Data Products

Miller:

- CARVE-Airborne measurements of greenhouse gases at local to regional scales in the Alaskan Arctic
- CARVE: Alaskan Fire Emissions Database (AKFED), 2001-2013
- Quantify the 2005-2015 changes in permafrost, carbon fluxes, and energy balance in the Alaskan Arctic as it transitions into a seasonally sea ice-free state
- Baseline record of atmospheric observations, carbon flux patterns and magnitudes for Alaskan regions

Moghaddam:

- Remote sensing based maps of soil profile characteristics in Alaska permafrost landscapes using time series of airborne P-band synthetic aperture radar

Munger:

- Meteorological fields, transport footprints, optimized flux fields constrained by atmospheric mixing ratio data and vegetation remote sensing, identification of significant anomalies in ecosystem function (focused on North Slope, 2000-present)

Natali:

- Maps of surface properties of permafrost landscapes for areas studied
- Multi-scale freeze-thaw products for areas studied
- Winter CO_2 flux, soil moisture, temperature, snow depth of study sites

Wilson:

- Carbon emissions of permafrost study sites

Other expected products / outcomes

- Open hole hazards map (Meyer)
- “Cooking fuels” map (Meyer)
- Engagement with local communities and agencies

Partnerships, moving forward

Would like input on strengthening and developing partnerships with management agencies and Alaskan Native organizations

Develop relationships to reduce disturbance from field monitoring to local communities

Mechanisms for presenting results to partners