Leaf to Landscape Scale Remote Sensing of Arctic Vegetation Structure and Function

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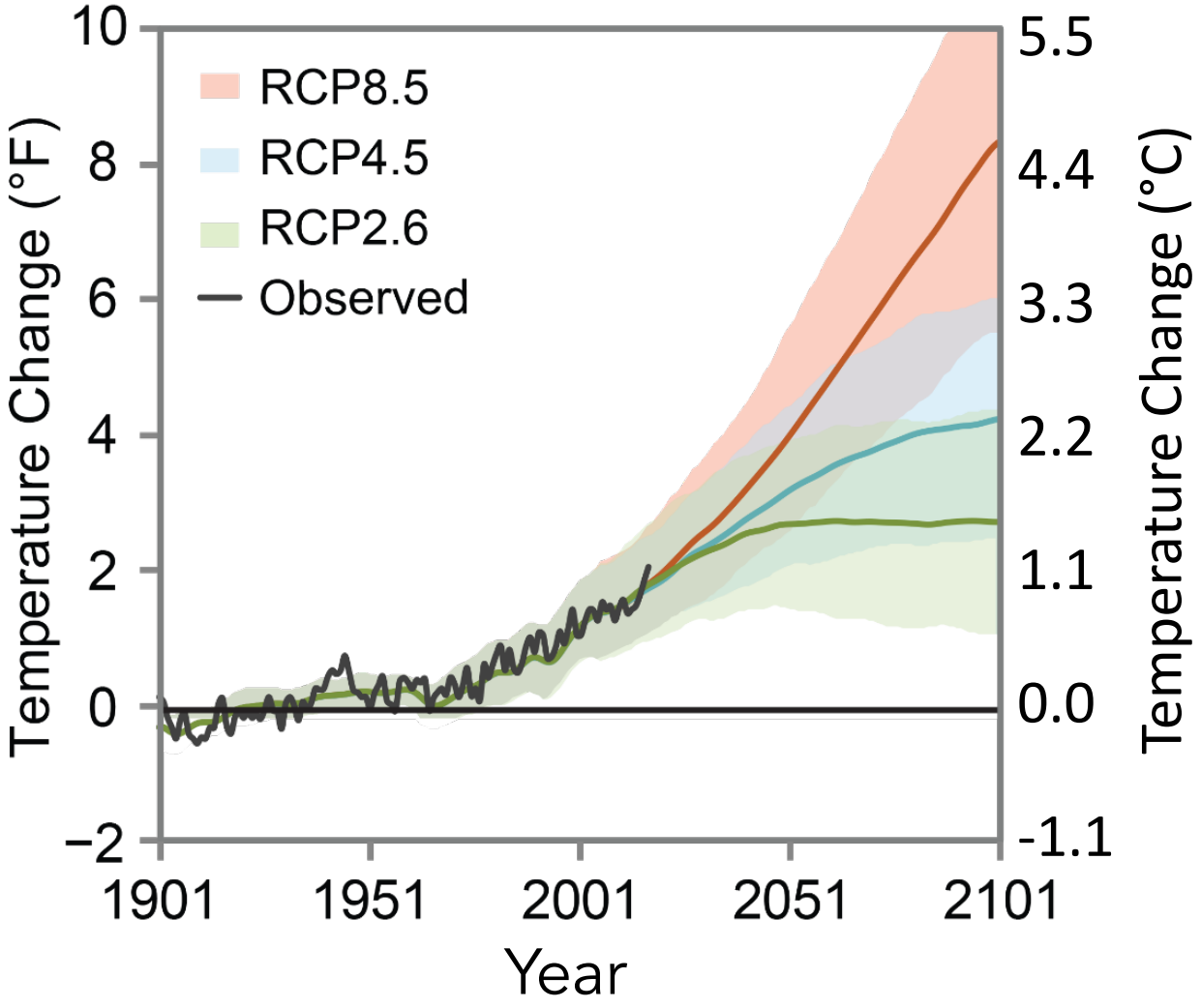
Skookum Pass (Mile, 53 Council Road), Seward Peninsula, Alaska

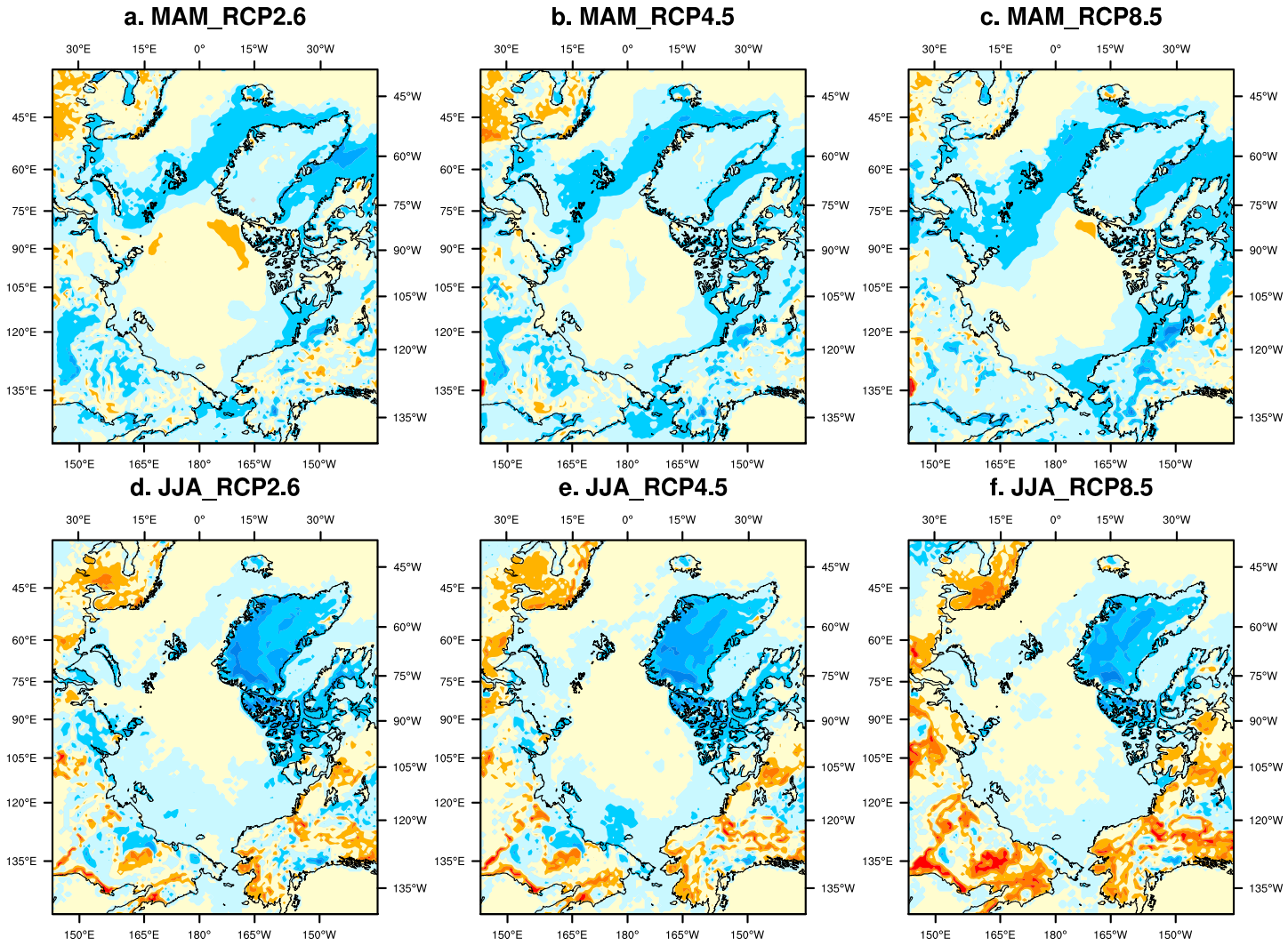
Projected Global Temperature Change Resulting from Different CO_2 Emission Scenarios



Reference period 1901-1960, lines show mean ± 2 S.D. of CMIP5 models

USGCRP (2017)

Biophysical Feedbacks to Climate in the Arctic



Primarily Albedo feedback

Zhang et al. (2018)

Primarily ET feedback

NGEE-Arctic

U.S. DEPARTMENT OF ENERGY

Office of Biological and Environmental Research

Ivotuk, AK

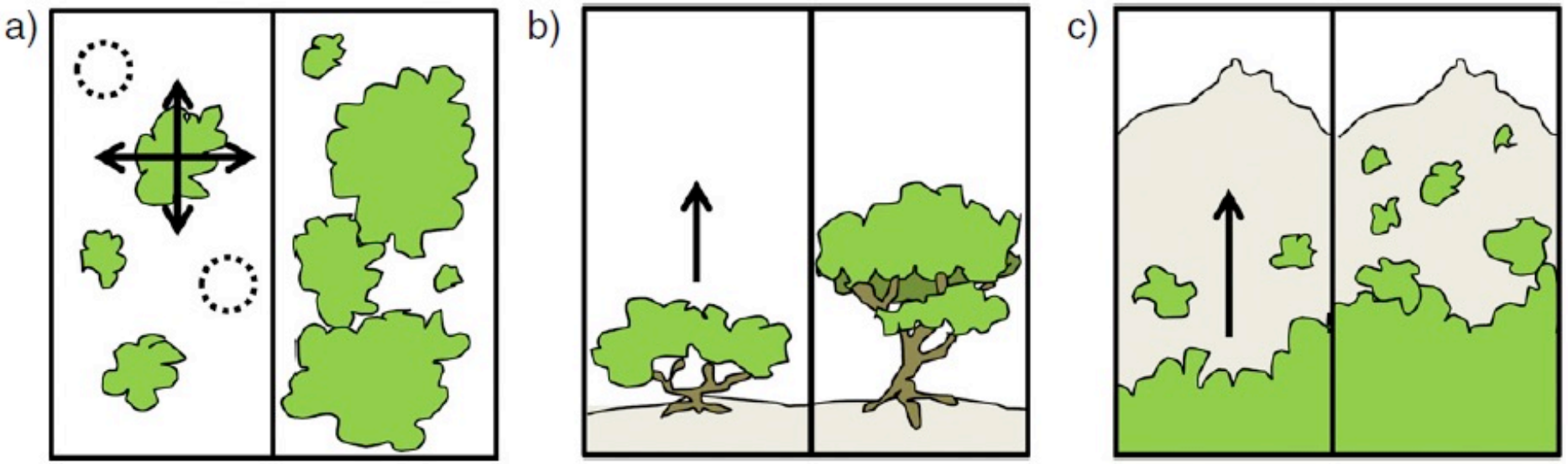
Ten-year project to reduce uncertainty in Earth System Models (ESMs) through the development of a predictive understanding of carbon-rich Arctic ecosystem processes and feedbacks to climate – focusing on:

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

U.S. DEPARTMENT OF ENERGY | OAK RIDGE National Laboratory | Los Alamos NATIONAL LABORATORY | BERKELEY LAB | BROOKHAVEN NATIONAL LABORATORY | UAF UNIVERSITY OF ALASKA FAIRBANKS

Shrub Expansion in the Arctic

Myers-Smith et al. 2011 (*Environmental Research Letters*)



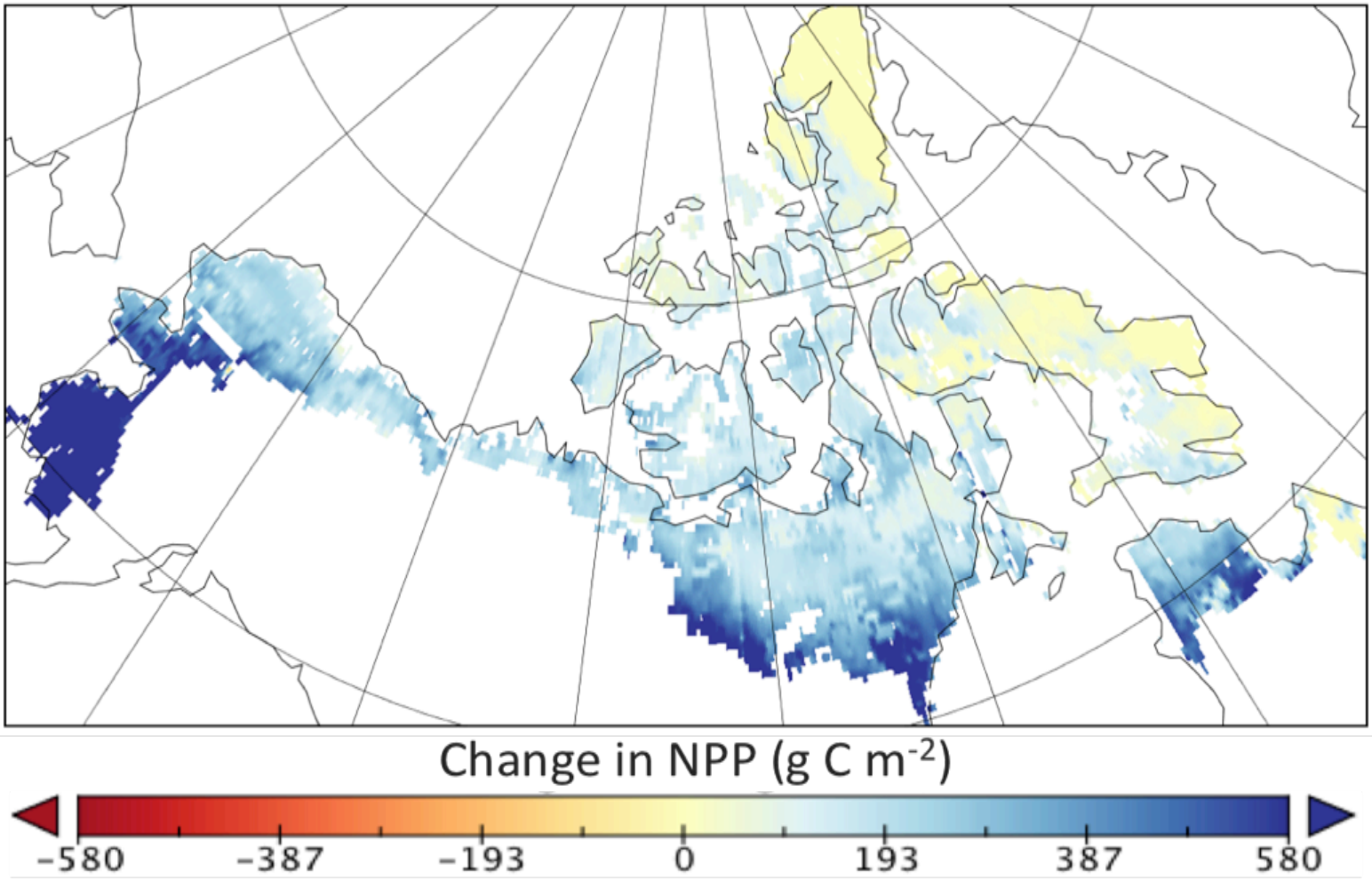
Infilling

Growth

Migration of existing shrubline

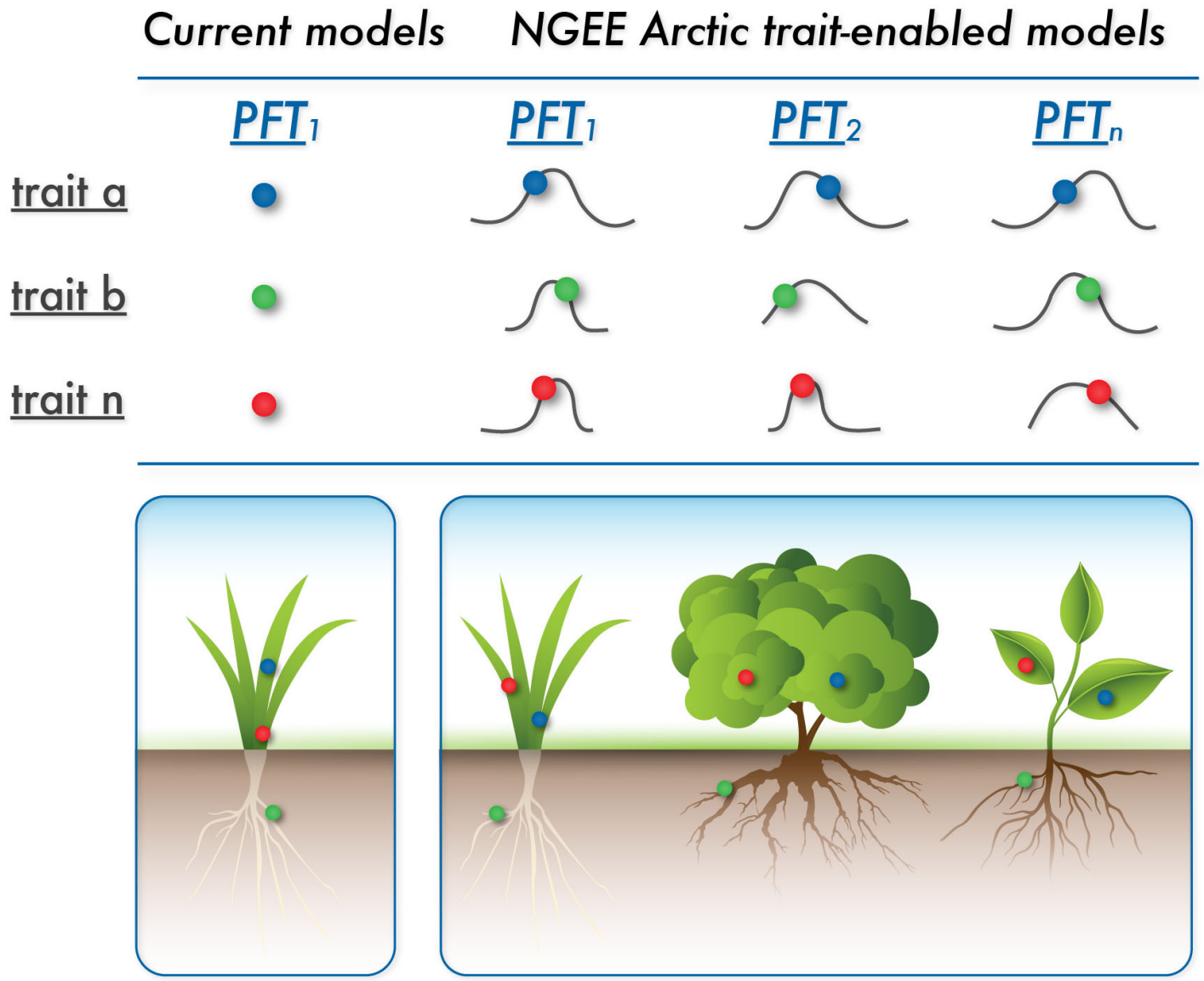
Shrub Expansion in the Arctic

Change in Shrub Net Primary Productivity (NPP)
2100 – 2010 (*ecosys* model, RCP8.5)

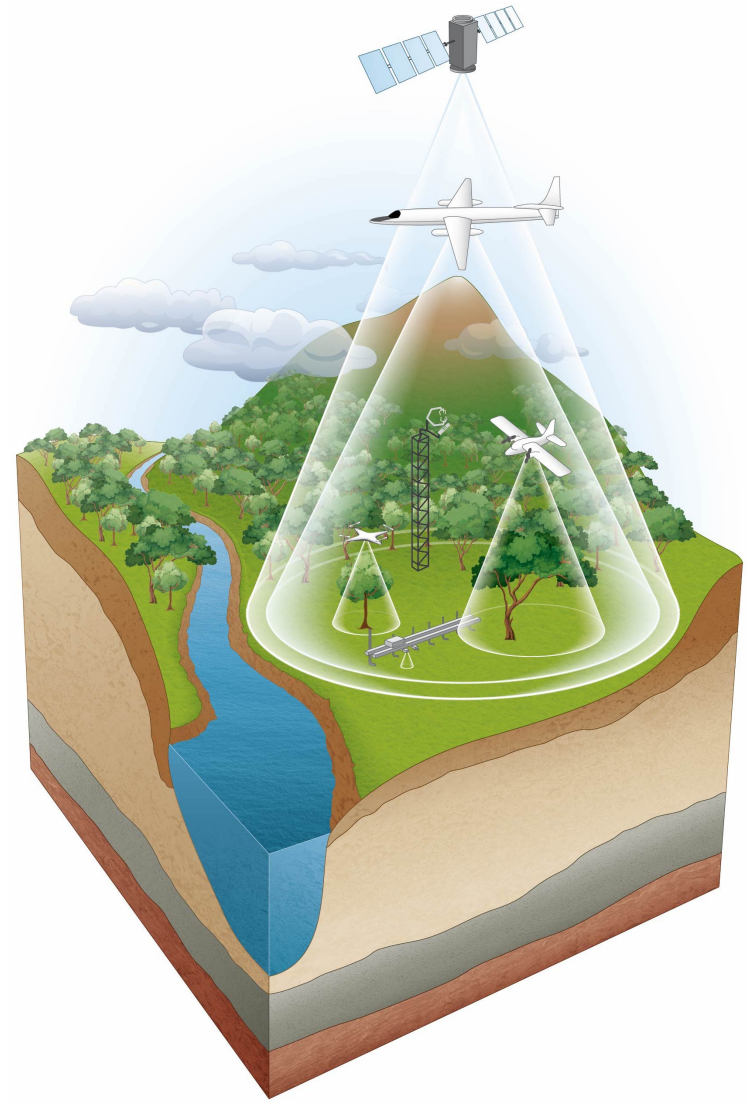


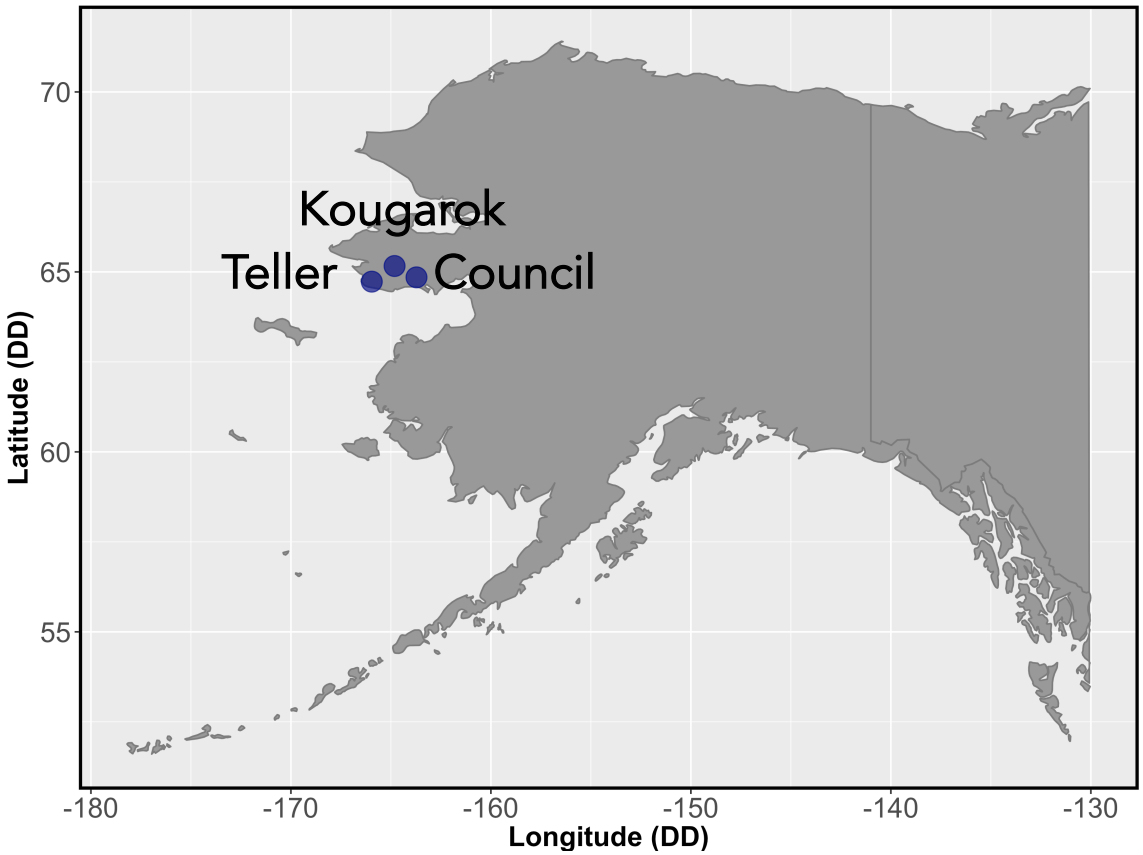
Mekonnen, Riley, and Grant, 2018 (*Global Change Biology*)

Improving Model Parameterization



Multi-scale Remote Sensing of Arctic Vegetation to Inform Modeling



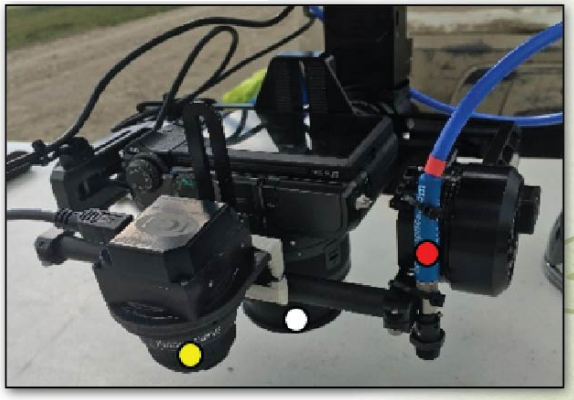


Unmanned Aerial Systems (UASs)

(I) *Osprey* UAS

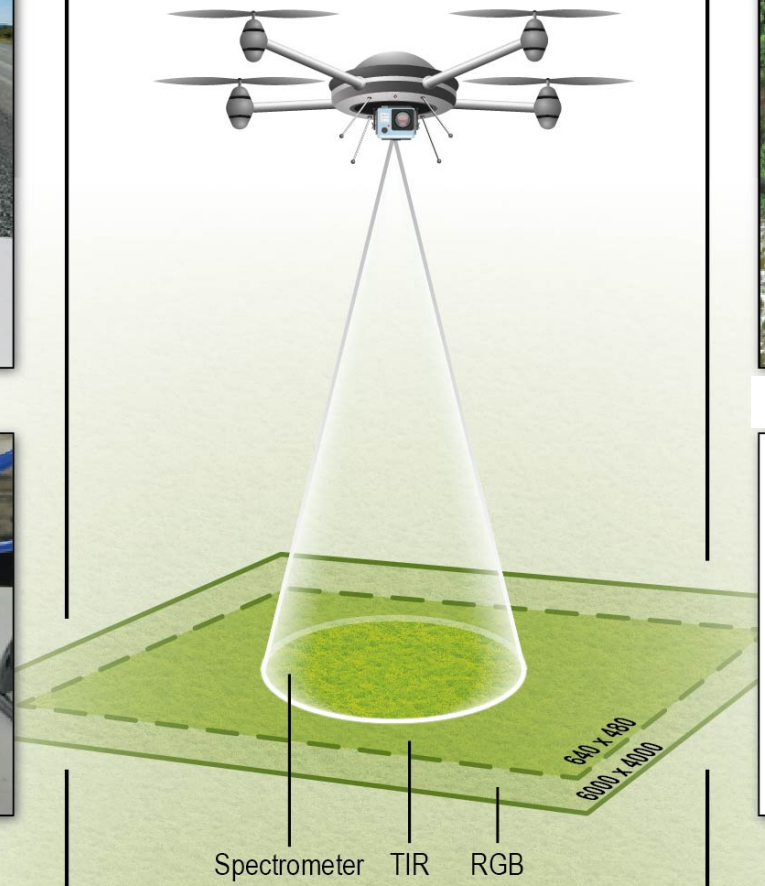
(a) UAS Platform

(b) Multi-sensors



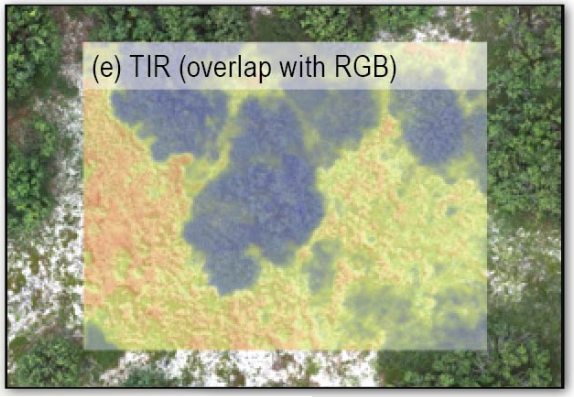
(II) Sensor Footprints

(c) Images & spectra

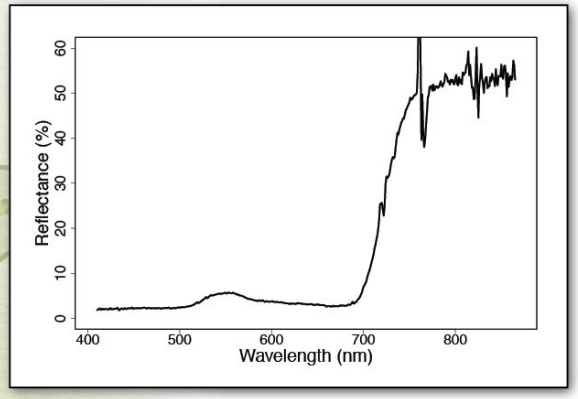


(III) UAS Data Products

(d) RGB & TIR imagery



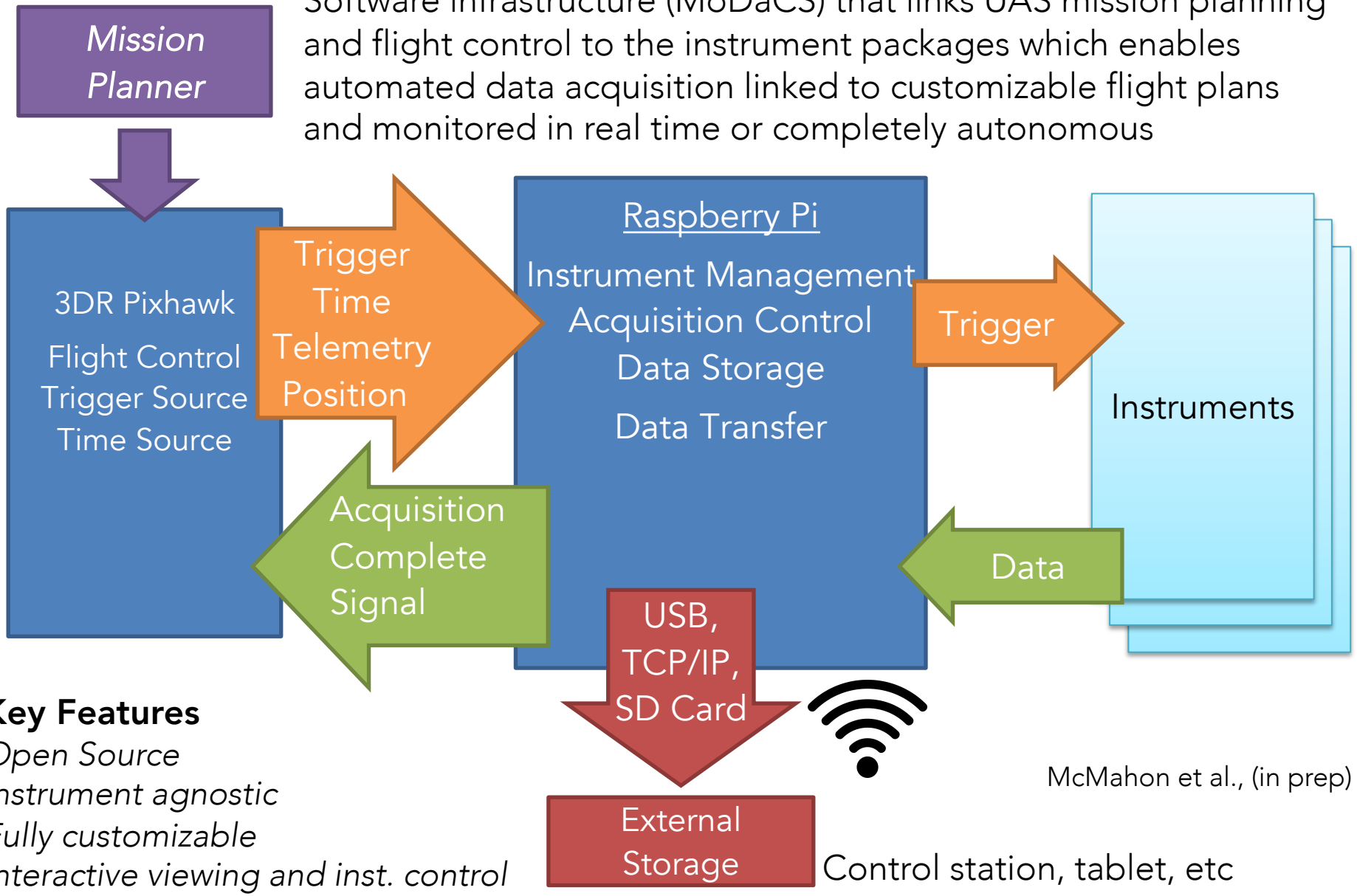
(F) Reflectance spectra



Meng et al., in prep

UAS data acquisition & flight management

Software infrastructure (MoDaCS) that links UAS mission planning and flight control to the instrument packages which enables automated data acquisition linked to customizable flight plans and monitored in real time or completely autonomous

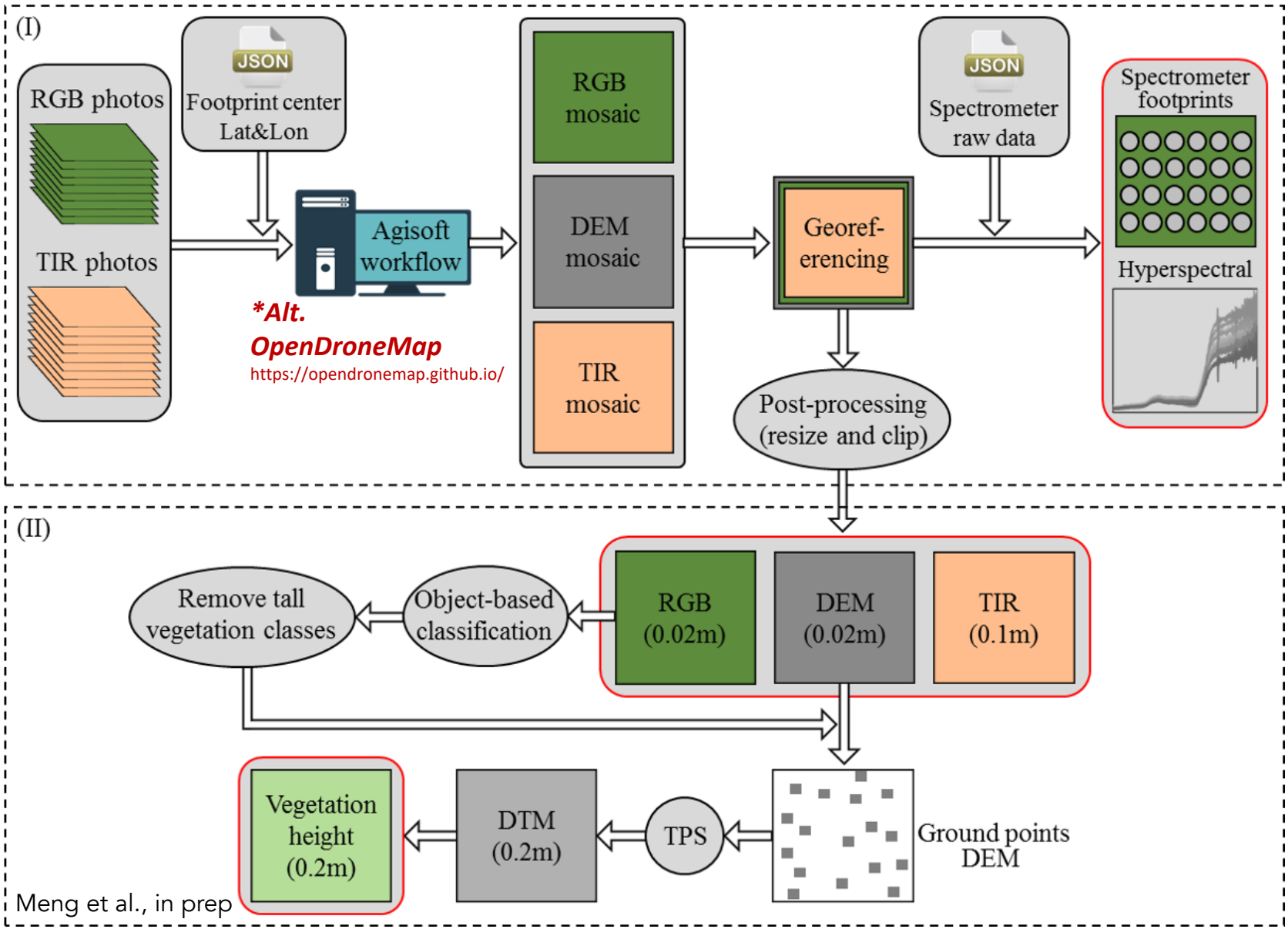


Key Features

Open Source
Instrument agnostic
Fully customizable
Interactive viewing and inst. control

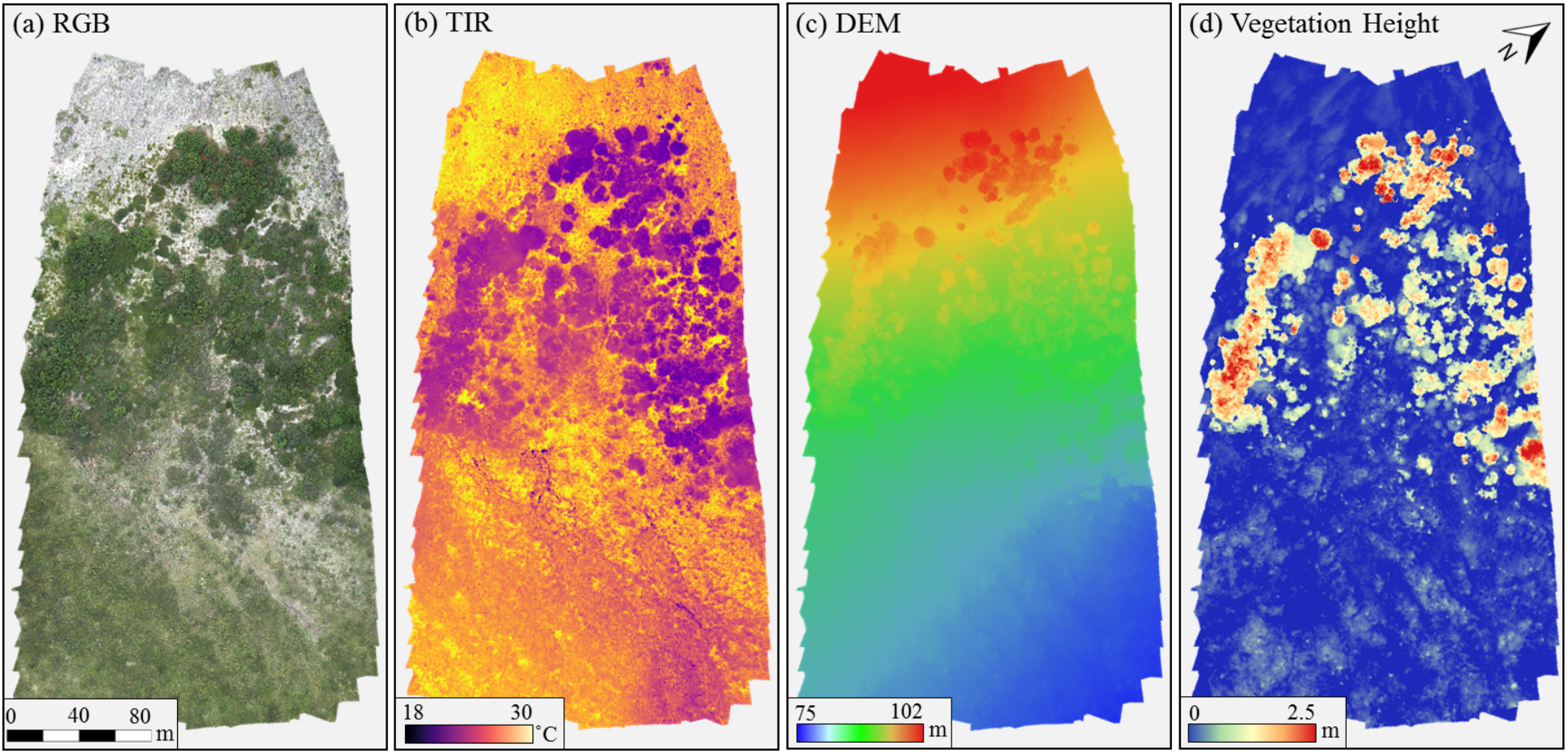
McMahon et al., (in prep)

UAS Data Processing Workflow



UAS Remote Sensing of Arctic Vegetation

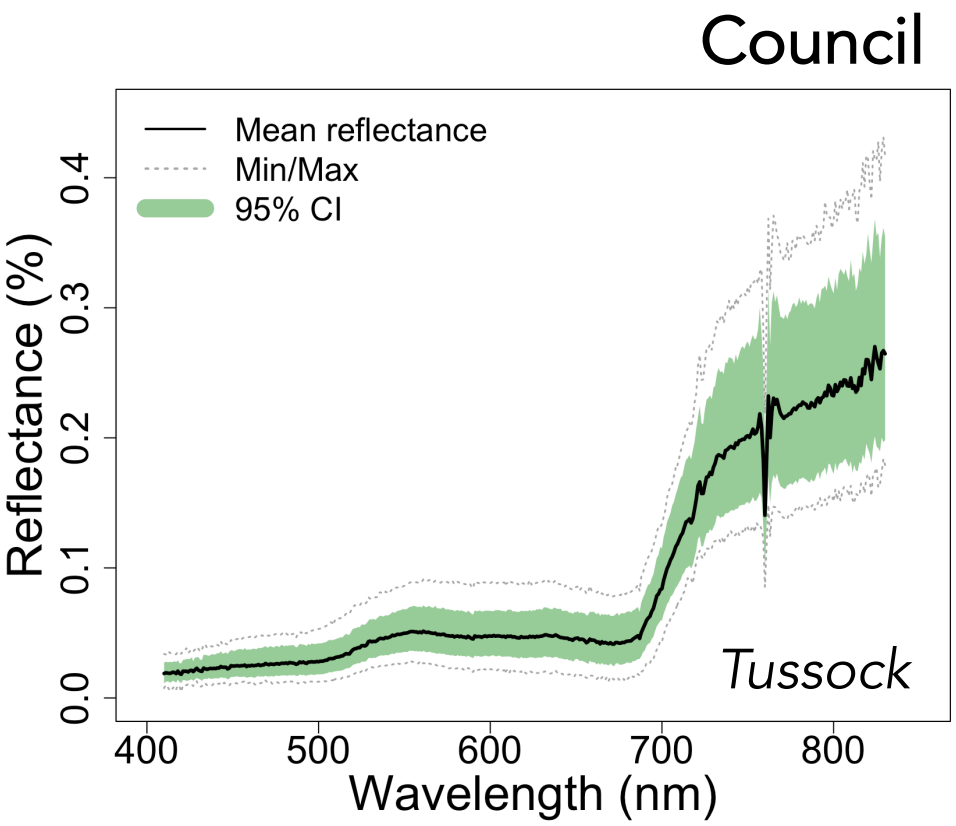
Kougarok

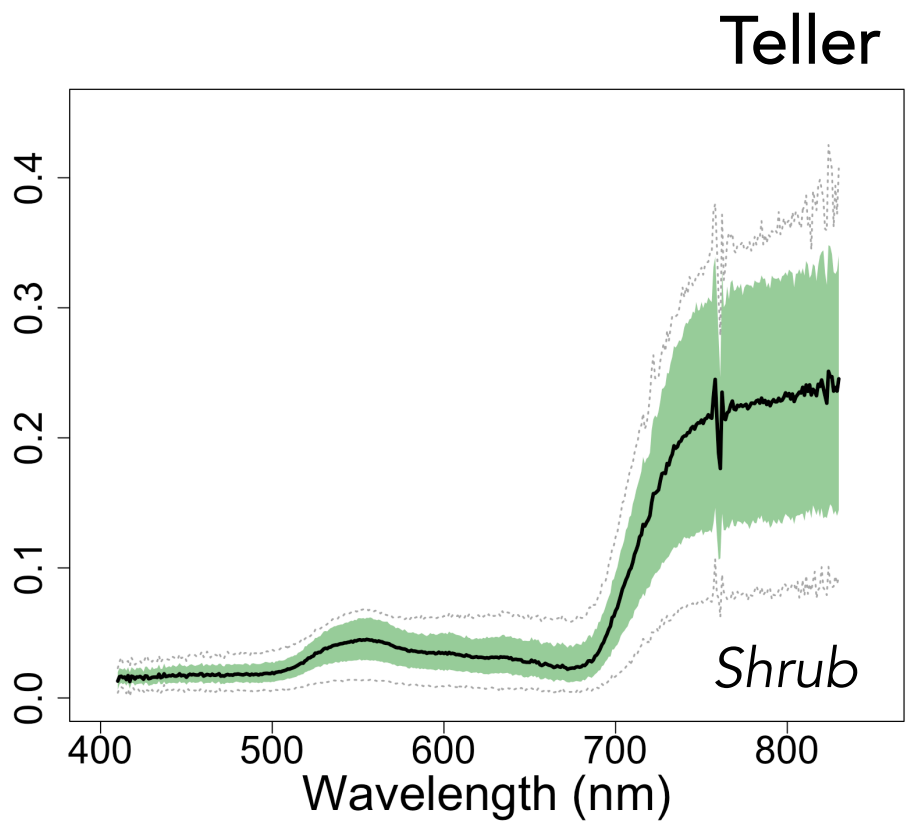


Imaging systems (RGB & TIR) generate high resolution ortho-mosaic imagery and a corresponding digital elevation model (DEM) from SfM. We then calculate vegetation height using the DEM and an interpolated digital terrain model (DTM)

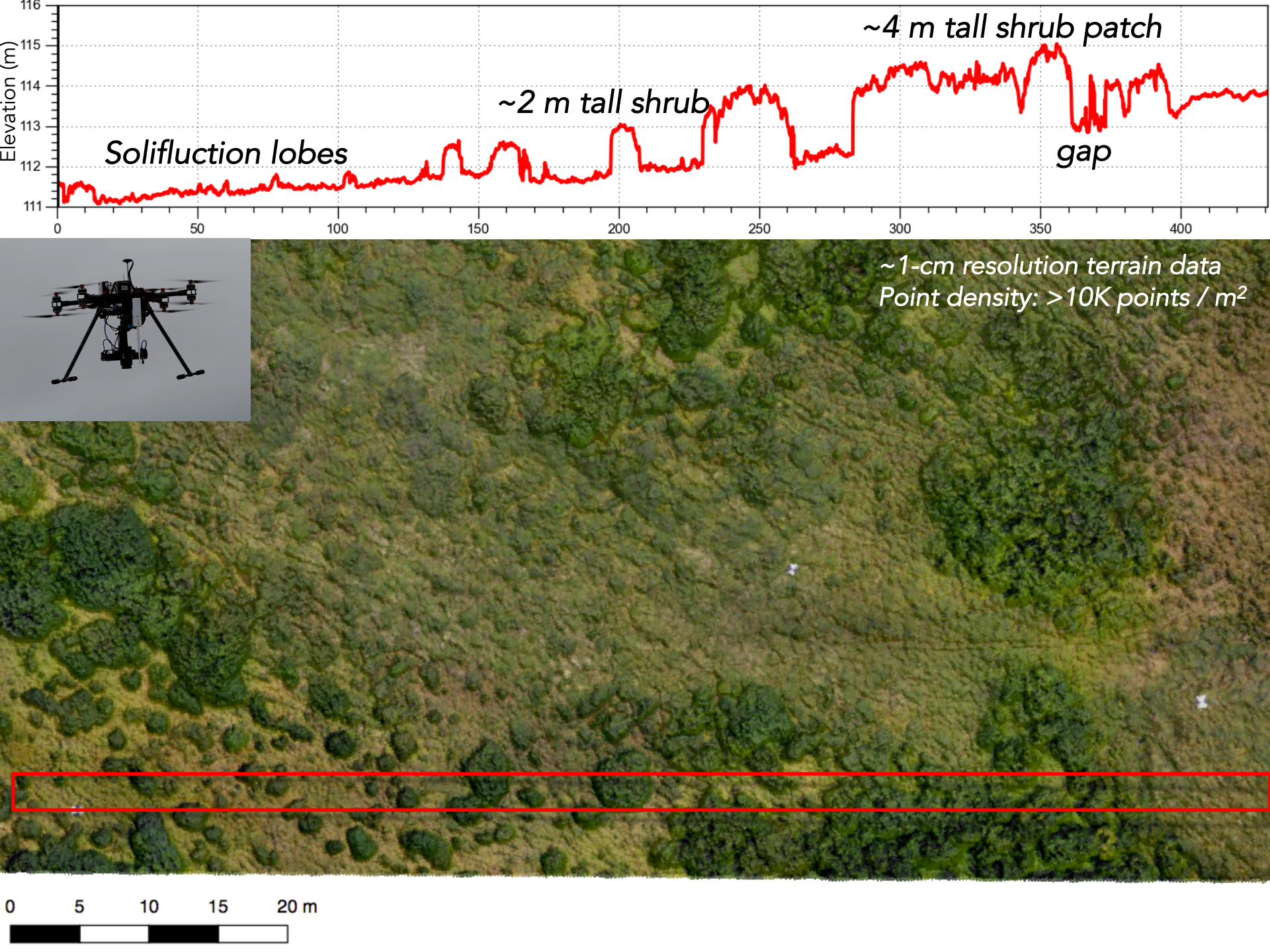
Meng et al., in prep

UAS Remote Sensing of Arctic Vegetation

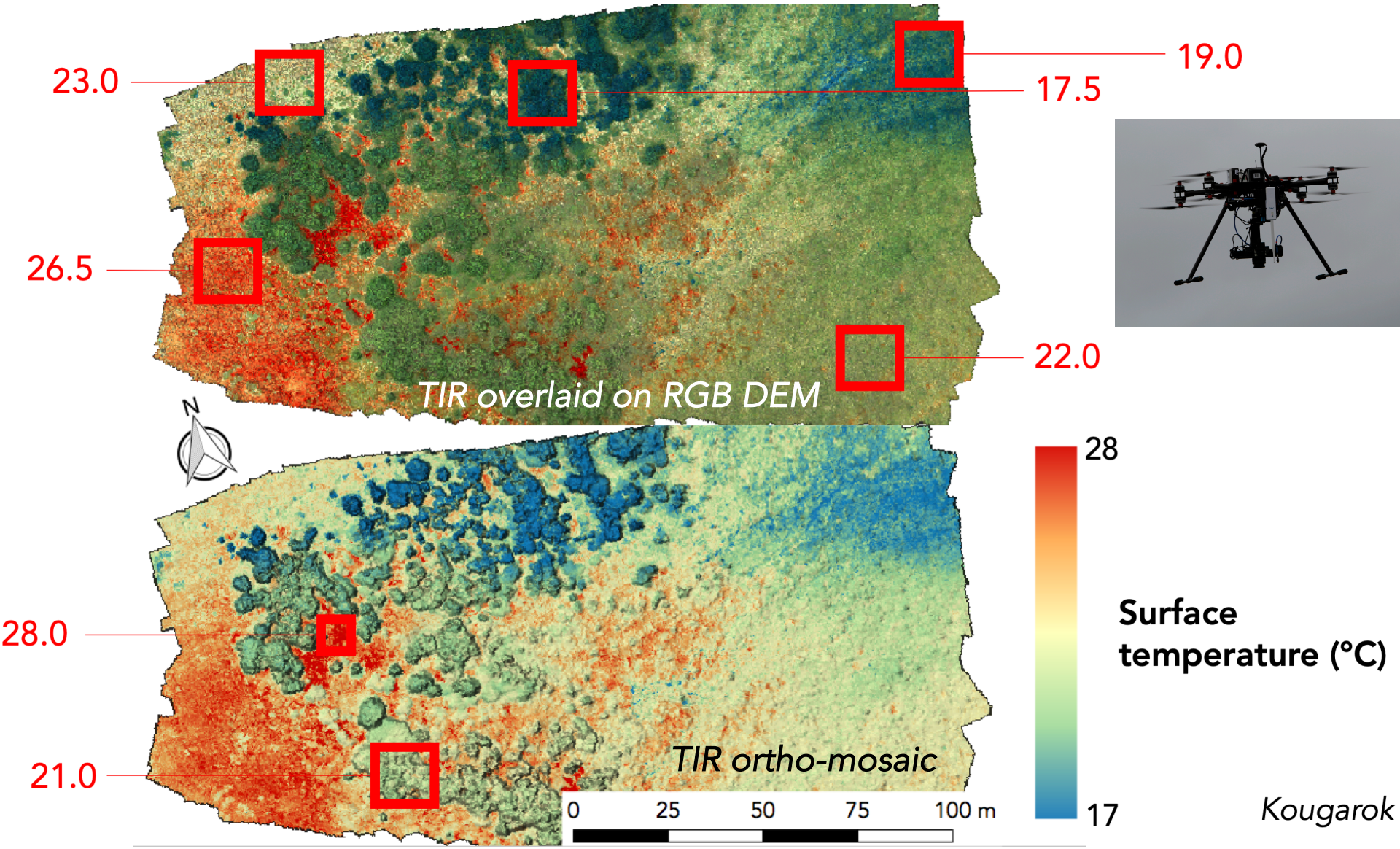




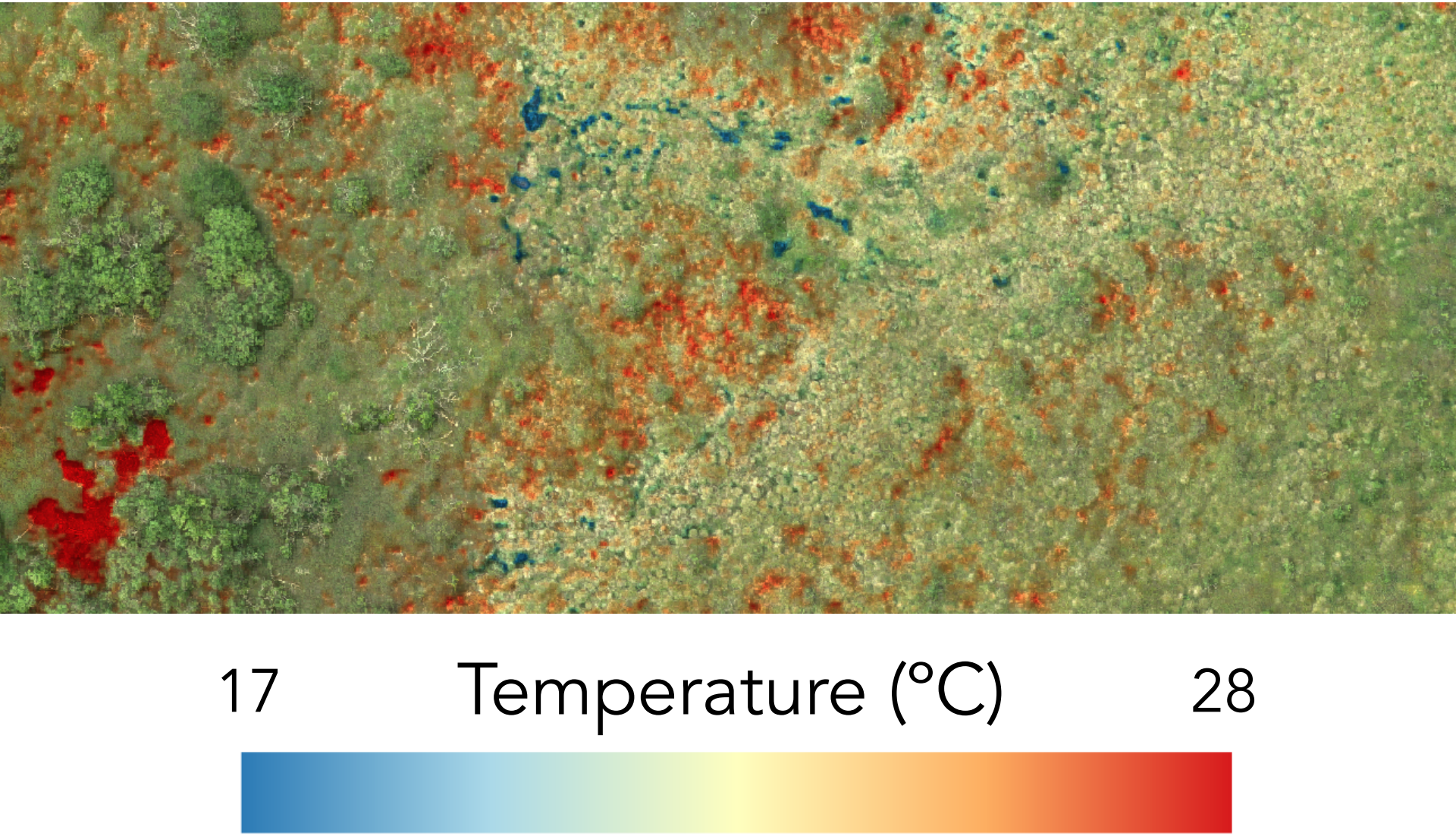
We are measuring the variation in surface reflectance across each UAS flight using our dual OceanOptics FLAME spectrometer configuration, which can account for variable illumination conditions


Elevation (m)
116
115
114
113
112
111
0
50
100
150
200
250
300
350
400
~4 m tall shrub patch
~2 m tall shrub
Solifluction lobes
gap
~1-cm resolution terrain data
Point density: >10K points / m²
0
5
10
15
20 m

Spatial Variation in Surface Temperature

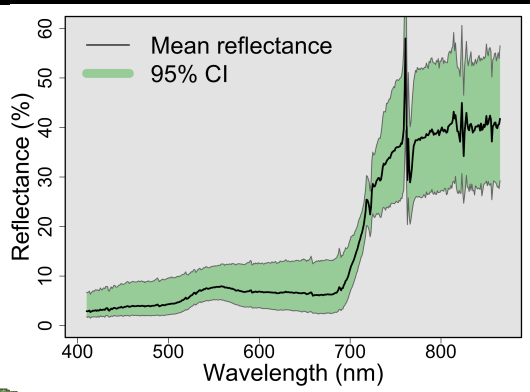


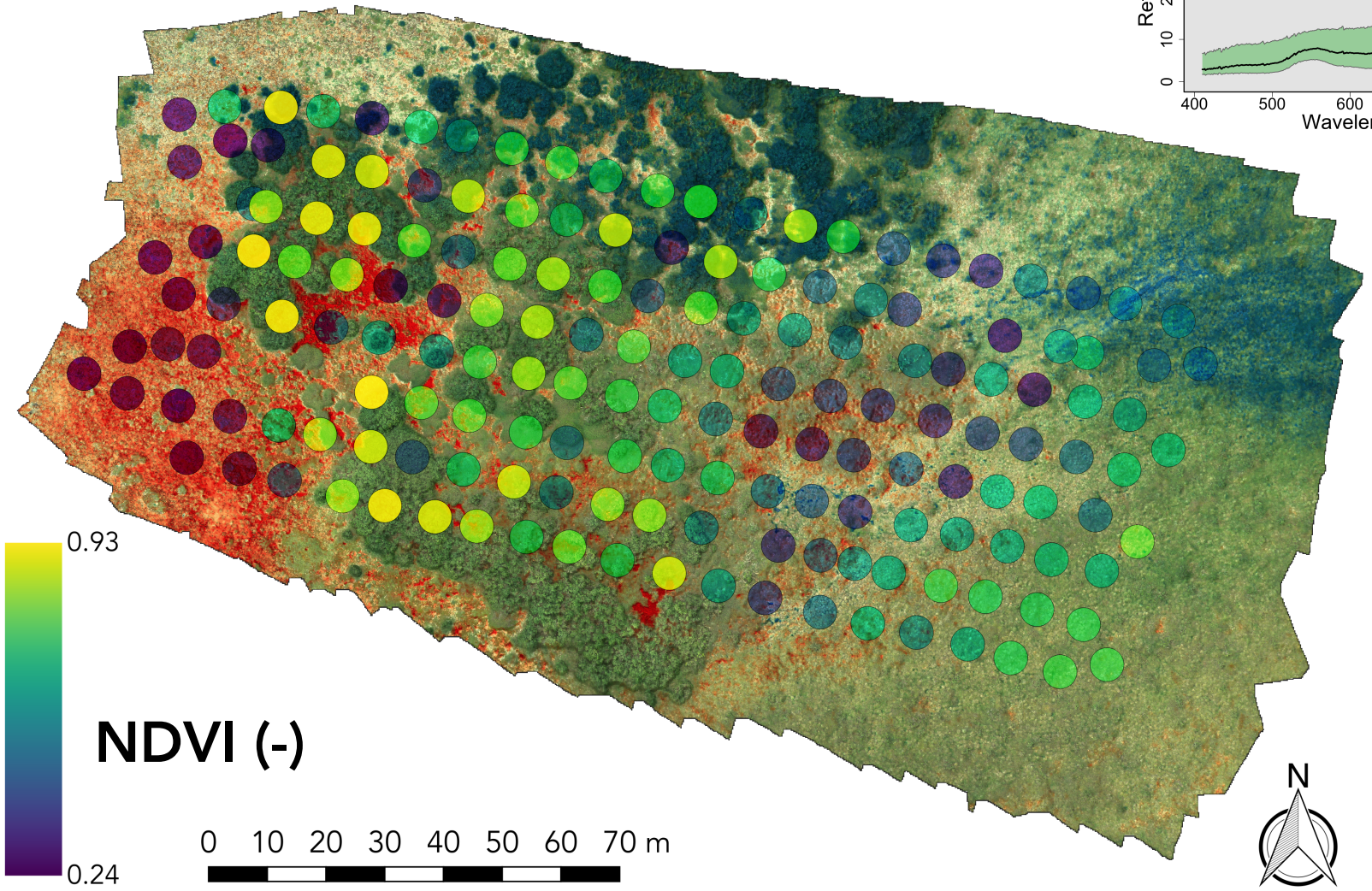
Fine-scale Temperature Variation – Driven by Vegetation Composition & Structure



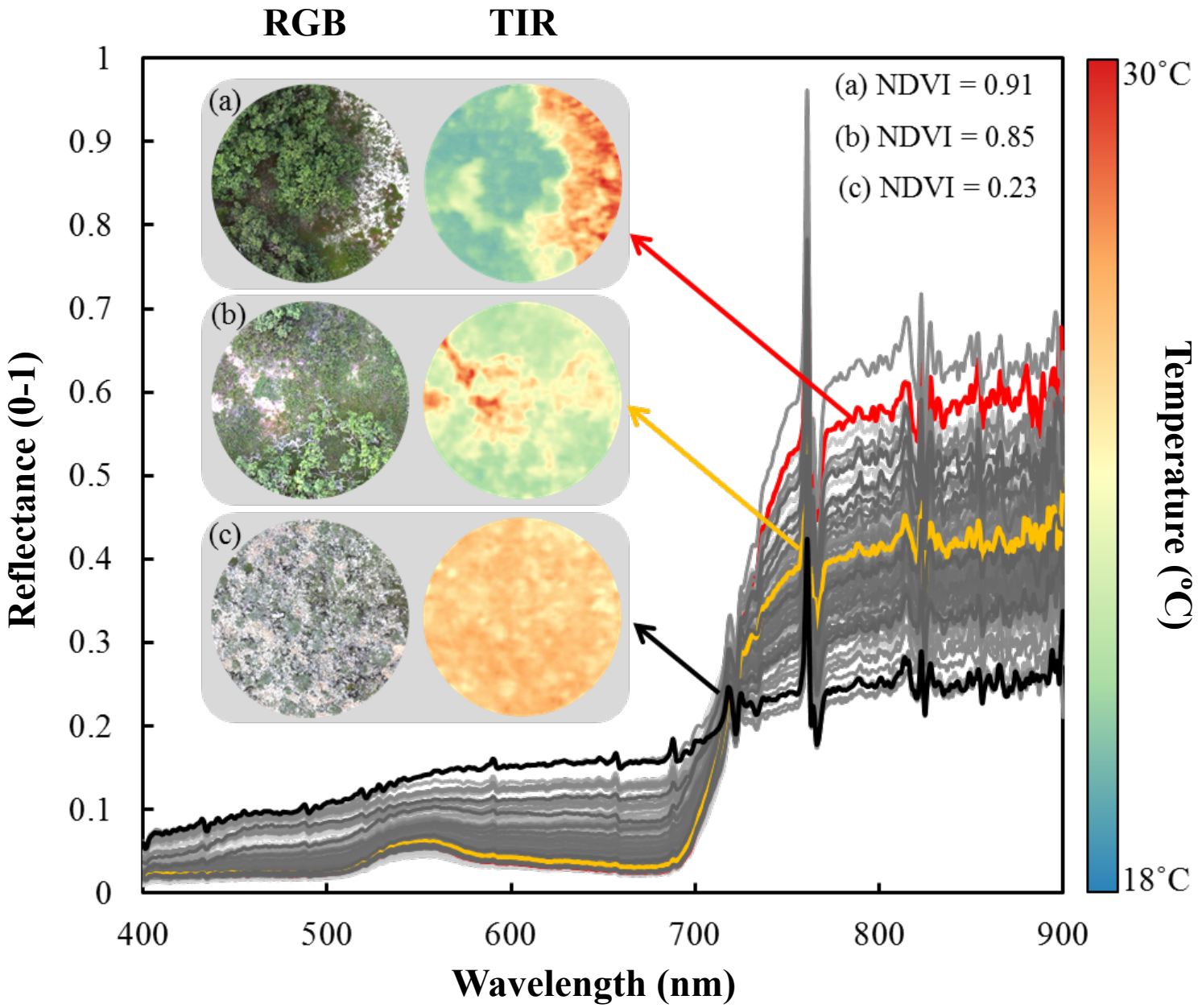
Landscape Variation in Vegetation Optical Properties

Higher surface reflectance in shrub dominated areas

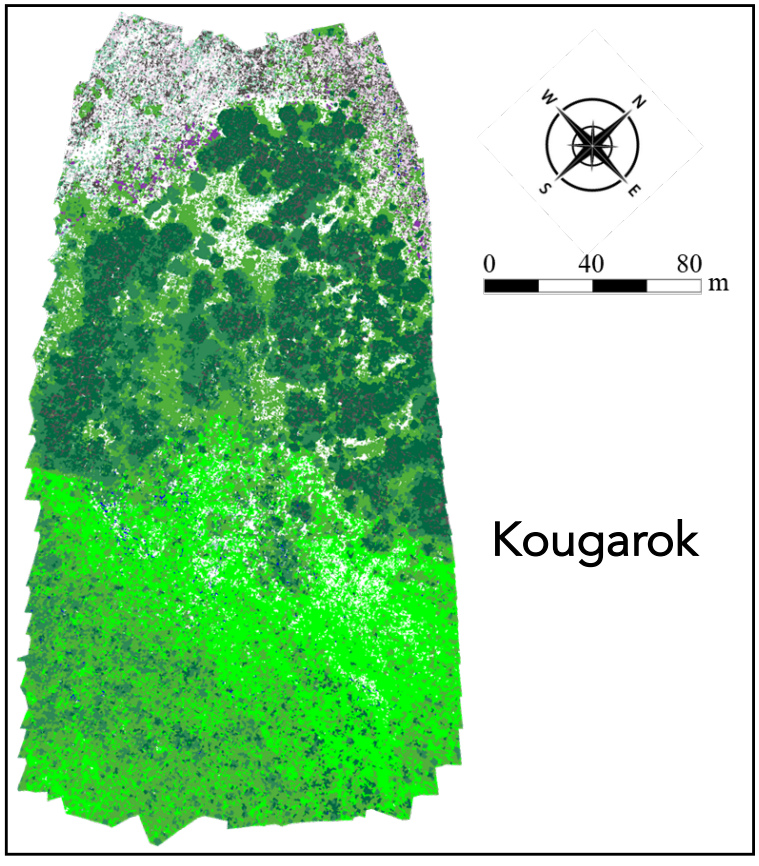


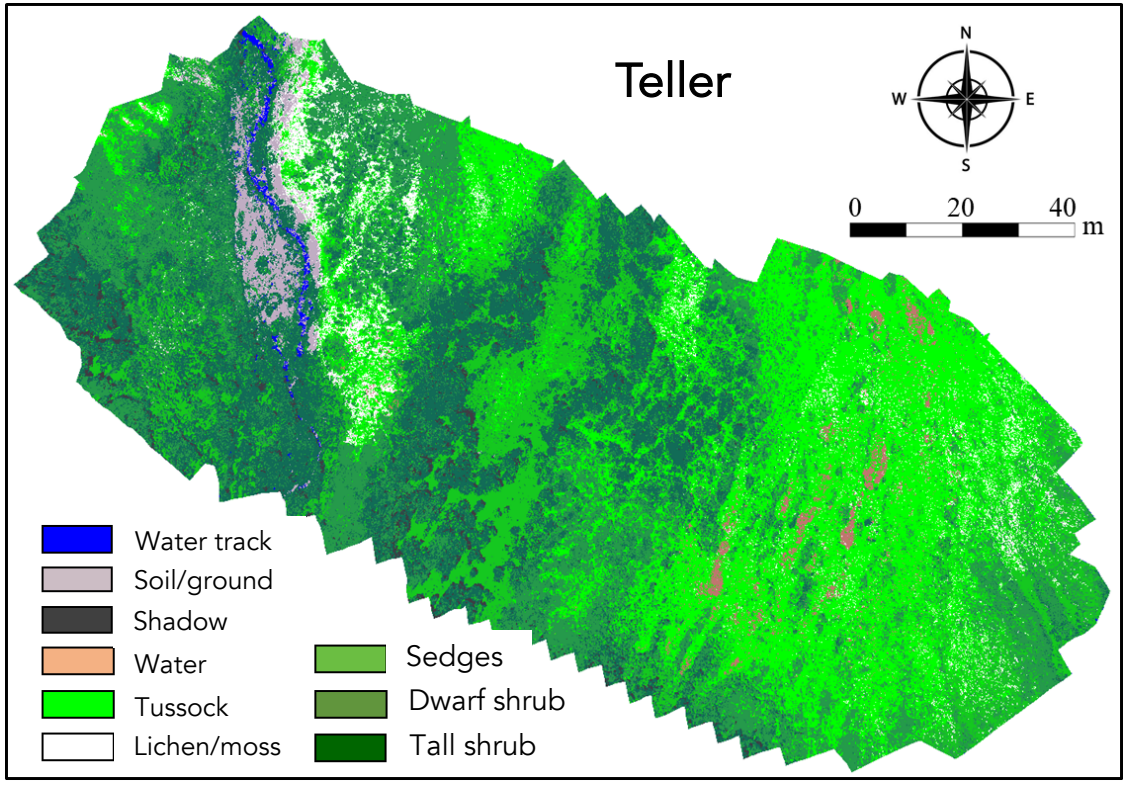


Multi-sensor Vegetation Characterization



Mapping Species Composition at Fine Scales





Alder

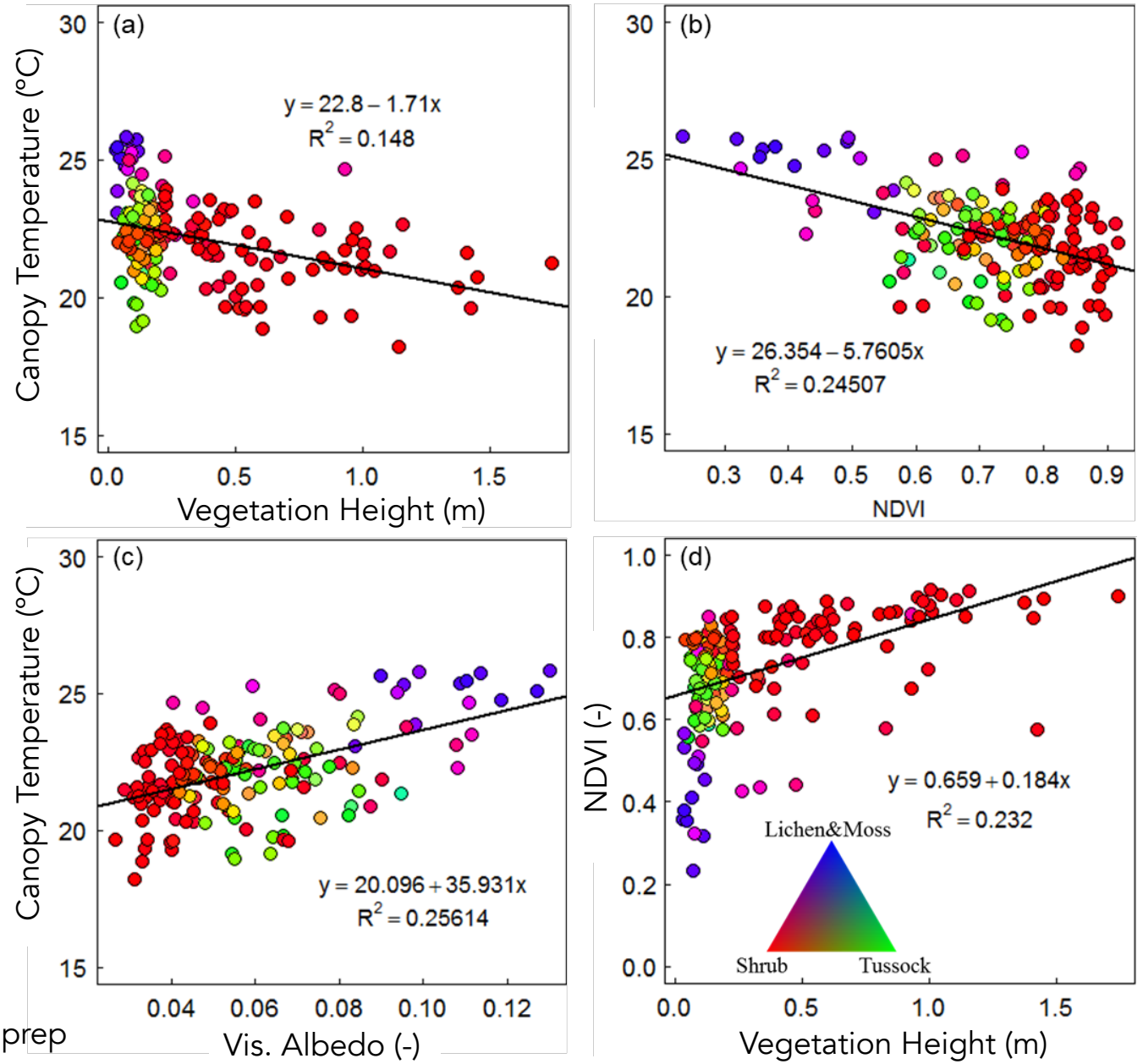
Birch

Willow

Tussock

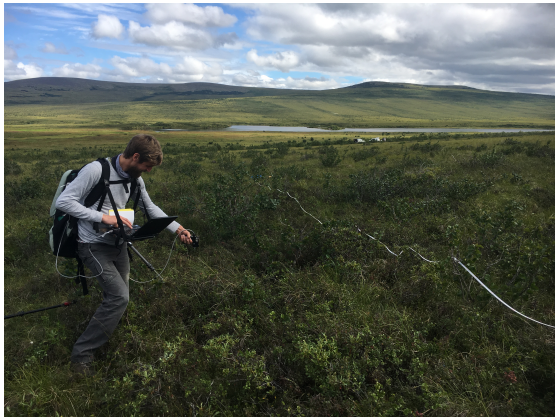
Lichen

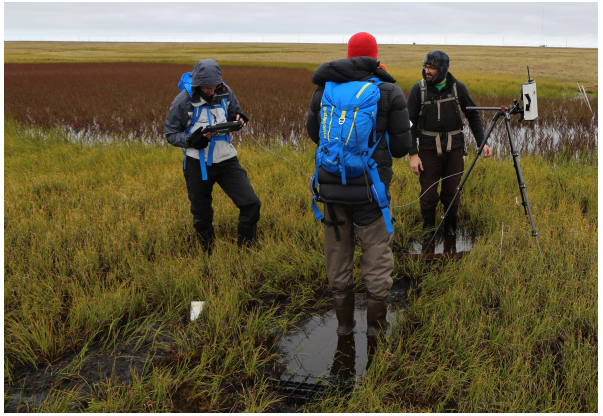
Spatial Patterns Driven by Species Composition & Structure

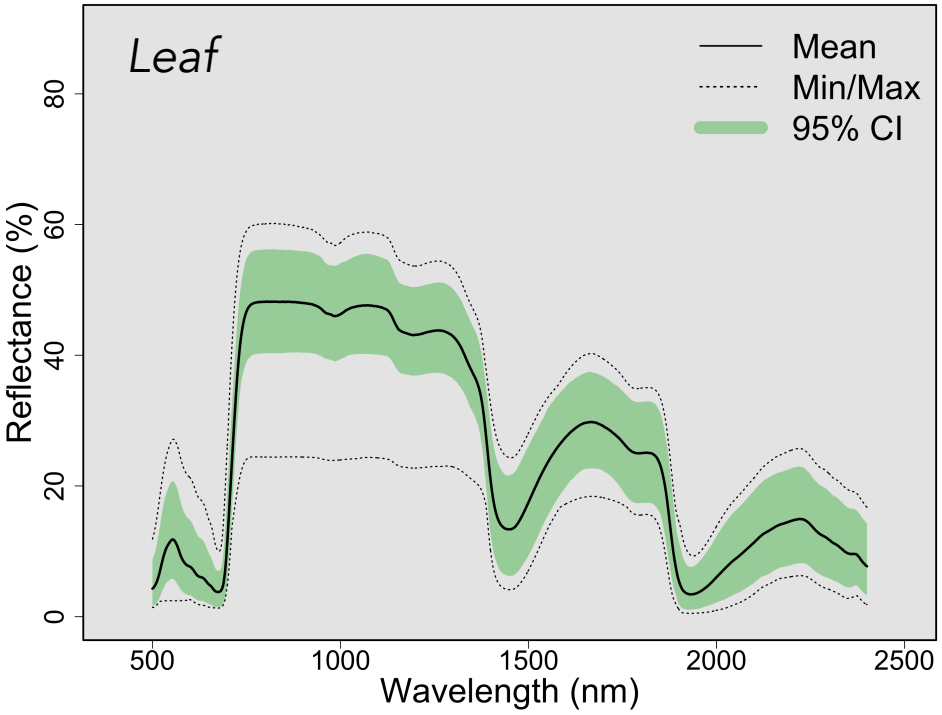


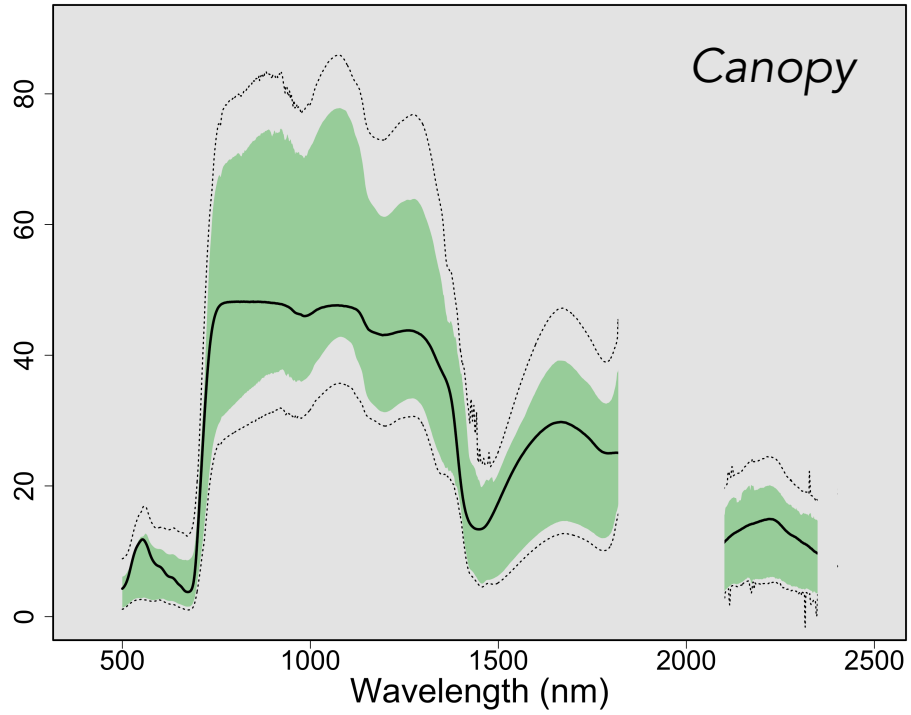
Meng et al., in prep

Scaling Arctic Vegetation Functional Traits

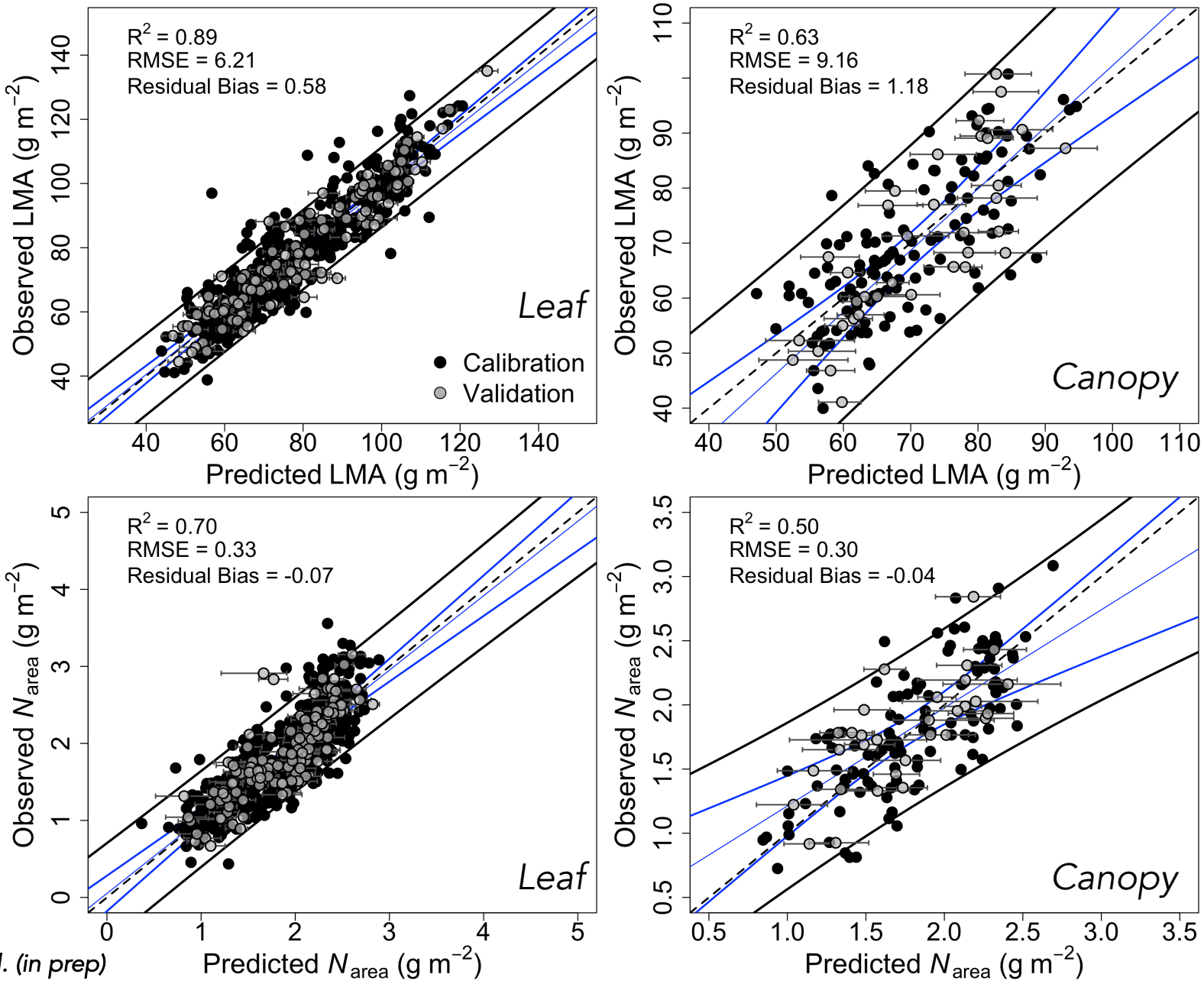






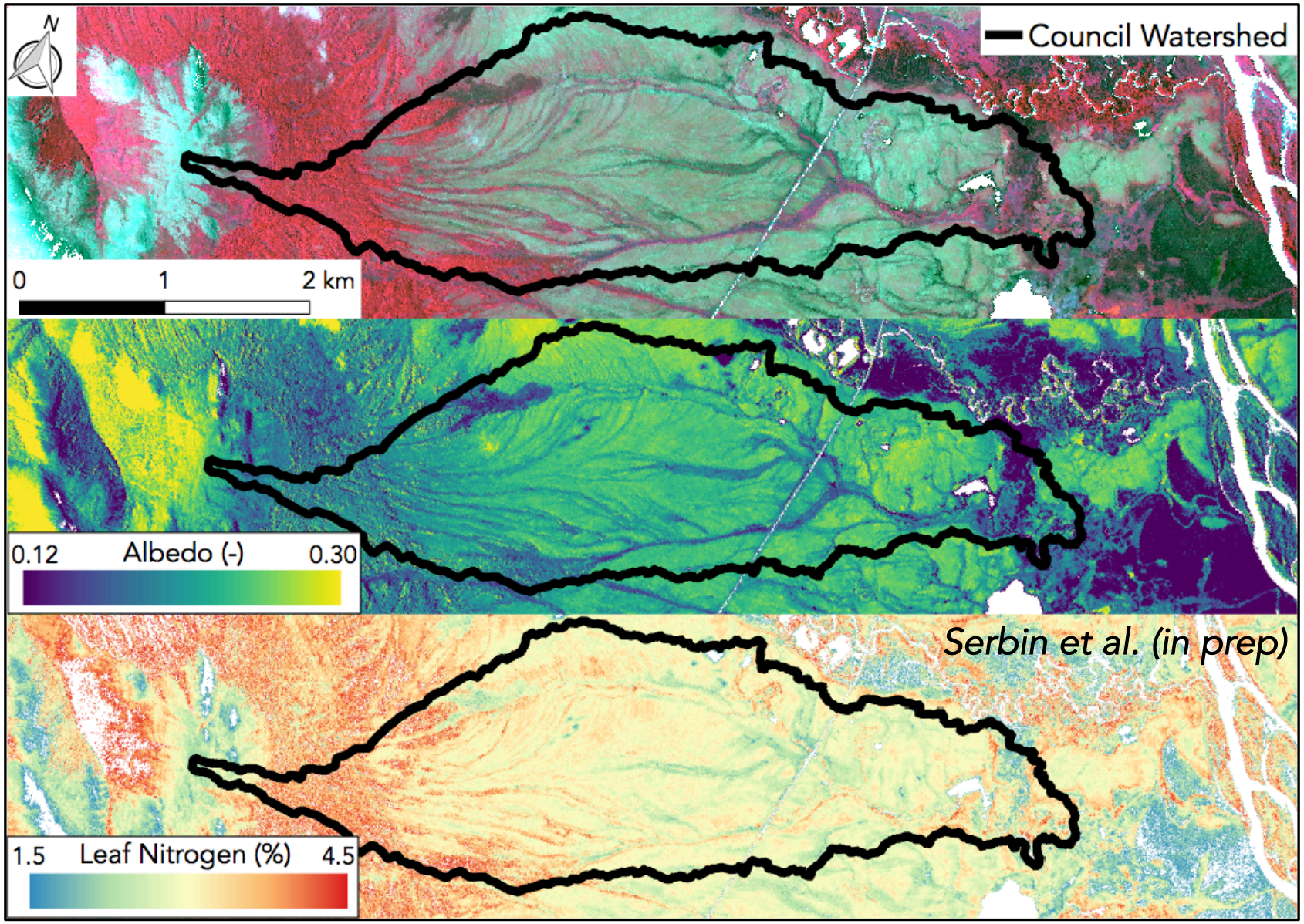


Scaling Arctic Vegetation Functional Traits



Serbin et al. (in prep)

Mapping Arctic Vegetation Function



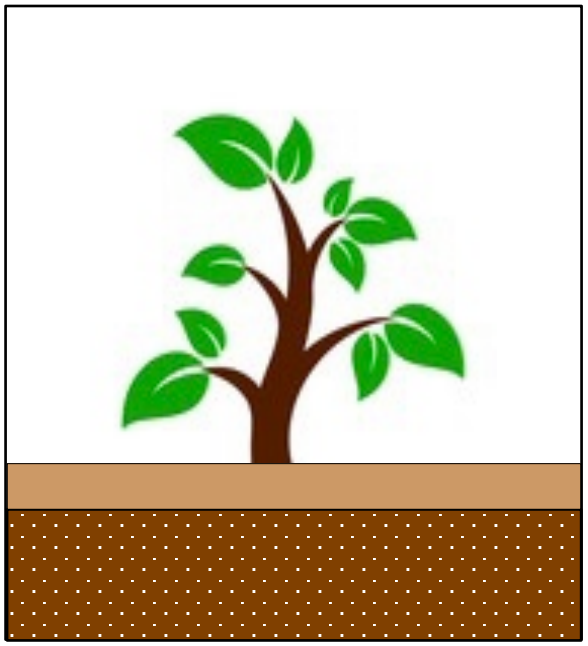
Leveraging NASA AVIRIS-NG ABoVE Airborne Campaign data

Integrating Remote Sensing and Modeling

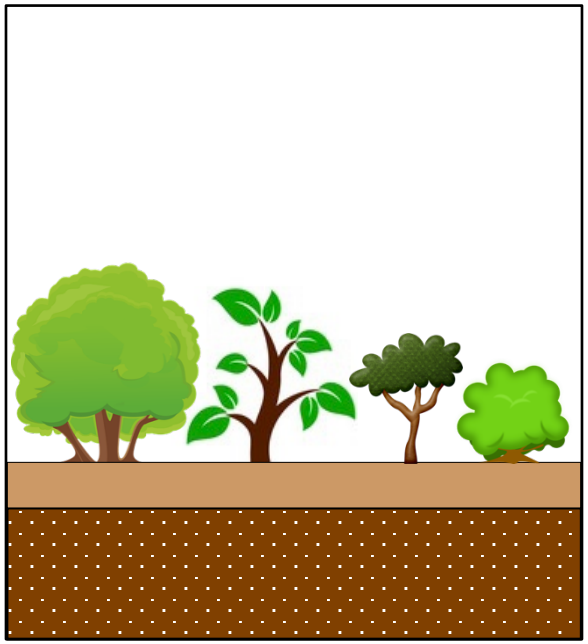
ELM
"Big-Leaf" vegetation

FATES
Demographic vegetation

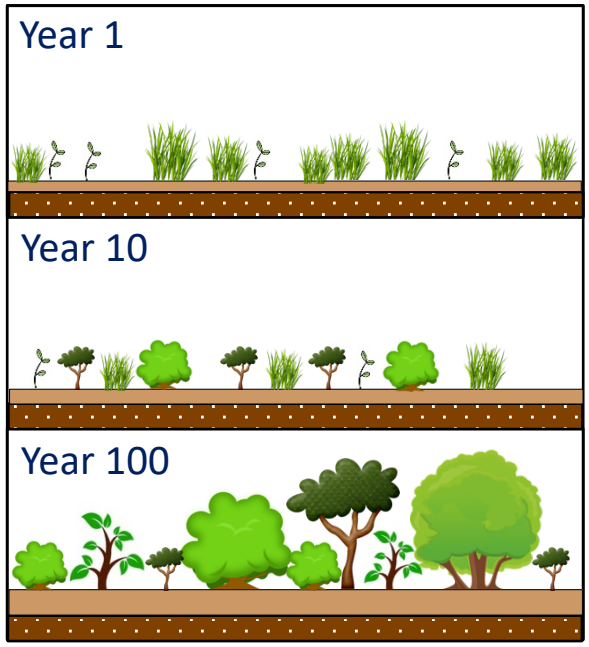
ELM-FATES
Patch & Cohort Dynamics



DOE E3SM Land Model



Functionally Assembled Terrestrial Ecosystem Simulator



Provide initialization, parameterization, and benchmarking data to test ELM/FATES

Thank You!
Questions?

Acknowledgements:

Margaret Torn – LBNL
Sebastian Biraud – LBNL
Alexey Shiklomanov – PNNL
Charles Miller – NASA JPL
Verity Salmon – ORNL
Colleen Iversen – ORNL
Terri Velliquette – ORNL
Alison Boyer – ORNL
Forrest Hoffman – ORNL
Jitu Kumar – ORNL
Wil Lieberman-Cribbin - ITE
Bailey Morrison – BNL

NASA ABoVE