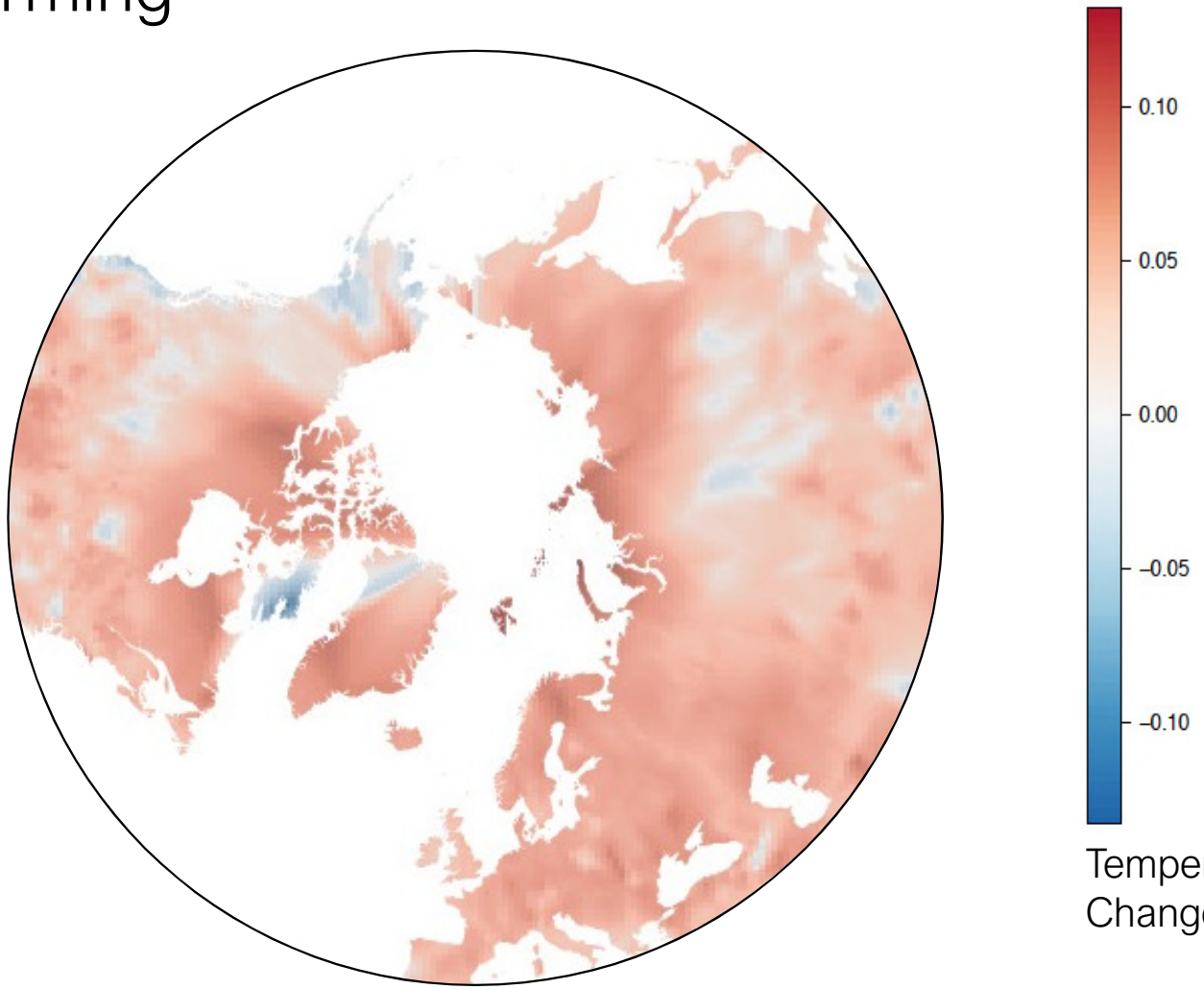
Leveraging Drones to Quantify the Landscape-Context of Tundra Biodiversity Change

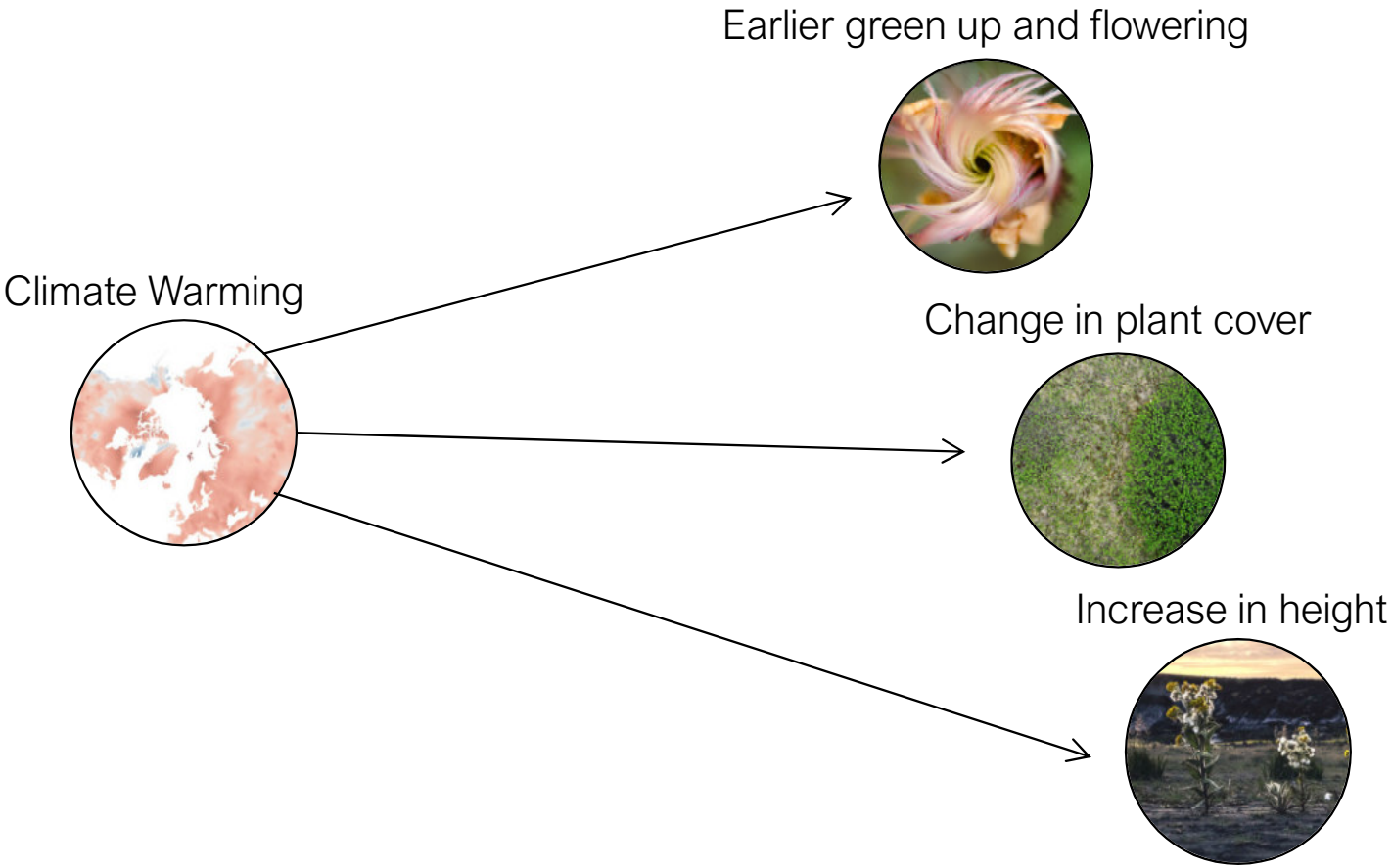
Jeffrey Kerby[1,2], Isla Myers-Smith[2] and the HiLDEN Network[3]

[1] Neukom Institute & Institute of Arctic Studies, Dartmouth College, [2] School of Geosciences, University of Edinburgh, [3]ArcticDrones.org

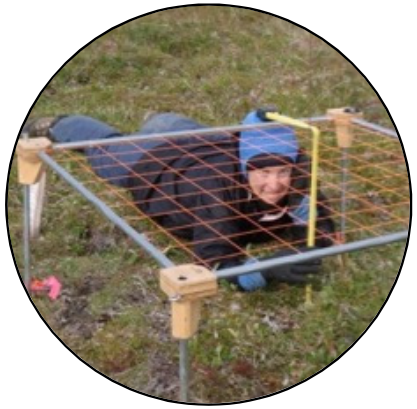
The Arctic is warming



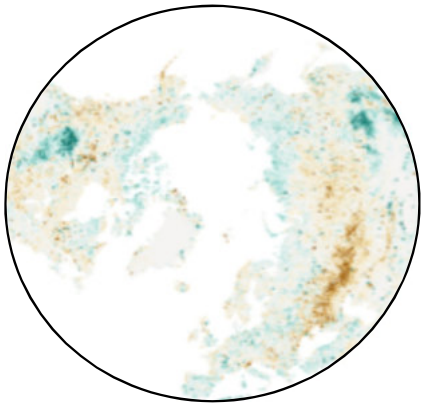
Mean Annual Temperature Change 1978 to 2013


Earlier green up and flowering
Climate Warming
Change in plant cover
Increase in height

Observation

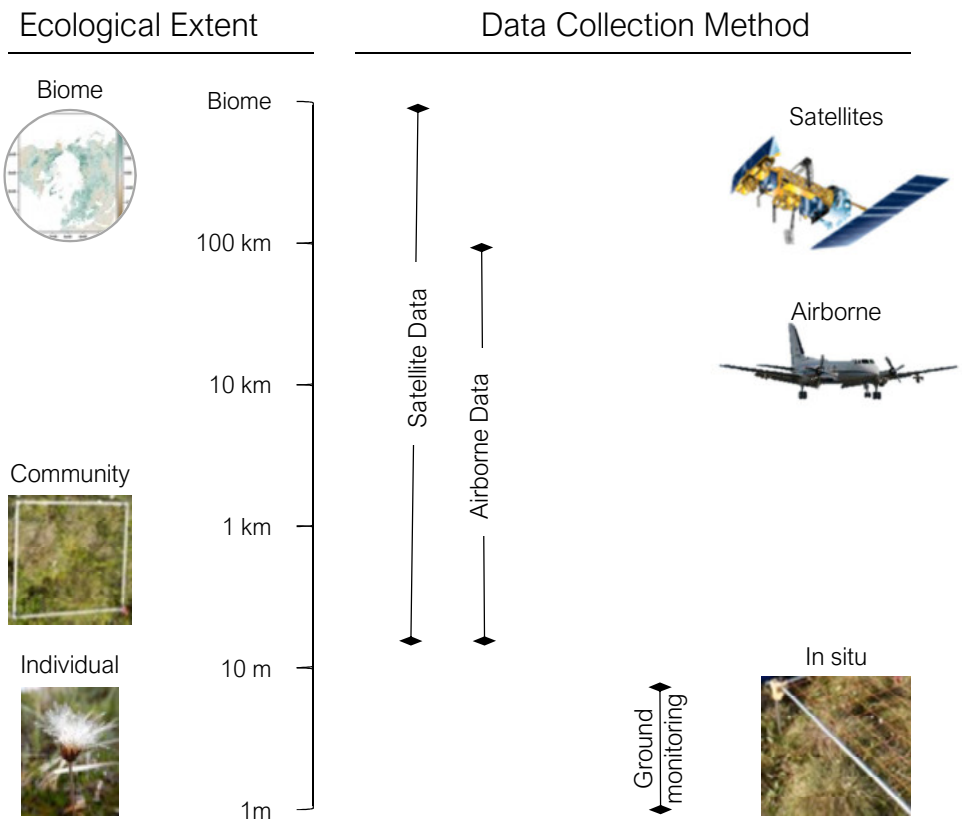


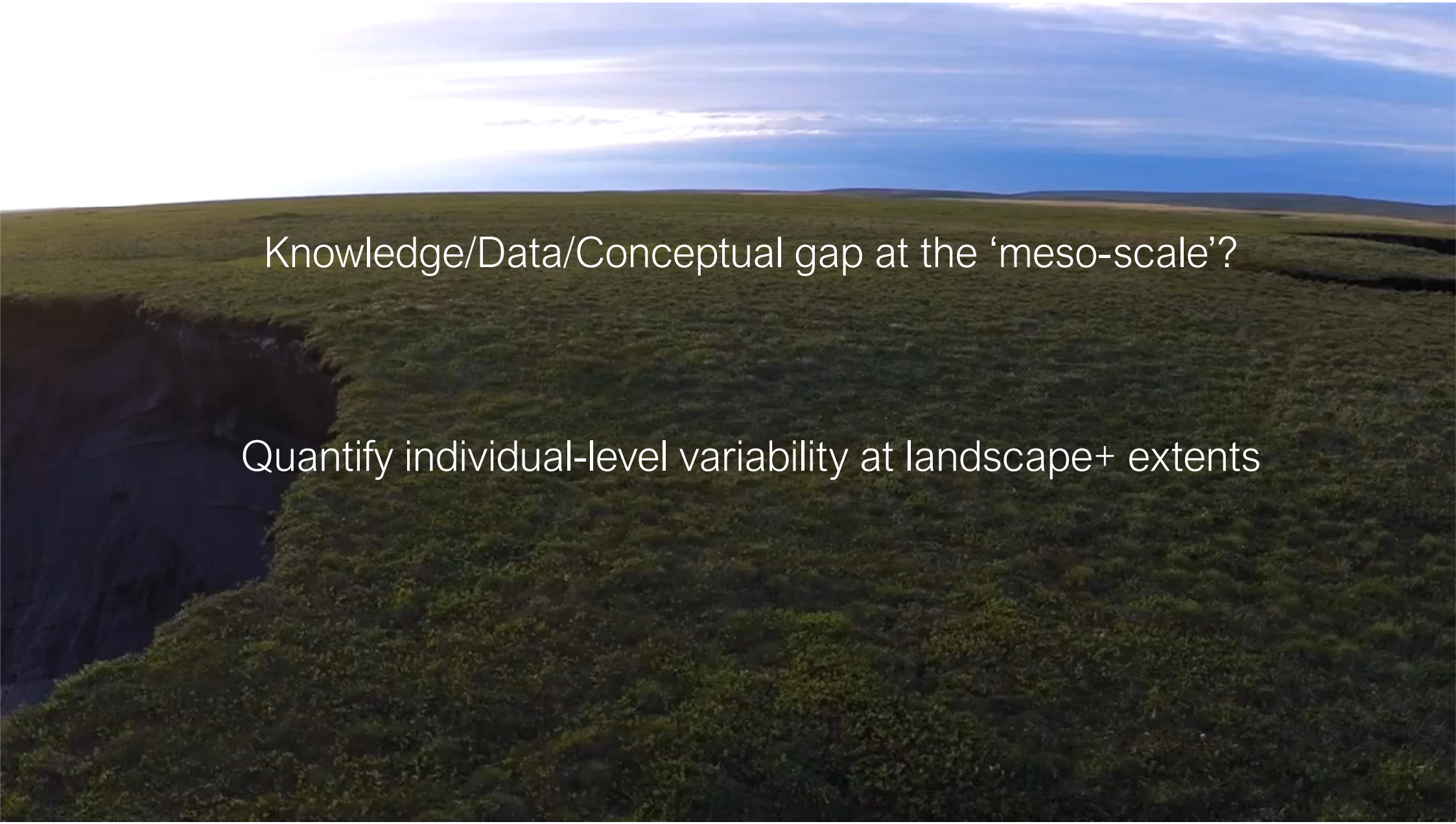
Modeling



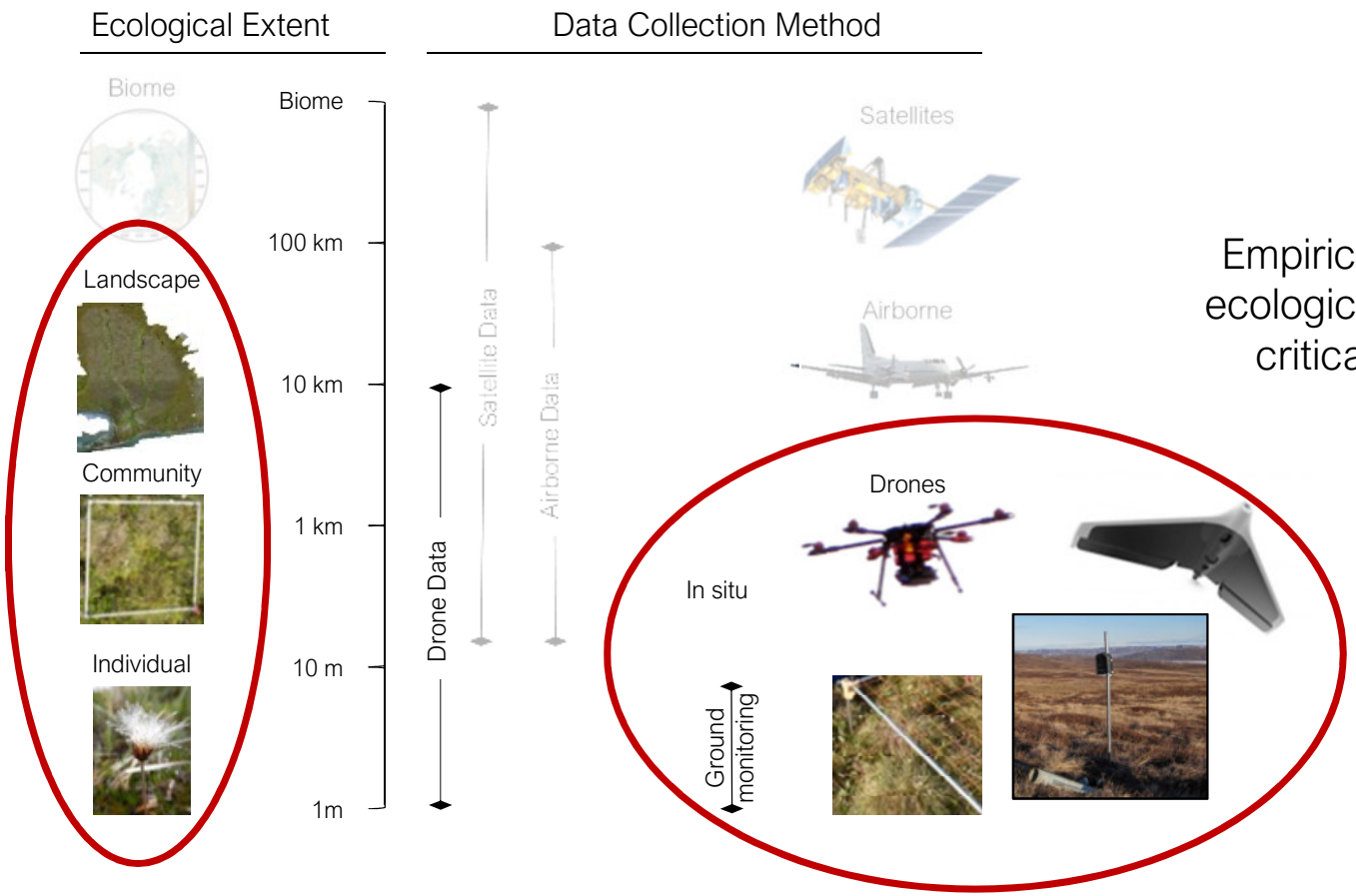
Experimentation

How to we measure ecological variability? Pattern? How does this shape our research?




Knowledge/Data/Conceptual gap at the ‘meso-scale’?
Quantify individual-level variability at landscape+ extents

How to we measure ecological variability? Pattern? How does this shape our research?



In situ measurements

Empirical measures of ecological variability are critical for scaling!

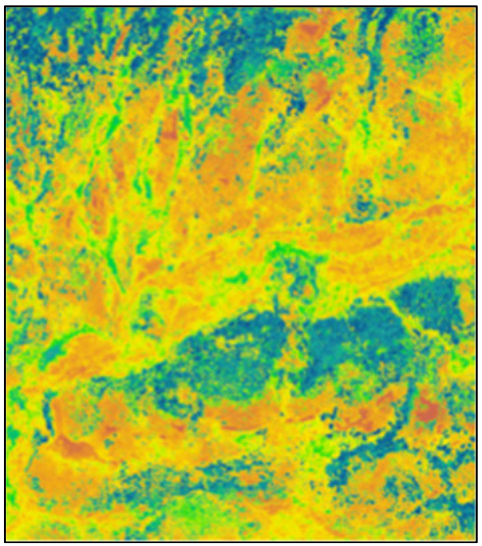
HiLDEN fieldwork with Greg Henry and Alexandra Fiord Team

Drones in Tundra Ecology

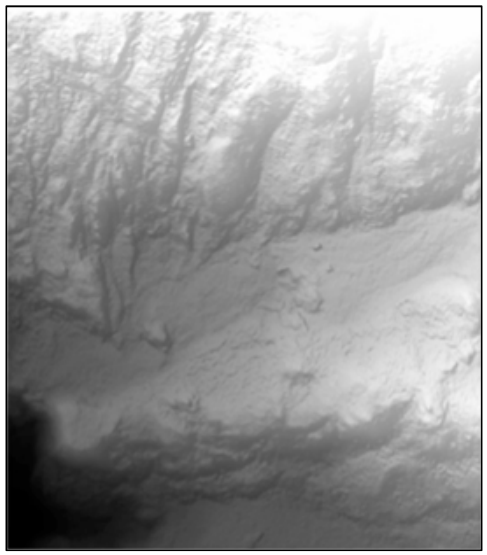
- Basic drone products:
- Orthophotos (RGB and multispectral)
- Digital Surface Models

Orthophoto (RGB)

Orthophoto (multispec)

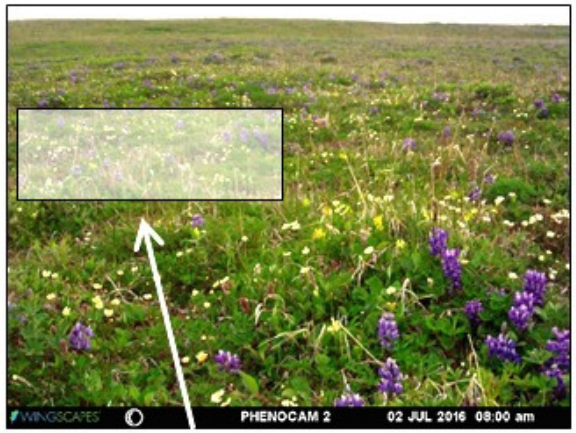


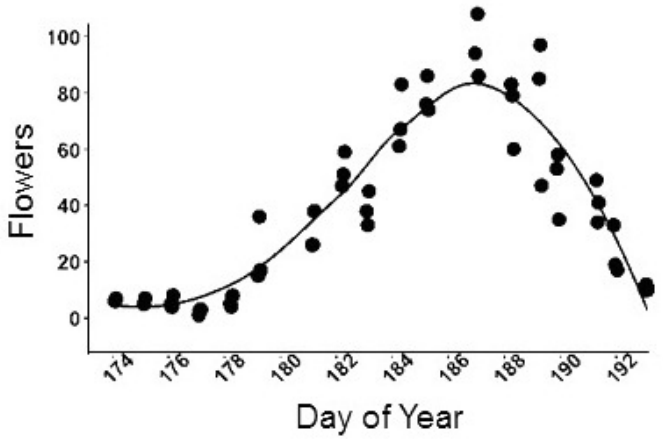
Surface Model



Censuses

Through space

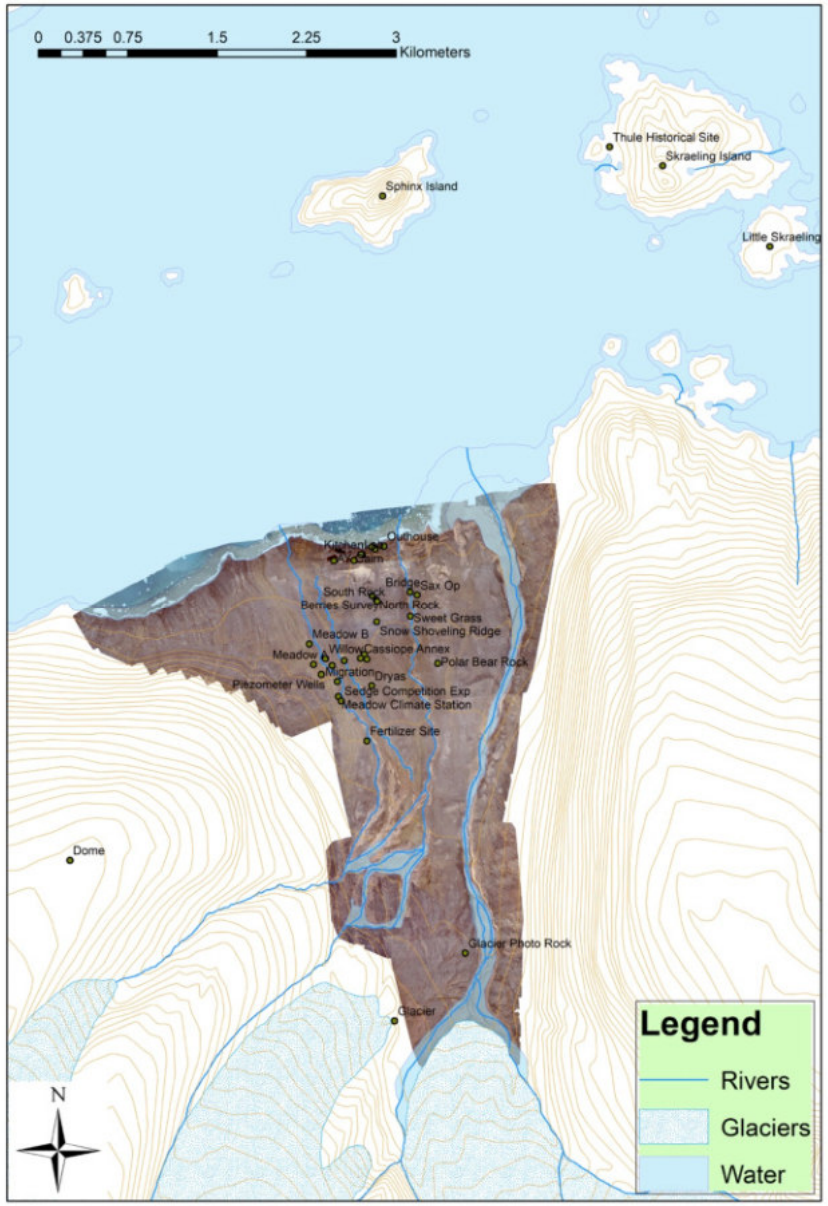




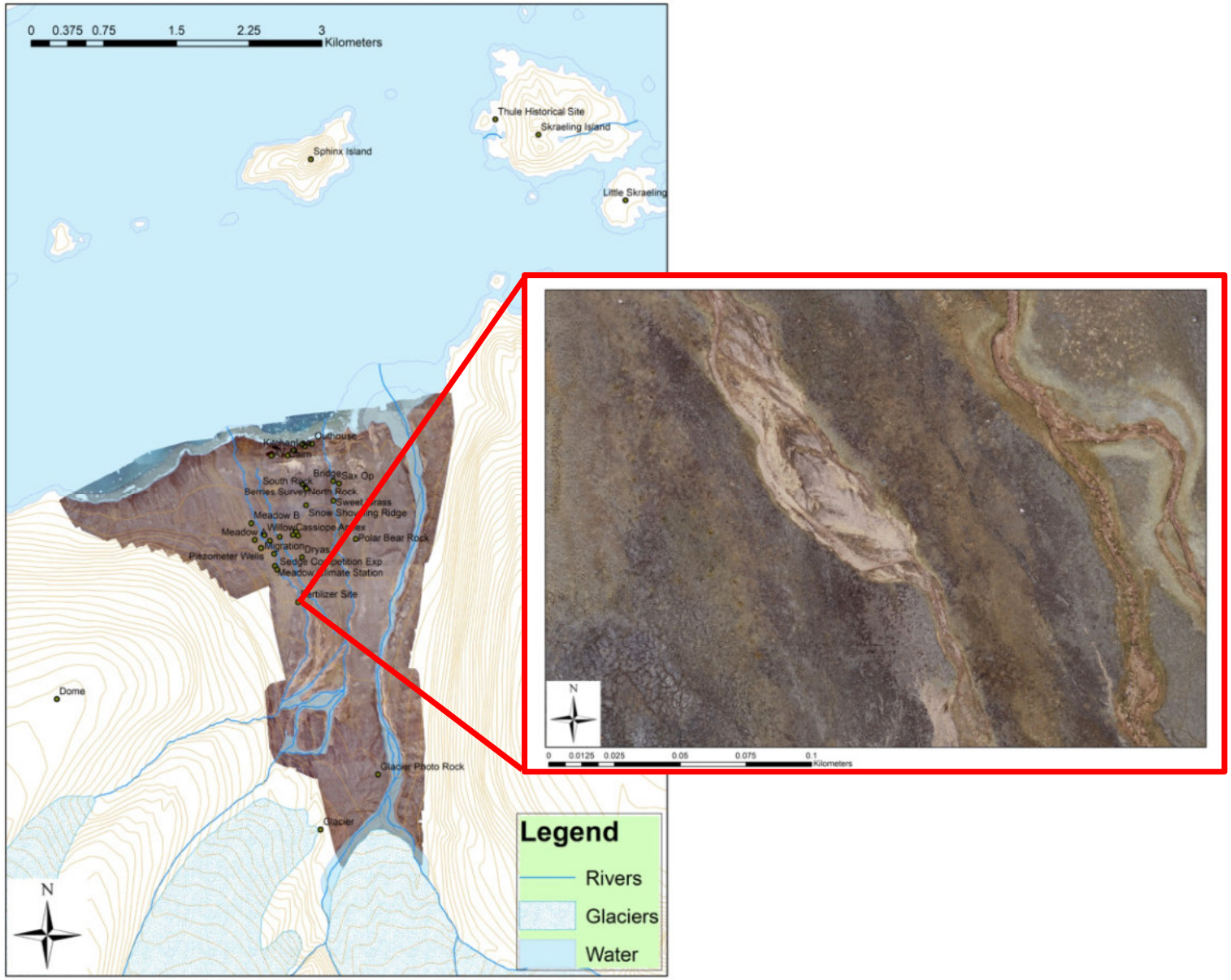
Through time

in prep

0 0.375 0.75 1.5 2.25 3
Kilometers
Thule Historical Site
Skraeling Island
Sphinx Island
Little Skraeling
Outhouse
Kitchen
Cairn
Bridge
Sax Op
South Rock
Berries Survey
North Rock
Sweet Grass
Snow Shoveling Ridge
Meadow B
Willow
Cassiope Annex
Meadow A
Polar Bear Rock
Migration
Dryas
Piezometer Wells
Sedge Competition Exp
Meadow Climate Station
Fertilizer Site
Dome
Glacier Photo Rock
Glacier
N
Legend
Rivers
Glaciers
Water



1-2 days of drone mapping


0 0.375 0.75 1.5 2.25 3
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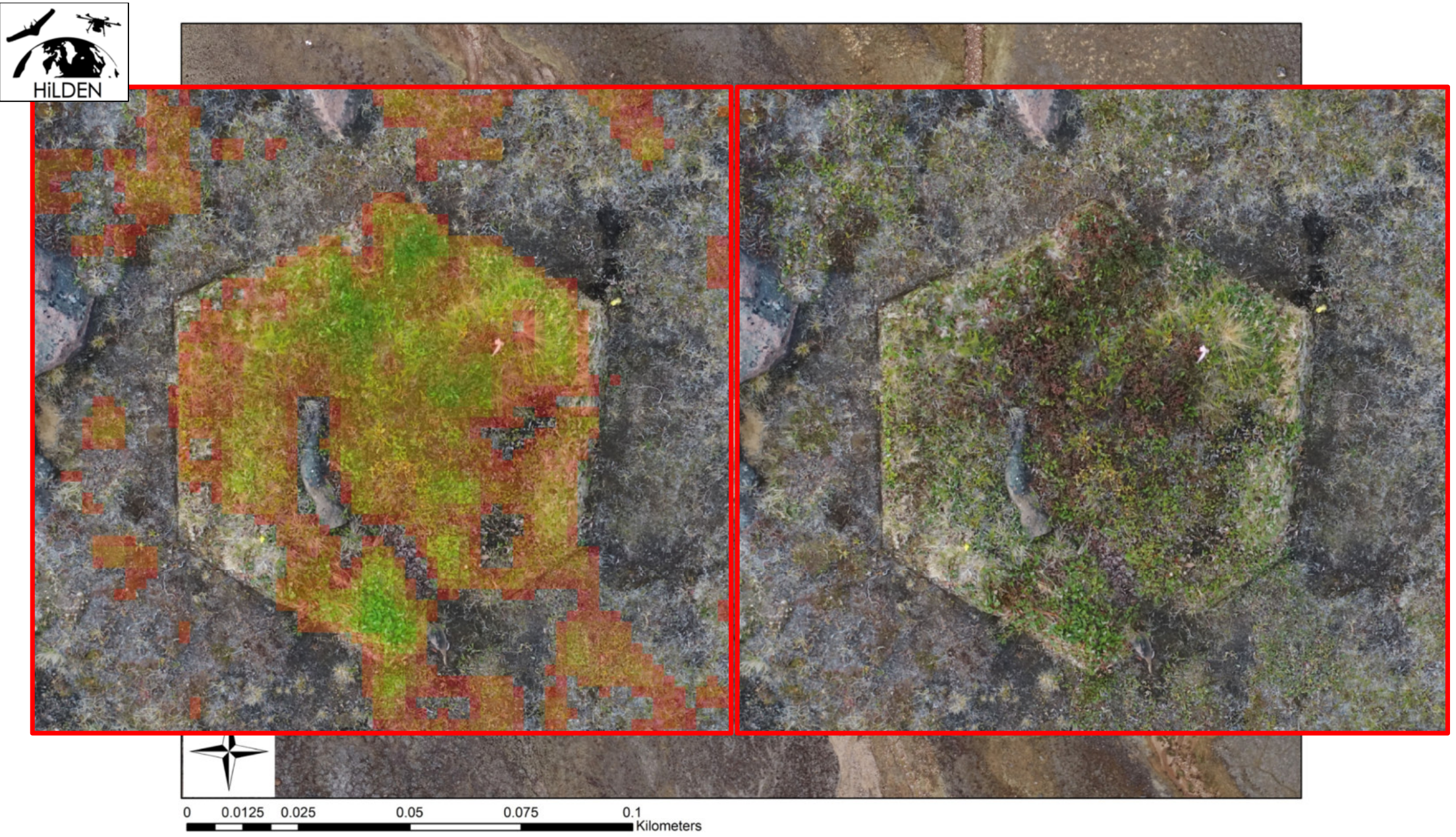
N
0 0.0125 0.025 0.05 0.075 0.1
Kilometers

HiLDEN

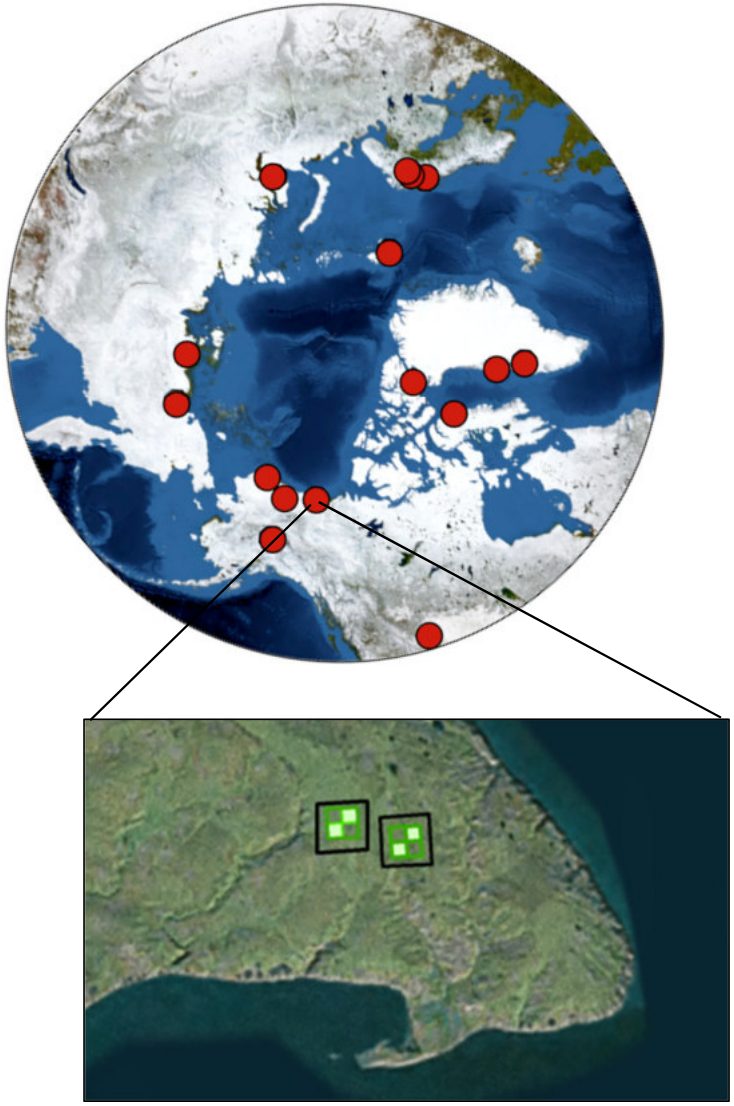
N
0
0.0125
0.025
0.05
0.075
0.1
Kilometers


HiLDEN
0
0.0125
0.025
0.05
0.075
0.1
Kilometers

High Latitude Drone Ecology Network

HiLDEN

ArcticDrones.org



- Established winter 2017

- Preliminary field season May – September 2017
- Follow-up field season May – September 2018

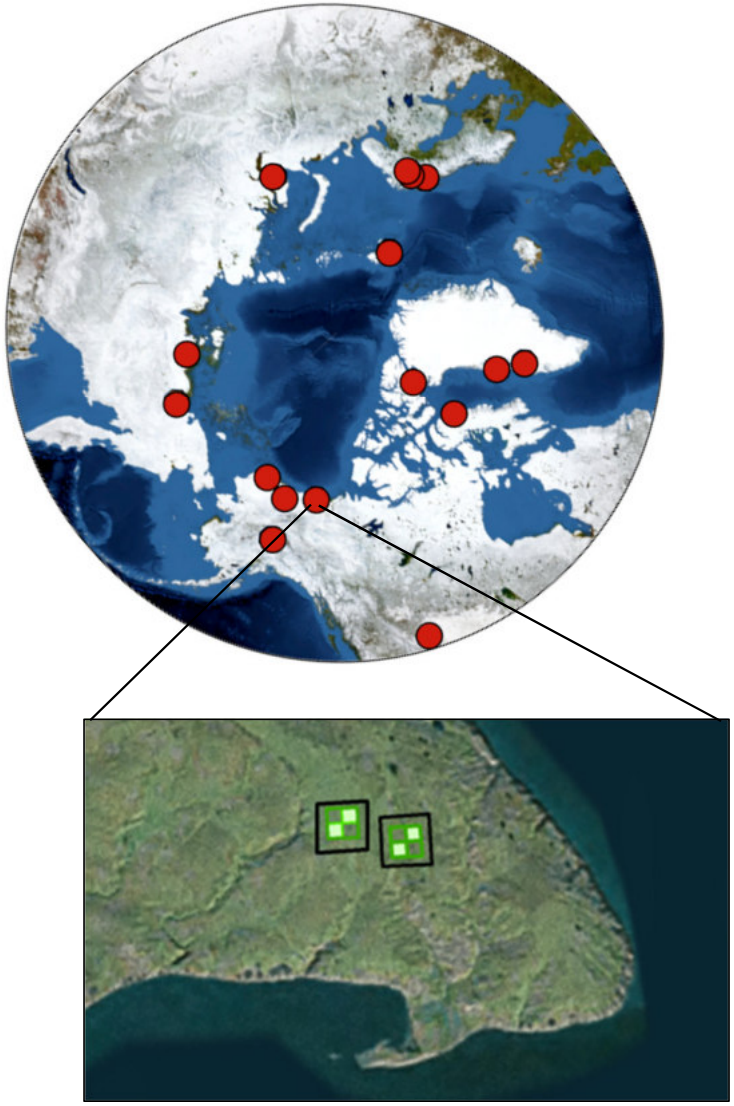
- 40+ researchers across dozens of sites
- Data from Canada, USA, Greenland, Sweden, Finland, Svalbard, Russia

- Several TB of photos submitted/housed on secure web-server

High Latitude Drone Ecology Network

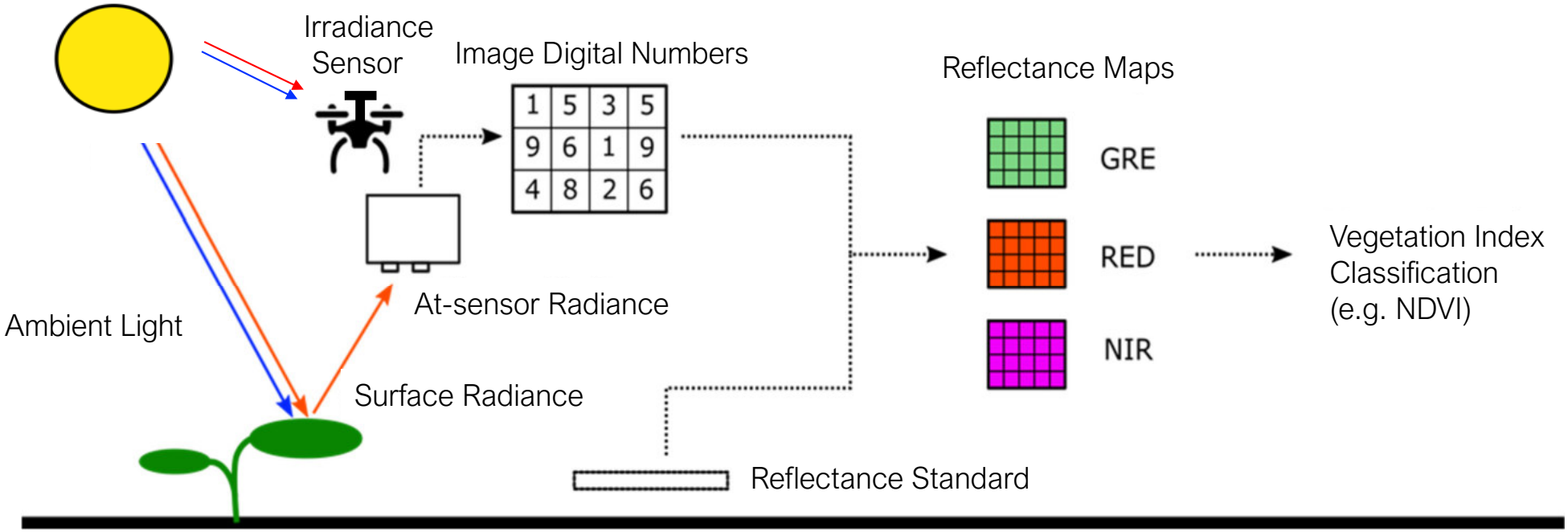
HiLDEN

ArcticDrones.org



- HiLDEN initially focused on scaling patterns of vegetation productivity.
- Developed base-level standards for consistent data comparisons across sites and through time.
- Protocols could help existing networks add value to legacy and future datasets.

Managing Signal to Noise:



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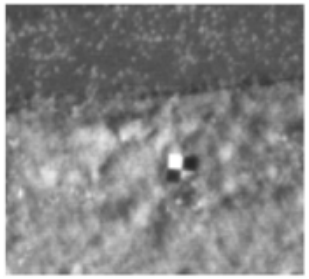
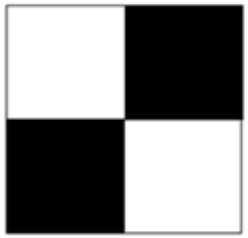
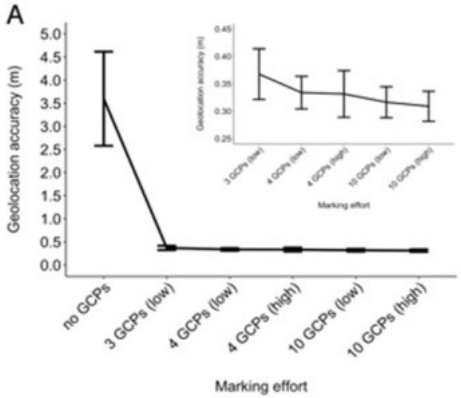


B



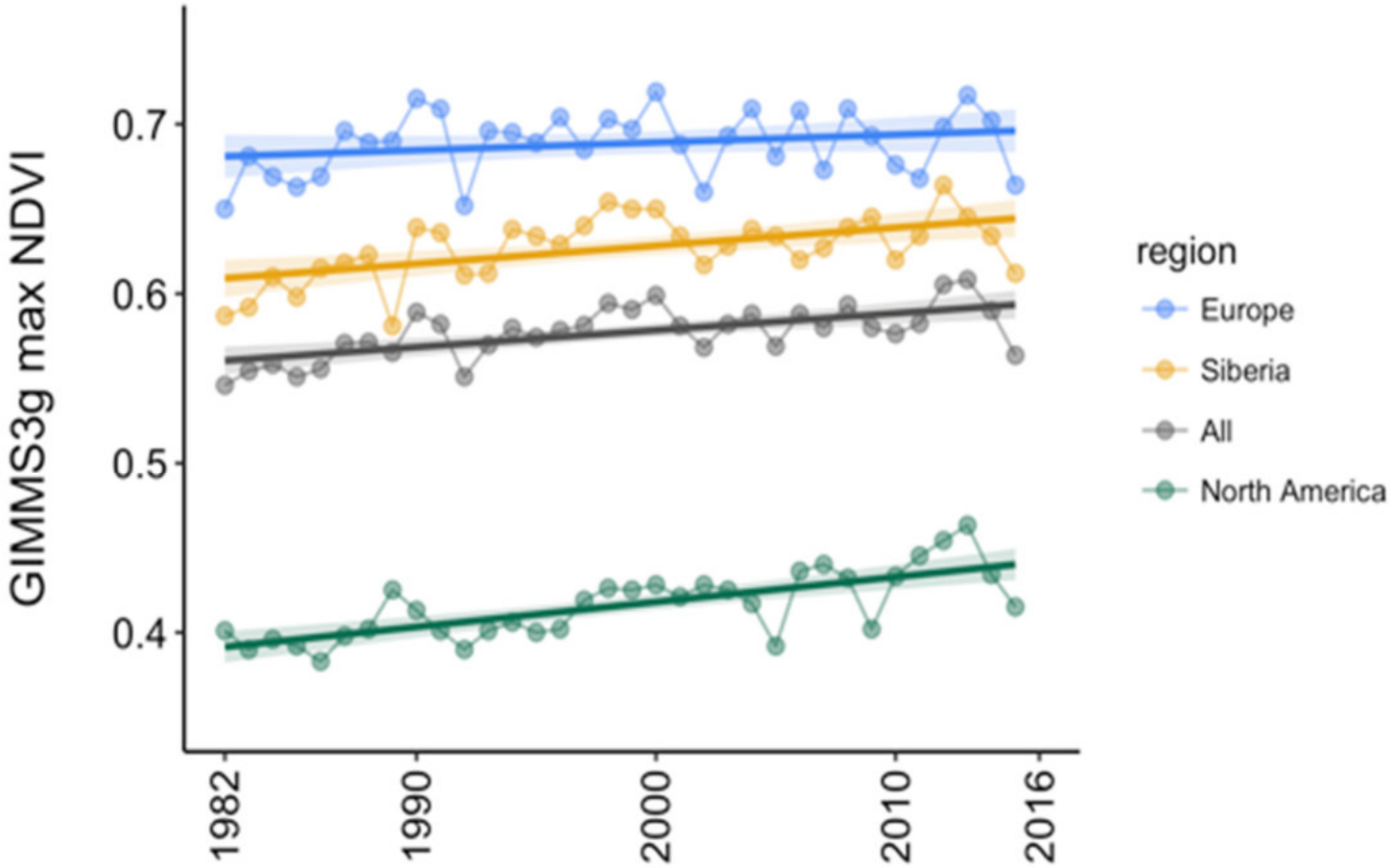
Ground Control Points

A



Modified from: Assmann et al *Accepted*

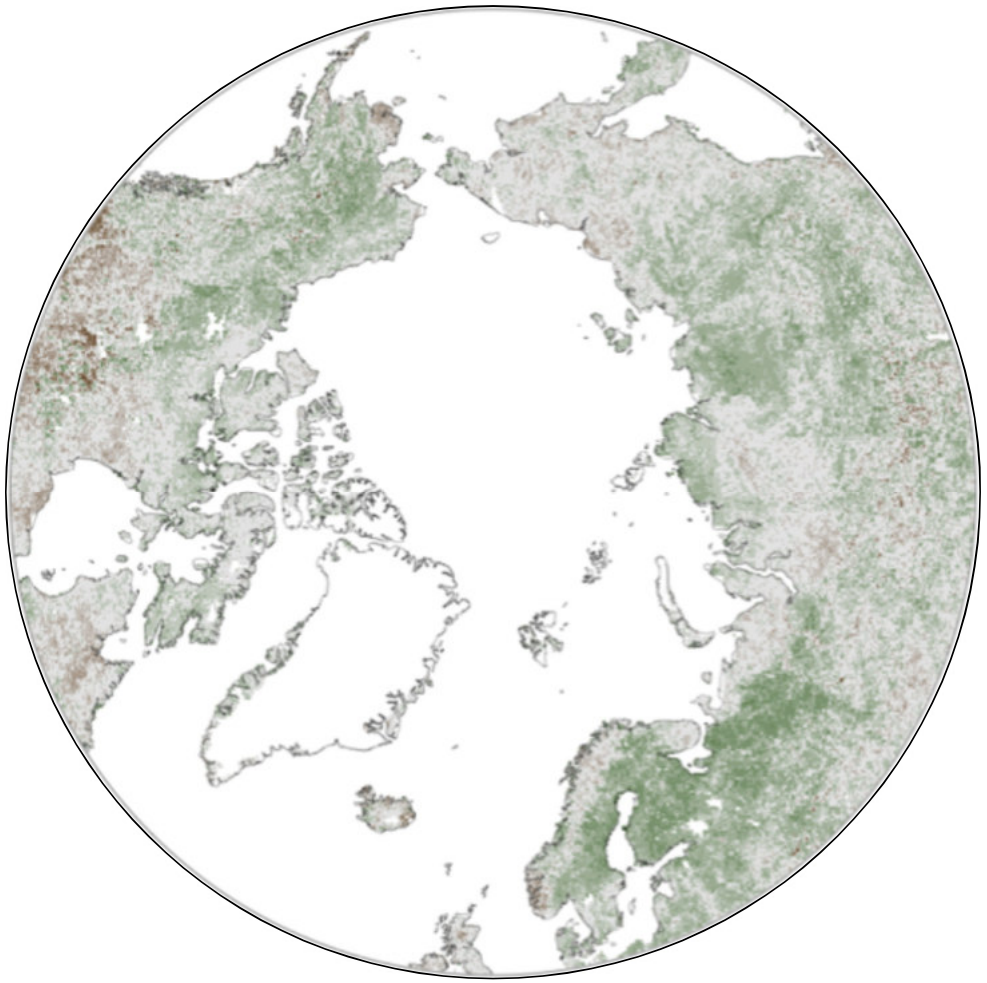
The Arctic is greening



GIMMS 3g AVHRR Satellite Data 1982 to 2015

Myers-Smith, Kerby *et al.* in prep.

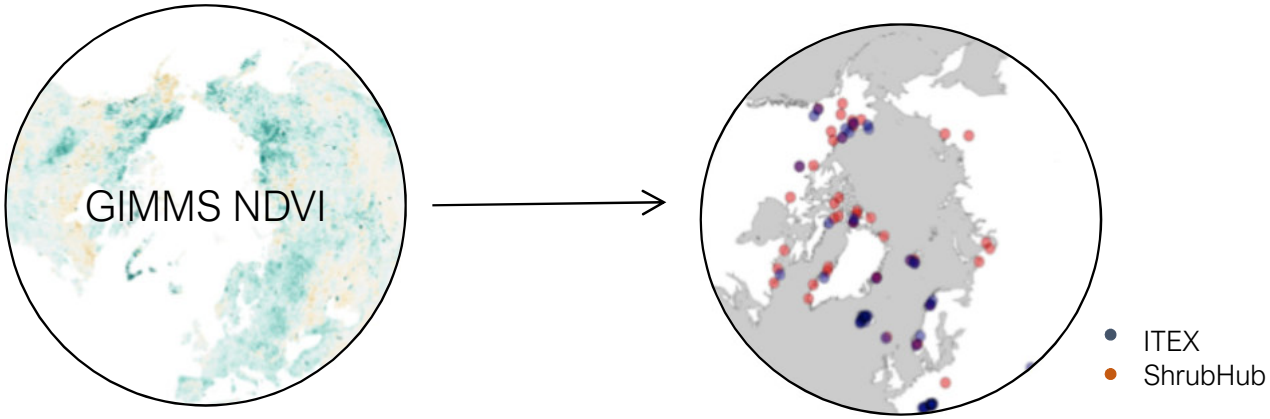
The Arctic is greening

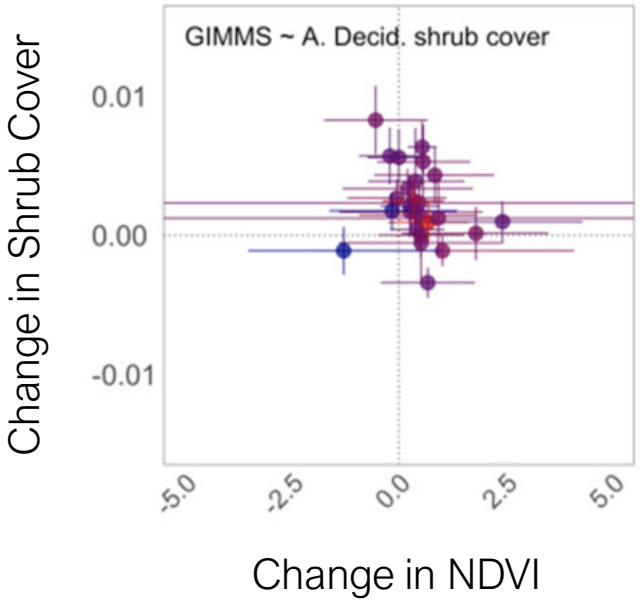


Increasing NDVI

Decreasing NDVI

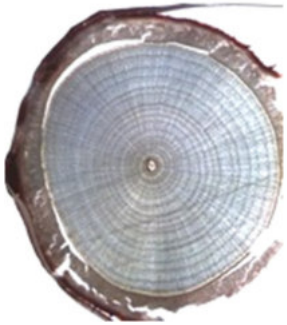
Increasing greenness ~ plant cover change?

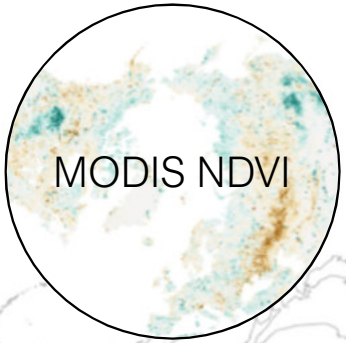


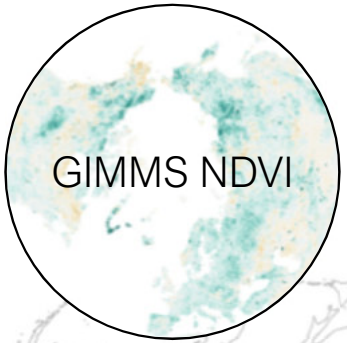


Myers-Smith *et al.* in prep.

Increasing greenness ~ shrub growth?

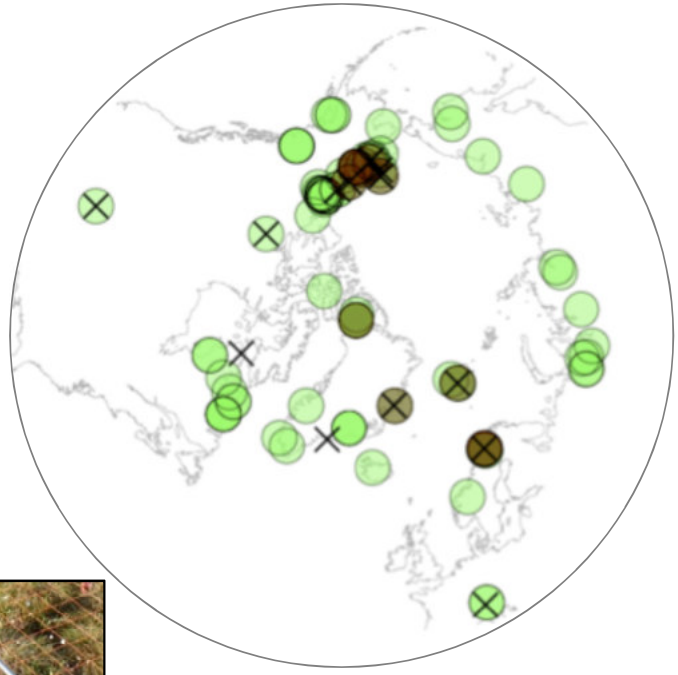


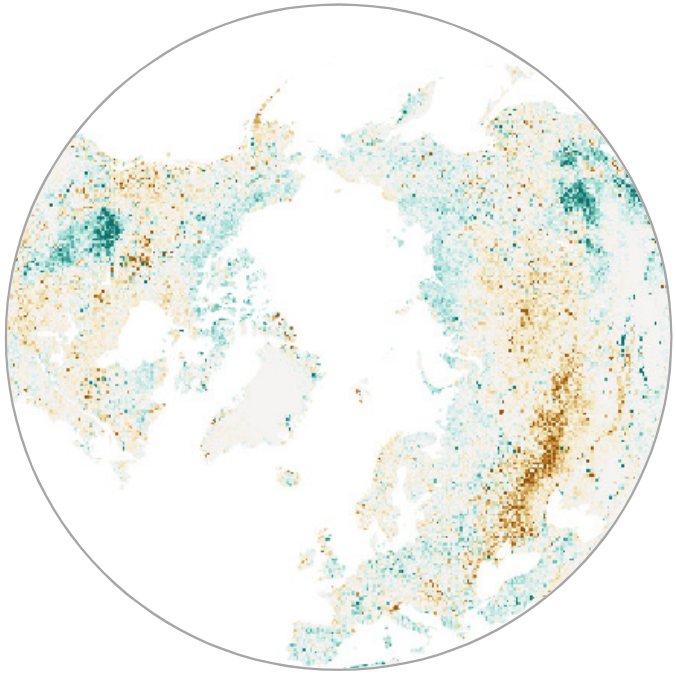




Myers-Smith *et al.* in prep.

Conceptual Challenge: connecting plots to satellites?



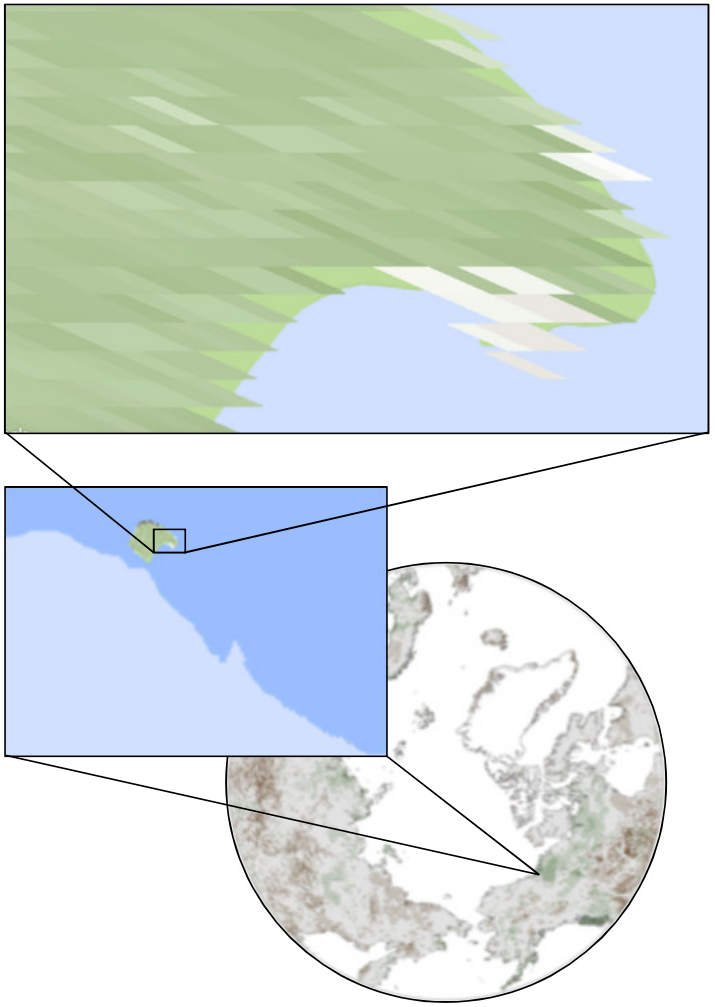


× Stable cover
Increasing cover
Decreasing cover

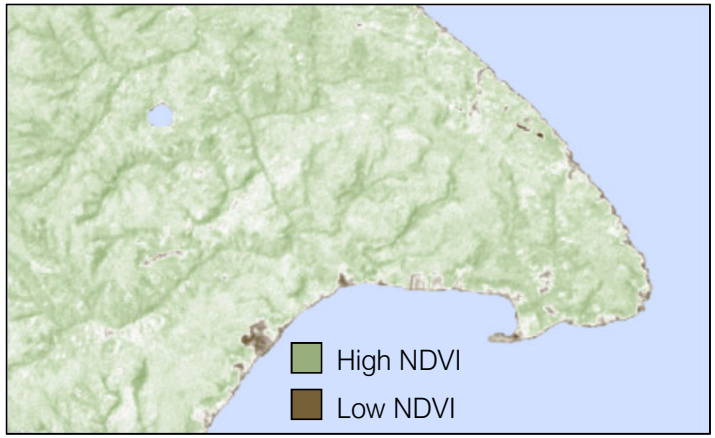
Myers-Smith *et al.* in prep.

Scale, variability, and the nature of patterns.

A. MODISv6 data for peak season 2016



B. Landsat8 data for peak season 2016



C. Sentinel2 data for peak season 2016

Pattern is related to the scale at which it is measured.

Spatial and temporal variability in any measure of...

- Diversity
- Cover
- Phenology
- Productivity

All will display scale-dependent patterns.

Myers-Smith, Kerby *et al.* in prep.

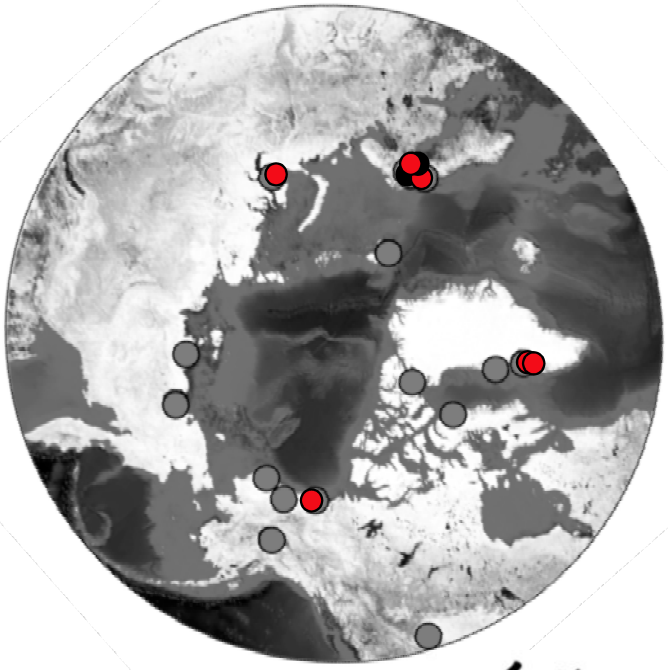
Drone vs. Satellite NDVI comparisons

HiLDEN

Do drone measured vegetation indices match satellite derived vegetation indices around the Arctic?

Drone vs. Satellite NDVI comparisons (2017 HiLDEN data)

Low Arctic

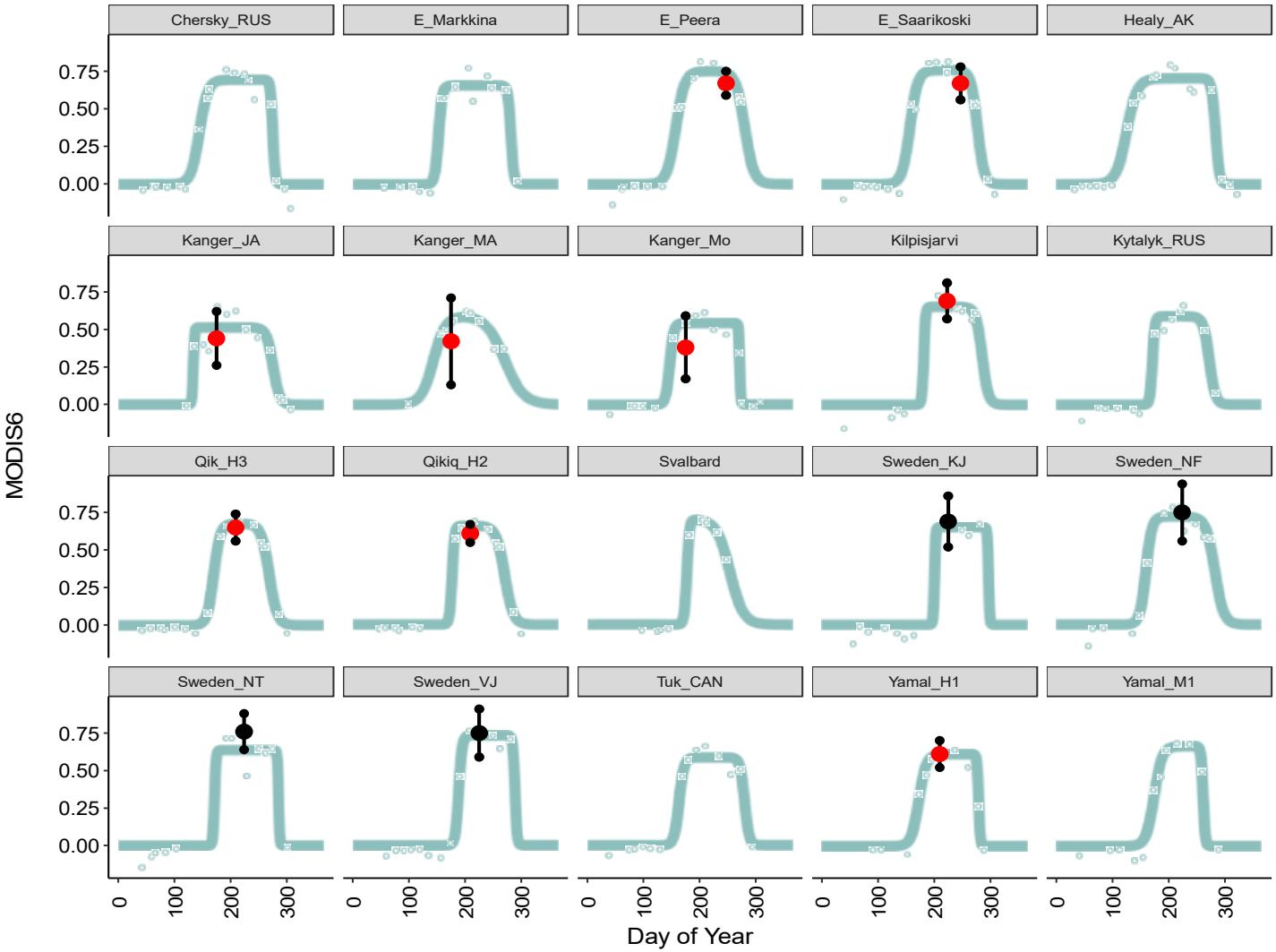


● = calibrated multispectral drone

● = non-calibrated multispectral drone

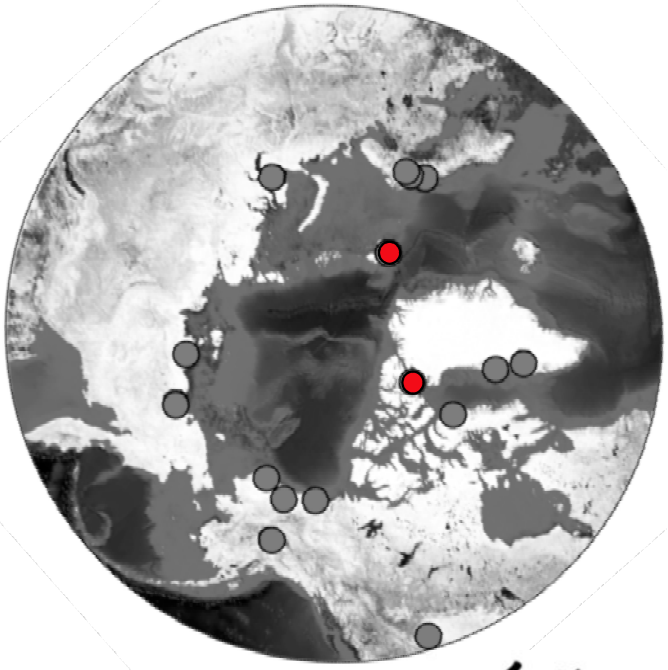
HiLDEN

= MODIS NDVI



Drone vs. Satellite NDVI comparisons (2018 HiLDEN data)

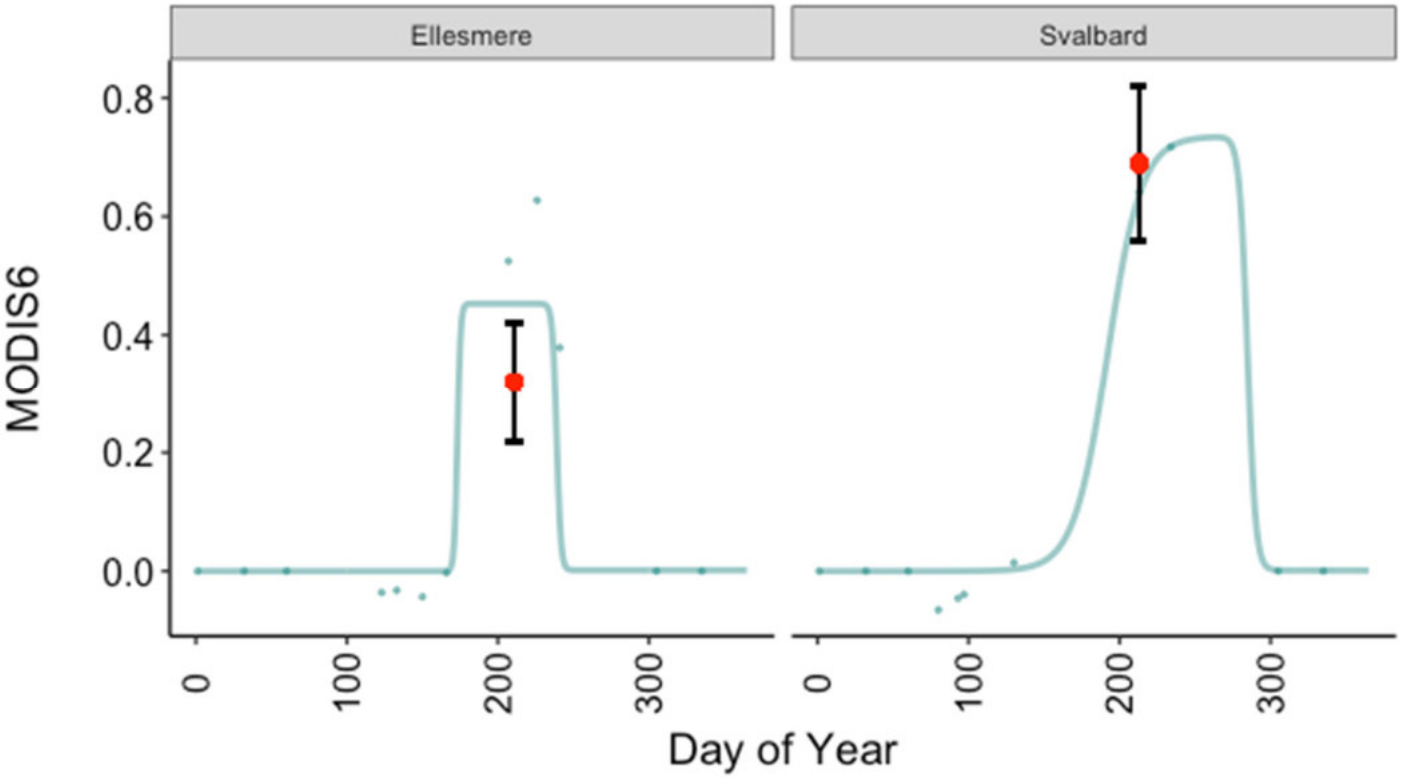
High Arctic



● = calibrated multispectral drone

HiLDEN

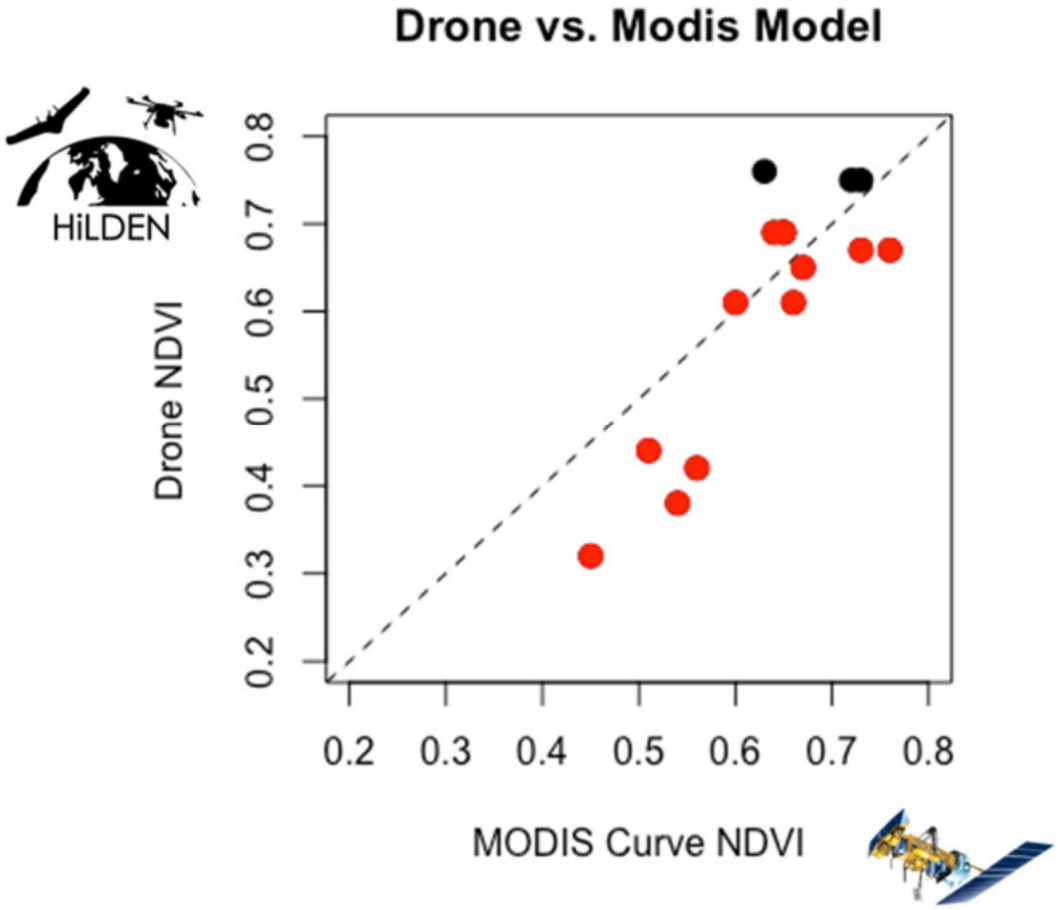
— = MODIS NDVI



Drone vs. Satellite NDVI comparisons

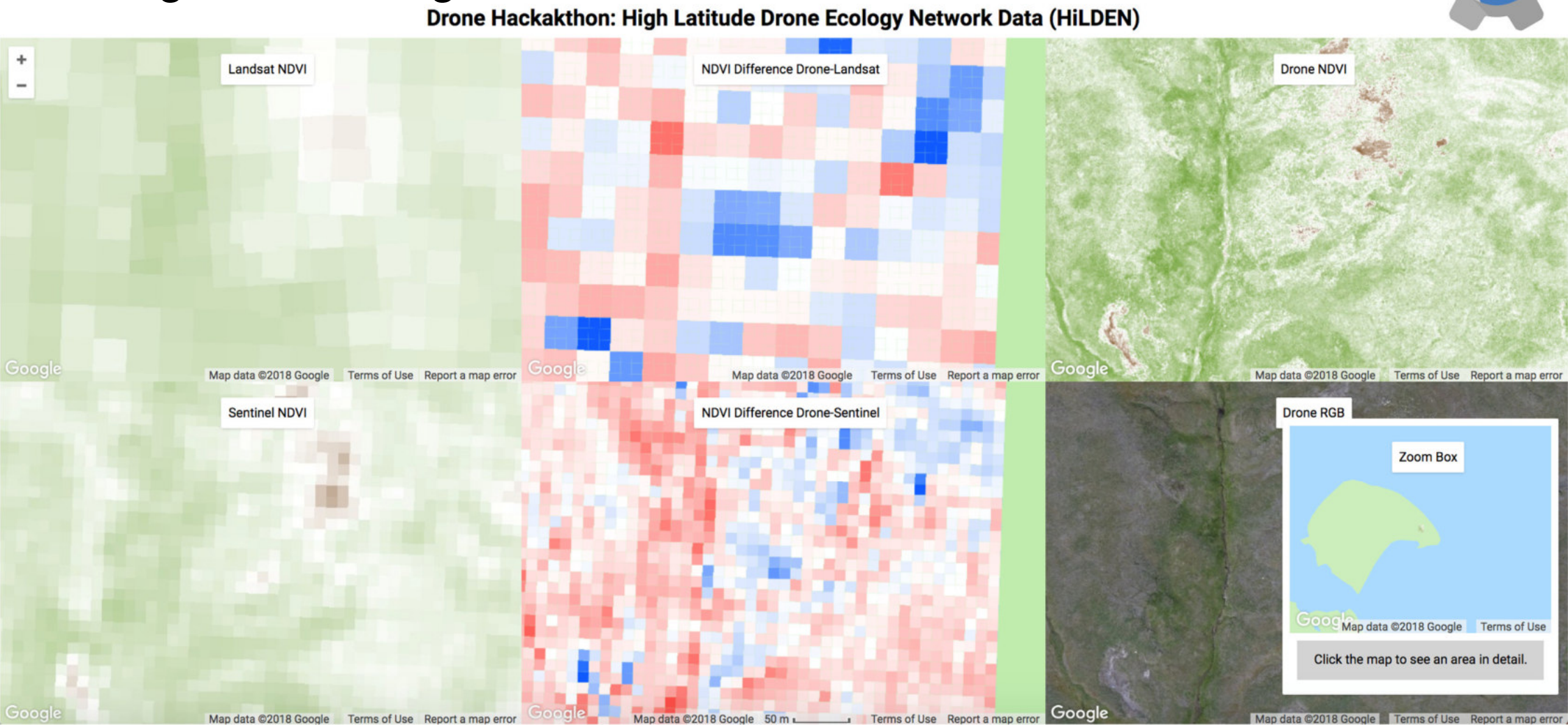
● = calibrated multispectral drone

● = uncalibrated multispectral drone



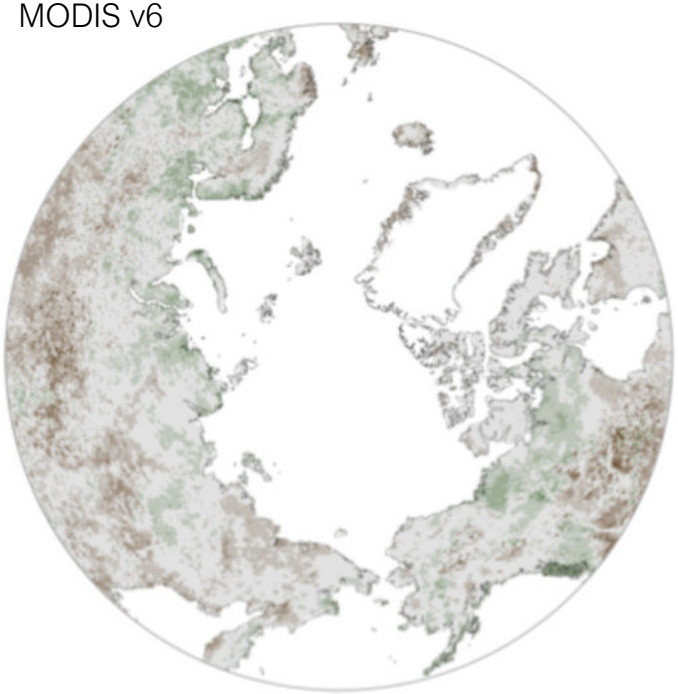
Sub-landscape influences on satellite greening trends?

Google Earth Engine



Ecological heterogeneity impacts greening patterns...

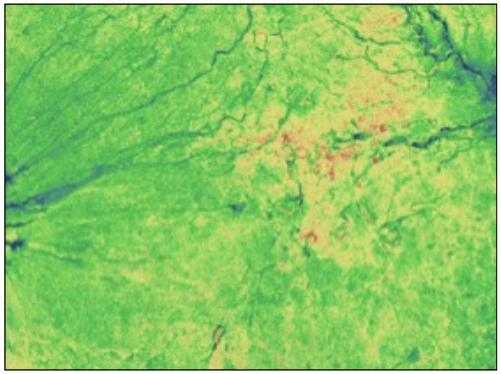
NDVI
MODIS v6



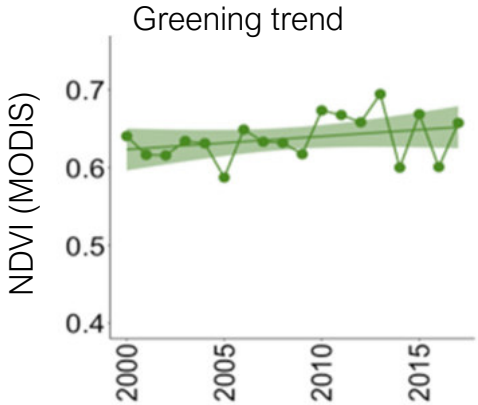
Increasing NDVI
Decreasing NDVI

HiLDEN

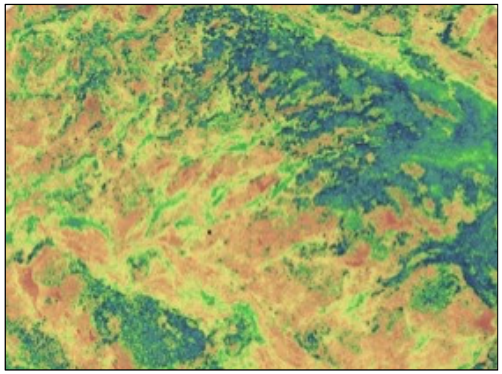
Low heterogeneity: Qikiqtaruk, Canada



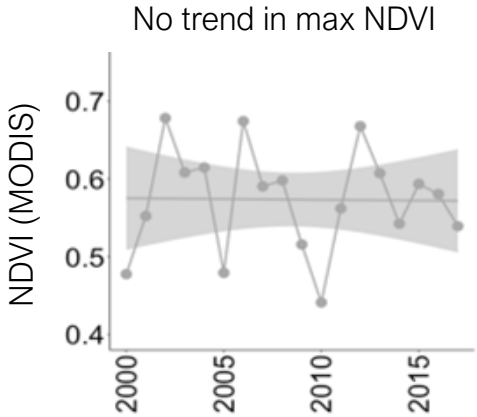
Drone-derived NDVI



High heterogeneity: Kangerlussuaq, Greenland



Drone-derived NDVI



Myers-Smith, Kerby *et al.* in prep.

Geomorphological controls on vegetation

Building on foundational work:
Quantitative
Logistically feasible
Replicable
Scalable

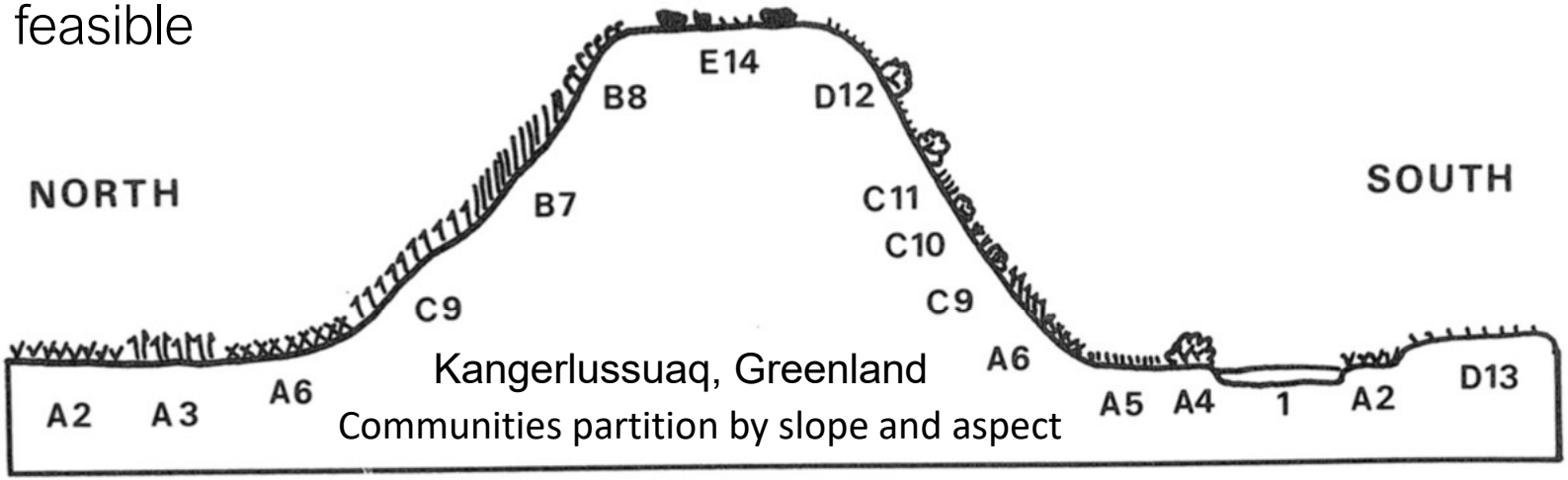
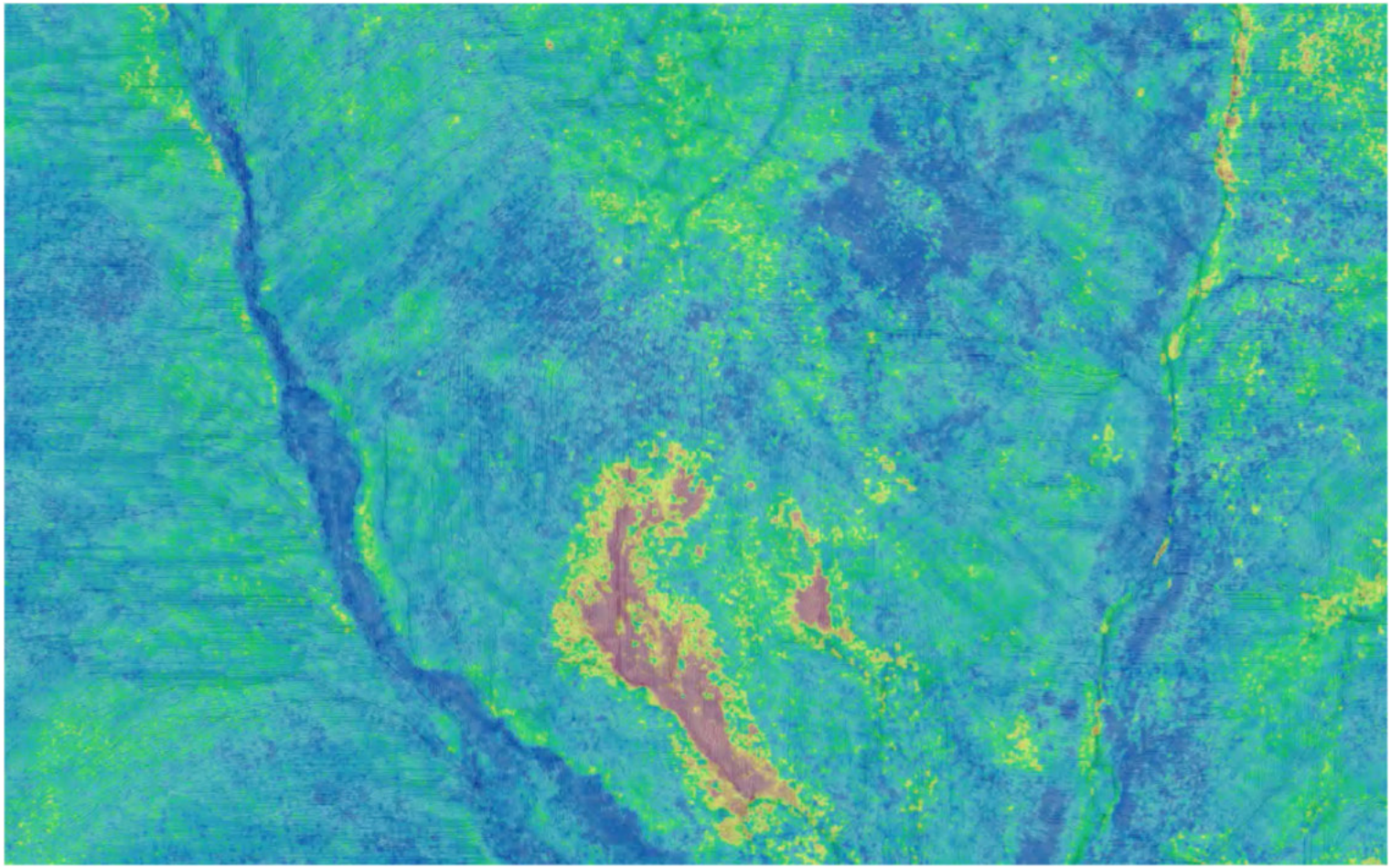


Fig. 5. Schematic example of the distribution of vegetation types on the Kangerlussuaq inland range. Code numbers refer to description in Fig. 4.

Thing 1984, Danish Review Game Biology

Geomorphological controls on vegetation

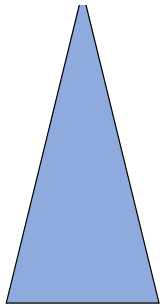


Spatial grain drives the strength of relationship? Clarify scale of mechanism?

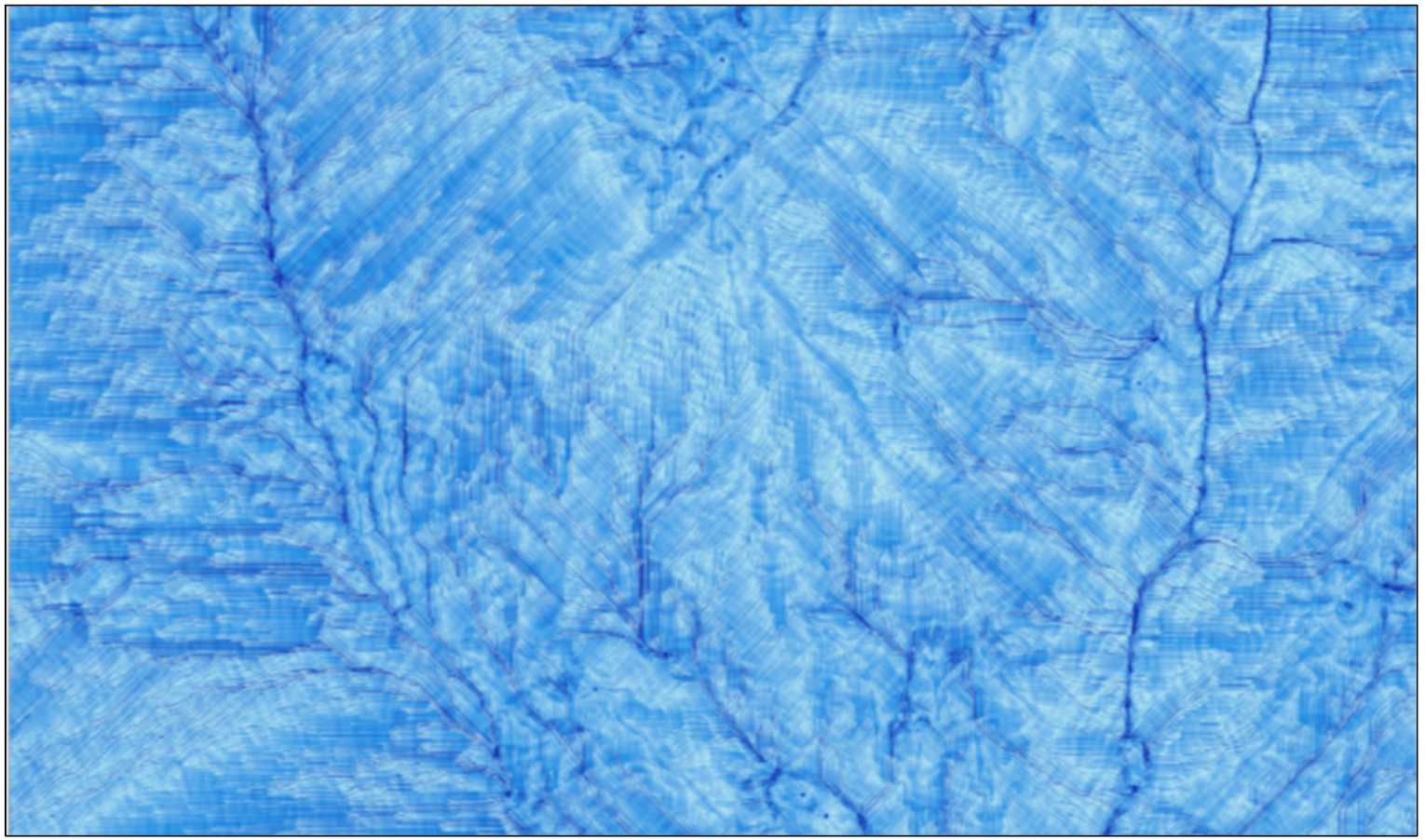
HiLDEN

Derived landscape covariates…at appropriate scale?

Altitude: Low



Pixel Size
<1 cm

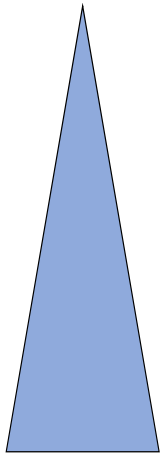


Topographic Wetness Index

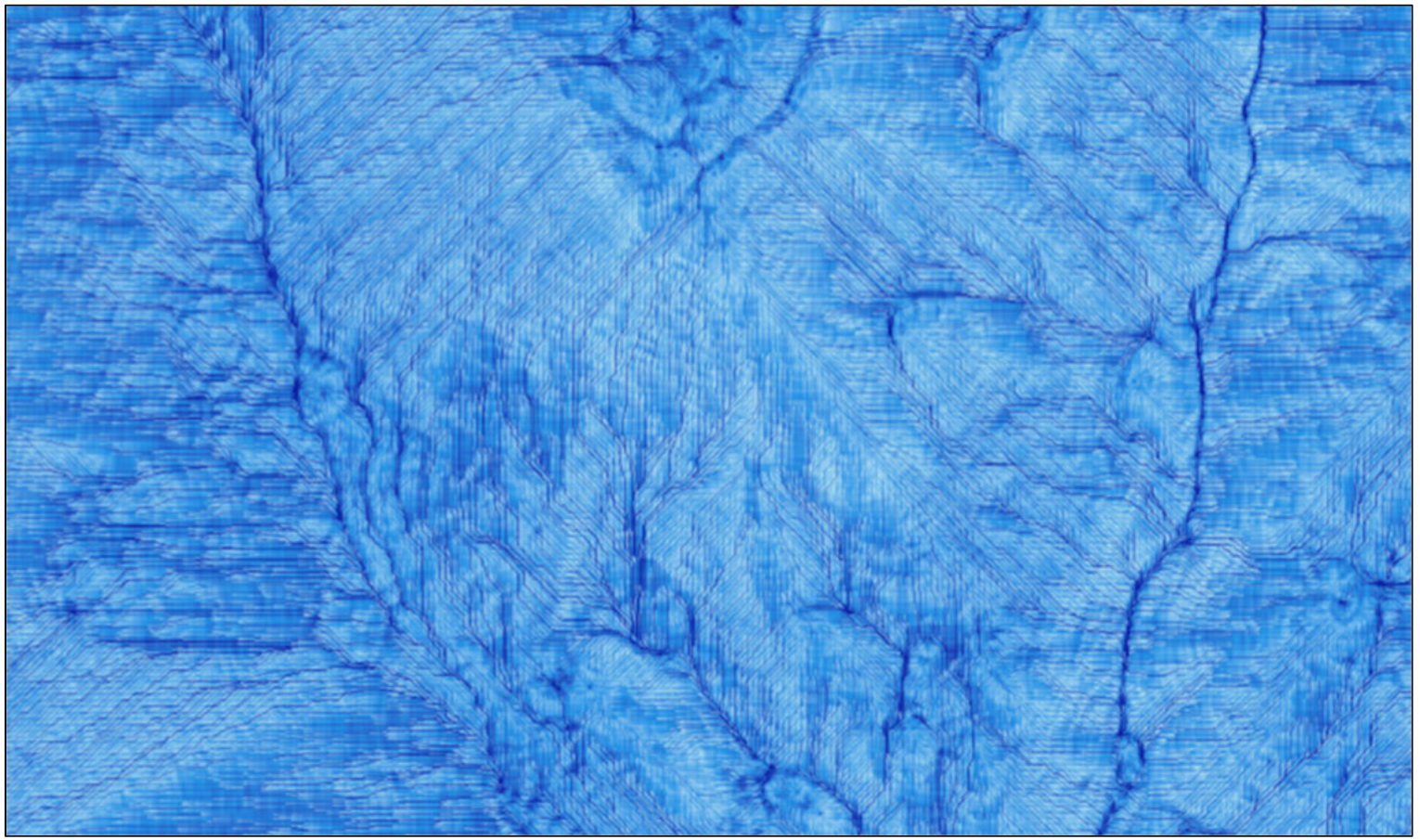
All drone data: Minimum pixel size depends on flight altitude

Derived landscape covariates…at appropriate scale?

Altitude: Mid



Pixel Size
~4 cm

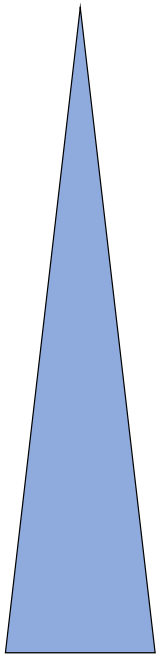


Topographic Wetness Index

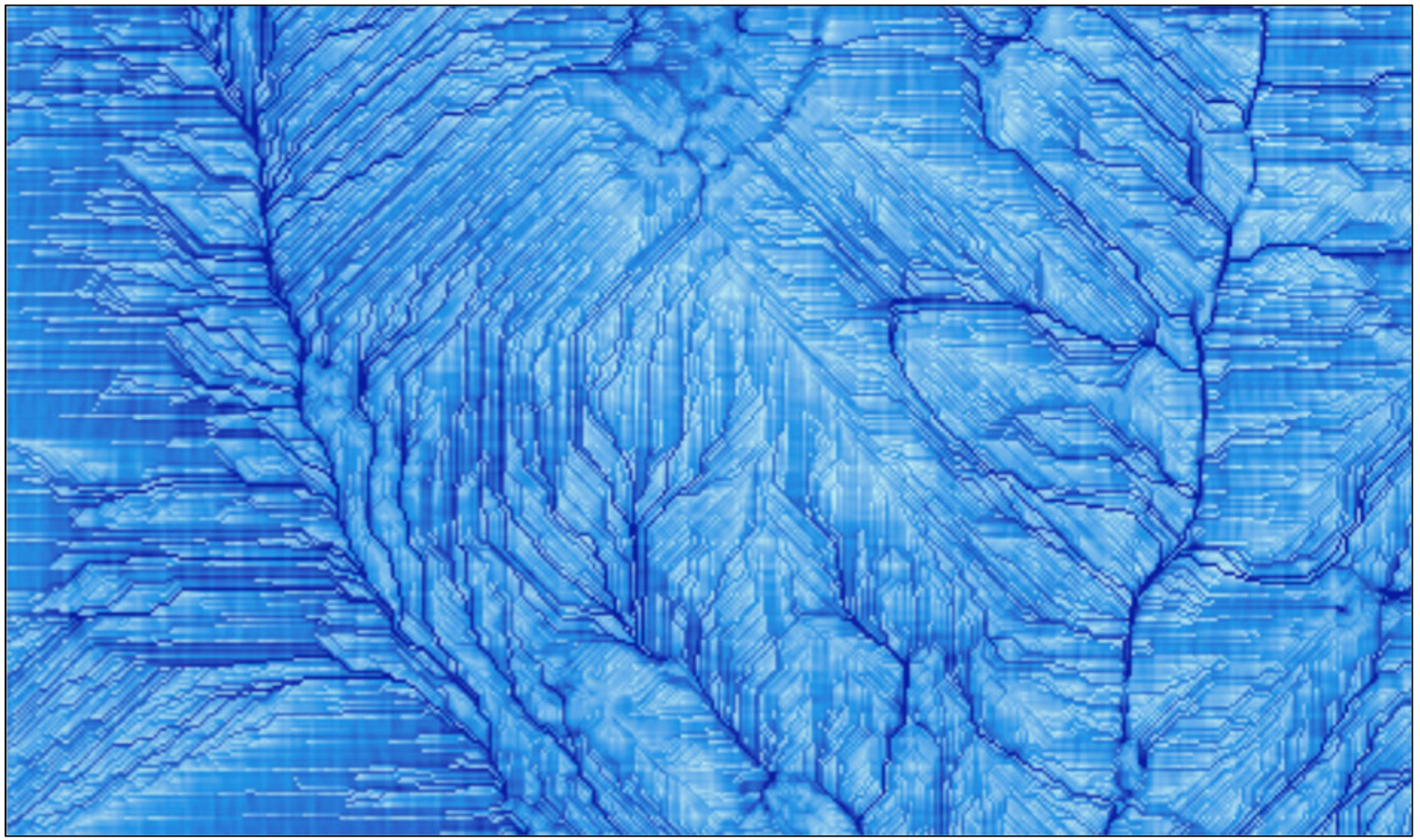
All drone data: Minimum pixel size depends on flight altitude

Derived landscape covariates…at appropriate scale?

Altitude: High



Pixel Size
~15 cm

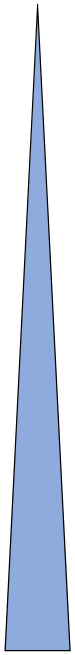


Topographic Wetness Index

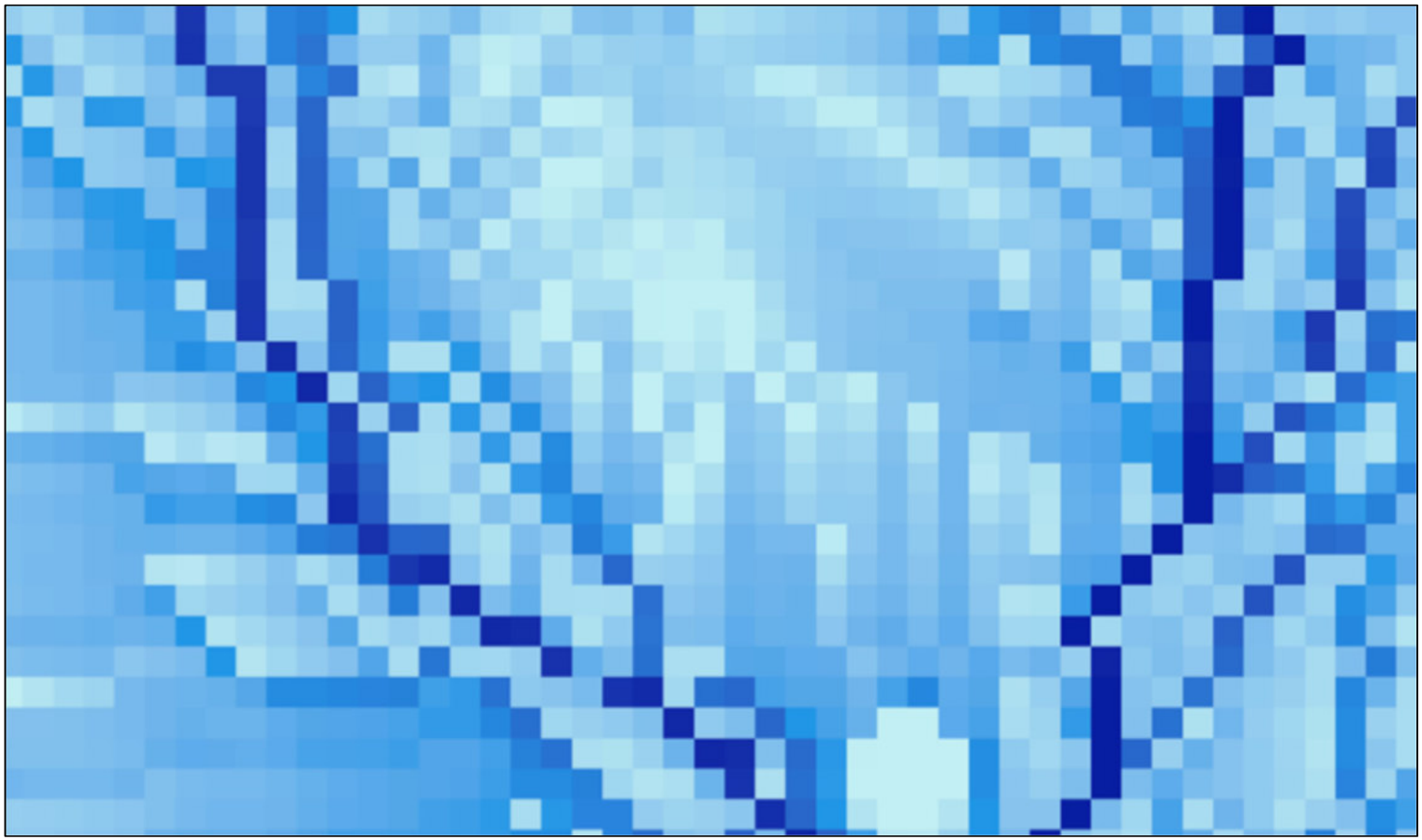
All drone data: Minimum pixel size depends on flight altitude

Derived landscape covariates…at appropriate scale?

Altitude: Very High

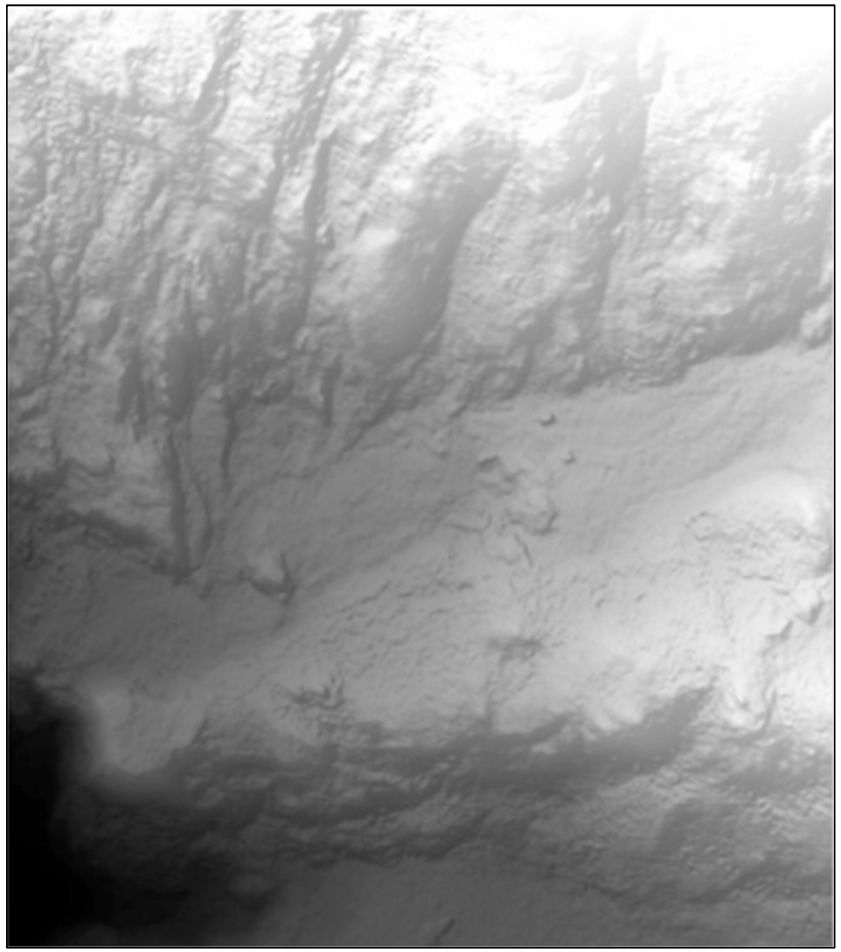


Pixel Size
~500 cm

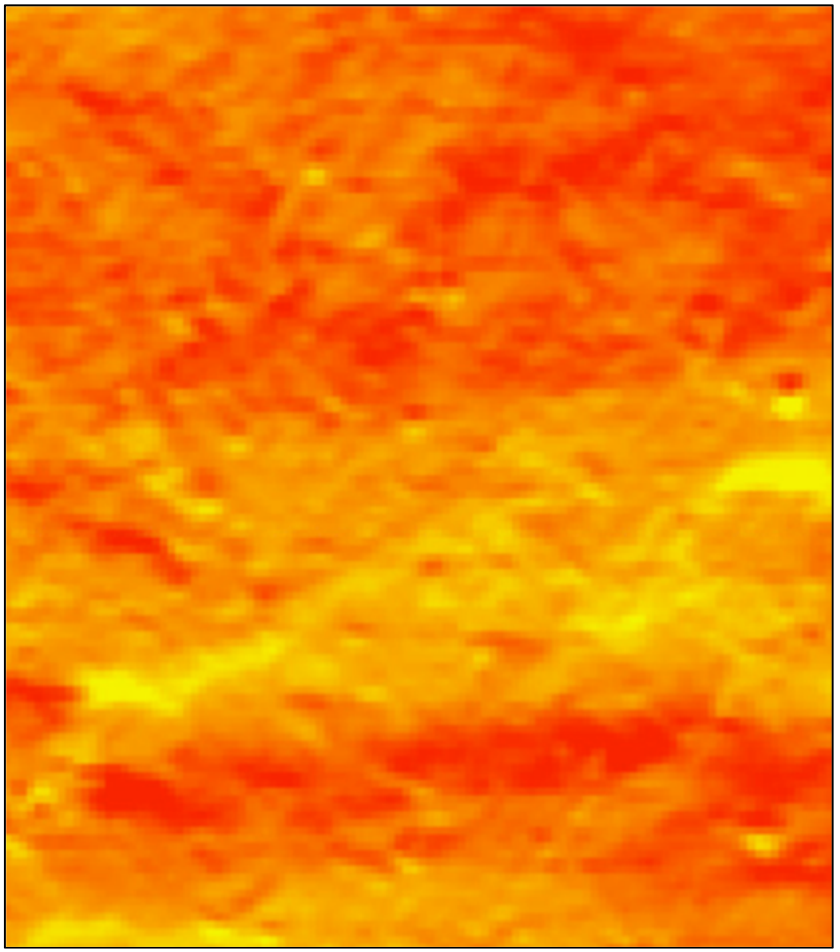


Topographic Wetness Index

Derived landscape covariates…

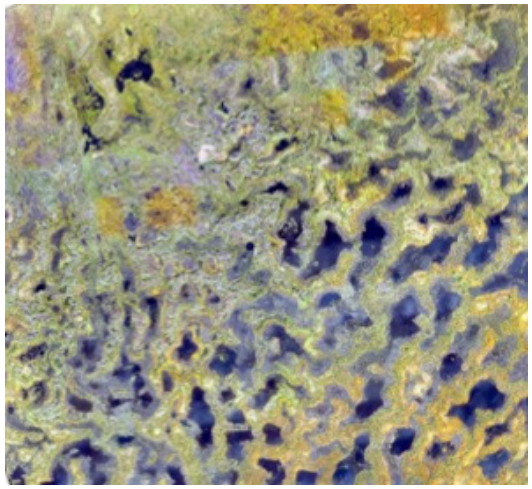


Elevation



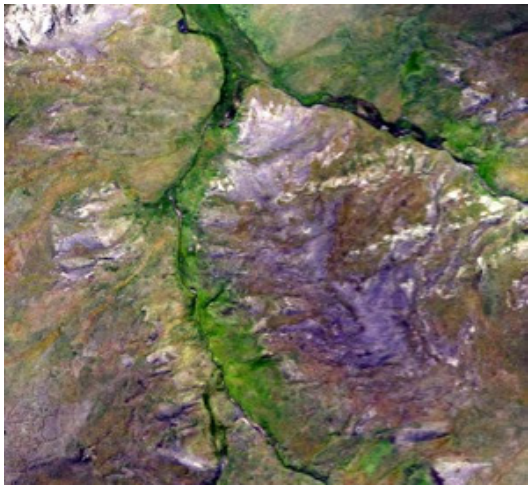
Seasonal Radiation Inputs (W/m^2)

Contextualize and Classify Landcover Across Sites



Finland

Greenland

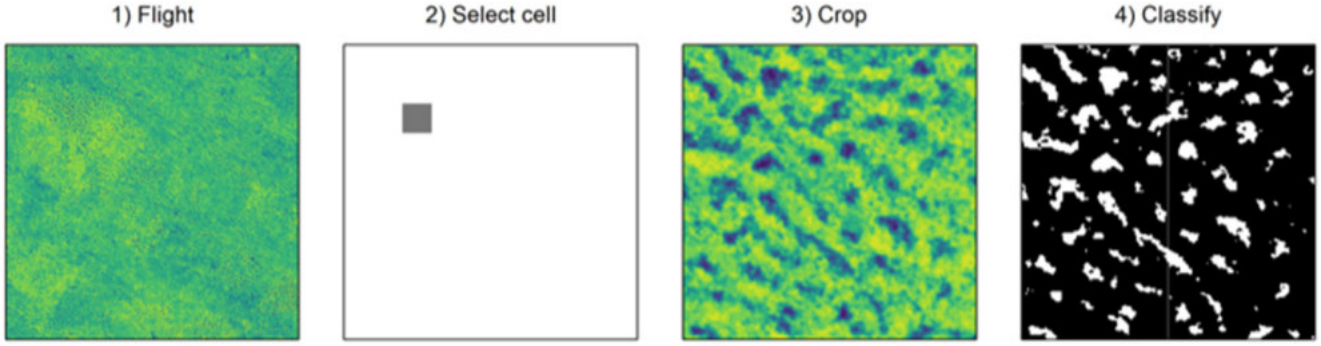


Yukon

NWT

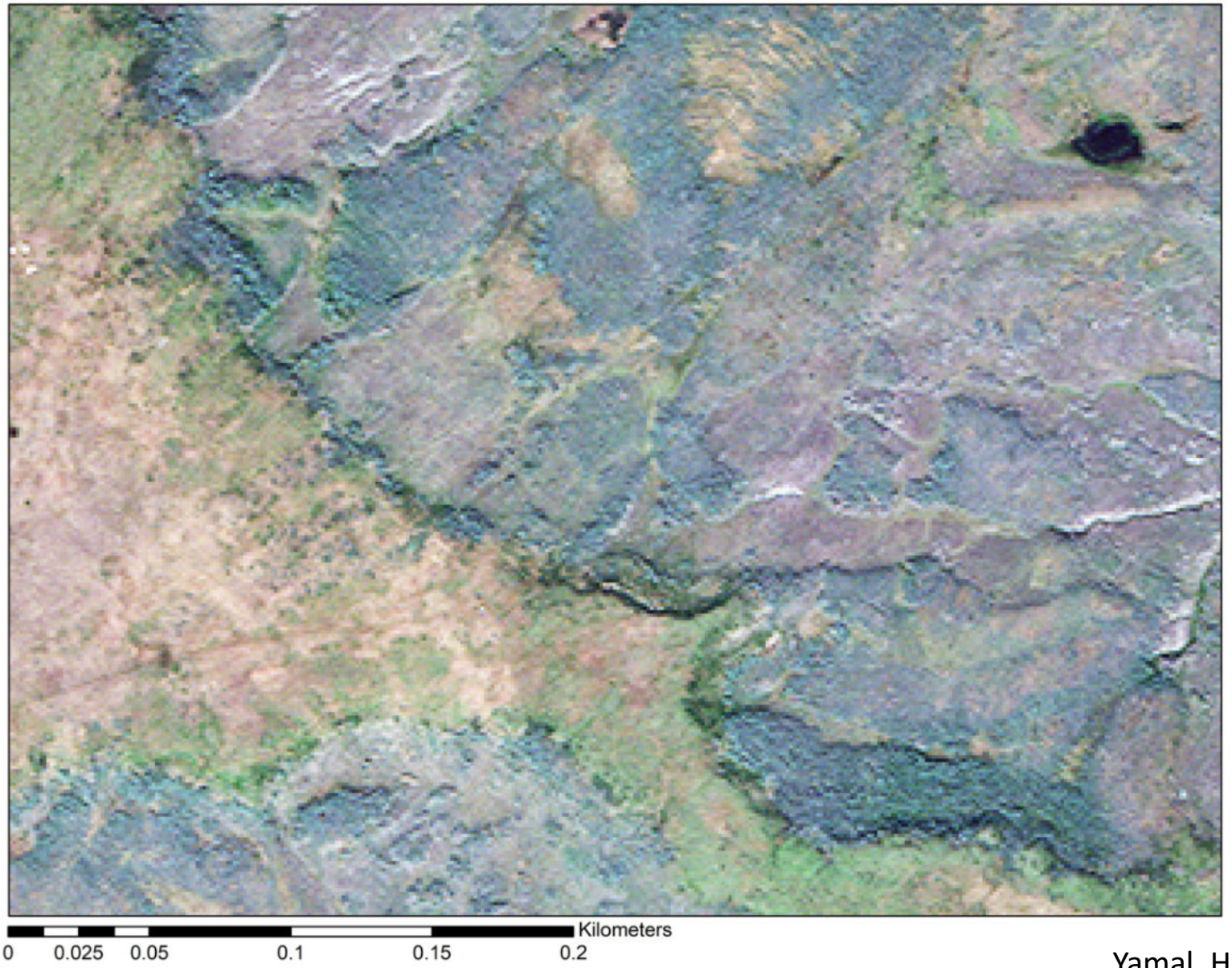
Kerby *et al.* in prep.

(e.g. vegetated vs bare ground)



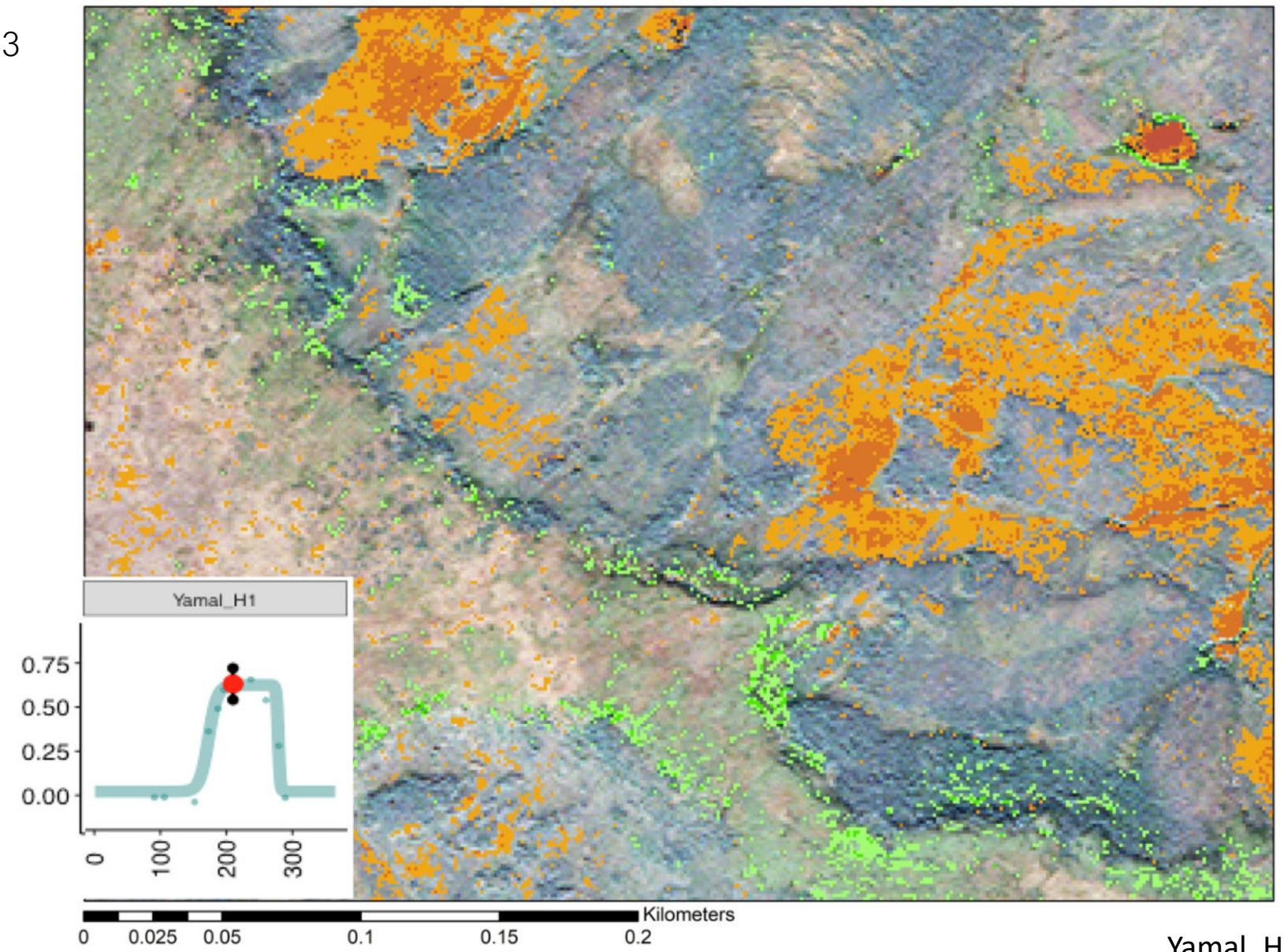
Assmann *et al.* in prep.

Worldview 3



Yamal, HUMANOR Fieldwork

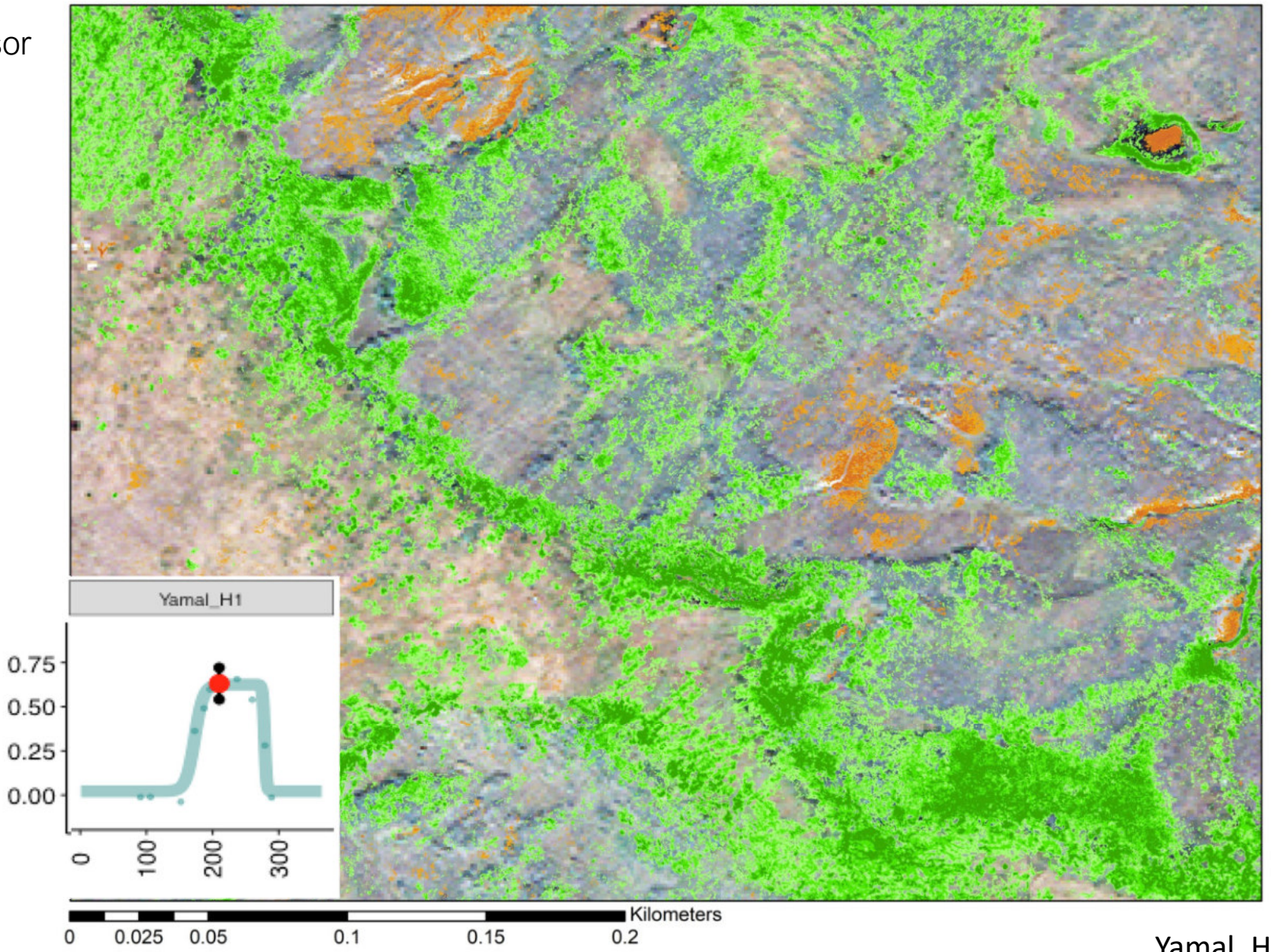
Worldview 3
NDVI



Orange <0.4
Green >0.6

Yamal, HUMANOR Fieldwork

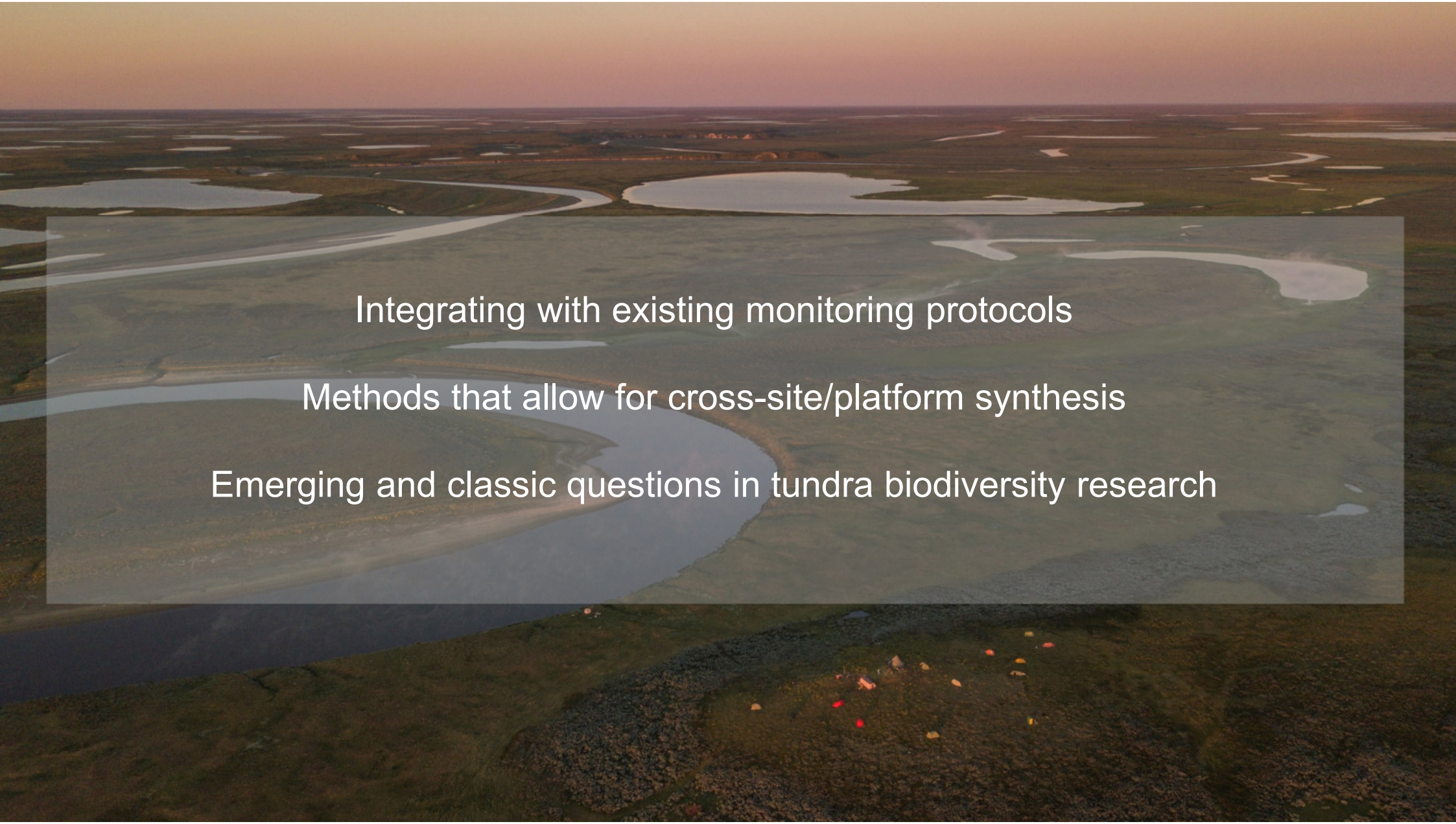
Drone Sensor
NDVI



Within landcover
Variability.

Orange <0.4
Green >0.6

Yamal, HUMANOR Fieldwork


Integrating with existing monitoring protocols
Methods that allow for cross-site/platform synthesis
Emerging and classic questions in tundra biodiversity research

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