Floating the idea of ITEX drone protocols: From the Yukon Coast to the circum-Arctic?

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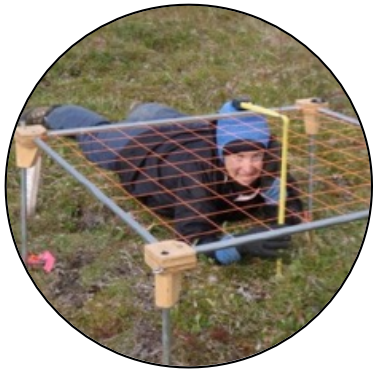
[1] Neukom Institute & Institute of Arctic Studies, Dartmouth College, [2] School of Geosciences, University of Edinburgh

ITEX Protocols

Shared Methodology



Document Change

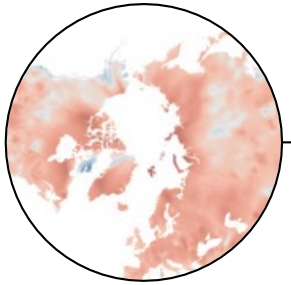
Understand Drivers

Global Change Drivers

Tundra Ecosystem Responses

Ecosystem-level Impacts

Climate Warming



Sea Ice Melt

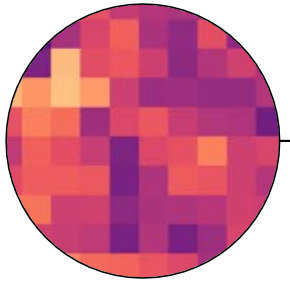
Permafrost Thaw

Compositional Change

Phenology Change

Trait Change

Surface Reflectance



Trophic Impacts

Carbon Storage

In situ

Compositional Change

Phenology Change

Trait Change

In situ

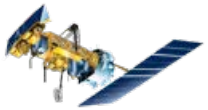
Below-ground

Compositional Change

Phenology Change

Trait Change

Satellites



Airborne

In situ

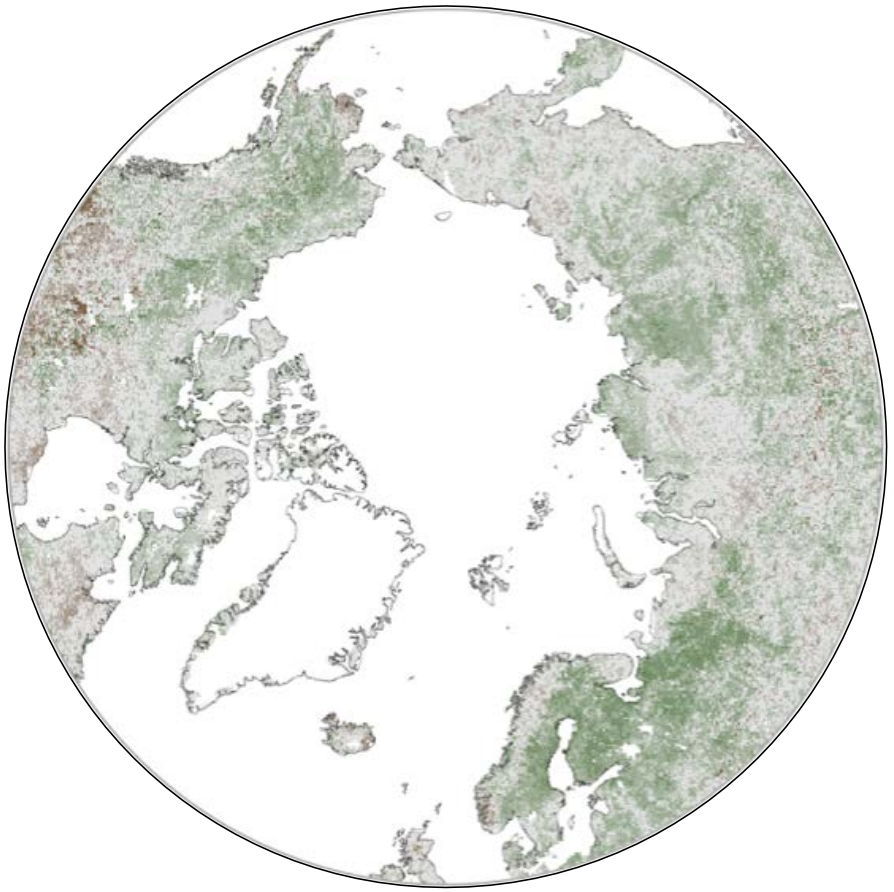
Below-ground

Compositional Change

Phenology Change

Trait Change

The Arctic is greening

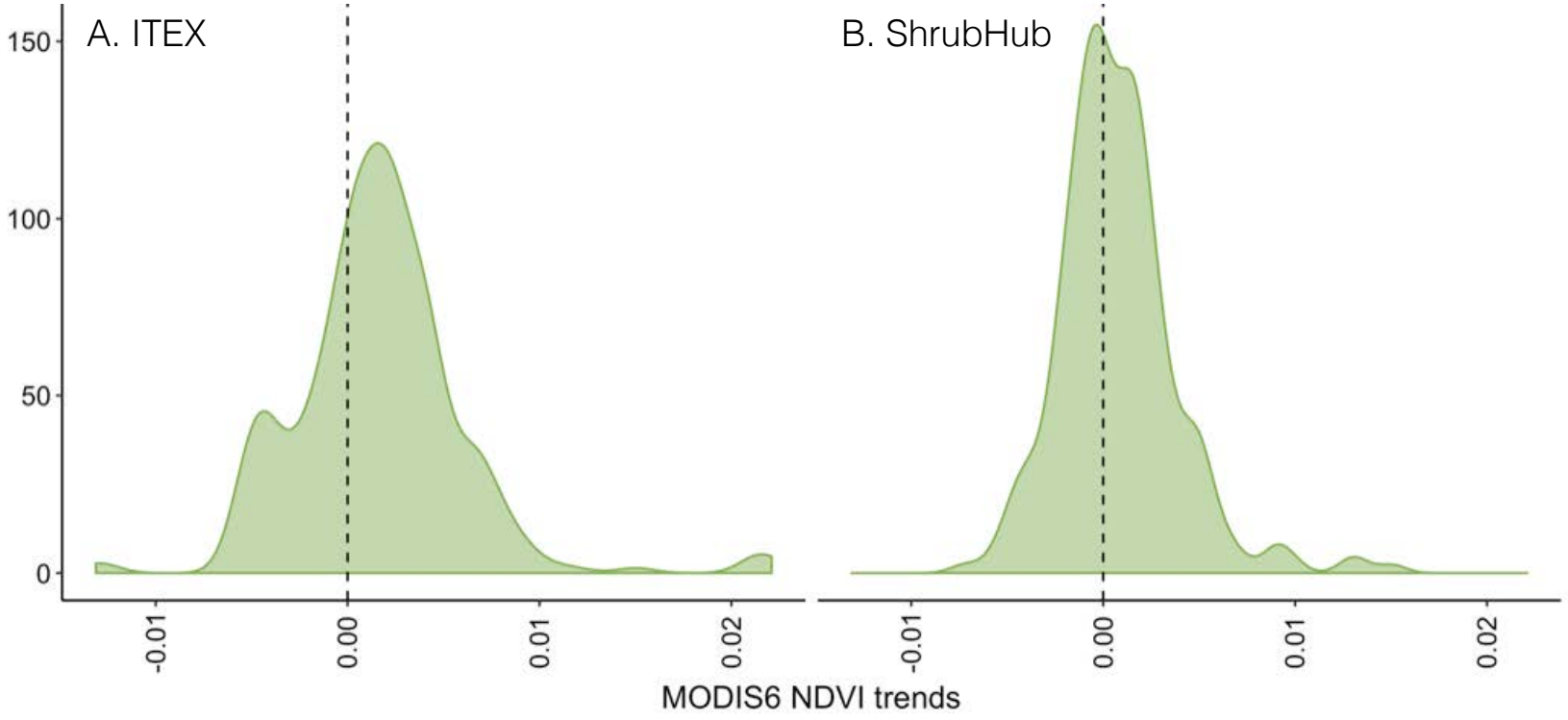


Increasing NDVI

Decreasing NDVI

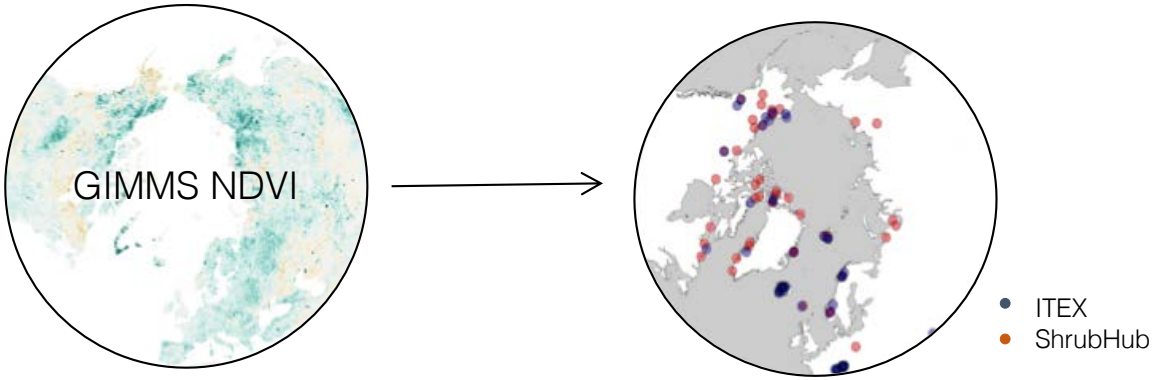
GIMMS 3g Satellite Data 1982 to 2015

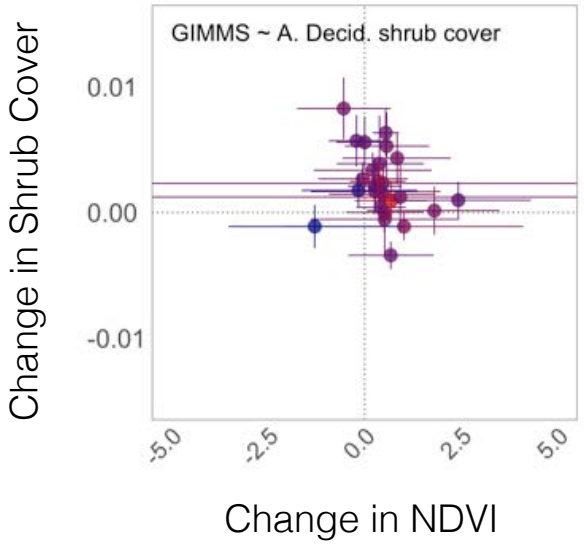
Trends in NDVI among ITEX and ShrubHub sites



Myers-Smith *et al.* in prep.

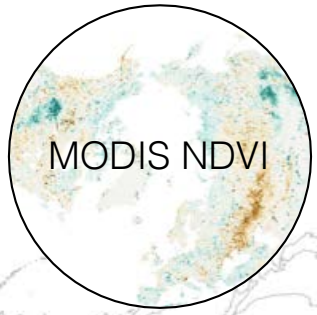
Increasing greenness ~ plant cover change?





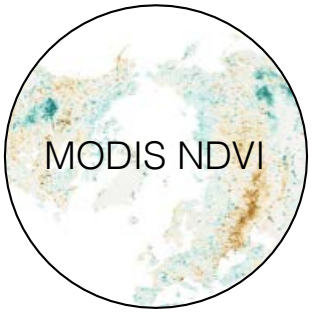
Myers-Smith *et al.* in prep.

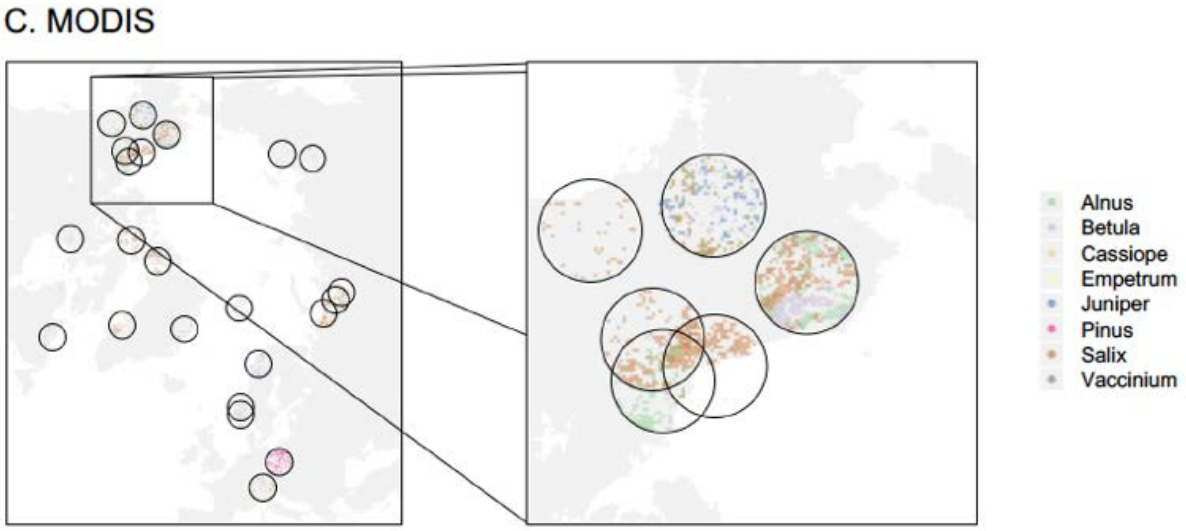
Increasing greenness ~ shrub growth?



Myers-Smith *et al.* in prep.

Increasing greenness ~ shrub growth?

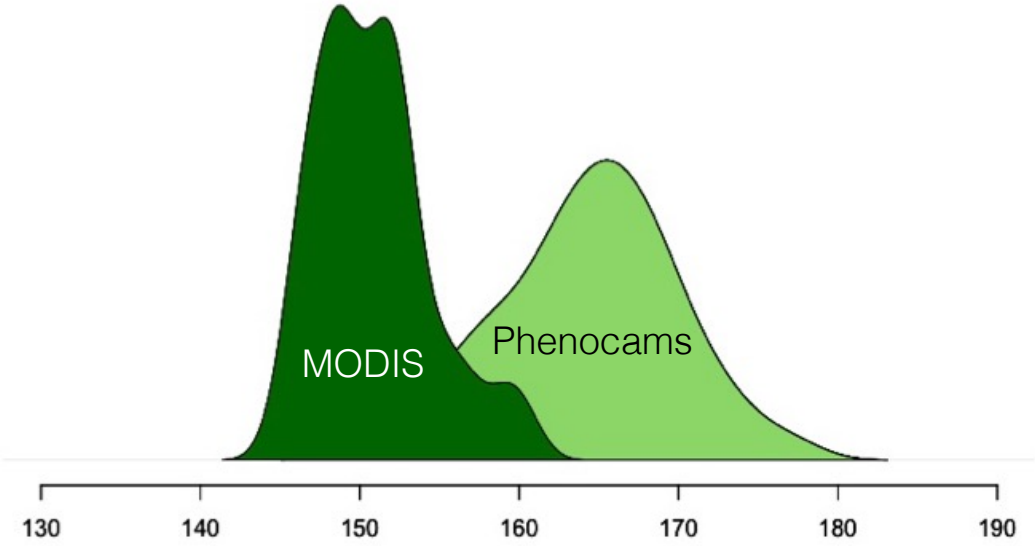




Myers-Smith *et al.* in prep.

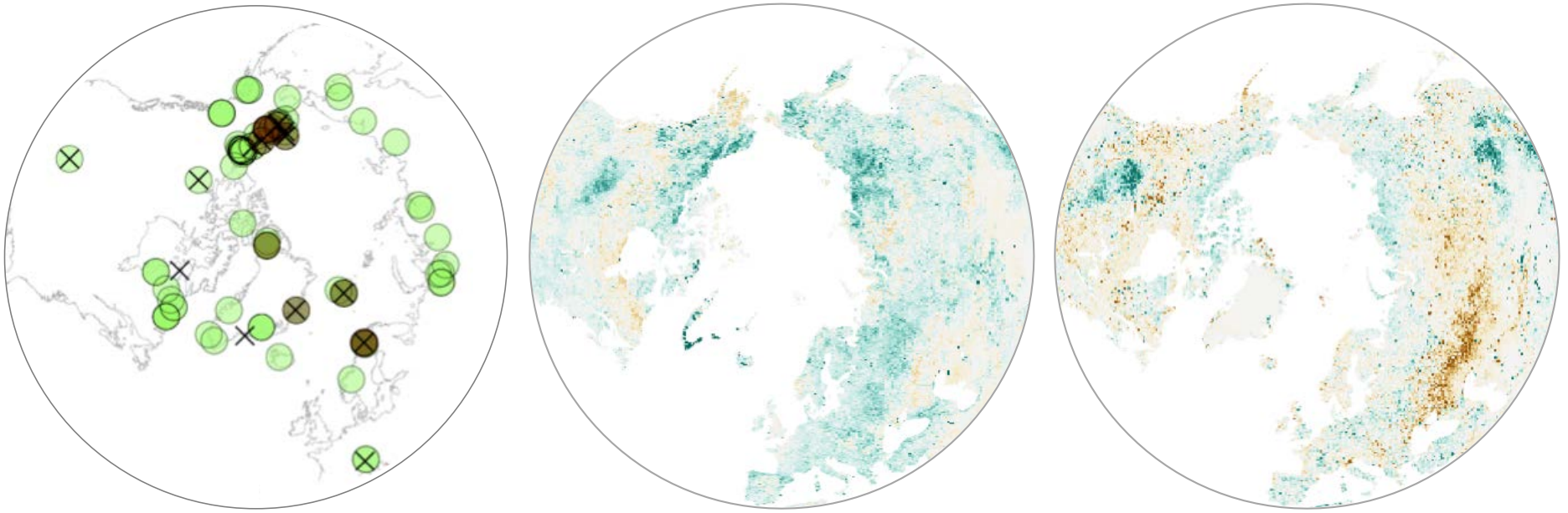
Increasing greenness ~ plant phenology?

Start of growing season dates from satellite and phenocam networks in Greenland



Kerby *et al.* in prep.

Conceptual Challenge: scaling from plots to satellites?

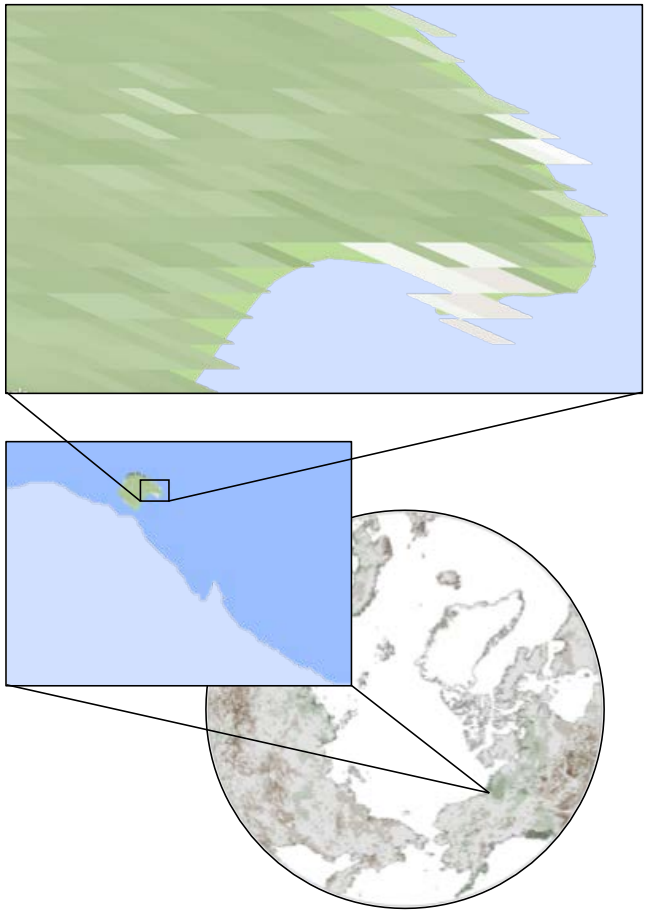


× Stable cover
Increasing cover
Decreasing cover

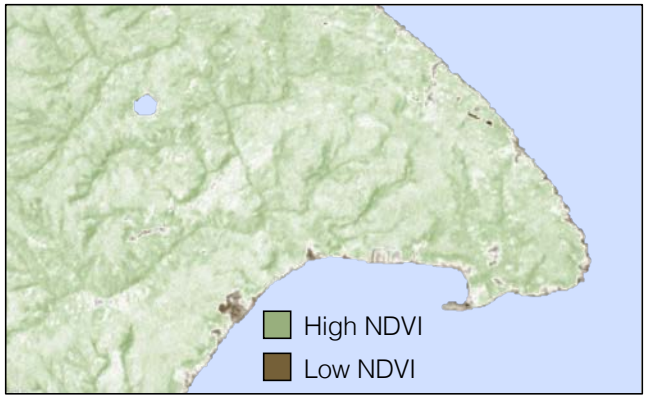
Myers-Smith *et al.* in prep.

Conceptual Challenge: scaling from plots to satellites?

A. MODISv6 data for peak season 2016



B. Landsat8 data for peak season 2016



C. Sentinel2 data for peak season 2016

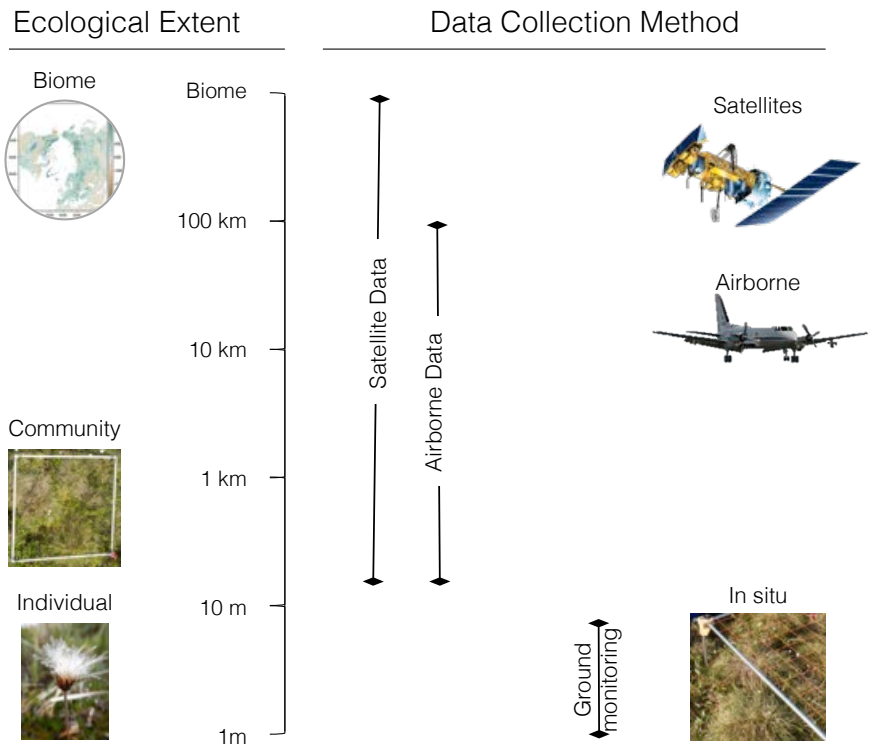
Pattern is related to the scale at which it is measured.

Spatial and temporal variability in any measure of...

- Diversity
- Cover
- Phenology
- Productivity

All will display scale-dependent patterns. Myers-Smith *et al.* in prep.

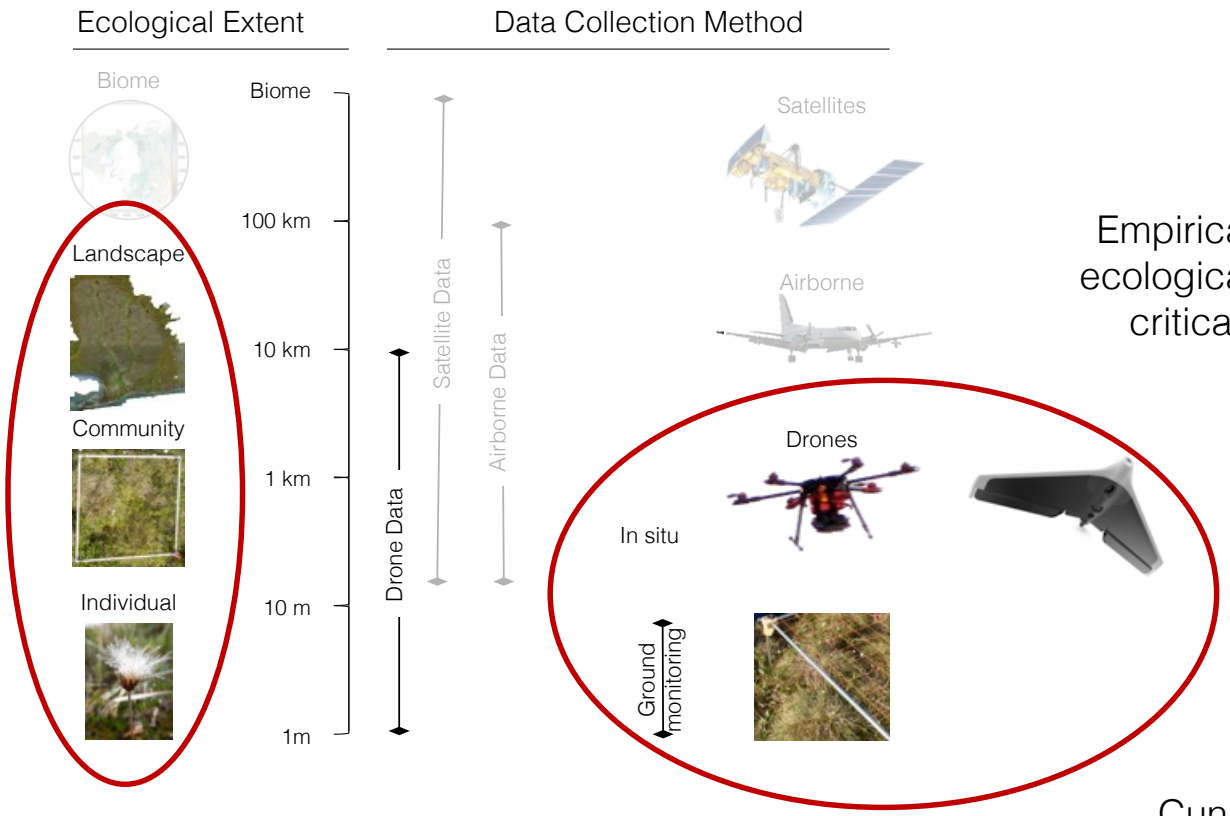
How to we measure ecological variability? At different scales?



Cunliffe *et al.* in prep.


Logistical Challenge:
Quantify individual / community-level variability
at moderate extents

How to we measure ecological variability? At different scales?



In situ measurements

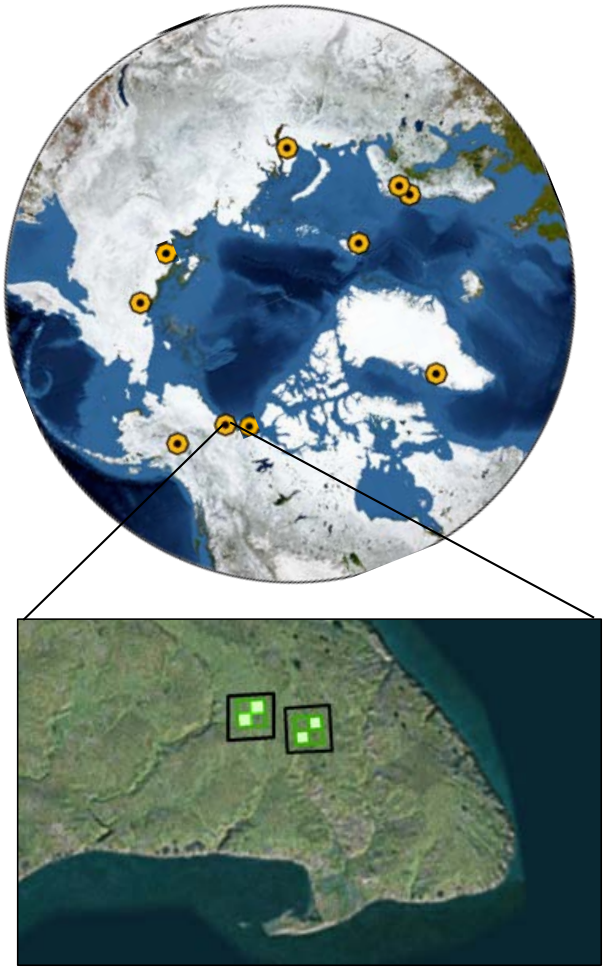
Empirical measures of ecological variability are critical for scaling!

Cunliffe *et al.* in prep.

High Latitude Drone Ecology Network

HiLDEN

ArcticDrones.org



- Established winter 2016/2017
- First field season May – September 2017

- Twenty researchers across 11 regions
- Data from Canada, USA, Greenland, Sweden, Finland, Svalbard, Russia

- 900+ GB of photos submitted

- Dedicated cloud-based server with web interface.

High Latitude Drone Ecology Network

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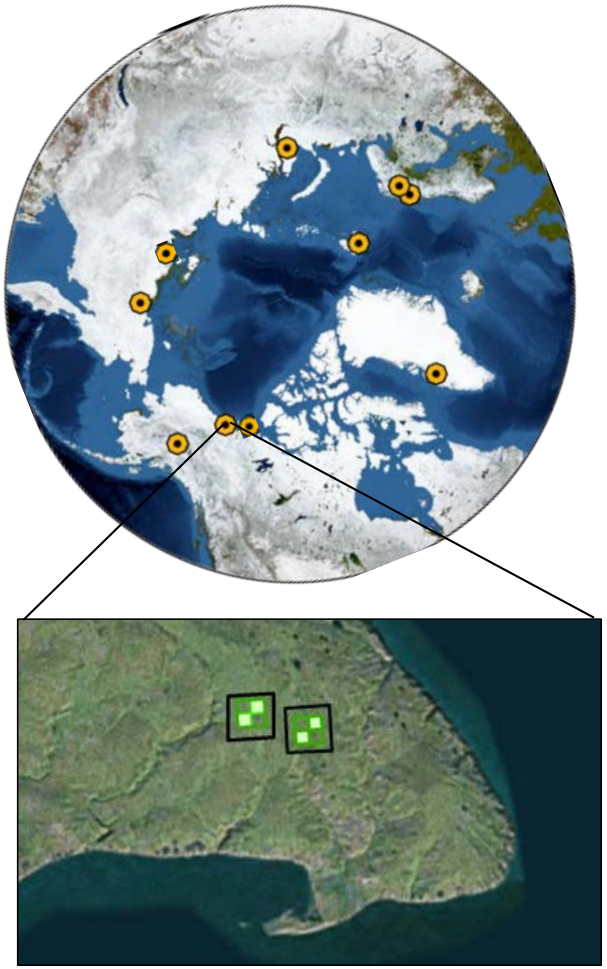
ArcticDrones.org



- HiLDEN initially focused on scaling greenness patterns.
- Developed protocols for consistent data comparisons across sites and through time.
- Protocols could help model ITEX efforts to add value to existing and future datasets.

Drones for ITEX?

1. Begin with straight forward protocols that require low time investment and little previous experience.

2. Ensure protocols are informed by principles from field of remote sensing.

3. Adapt these from elements of HiLDEN protocols that succeeded.

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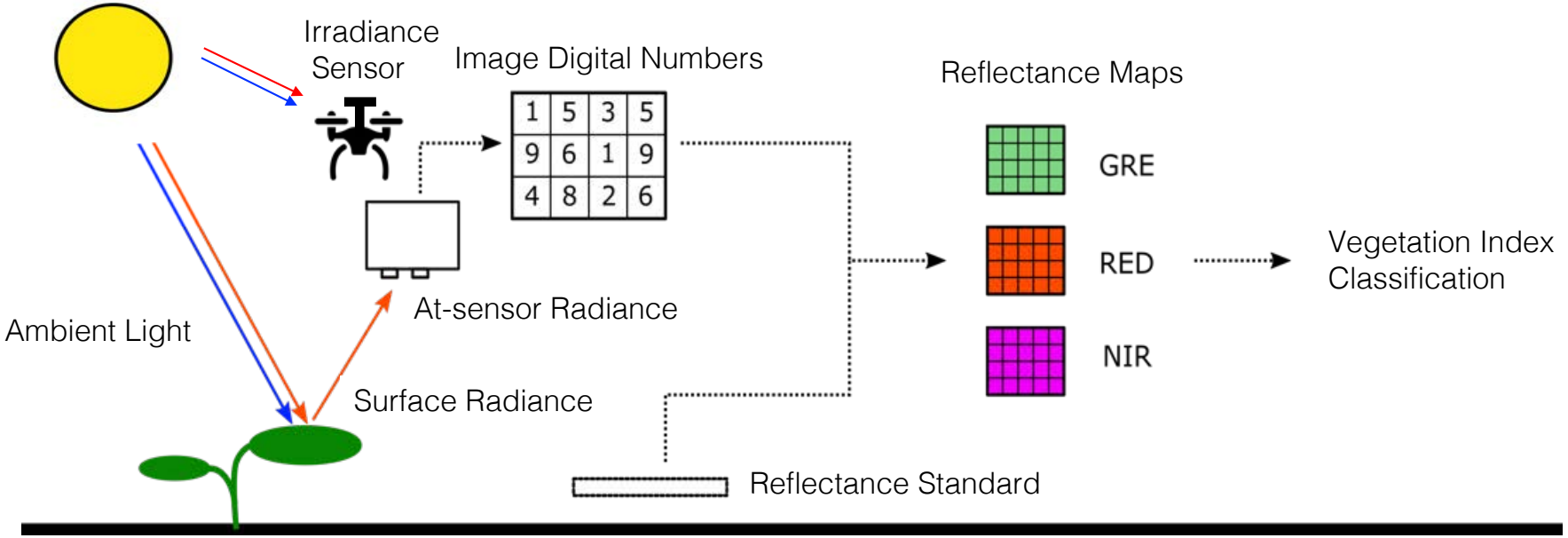
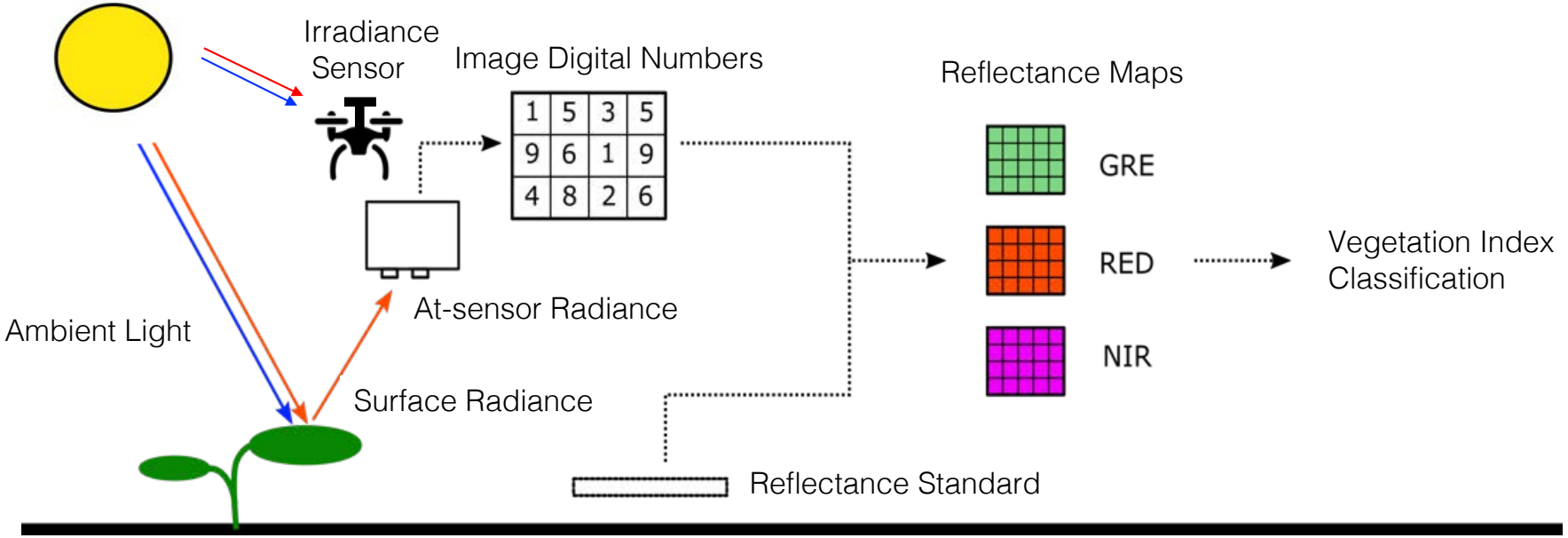
Protocol Basics:



Assmann *et al.* in prep.

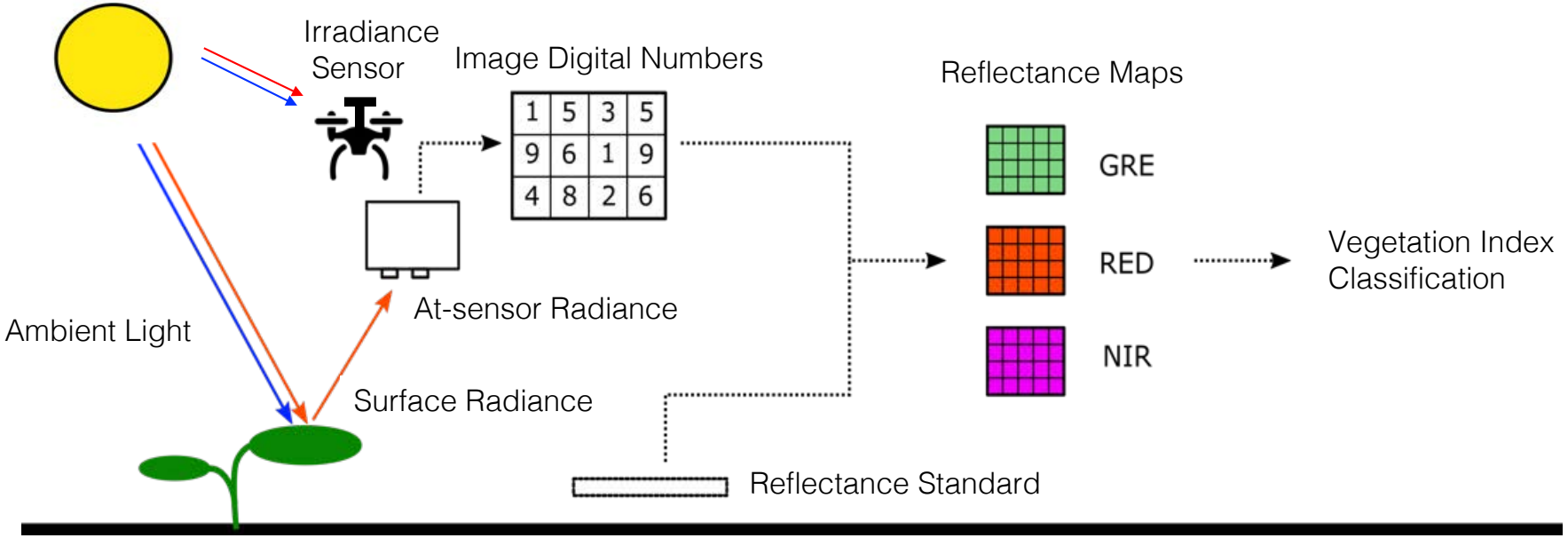
Protocol Basics: An easy to use platform



Reliable platform: Phantom 4 Pro/Advanced
Good RGB camera for all around mapping use.

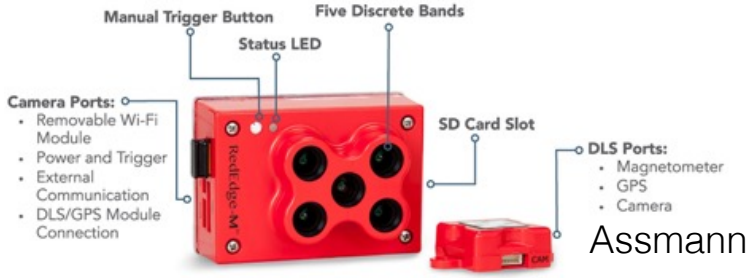
Assmann *et al.* in prep.

Protocol Basics: Consistent spectral calibration!



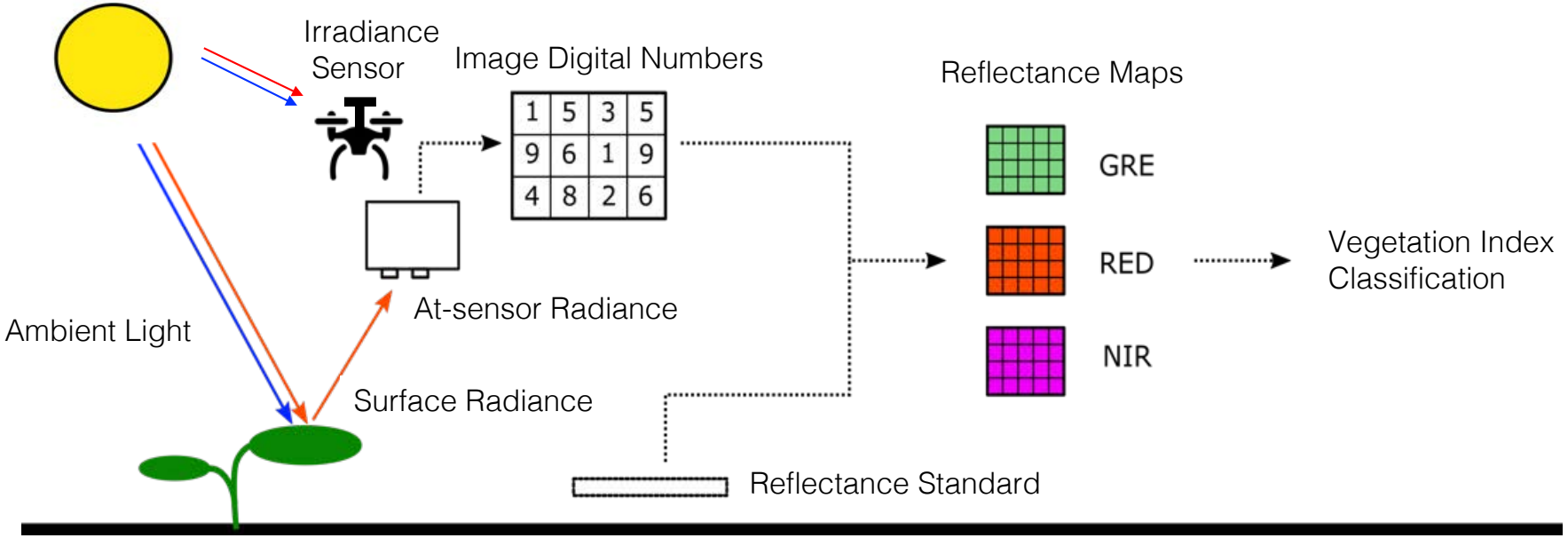
What we use for multispectral mapping:
Parrot Sequoia 4 narrow band global shutter

Excellent (better?) alternative: Micasense Red Edge



Assmann *et al.* in prep.

Protocol Basics: Consistent spectral calibration!

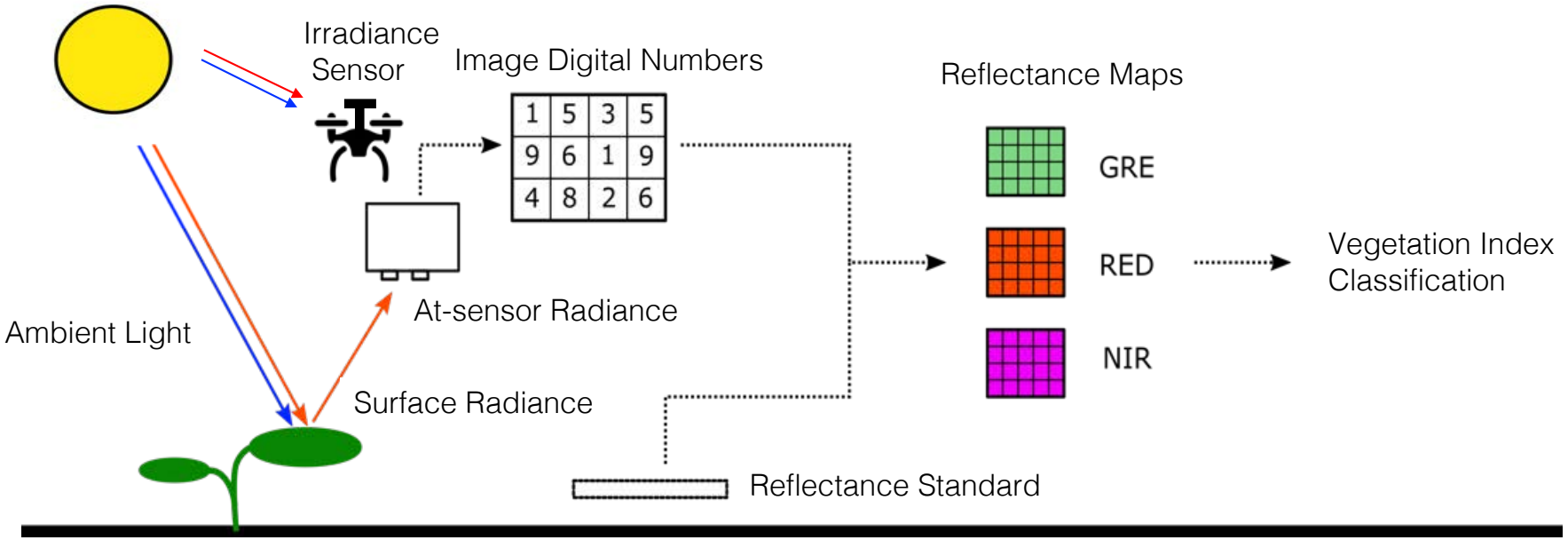


What we use (not pictured):
Zenith ultralight 50% reflectance panels (Sphere optics)

Many alternatives, merits/drawbacks can be discussed:
Micasense calibration panel (seen here)

Assmann *et al.* in prep.

Protocol Basics: Consistent spectral calibration!

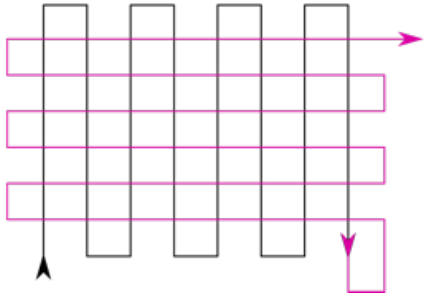


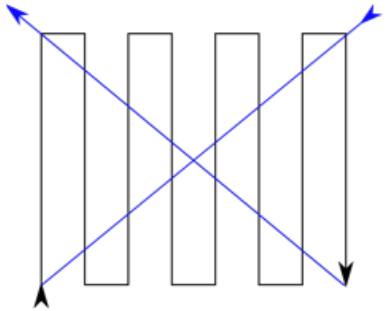
What we use:
Pix4D

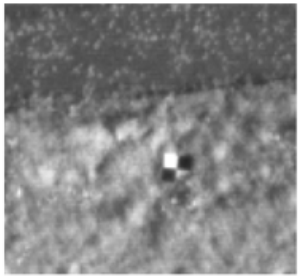
Also consider:
Agisoft Photoscan Pro

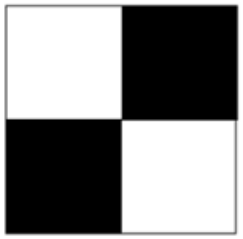
Assmann *et al.* in prep.

Protocol Basics: Flight planning and spatial constraint

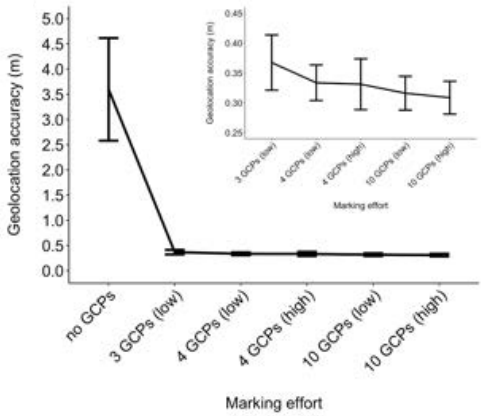


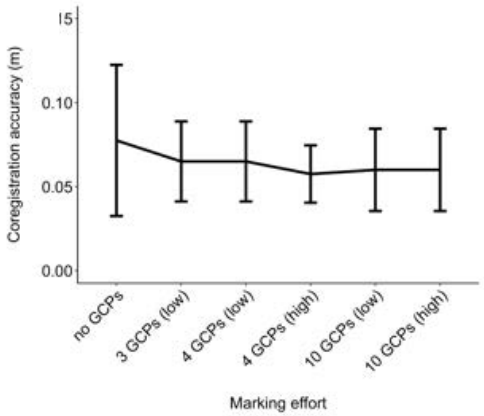






Ground Control Points (3+)





- Keep detailed flight notes on weather!
- More details: Assmann et al. in prep. ArcticDrones.org

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ArcticDrones.org

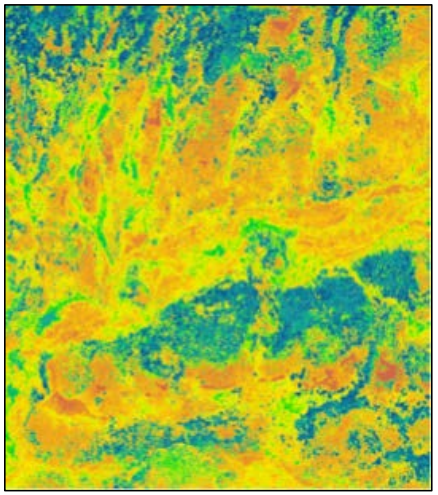
Drones for ITEX?

International Tundra Experiment

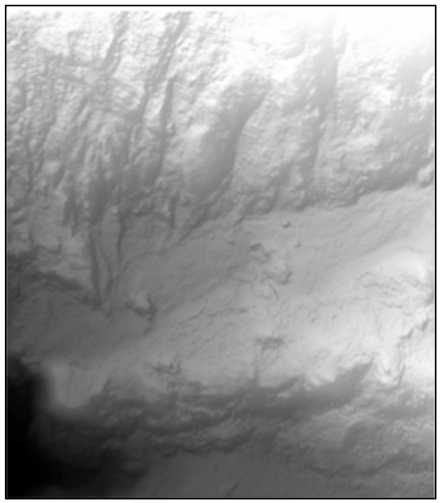
- Basic drone products:
- Orthophotos (RGB and multispectral)
- Digital Surface Models

Orthophoto (RGB)

Orthophoto (multispec)



Surface Model



Best grain (pixel size) and extent (area coverage around ITEX plots)?

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ArcticDrones.org

Drones for ITEX?

What can we derive/model from these basic drone products?

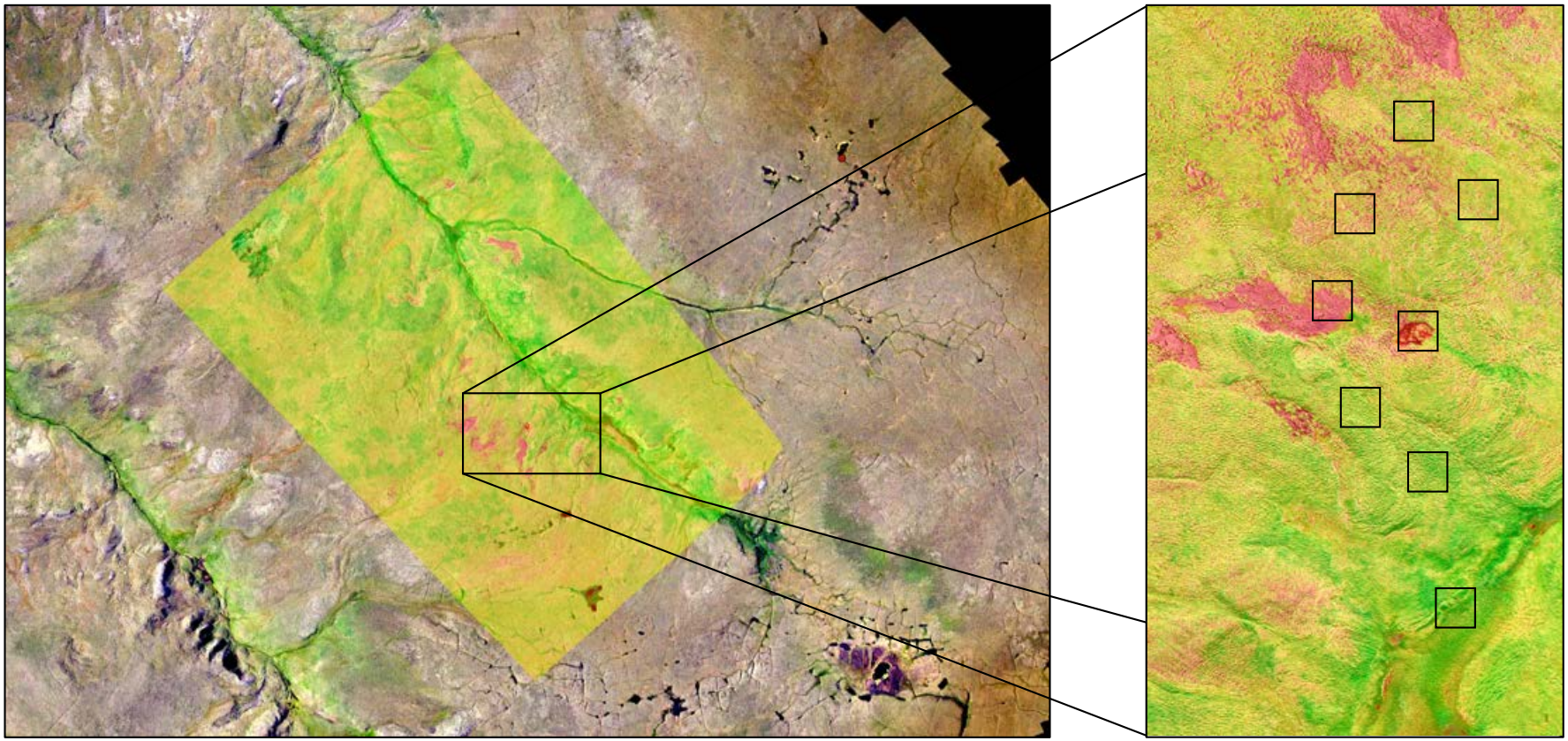
1. Landcover metrics
2. Flower counts
3. Water flow and accumulation
4. Radiation loads
5. Wind exposure
6. Snow melt
7. Thaw slump change
8. Biovolume estimates…

Generally: response variables, covariates, and/or spatial context.

All at multiple scales.

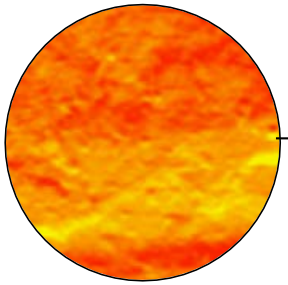
ArcticDrones.org

Capture the landscape context of vegetation change



Quantify drivers of change

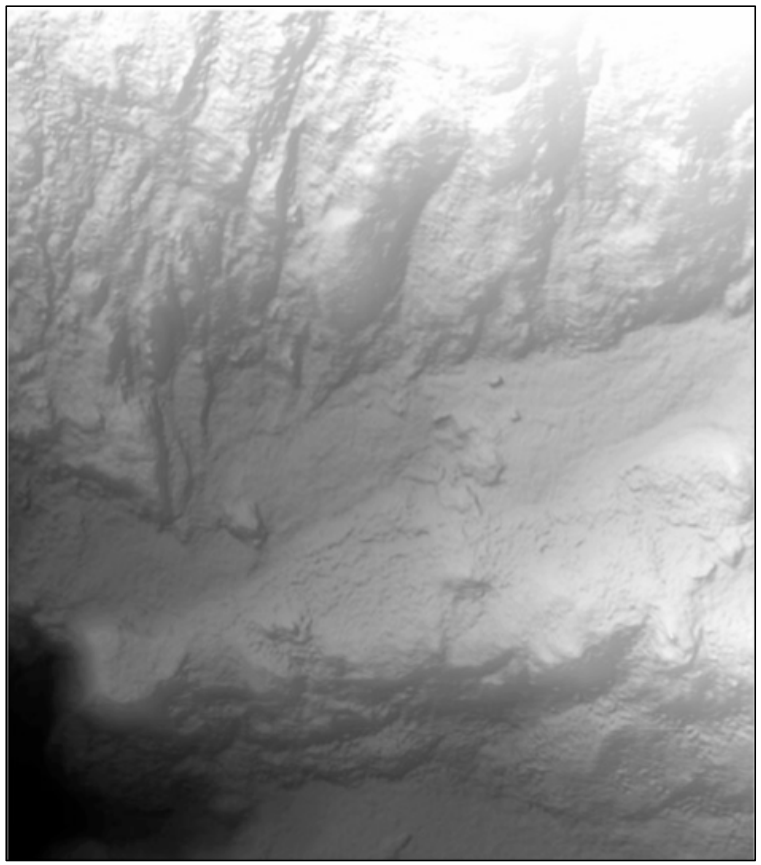
Landscape level warming



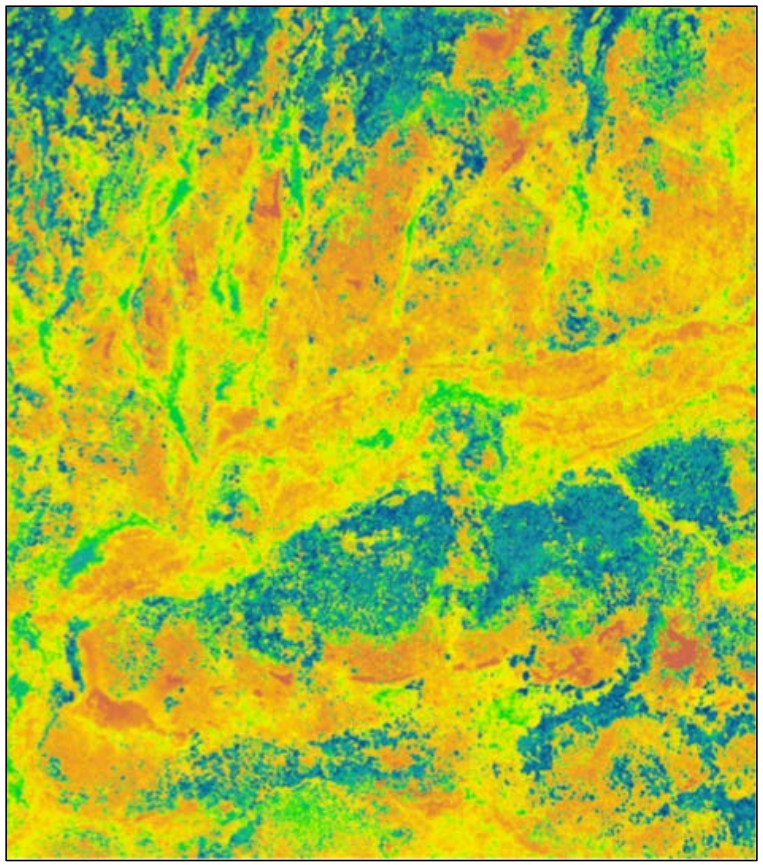
Soil moisture change

Permafrost disturbance

Link surface models with spectral patterns of productivity

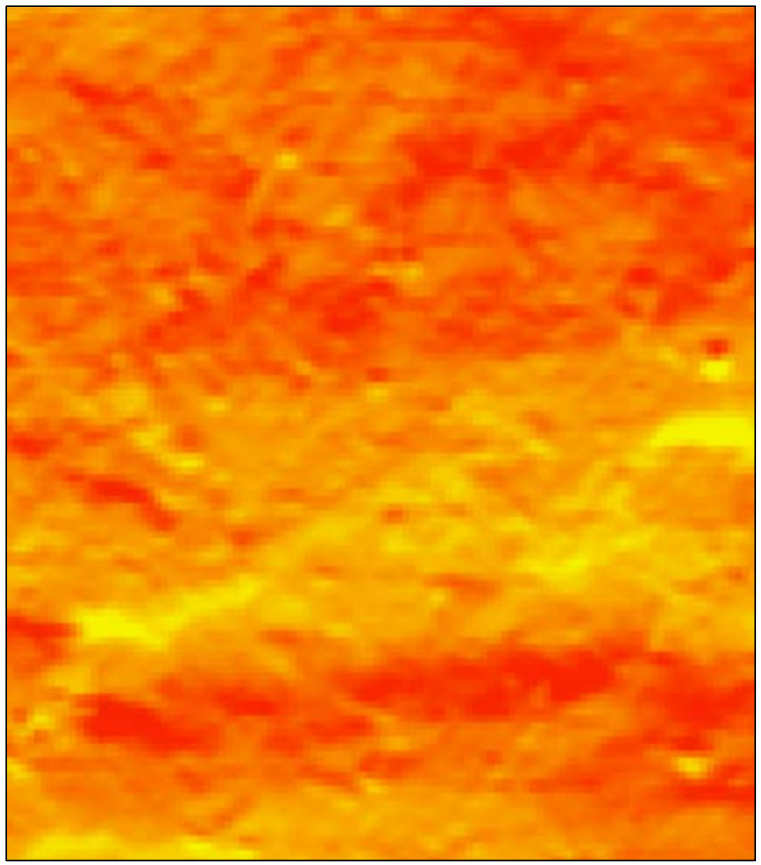


Elevation

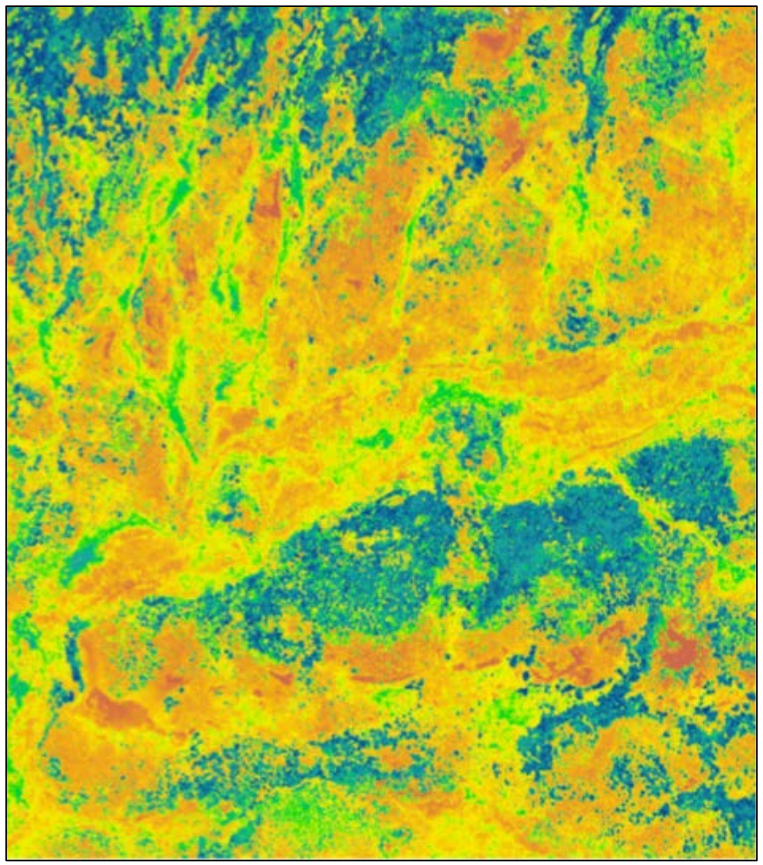


Calibrated NDVI

Derive continuous predictor variables from surface models



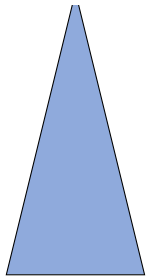
Seasonal Radiation Inputs (W/m^2)



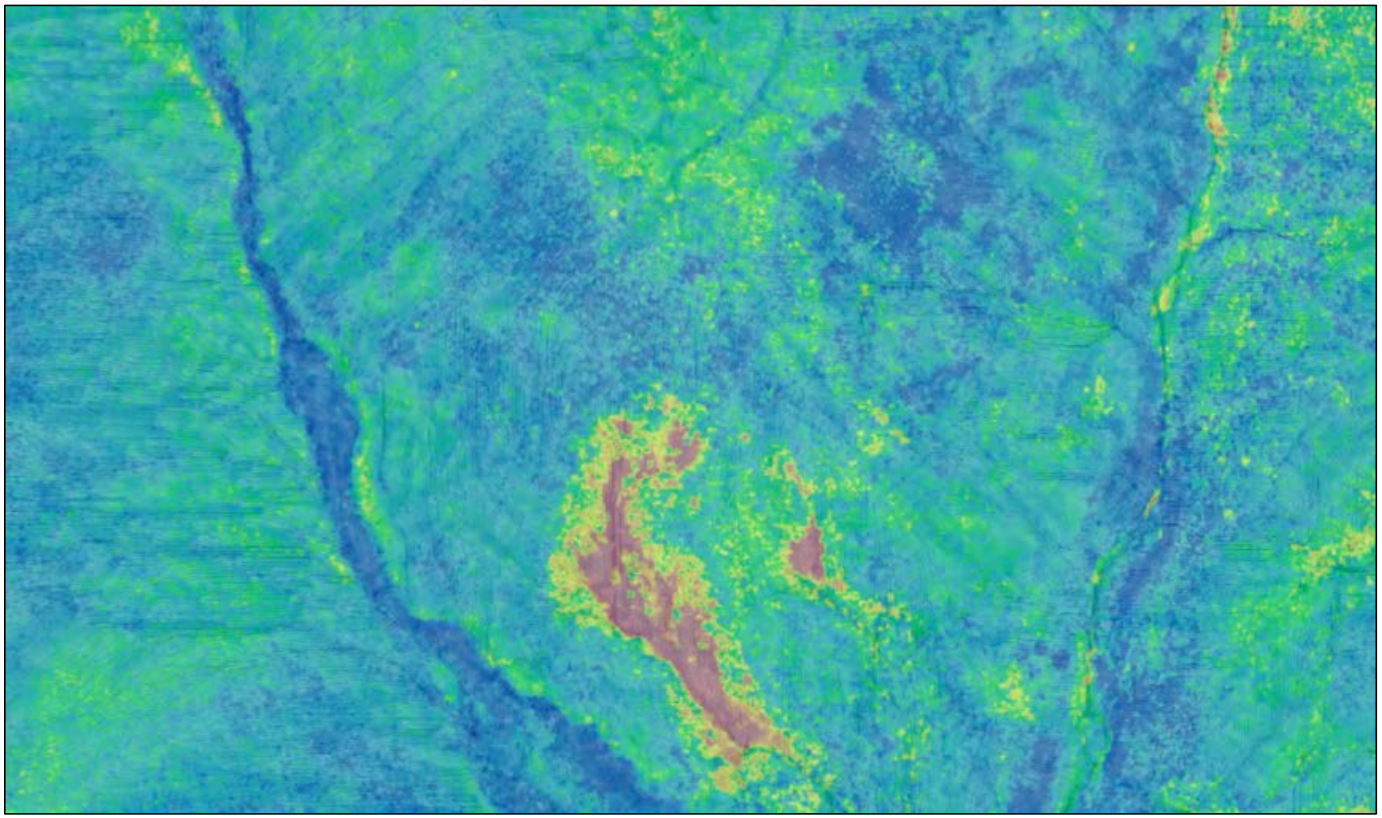
Calibrated NDVI

Scale matters for predictor variables from surface models

Altitude: Low



Pixel Size
<1 cm

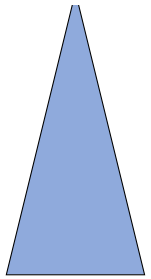


Topographic Wetness Index

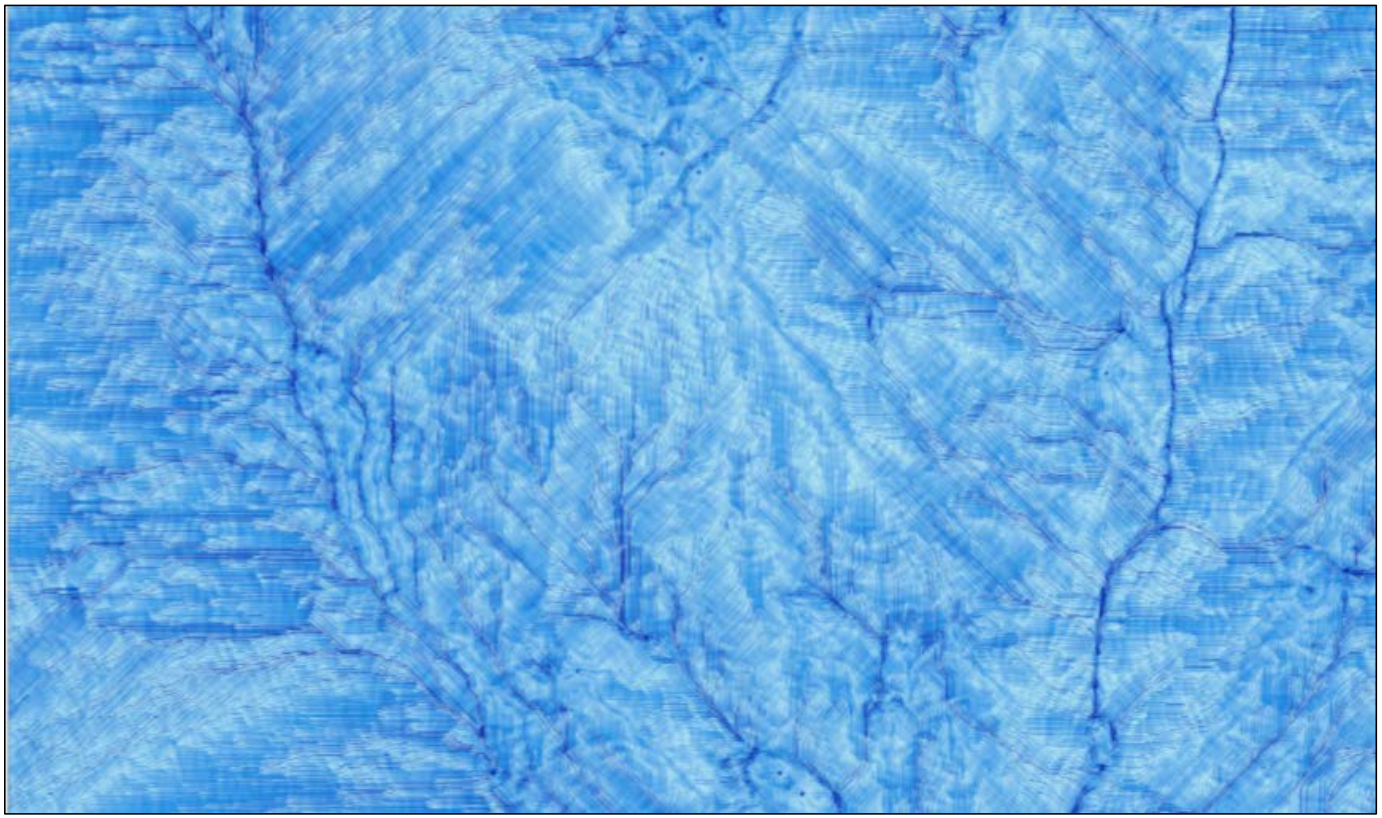
All drone data: Minimum pixel size depends on flight altitude

Scale matters for predictor variables from surface models

Altitude: Low



Pixel Size
<1 cm

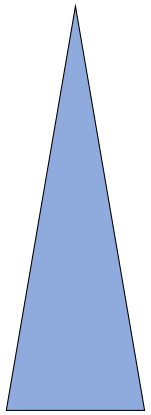


Topographic Wetness Index

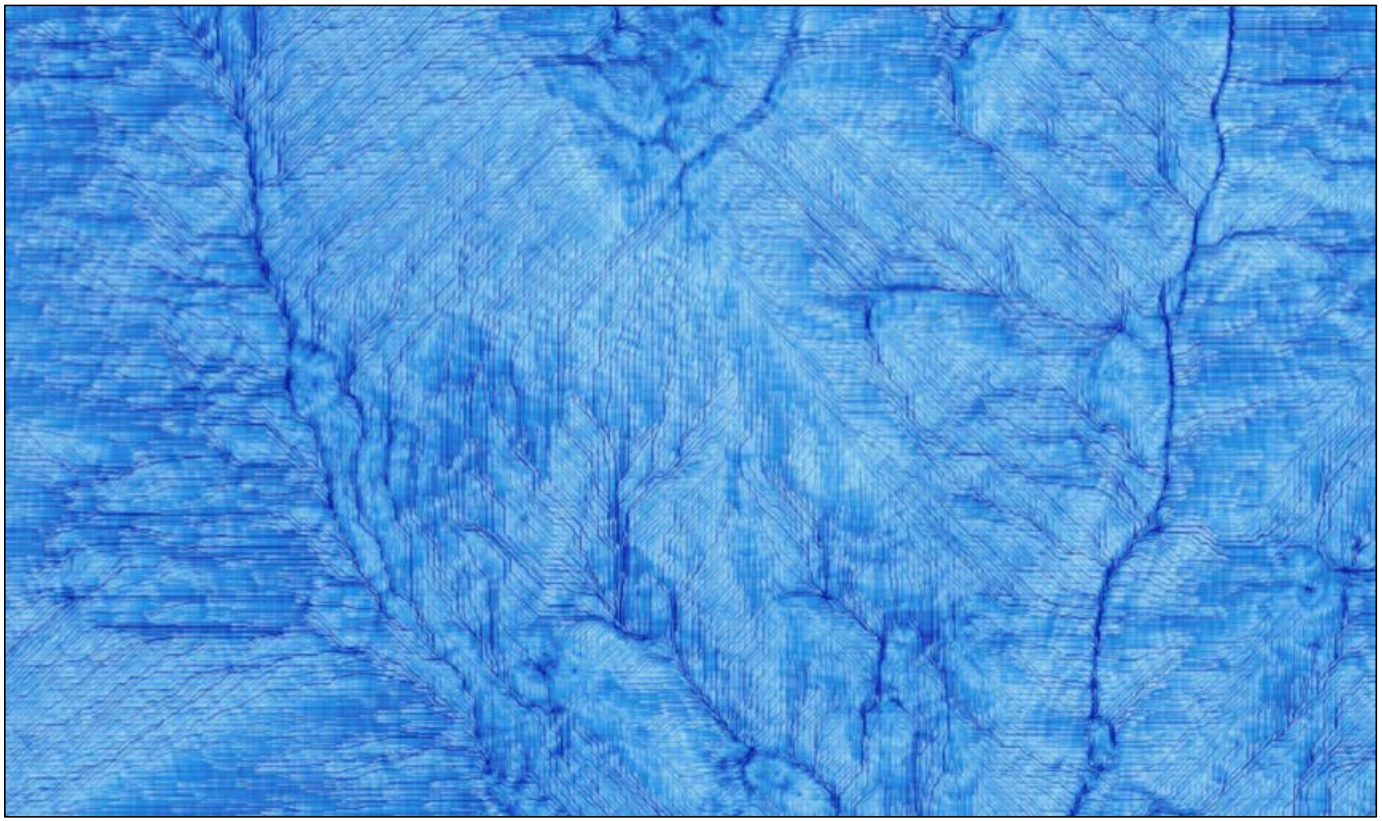
All drone data: Minimum pixel size depends on flight altitude

Scale matters for predictor variables from surface models

Altitude: Mid



Pixel Size
~4 cm

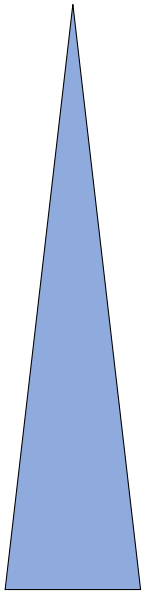


Topographic Wetness Index

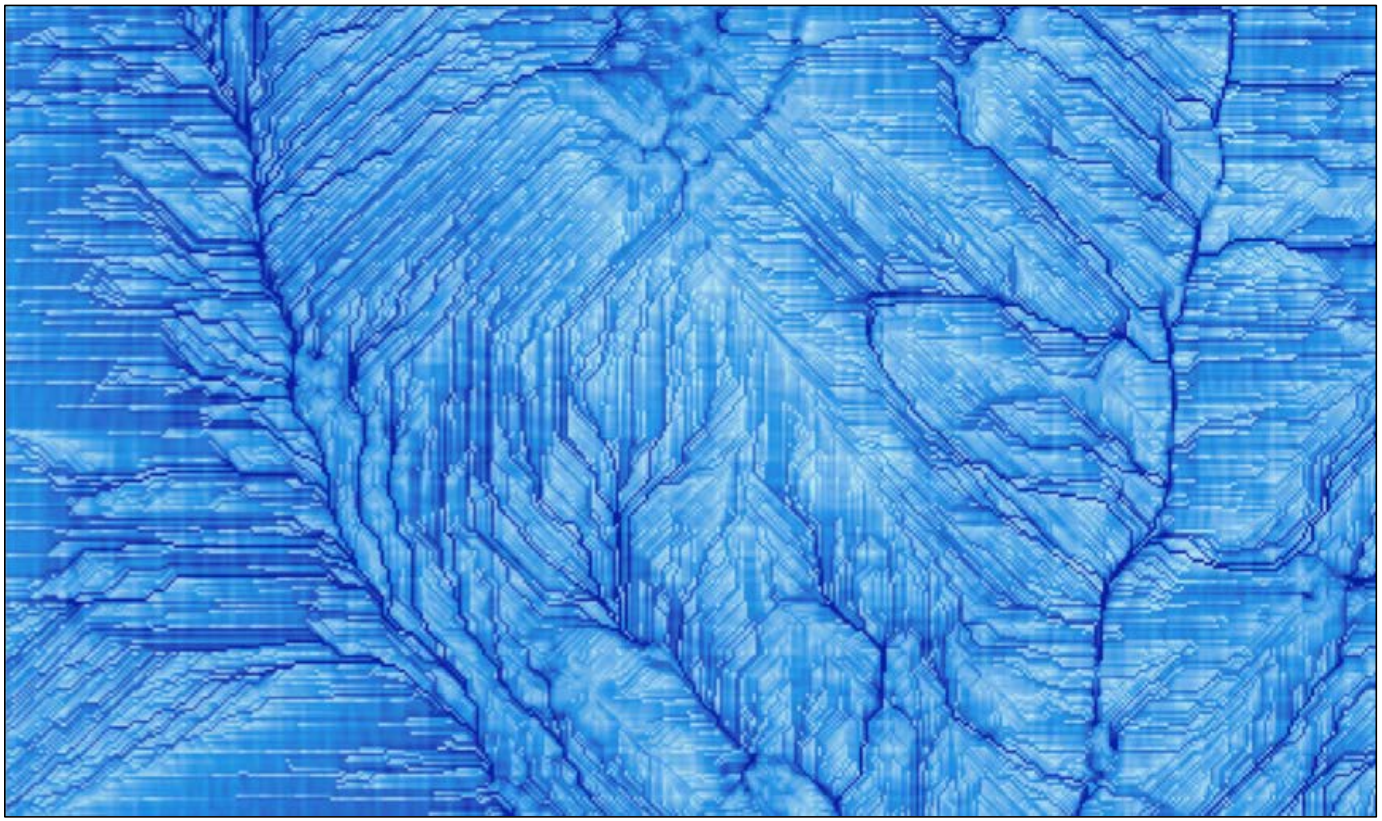
All drone data: Minimum pixel size depends on flight altitude

Scale matters for predictor variables from surface models

Altitude: High



Pixel Size
~15 cm

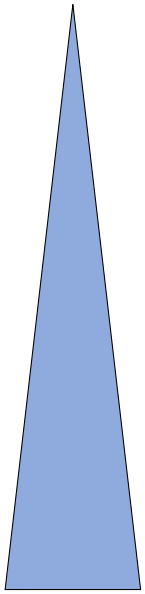


Topographic Wetness Index

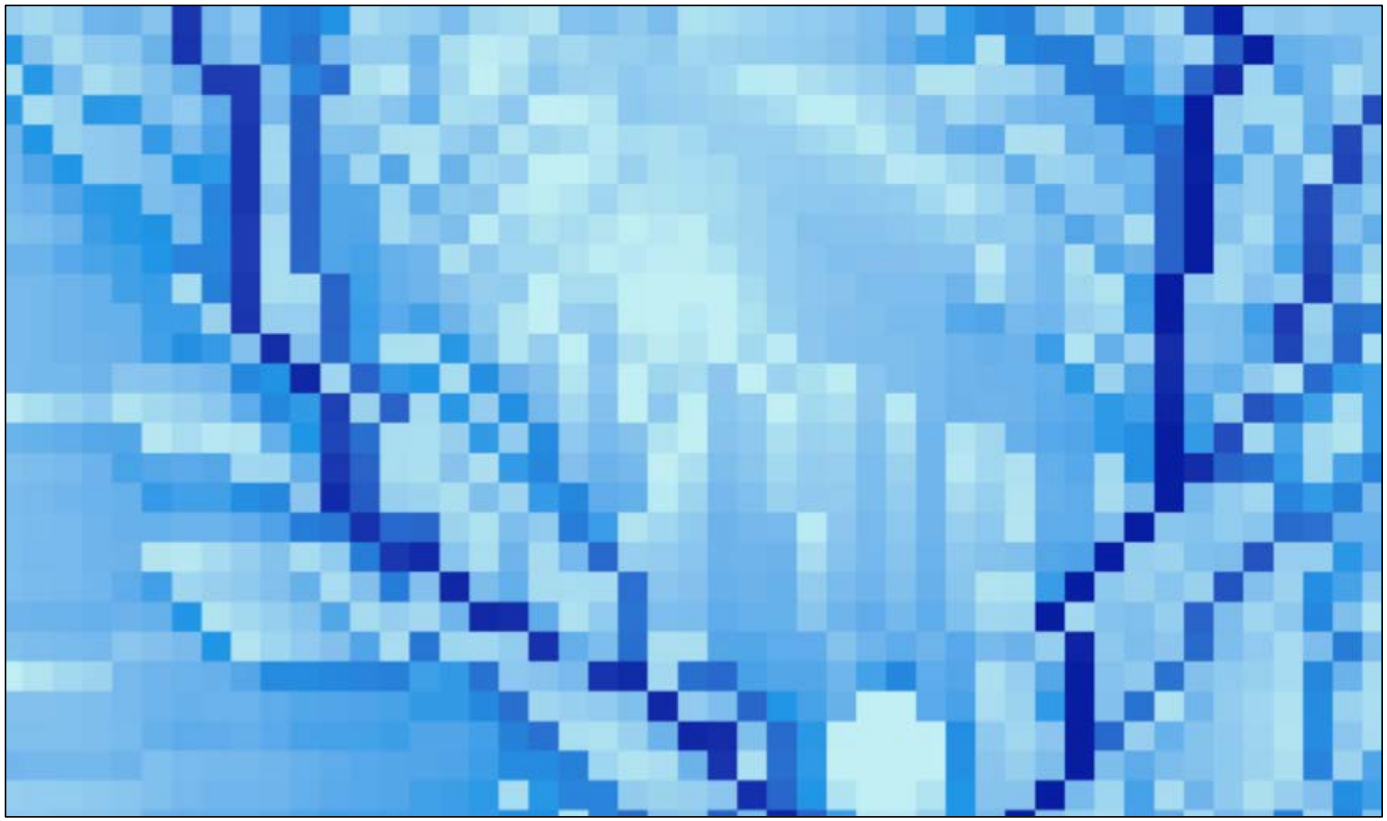
All drone data: Minimum pixel size depends on flight altitude

Scale matters for predictor variables from surface models

Altitude: Very High



Pixel Size
~500 cm



Topographic Wetness Index

All drone data: Minimum pixel size depends on flight altitude

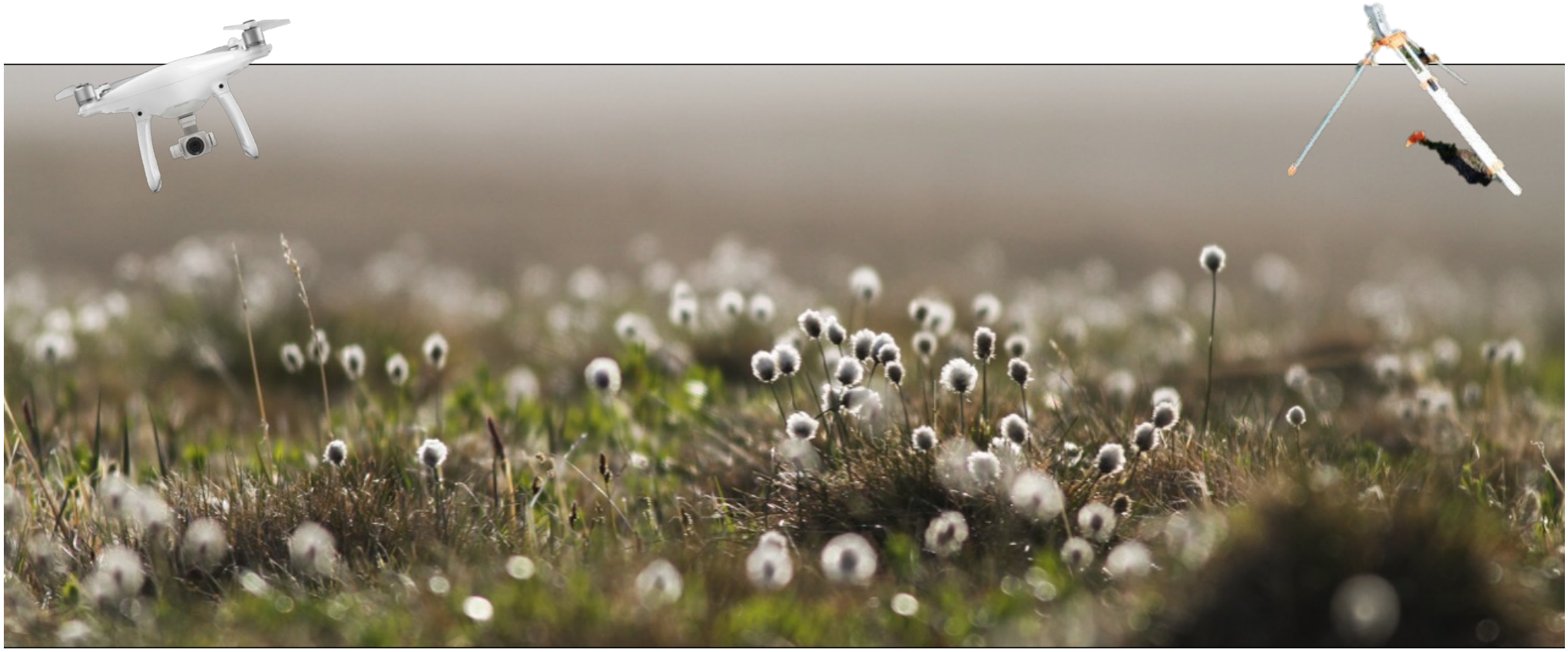
Quantify drivers of change

Compositional Change

Phenology Change

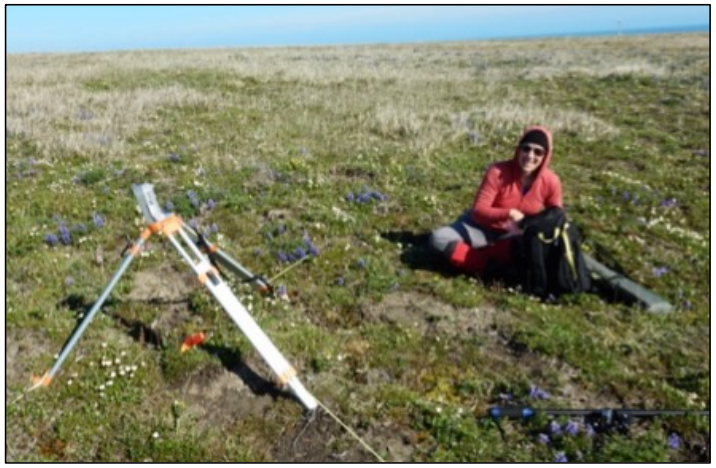
Trait Change

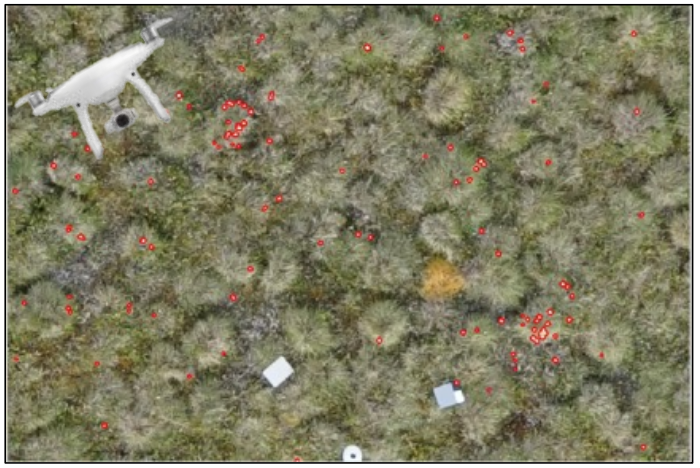
Quantify changes across scales



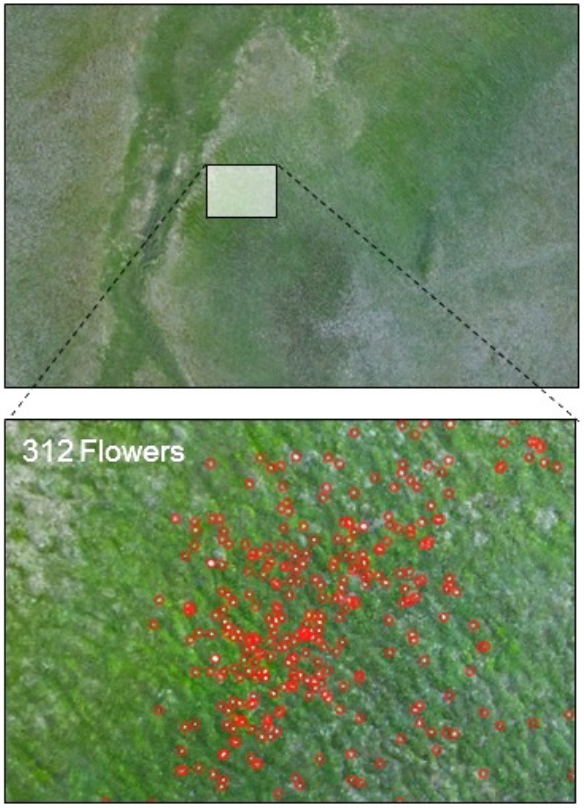
Data collection across scales

	Individual	→	Community	→	Landscape
Frequency	3 – 7 days		hourly		monthly
Extent	One plant		10 x 10 m		1000 x 1000 m



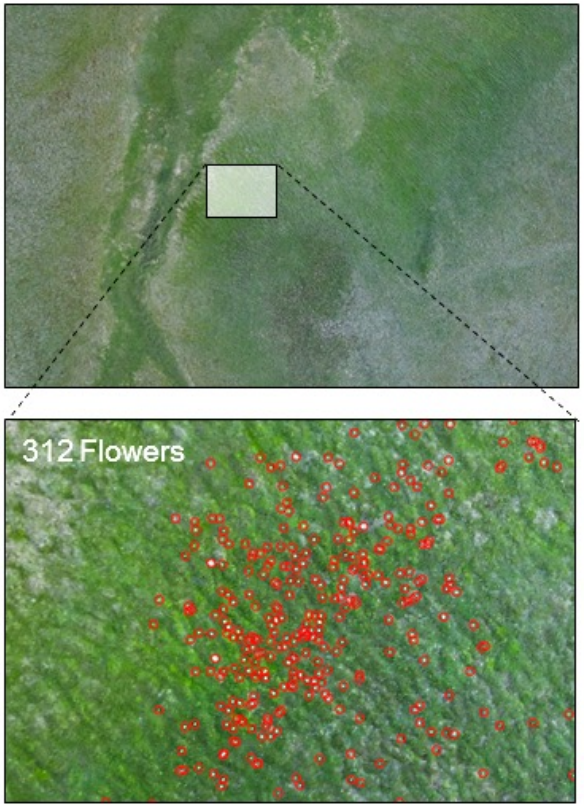


Object-based analyses: counting flowers

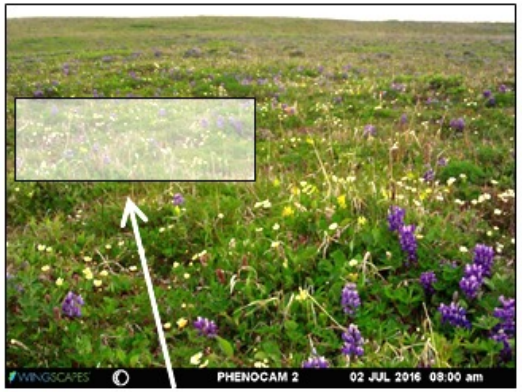


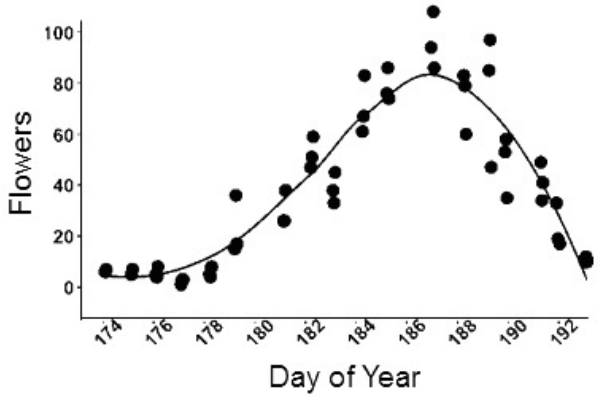
Through space

Object-based analyses: counting flowers



Through space

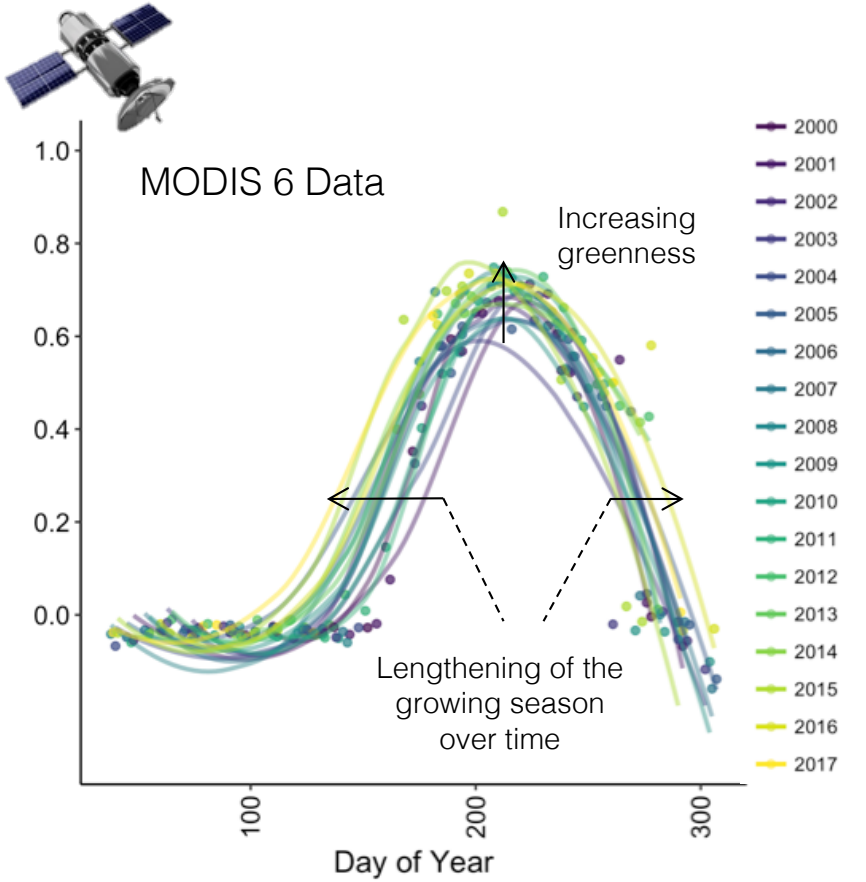


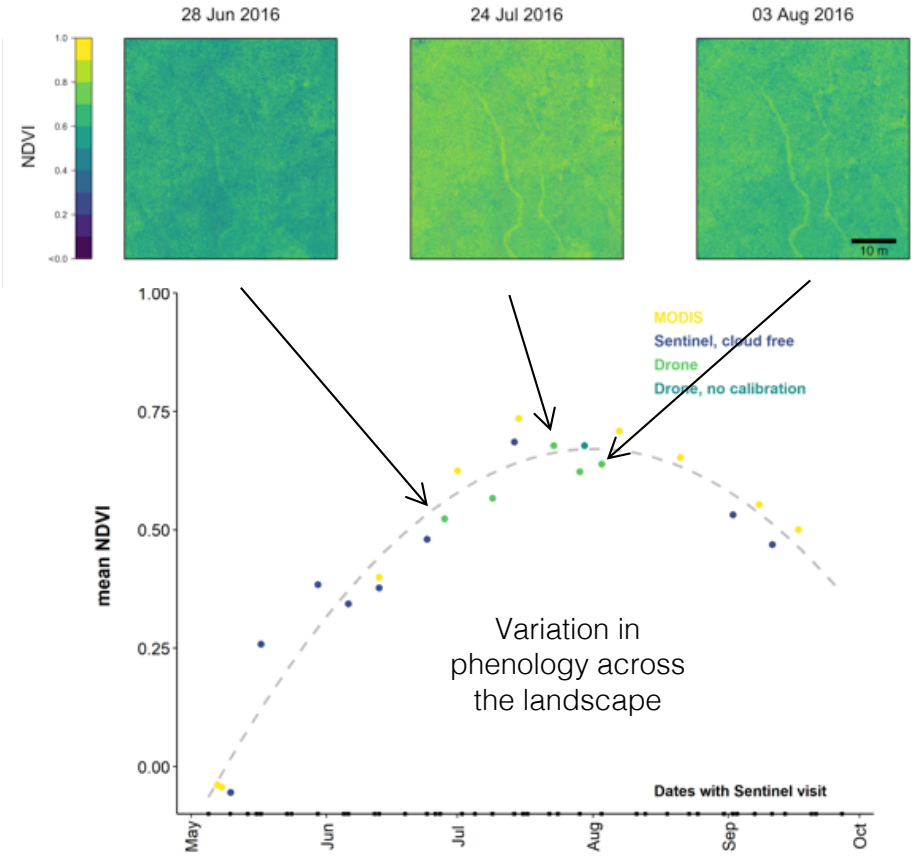


Through time


WINGSCAPES
PHENOCAM 4
17 JUN 2017 06:00 am

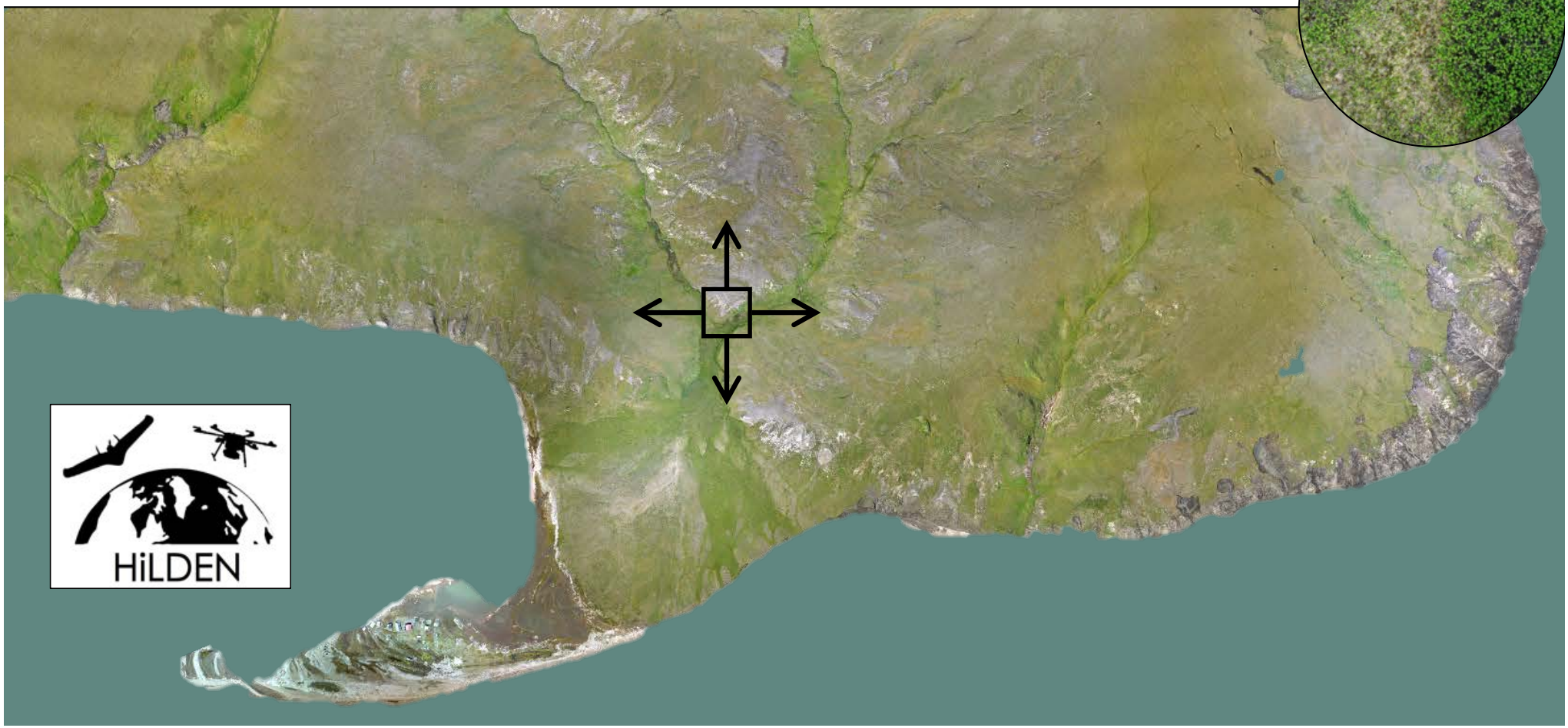
Phenology change over space and time



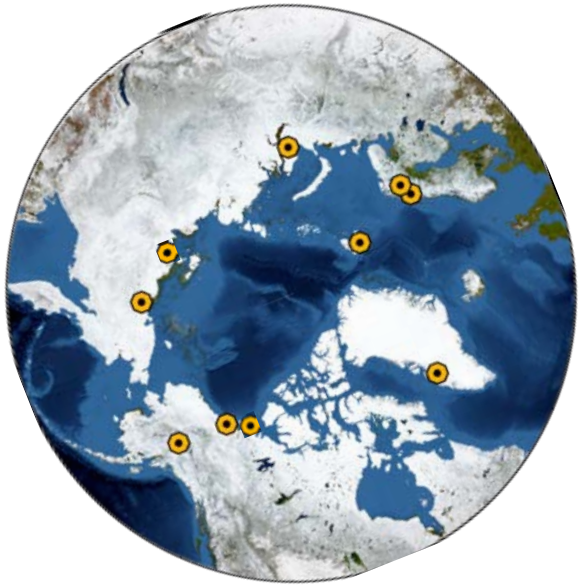


Assmann *et al.* in prep.

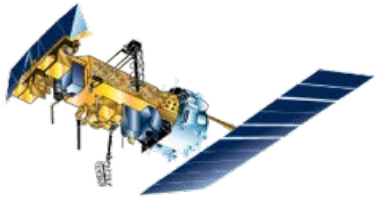
Sub-landscape influences on satellite greening trends?



Drone vs. Satellite NDVI comparisons (2017 HiLDEN data)

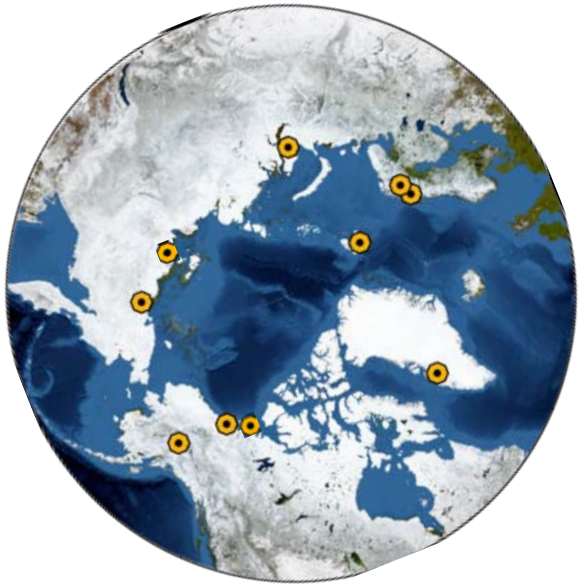


HiLDEN



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

Drone vs. Satellite NDVI comparisons (2017 HiLDEN data)

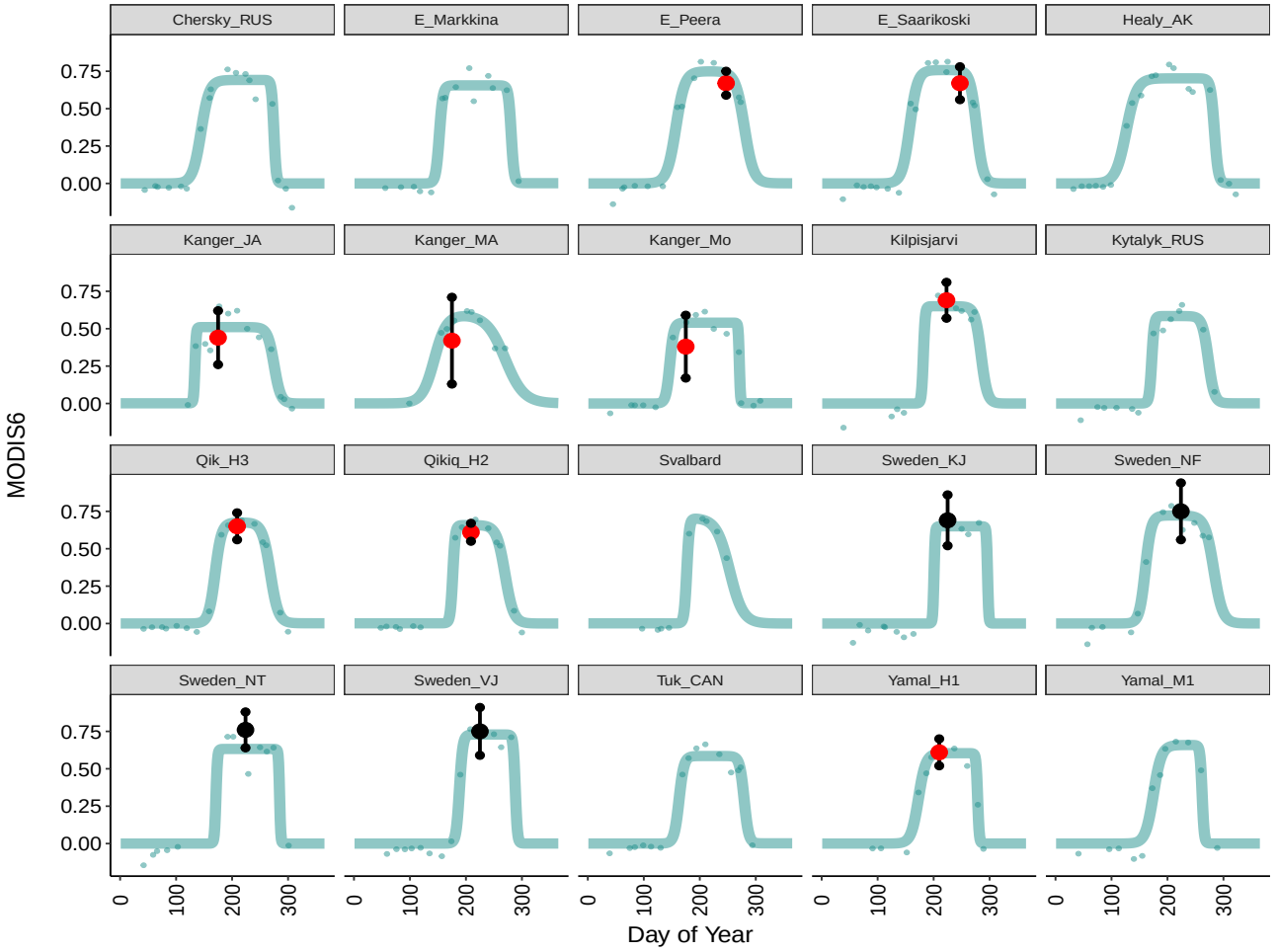


● = calibrated multispectral drone

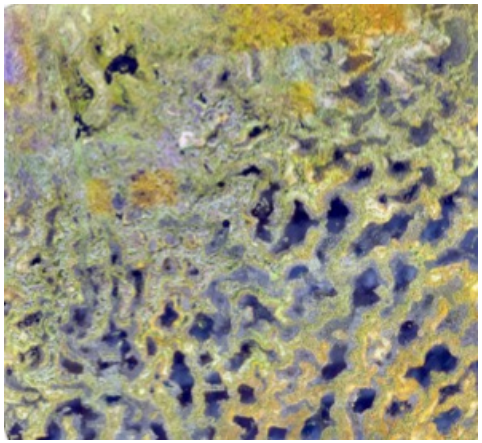
● = uncalibrated multispectral drone

HiLDEN

= MODIS NDVI

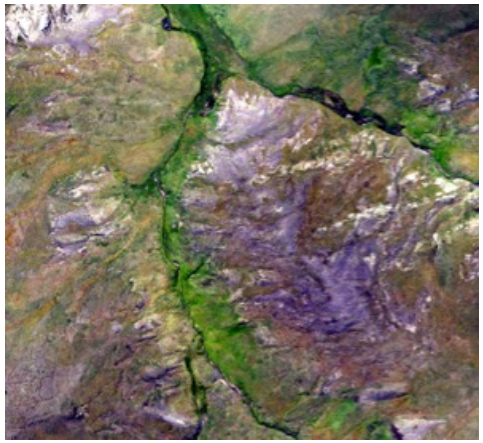


Contextualize landcover across sites



Finland

Greenland

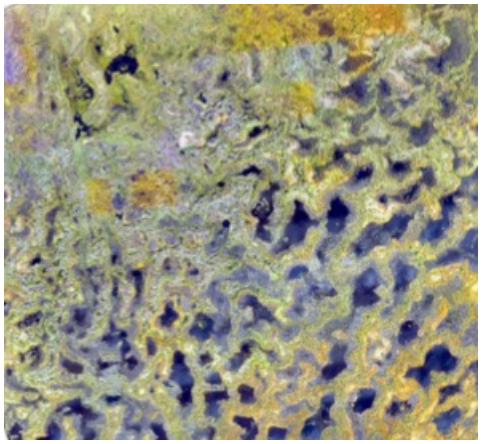


Yukon

NWT

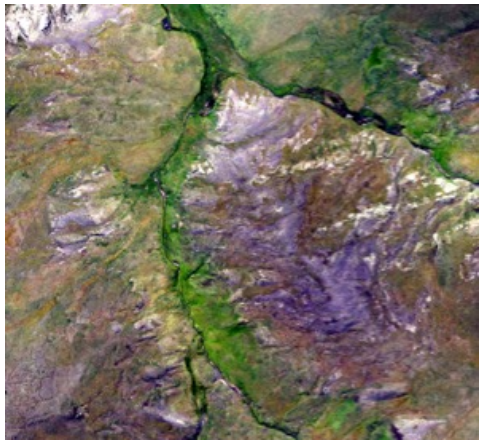
Kerby *et al.* in prep.

Contextualize landcover across sites



Finland

Greenland

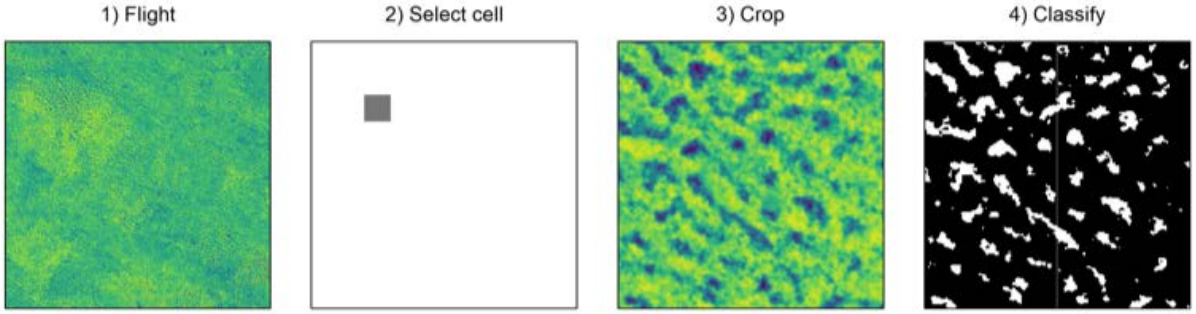


Yukon

NWT

Kerby *et al.* in prep.

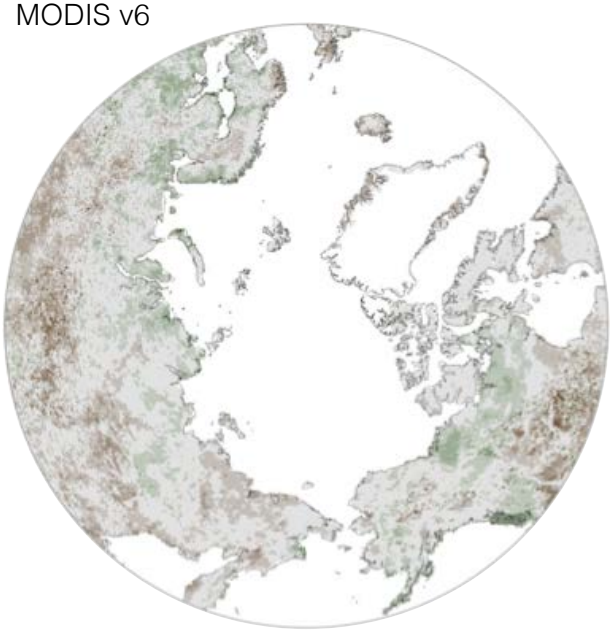
Classify landcover types (e.g. vegetated vs bare ground)



Assmann *et al.* in prep.

Ecological heterogeneity impacts greening patterns...

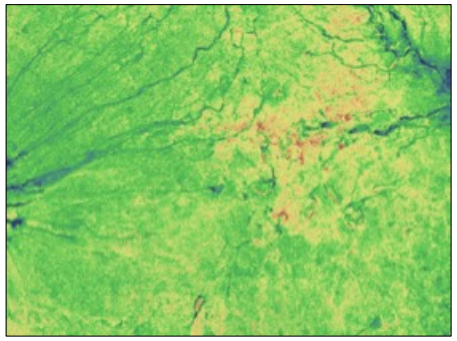
NDVI
MODIS v6



Increasing NDVI
Decreasing NDVI

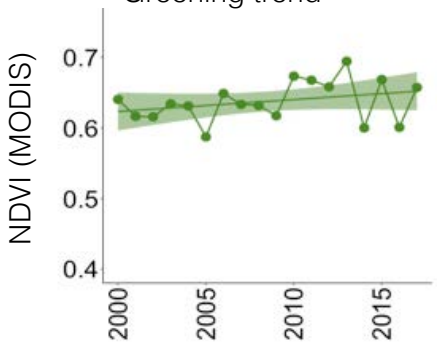
HiLDEN

Low heterogeneity: Qikiqtaruk, Canada

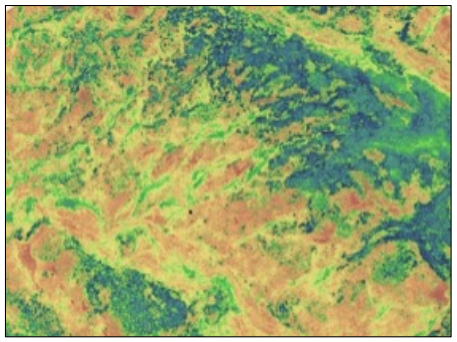


Drone-derived NDVI

Greening trend

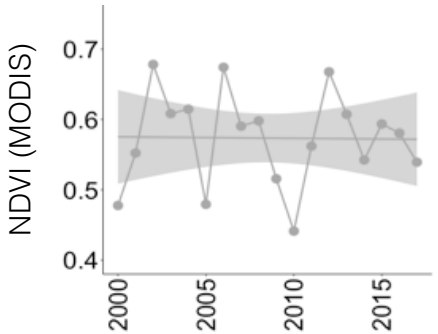


High heterogeneity: Kangerlussuaq, Greenland



Drone-derived NDVI

No trend in max NDVI



Myers-Smith *et al.* in prep.

Drones for ITEX?

What can we do with drone data?

Compare to satellite values, but also to plot-level data.

Fill in gaps and augment existing monitoring.

Ask new landscape-scale questions.

Drones for ITEX?

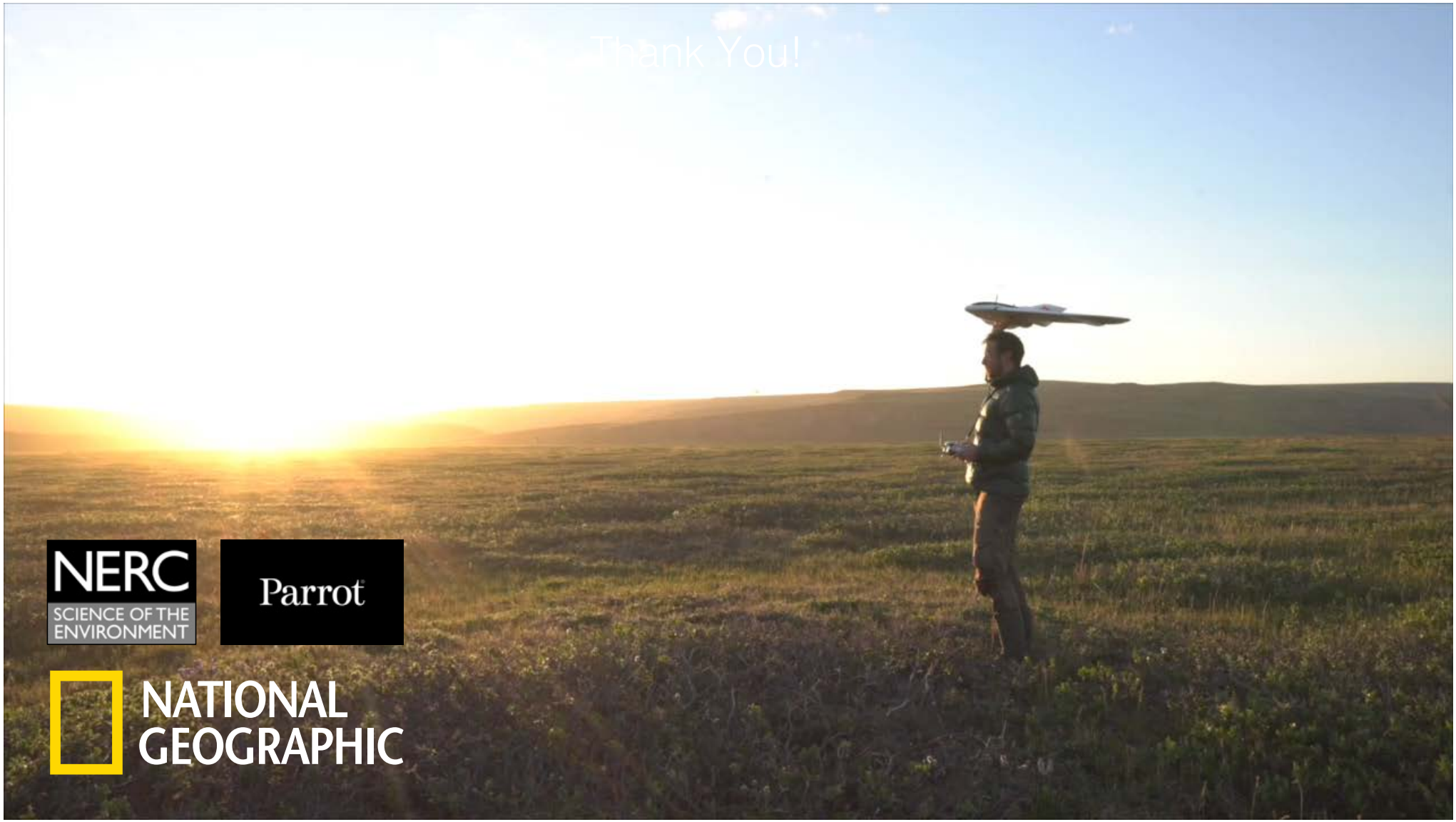
How should we do this?

Use standardized and informed protocols to ensure comparability through time and across sites.

Keep things simple as network builds capacity.

Choose appropriate use cases.

Metadata and data-storage plans streamline analyses and are useful to future projects.


Thank You!
NERC
SCIENCE OF THE ENVIRONMENT
Parrot
NATIONAL GEOGRAPHIC