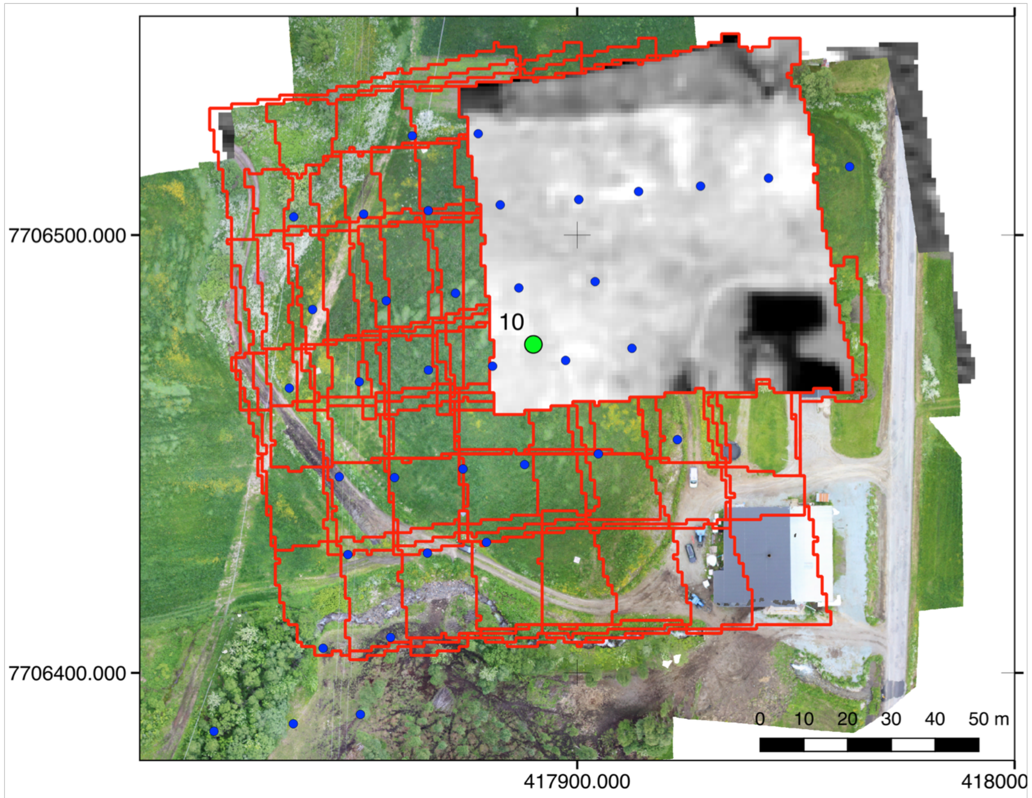
Does BDRF information from overlapping UAV images improve grassland yield mapping in northern Norway?

Corine Davids (Norut / NORCE)
Marit Jørgensen (NIBIO)



NIBIO
NORSK INSTITUTT FOR BIOØKONOMI

norut
NORTHERN RESEARCH INSTITUTE

INTRODUCTION

- Grassland cultivation for animal feed is the key agricultural activity in northern Norway.
- Yield and feed quality typically decrease with the age of the field.
- Mapping local and regional variability in yield will aid farmers and agricultural advisors with management decisions.

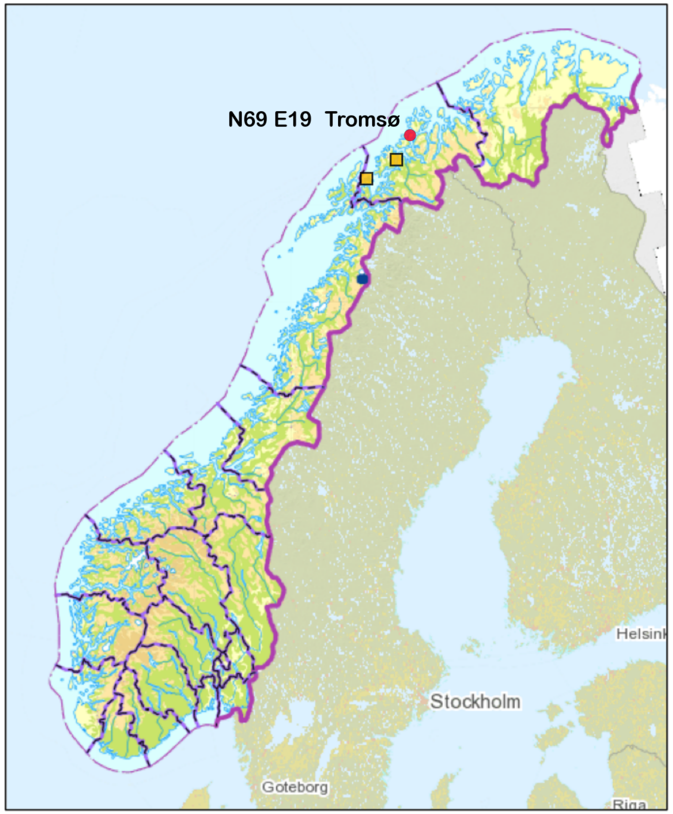
Objectives:

Investigate the relationship between spectral reflectance and yield for cultivated grasslands of different ages, botanical composition and productivity in northern Norway.

To investigate if anisotropic reflectance properties, which provide information on the vegetation structure, can improve the mapping of biomass in cultivated grasslands.

SITE DESCRIPTION

- Location: northern Norway, ca 69°N
- Max sun elevation: 45°
- Coastal climate: often partial/full cloud cover
- Field ages between 1 – 10 years
- Changing botanical composition with the age of the field



MEASUREMENTS

Equipment:

- multirotor UAV with gimbal
- Rikola hyperspectral frame camera (500 - 900 nm)
- Canon EOS M RGB camera/MAPIR NDVI camera
- Light intensity sensor
- Topcon GR-5 RTK GNSS GPS receiver
- SphereOptics reflectance targets (25%, 50%, 95%)
- Fieldspec 3 spectroradiometer (350 - 2500 nm)

In situ data, 25-50 sample locations per field:

- Fieldspec measurements, at 60° and nadir
- Recordings of botanical composition
- Wet and dry weight of 0.25m^2 samples

Band 1	Band 2	Band 3	Band 4	Band 5	Band 6	Band 7	Band 8	Band 9	Band 10	Band 11	Band 12	Band 13	Band 14	Band 15
502.65	530.73	559.91	570.39	609.91	644.93	664.7	684.81	705.22	725.05	740.34	760.14	782.64	809.6	842.22

PROCESSING

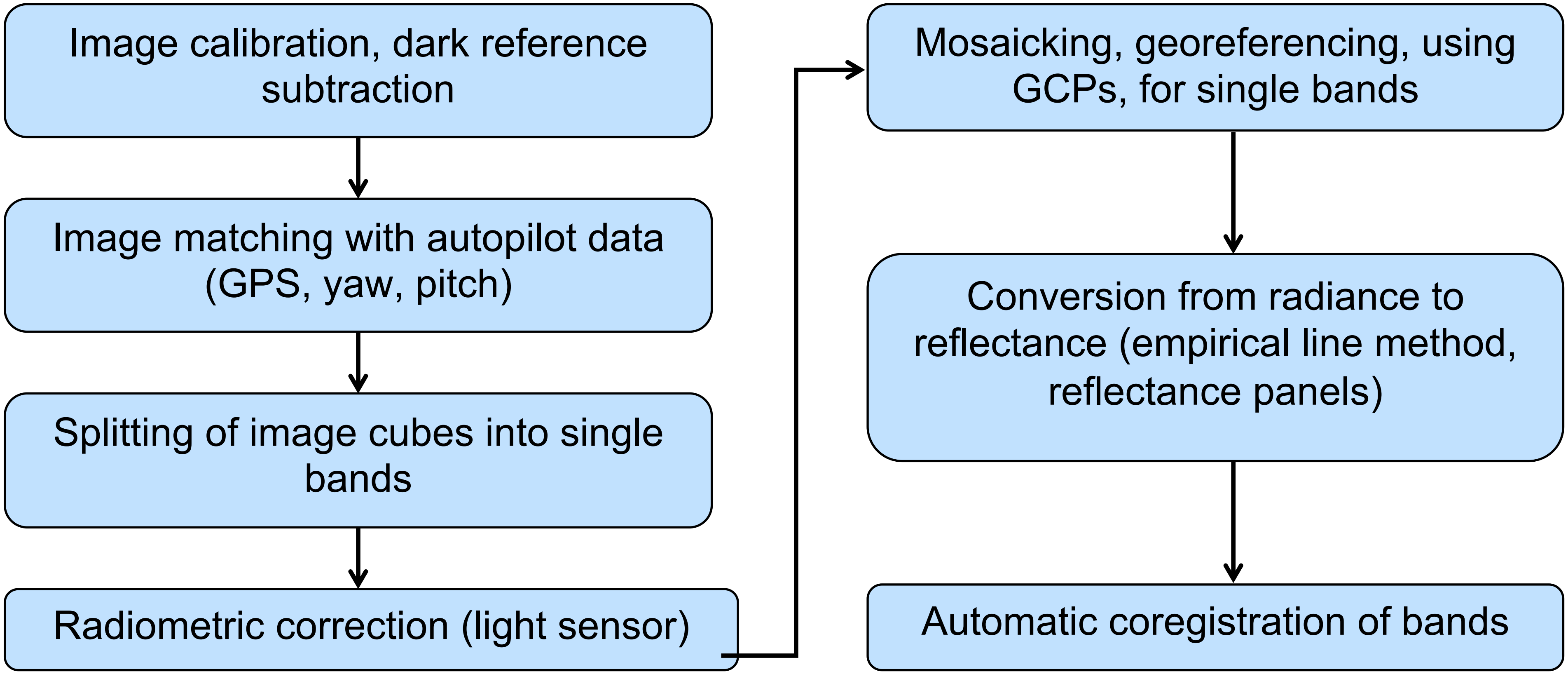
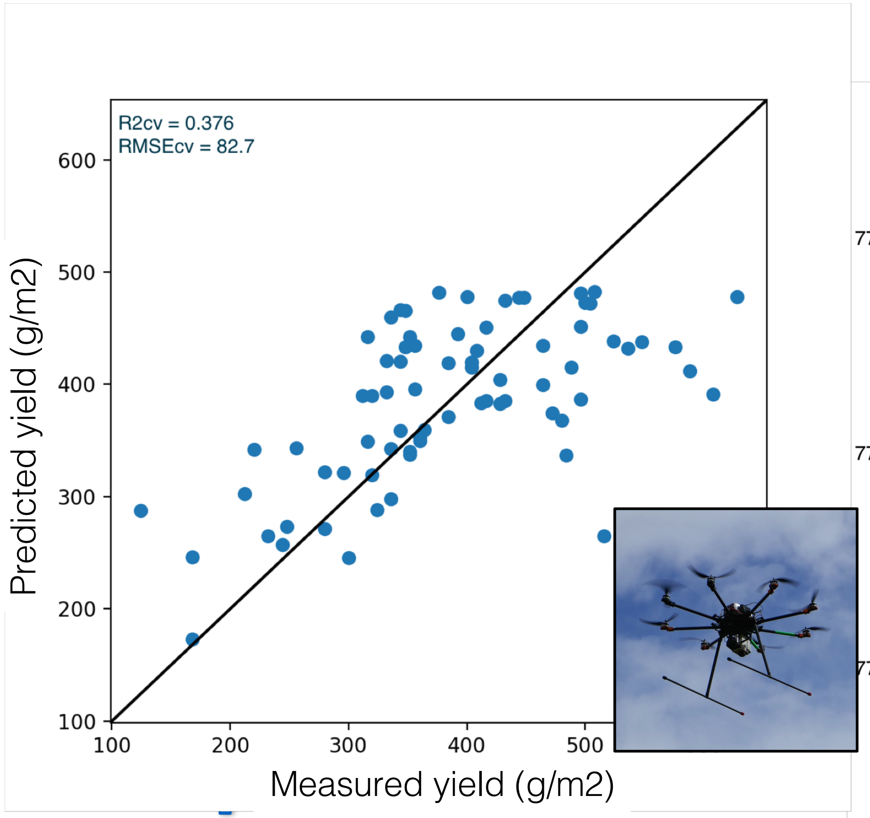
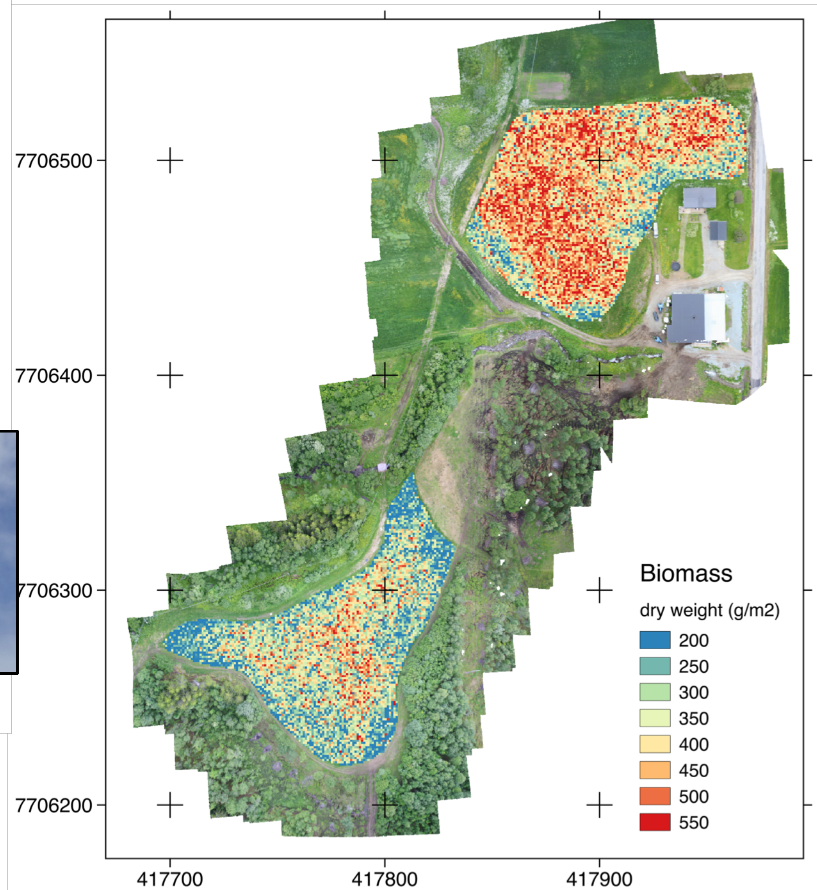


Image calibration, dark reference subtraction
Image matching with autopilot data (GPS, yaw, pitch)
Splitting of image cubes into single bands
Radiometric correction (light sensor)
Mosaicking, georeferencing, using GCPs, for single bands
Conversion from radiance to reflectance (empirical line method, reflectance panels)
Automatic coregistration of bands

INITIAL RESULTS

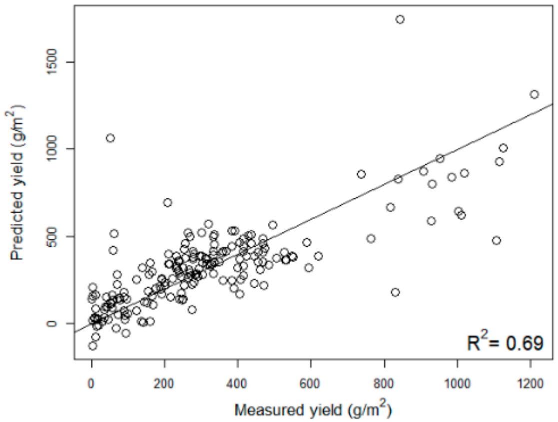
Regression (PLSR) using all 15 bands (400-900nm) without BRDF

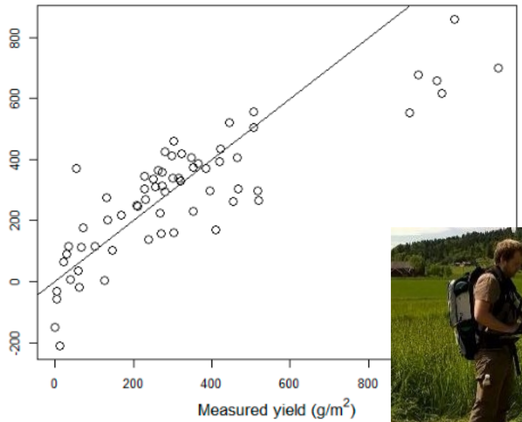




Predicted biomass without BRDF information

(Davids et al., 2018)



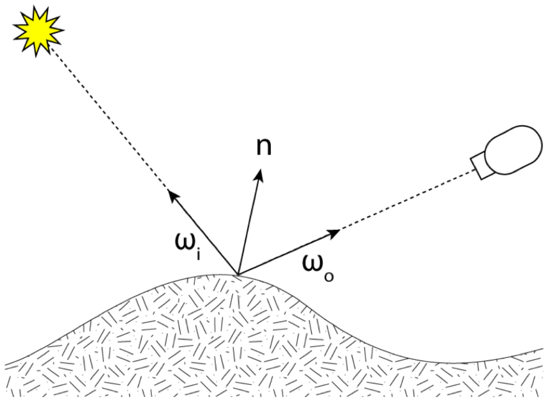


(Ancin et al., 2019)

THEORY REFLECTANCE ANISOTROPY

Most natural surfaces show an anisotropic reflectance (Bidirectional Reflectance Distribution Function) based on optical and structural properties of the surface; for vegetation:

- Canopy heterogeneity and architecture
- Orientation of the leaves
- Shadowed and sunlit parts are viewed differently from different observation and illumination angles
- Varying proportions of canopy – ground
- Depends on the illumination and observation geometry



THEORY REFLECTANCE ANISOTROPY

Semi-empirical **Rahman-Pinty-Verstraete model** (Rahman et al., 1993; Roosjen et al., 2017) defines the anisotropy by 4 parameters:

$$R_s(\theta_i, \varphi_i; \theta_r, \varphi_r) = \rho_0 \frac{cos^{k-1}\theta_i cos^{k-1}\theta_r}{(cos\theta_i + cos\theta_r)^{1-k}} F(g)[1 + R(G)]$$

ρ_0, k: describe amplitude and bowl shape of anisotropy curve

Θ: forward/backward scattering

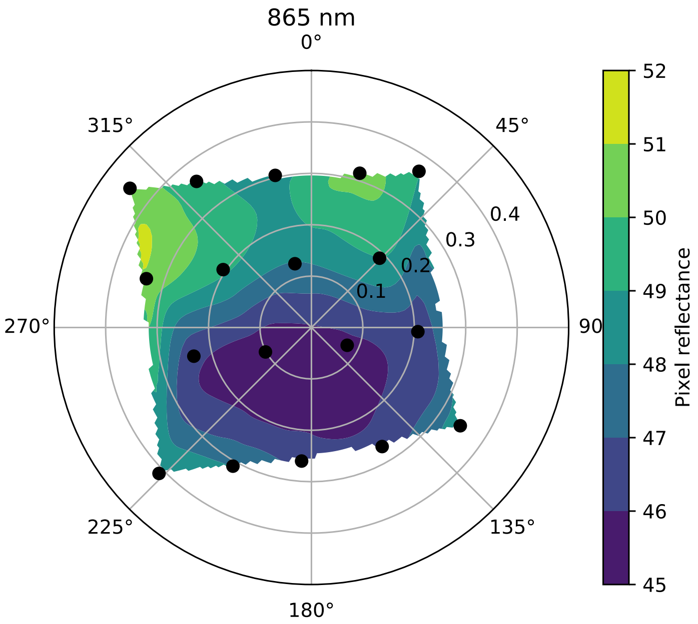
ρ_c: hotspot effect

Θ_i, φ_i: sun/view zenith and azimuth angles

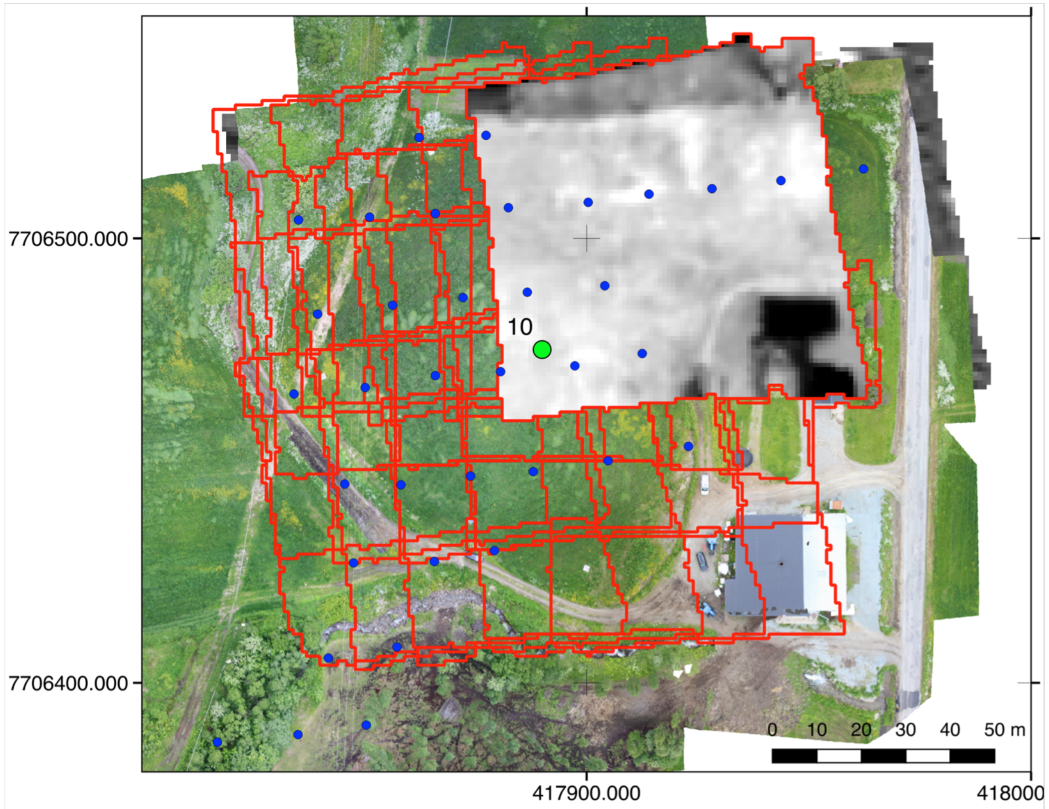
Input:

- illumination and viewing geometry, corrected for the topography, per pixel
- reflectance values per pixel per geometry

THEORY BRDF

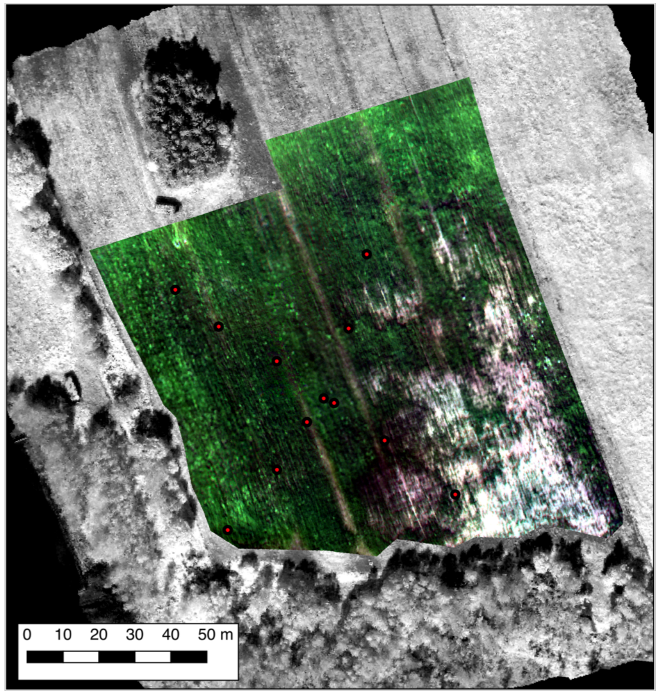


Variation in reflectance values for sample point 10, depending on view angle.

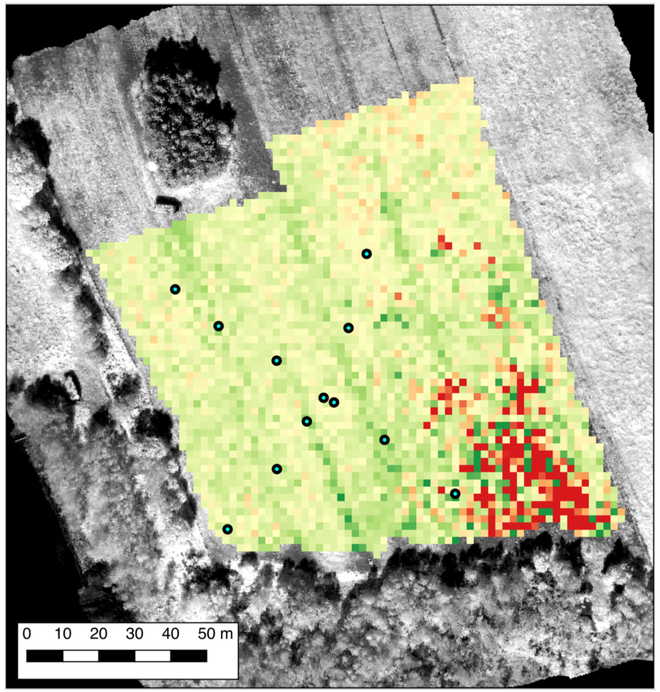


Sample point 10 is covered by 18 overlapping images, with different sun-object-viewing angles. Red polygons outline the images that cover point 10, blue dots indicate all image locations.

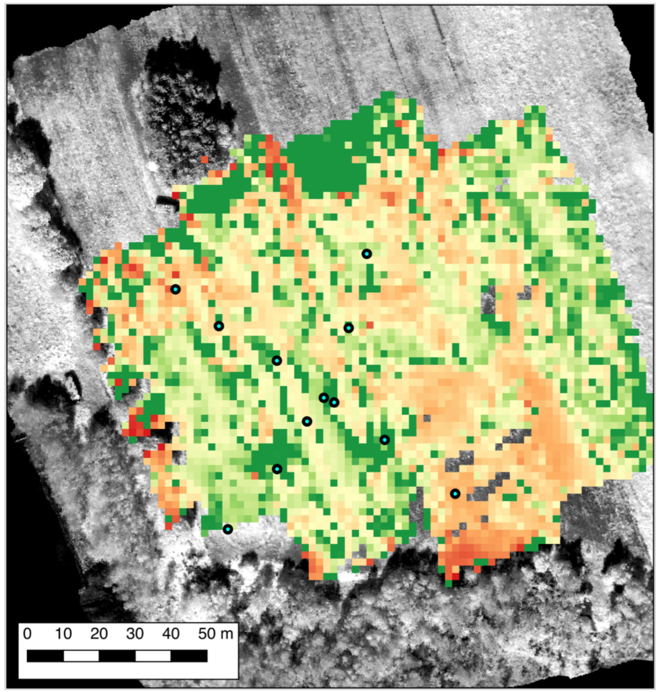
EARLY RESULTS



Simulated RGB image



mNDVI 705
$(R_{740}-R_{705}) / (R_{740}+R_{705}-2*R_{560})$



ρ_0 (band 842 nm)

DISCUSSION AND CHALLENGES

- Based on visual comparison with simulated RGB image and ground observations, there appears to be a correlation between ρ_0 and biomass.
- Higher ρ_0 values indicate a more fully developed canopy.
- No obvious correlation between the k and Θ parameters and biomass / canopy development in NIR

- Need at least 80% overlap in both directions
- Best flight direction relative to the sun
- Good calibration needed, particularly at high latitudes with low sun elevation
- We used existing data, not specifically collected for extracting multi-angular information

FURTHER WORK

- Improving the radiometric correction methods to calibrate for variable lighting conditions
- Finalise modelling for all wavelengths and fields
- Regression analysis
- Apply to other applications, e.g. mapping of Arctic vegetation
- Improve image collection method