ABoVE Spectral Imaging WG

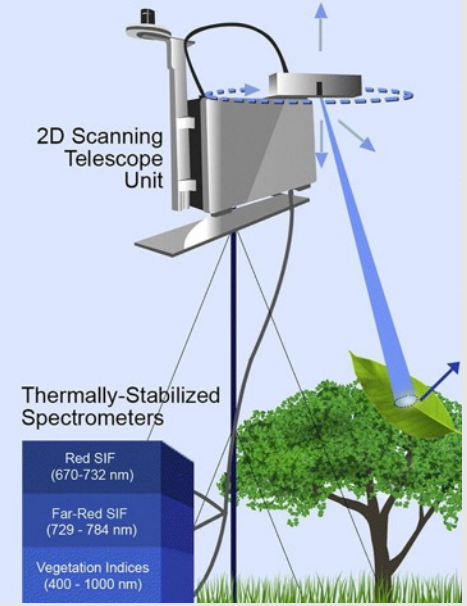
6/29/20

Agenda

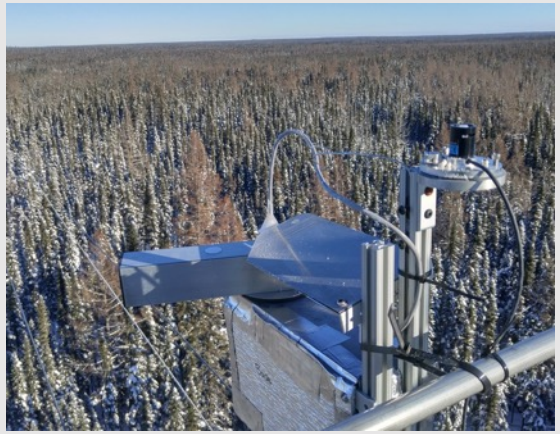
- Flash talks
  - Anne Nolin*
  - Crystal Shaaf*
  - Zoe Pierrat
  - Kevin Turner
  - Phil Townsend*
  - Dedi Yang and Shawn Serbin
  - Wouter Hantson
  - Peter Nelson
  - Matt Macander
  - Fred Huemmrich
- Collaboration discussion
  - What are the interesting scaling questions we want to address as a group?
- Future meetings?

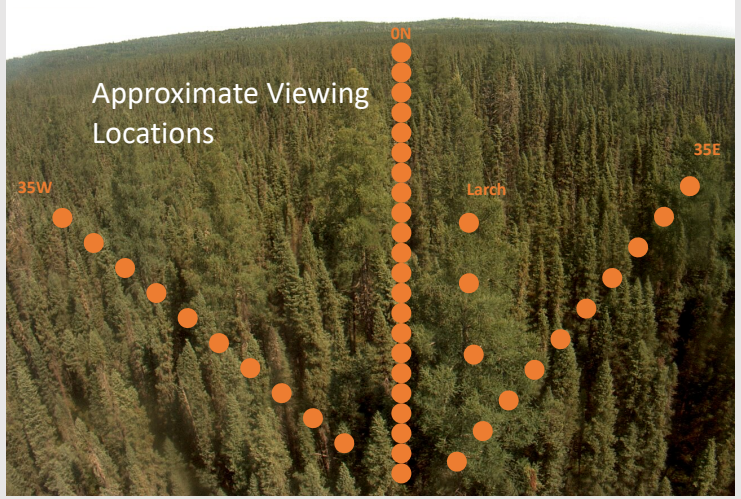
* Slides not included

Using PhotoSpec to measure SIF at the Old Black Spruce Site (OBS) in Saskatchewan, CA



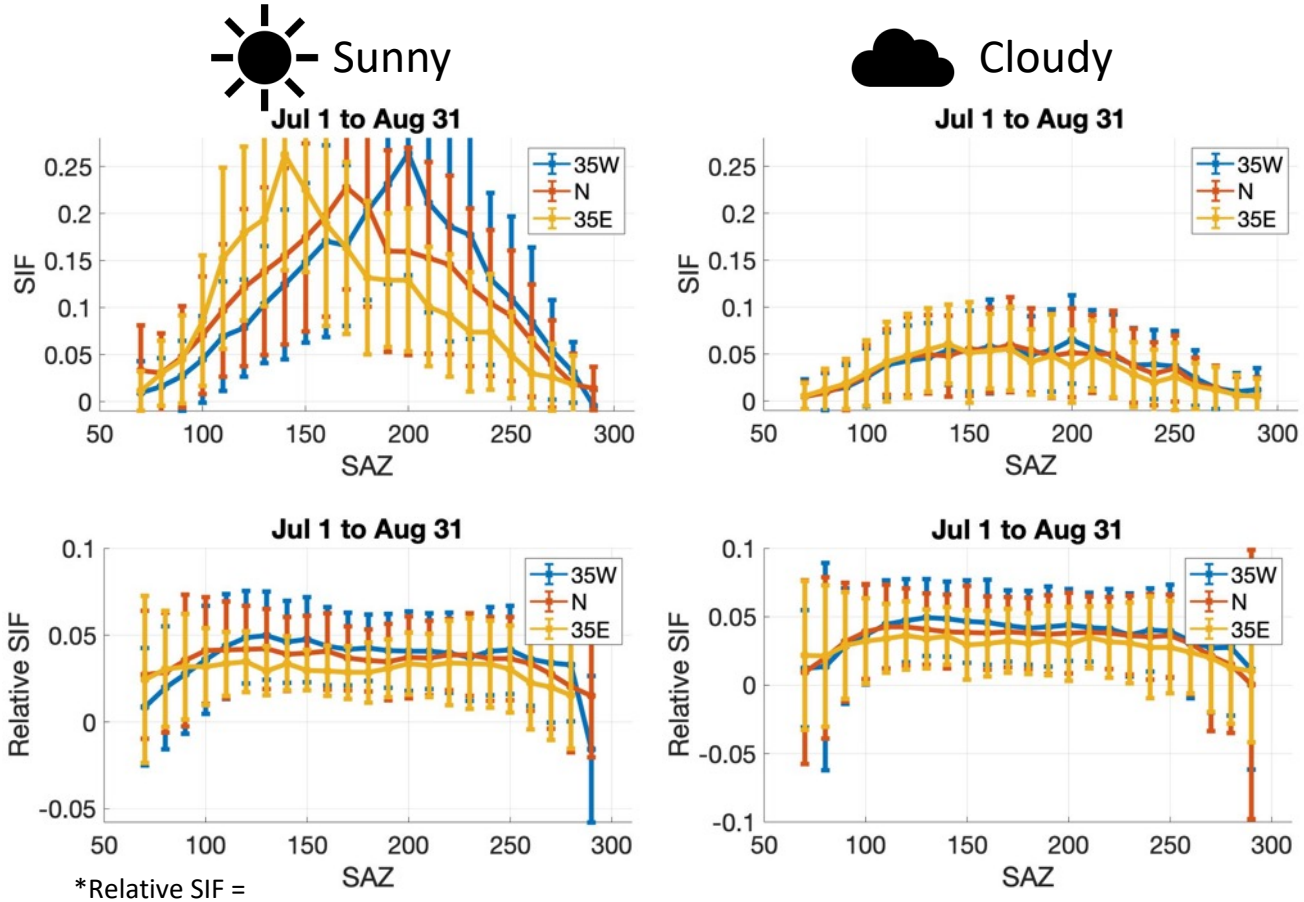
- Narrow FOV (0.7 deg)
- Fraunhofer line-based SIF retrieval (Red and Far Red)
- NDVI, PRI, CCI, NIRv





- ~20 seconds per scan
- ~30 minute repetition rate

SIF signal depends on lighting conditions and azimuthal viewing direction

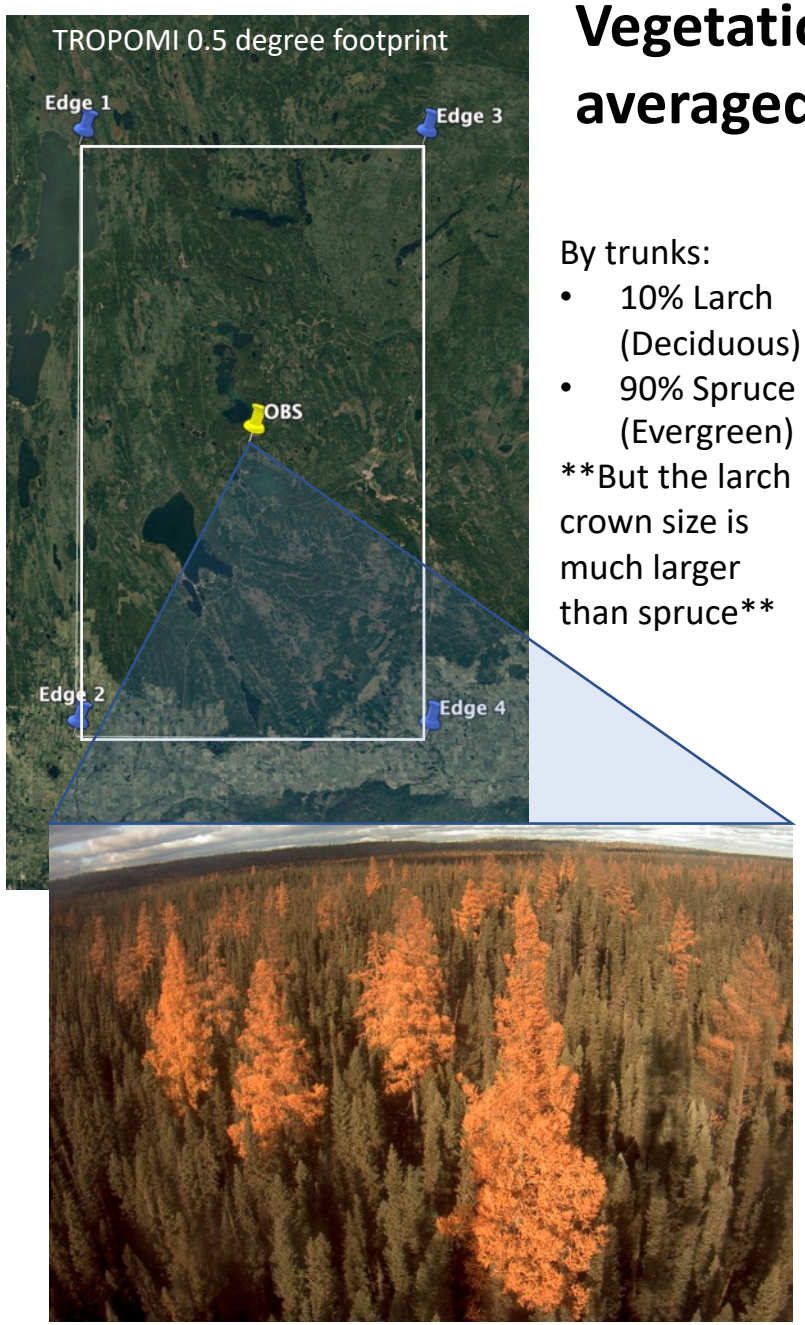


*Relative SIF = SIF/intensity of retrieved light

Interested in:

- Deeper investigation of viewing geometry (elevation)
- Model comparisons (SCOPE) (DART?)
- Angular dependence of other veg indices

Vegetation/species information is important for interpreting spatially averaged satellite SIF



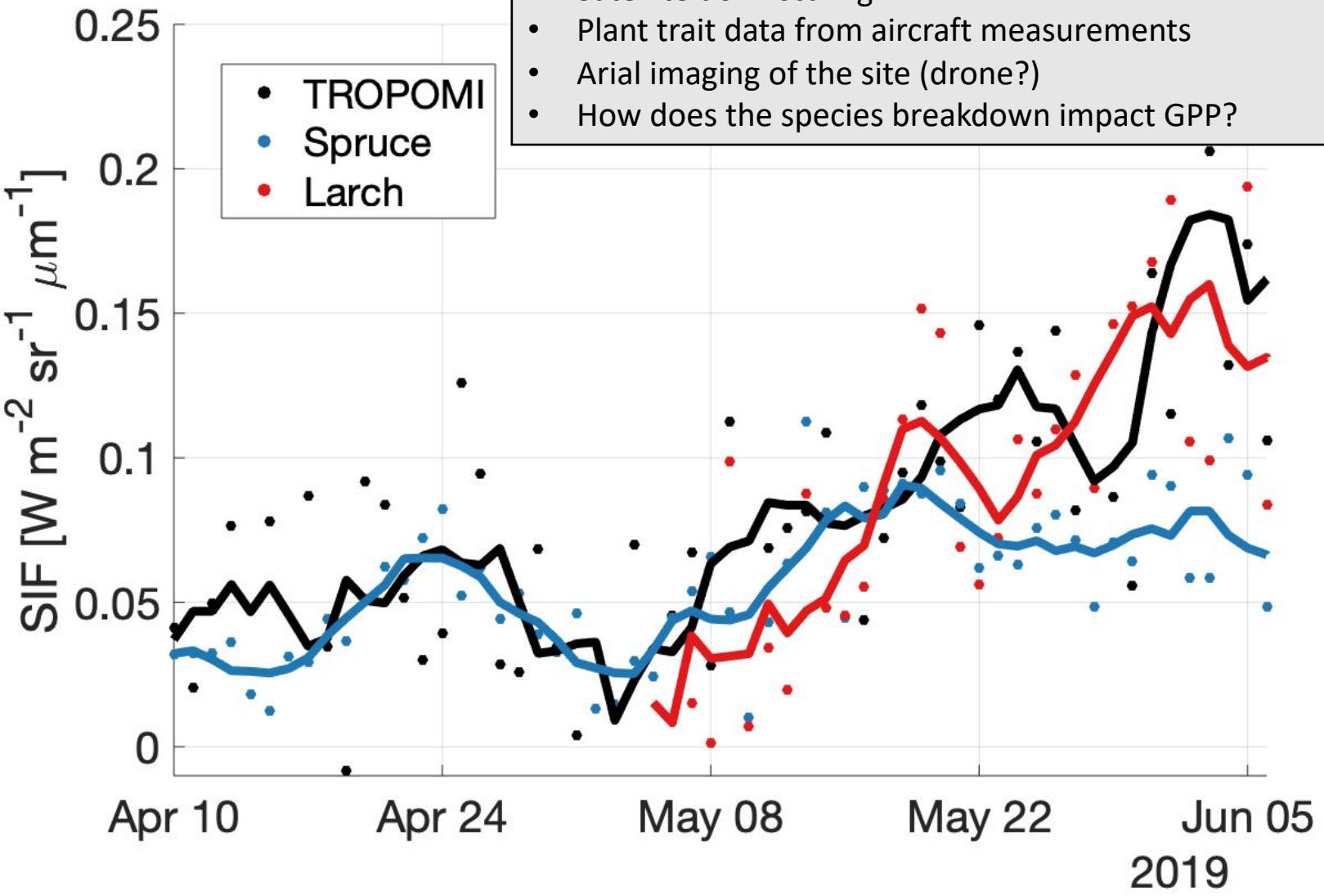
By trunks:

- 10% Larch (Deciduous)
- 90% Spruce (Evergreen)

But the larch crown size is much larger than spruce

Interested in:

- Satellite downscaling
- Plant trait data from aircraft measurements
- Arial imaging of the site (drone?)
- How does the species breakdown impact GPP?

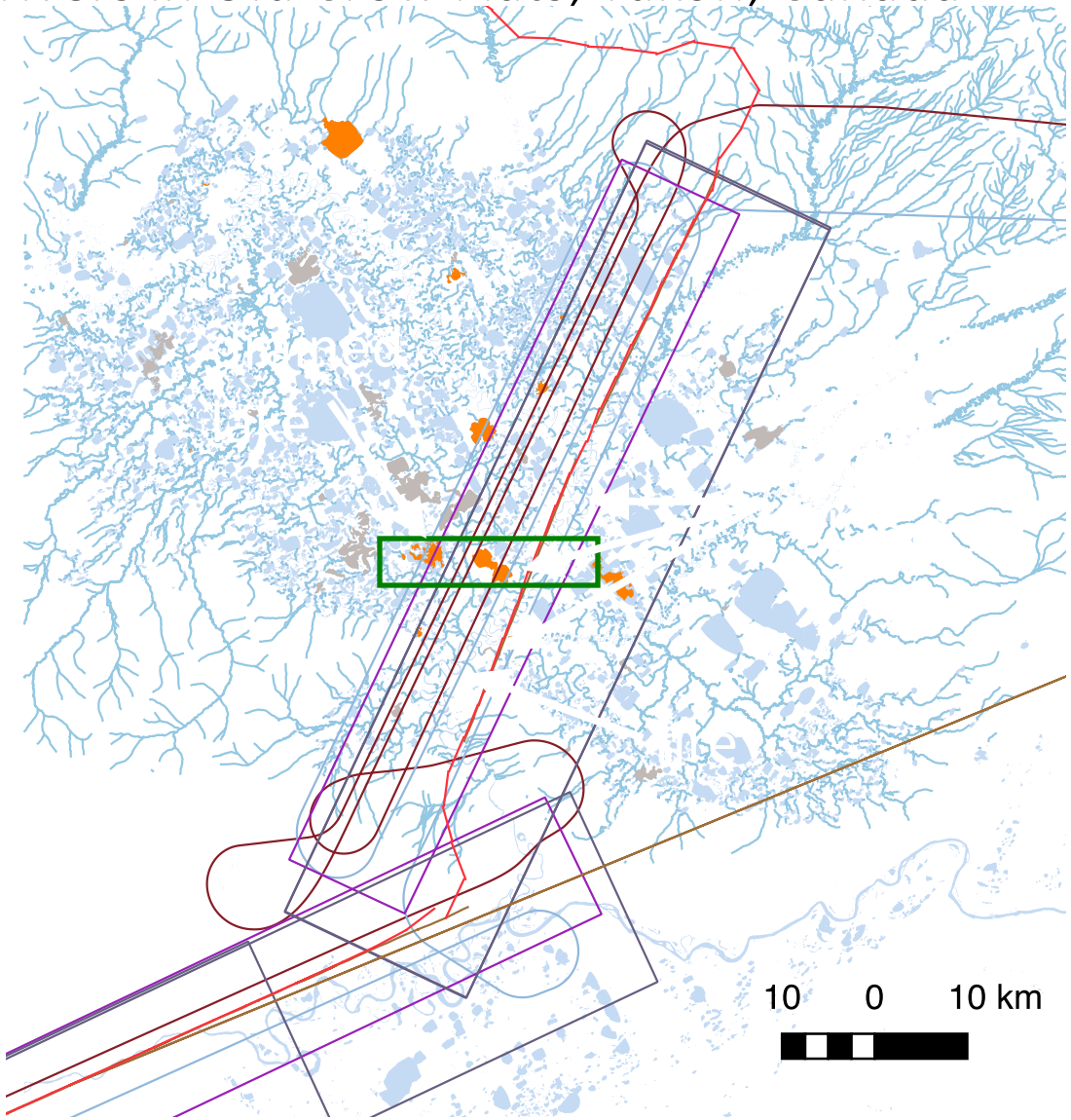


Inventorying climate-induced landscape changes and associated impacts on lakes and rivers in Old Crow Flats, Yukon, Canada

<u>2017-19</u>

- AVIRIS-NG
- UAVSAR
  - L and P bands
- LVIS
- AirSWOT

- UAV (multirotor, fixed w.)
  - Sequoia multispec
  - SODA RGB
  - Thermal



Kevin Turner

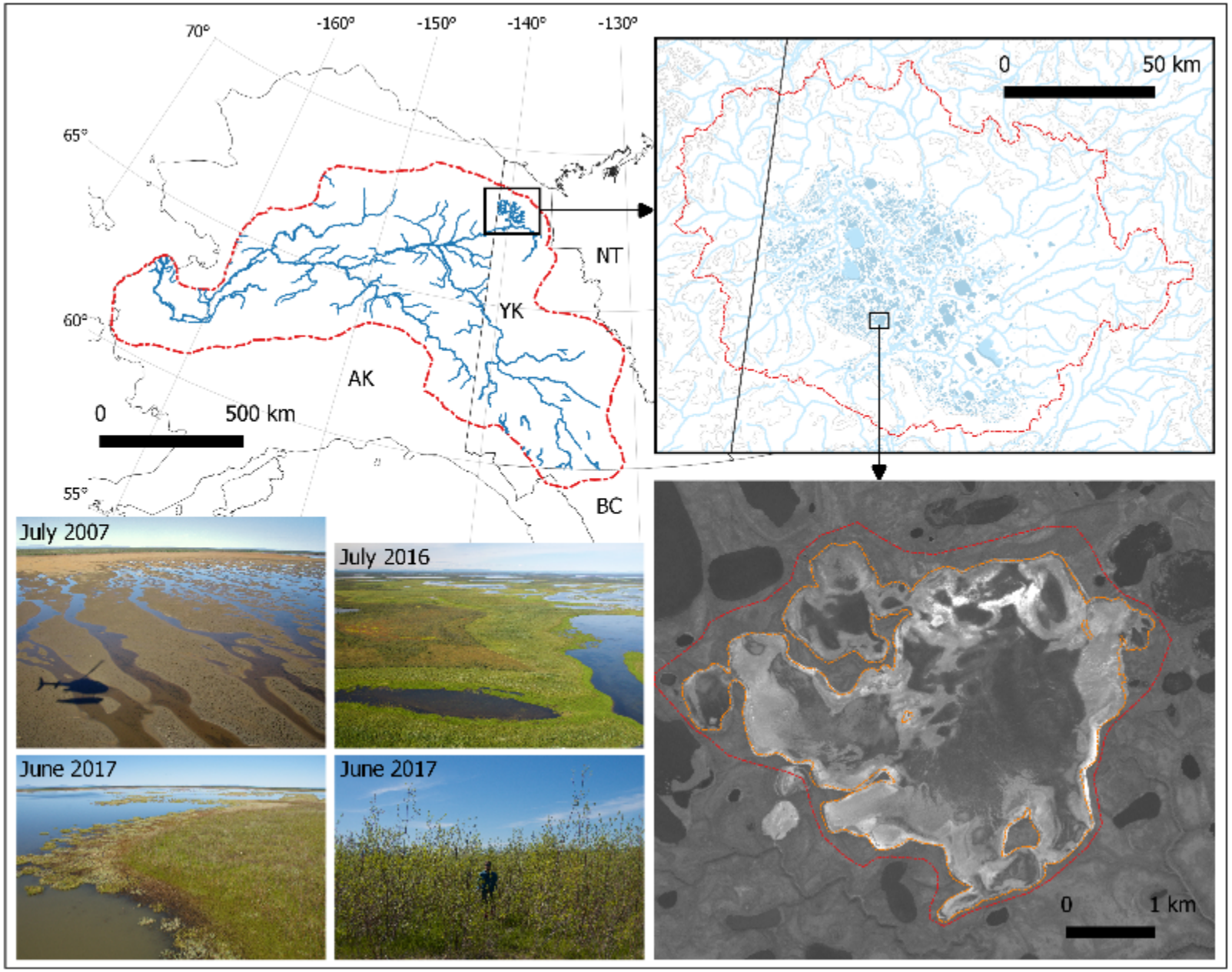
Dept. Geog. and Tour Studies, Dept. Earth Science

29-June-2020

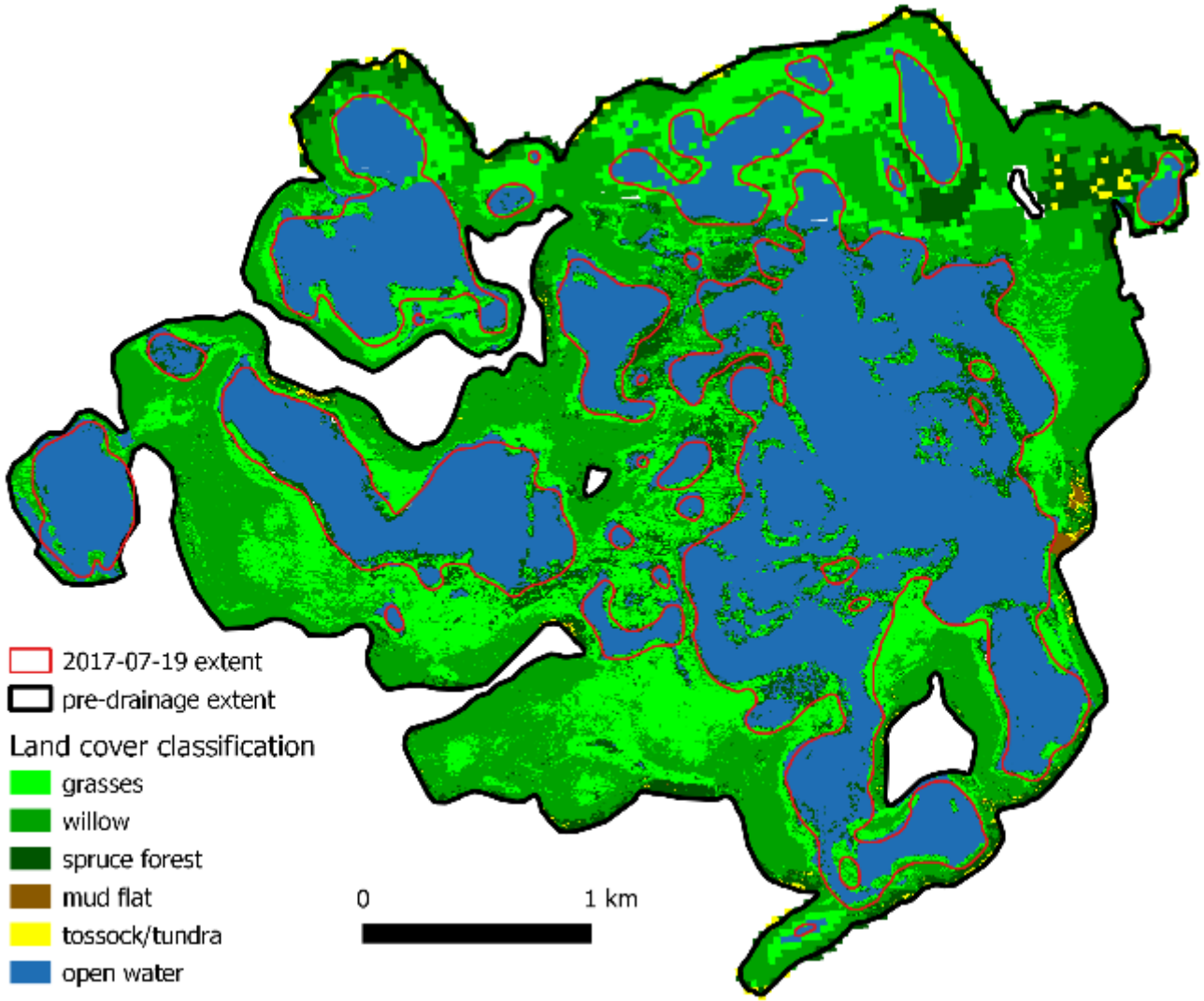
Multispectral WG

Update

Using AVIRIS-NG and UAV data to identify land cover change in a drained thaw lake basin and biogeochemical influence



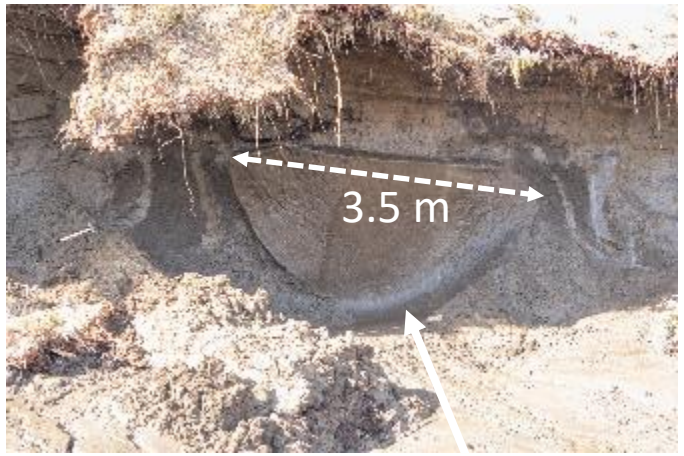
Detecting hydrological responses of a drained thermokarst lake to drastic changes in catchment land cover

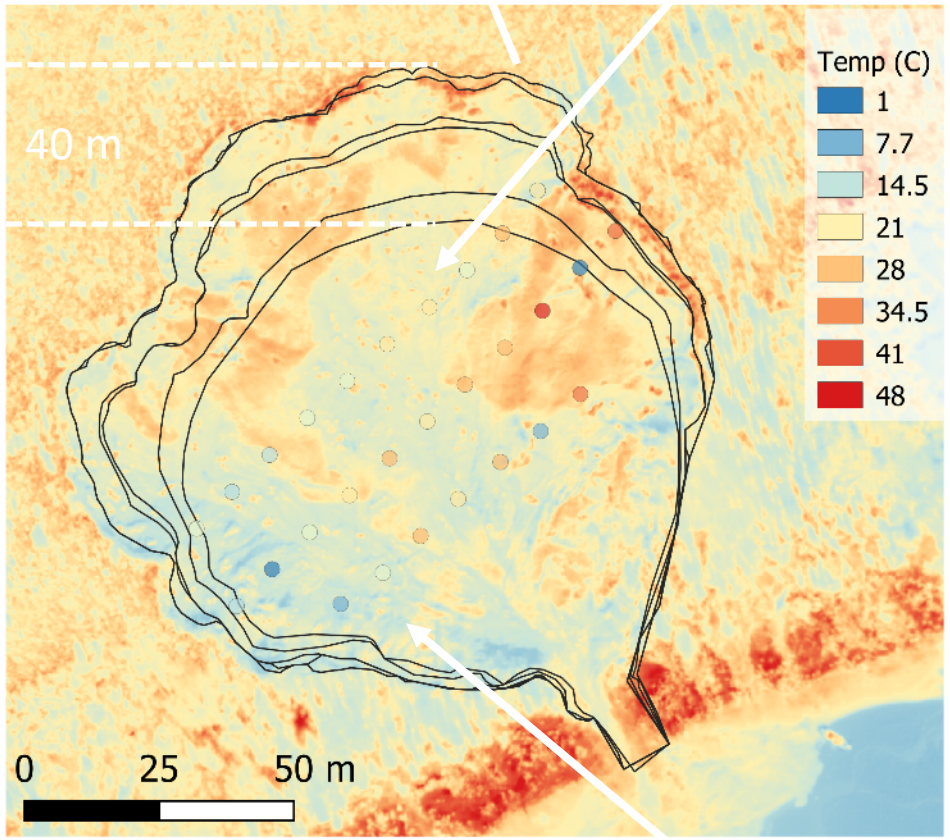


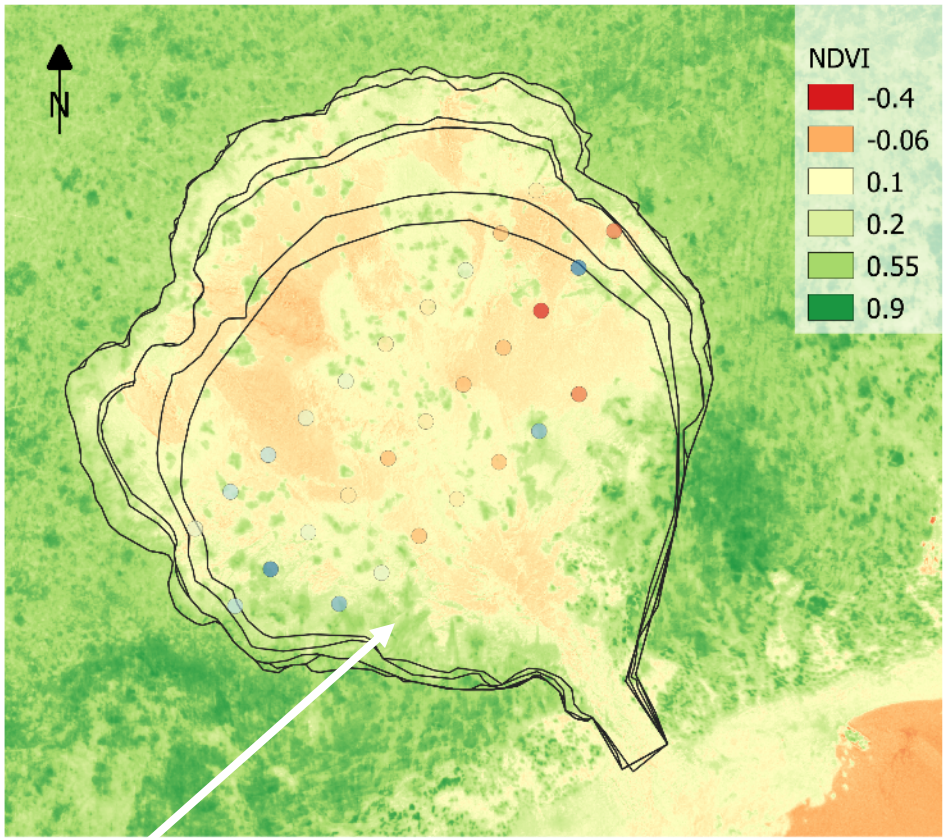
- Maximum likelihood classification using 28 AVIRIS-NG bands ranging G, R, R-edge, NIR
- Training pixels from UAV surveys
- Water sampled during 13 years for biogeochem analysis

Tall willow vegetation encroached on 30% of the former lakebed

Turner et al, submitted to Arctic Science


3.5 m


40 m
Temp (C)
1
7.7
14.5
21
28
34.5
41
48
0
25
50 m

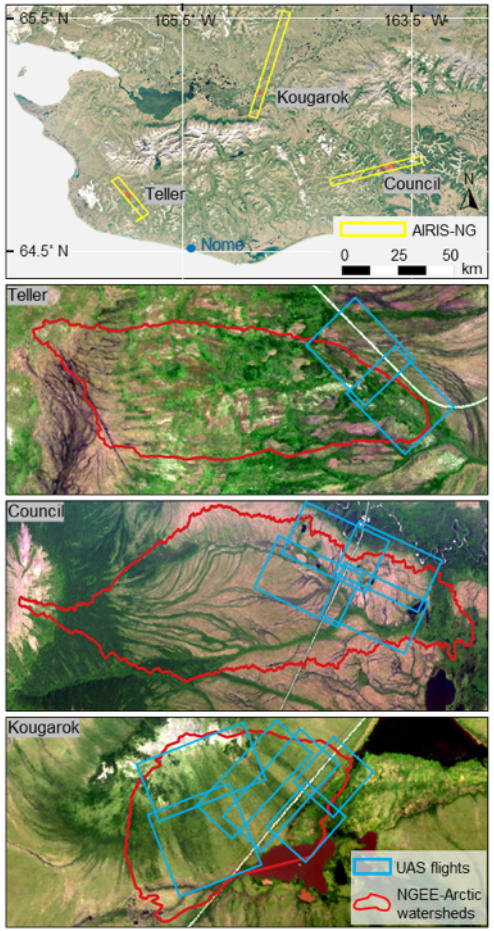

N
NDVI
-0.4
-0.06
0.1
0.2
0.55
0.9

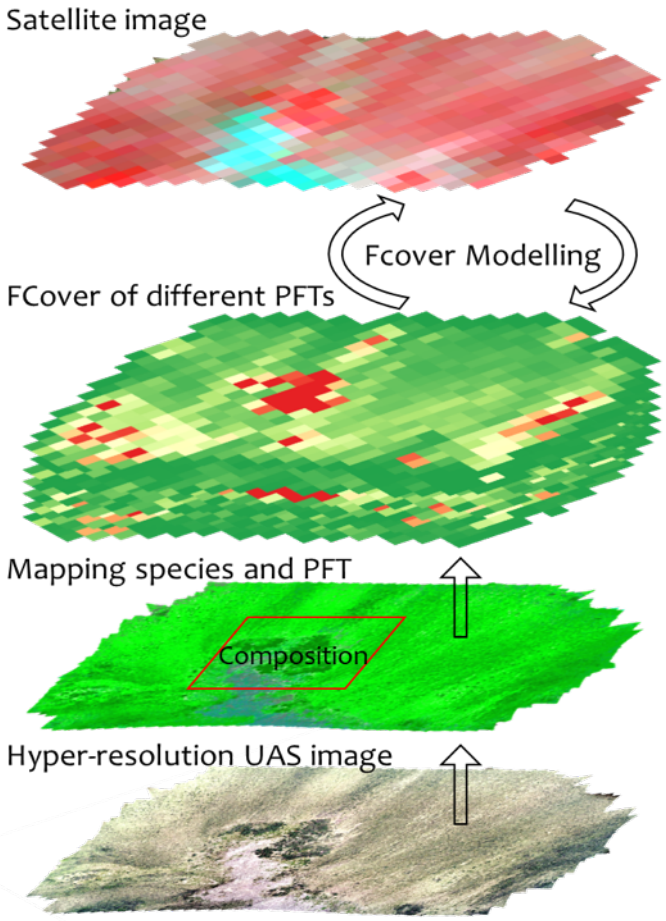
Dedi Yang and Shawn Serbin

We develop a machine learning model to predict the fractional cover of twelve arctic PFTs, by combining high-resolution UAS remote sensing.

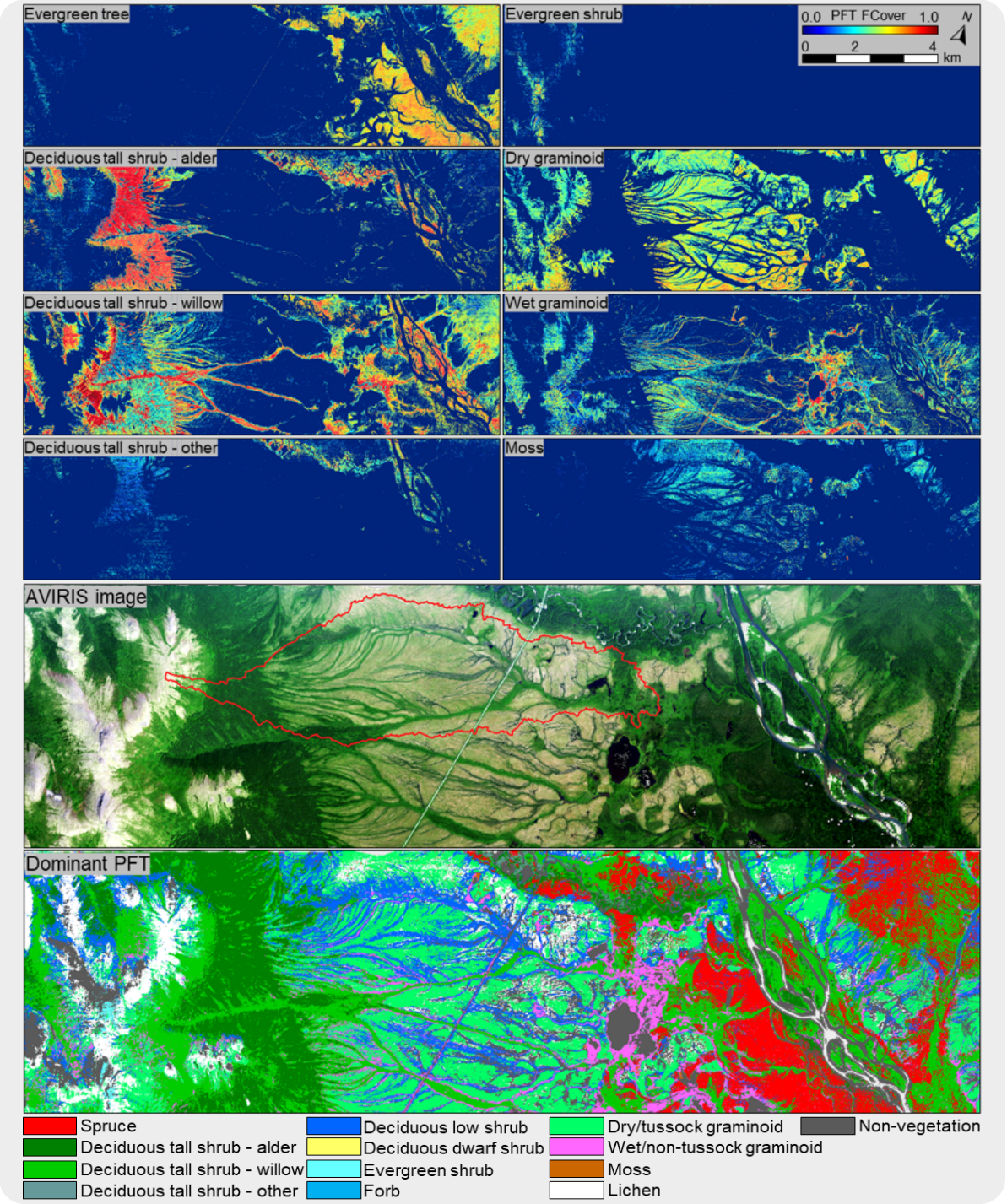
The model predicted fractional covers and dominant PFTs reveal high spatial heterogeneity in tundra vegetation composition, providing a means to address the 'scaling' issues for vegetation mapping.

The mapped PFT fractional cover provide novel vegetation composition inputs to process-based modeling

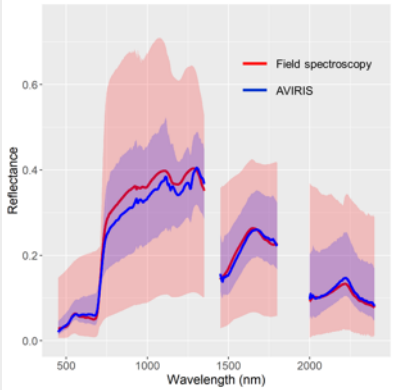




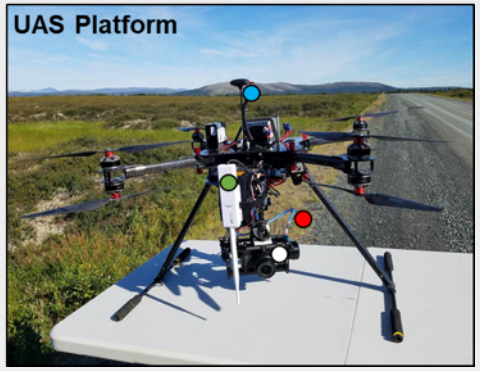
Daryl Yang et al., in preparation

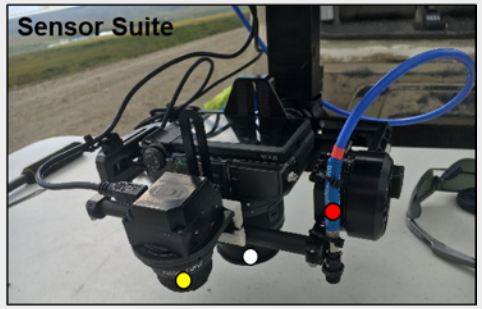


Ground spectra collection

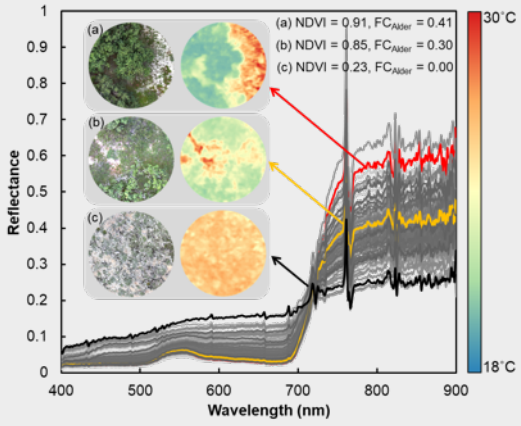


UAS hyperspectral, thermal, and structural remote sensing





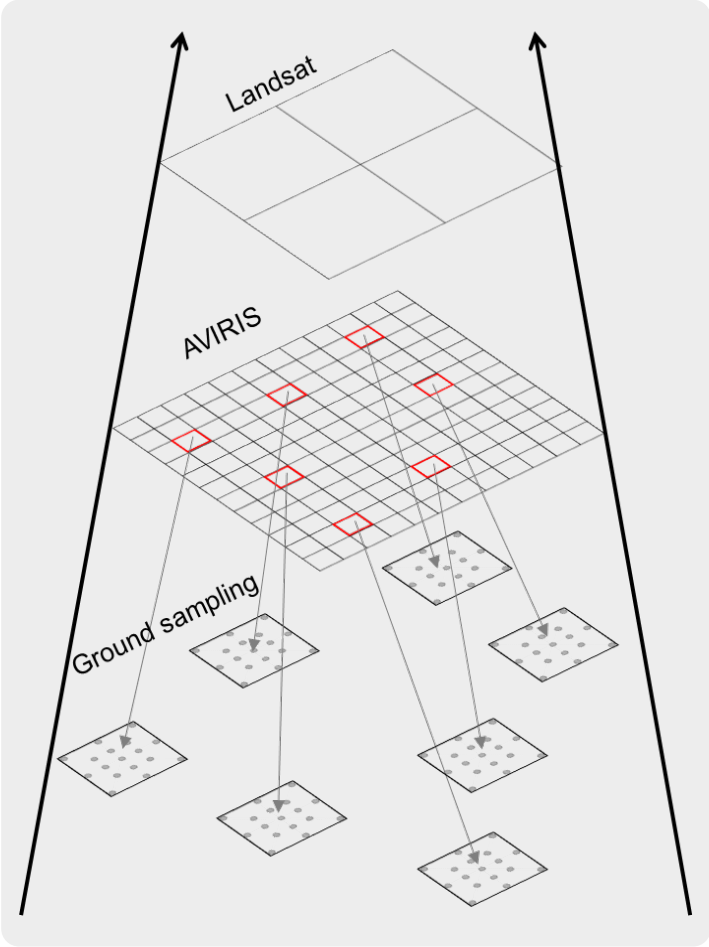
RGB camera · WiFi connector · GPS
TIR camera · VNIR spectrometer

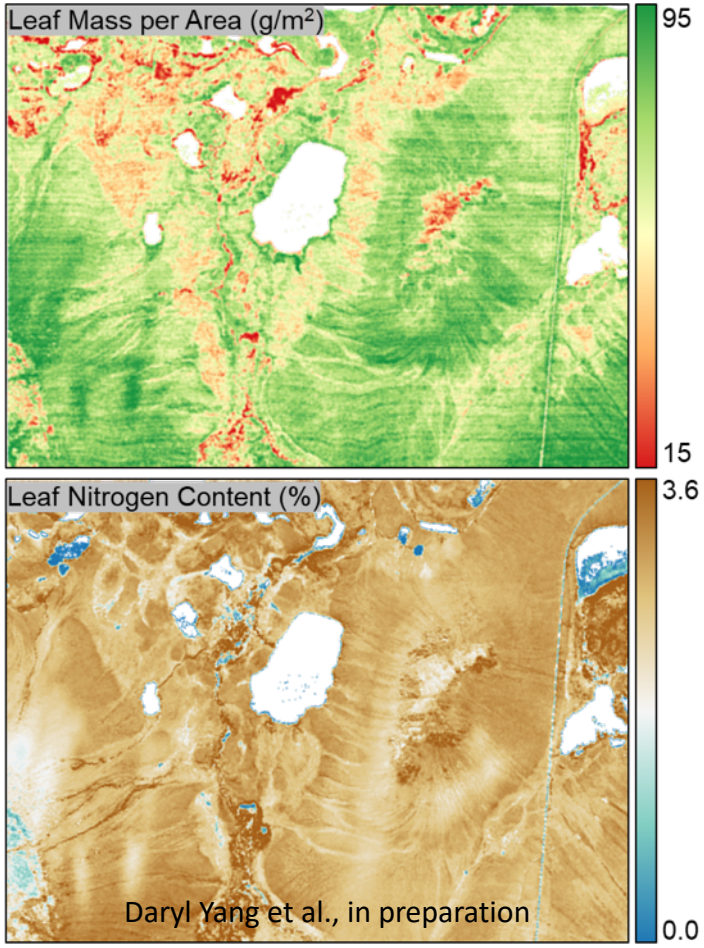


We collect field spectroscopy at species, plot, and transect levels, at the three NGEE-Arctic field sites, for validating our UAS and AVIRIS surface reflectance products, which are collectively used to scale up plant functional traits from the ground to space.

Our trait scaling results show that AVIRIS spectra provide important datasets for capturing the spatial variation in plant functional traits.

We also find vegetation mixing, non-vegetated surfaces play important roles in the 'scaling' processes, which should be better accounted for in future studies.

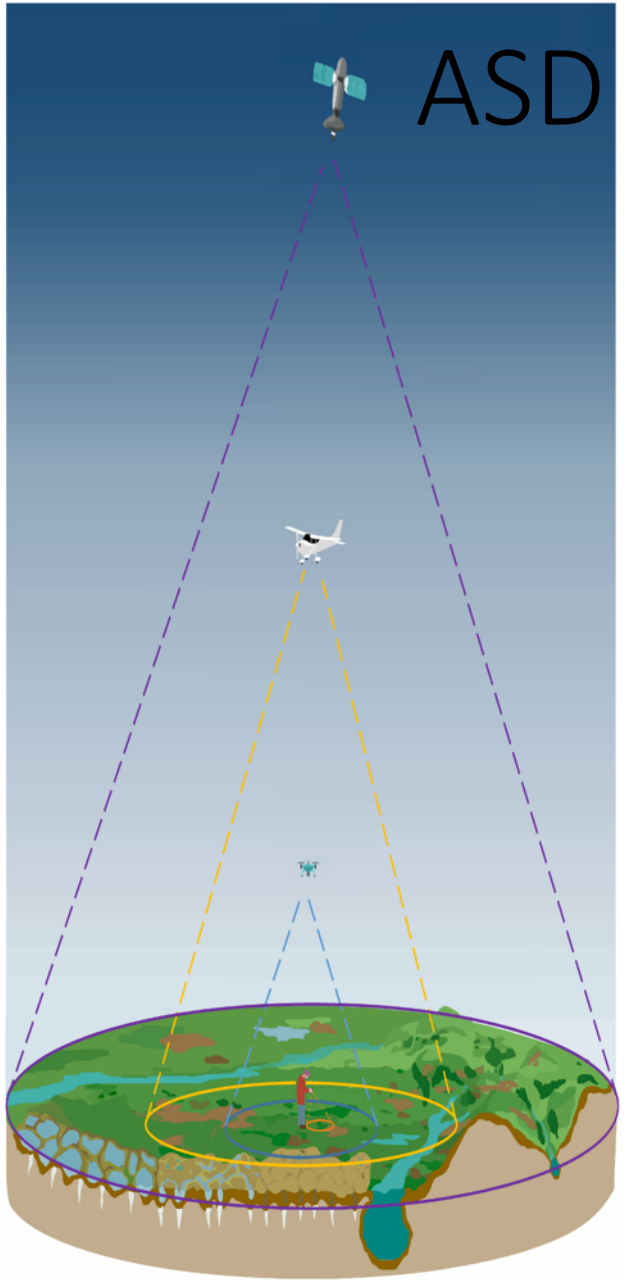


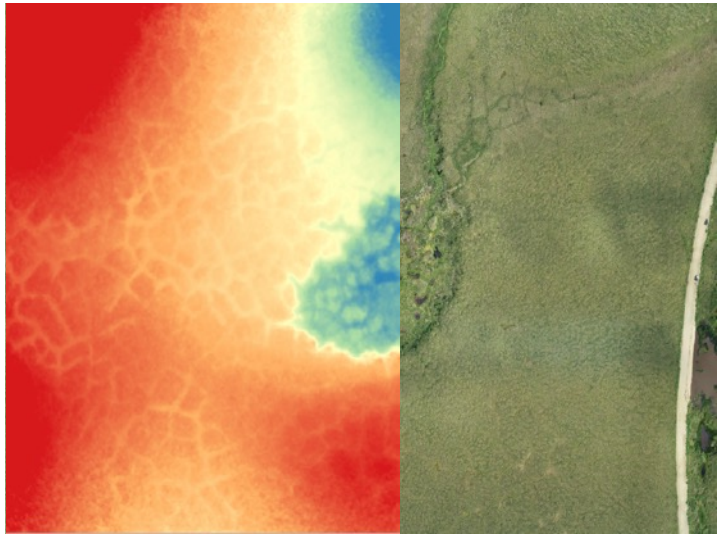


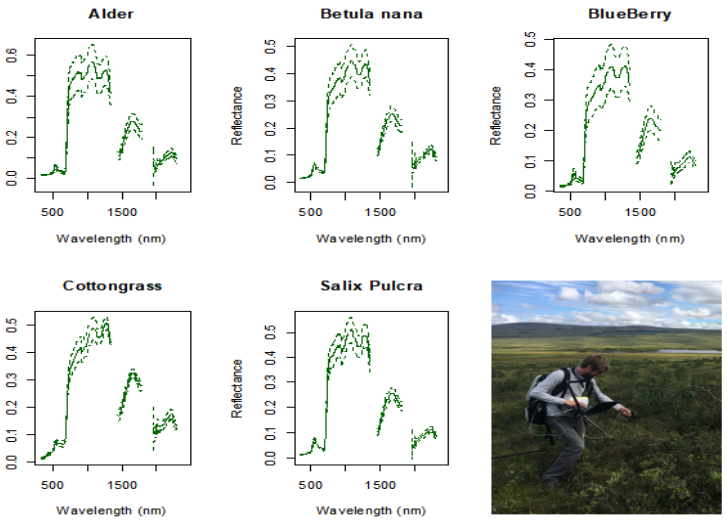
Thaw Functional Traits and Disturbance History to characterize Changing Permafrost Landscapes

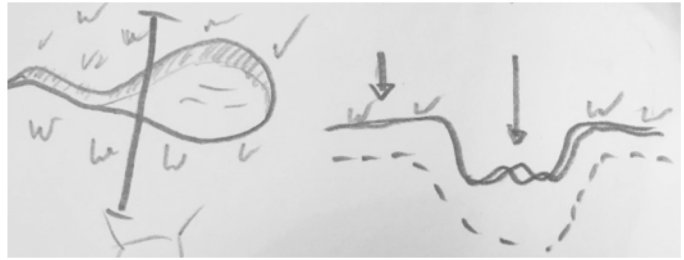
Wouter Hantson & Dan Hayes University of Maine
Dedi Yang & Shawn Serbin Brookhaven NL

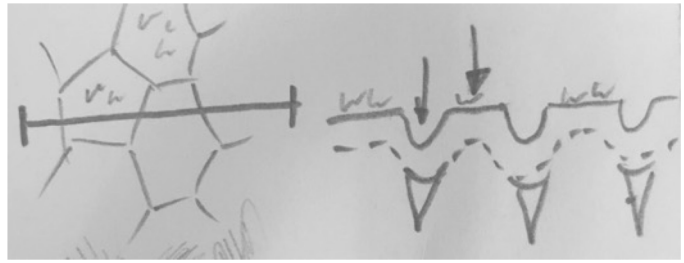
ASD Transects & UAV

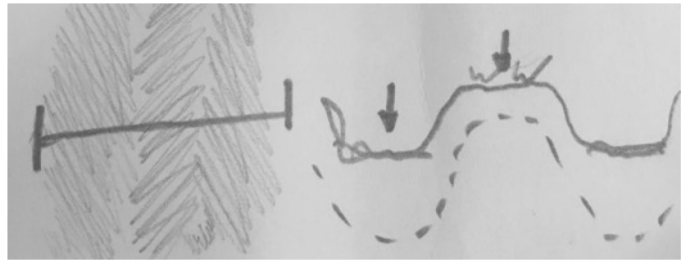


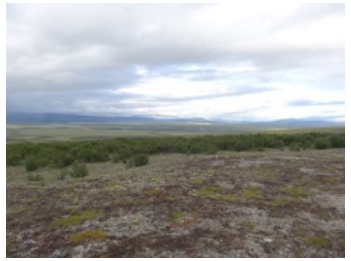


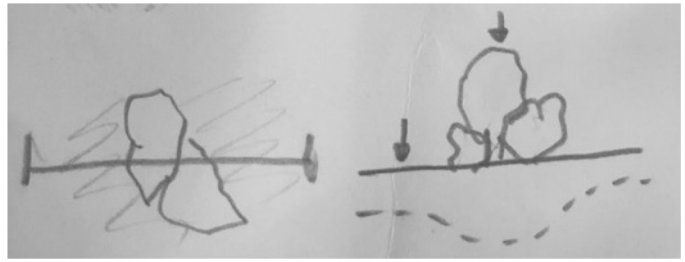




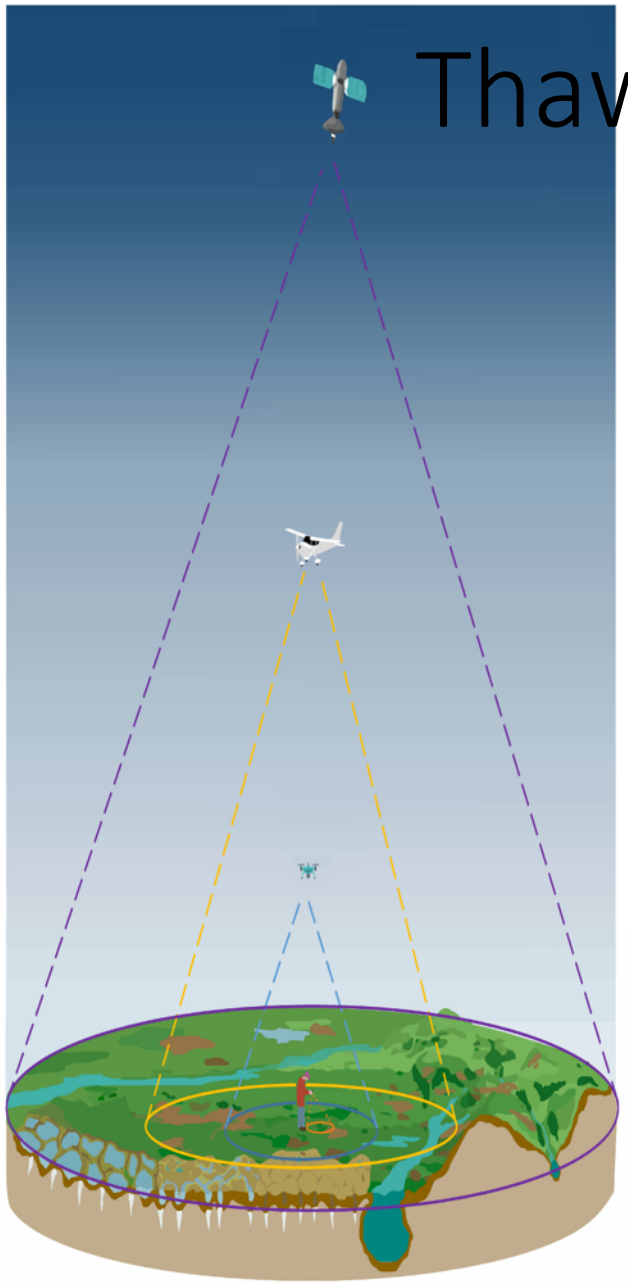


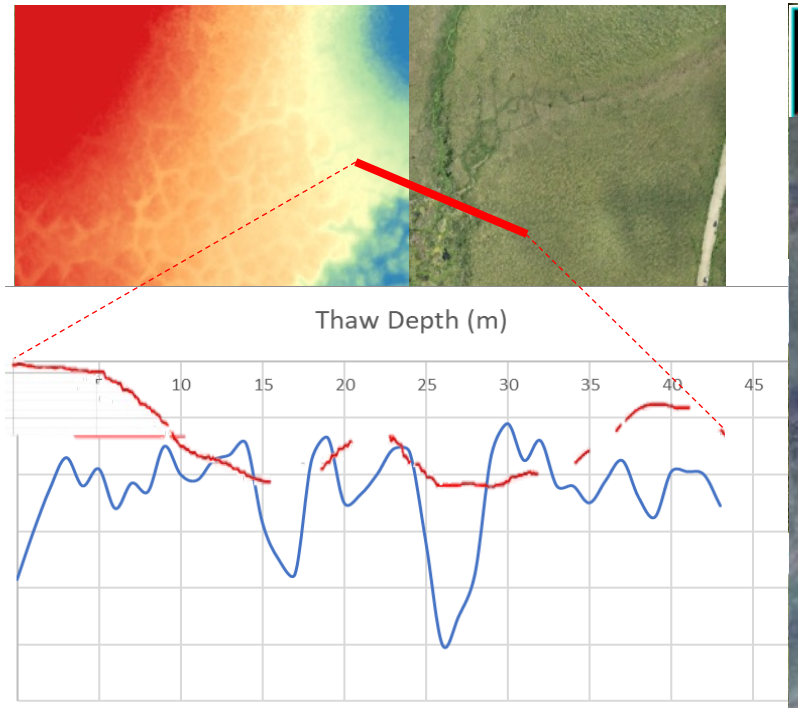


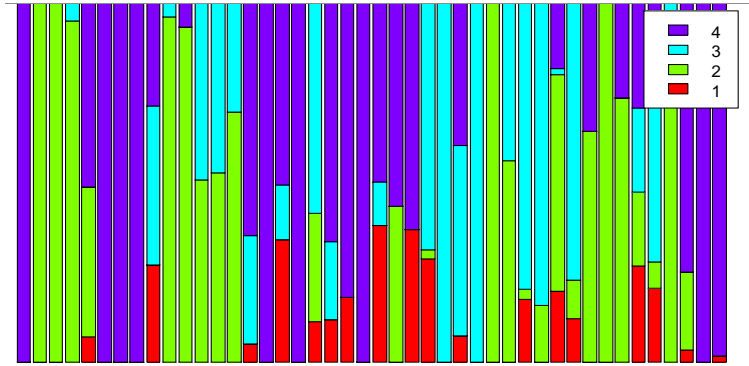


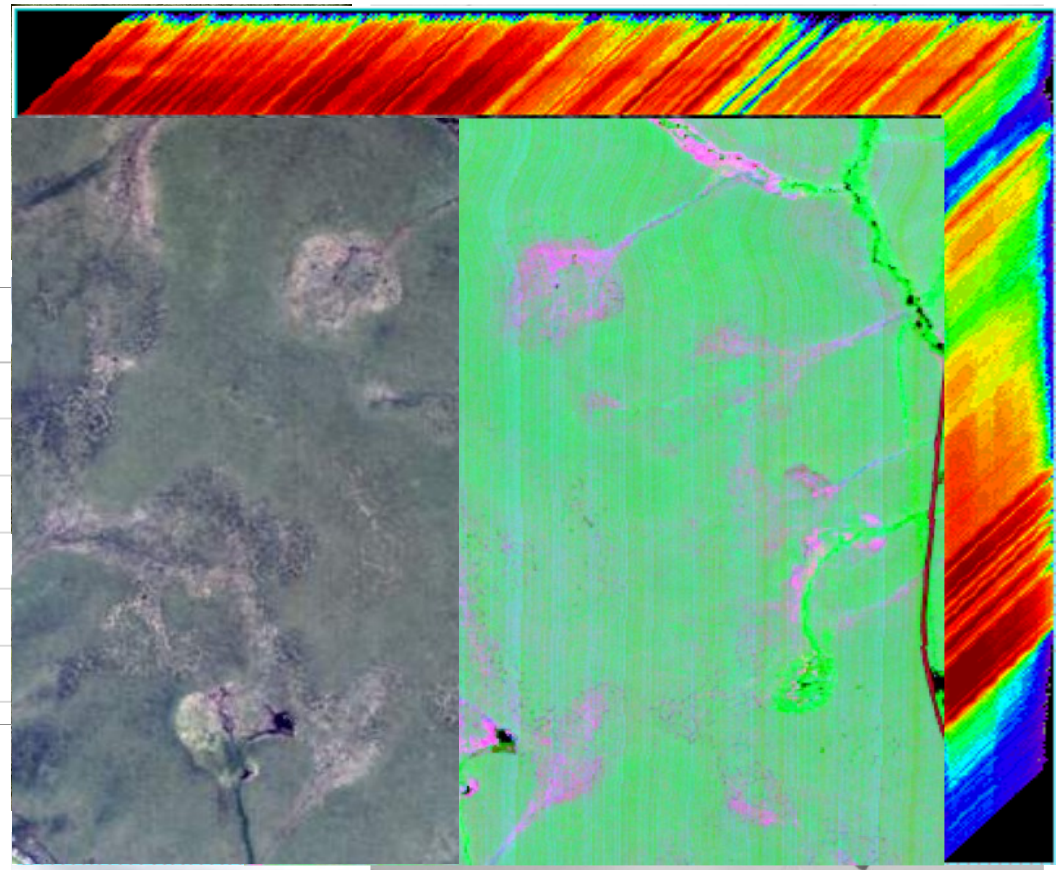


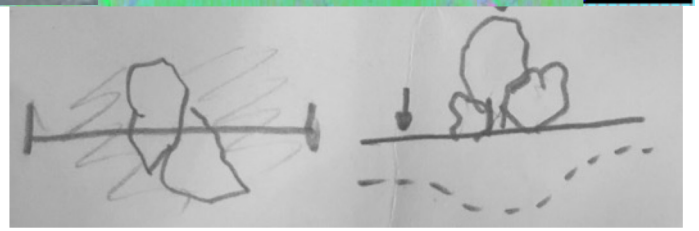
Thaw Functional Traits



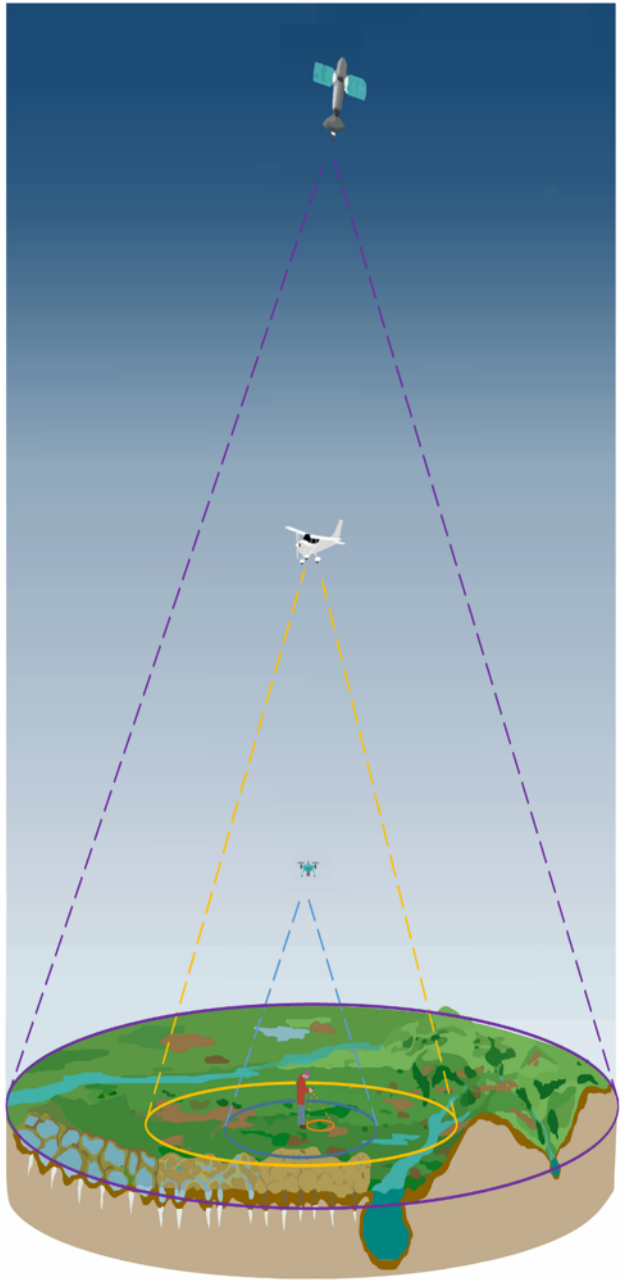


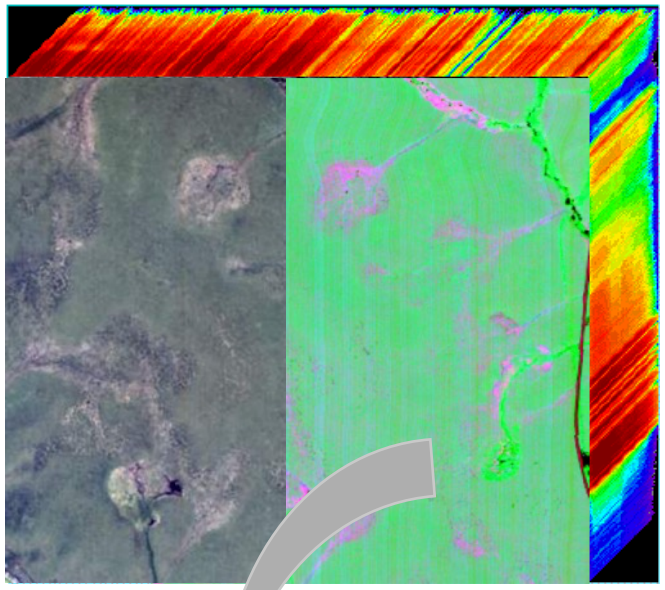


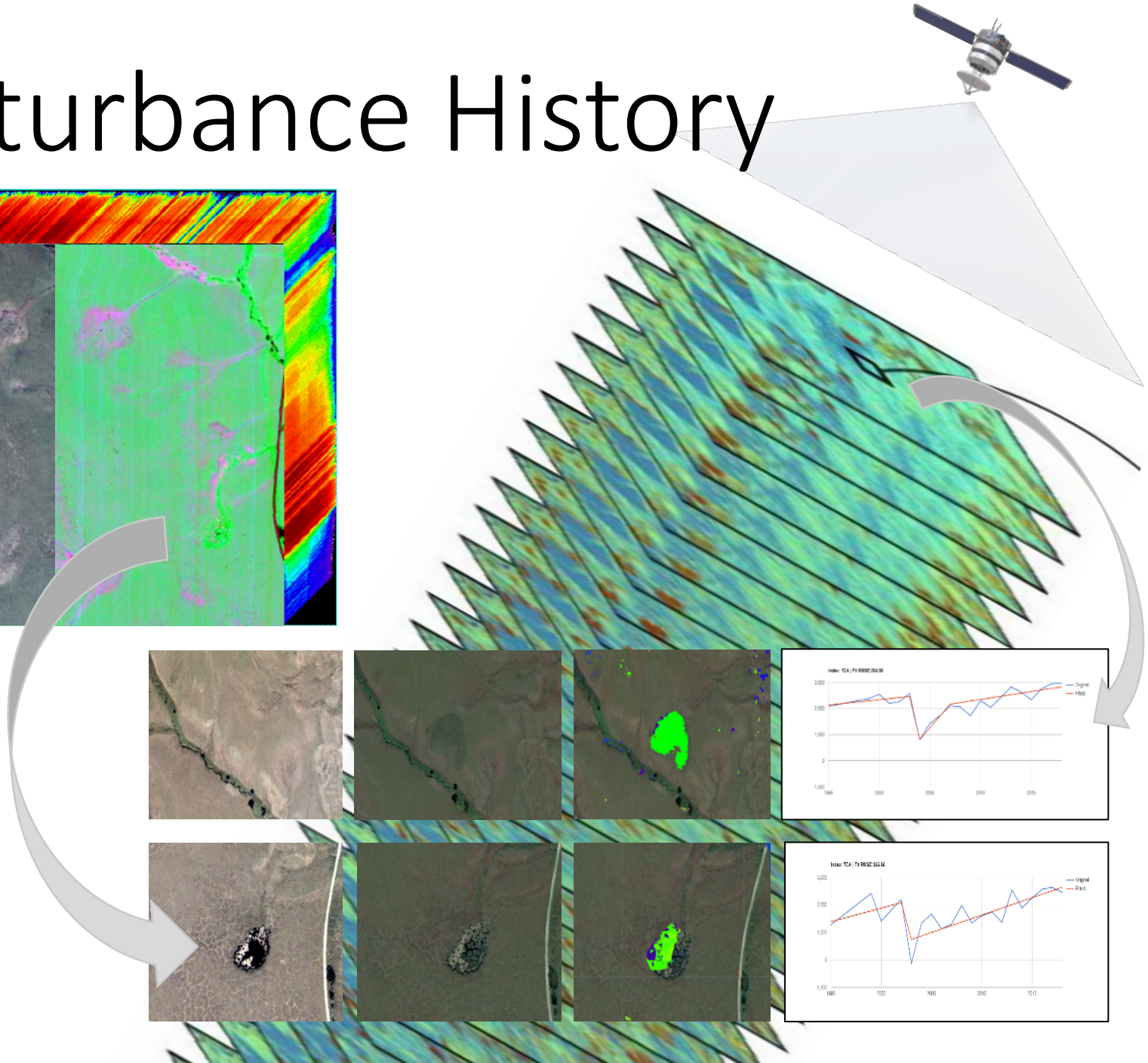




Disturbance History



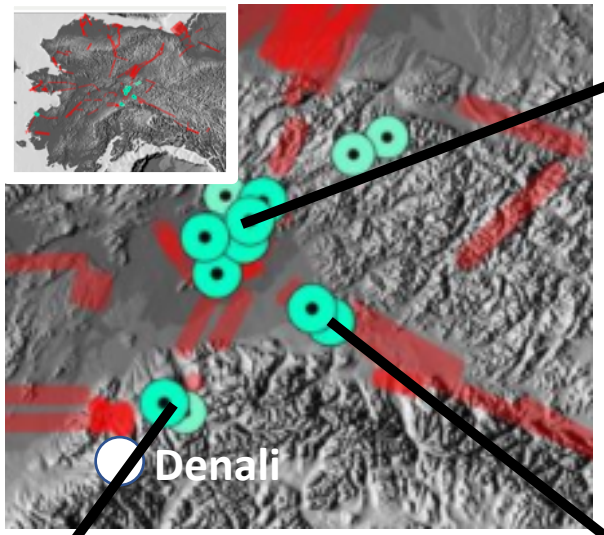


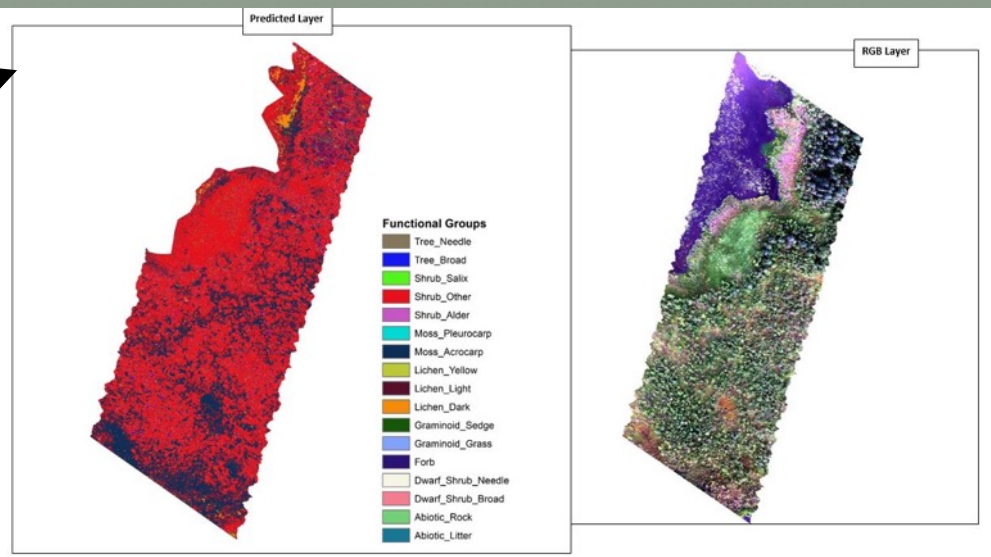


LECOSPEC: Landscape ecological spectroscopy produces fine-grained vegetation maps using UAV-based imaging spectroscopy and scanning spectroscopy in the Arctic and boreal biomes

Peter R. Nelson, Kevaughan Smith , Jane Pettit, David Paradis. Matthew Macander

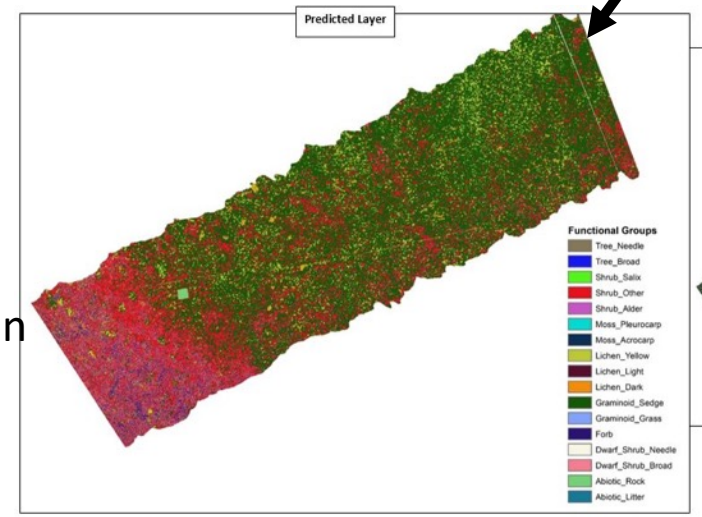
Project summary: 1) UAV-based VNIR imaging spectrometer & ground spectradiometer collections
2) Random forest classifier trained on ground spectra applied to UAV data to make plant functional type (PFT) maps
3) Example output in ABoVE domain coincident with AVIRIS ng (red) and UAV collections (green dots).

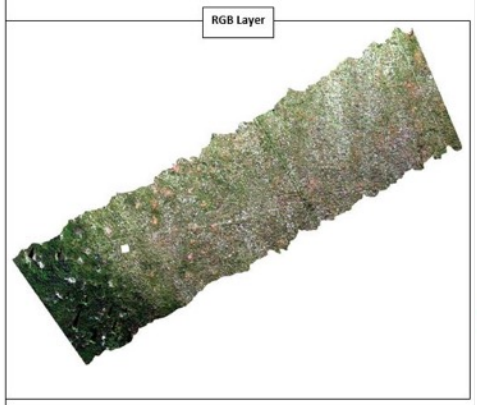




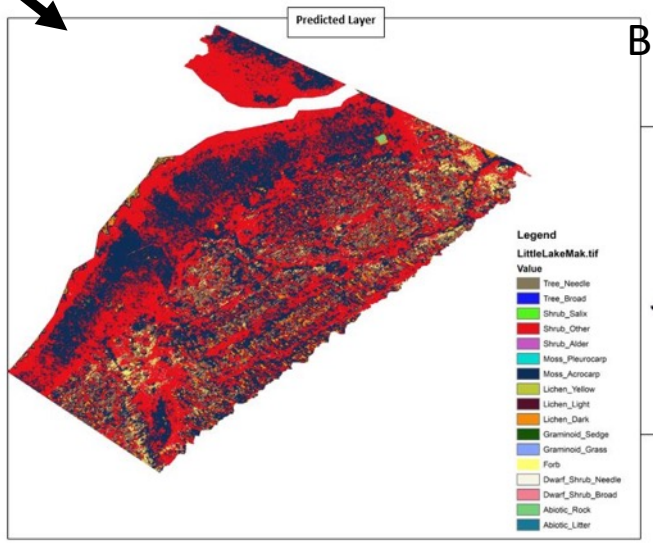
Big Trail Lake, Fairbanks

Peter R. Nelson
Schoodic Institute & University of Maine, Fort Kent





8 mile lake, Healy



Little Lake

https://github.com/nelsopet/lecospec
http://lecospec.weebly.com/

LECOSPEC: UAV-based VNIR PFT maps … ground spectra

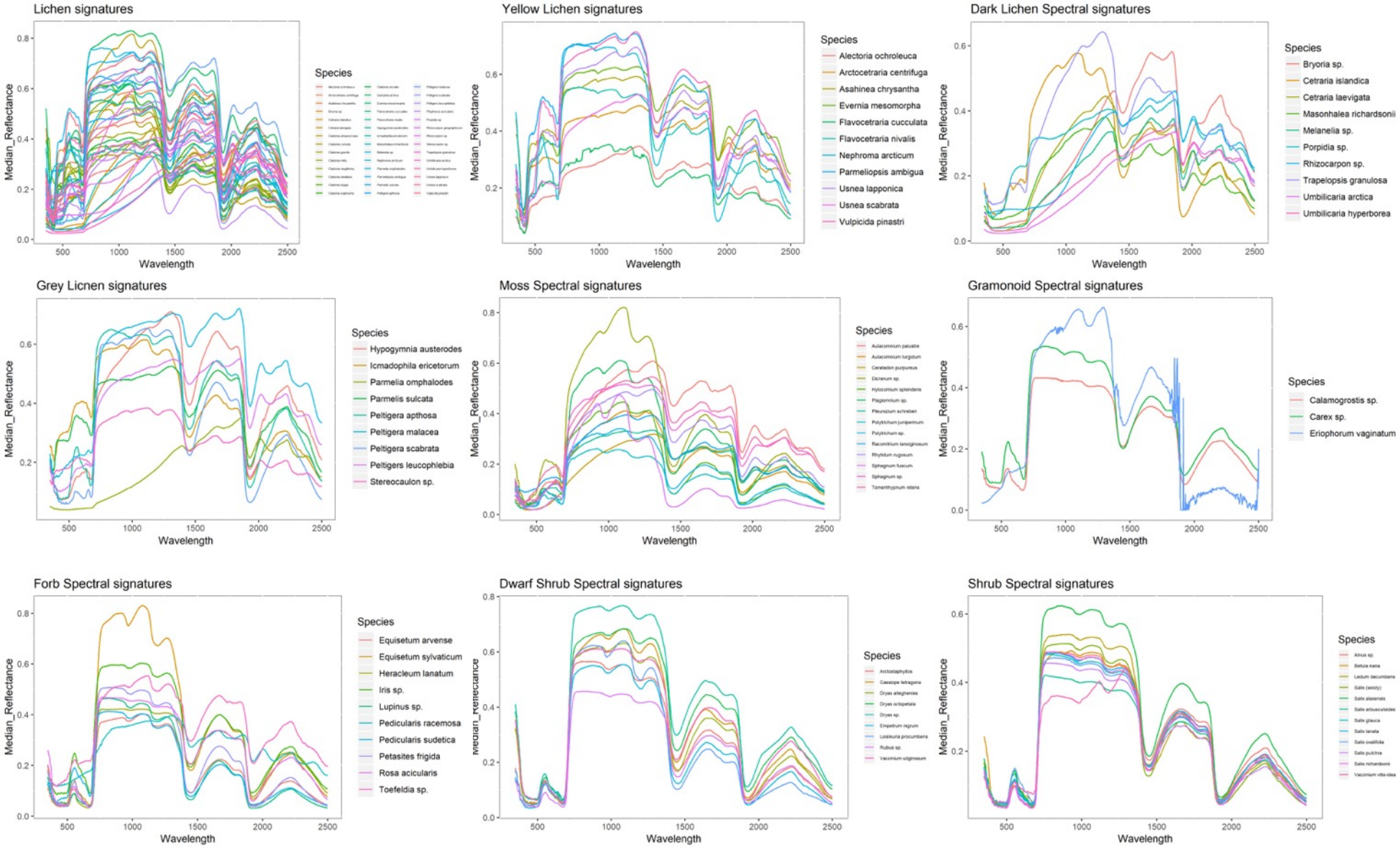


Table: Final 19 class PFT categories with numbers of scans per class used in the random forest models

Class3	n
Abiotic_Litter	11
Abiotic_Rock	19
Abiotic_Soil	8
Dwarf_Shrub_Broad	101
Dwarf_Shrub_Needle	19
Forb	51
Graminoid_Grass	4
Graminoid_Sedge	15
Lichen_Dark	133
Lichen_Light	65
Lichen_Yellow	153
Moss_Acrocarp	44
Moss_Pleurocarp	14
Moss_Sphagnum	10
Shrub_Alder	44
Shrub_Other	61
Shrub_Salix	50
Tree_Broad	10
Tree_Needle	17

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NASA

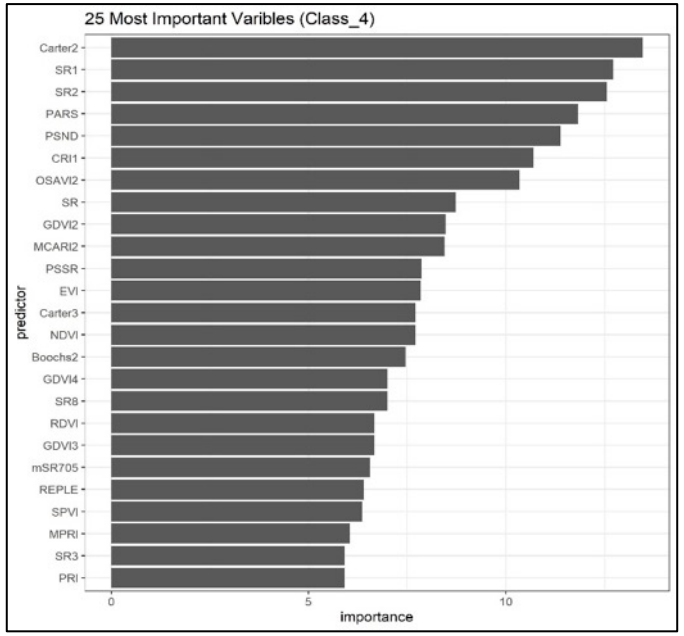
ABoVE ARCTIC - BOREAL VULNERABILITY EXPERIMENT

https://github.com/nelsopet/lecospec
http://lecospec.weebly.com/

LECOSPEC: UAV-based VNIR PFT maps … Results & Error statistics

Fubctional Groups	Abiotic	Dwarf Shrub	Forb	Graminoid	Lichen	Moss	Shrub	Tree	class.error
Abiotic	28	0	0	0	5	2	3	0	0.26
Dwarf Shrub	0	83	1	1	2	3	30	0	0.31
Forb	0	1	23	1	12	0	13	0	0.54
Graminoid	0	2	1	13	2	0	0	1	0.32
Lichen	3	4	0	0	334	5	0	0	0.03
Moss	0	4	1	0	12	50	1	0	0.26
Shrub	1	17	2	4	3	5	123	0	0.21
Tree	0	1	1	0	0	0	3	22	0.19

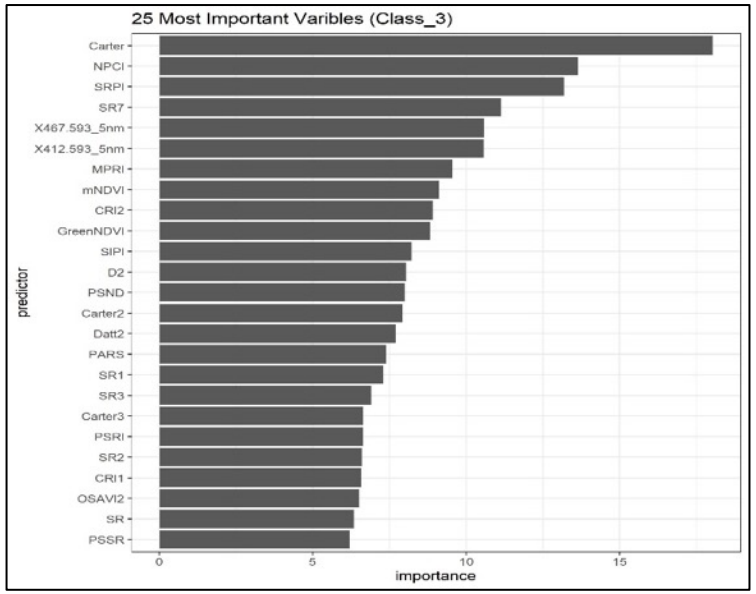
Fig: Confusion matrix and variable importance for models with 8 PFT classes



Functional Group	Abiotic_Litter	Abiotic_Rock	Abiotic_Soil	Dwarf_Shrub_Broad	Dwarf_Shrub_Needle	Forb	Graminoid_Grass	Graminoid_Sedge	Lichen_Dark	Lichen_Light	Lichen_Yellow	Moss_Acrocarp	Moss_Pleurocarp	Moss_Sphagnum	Shrub_Alder	Shrub_Other	Shrub_Salix	Tree_Broad	Tree_Needle	class.error
Abiotic_Litter	5	0	0	0	0	0	0	0	2	0	0	0	0	0	0	4	0	0	0	0.54545
Abiotic_Rock	1	16	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0.15789
Abiotic_Soil	0	4	3	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0.625
Dwarf_Shrub_Broad	0	0	0	78	2	2	0	0	1	0	0	1	0	0	0	13	4	0	0	0.22772
Dwarf_Shrub_Needle	0	0	0	7	6	1	0	0	0	0	0	2	0	0	0	3	0	0	0	0.68421
Forb	0	0	0	1	0	30	0	1	4	1	2	1	0	0	2	3	5	0	0	0.4
Graminoid_Grass	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0
Graminoid_Sedge	0	0	0	2	0	1	0	11	0	1	0	0	0	0	0	0	0	0	0	0.26667
Lichen_Dark	0	0	0	3	0	1	0	0	122	1	5	0	0	1	0	0	0	0	0	0.08271
Lichen_Light	0	0	0	0	0	1	0	0	10	51	2	0	1	0	0	0	0	0	0	0.21538
Lichen_Yellow	0	0	0	0	0	0	0	0	4	2	147	0	0	0	0	0	0	0	0	0.03922
Moss_Acrocarp	1	0	0	1	2	1	0	0	5	0	0	30	2	0	0	2	0	0	0	0.31818
Moss_Pleurocarp	0	0	0	0	0	0	0	0	1	2	1	7	3	0	0	0	0	0	0	0.78571
Moss_Sphagnum	0	0	0	0	0	0	0	0	4	0	0	1	0	5	0	0	0	0	0	0.5
Shrub_Alder	0	0	0	4	0	0	0	0	0	0	0	0	0	0	25	2	13	0	0	0.43182
Shrub_Other	1	0	0	13	0	1	0	2	1	1	0	2	0	0	0	35	3	2	0	0.42623
Shrub_Salix	0	0	0	9	0	1	0	0	0	0	0	0	0	0	8	3	28	0	1	0.44
Tree_Broad	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	7	0	0.3
Tree_Needle	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	16	0.05882

Fig: Confusion matrix and variable importance for models with 19 PFT classes

Total Number of bands used (400 – 900) = 272, an additional 196 derivatives were calculated which were reduced to 87 less correlated and important variables used for mapping



- 19 class models had lower global error than 8 class models
- Carter vegetation indices were the single most important predictor of PFT classes
- Narrow band (5nm) features at 412 and 467 nm were the fifth and sixth most important variables in the 19 class model
- Broadleaved shrub categories were difficult to separate
- Conifer trees and lichen classes were very easily separated

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ABoVE ARCTIC - BOREAL VULNERABILITY EXPERIMENT

https://github.com/nelsopet/lecospec
http://lecospec.weebly.com/

LECOSPEC: UAV-based VNIR PFT maps … Data/Output/Products

- 1000 scans (350-2500nm, 1nm bands) of 100 vascular and non-vascular plant species in Alaska part of ABoVE domain available for collaborators (not published on DAAC/ECOSIS yet)

- Code pipeline available to public for image classification and regression (random forest) of any hyperspectral imagery based on a spectral library at https://github.com/nelsopet/lecospec

- Orthorectified surface reflectance product (326 bands, 400-1000 nm, ca. 4cm GSD) collected around ABoVE domain under AVIRIS ng from UAV-based VNIR imaging spectrometer and classified plant functional type (PFT) maps available upon request

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LECOSPEC: UAV-based VNIR PFT maps … Conclusions:

- Balancing global error vs distribution of error in classes of interest (eg. Lichens) remains a challenge
  - Collect/pool spectra to fill in gaps in what targets are present in the images (eg. Lacustrine vegetation)
- Vegetation indices are consistently better predictors of plant functional type compared to variable band width predictors (5,10,50 and 100nm wide)
- Balance sampling between categories of plant functional types
- Use Spectralon (vs other scene white reference) for consistent radiometric calibration between scenes

https://github.com/nelsopet/lecospec
http://lecospec.weebly.com/

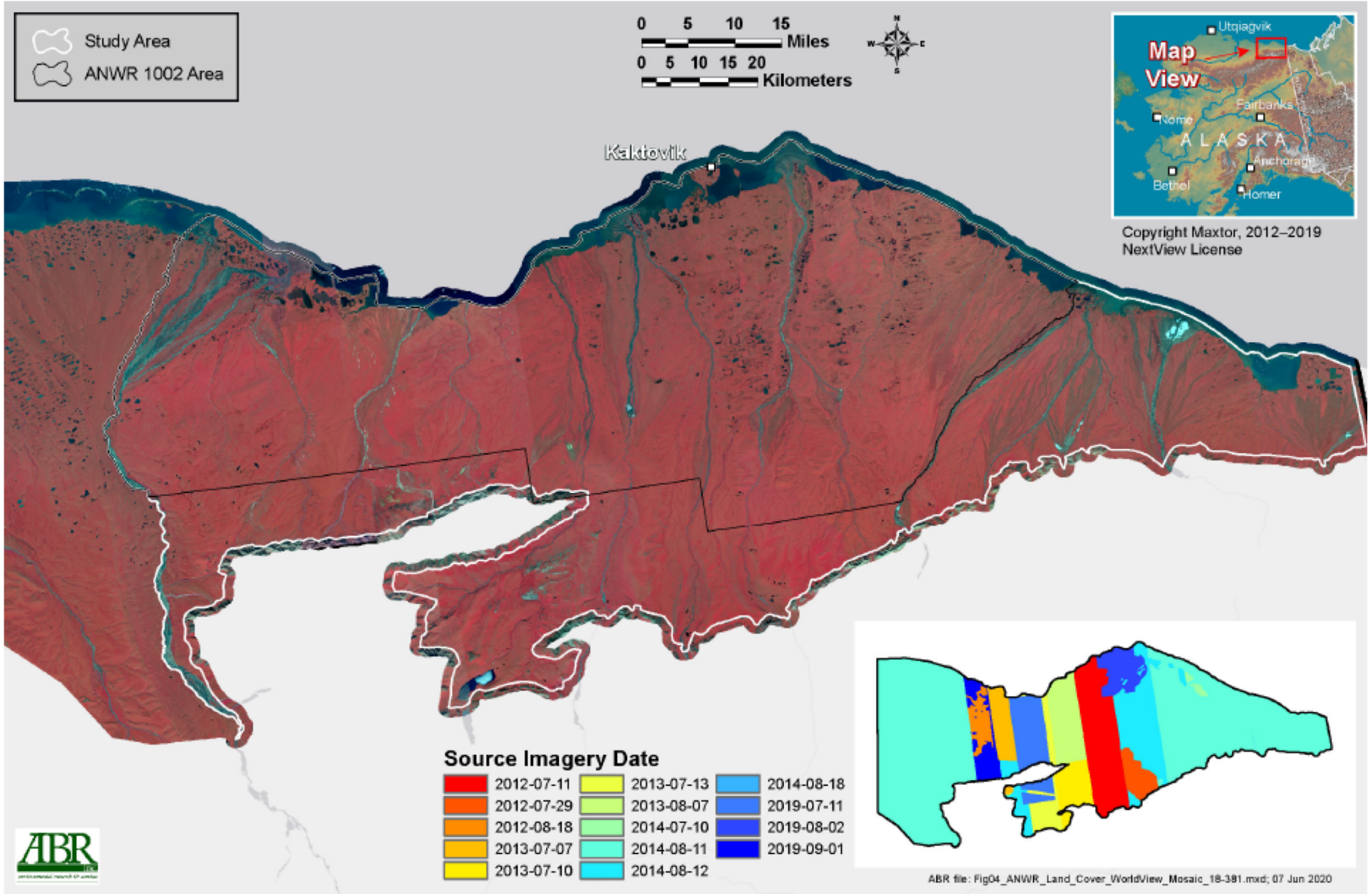
LECOSPEC: UAV-based VNIR PFT maps … Questions for the group:

- Consistent radiometric calibration between projects
- Universal vs. scene-specific algorithms (spectral library vs. digitizing patches of targets in images)
- What kind of models are you using (regression or classification)?
  - Radiative transfer
  - Nonlinear/ML/AI
  - Mixture/hybrid models using both kinds of derivations of the spectra
- Shared consistent, ecologically meaningful plant taxonomic scheme(s)?
- Hi res water/abiotic mask?

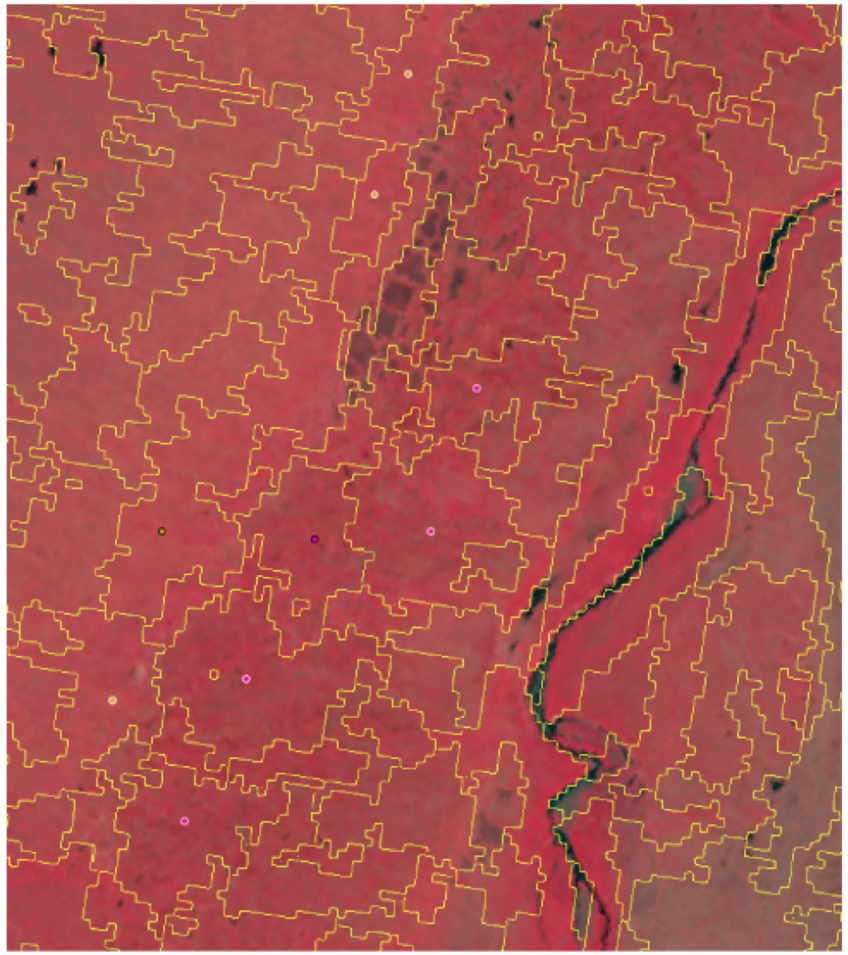
https://github.com/nelsopet/lecospec
http://lecospec.weebly.com/

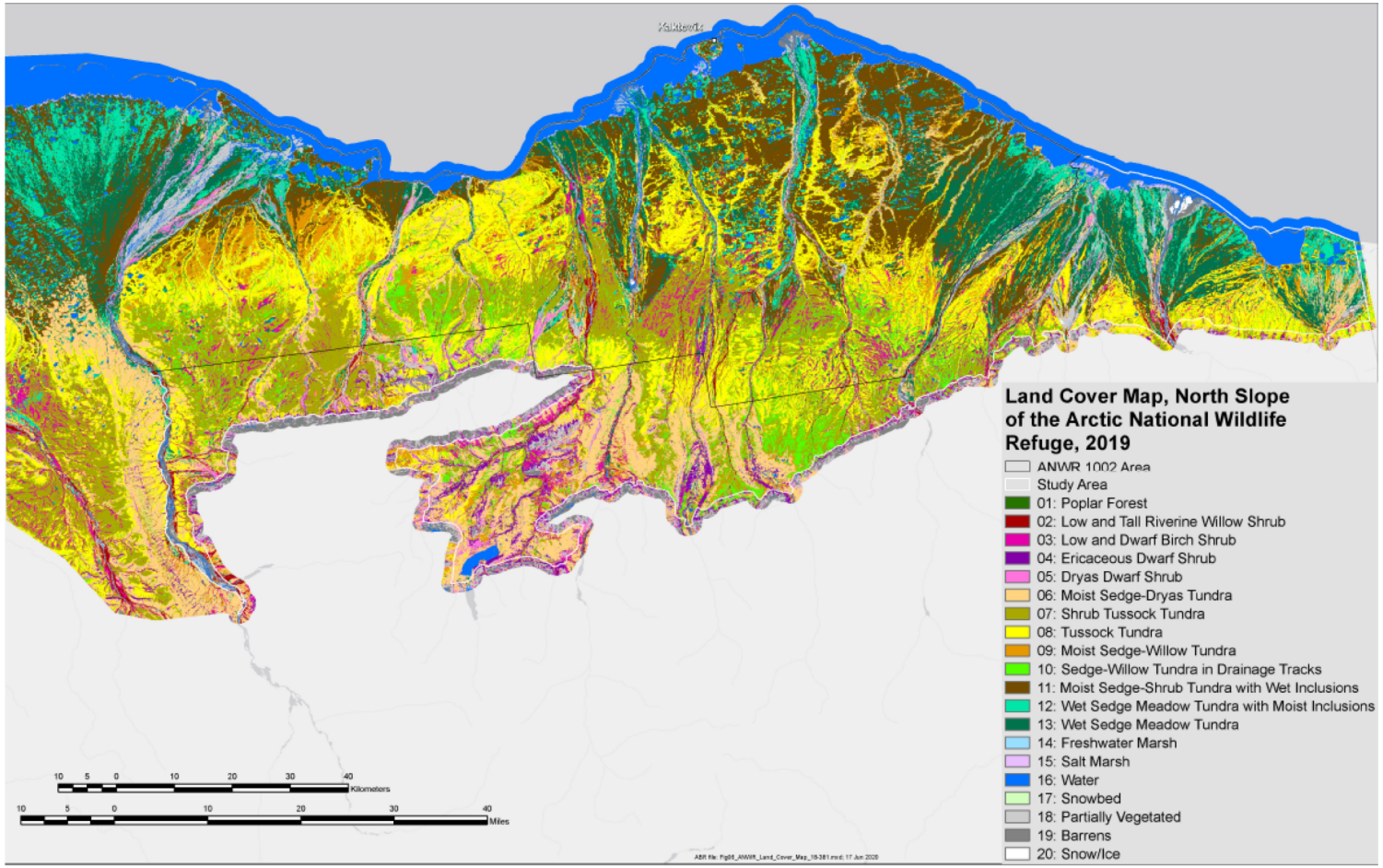
Spectral Calibration to provide consistent WV2/3 Mosaics (Calibrated to Landsat 8 SR)

Matt Macander

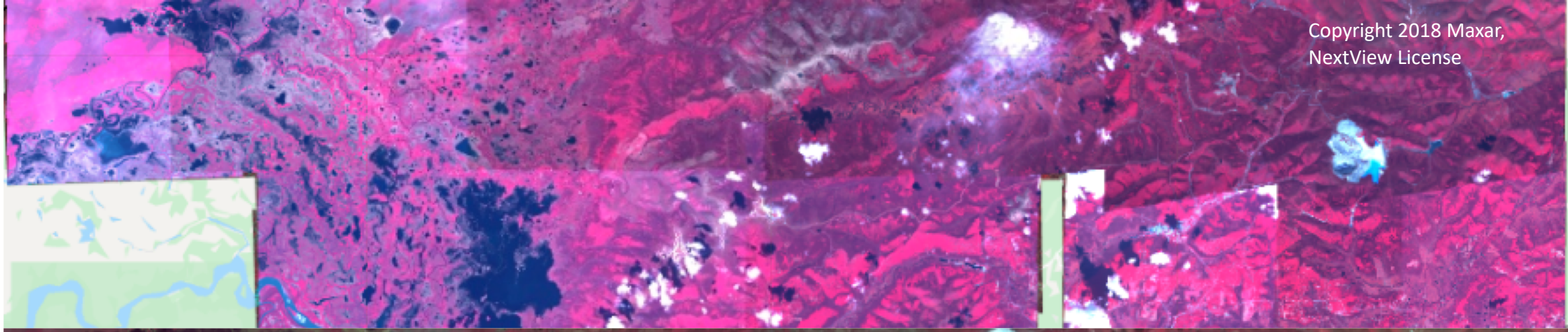


Classification Example



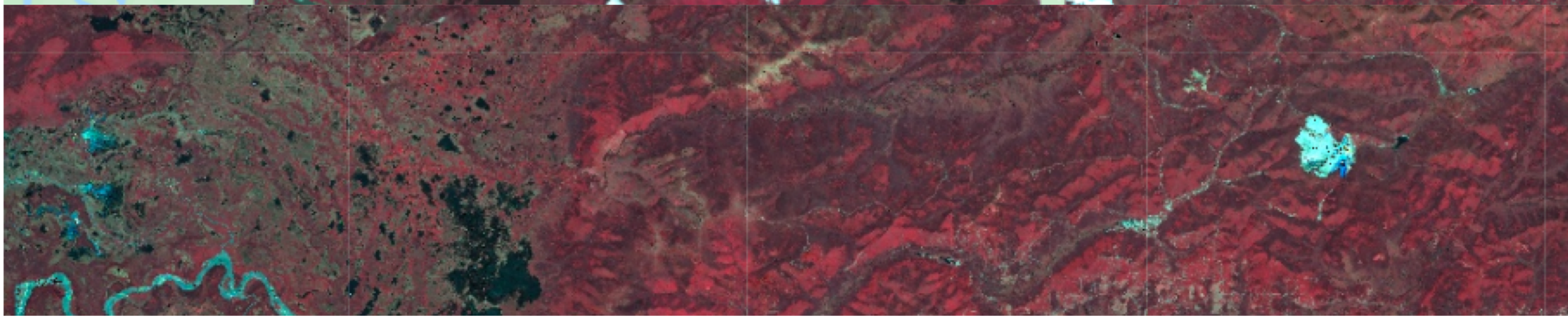


WV2,3 DN
27 May– 3
June 2018



WV2,3 SR
27 May– 3
June 2018

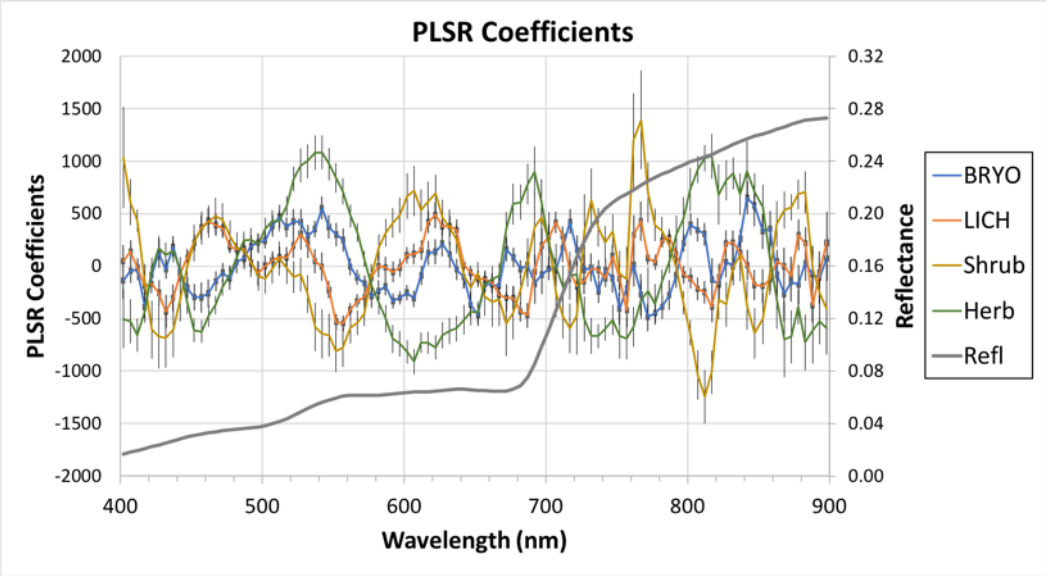
Landsat
SR
1 June
2018



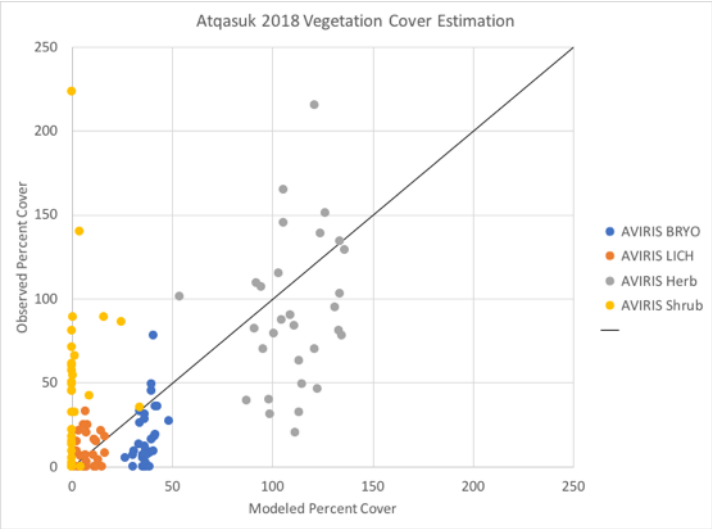
Hyperspectral Mapping of Tundra Vegetation Cover Types

K.F. Huemmrich (UMBC), C. Tweedie (UTEP), S. Vargas Z. (UTEP), P. Campbell (UMBC), E.M. Middleton (VCU)

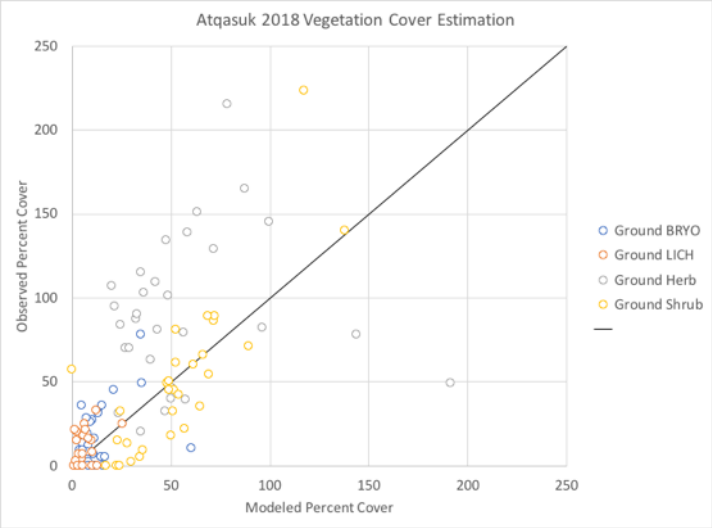
Use PLSR applied to training data of spectral reflectance convolved to AVIRIS NG bands and point drop canopy cover estimates from BRW & ATQ CALM grids 2010-2017

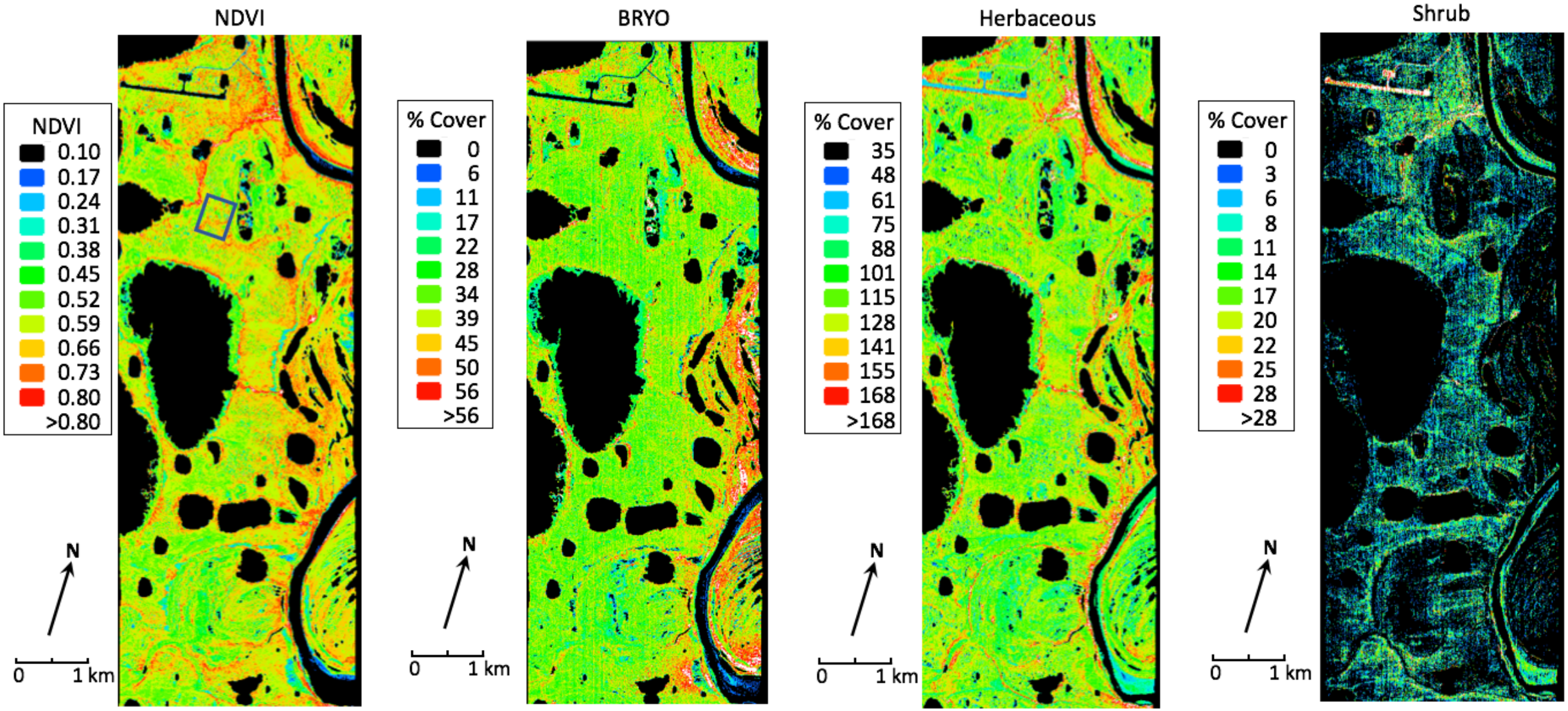


Thanks to Robert Hollister, Steve Oberbauer, Mariana Orejel, Mayra Melendez, Hector Dominguez, Tabatha Fuson, Stephen Escarzaga, Ryan Cody, Hana Christoffersen, Jake Harris, and Caitlyn Betway for the field measurements. This work is supported by NASA grant NNX17AC58A.



For all four of the vegetation types the correlation with the AVIRIS NG derived cover is 0.56 and the RMSE is 42.7% cover. Shrub coverage has the worst prediction and removing shrubs from the set gives values for the rest of the covers of R=0.79 and RMSE=31.9% cover.



For all four of the vegetation types the correlation for ground spectra derived cover is R=0.66 and RMSE=36.7% cover.

Hyperspectral Mapping of Tundra Vegetation Cover Types