Roisin Commane, Sue Natali, Abhishek Chatterjee

Carbon Dynamics Working Group 2018

Abhishek **Chatterjee** –- Goddard
Róisín **Commane** -- Columbia
Sue **Natali** –- WHRC

Jim **Abshire** -- NASA GSFC
Logan **Berner** -- NAU
Melanie **Engram** – UAF
Eugenie **Euskirchen** -- UAF
Joshua **Fisher**-- NASA JPL
John **Gamon** -- University of Alberta
Helene **Genet** -- Inst. Arctic Biology
Scott **Goetz** -- NAU
Peter **Griffith** – NASA GSFC/SSAI
Guido **Grosse** -- AWI
John **Henderson** -- AER
Fred **Huemmrich** -- GSFC/UMBC
Julie **Jastrow** -- Argonne NL
Torre **Jorgenson** -- AK Ecoscience
Ralph **Keeling** – UCSD Scripps
Gretchen **Keppel-Aleks** -- Michigan
John **Kimball** -- Univ of Montana
Erik **Larson** -- Harvard University
Prajna **Lindgren** – UAF

Michelle **Mack** -- NAU
Juha **Metsaranta** – Nat. Res. Canada
Franz **Meyer** – UAF
Chip **Miller** -- NASA JPL
Mahta **Moghaddam** – USC
Bill **Munger** -- Harvard
Christopher **Neigh** -- NASA GSFC
Walt **Oechel** -- SDSU
Kate **Orndahl** -- NAU
Neal **Pastick** -- USGS / EROS
Christopher **Potter** – NASA ARC
Ben **Poulter** -- NASA GSFC
Dave **Risk** -- St.FXU, Canada
Adrian **Rocha** -- Notre Dame
Brendan **Rogers** -- WHRC
Torsten **Sachs** -- GFZ
Christina **Schaedel** -- NAU
Kevin **Schaefer** -- NSIDC
Luke **Schiferl** - Harvard
Ted **Schuur** -- NAU

Eric **Stofferahn** -- JPL
Oliver **Sonnentag** -- Montreal
Rob **Striegl** -- USGS
Colm **Sweeney** - - NOAA ESRL
Suzanne **Tank** -- Alberta
Kevin **Turner** -- Brock U.
Craig **Tweedie** -- Texas at El Paso
Sander **Veraverbeke** – UCI
Katey **Walter Anthony** – UAF
Jennifer **Watts** -- WHRC
Kim **Wickland** -- USGS
Emily **Wilson** -- NASA GSFC
Lisa **Wirth** – UAF
Steve **Wofsy** -- Harvard
Curtis **Woodcock** -- BU
Debra **Wunch** – U. Toronto
Yonghong **Yi** -- U. Montana
Rong **Yu** -- U. Nebraska

Carbon Dynamics Projects

2015
- Gamon-01
- Kimball-04
- Meyer-01
- Miller-C-01, 02, 03
- Moghaddam-03
- Munger-03
- Natali-01
- Striegl-01 (*Hydr*)
- Wilson-01

2017
- Keeling-08
- Miller-05
- Munger-04
- Neigh-01
- Oechel-01
- Rocha-01
- Rogers-02
- Sweeney-01
- Wunch-01

New
- **Abshire-01**
- **James-01**

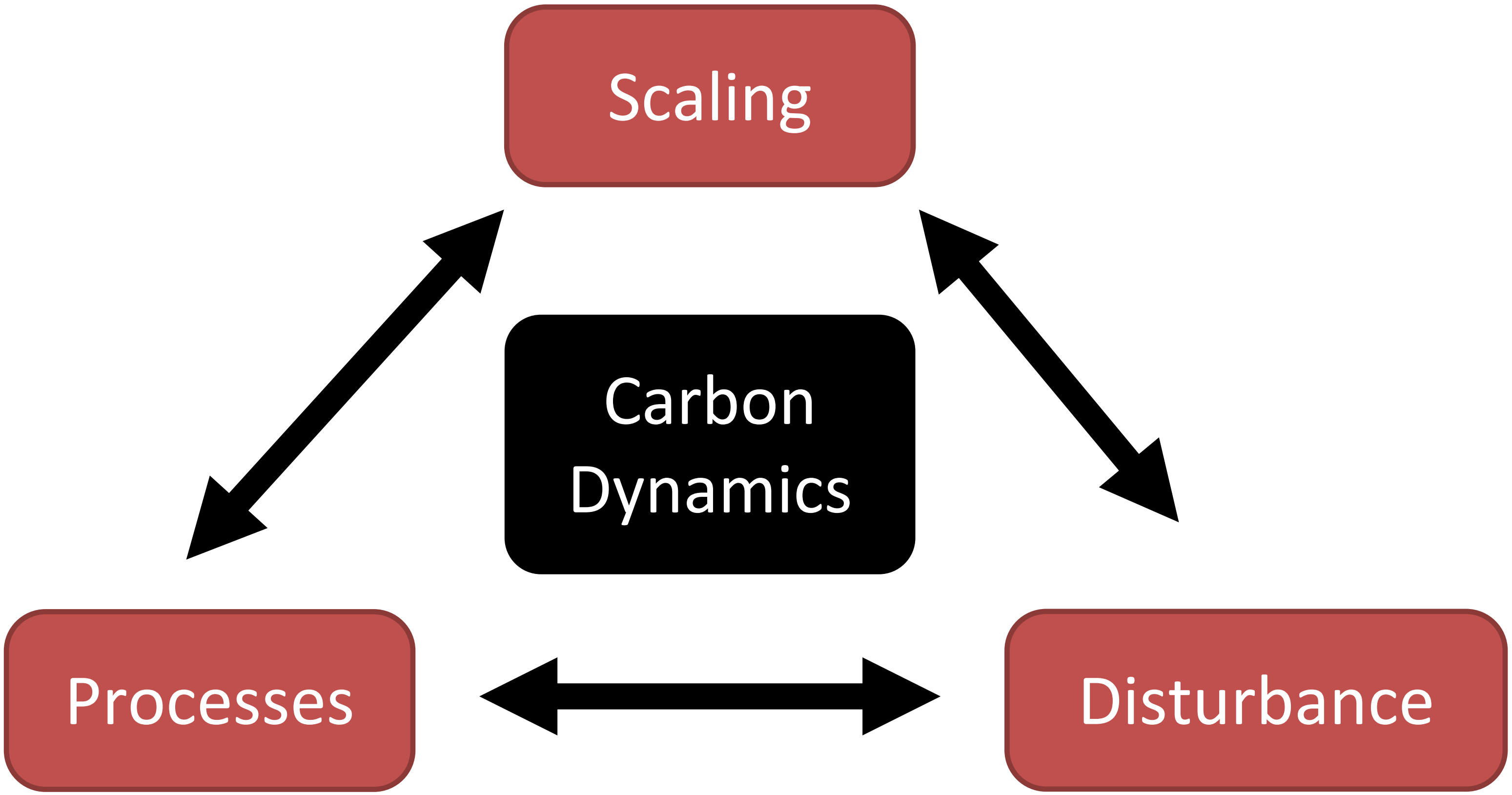
High-level CDWG Science Questions

1. What are the magnitudes of carbon pools and fluxes within the ABoVE domain?

2. How are changes in vegetation distribution, hydrology, climate and disturbance influencing the carbon balance?

3. How will estimated sources and sinks of CO_2 and CH_4 change in response to projected changes in the above drivers?

High-level CDWG Science Questions



Targeted Science Questions

1. Spatial scaling and temporal trends:

- What is representative scaling?
- How do we test these scaling methods?
- Measurements on various scales:
  - Chambers, eddy towers, tall towers, aircraft, total column, satellite

- Seasonal trends inherent in our understanding of spatial scaling but do scaling relationships hold on an inter annual and decadal basis?
- Mismatch of temporal scales: Vegetation changes over time vs microbial changes.

- Calculate the annual fluxes and resolve Bottom up VS top down

Targeted Science Questions

2. Processes driving carbon fluxes

- Define process based relationships from observations: **Response functions**
  - Hydrologic/lateral transport; Terrestrial-Aquatic interface/links
  - Cold season dynamics and carbon fluxes; near-surface permafrost dynamics (freeze/thaw timing, active layer thickness, etc.), surface hydrology and vegetation dynamics

- Are these processes represented in models? How do we define what is missing?
- Can we use measurements at various scales to quantify missing fluxes?

What are the main drivers and lag times for inter annual variability of carbon fluxes?
What is driving the increase in fall respiration from tundra? New or old carbon? No increase in CH_4?

Targeted Science Questions

3. Disturbance effects on carbon dynamics

Disturbance changes processes level and temporal dynamics (through processes)
Disturbance then changes how we scale up these processes.
For example; Regrowth relationships different to unburnt ecosystems

Carbon Dynamics Breakout Group

Carbon Dynamics WG affected by every other working group and want and need more input from you all

Carbon Dynamics Working Group

Rogers

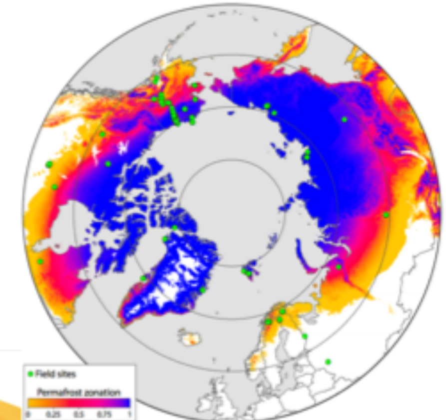
Science Updates from Rogers-02

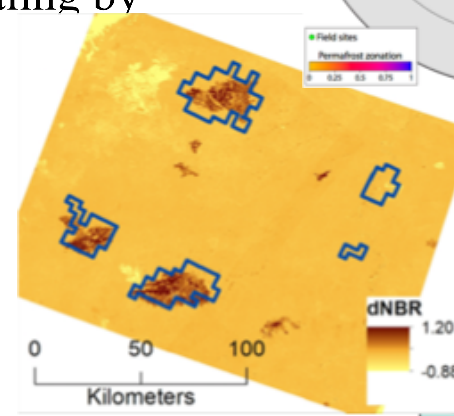
1. Circumpolar CO_2 flux synthesis
   - Collecting & extracting data
   - Upcoming flux synthesis workshop (NCEAS, Schuur)
   - Aim to develop monthly/seasonal models for scaling by next year

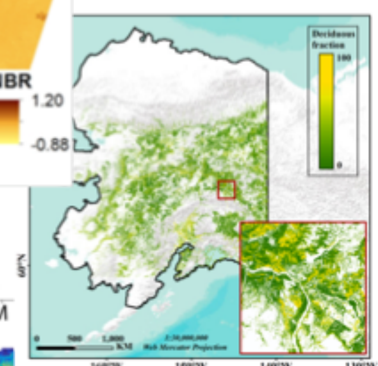
2. Siberian fire database (1979-)
   - Validating AVHRR fire polygons
   - Will merge with modern sensors & products

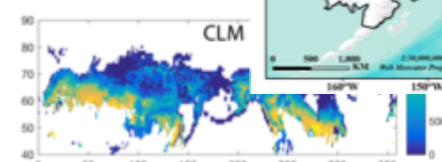
3. Plant Functional Type mapping
   - Mapping deciduous fraction with Landsat in AK
   - Will extend into Canada and several time periods
   - Will use to understand change & validate pan-arctic AVHRR estimates

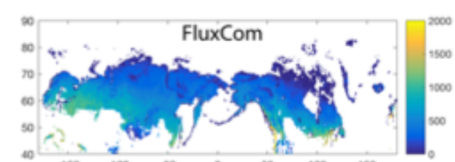
4. Prognostic modeling
   - Comparing CLM to CO_2 benchmarks
   - Aim to initiate model experiments of changing seasonal CO2 cycles by next year











Science Updates from Turner-01

Old Crow Flats, Yukon, Canada

2017 field work outcomes:

- Surveyed active layer and vegetation characteristics at six plots spanning land cover types including a 2017 burn
    - Included UAV and DGPS for land cover classification and 3D mapping

1. DGPS and UAV survey of retrogressive thaw slump
2. Monitored water level in 2 lakes in OCF and 18 near Yellowknife
3. Water chemistry (6th year), isotopes (11th year), and TSS for 23 creeks, 14 monitoring lakes and 3 bogs
    1. Analysis included DIC/DOC ppm and □^{13}C
    2. Conducted in early June and late August
4. Data imagery collected during ABoVE AC will be useful for identifying lake and river catchment properties

Publications 2017:

- Balabubramaniam AM, AS Medeiros, **KW Turner**, RI Hall, BB Wolfe. 2017. Biotic responses to multiple aquatic and terrestrial gradients in shallow subarctic lakes (Old Crow Flats, Yukon Territory, Canada). Arctic Science: 3: 277-300, dx.doi.org/10.1139/as-2016-0021
- MacDonald LA, BB Wolfe, **KW Turner**, L Anderson, CD Arp, SJ Birks, F Bouchard, TWD Edwards, N Farquharson, RI Hall, I McDonald, B Narancic, C Ouimet, R Pienitz, J Tondu, H White. 2017. A synthesis of thermokarst lake water balance in high-latitude regions of North America from isotope tracers. Arctic Science: 118-149, dx.doi.org/10.1139/as-2016-0019
- Bouchard F, LA MacDonald, **KW Turner**, JR Thienpont, AS Medeiros, BK Biskaborn, J Korosi, RI Hall, R Pienitz, BB Wolfe. 2017. Paleolimnology of thermokarst lakes: a window into permafrost landscape evolution. Arctic Science: 91-117, dx.doi.org/10.1139/as-2016-0022
- Tondu JM, **KW Turner**, JA Wiklund, BB Wolfe, RI Hall, I McDonald. 2017. Limnological evolution of Zelma Lake, a recently drained thermokarst lake in Old Crow Flats (Yukon, Canada). Arctic Science 220-236, dx.doi.org/10.1139/as-2016-0012

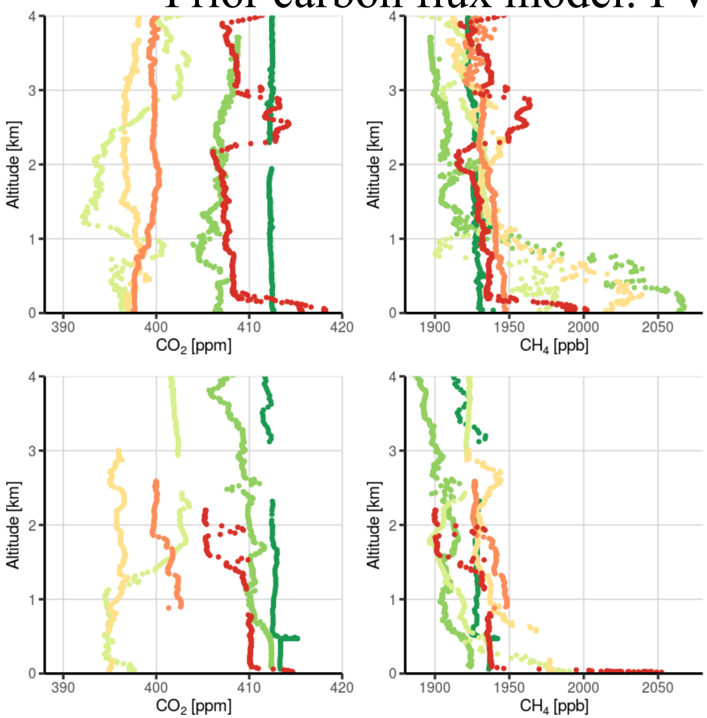
Recent MSc competed:

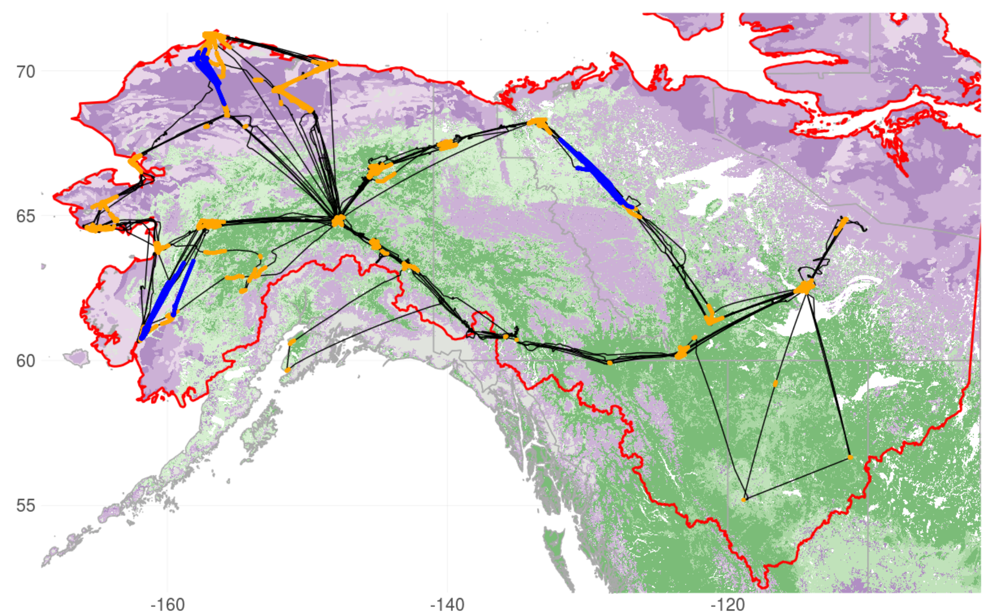
Daniel Hughes, 2018, Detecting spatial variation in hydrology and carbon export across a lake-rich permafrost landscape: Old Crow Flats, Yukon, Canada. Brock University, St. Catharines, Ontario, Canada

Sweeney

Analysis Updates from Sweeney-01

1. ArctiCAP flights successfully completed
2. Luke Schiferl started as a postdoc on the project on January 1
   (**Schiferl Poster #100**)
3. Regional Fluxes of CO_2 and CH_4 fluxes: Geostatistical Inverse Analysis
   - Airborne Profiles to calculate regional atmospheric enhancements
   - Transport model (WRF-STILT) will be run in Feb
   - Prior carbon flux model: PVPRM-SIF



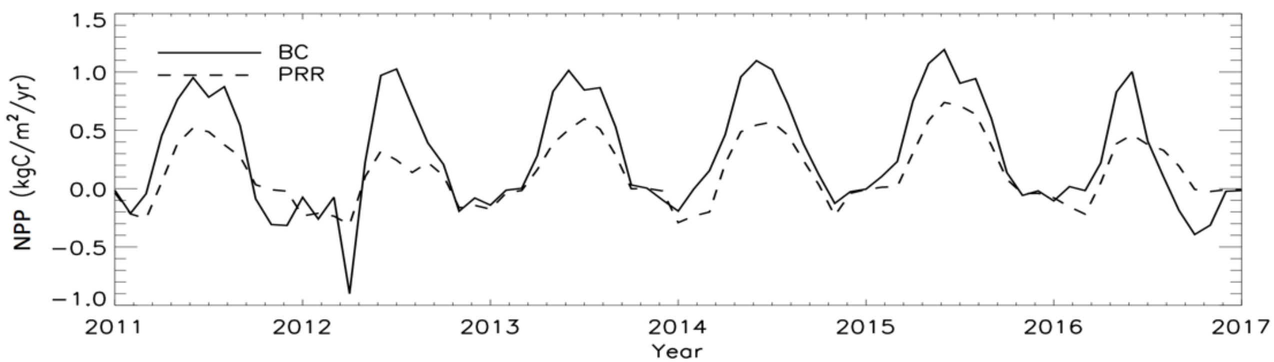


Carbon Dynamics Working Group

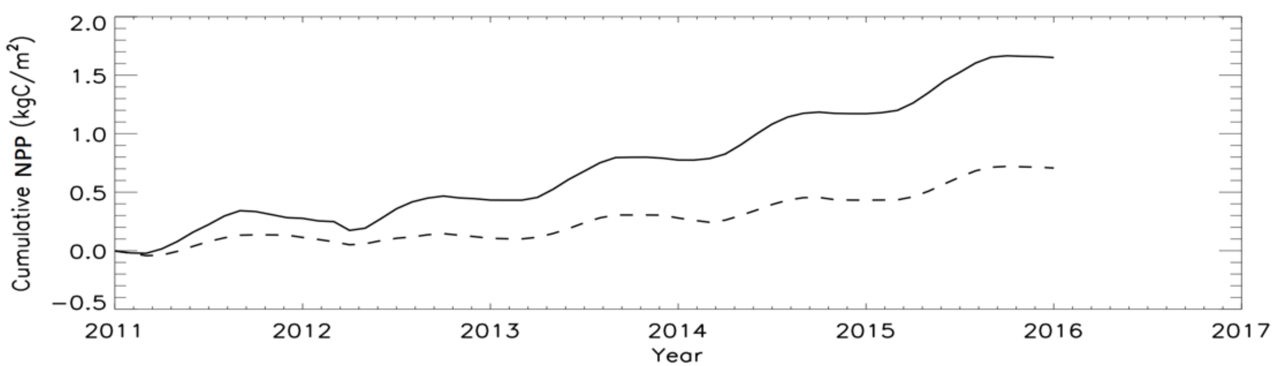
Munger

Science Updates from Munger-04

1. Erik Larson started as a postdoc on the project (**Larson Poster #92**)
2. Ecosystem Demography Model (ED)
   - Currently adapting peatland module to include permafrost
   - Using eddy flux data from various North Slope sites
   - Running site specific before extending to ABoVE wide simulations.



Simulated NPP in black spruce forests at Bonanza Creek and Poker Flat Research Range over the past 6 years.



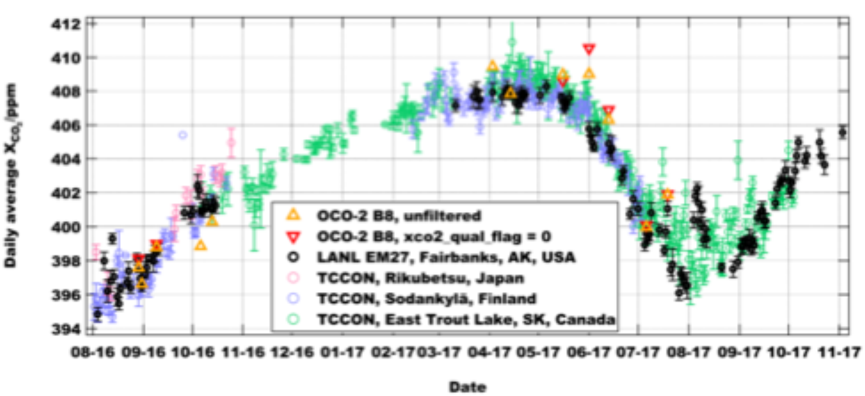
Carbon Dynamics Working Group

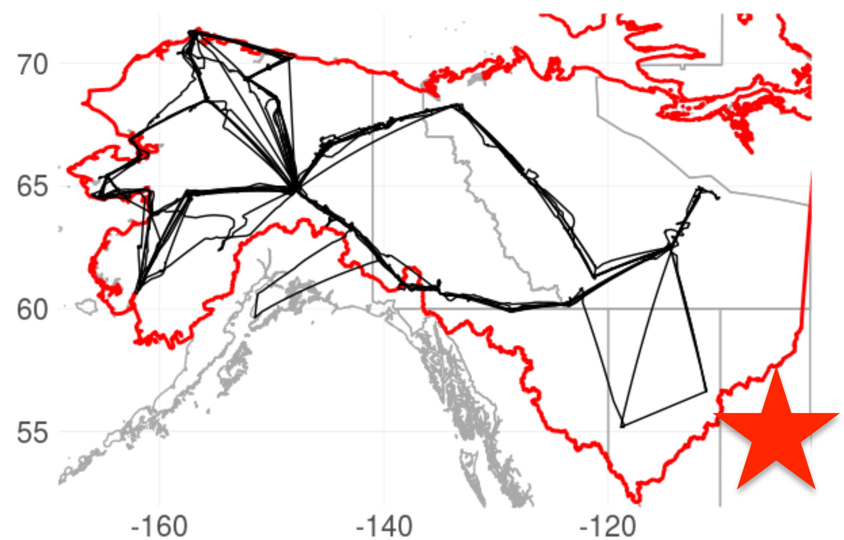
Wunch

Analysis Updates from Wunch-01

1. Portable ground-based remote sensing of XCO2 and XCH4
   (**Niki Jacobs Poster #57)** Mini TCCON helping with OCO2 arctic XCO2

2. East Trout Lake TCCON site
   with XCO2, XCH4, XCO and XOCS (**Commane Poster #59**)
   Measurements ongoing. Interpretation and Analysis in development



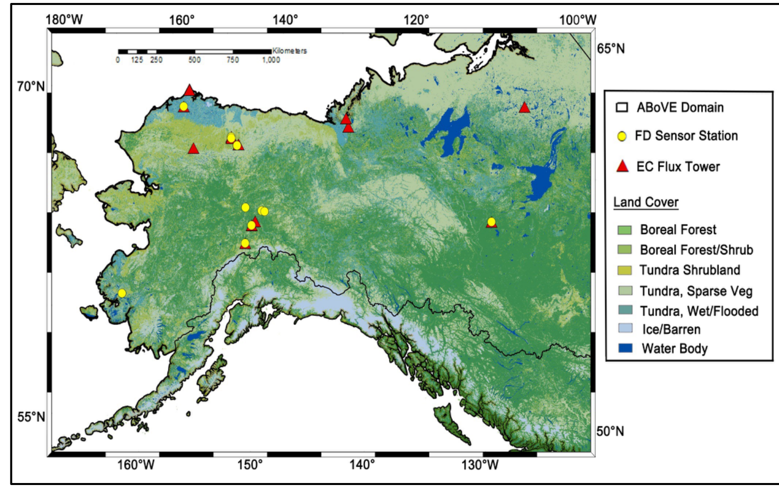


Carbon Dynamics Working Group

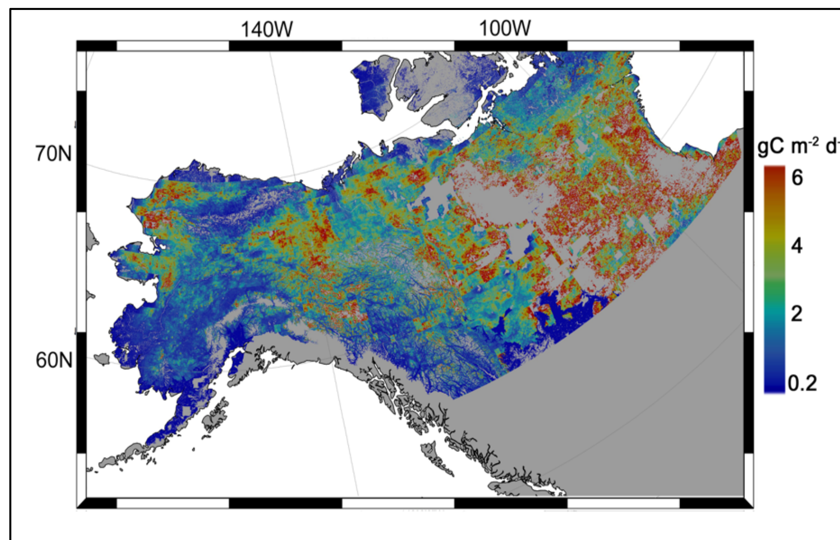
Natali

Science Updates from Natali-01

- New **Forced Diffusion** (FD) sensor network installed. *12 Stations within ABoVE domain.*
- **Environmental data** collected at FD sites: *soil temp. & moisture, snow cover, permafrost active & organic layer depth, soil chemistry.*
- Assembling **eddy covariance (EC) CO_2** records from *23 tower sites* (yrs. 2016 to 2017).
- FD, EC tower data & **pan-Arctic winter flux synthesis** (Natali-01 & Rogers-02) show *cold season soil CO_2 losses < 1 to > 4 gC m^{-2} d^{-1}.*
- **100-m mapping of seasonal CO_2** for domain; *remote sensing inputs + statistical modeling.*



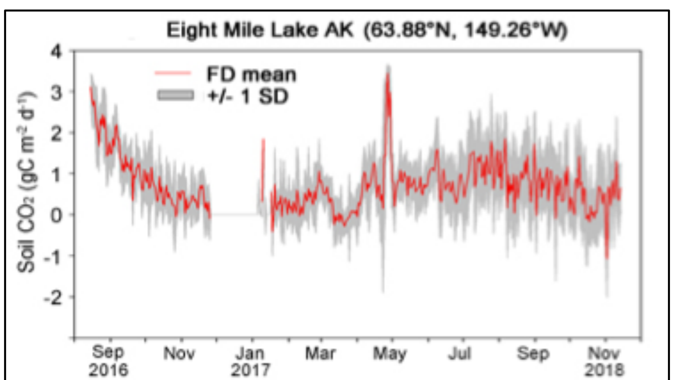
Estimated Soil CO_2 Flux for September 2016 (CO_2 ~ *f*(Permafrost Index, LST, FW, SM))



Example CO_2 Flux from FD Sensor

Total: 249 gC m^{-2} (Aug. 16 to Aug. 17)

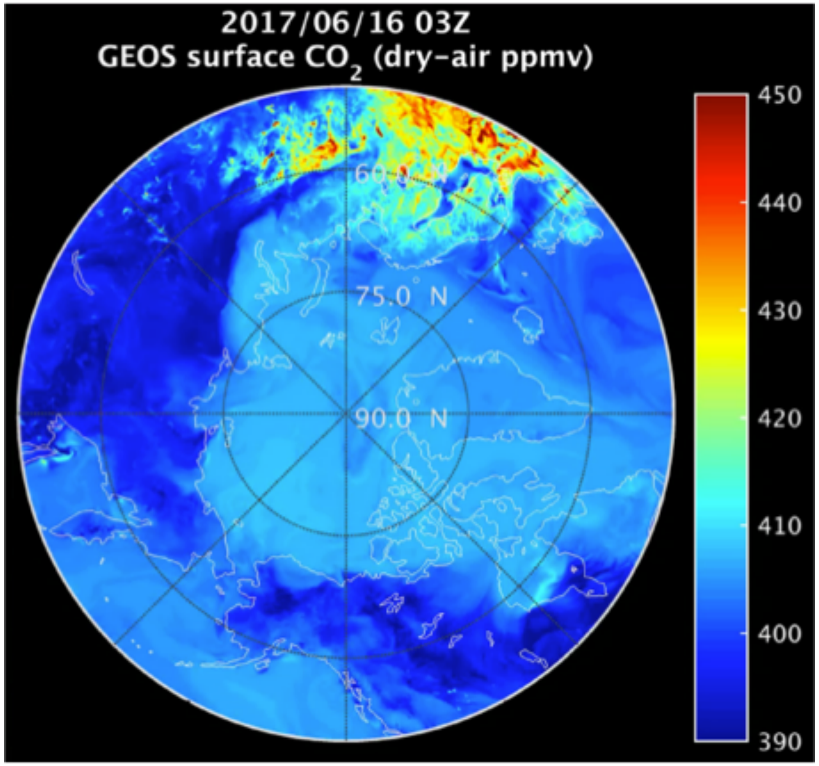
Watts Poster #50



Science Updates from Chatterjee-01

- Coupled land-ocean-atmosphere system running at ~0.5º (and 12.5 km) that outputs multiple species of carbon (CO_2, CH_4, CO)
- How reasonable were the baseline terrestrial fluxes and the atmospheric carbon conc. simulated during the 2017 AAC?
- Planned evaluation against -
  - flux tower observations of CO_2 and CH_4 fluxes
  - aircraft observations of atmospheric CO_2 and CH_4

  waiting on data from individual PIs



Sample GEOS-5 run for Summer 2017 (AAC)

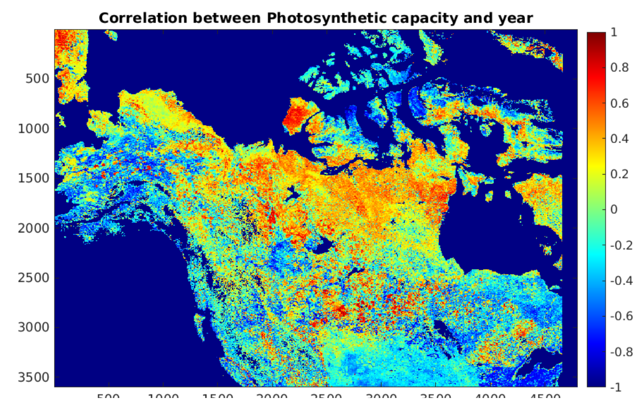
Carbon Dynamics Working Group

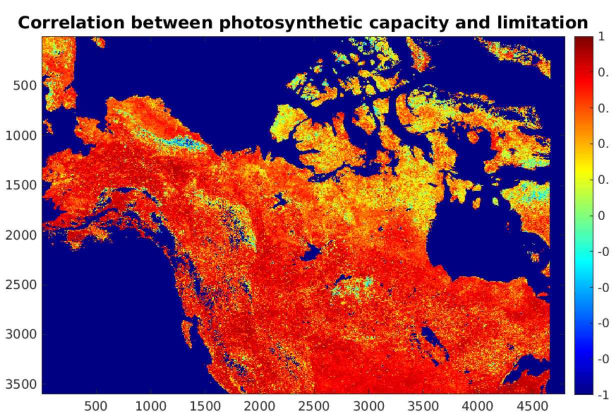
Gamon

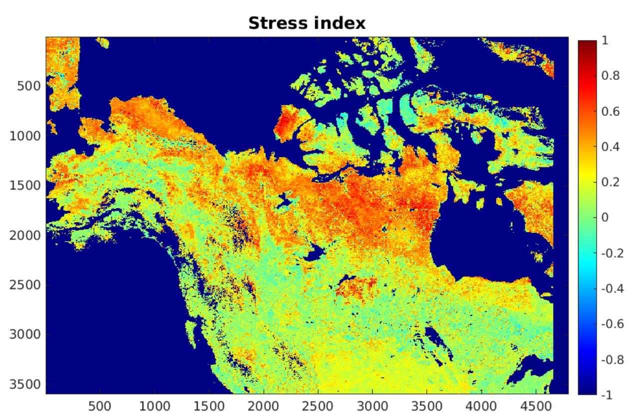
Analysis Updates from Gamon-01

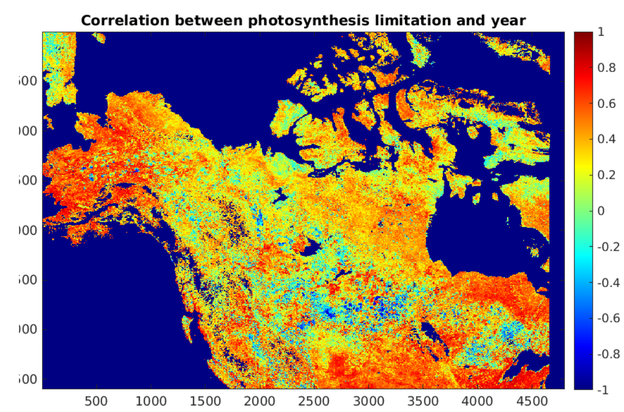
Remote-sensing derived estimation of arctic and boreal ecosystems productivity : bridging remote-sensing and ecophysiology

1. Gabriel Hmimina and Rong Yu (**Hmimina Poster #79**)
2. The light-curve model can be used to estimate the changes in photosynthetic capacity and limitation separately for each pixel
3. The balance between those two components may inform us on how well-adapted to their climate ecosystems are.









Carbon Dynamics Working Group

Potter

Science Updates from Potter-01

Biospheric Science

Ames Research Center

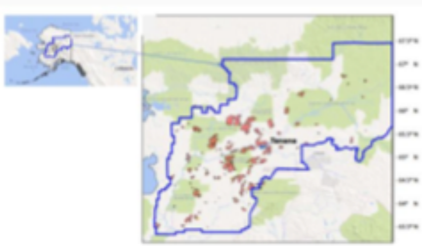
Recovery Rates of Vegetation Green Cover in Severely Burned Ecosystems of Interior Alaska Derived from NASA Satellite Image Analysis

Author and Contact: Christopher Potter, NASA Ames Research Center, chris.potter@nasa.gov

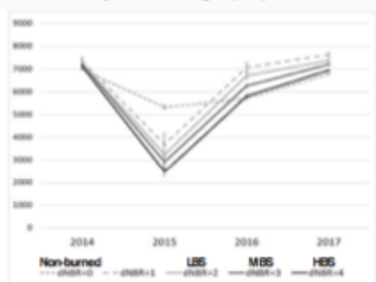
- Background: In the summer of 2015, hundreds of forest fires burned across the state of Alaska, resulting in the second highest acreage burned for the state in a single year. As of mid-September 2015, 2.1 million hectares (5.1 million acres) had burned statewide in over 700 different wildfires. Recovery of vegetation green cover over the following two growing seasons from the Normalized Difference Vegetation Index (NDVI) was compared among Landsat burn severity classes (low - LBS, moderate - MBS, or high - HBS) in pre- and post-fire images for the Yukon-Kuyukuk region. Trends in NDVI were examined in wetland vegetation cover burned at HBS during wildfires that occurred in 2004 and 2009 to extend the recovery time-series analysis to more that a decade.

- Early Results: Compilation of burn severity class areas for 113 large wildfires mapped in 2015 from the Landsat MTBS (Figure 1) totaled to 1.64 million hectares burned across the Yukon-Koyukuk region of Alaska that summer, with averages of 30% and 27% at MBS and HBS fraction per fire, respectively. Total regional 2015 burned areas in the region were estimated at 0.47 million ha MBS and 0.52 million ha HBS. Based on MODIS 250-m July NDVI from 2014 to 2017 averaged within burned area boundaries, HBS green vegetation cover initially decreased by 65% from 2014 to 2015 and then recovered to nearly pre-fire NDVI levels by 2017 (Figure 2). Average LBS green vegetation cover initially decreased by 50% from 2014 to 2015 and then recovered to 5% above pre-fire NDVI levels by 2017. The largest contiguous boreal wetland areas burned in the 2004 Boundary Fire recovered to near pre-fire NDVI levels by 2014 (Figure 3), whereas the largest contiguous boreal wetland areas burned in the 2009 Minto Flats Fire have yet to recover to pre-fire NDVI levels by 2017. The change in seasonal NDVI profiles before and after the Minto Flats Fire is indicative of a shift from evergreen (conifer tree) to deciduous (birch, alder, willow) shrub/tree cover.

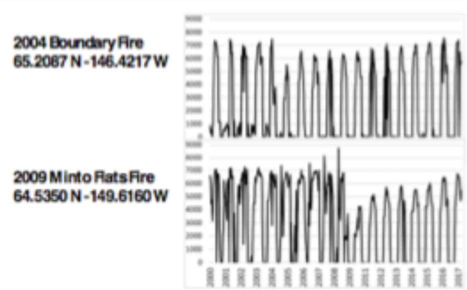
1. Wildfires of 2015 in the Yukon-Kuyukuk region



2. MODIS 250-m July NDVI averages (2SE) in 2015 burn classes



3. MODIS 250-m NDVI time series for HBS of largest wetland areas burned in Yukon-Kuyukuk wildfires of 2004 and 2009



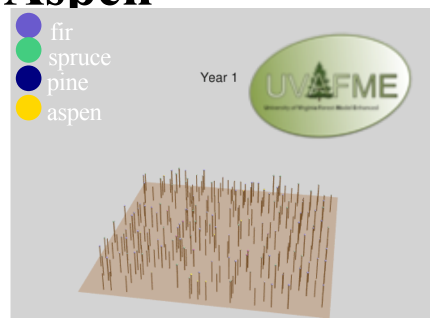
Carbon Dynamics Working Group

Armstrong

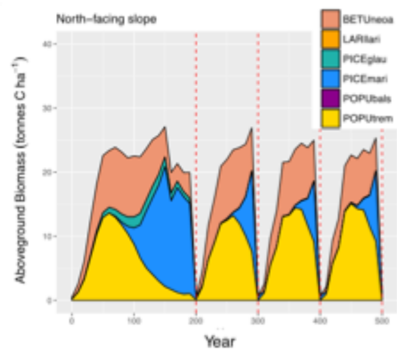
Foster

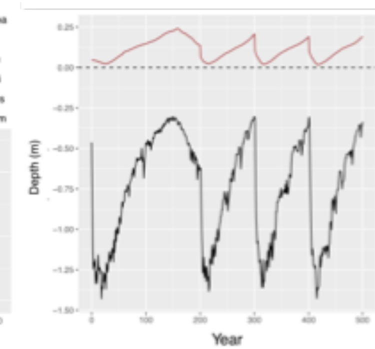
Science Updates from Goetz -01

Individual-based modeling in interior AK/ lower Boreal Aspen



UVAFME updated to include calculation of **permafrost depth,** better **litter** and **nutrient formulations, and fuels tracking** and **litter/humus consumption**

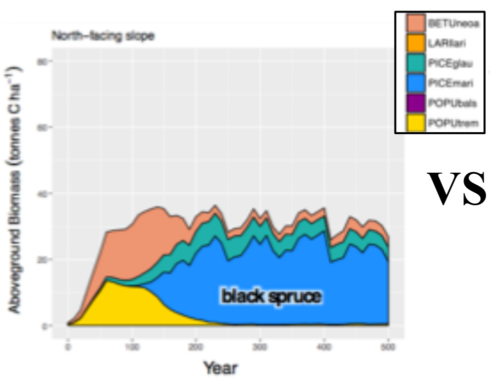




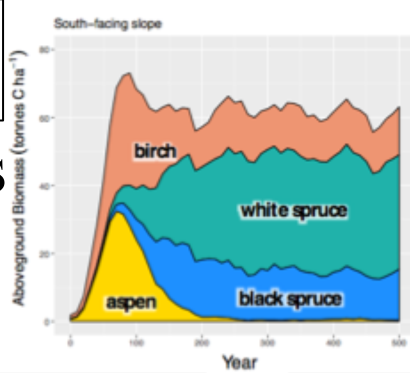
University of Virginia Forest Model Enhanced (UVAFME)

individual tree- based model that simulates tree growth and response to external factors & tree-tree competition

Can now accurately differentiate between low biomass, black spruce sites, and high biomass, mixed deciduous/white spruce sites



VS



Updates increase fire-soils-vegetation interactions. Recurring fires act to open canopy, decrease organic layer depth, and increase active layer depth. As forest and soils regrow, active layer depth

Aspen Results: Aboveground biomass declines after climate change is introduced. Fire frequency increases, stems fluctuate following fire patterns. Northern sites affected more than southern sites.