Carbon Dynamics Working Group

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Carbon Dynamics Projects

- Gamon-01
- Kimball-04
- Meyer-01
- Miller-C-01, 02, 03
- Moghaddam-03
- Munger-03
- Natali-01
- Striegl-01 (*Hydrology*)
- Wilson-01
- **Keeling-08**
- **Miller-05**
- **Munger-04**
- **Neigh-01**
- **Oechel-01**
- **Rocha-01**
- **Rogers-02**
- **Sweeney-01**
- **Wunch-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
- **NSF Arctic Observing Network**
- **NASA Atom airborne campaign**

Other Stakeholder Organizations

- Alberta Biodiversity Monitoring Institute
- Alaska Ecoscience
- Atmospheric and Environmental Research
- **Flux Tower sites**

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)

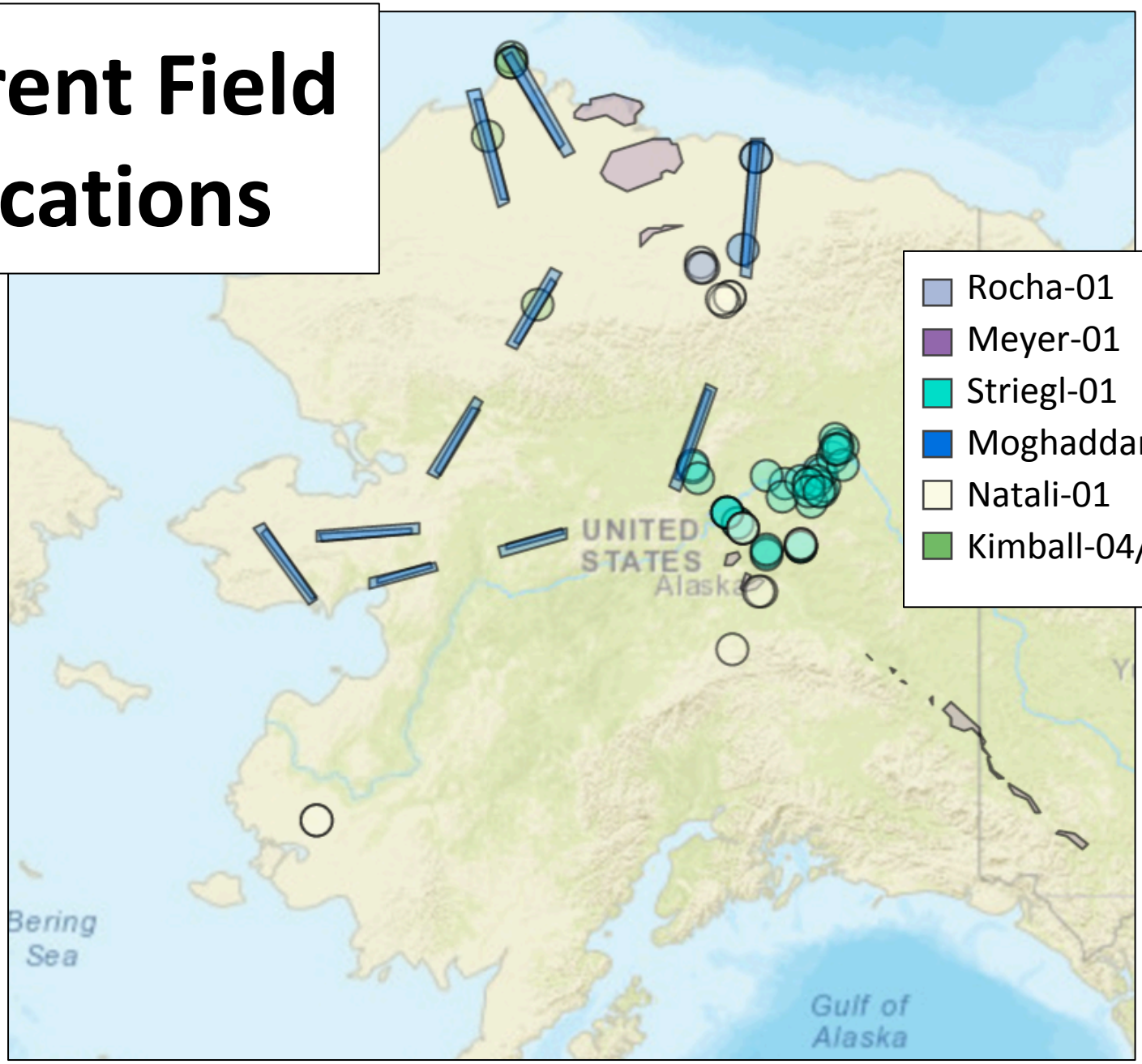
Field Measurements, overview

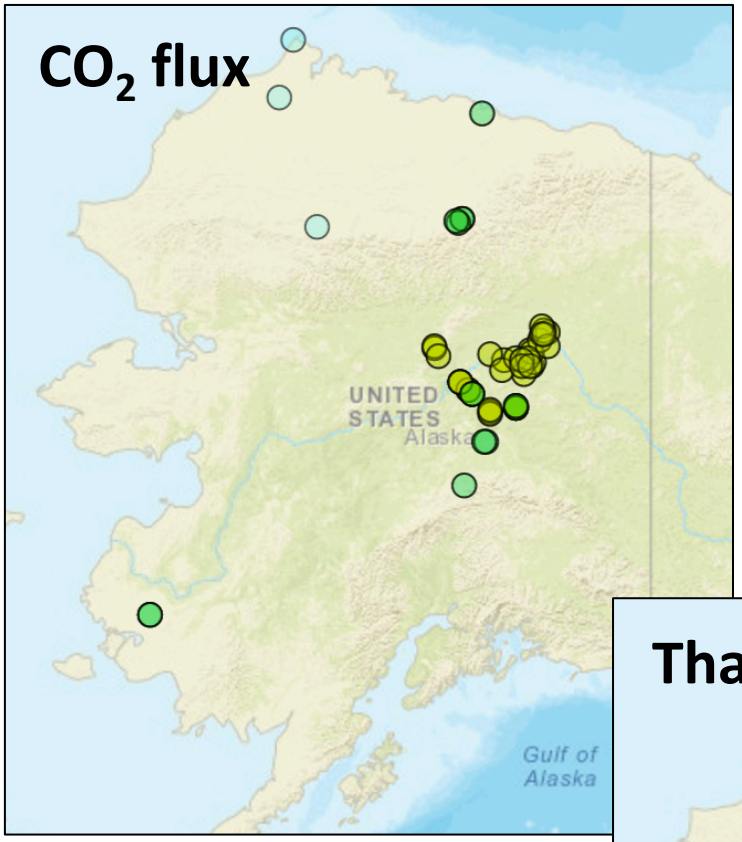
1. Carbon fluxes from terrestrial and aquatic sites
2. Soil & water carbon pools and OM composition
3. Water environ. parameters (e.g., temp, pH)
4. Optical phenology
5. Soil moisture and temperature, thaw depth
6. Streamflow & hydrological measurements

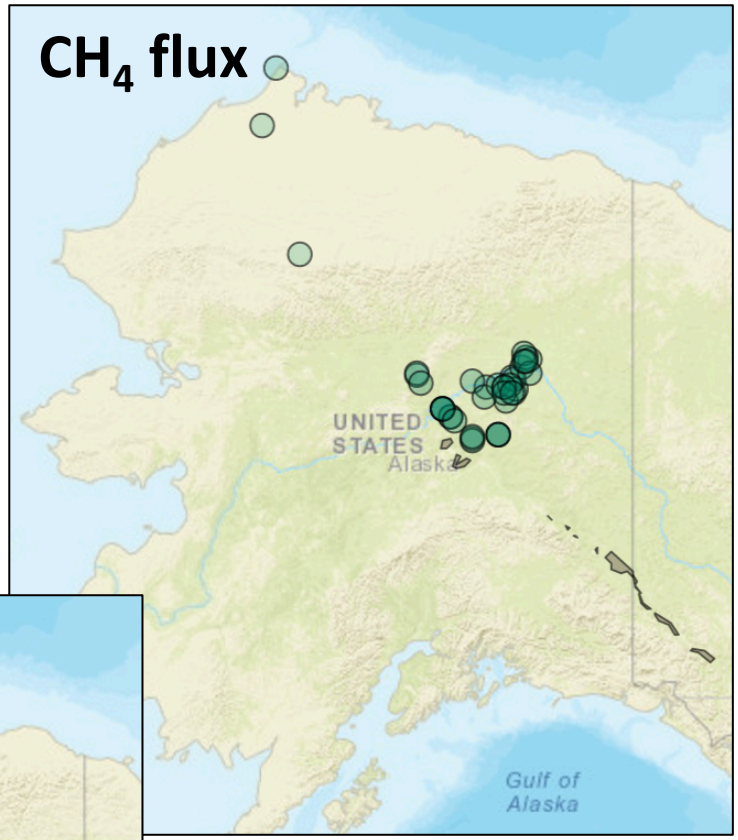
Field Measurements
Pre-existing Networks

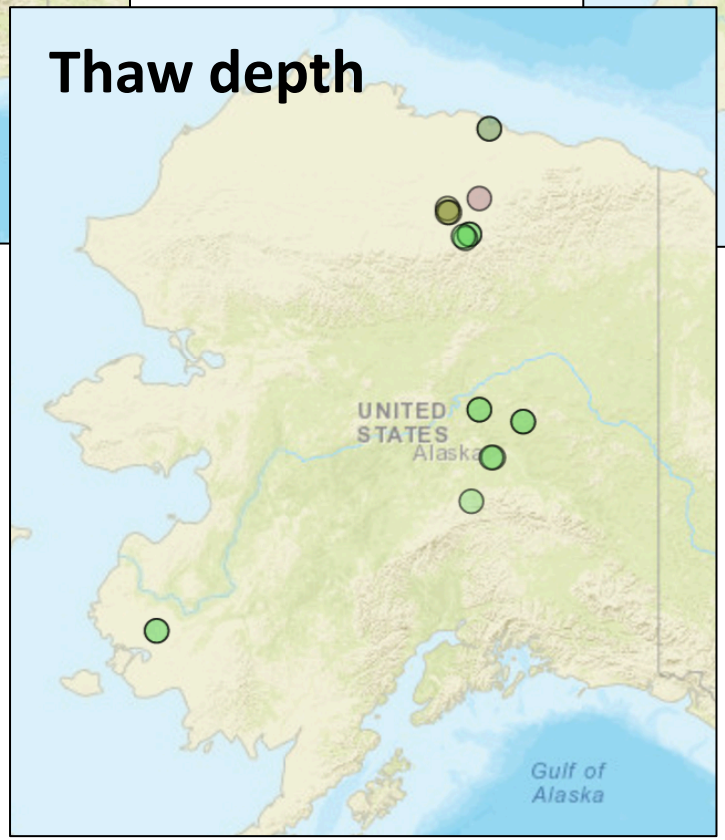
CO_2 and CH_4 fluxes, Eddy covariance towers
Atmospheric trace gasses: CO2, CH4, CO from tall towers
Optical phenology, Eddy tower sites
Active Layer Depth, CALM Network and tower sites
Active layer and permafrost temperatures, Borehole network
Meteorology and environmental parameters, tower and other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

Current Field Locations





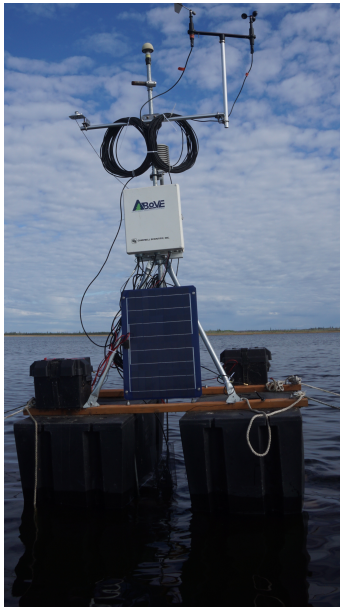




ARCTIC BOREAL VULNERABILITY EXPERIMENT

NASA

Field Research Highlights



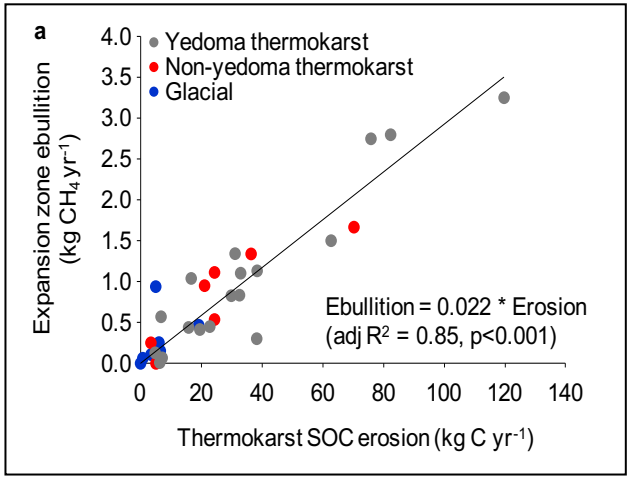
Lake chemistry monitoring (Striegl-01)

Striegl-01

- **Lake water quality & dissolved CO_2** sensors at 2 lakes
- **Lake chemistry & fluxes** at 20 lakes in Yukon Flats, AK
- **Stream and permafrost seep carbon chemistry, flux** & flow network established at ~ 8 catchments in AK

Meyer-01

- **Bubble surveys completed for SAR validation**
- Historical optical images rectified**; historical & current lake mapping** completed
- **Quantified CH_4 emissions from thaw lakes** (Walter Anthony et al., Nature Geo 2016)



Relationships between soil organic carbon input and lake methane emissions. (*Walter Anthony et al.* 2016; *Meyer-01*))

Field Research Highlights

Kimball-04

- **Eddy covariance flux retrievals** at Barrow, Atqasuk and Ivotuk
- Installing **soil temperature & moisture network** in and adjacent to the flux tower footprints at **Ivotuk and Atqasuk** in summer 2017

Gamon-01

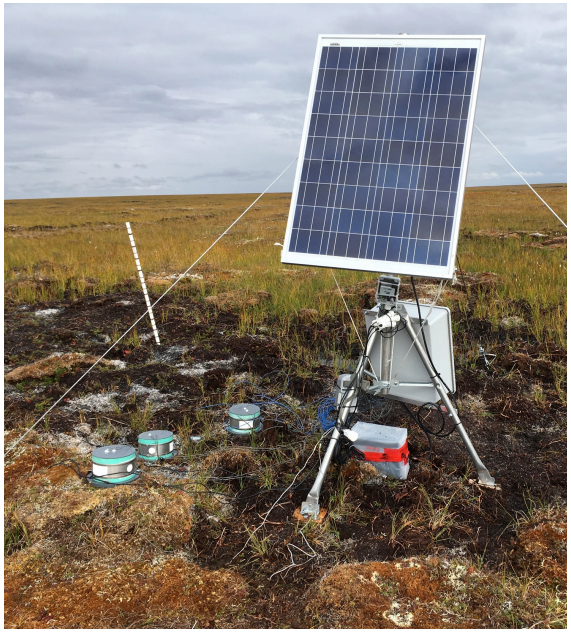
- **Eddy covariance CO_2 flux data collected** from across ABoVE domain
- **Partitioning 16 years of flux tower NEE data** to develop consistent data record

Natali-01

- Automated **soil CO_2 flux systems, temperature & moisture probes** installed at 10 AK sites
- **Vegetation/soil surveys** at these sites

Moghaddam-03

- **Soil moisture sensors** installed at two locations w/ satellite communication



Field: lessons learned & synergies

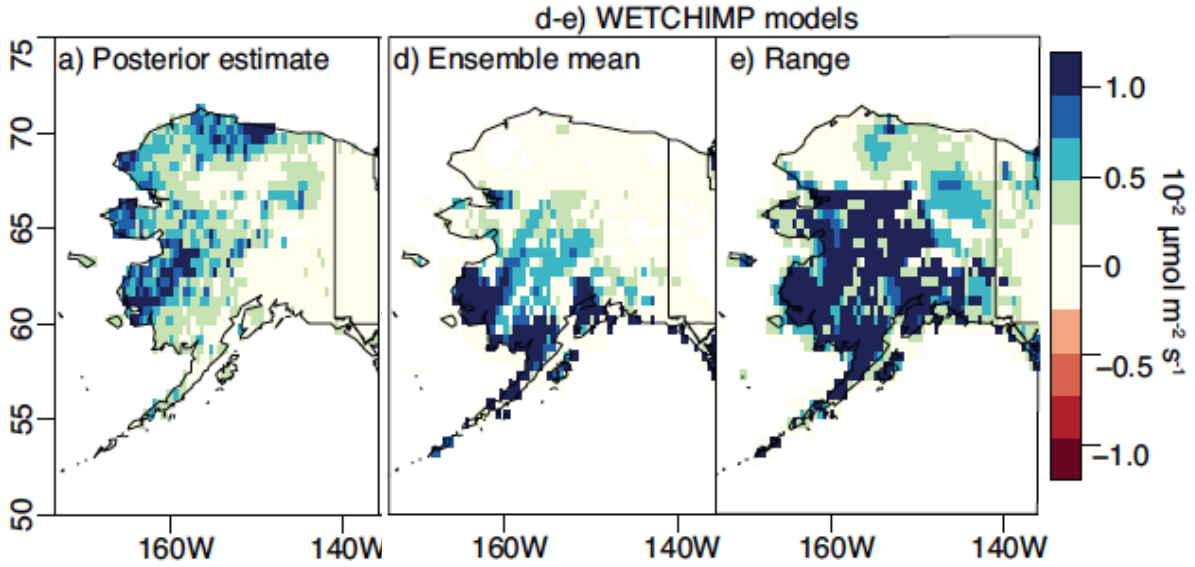
- **Lessons learned** & impacts on 2017 field
  - Natali: instrumentation issues highlight the need for remote communication; 2 sites may be relocated; increase power supply
  - Moghaddam: based on field observations of soil structure, update radar models for organic soils.
  - Moghaddam: more extensive sampling of organic soils within the radar flight tracks
- Identified **synergies** with other WG projects
  - Moghaddam: soil moisture sensor installation near Natali sites; collaboration Tabatabaeenejad

Airborne RS: Plans & measurement needs

- Gamon: Compare **SiF data** from airborne measurements to GPP estimates from reflectance indices
- Moghaddam: Conducting 3 sets of flights of **L-band and P-band radars (UAVSAR and AirMOSS)** in Alaska and additional lines that extend to Canada.
- Moghaddam**:** Produced **maps of active layer thickness** and preliminary maps of **soil moisture content** for most of the existing AirMOSS+UAVSAR flight lines acquired in 2015
- Meyer: Continue to collect **aerial photos of frozen lakes** for remote sensing analysis of methane seeps associated with lake ice

Airborne results: CARVE

- More than 50% of the North Slope CH_4 flux occurs during the cold season (Zona et al., PNAS, 2016)
- No significant increase in long-term CH_4 emissions from North Slope Alaska (Sweeney et al., GRL, 2016)
- Alaska CH_4 fluxes (2012-2014) estimated from CARVE (S. Miller et al., GBC, 2016)



Satellite Remote Sensing, overview

- 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

Remote sensing updates

- Gamon-01:
  - Analysis of **MODIS, meteorological & CO_2 flux data from tower sites within the ABoVE domain**
  - Application of MODIS-derived **Chlorophyll:Carotenoid Index (CCI) as indicator of photosynthetic phenology** (**Gamon et al., PNAS 2016**)
  - Examining sun angle and viewing angle effects on reflectance values and vegetation indices (MODIS MAIAC C6); **products to correct for angular effects**
- Striegl-01: Remote sensing analyses of lake distribution & color; vegetation & ground surface conditions

Remote sensing updates

- Kimball-04: Data from > 14 eddy covariance sites used to calibrate/validate **remote sensing based terrestrial carbon flux model**, output daily at a 1-km resolution
- Moghaddam-03: Plan to incorporate PALSAR-2 & Sentinel-1/2 into analyses. Upscale from airborne tracks to regional/statewide scale
- Natali-01: EVI (MOD13Q1) as driver of pan-Arctic non-growing season respiration

Modeling

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 & applications

Type of Model	**Applications**
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)
Statistical model	**Drivers of winter CO_2 emissions,** response functions (Natali)

Modeling updates

- Kimball: Data from > 14 eddy covariance sites being used to calibrate/validate a remote sensing based Terrestrial Carbon Flux model, output daily at a 1-km resolution
- Moghaddam: Collaborative w/ Kimball's group—modeling permafrost active layer dynamics & sensitivity to landscape spatial heterogeneity
- Gamon: Statistical & machine learning methods to understand how new MODIS dataset relates to fluxes, as foundation for GPP modeling

Education, Outreach & Stakeholder Engagement

- Several new **postdocs** & **graduate students** on a number of CDWG projects
- **Collaboration with USFWS and the Western Boreal LCC**; field support from Yukon Flats National Wildlife Refuge (*Striegl-01*)
- **Collaboration with ARCUS to establish STEM outreach with remote Alaska Native communities**; focused on validation of NASA/ABoVE remote sensing data products and collection of thaw depth, snow cover, soil moisture, soil temperature, and land disturbance data (Kimball-04)
- **Coordination of data sharing with the NPS Inventory & Monitoring Networks** in preparation for upcoming airborne activities (Kimball-04)
- Working to **engage Canadian colleagues** in ABoVE activities (Kimball-04).
- Vegetation and thaw depth **data sharing with Yukon Delta National Wildlife Refuge** (Schaefer-05, Natali-01)
- Field work with high school teacher and students; **integrating ABoVE CO_2 flux data into high school curriculum** (Natali-01)
- Presentation about lake **CH4 emissions for middle school students** in UAF's AK Summer Research Academy (Meyer-01)
- Methane lake emissions research featured in social media and many **print, radio and television interviews** (Meyer-01)

Gaps/needs

- Soil moisture, soil organic content, and ALT data from Canada for airborne cal/val
- Data from Canadian sites, esp winter CO_2 flux
- CH_4 oxidation: drivers, magnitude & variation across ABoVE domain
- Integration of terrestrial and aquatic fluxes, using airborne, field sampling and satellite data
- High resolution 3-km Polar WRF reanalysis fields for the ABoVE domain through 2018 (currently 2012-2016)
- Integration among groups through joint working group meetings—especially with hydrology/permafrost
- CDWG co-leads w/ expertise in modeling/remote sensing