Next Generation Ecosystem Experiment in the Arctic (NGEE-Arctic)

Shawn Serbin[1]

Ran Meng[1], Andrew McMahon[1], Kim Ely[1], Alistair Rogers[1], Bryan Curtis[2], Ori Chafe[2], Haruko Wainwright[2], Sebastian Biraud[2], Sigrid Dengel[2], Margaret Torn[2], Baptiste Dafflon[2], Christian Anderson[3], Cathy Wilson[3], Jitu Kumar[4], Stan Wullschleger[4], and the NGEE-Arctic team

U.S. Department of Energy

1 Brookhaven National Laboratory

2 Berkeley Lab

3 Los Alamos National Laboratory

4 Oak Ridge National Laboratory

University of Alaska Fairbanks

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U.S. DEPARTMENT OF ENERGY

1 BROOKHAVEN NATIONAL LABORATORY

2 BERKELEY LAB

3 Los Alamos NATIONAL LABORATORY

4 OAK RIDGE National Laboratory

UAF UNIVERSITY OF ALASKA FAIRBANKS

NGEE-Arctic

U.S. DEPARTMENT OF ENERGY

Office of Biological and Environmental Research

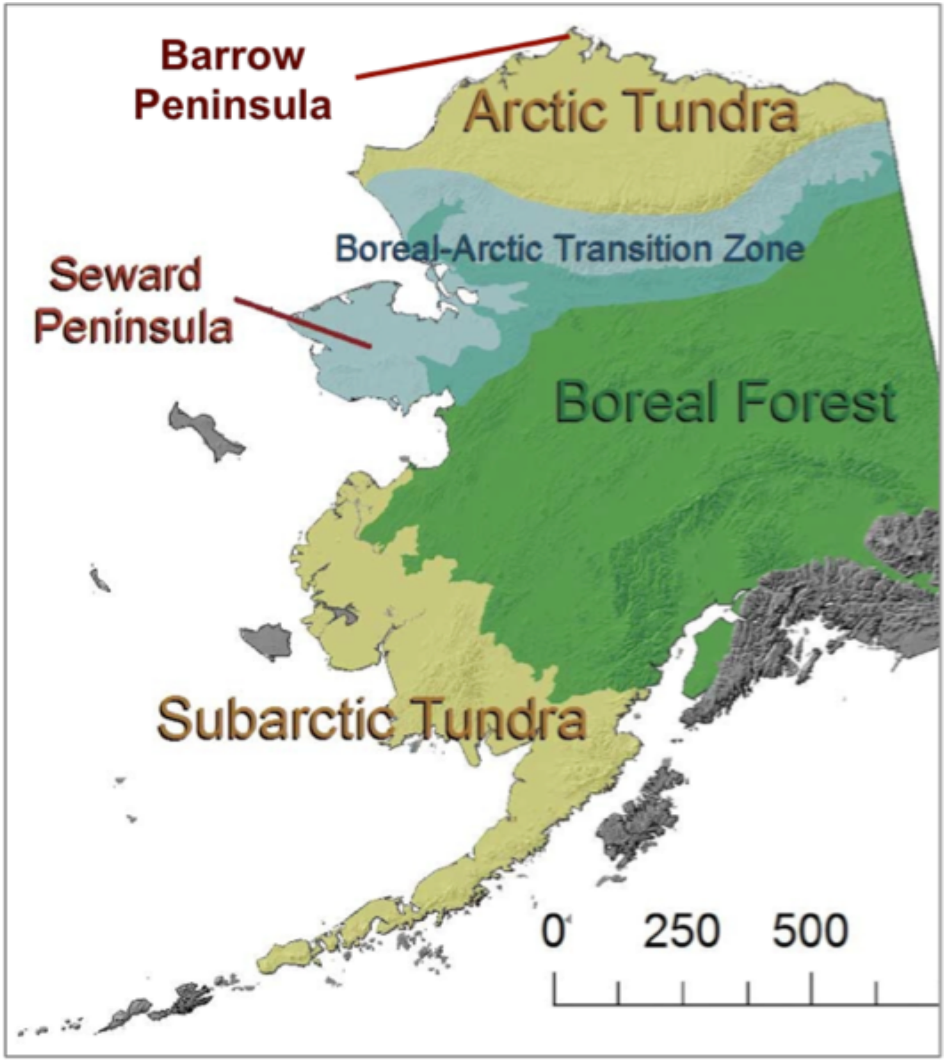
Ivotuk, AK

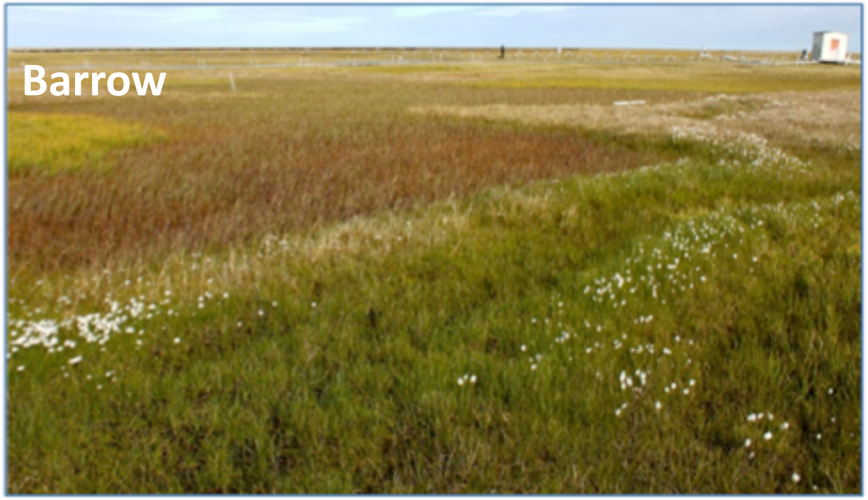
Ten-year project to reduce uncertainty in Earth System Models (ESMs) through the development of a predictive understanding of carbon-rich Arctic ecosystem processes and feedbacks to climate. Achieved through:

- Synthesis activities
- Experiments & manipulations
- Observations across scales
- Model-data integration

NGEE-Arctic

Focus on better representation of sub-grid scale heterogeneity in ecosystem structure and function across arctic eco-climatic gradients





NGEE-Arctic

U.S. DEPARTMENT OF ENERGY

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Next Generation Ecosystem Experiments: Arctic
Ecosystem Processes · Modeling, Prediction · Systems Understanding

Five process-level foci:

Q1: How does the structure and organization of the landscape control the storage and flux of carbon and nutrients in a changing climate?

Q2: What will control rates of CO_2 and CH_4 fluxes across a range of permafrost conditions?

Q3: How will warming and permafrost thaw affect above- and belowground plant functional traits, and what are the consequences for Arctic ecosystem carbon, water, and nutrient fluxes?

Q4: What controls the current distribution of Arctic shrubs, and how will shrub distributions and associated climate feedbacks shift with expected warming in the 21st century?

Q5: Where, when, and why will the Arctic become wetter or drier, and what are the implications for climate forcing?

Ivotuk, AK

NGEE-Arctic

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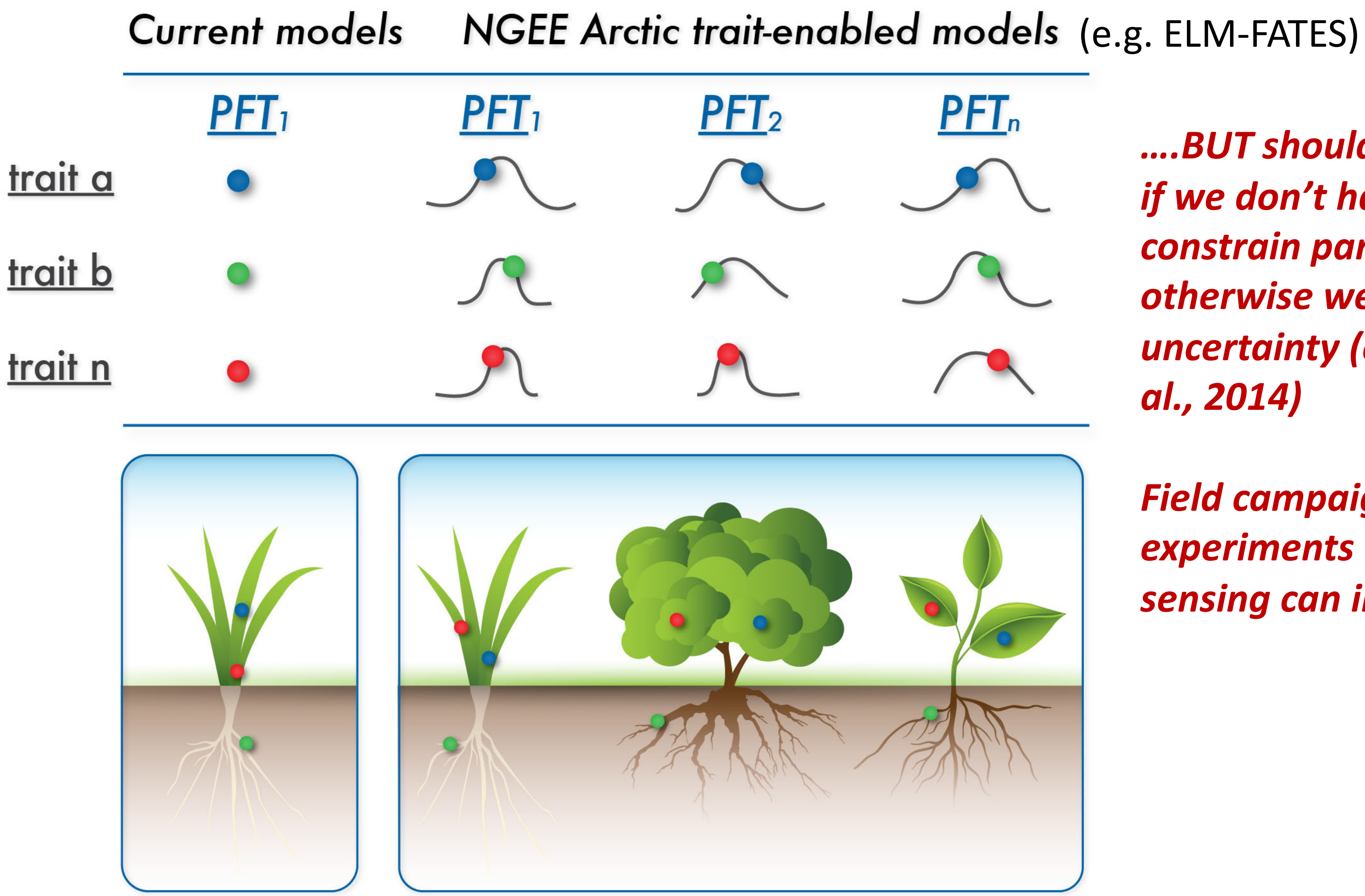
Ivotuk, AK

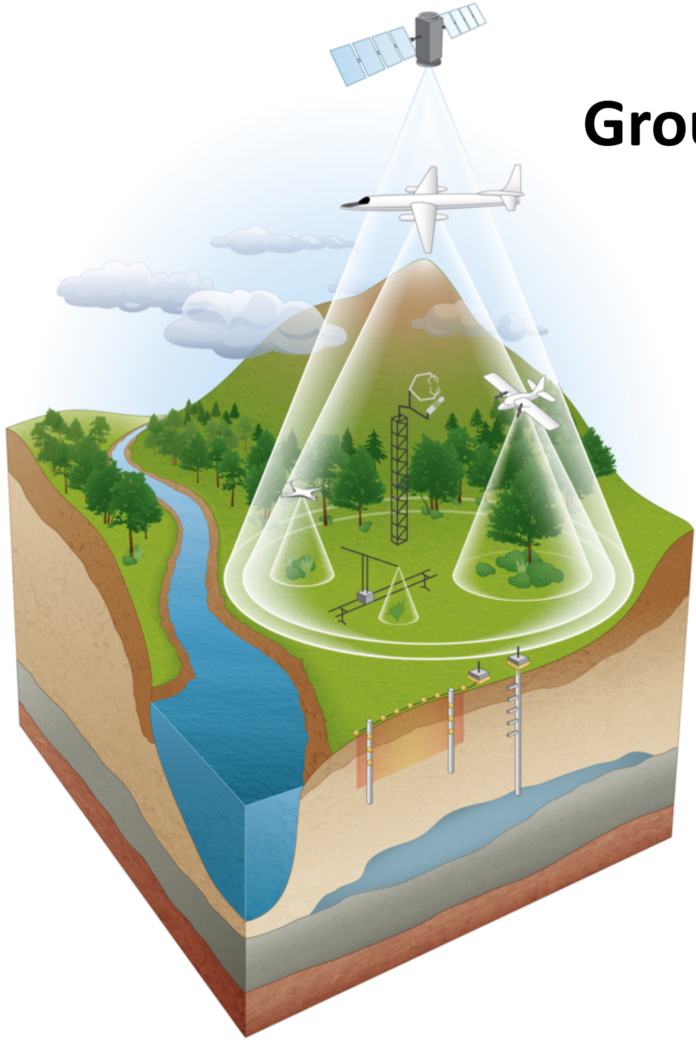
Improving model representation of trait diversity



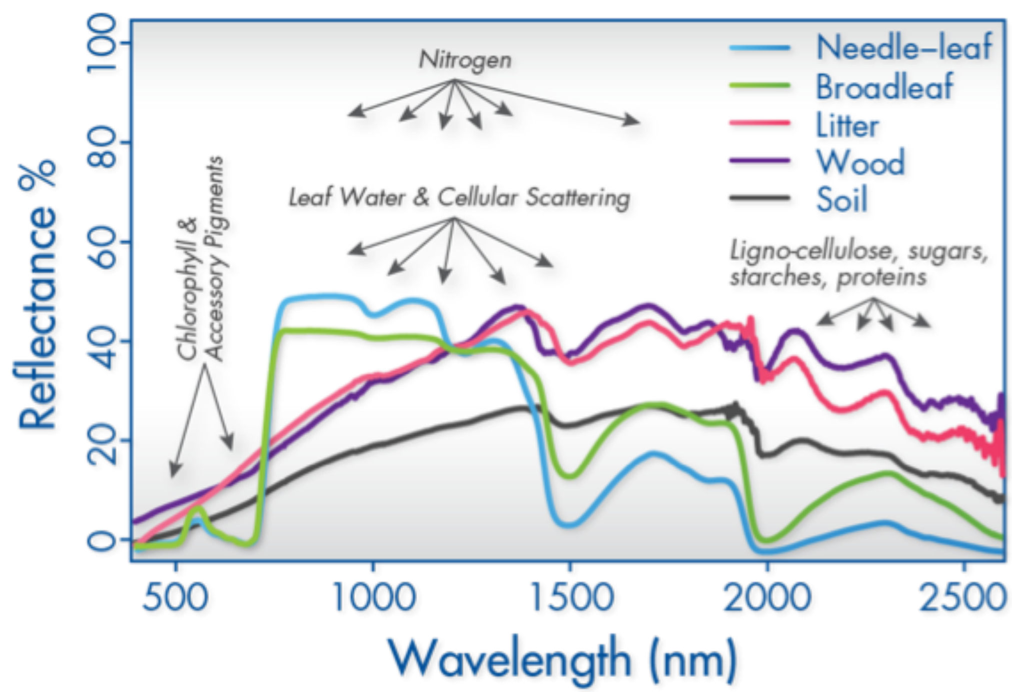
....BUT should not add PFTs if we don't have the data to constrain parameters; otherwise we get more uncertainty (e.g. Dietze et al., 2014)

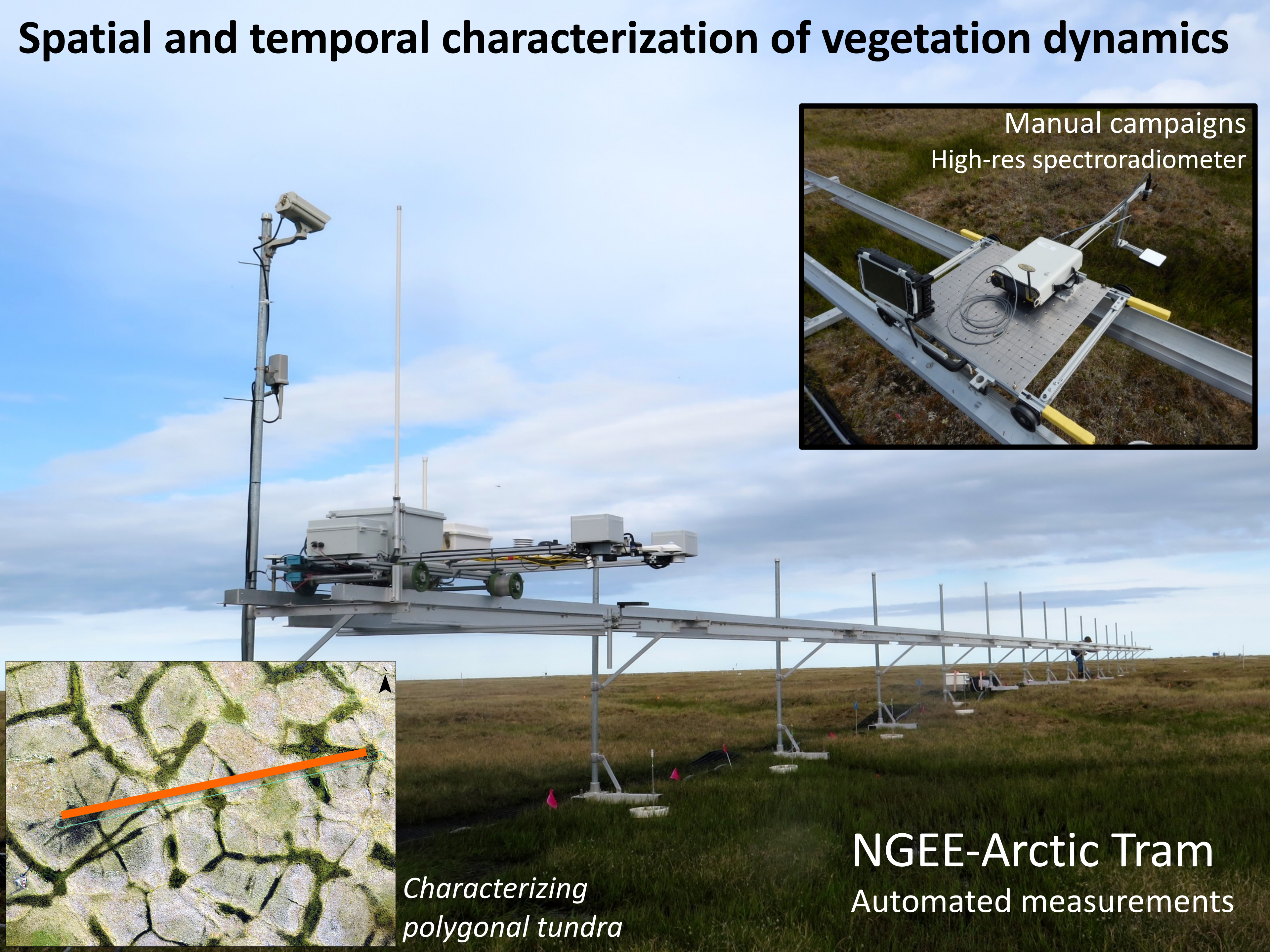
Field campaigns, experiments and remote sensing can inform models

NGEE-Arctic: Scaling approach

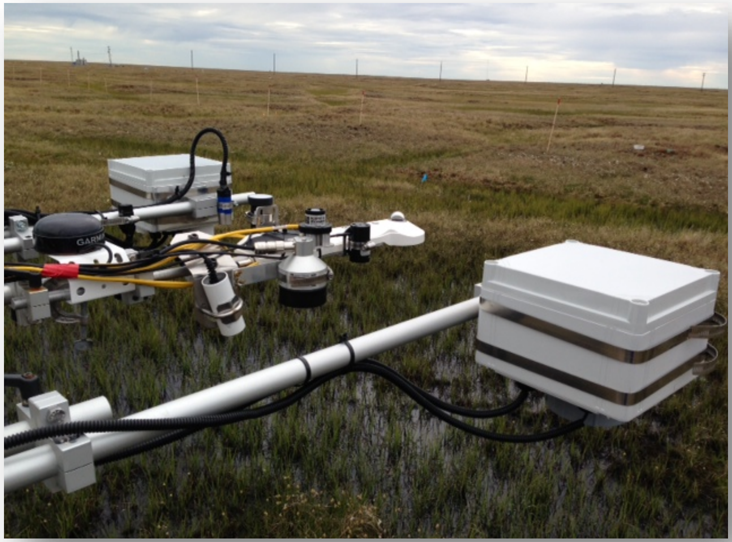


Ground -> Tram -> UAS -> ABoVE




Spatial and temporal characterization of vegetation dynamics
Manual campaigns
High-res spectroradiometer
Characterizing
polygonal tundra
NGEE-Arctic Tram
Automated measurements

NGEE tram: Automated sensors



Tram Sensor	Purpose
Net Radiometer	Albedo, LW, SW
IR Surface Temperature	Skin temperature of land surface
PAR, Incident & Reflected	Fraction of absorbed PAR
Spectral Red/NIR, Incident & Reflected	NDVI – Normalized Difference Vegetation Index
Spectroradiometer	Near-surface remote sensing (350-1100nm)
Thermal Camera	Spatial distribution of surface temperature
Sonic Distance Sensor	Snow and water depth
Digital RGB Camera	Photo of sensor footprint

Subsurface: Soil Moisture and Temp, Geophysics

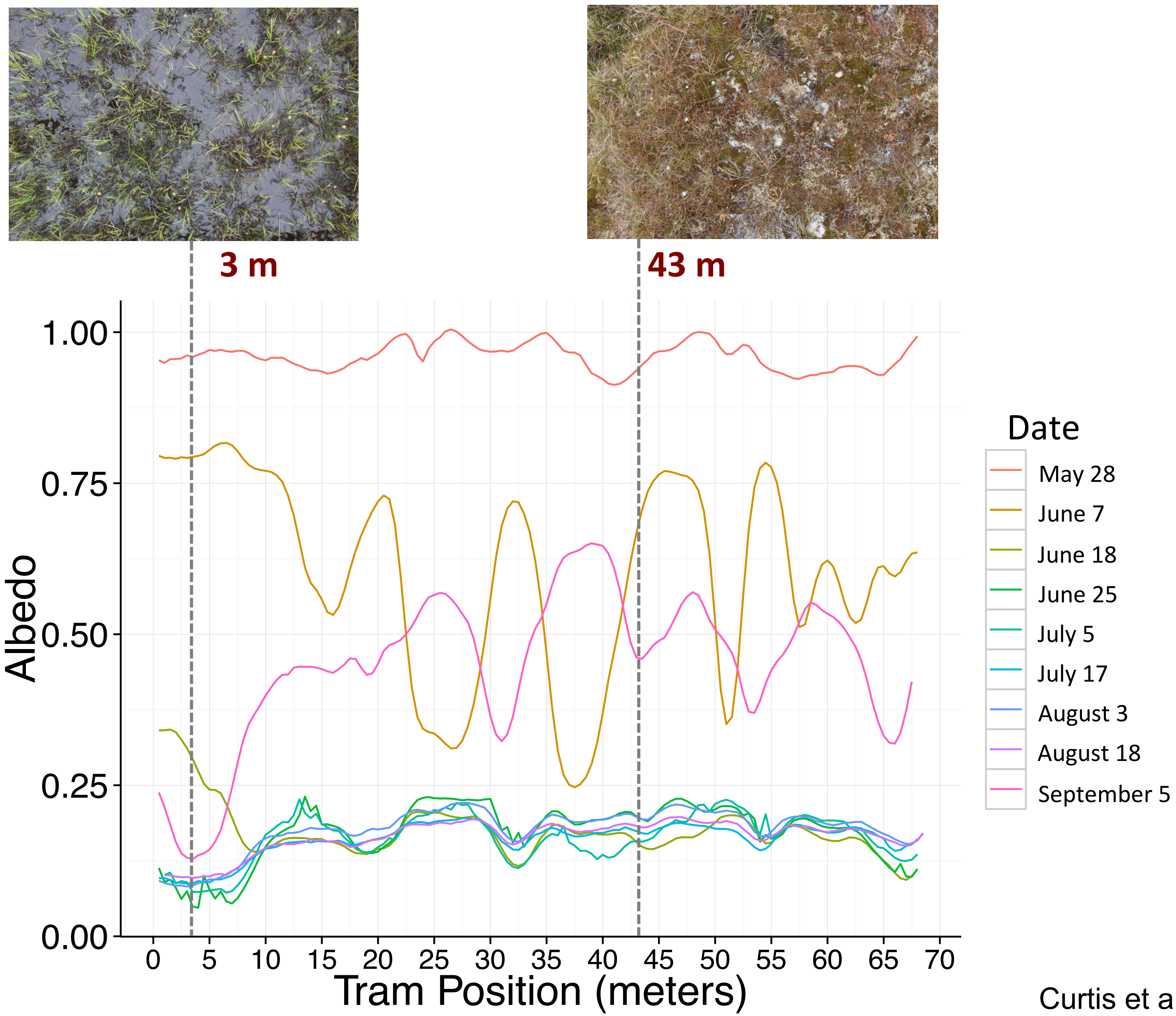
*PAR = photosynthetically active radiation

*LW = longwave radiation

*SW = shortwave radiation

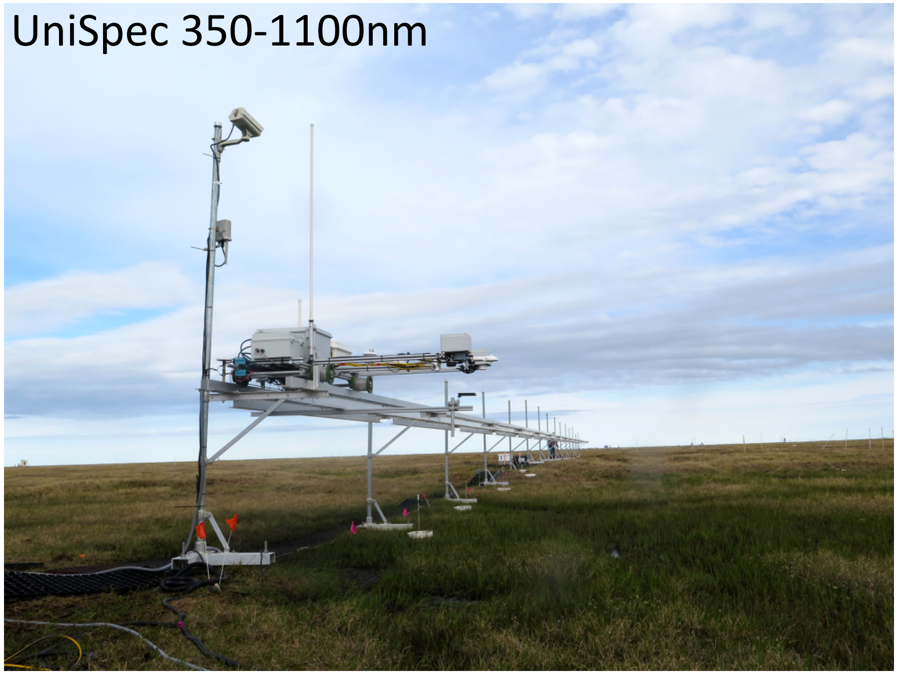
Curtis et al. (in prep); Serbin et al., (in prep)

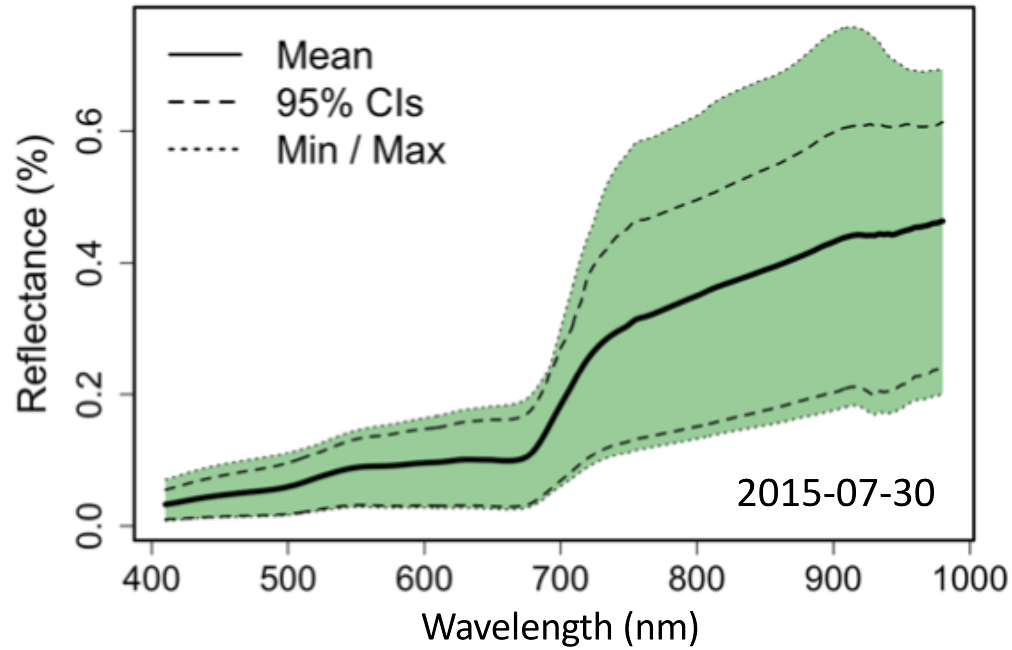
Tram albedo – net radiometer

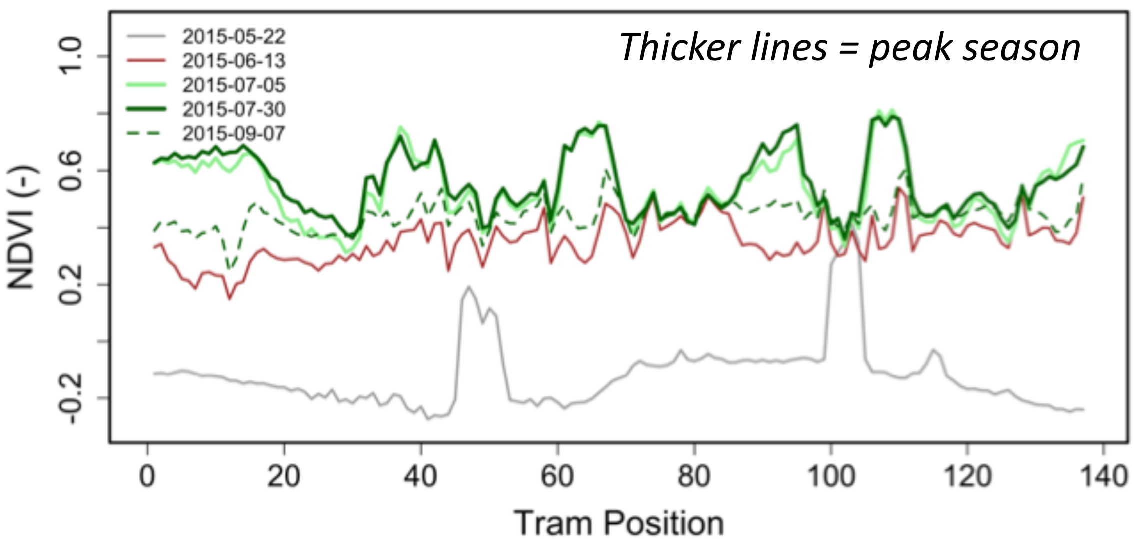


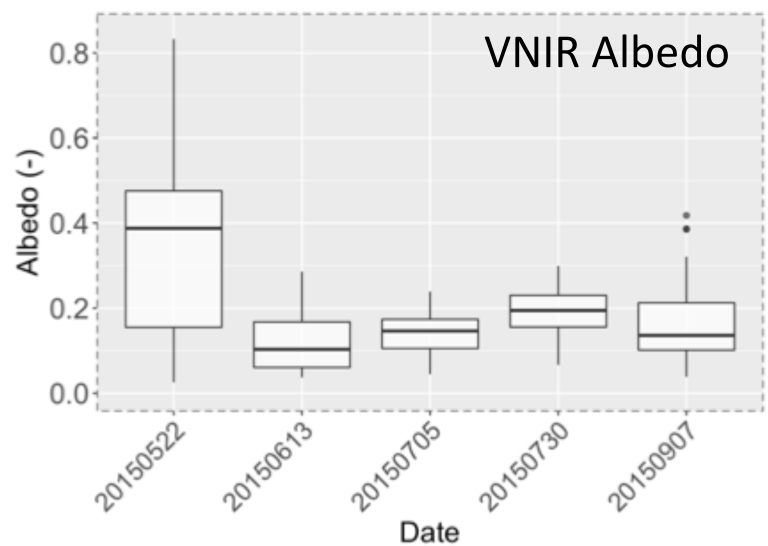
Curtis et al. (in prep)

Tram reflectance and albedo - spectroradiometer



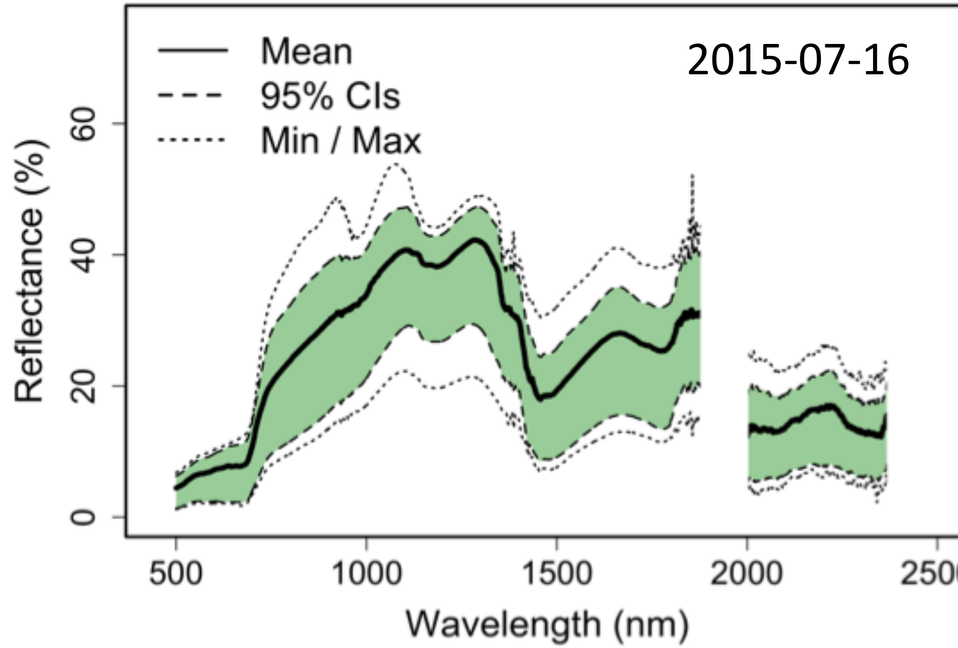




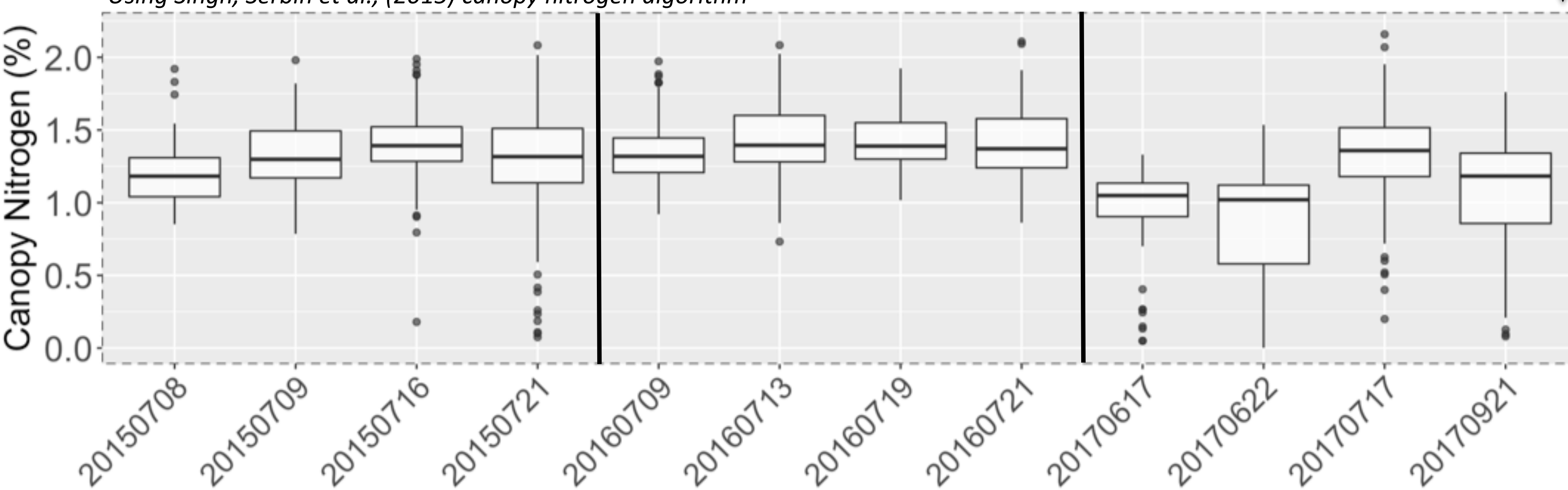


Serbin et al., (*in prep*)

NGEE Tram: Manual measurements



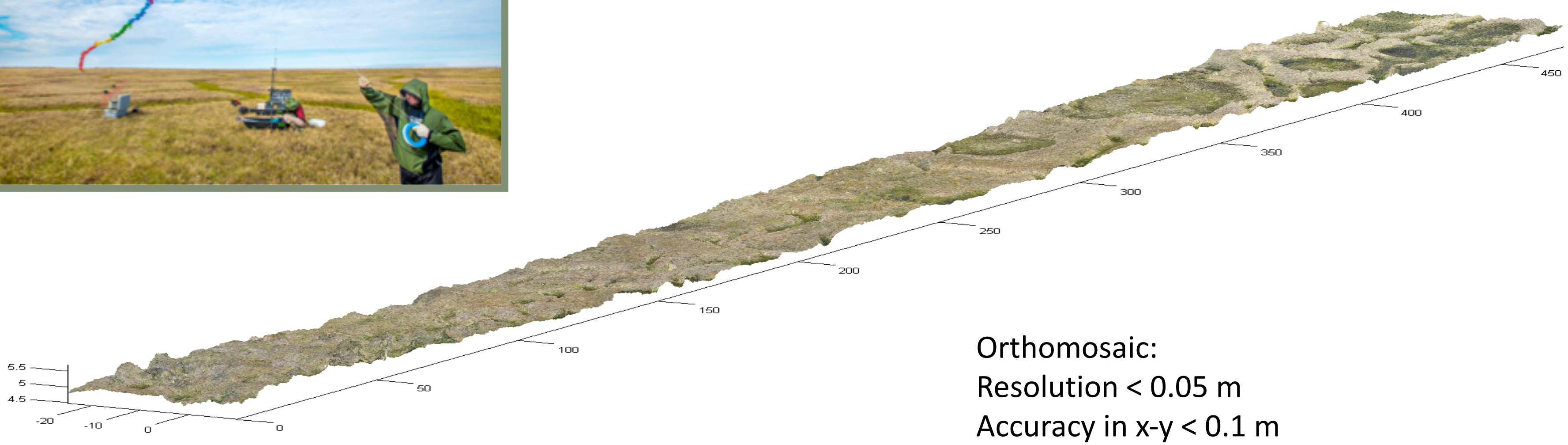
Using Singh, Serbin et al., (2015) canopy nitrogen algorithm



Serbin et al., (*in prep*)

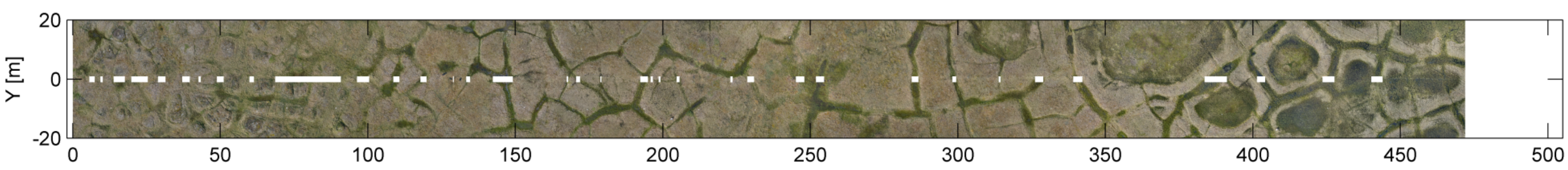
Connecting above and belowground processes

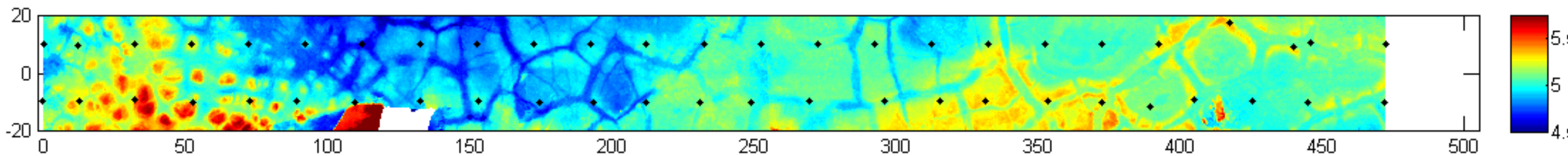
Kite & Electrical Resistivity Tomography (ERT)
Adjacent to tram line



Orthomosaic:
Resolution < 0.05 m
Accuracy in x-y < 0.1 m

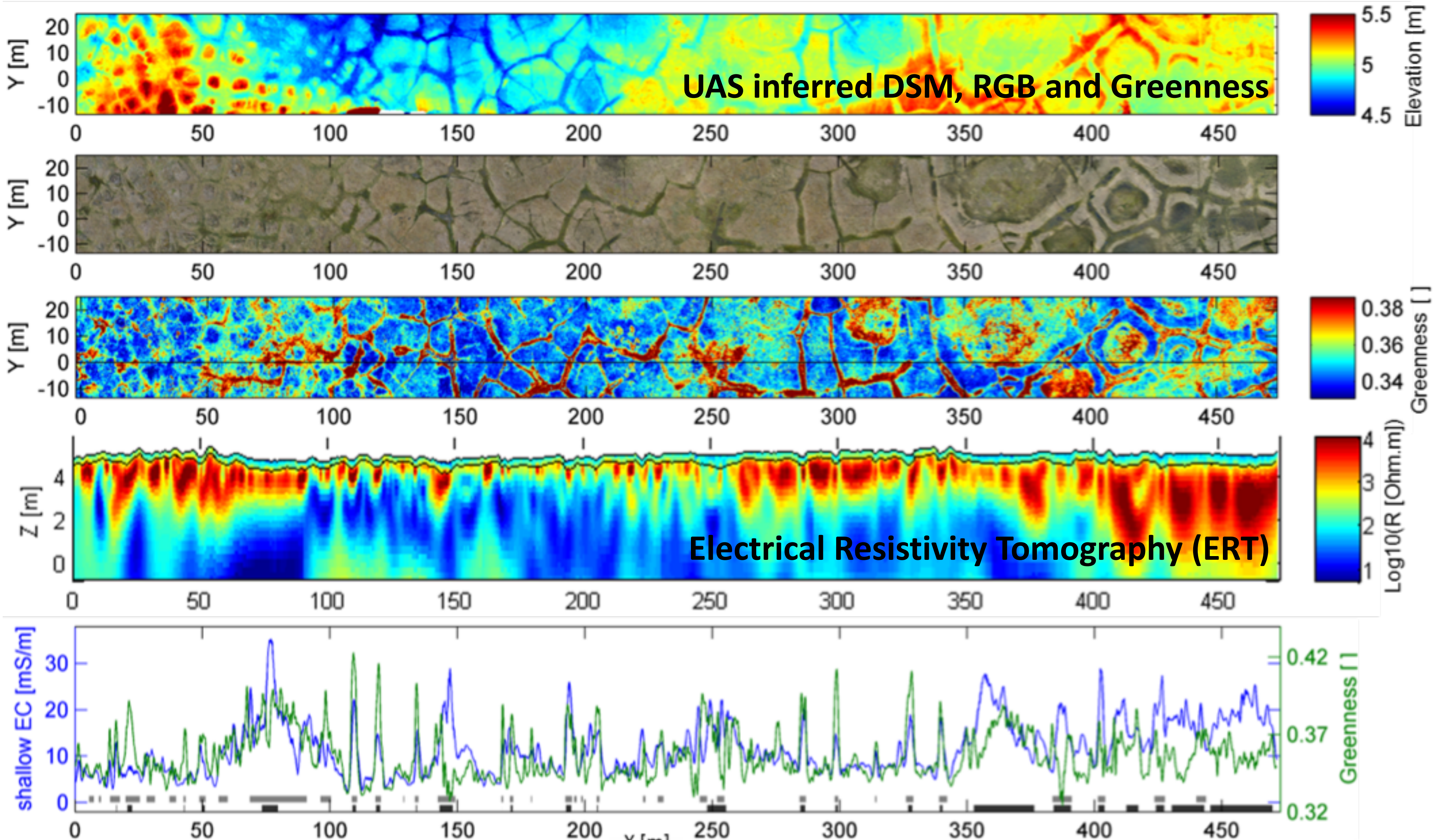
DEM: Accuracy in x-y-z < 0.1 m





Dafflon et al., JGR-B, 2017

Co-variability between vegetation and soil properties in Barrow

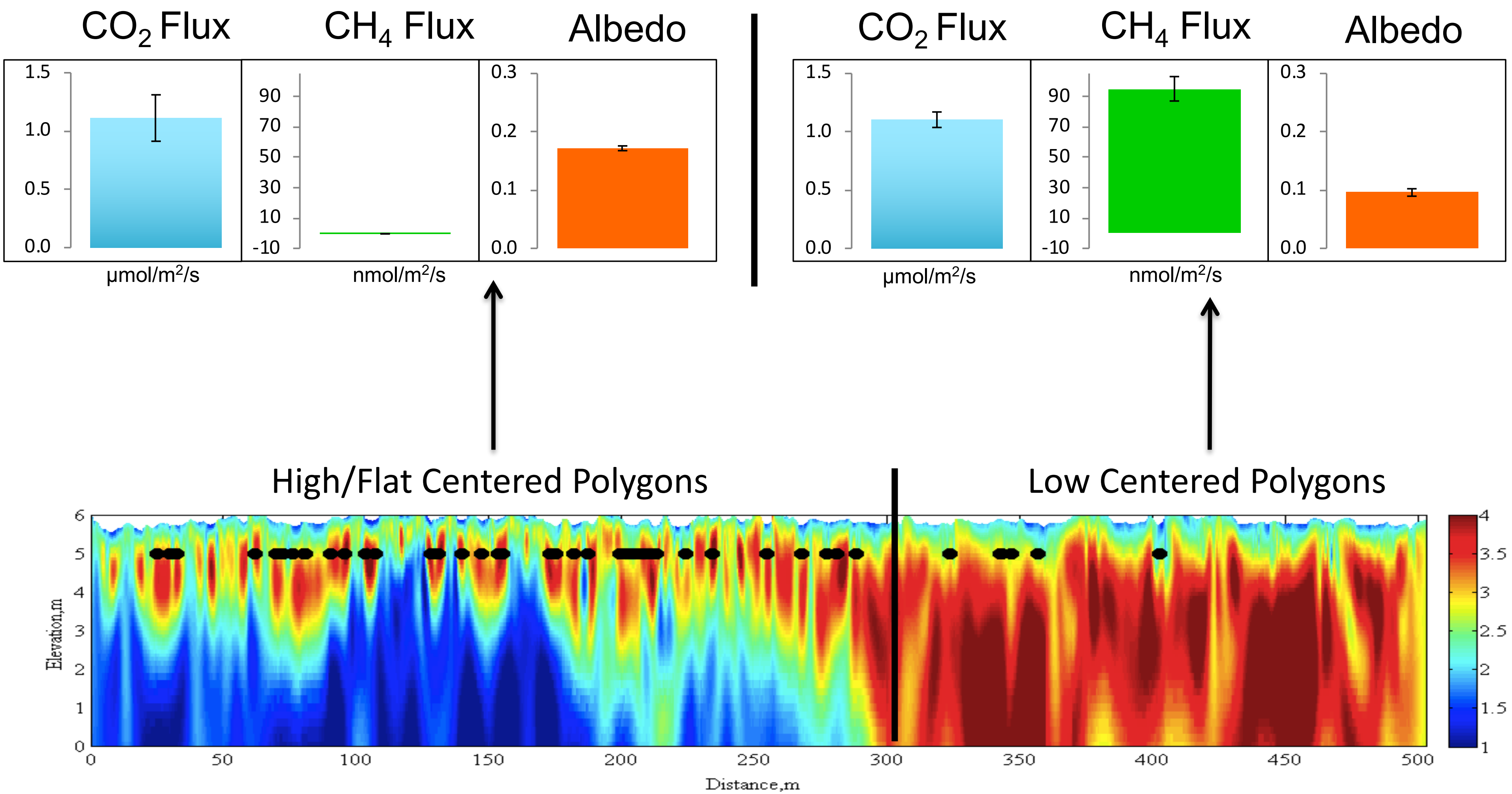


- Soil electrical conductivity from the top 20 cm in ERT (soil moisture proxy) and collocated greenness index shows correlation coefficient >0.75 (lowest match where deep surface water)
- Relationships can be used at larger scale for probabilistic mapping of soil moisture and ALT

Dafflon et al., JGR-B, 2017

Connecting above and belowground processes

Surface fluxes along tram line



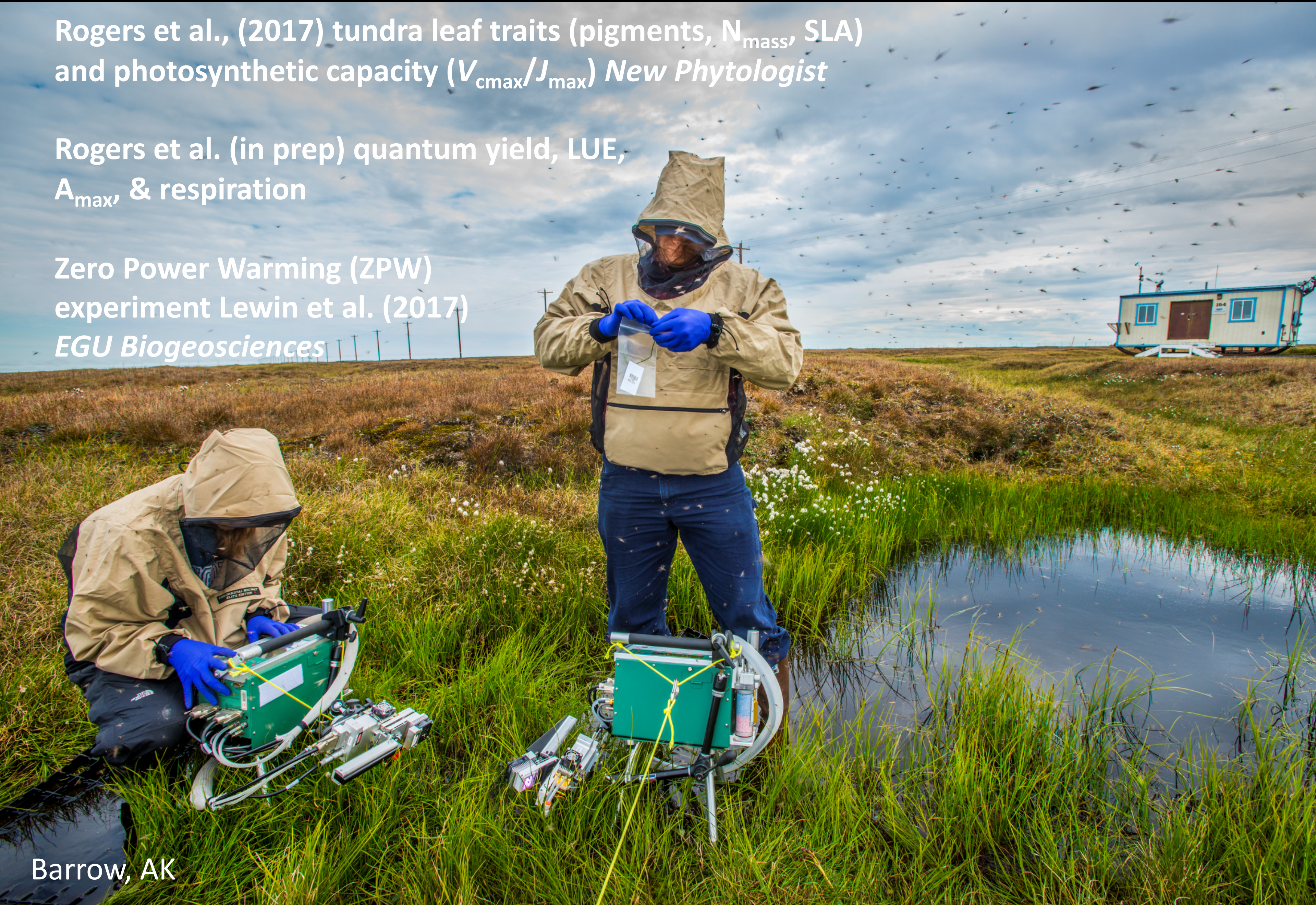
Wainwright et al 2015; Torn et al.

Measuring plant photosynthetic capacity

Rogers et al., (2017) tundra leaf traits (pigments, N_{mass}, SLA) and photosynthetic capacity (V_{cmax}/J_{max}) *New Phytologist*

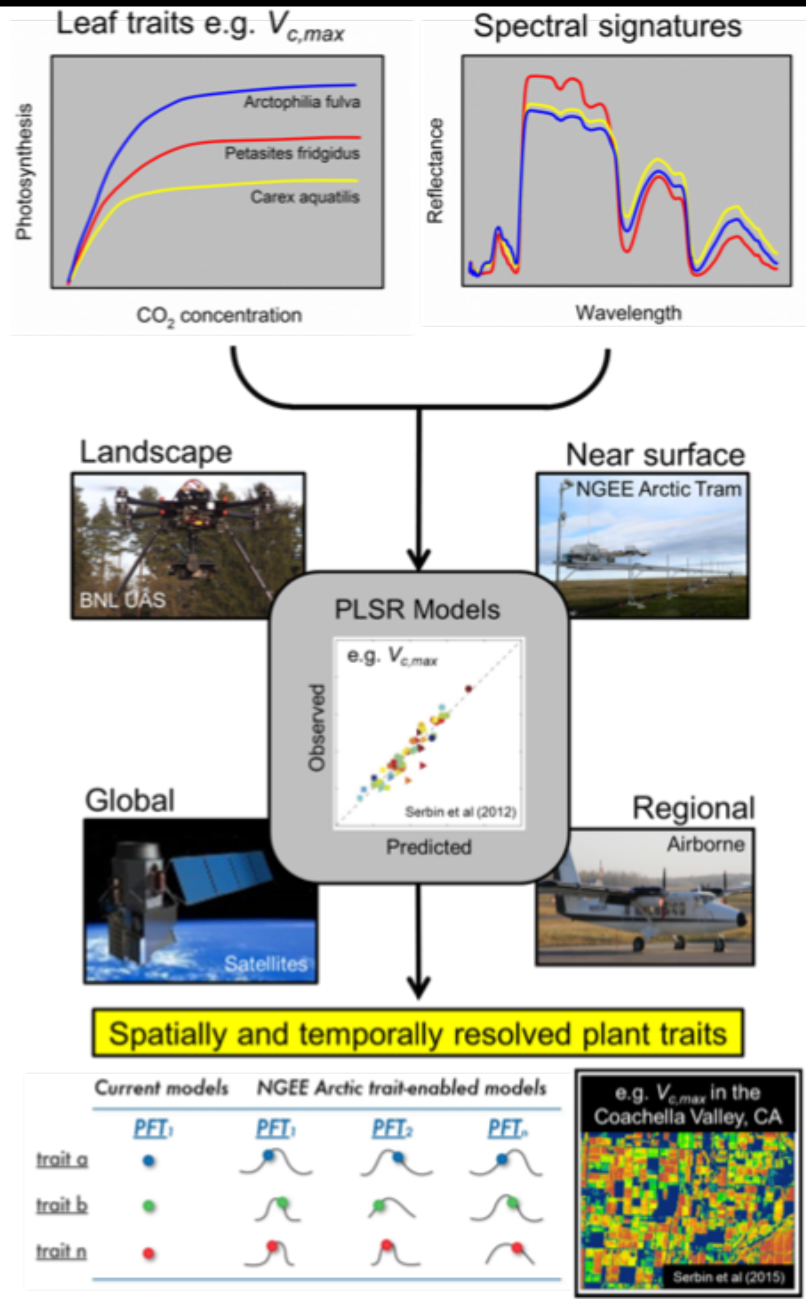
Rogers et al. (in prep) quantum yield, LUE, A_{max}, & respiration

Zero Power Warming (ZPW) experiment Lewin et al. (2017) *EGU Biogeosciences*

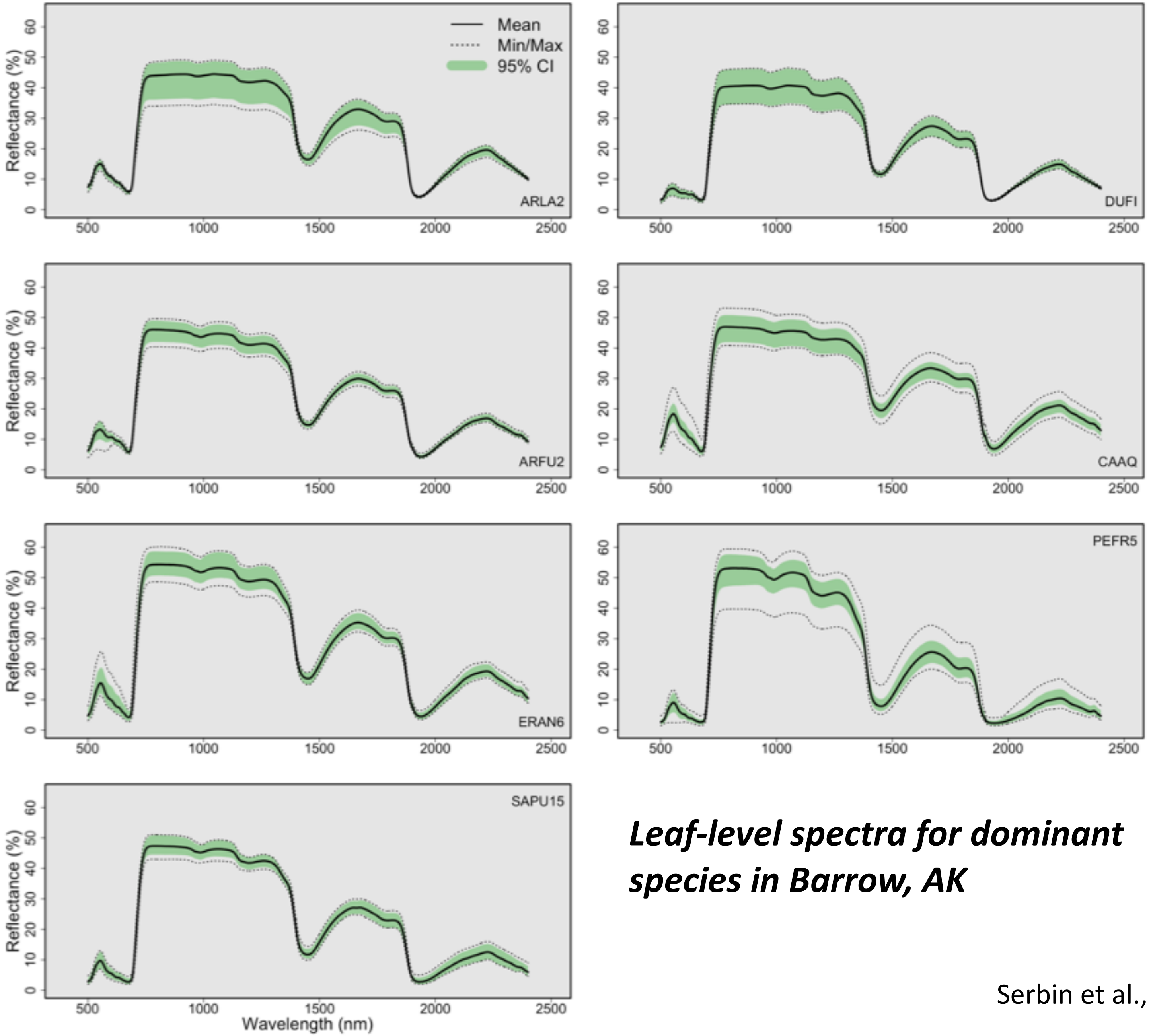


Barrow, AK

Spectroscopic trait scaling



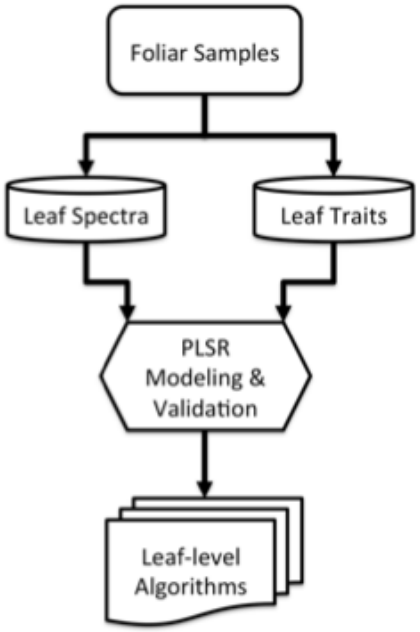
Capturing trait variation at the leaf scale

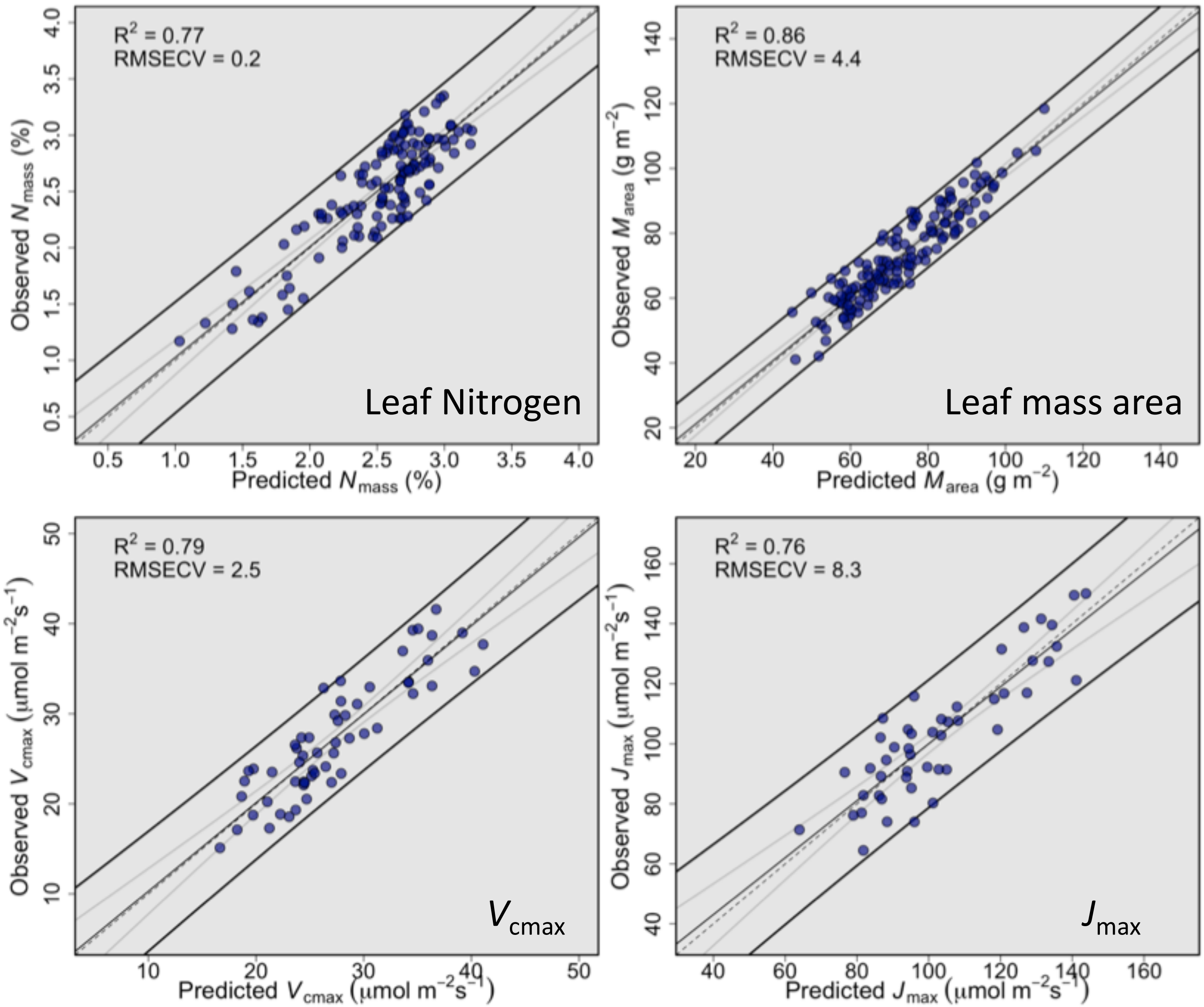


Leaf-level spectra for dominant species in Barrow, AK

Serbin et al., (*in prep*)

Capturing trait variation at the leaf scale





Serbin et al., (*in prep*)

High resolution mapping of PFT distributions in the BEO

Vegetation distribution across polygonal tundra:

- Polygonal microtopography plays important role in regulating hydrologic and thermal regimes of permafrost tundra
- Vegetation distribution across the landscape is influenced by moisture availability and thermal regimes

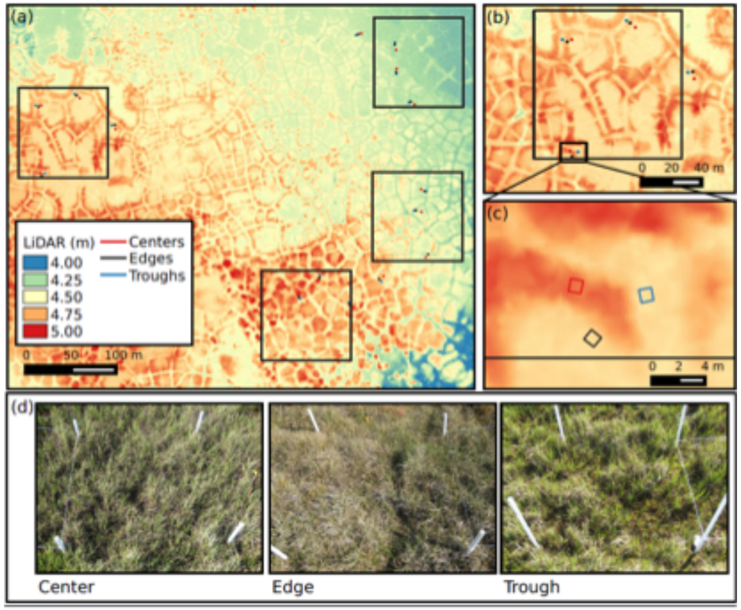
Remote Sensing and Field Observation:

- WorldView-II data
- Repeat imagery &capturing phenological stage (i.e. green-up, brown-down) can help distinguish different vegetation communities
- High-res (e.g. LiDAR) DEM provides detailed information on the microtopography of the landscape

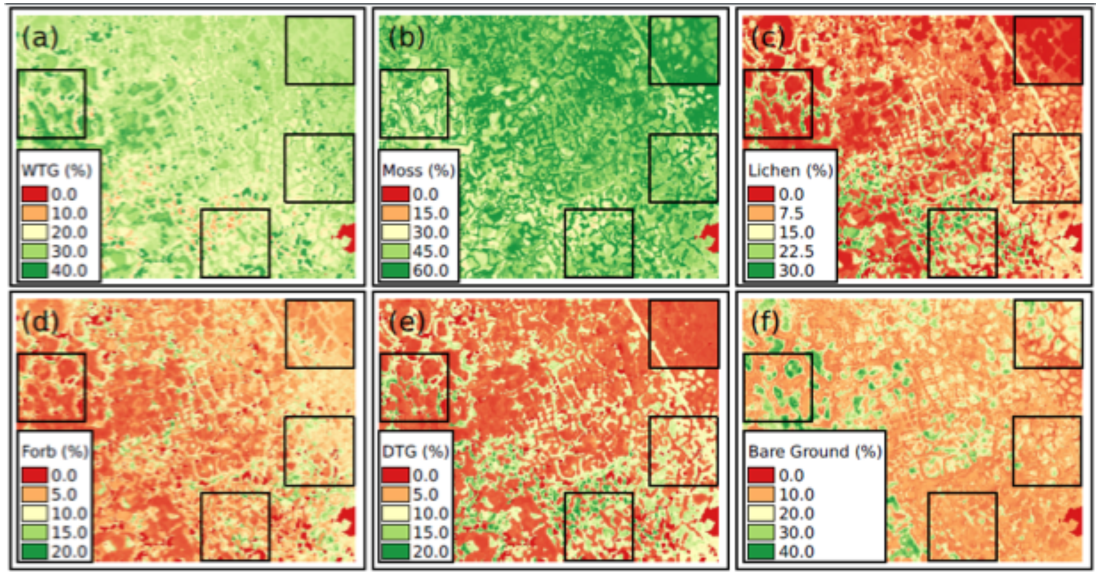
Plant Functional Type Mapping:

- Field vegetation surveys and remote sensing were used to develop models to estimate the fractional PFT coverage at 2.0m resolution

Plots across polygon microtopography



Fractional PFT distribution across BEO

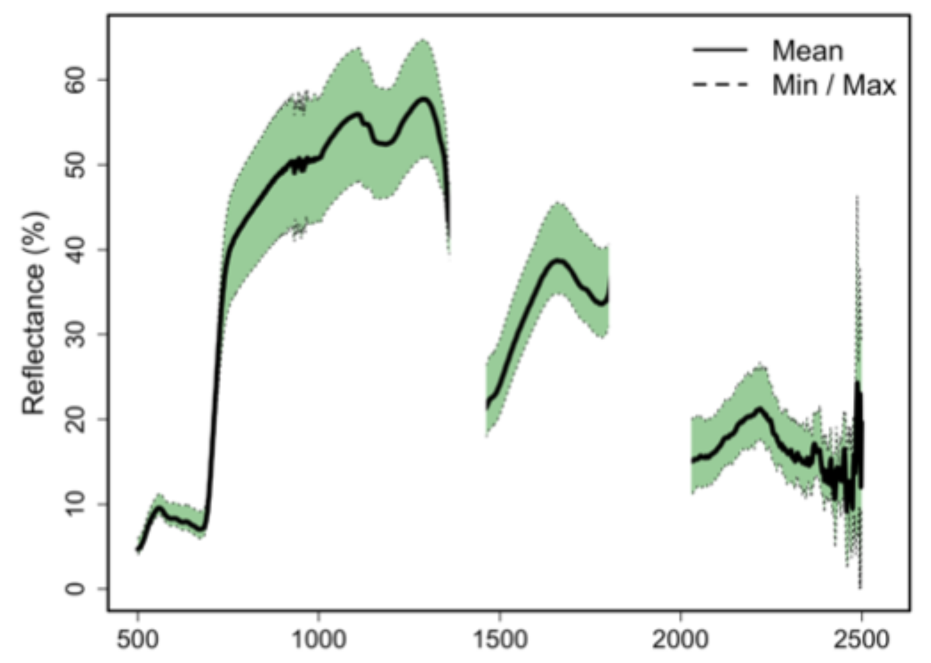


ORNL group (Langford, Kumar, Hoffman, et al)

Langford et. al, 2016 doi: [10.3390/rs8090733](10.3390/rs8090733)

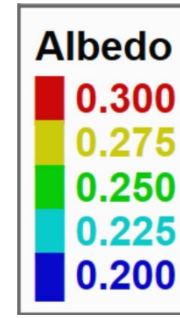

Unmanned Aerial Systems (UASs)
2017 Nome campaign

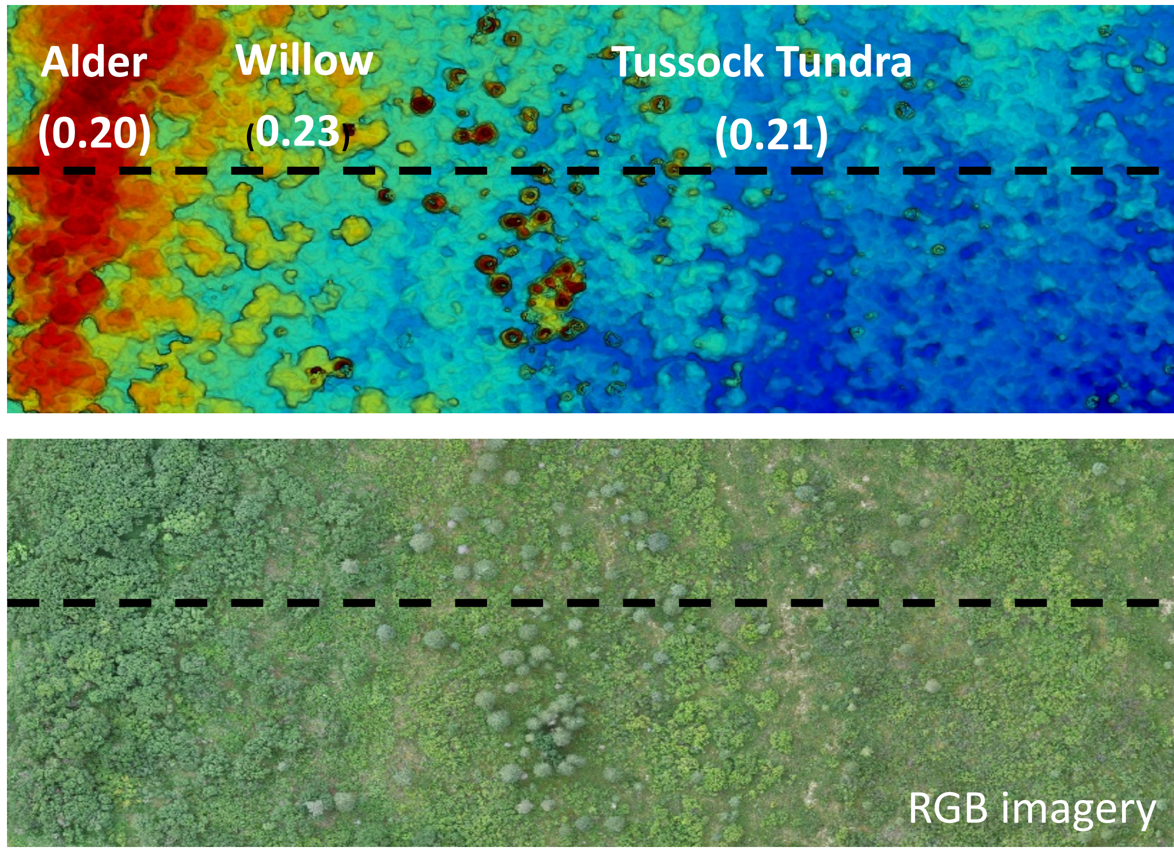
Field spectroscopy & ground validation



UAS Campaigns: Mapping watershed-scale albedo

Utilizing multiple groups and platforms to scale up, characterize fine-scale variation and link with broader-scale imagery (e.g. ABoVE)





Biraud et al., (in prep)

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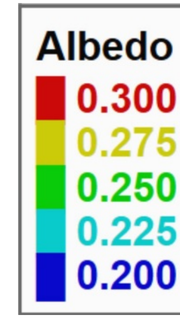
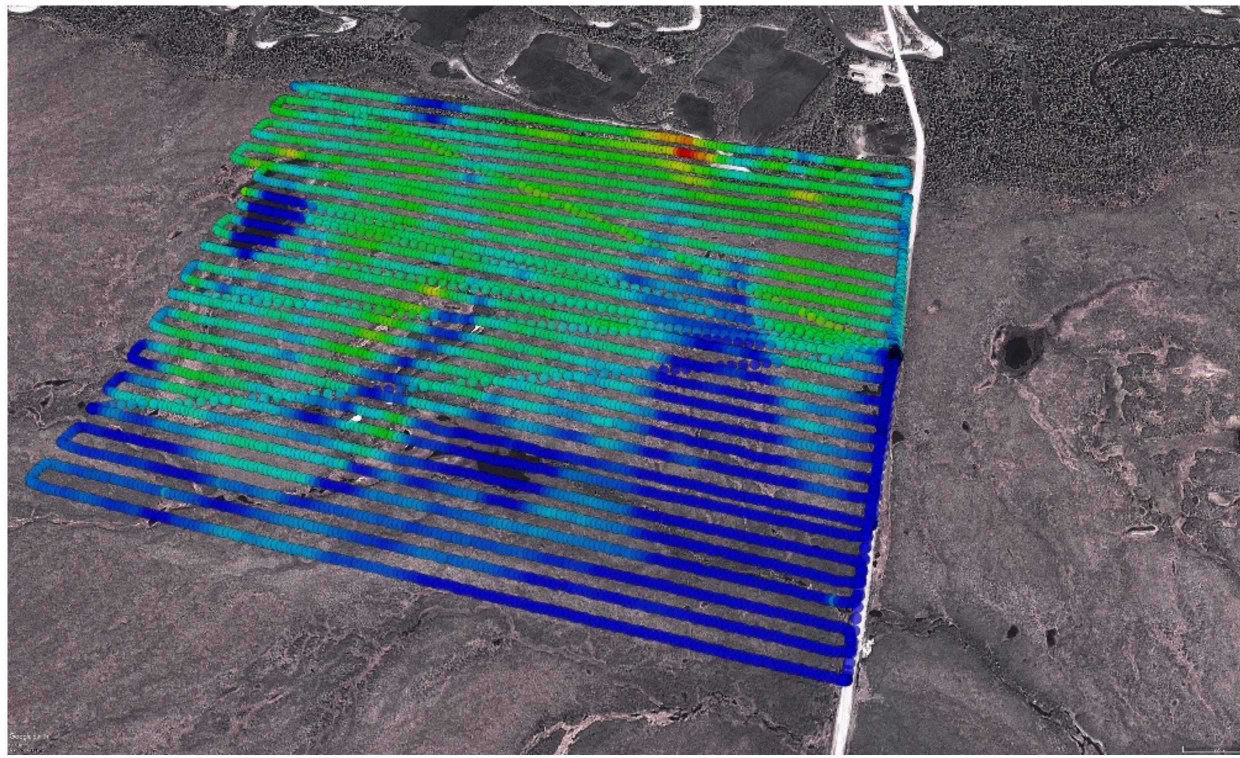


Exploring spatial patterns of albedo, scale effects, and shrub vs non-shrub differences



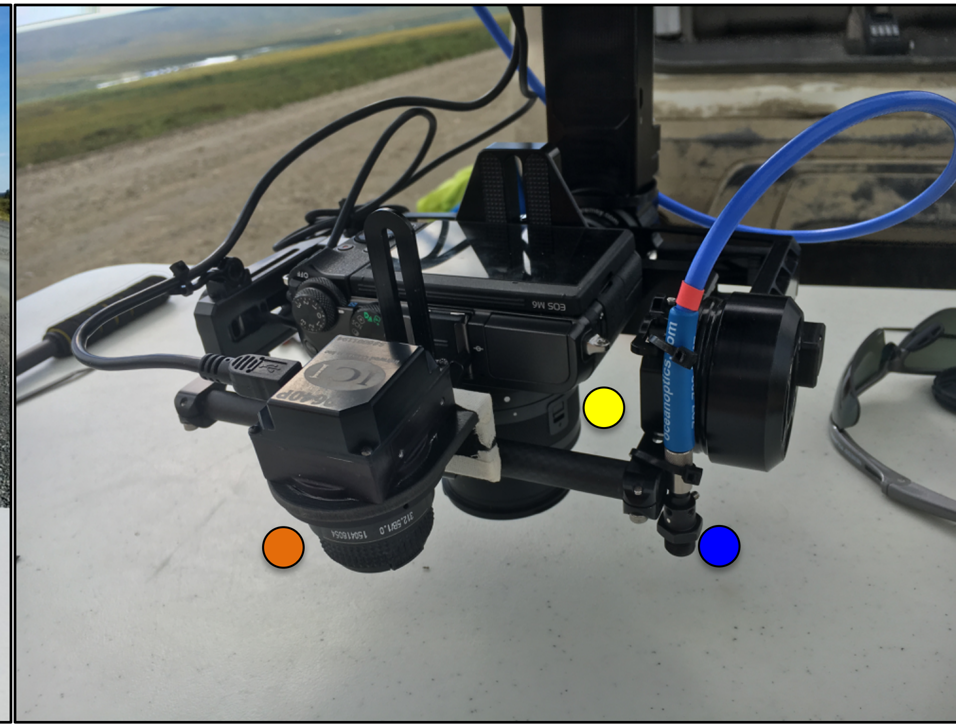
Council, AK – June 18th, 2017

Biraud et al., (in prep)

Multi-sensor: surface reflectance, thermal IR, & structure

Osprey octocopter

Instrument package

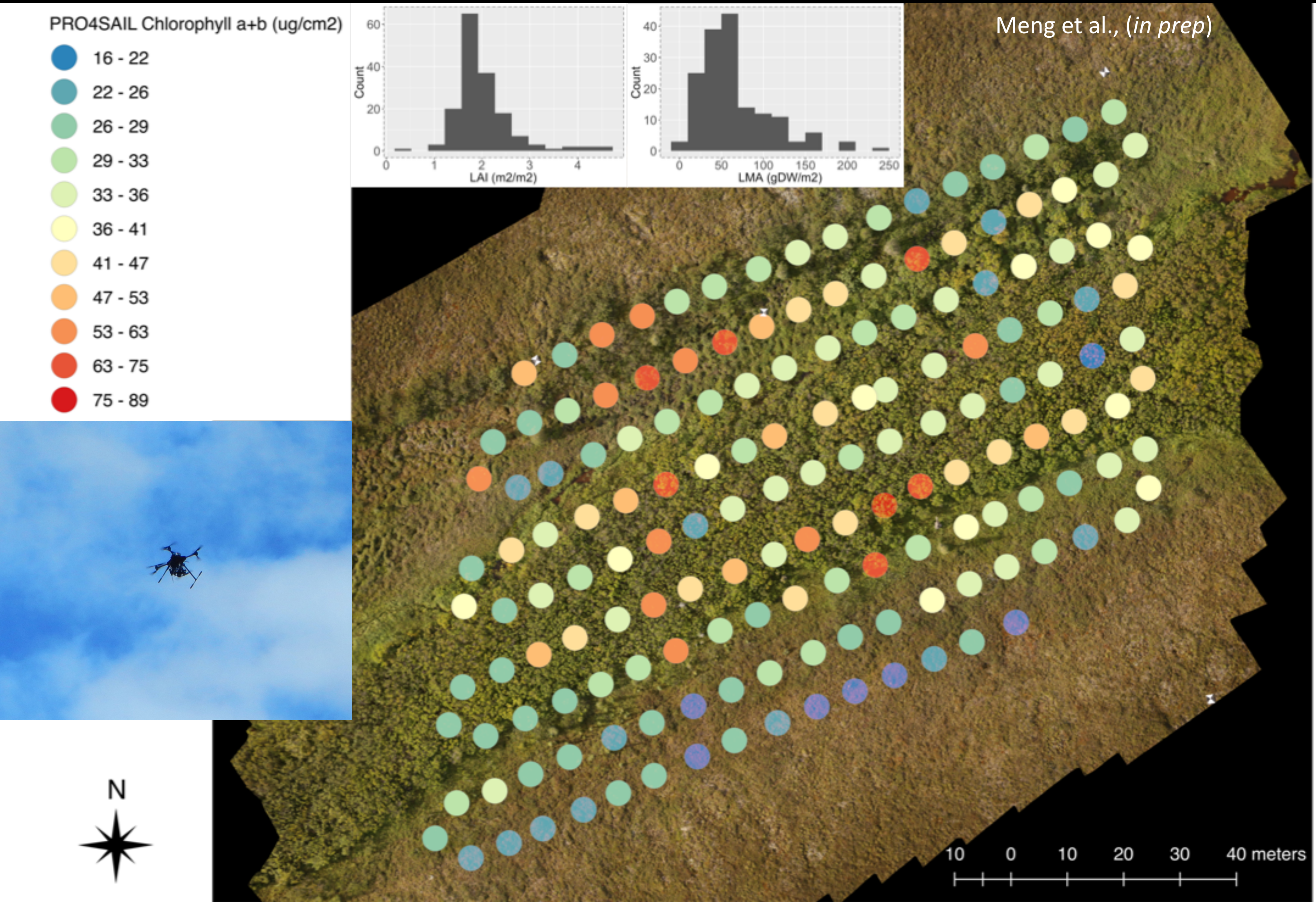


- High-res optical
- High-res TIR
- Dual spectrometers

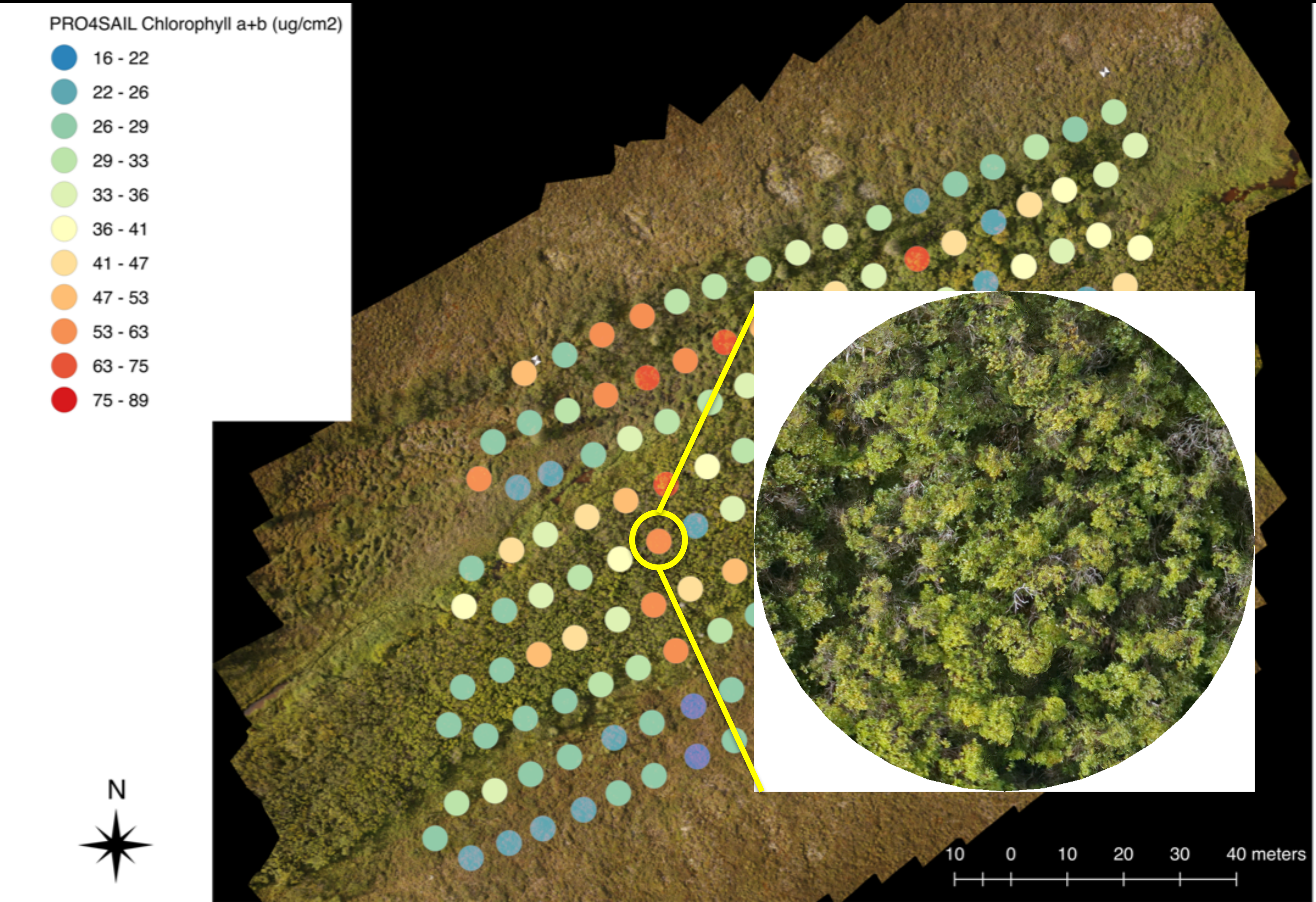
Meng et al., (*in prep*)

BROOKHAVEN NATIONAL LABORATORY

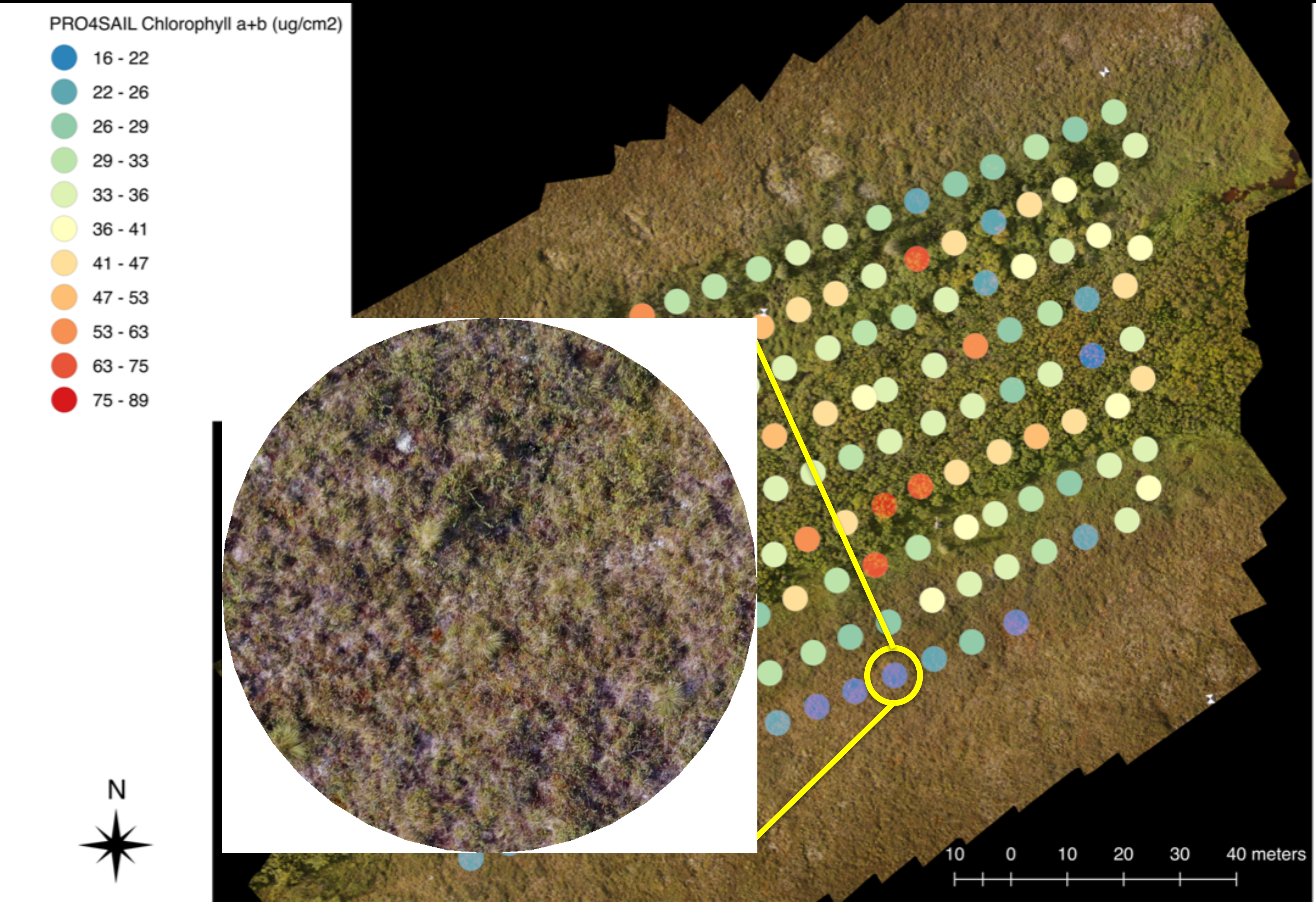
“Mapping” plant traits



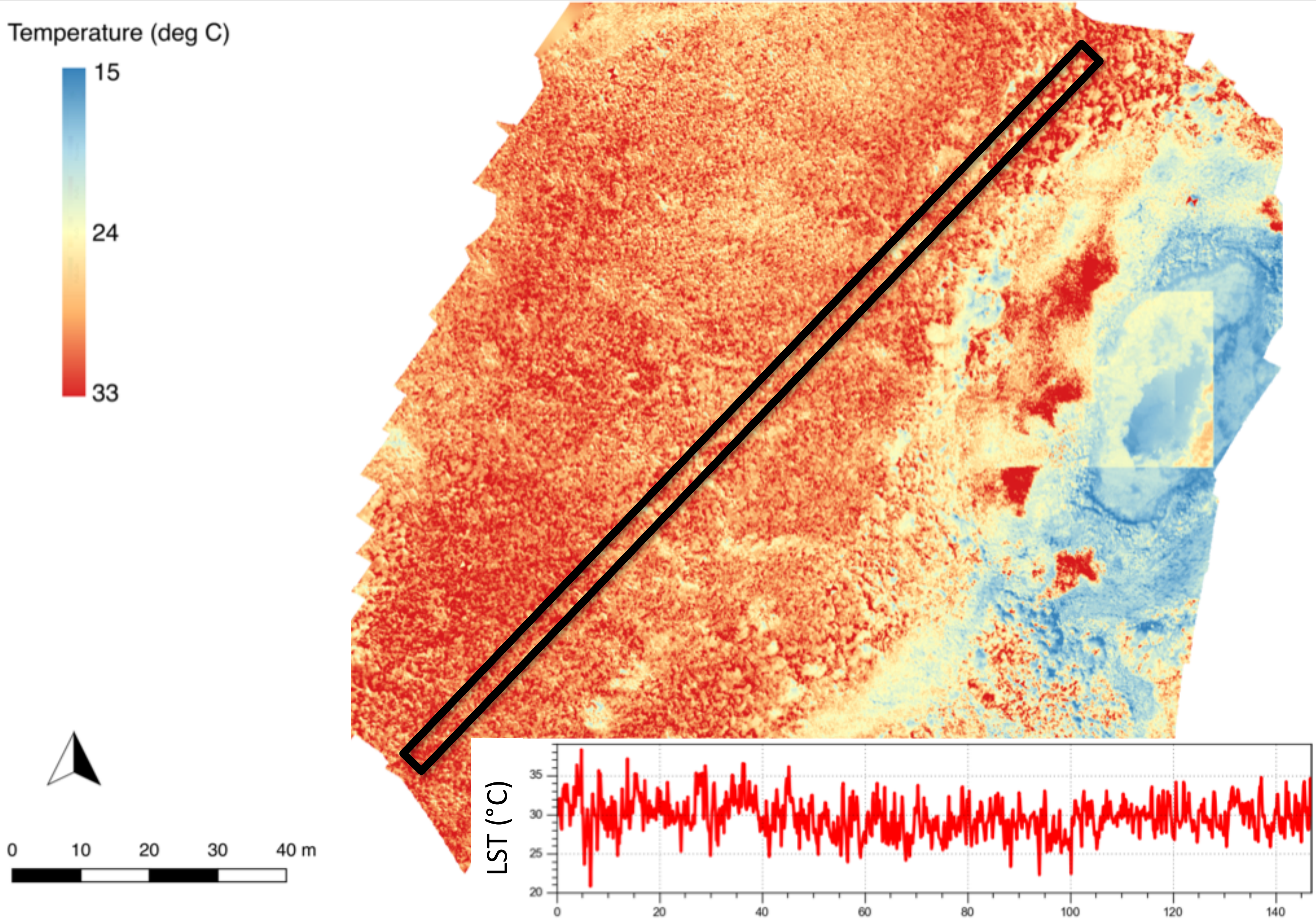
"Mapping" plant traits



“Mapping” plant traits

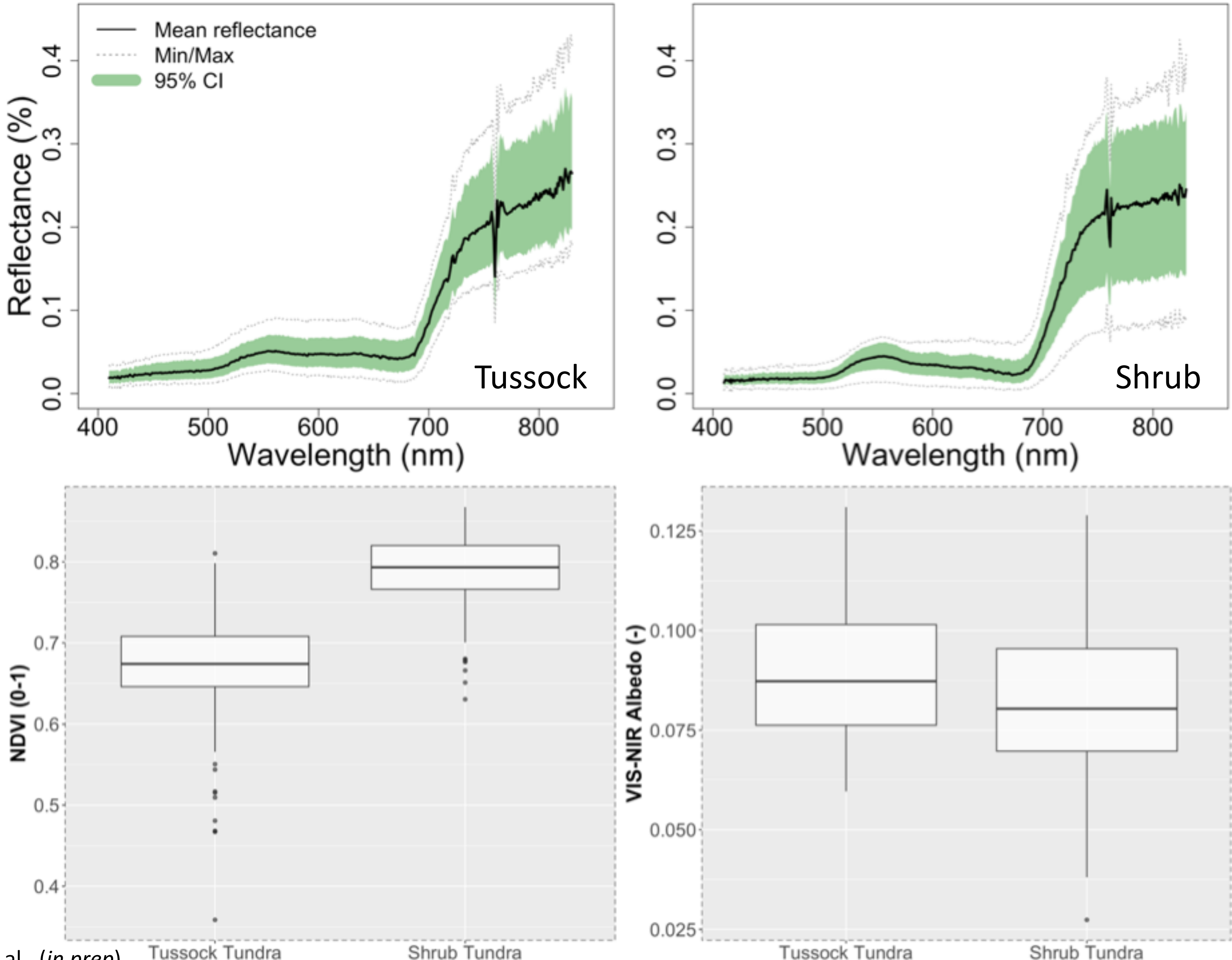


UAS mapping of surface thermal variation



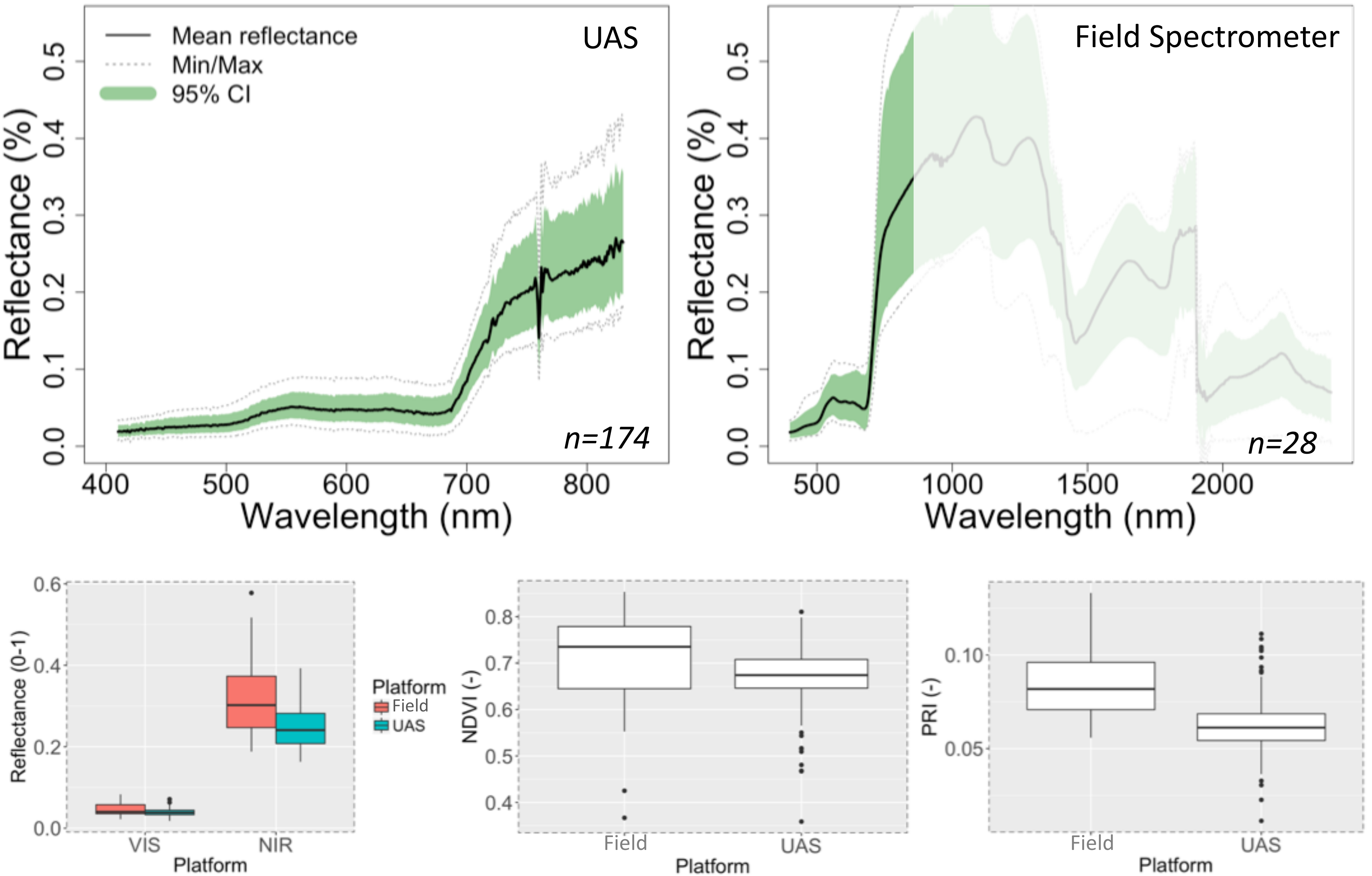
Meng et al., (*in prep*)

Comparing canopy albedo – tussock vs shrub

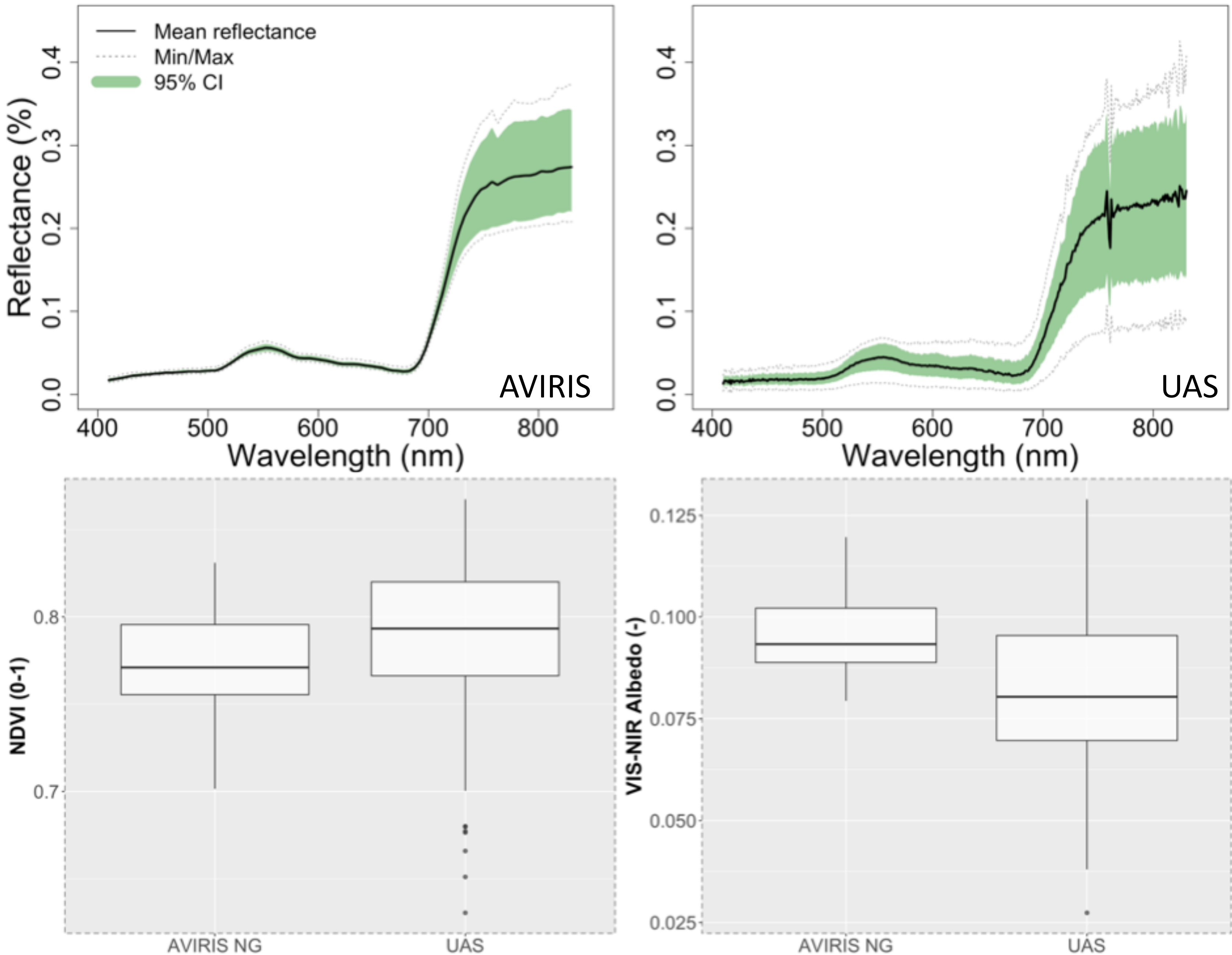


Meng et al., (*in prep*)

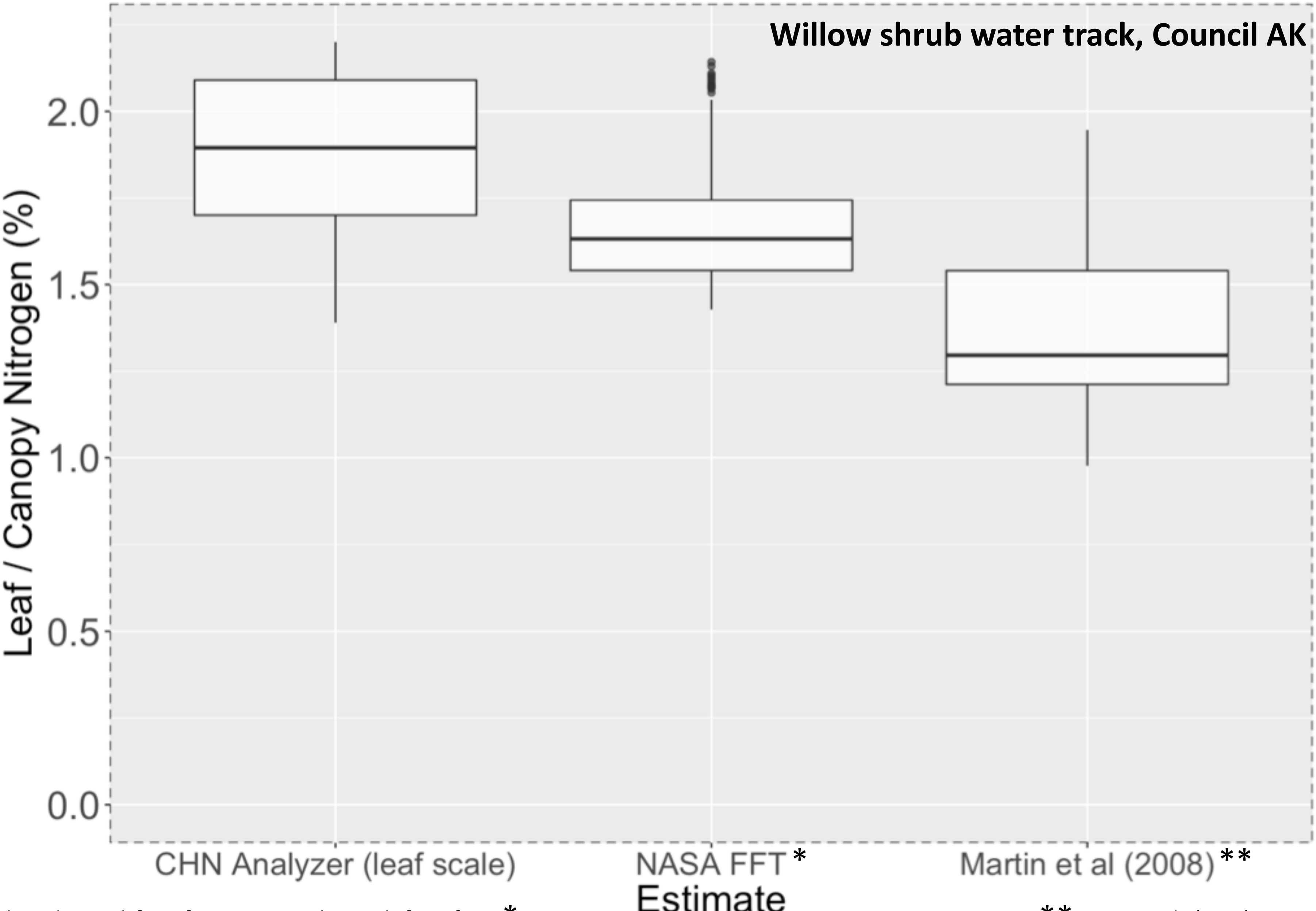
Ground evaluation of UAS spectral data



Comparing canopy albedo – UAS vs AVIRIS NG



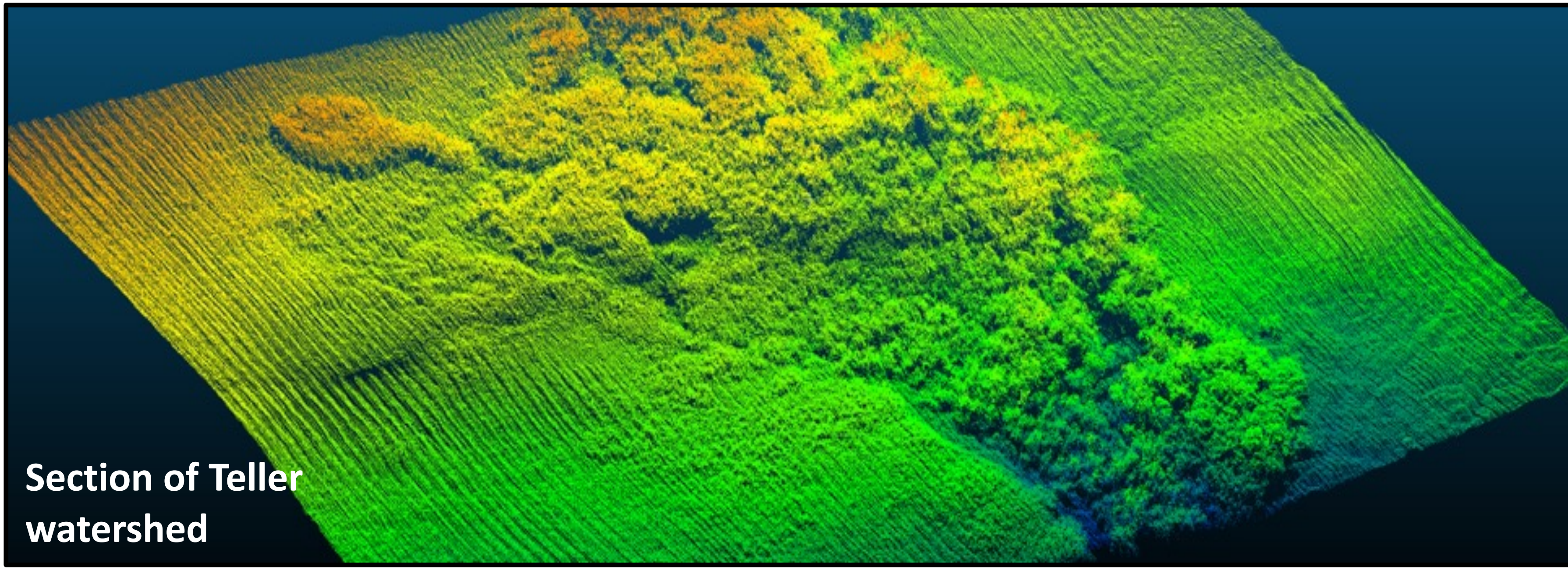
Estimating canopy nitrogen w/ AVIRIS NG



Singh, Serbin et al. [2015] *Eco. Apps;* Serbin et al., [2015] *RSE* *

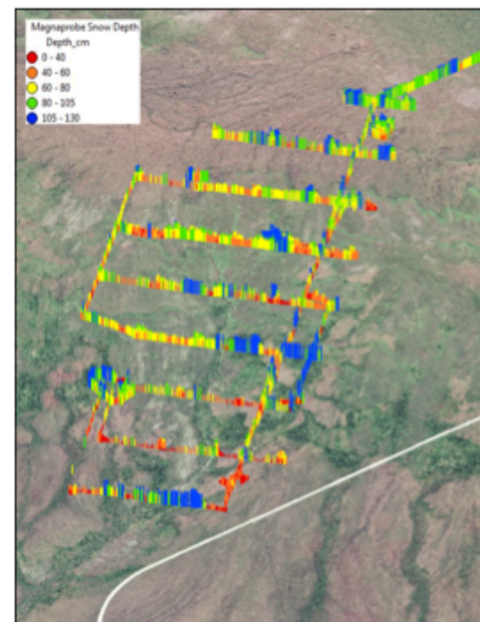
** Martin et al., (2008) *RSE*

Watershed-scale hydrology



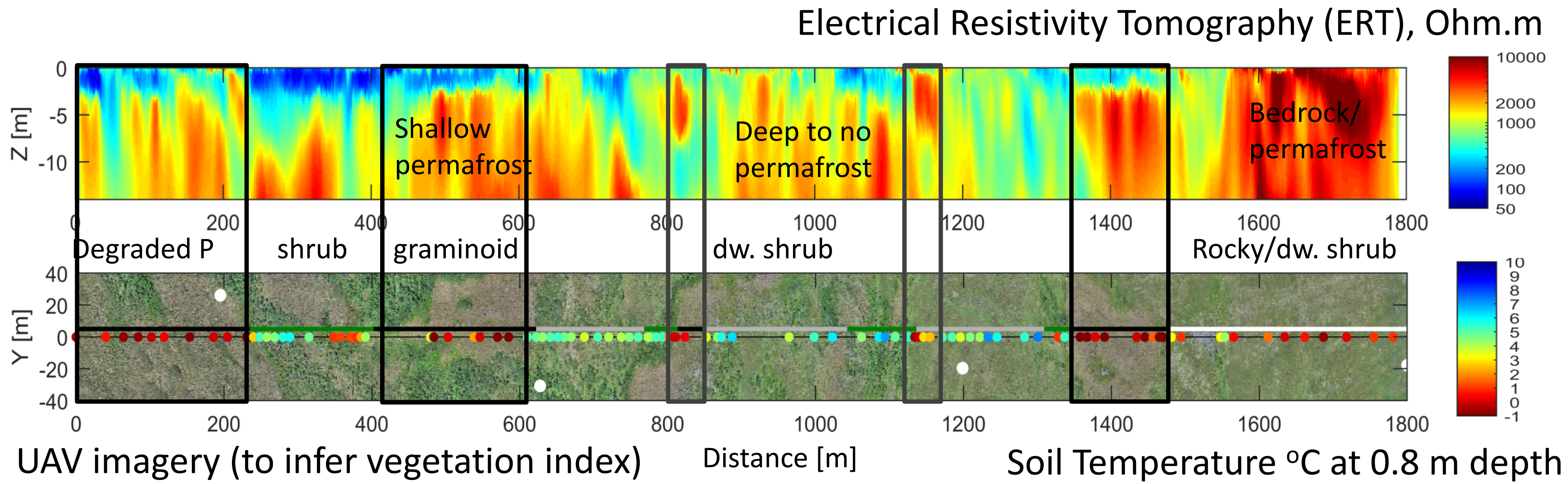
UAS LiDAR surveys

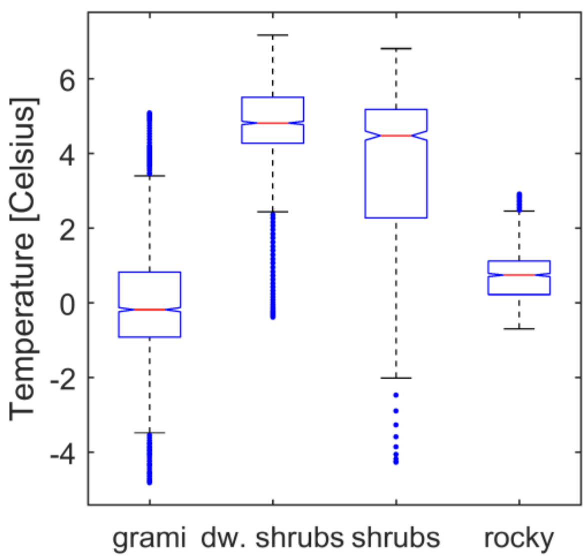
Teller snow surveys

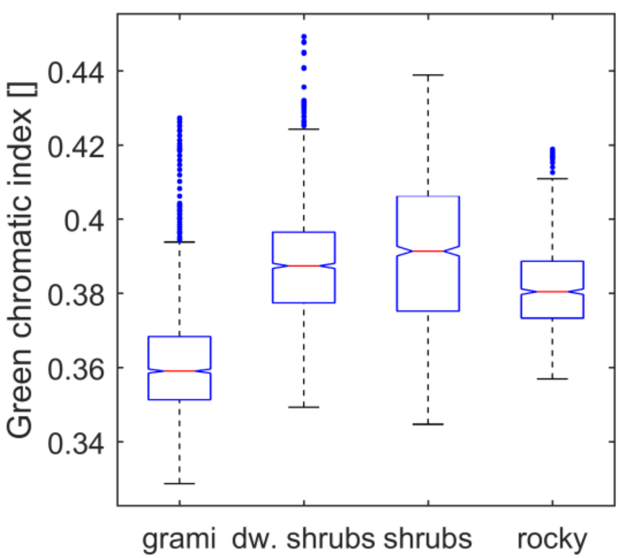


Cathy Wilson's and LANL group

Interaction between soil temperature, plant type, soil wetness and permafrost characteristics







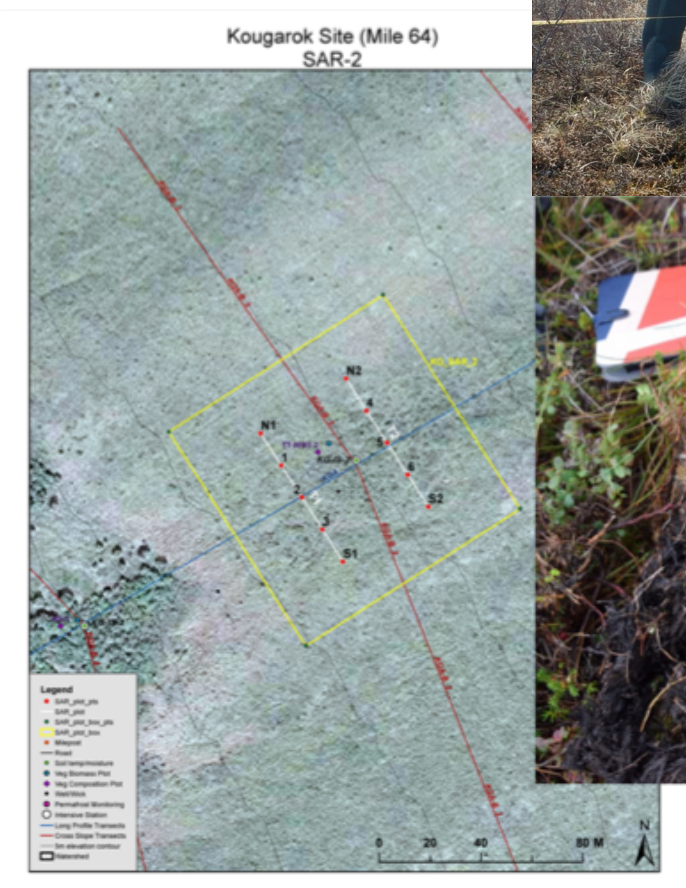
Preliminary results show :

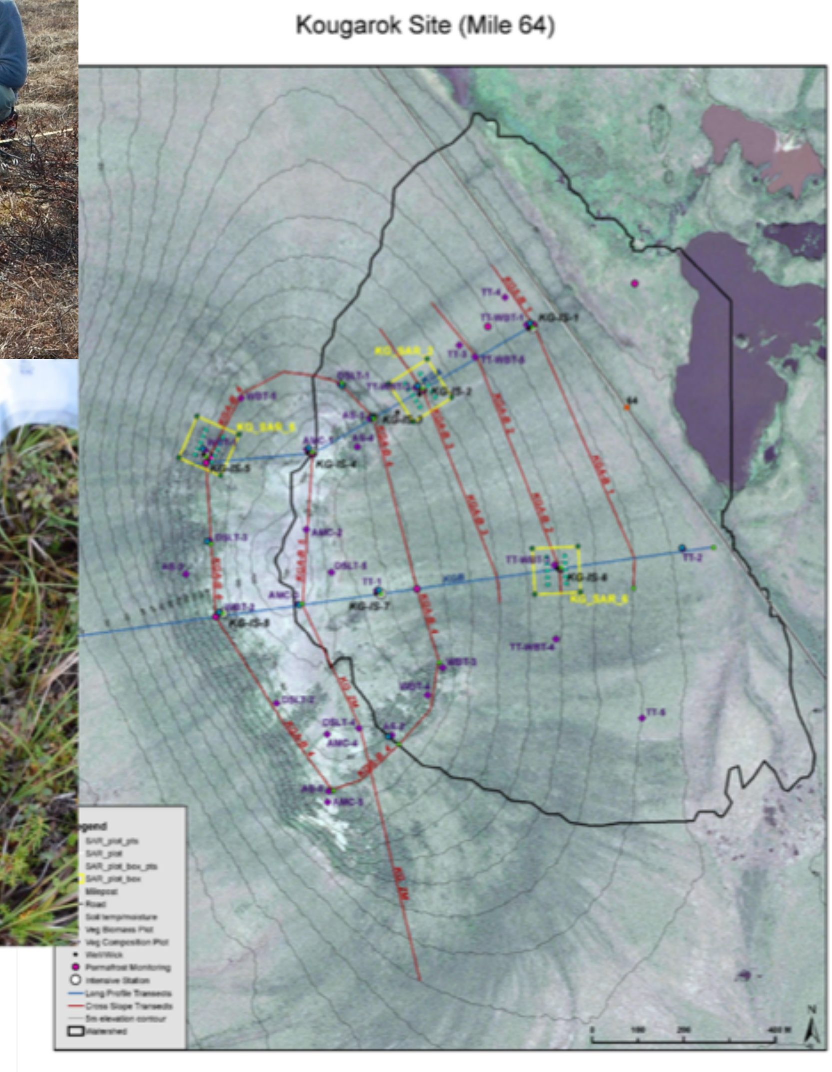
- Shallow permafrost under graminoid areas (cold, wet, low greenness), degraded polygons and edge of solifluction lobes
- Shrubs show complex distribution but generally over deep (with talik) to no permafrost

Dafflon et al., in prep

NASA ABoVE SAR campaign

Cathy Wilson's and LANL group





NASA ABoVE SAR campaign

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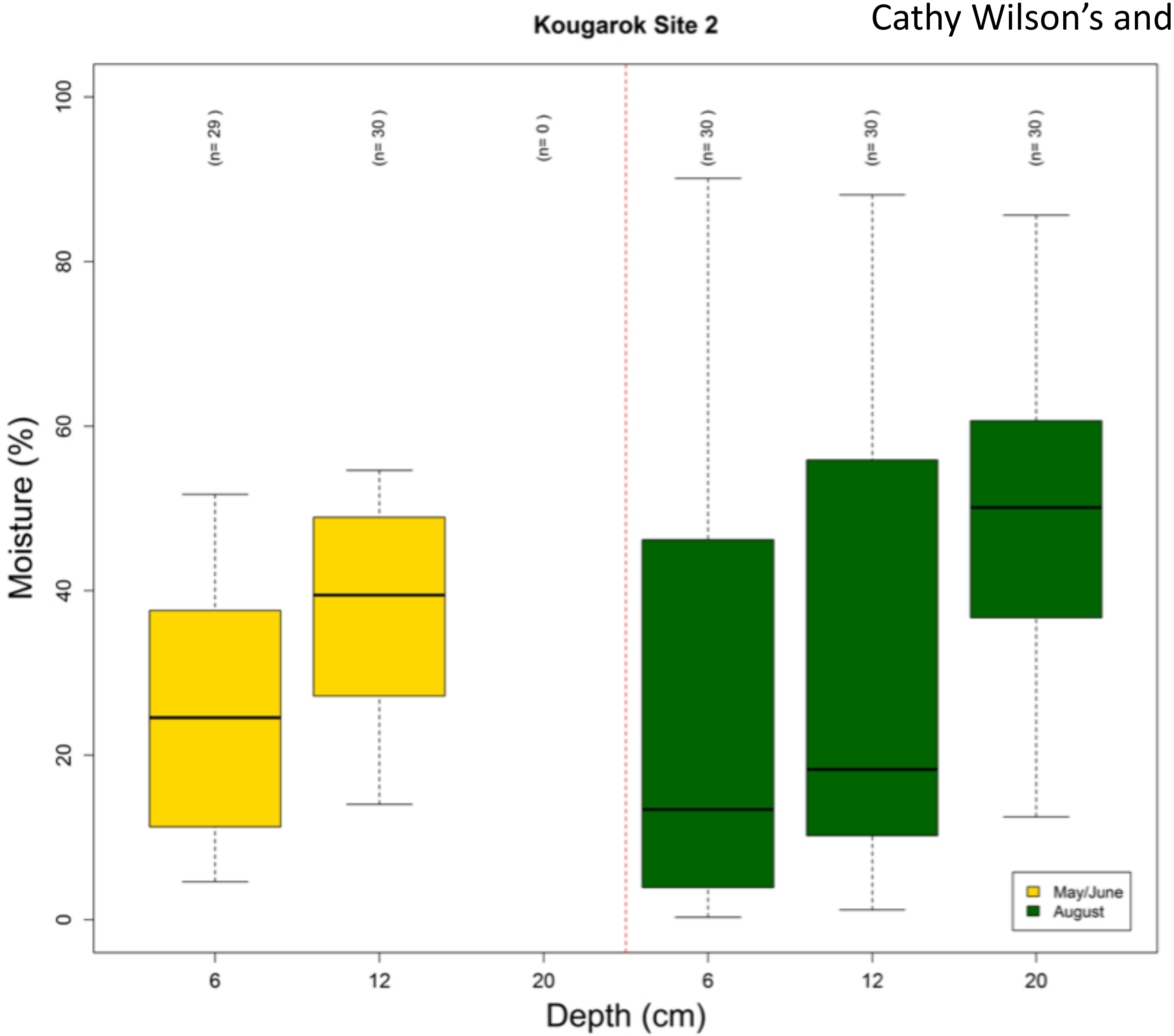

Summary and next steps

- NGEE-Arctic has collected a number of datasets across a range of scales to characterizing patterns in structure and function. Could be leveraged by ABoVE for cross-WG collaborative opportunities
- The 2017 airborne campaign data will be used for mapping and scalng, but critically missing Teller and Kougarok sites. Also Barrow timing was too early for peak biomass. Repeat in ‘18?
- Need to identify key science/knowledge gaps, critical datasets, and continue coordination w/ ABoVE (field and airborne)

On the road to Council, AK