Carbon Dynamics Working Group

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Scott **Goetz** -- Woods Hole Research Center
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Fred **Huemmrich** -- NASA GSFC/UMBC
Julie **Jastrow** -- Argonne National Laboratory
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John **Kimball** -- University of Montana
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Michelle **Mack** -- Northern Arizona University
Franz **Meyer** – Univ. of Alaska, Fairbanks
Chip **Miller** -- NASA JPL
Mahta **Moghaddam** – Univ. of Southern California
Bill **Munger** -- Harvard University
Neal **Pastick** -- USGS / EROS
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Ted **Schuur** -- Northern Arizona University
Rob **Striegl** -- United States Geological Survey
Suzanne **Tank** -- University of Alberta
Sander **Veraverbeke** – Univ. of California, Irvine
Katey **Walter Anthony** – Univ. of Alaska, Fairbanks
Jennifer **Watts** -- NTSG, University of Montana
Kim **Wickland** -- United States Geological Survey
Emily **Wilson** -- NASA GSFC
Lisa **Wirth** – Univ. of Alaska, Fairbanks
Steve **Wofsy** -- Harvard University

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
- 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

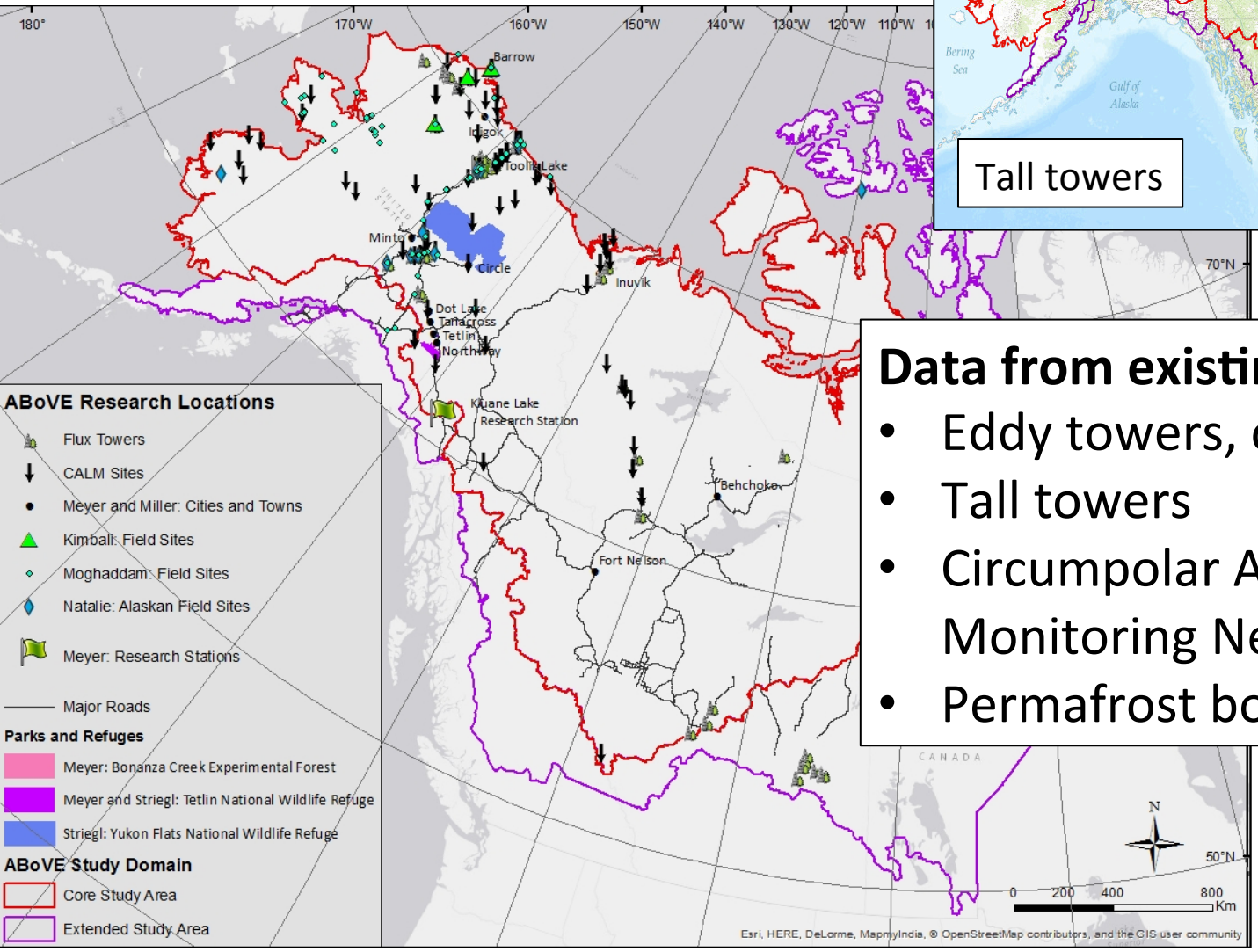
Other stakeholder Organizations

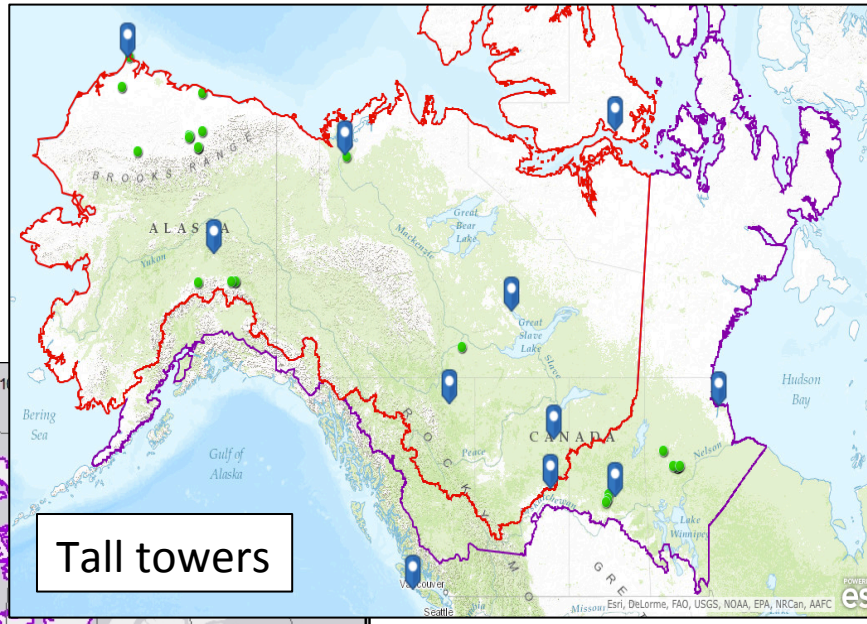
- Alberta Biodiversity Monitoring Institute
- Alaska Ecoscience
- Atmospheric and Environmental Research

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



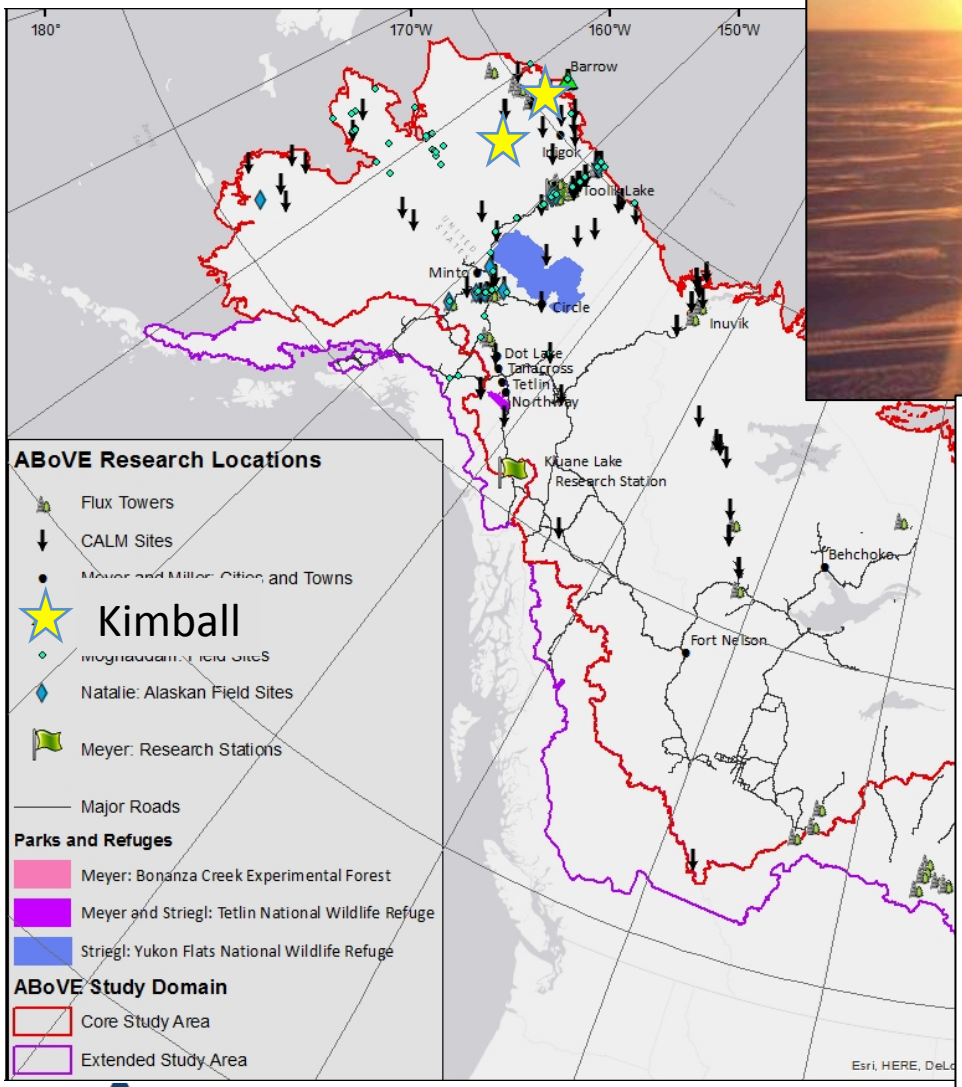


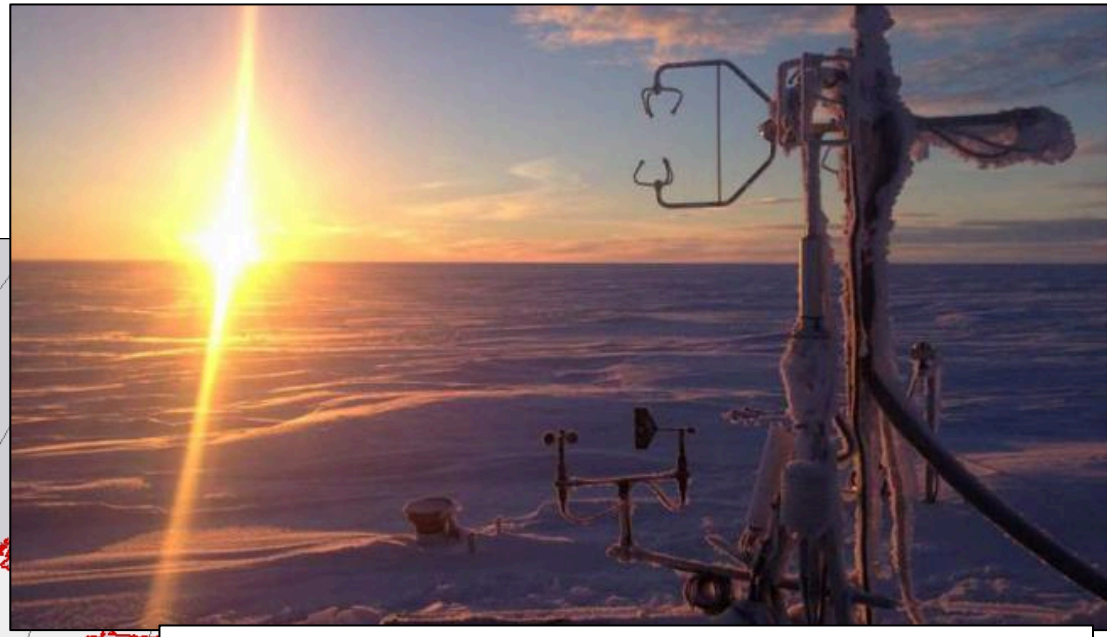
Tall towers

Data from existing networks

- Eddy towers, optical phenology
- Tall towers
- Circumpolar Active Layer Monitoring Network
- Permafrost boreholes

Field: Kimball





Field dates: Fall 2016

Measurements

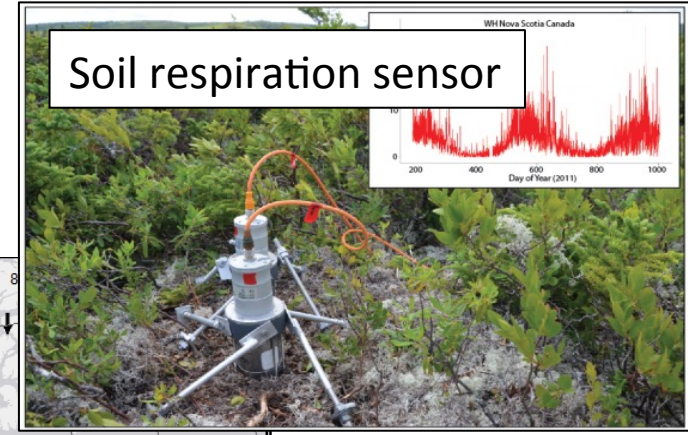
- Soil moisture & temperature
- Sample every second
- Temp measured every cm, in soil, above soil, and in wells to measure water table, snow & thaw depths

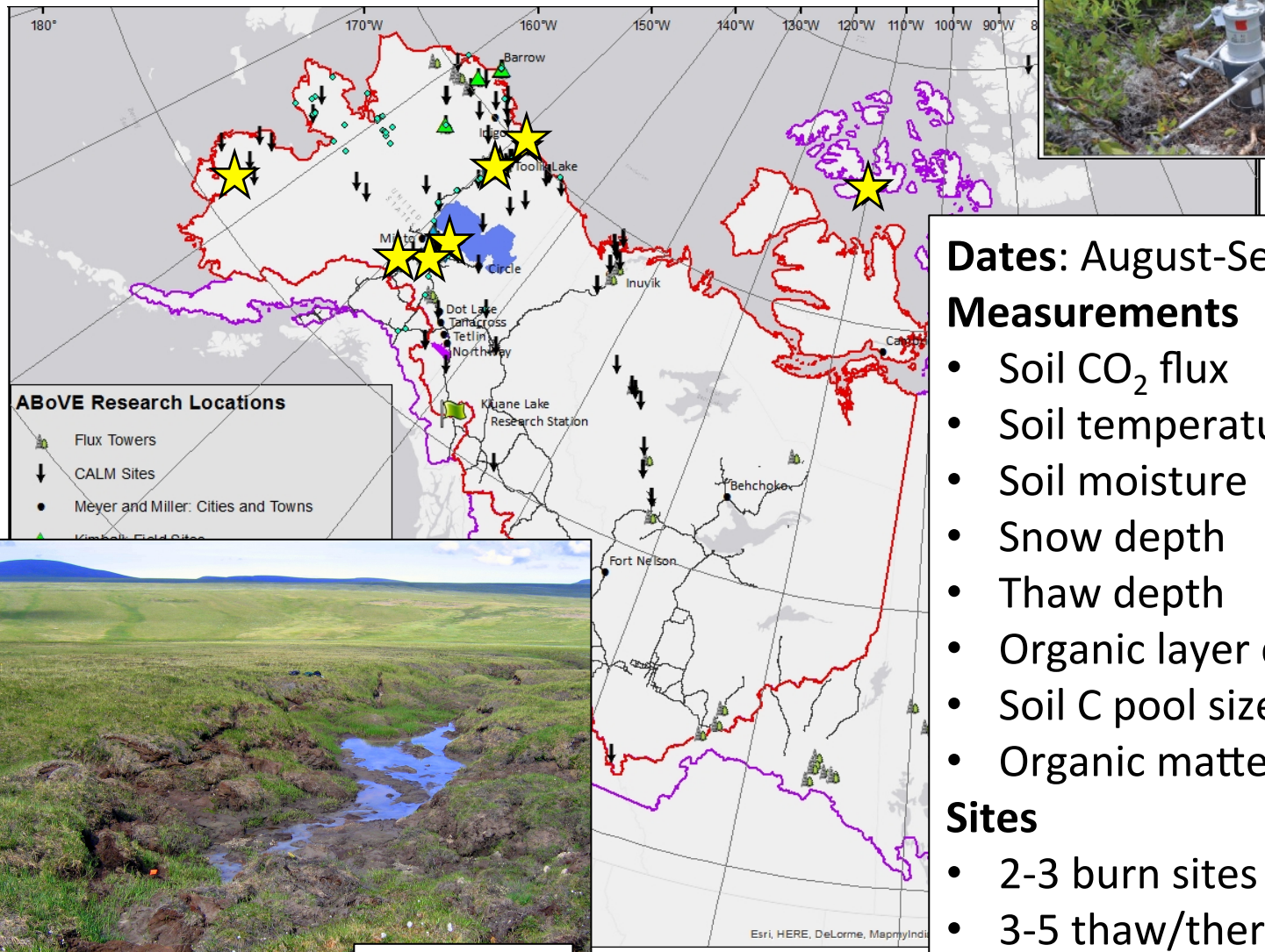
Sites

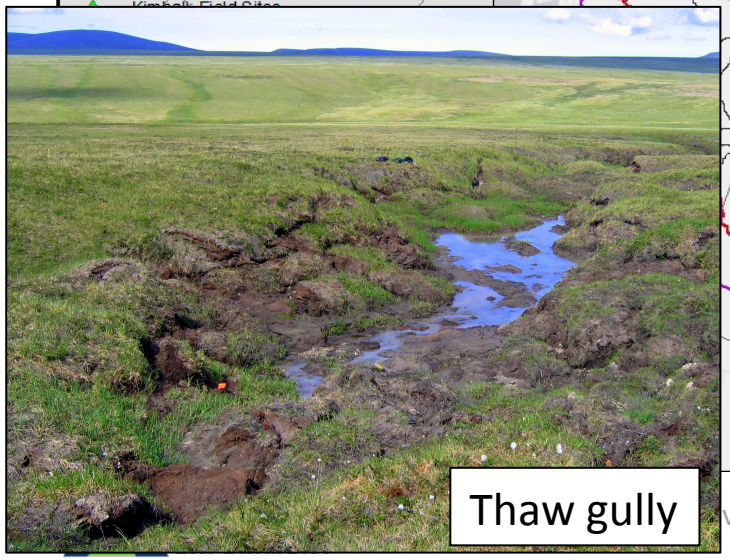
- Ivotuk & Atqasuk (+ Barrow)

ARCTIC BOREAL VULNERABILITY EXPERIMENT

Field: Natali







Dates: August-Sept 2016

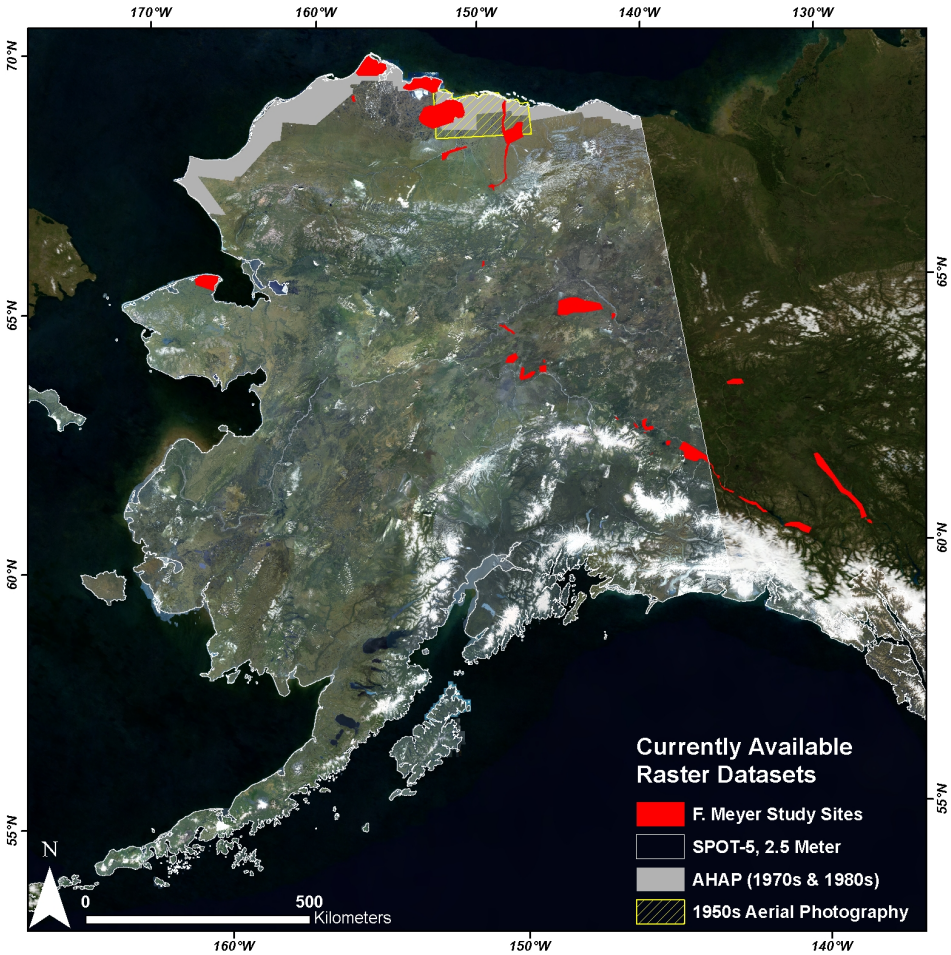
Measurements

- Soil CO_2 flux
- Soil temperature
- Soil moisture
- Snow depth
- Thaw depth
- Organic layer depth
- Soil C pool size
- Organic matter composition

Sites

- 2-3 burn sites
- 3-5 thaw/thermokarst
- 2-3 eddy flux sites

Field: Meyer

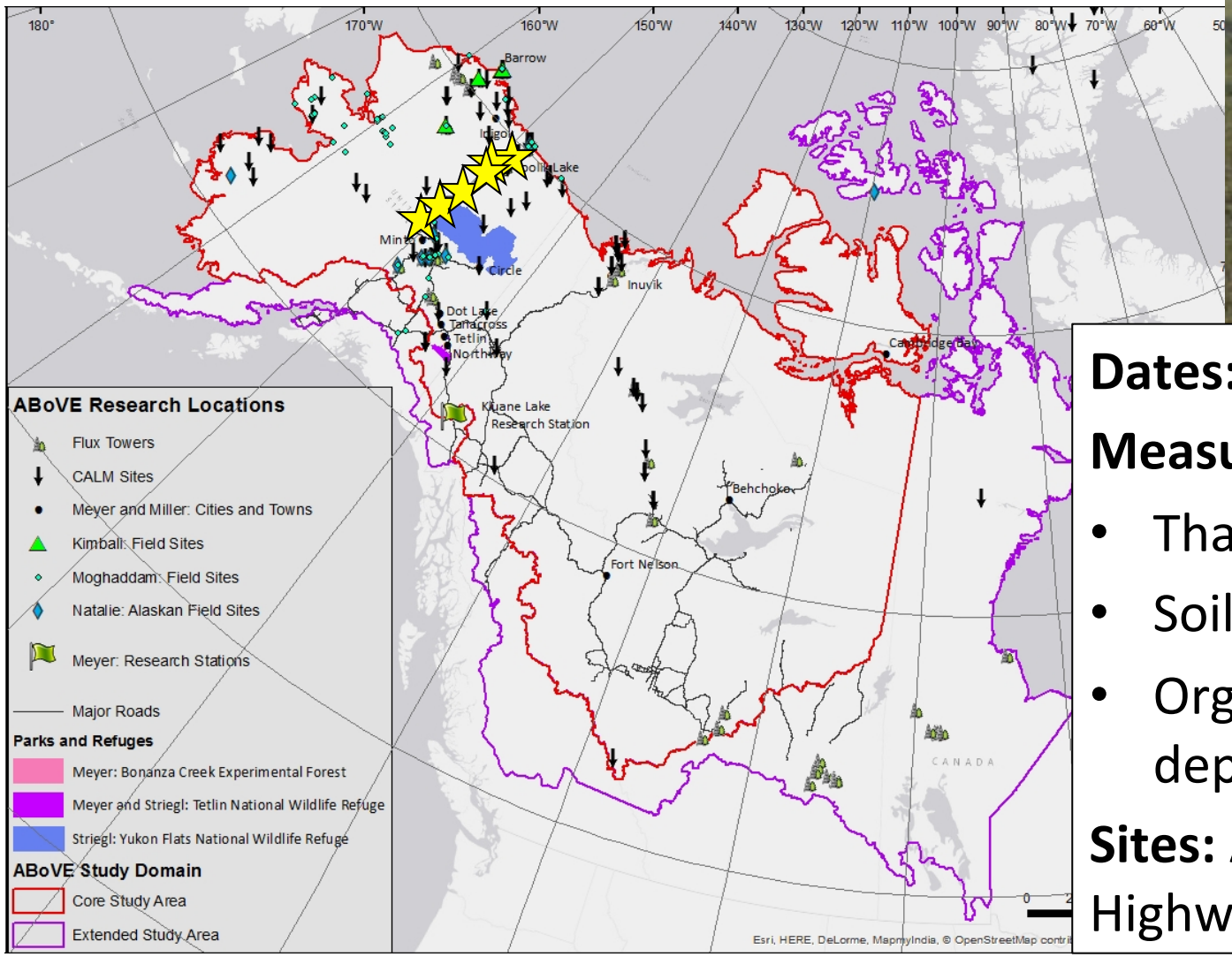


Dates: Fall after freeze up, 2016

Measurements

- Lake CH_4 ebullition, bubble traps
- Geophysical measurements of thaw-bulbs
- Soil organic carbon (SOC) sampling at eroding shores
- Sample collection of CH_4 and SOC for 14C

Field: Moghaddam



Dates: August 2016

Measurements

- Thaw depth
- Soil moisture
- Organic layer depth

Sites: Along Dalton Highway

Spaceborne Remote Sensing-Summary

- Maps of vegetation type, growing season length & gross primary productivity, 1-km resolution throughout the ABoVE domain
- Maps of lake area change and CH_4 ebullition, tens of meters of resolution throughout the ABoVE domain
- Active layer characteristics, including thaw depth, soil moisture, and organic layer thickness, tens of meters of resolution, several transects throughout the ABoVE domain.
- Depth to water table, tens of meters of resolution, several transects throughout the ABoVE domain.
- Fractional open water and surface inundation dynamics, 1-km resolution, select regions in ABoVE domain
- Surface freeze-thaw dynamics, 6 km resolution, throughout the ABoVE domain
- Carbon dioxide and methane total column and flux estimates over the Mackenzie Basin
- Various combinations of above to produce time-series dynamics and spatial multi-scale products

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

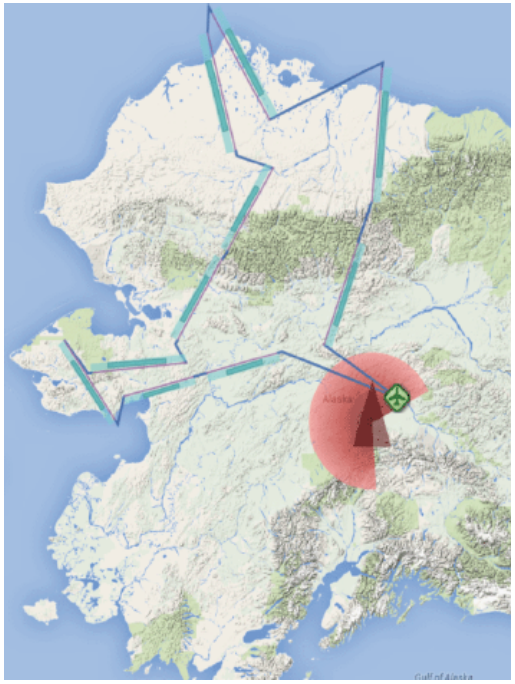
Wilson:

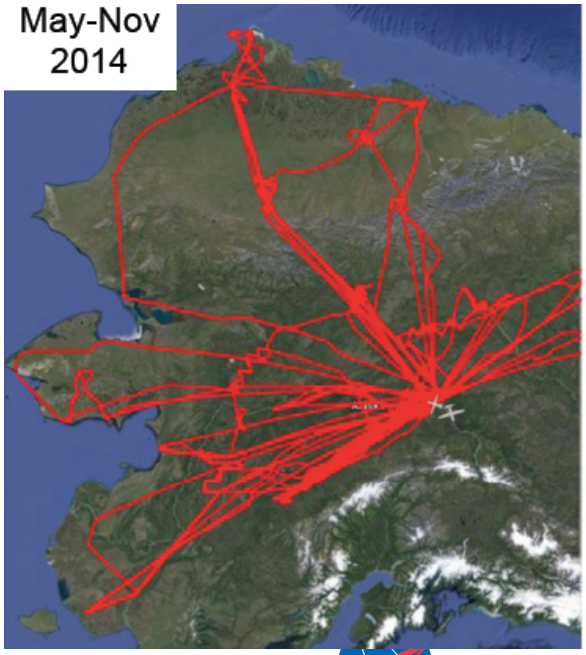
- Carbon emissions of permafrost study sites

Airborne Remote Sensing

- AirMOSS & L-band UAVSAR: permafrost soil properties – active layer moisture, freeze-thaw, active layer depth, organic layer thickness, and depth to water table (Moghaddam), **April 2016**

- CARVE-CAN: Atmospheric CO_2 and CH_4 concentrations and flux estimates (Miller), Mackenzie River Basin





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)

Models & outputs

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:	Impacts 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)

Status of AIP

Overarching needs:

- CDWG co-chair or sub-working group leads to head RS and modeling components of the AIP and to help integrate parts
- Conceptual coordination among projects and among field/RS/modeling components
  - We need a conceptual model that includes relevant processes
  - Overlay CDWG projects on the conceptual model
  - Will facilitate identification of data gaps

Status of AIP

- Field measurement efforts:
  - Need to finalize field sites & sampling dates
  - Need to develop/share common measurement protocols, standard projections/datum/format—among & within WG
- Remote sensing efforts & expected products:
  - Fairly complete, but should identify an RS lead
- Modeling efforts & expected outputs:
  - Needs some integration, clarify how the different parts fit together
- Timing, coordination & synergies among WG
  - Member representation from modeling, fire & hydrology —coordinate so that we don't replicate efforts

Status of AIP

- Identified data gaps / needs:
  - Eddy tower longevity and accessibility
    - Explore option of ABoVE-led data sharing agreement
    - Short-term goal: ensure field site data are being collected and archived
    - Long-term goal: address the sustainability of the field flux network
  - Tall towers, spatial gaps in regional estimates
    - Toolik, **Y-K Delta**, Seward Peninsula

Status of AIP

Airborne observation desires

- Snow properties (cross-disc. linkages; LiDAR/ optical-IR/micro.)
- Active layer properties (dual freq. SAR)
- Greening/browning (SIF/surface water/ hyperspec.)
- Trace gas concentrations **<u>and fluxes</u>**