ACME-V mission in the North Slope of Alaska (Airborne Carbon MEasurements)

LBNL: Sébastien Biraud & Margaret Torn
BNL: Art Sedlacek & Stephen Springston
AAF: mentors and support Team
and many others

Crew members (from left to right). Clayton Eveland, John Hubbe, Allen Cordle, Sebastien Biraud, and Albert Mendoza

Why do we care about the Arctic (land)?

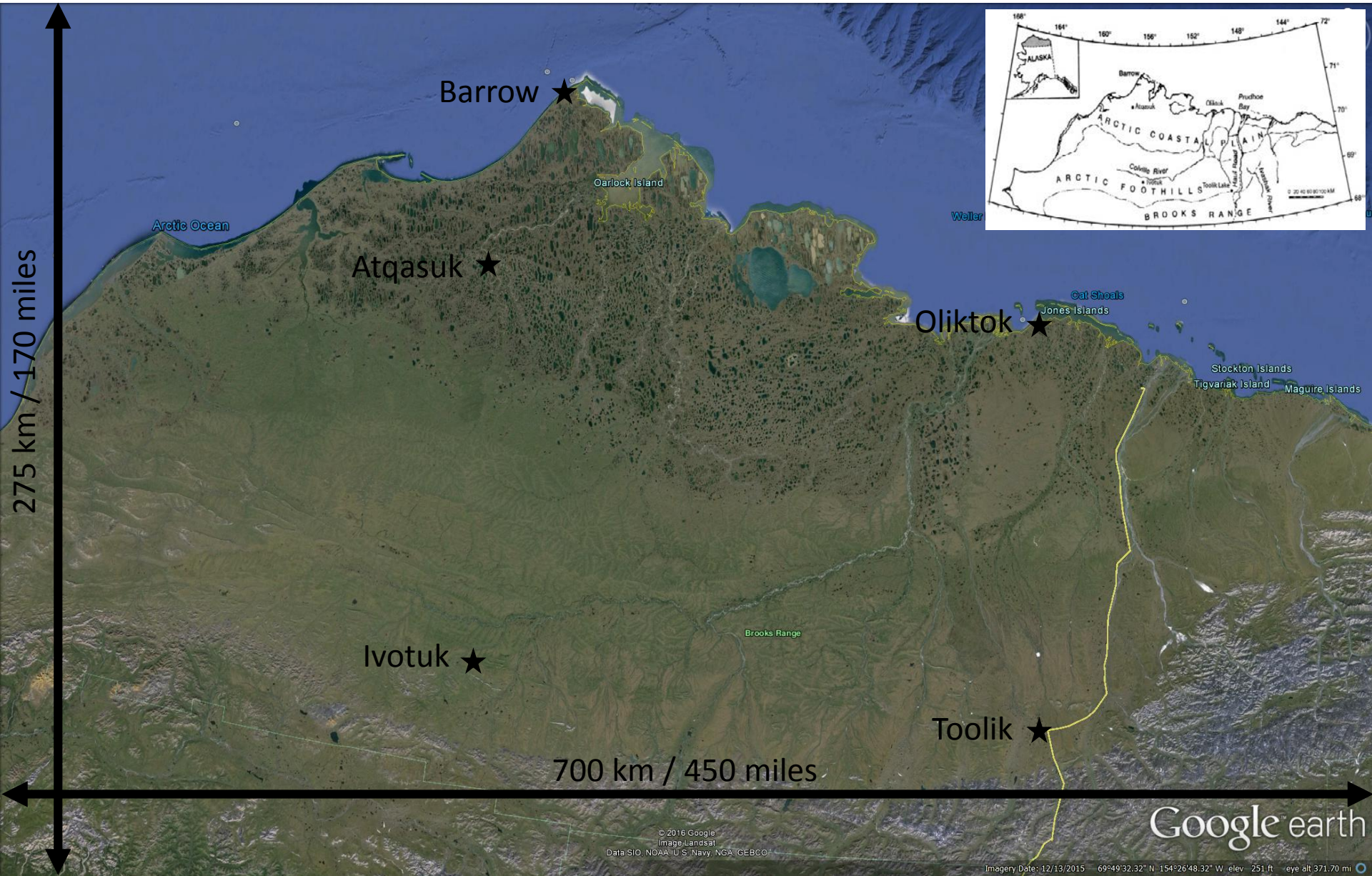
Atmosphere Today ~800 PgC (~400 ppm)

Arctic soils contain = 1300+/-200 PgC
(Tarnocai et al, GBC, 2009)

Sufficient frozen C in the Arctic to increase atmospheric CO_2 by 2-to-3

Large spatial heterogeneity in:
- Inundation
- Surface albedo

Why an airborne campaign?



Our Science Questions

#1: What controls spatial and temporal variability in atmospheric CO_2 and CH_4?

#2: Can we use multi-species observations to distinguish between biogenic, thermogenic, and anthropogenic sources of CO_2 and CH_4?

#3: What are the implications for radiative forcing?

#4: What can we learn about spatial variability of surface characteristics between Oliktok and Barrow?

#5: Can we estimate CH_4 emissions at regional scale?

Our Implementation – ACME-V campaign

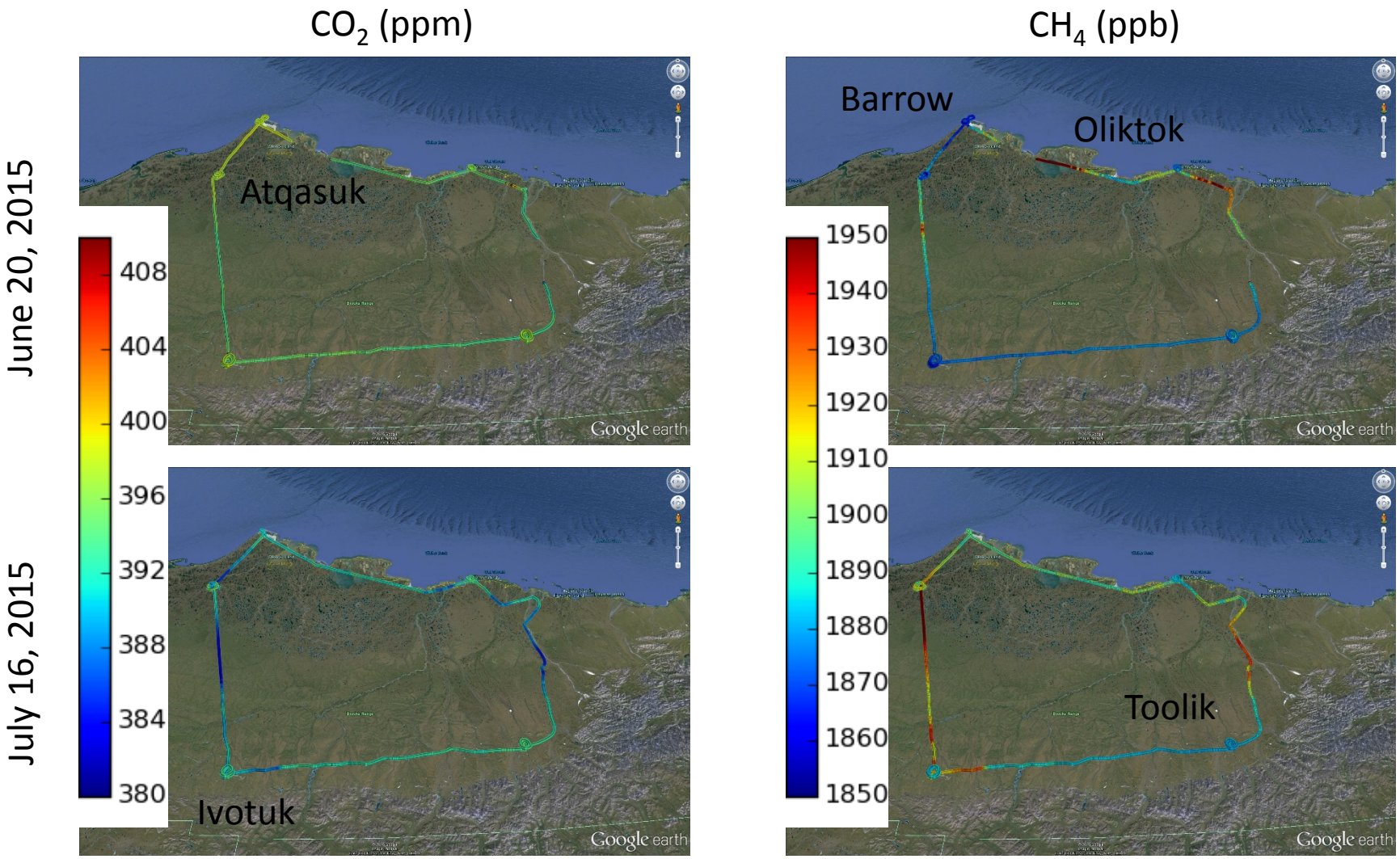
- **Use of ARM & AAF assets**
  - Trace gas observations
  - Clouds and aerosols property observations
  - Solar and infrared radiation measurements

- **Focused on NSA**
  - Flight path crisscrossing region
  - Anchored by established ground-sites

- **Frequent flights**
  - 2015: June 1 (DOY=158) – September 15 (DOY=258)
  - 38 flights
  - 140 science flight hours

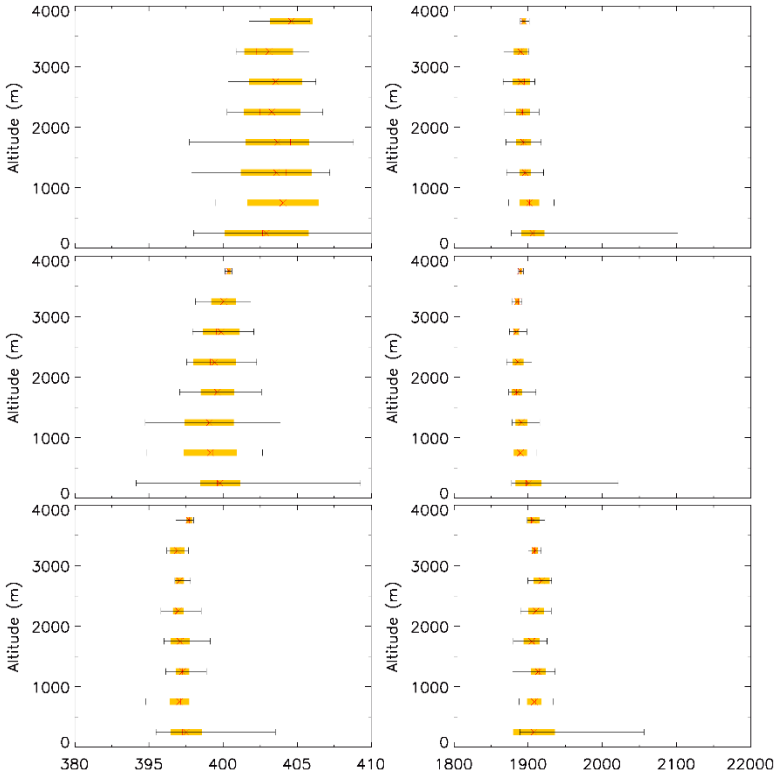
- **Low elevation flights**
  - < 500m agl
  - With vertical profiling over fixed-sites

#1: Spatial/Temporal Variability in CO_2 and CH_4



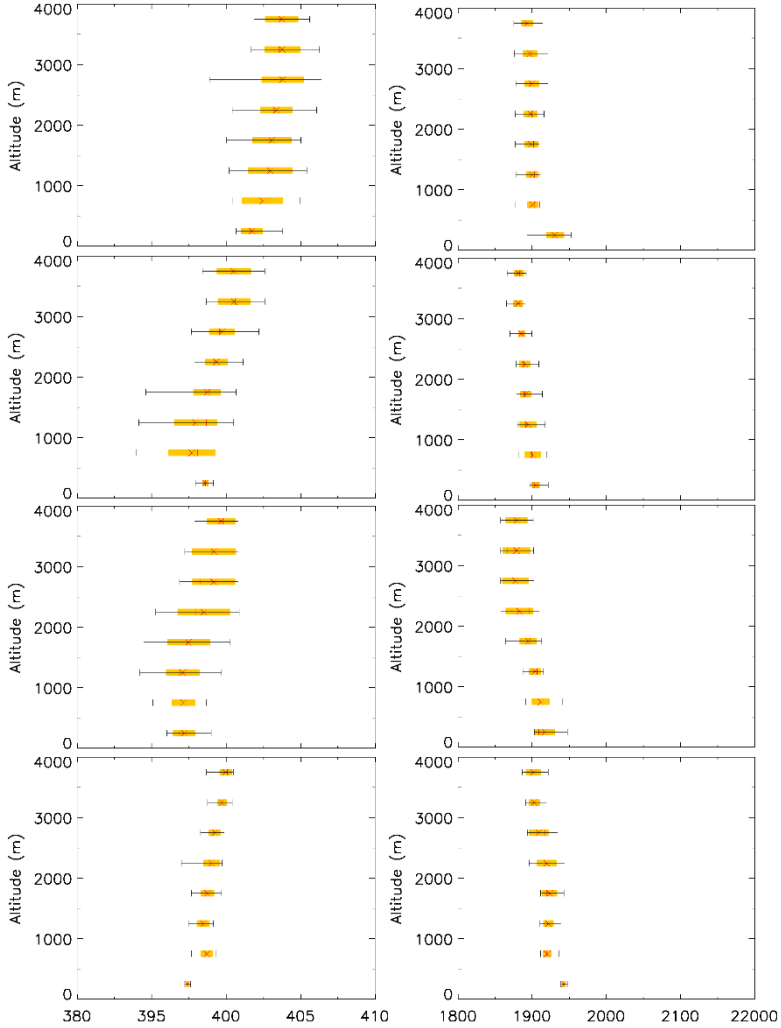
#1: Vertical Profiles over fixed Sites

Oliktok



NO FLIGHT POSSIBLE

Toolik



Jun

Jul

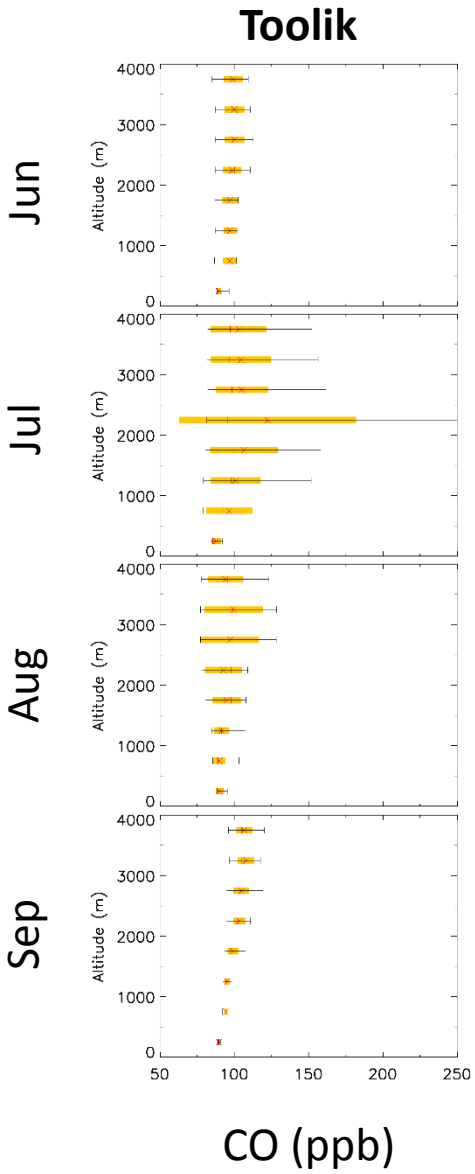
Aug

Sep

CO_2 (ppm) CH_4 (ppb)

CO_2 (ppm) CH_4 (ppb)

#2: Biomass Burning influence

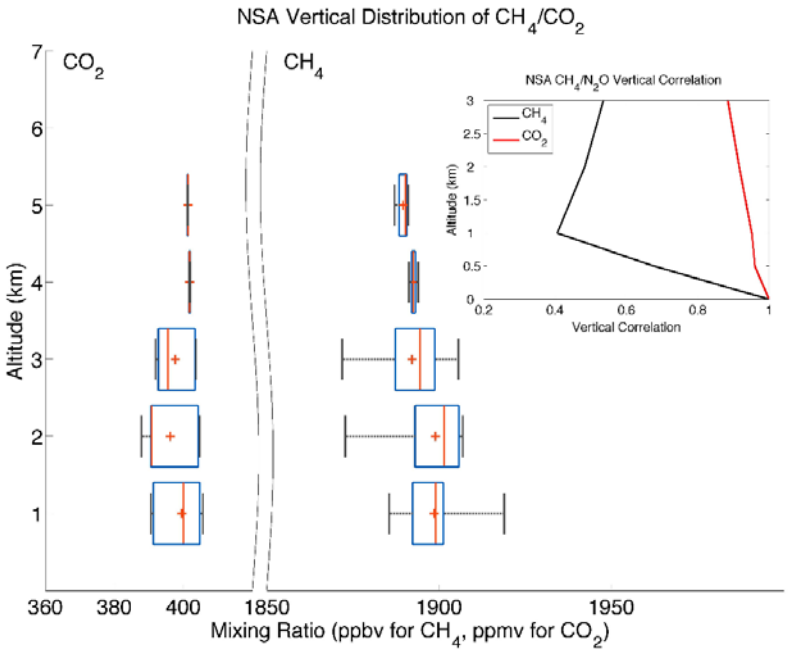


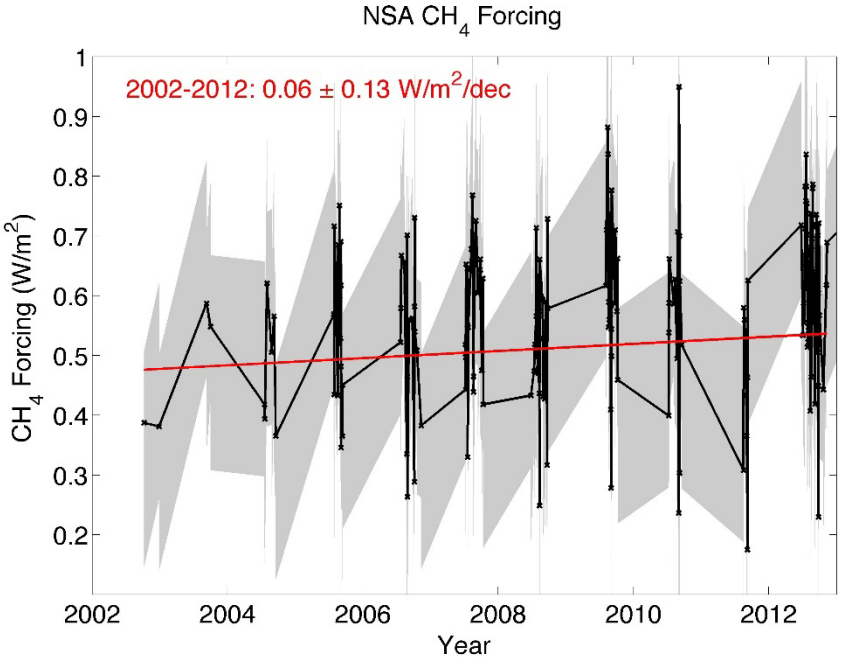
- Elevated CO mixing ratio (and refractory Black Carbon)
- Aerosols stratification

=> Document aerosols properties over the Arctic

See Sedlacek et al. poster

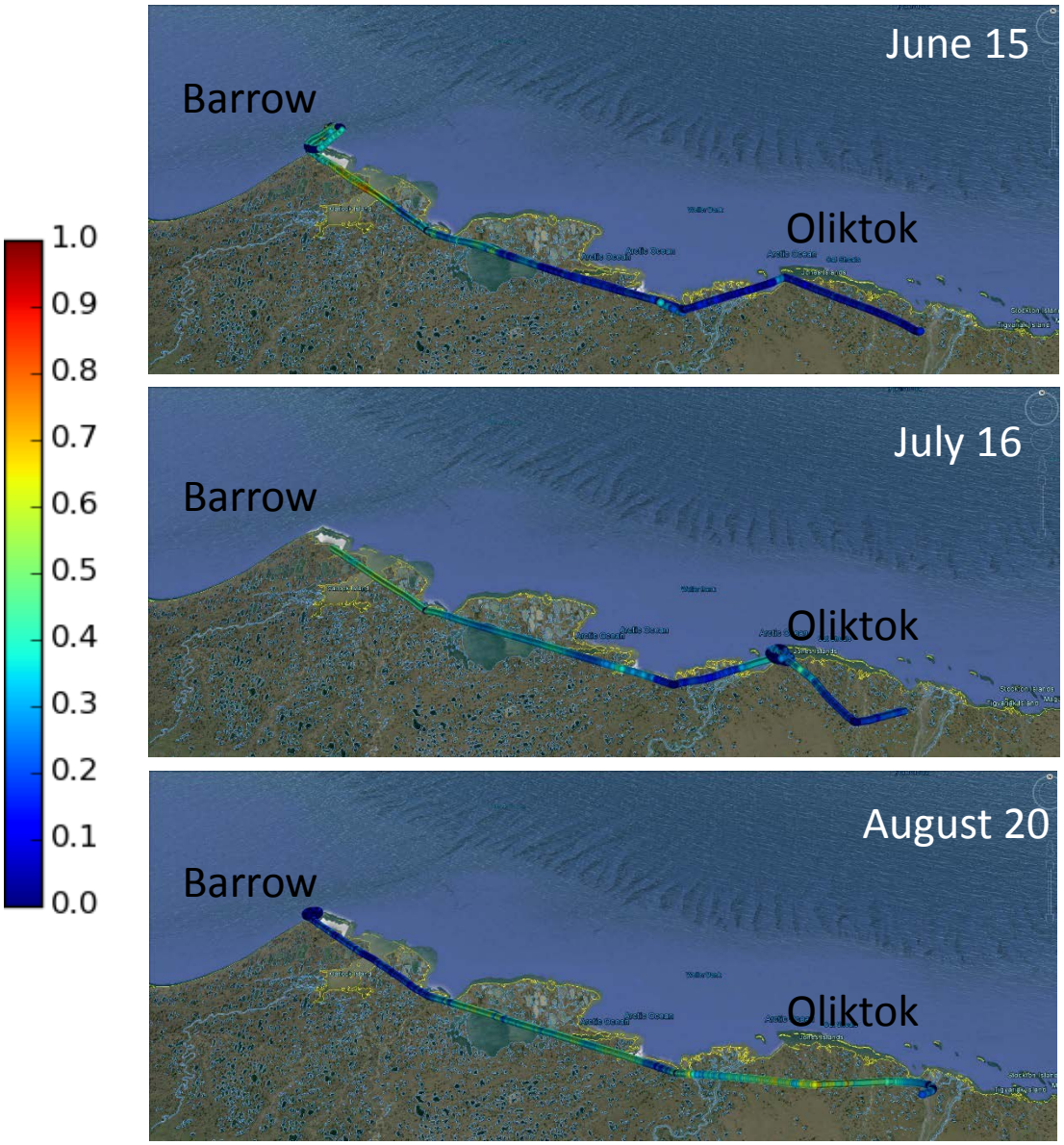
#3: Implication for Infrared Radiative Forcing





See Feldman et al. poster

#4: Spatial Variability of Surface Albedo



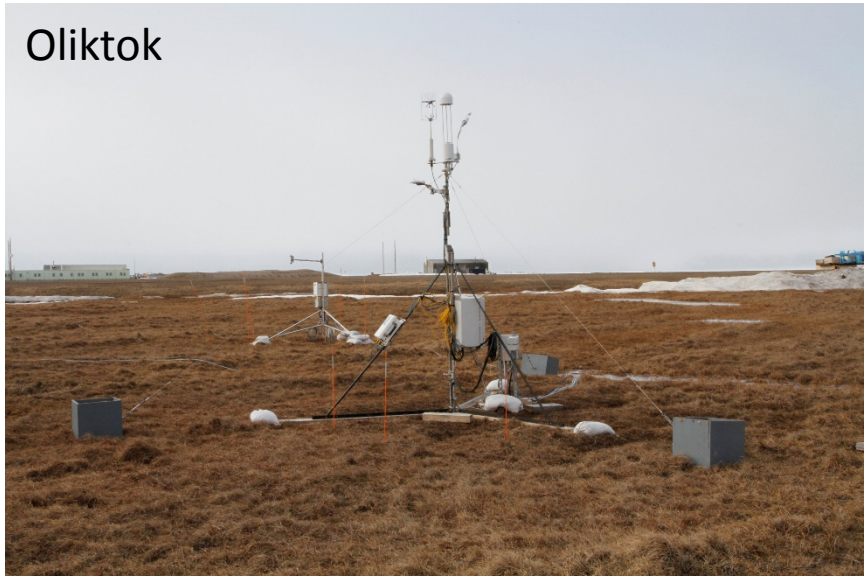
Preliminary data!

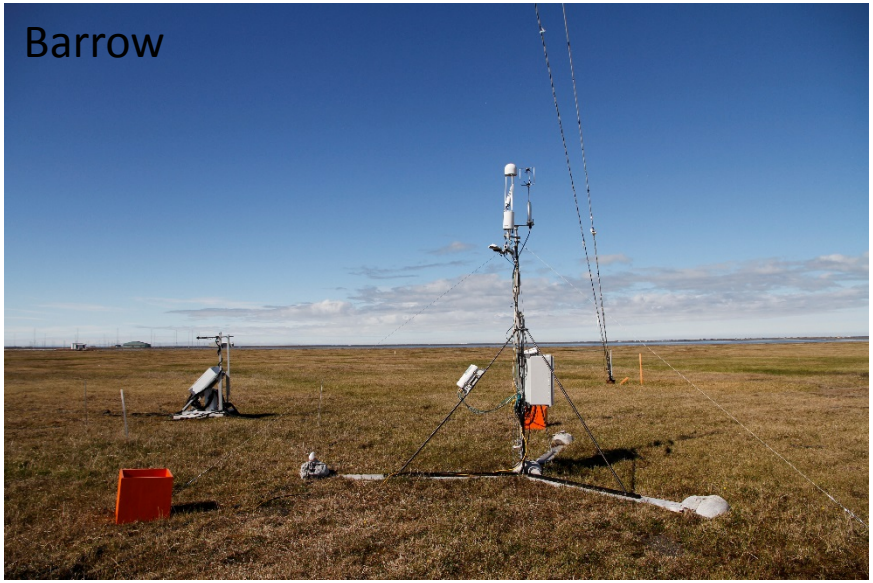
- Solar radiation measured by Delta-T SPN1
- Upwelling radiation corrected for aircraft tilt (Long et al., 2010)
- Albedo = Nadir / Zenith

=> Large spatial and temporal variability

#5: Estimate of CH_4 source at Ecosystem scale

Eddy Covariance Technique (ARM ECOR datastream and CH_4 VAP)





#5: Estimate of CH_4 source at Regional scale

CH_4 FLUX optimization framework

Observations
CH_4 enhancement over background (ARM-ACME-V)
with no anthropogenic influence (CO < 150 ppb)

vs.

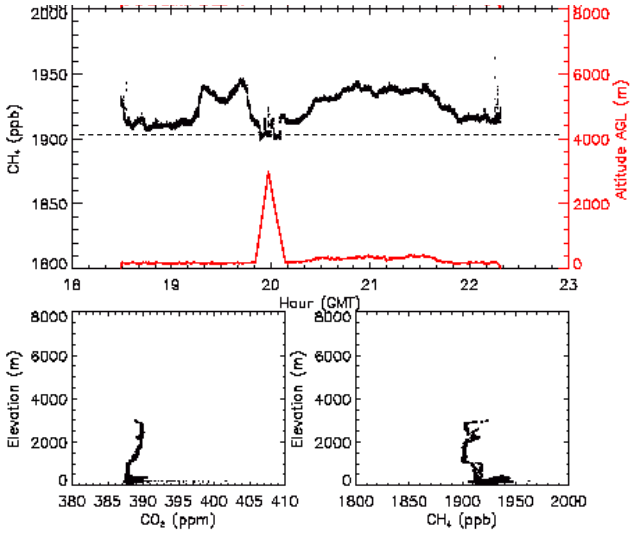
Model
Calculated CH_4 enhancement using CH_4 flux model
(Henderson et al., ACP, 2014)
×
surface influence
(WRF-STILT 3.5.1; Lin et al., JGR, 2003)

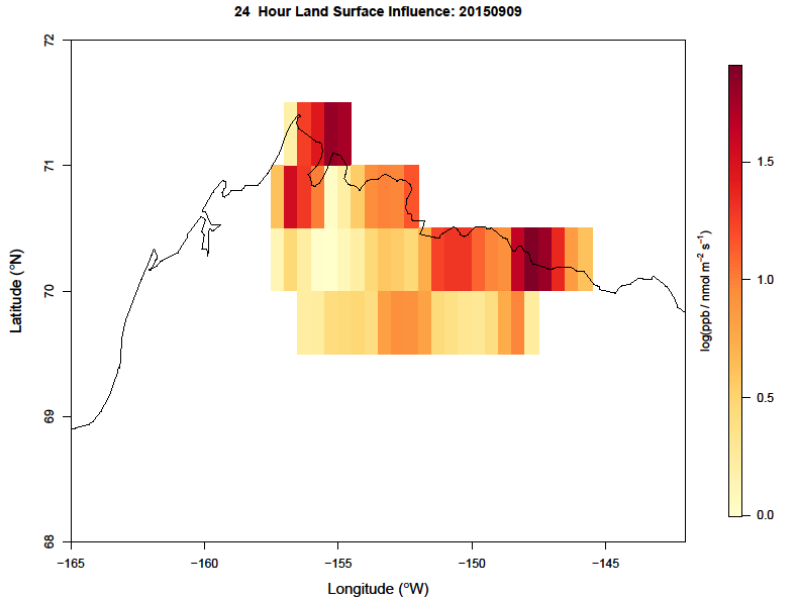
HARVARD UNIVERSITY

(Commane et al., in prep)

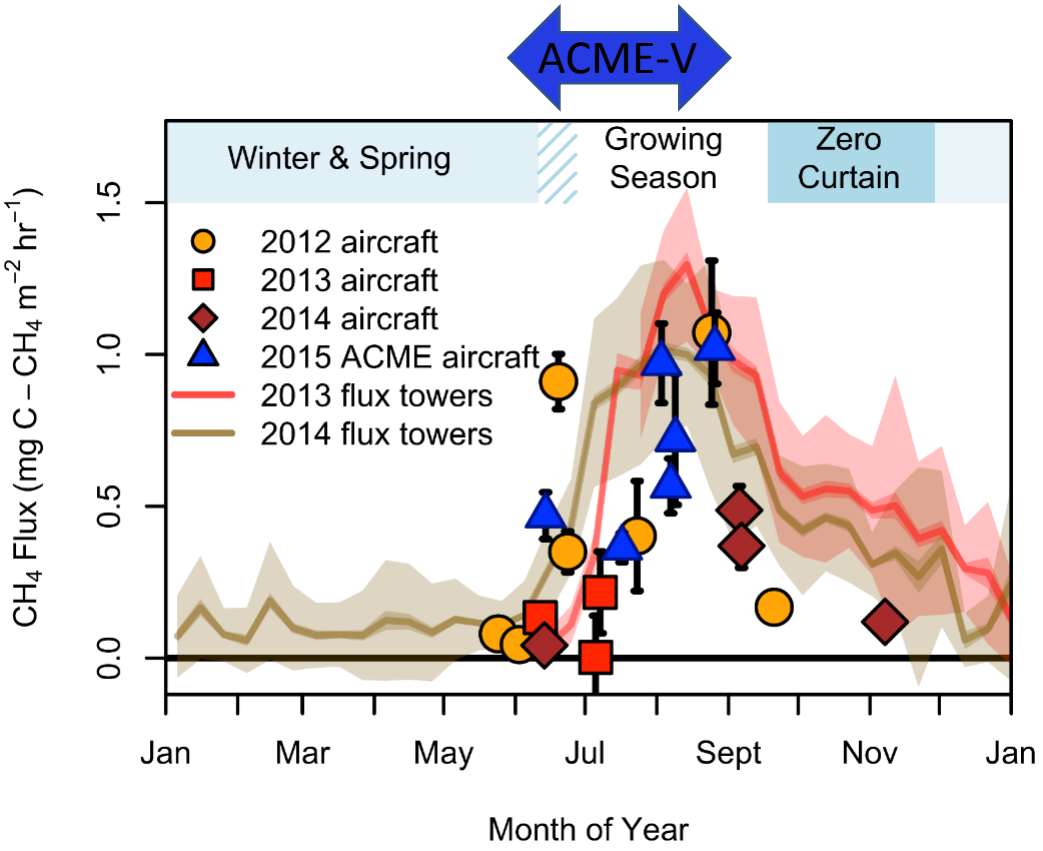
#5: Estimate of CH_4 source at Regional scale

September 9, 2015 flight (Tundra)





#5: Estimate of CH_4 source at Regional scale



(Adapted from Zona et al., PNAS, 2016) (Biraud et al., in prep)

Source from:
NASA CARVE data: Miller (JPL)
Eddy flux: *Zona, Oechel (SDSU);*
aircraft+WRF+STILT: *Commane, Lindaas, Chang (HU), Sweeney, Karion (NOAA)*

Lessons Learned and Future Work

#1: Drivers of spatial heterogeneity are different for CO_2 versus CH_4

#2: Mutli-tracers approach can be used for sources attribution (wildfire, fossil, and ecosystem)

#3: Vertical profiles are necessary to estimate CO_2 and CH_4 radiative forcing,

#4: It is critical to have better spatial coverage of surface properties, along the Oliktok/Barrow transect

#5: North Slope CH_4 fluxes peak in Mid-July through early September, and do not appear to be significantly increasing over time.

- Next Steps:
  - Apply framework to estimate regional fluxes of CO_2,
  - We hope for the opportunity to expand flights over shoulder season, as studies points out significant contribution to annual fluxes,
  - Use UAs at Oliktok to increase spatial coverage around fixed-site

How to Be involved?

ARM-ACME-V observations
Available from ARM archive:

http://www.arm.gov/campaigns/aaf2014armacmev

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