PI: John Kimball

Landscape Controls on the Arctic-Boreal Carbon Budget

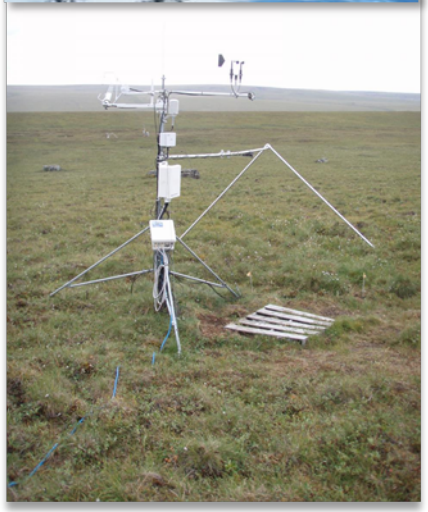
Project code: Kimball-04

Co-investigators: Walt Oechel (SDSU);

Charles (Chip) Miller (JPL)

Institutional Collaborations

- **Chris Derksen**: Environment Canada (CHARS, SMAP ST)
- **Philip Marsh**: Wilfrid Laurier U. (CHARS, Taiga Plains Research Network [TPRN])
- **Oliver Sonnentag**: U. Montreal (TPRN)
- **Peter Kirchner**: NPS (Southwest AK Network [SWAN])
- **Others**: Eugenie Euskirchen (UAF; AON, SMAP Cal/Val), John Kochendorfer (NOAA ATDD), Mahta Moghaddam(USC; SMAP, AirMOSS)



Motivation for Research

- Interactive effects of landscape warming, wetting/drying, PF thaw & fire greatly impact the Arctic-boreal Net Ecosystem Carbon Budget (NECB)
- Magnitude & trajectory of the NECB, incl. CO_2 exchange & wetland CH_4 emissions not well understood but are important ecosystem feedbacks to global climate
- Integrated field studies, modeling & remote sensing from ABoVE provide opportunities to improve understanding & model projections of ecosystem vulnerability

Tier 2 Science Questions & Objectives

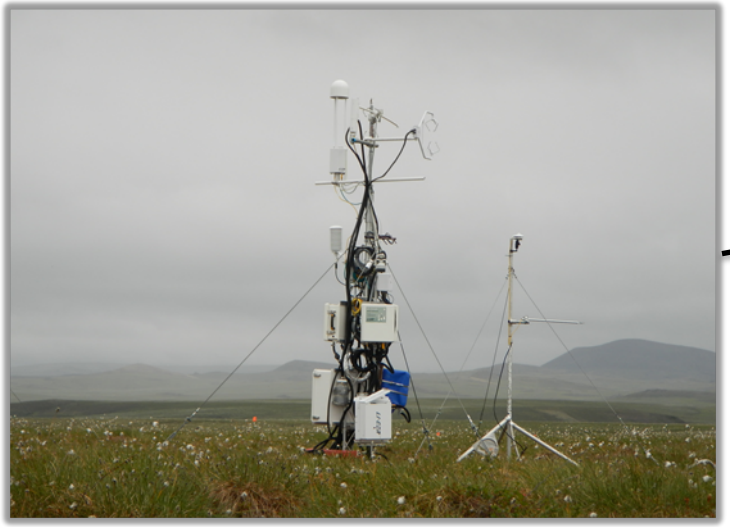
Research question(s):

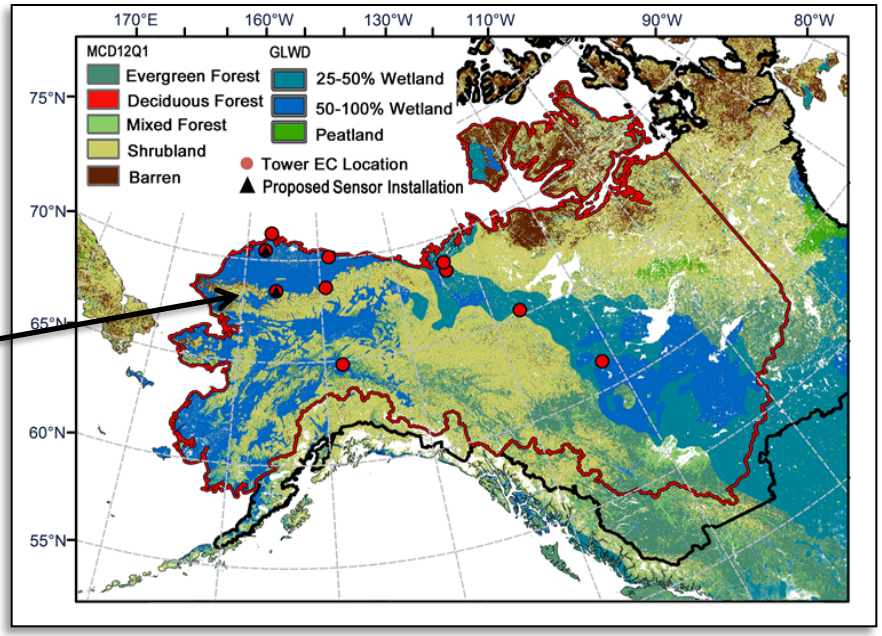
How are vegetation communities & land-atmosphere carbon exchange responding to landscape warming, changing hydrology, and disturbance? (ACEP 3.5-6; 3.2-4)

Objectives:

- Integrate *in situ* & remote sensing observations within a TCF model framework to estimate the NECB (CO_2, CH_4) & underlying drivers over a daily, 14+ yr (2003-16) record for the ABoVE domain with 1-km res.
- Quantify impacts of uncertainty in model assumptions & drivers on NECB accuracy
- Elucidate how climate trends & disturbance interact & alter the NECB

Field Studies



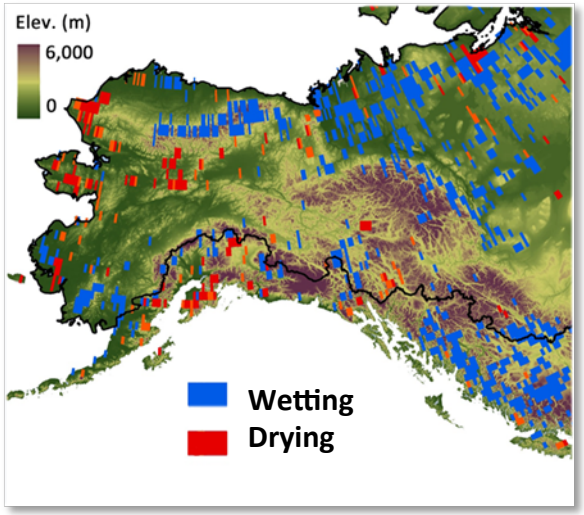


- ***In situ* data from tower EC sites (15)**
  - CO_2 & CH_4 fluxes; meteorology; soil & vegetation
  - Cal/Val for models & remote sensing
- **Soil T & moisture networks**
  - Regional measurements (e.g. NGEE, SWAN, CHARS)
  - Sensor installations at additional sites (2017)

Satellite Sensors & Data Records

- *SMAP*: FT, SM, L4 C–fluxes; 1/3/9/36 km res.(2015-16)
- *AMSR*: Ta, FT, Fw, VOD, SM; ≤ 25 km res. (2003-16)
- *MODIS*: VIs, FPAR, LST, LC, burn; ≤ 1 km res. (2003-16)
- *Landsat*: LC & water maps; 30 m res. (2003-16)
- *GeoEye*: < 2 m res, spatial scaling (2015-16)
- ALOS(2), Sentinal-1: ≤100m, SMAP synergy

AMSR Surface Fw Trends (2003-13)



Reanalysis Assets

- *GEOS-5*: ≥ 9 km res.; SMAP NRv04 & MERRA-2 (2003-16)
- *NCEP NARR*: 32 km res. (2013-16)
- *Polar WRF*: 3 km res. (2013-15)
- *WRF ERA-Interim*: 5-10 km res. (2003-14; UAF/IARC)

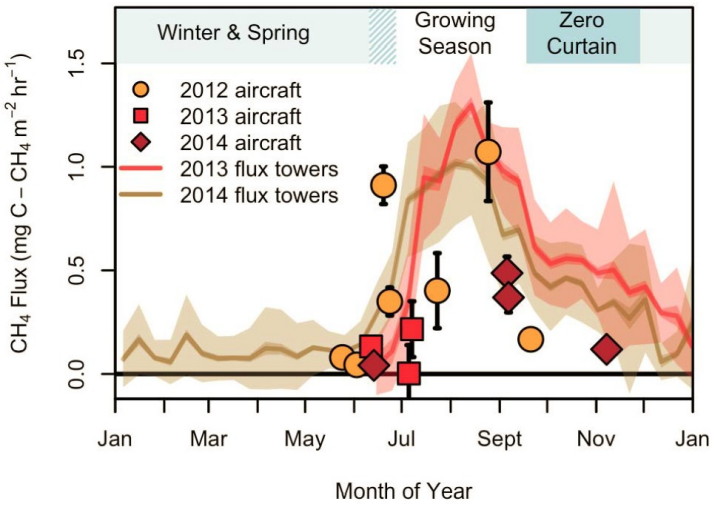
Airborne Remote Sensing

- **Existing airborne assets**
  - *CARVE*: Total column CO_2,CH_4, O_3 profiles
  - *HIPPO & AIRMETH*: CO_2 & CH_4 conc./fluxes
  - *AirMOSS*: P-Band radar

    PF, soil active layer, SM & SOM profiles
- **Potential for new data**
  - *AirMOSS & UAVSAR*: AK towers & transects
  - *CARVE acquisitions along tower transects*
  - *NASA SnowEx*: Optical & microwave;

    sub-regions and tower sites

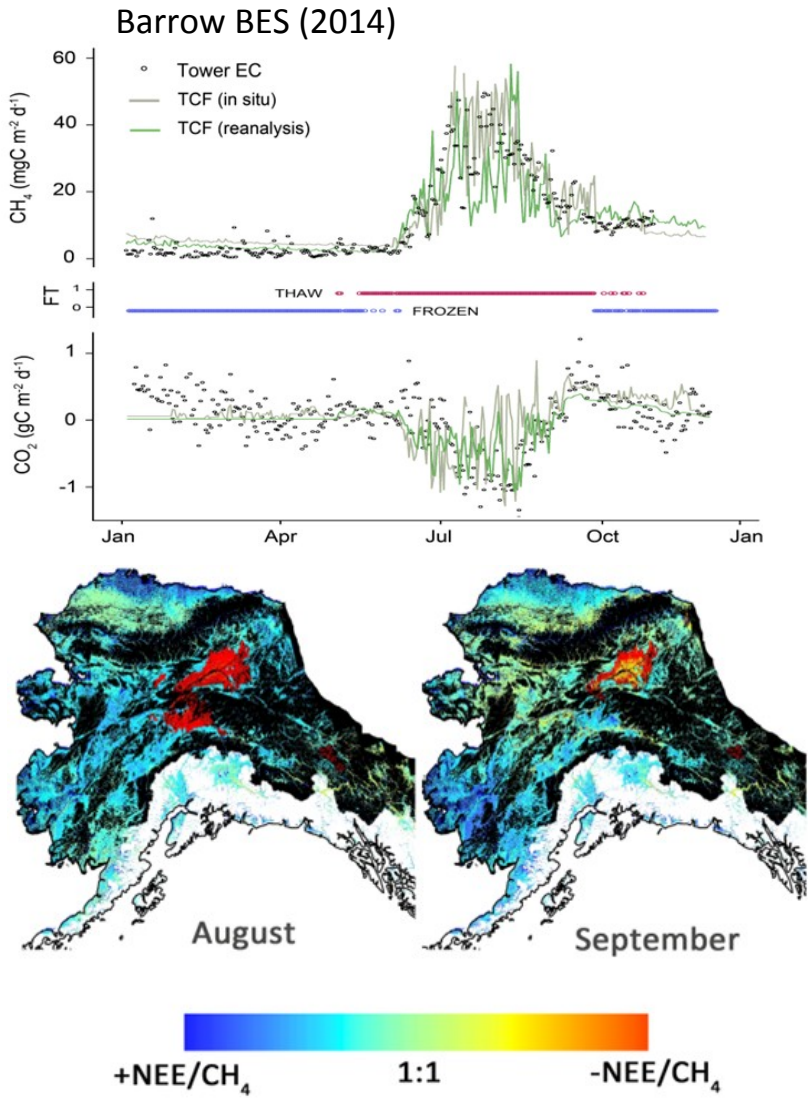
Tower/CARVE seasonality at Ivotuk AK



Zona et al. 2015

Modeling Approaches

- **Models:** Arctic-boreal Terrestrial Carbon Flux (TCF) model; TCF Pan-Arctic Water Balance Model (TCF-PWBM); SMAP L4_C algorithm
- **Driver data:** ***In situ*/*Reanalysis*** (VPD, SW_{rad}, T_{min}, T_{soil}, SM_{RZ}, Precip., Wind); ***Remote sensing*** (SM, T_{soil} , FT, Fw, VIs, FPAR, LC & burn area, PF active layer)
- **Cal/Val data:** CO_2 & CH_4 fluxes (chamber, tower EC, airborne), tower meteorology, SM, T_{soil}, PF active layer
- **Output formats:** 1 km Binary, GeoTiff, HDF5; EASE v2 grids; documented QC flags & product uncertainty



Geospatial Data Products

- **Primary products**: 1 km maps of daily CO_2 fluxes (GPP, NPP, R_{eco}, NEE), wetland CH_4 emissions, NECB; annual surface SOC stocks
- **Geographic coverage**: Tower sites; ABoVE domain
- **Temporal range**: 2003 to $\geq$ 2016
- **Grids/projections**: 1 km EASE v2 (polar or global); other formats as requested
- **Stakeholders**: US Federal (NPS, USFS, BLM, USACE) and State (AK DNR) agencies; CN CHARS & TPRN

Other expected products/outcomes

- Tower EC CO_2 & CH_4 fluxes; *in situ* T_{soil} & SM records
- Ecosystem metrics/indicators (2003 through 2016)

Product	Description	Resolution		Spatial
		Spatial	Temporal	Coverage
AMSR Land Surface Parameters				
Ta	Air temperature at 2 m height (18 & 23 GHz)	25 km	daily	ABoVE SD
VOD	Vegetation optical depth (18 GHz)	25 km	daily	ABoVE SD
SM	Surface soil moisture at ≤ 2 cm depth (6.9 & 10.7 GHz)	25 km	daily	ABoVE SD
FT	Surface freeze-thaw state (36.5 GHz)	12 & 25 km	daily	ABoVE SD
Fw	Fractional surface water inundation (18, 23, 89 GHz)	6 & 25 km	daily	ABoVE SD
Fw	Downscaled surface water inundation (89 GHz)	1 km	10 day	Sub-Regions
TCF Model Terrestrial Carbon Metrics				
GPP	Vegetation gross primary productivity (g C m^{-2} d^{-1})	1 km	daily	ABoVE SD
NPP	Vegetation net primary productivity (g C m^{-2} d^{-1})	1 km	daily	ABoVE SD
Reco	Ecosystem heterotrophic respiration (g C m^{-2} d^{-1})	1 km	daily	ABoVE SD
NEE	Net ecosystem CO_2 exchange (g C m^{-2} d^{-1})	1 km	daily	ABoVE SD
W-CH_4	Wetland CH_4 flux (mg C m^{-2} d^{-1})	1 km	daily	ABoVE SD
NECB	Net ecosystem carbon budget (g C m^{-2} d^{-1})	1 km	daily	ABoVE SD
SOC	Surface organic carbon stocks (kg C m^{-2})	1 km	annual	ABoVE SD
Ecosystem Environmental Metrics				
ENV Scalars	Ta, FT, SM, VPD constraints for GPP	1 km	daily	ABoVE SD
GSL	Annual growing season length (AMSR; MODIS)	1-12 km	annual	ABoVE SD
Key Ind. (FT)	Annual duration & Δ surface freeze/thaw (AMSR; SMAP)	12 km	annual	ABoVE SD
Key Ind. (Fw)	Annual duration & Δ annual surface water inundation (AMSR)	12-25 km	annual	ABoVE SD
Key Ind. (NECB)	Annual duration & Δ terrestrial carbon budgets (TCF)	6-25 km	annual	ABoVE SD