Spectral characterization of low Arctic tundra phenophase using high resolution VNIR reflectance data

14th International Circumpolar Remote Sensing Symposium

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Background

- Optical remote sensing of vegetation in tundra ecosystems is challenging

Background

- Low, complex canopy

Background

- Variable surface moisture

High spectral resolution remote sensing

Environmental Mapping and Analysis Program (EnMAP)

- 242 bands (423–2450 nm)
- Spectral resolution between 6.5 and 10 nm
- Spatial resolution of 30 m
- Planned launch in 2019

Sentinel-2, European Space Agency (ESA)

- 13 spectral bands (443 – 2190 nm)
- Spectral resolution between 15 and 120 nm
- Spatial resolution of 10 m (four broad band VNIR bands) to 20 m (six narrow bands in the red edge)

CHRIS-PROBA, European Space Agency (ESA)

- Mode 3
- 17 m

Hypothesis

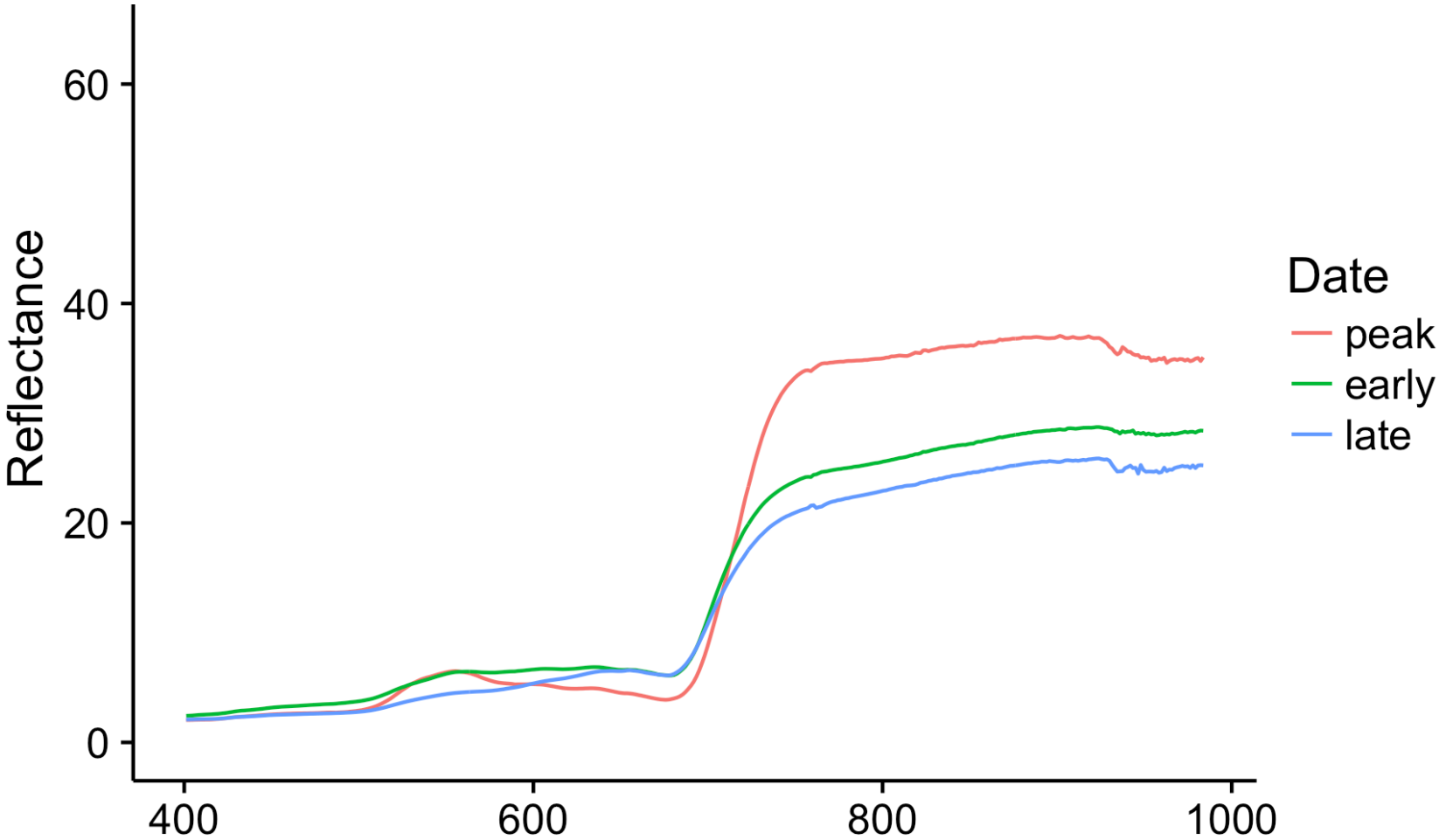
Vegetation pigment dynamics, rather than leaf and canopy structure, drive spectral signals of key phenological phases and community types in low Arctic tundra ecosystems

Leaf out

Peak greenness

Senescence

Hypothesis



Key Questions

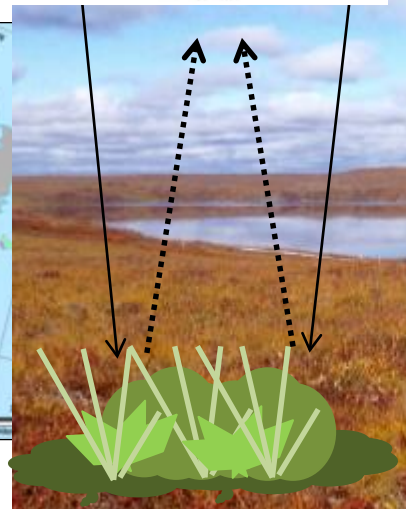
Can high spectral resolution data capture seasonal changes in pigment concentrations?

Are there a differences in pigment concentrations and pigment dynamics between vegetation communities?

Can we use the differences to identify photosynthetic activity?

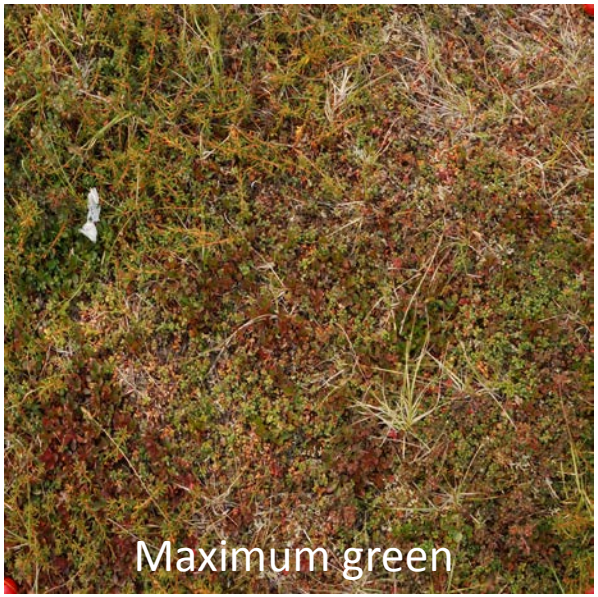
How does this scale from the plot to the landscape?

Data collection 2015/16

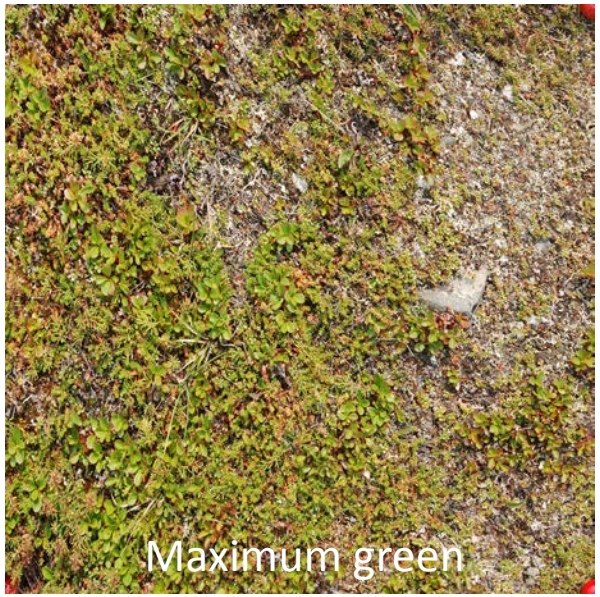


- GER 1500 512 bands (350-1050nm)
- 9 measurements per 1 x 1 m plot
- 6 dominant vegetation communities in the long-term Toolik Vegetation Grid (Circumpolar Arctic Vegetation Map, Walker et al. 2006)
- Early, peak and late season

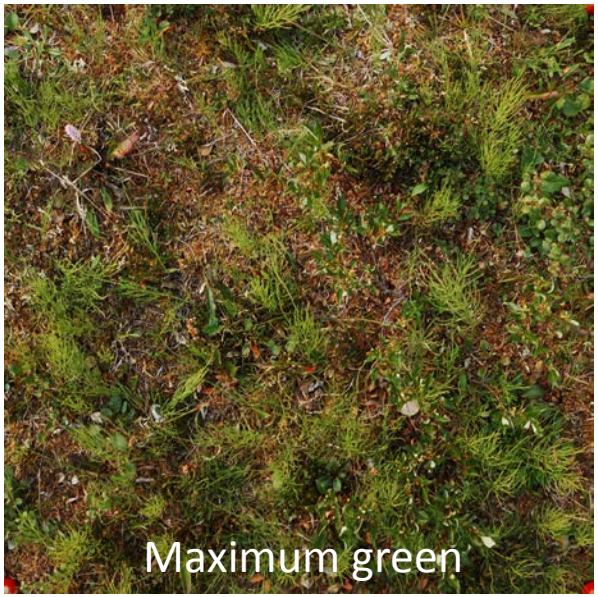
Dry prostrate shrub tundra



Dry tundra



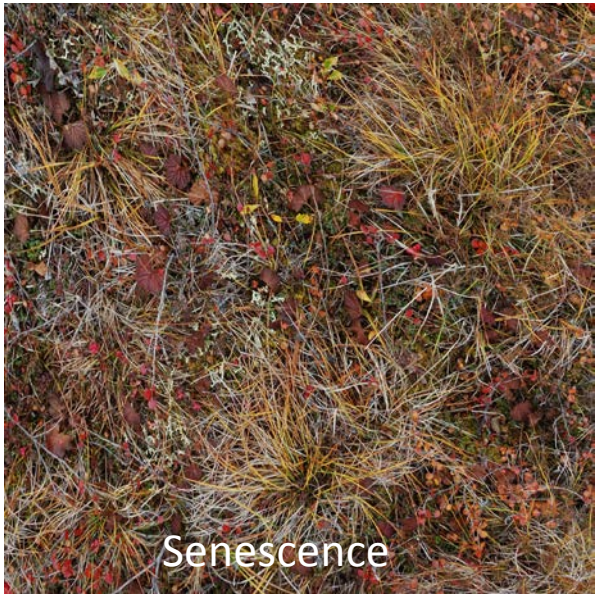
Early melting acidic snowbed



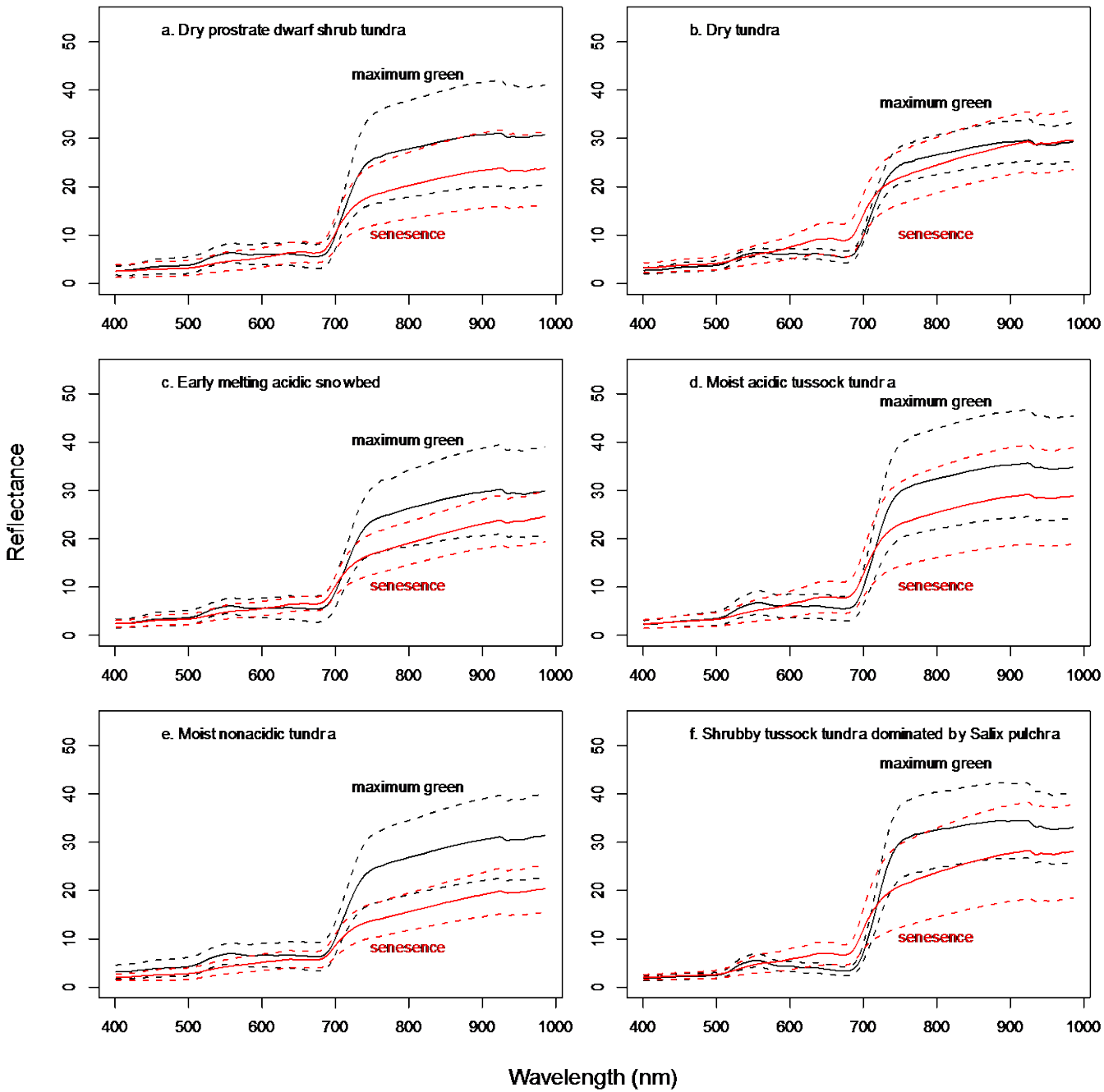
Moist acidic tussock tundra

Moist nonacidic tundra

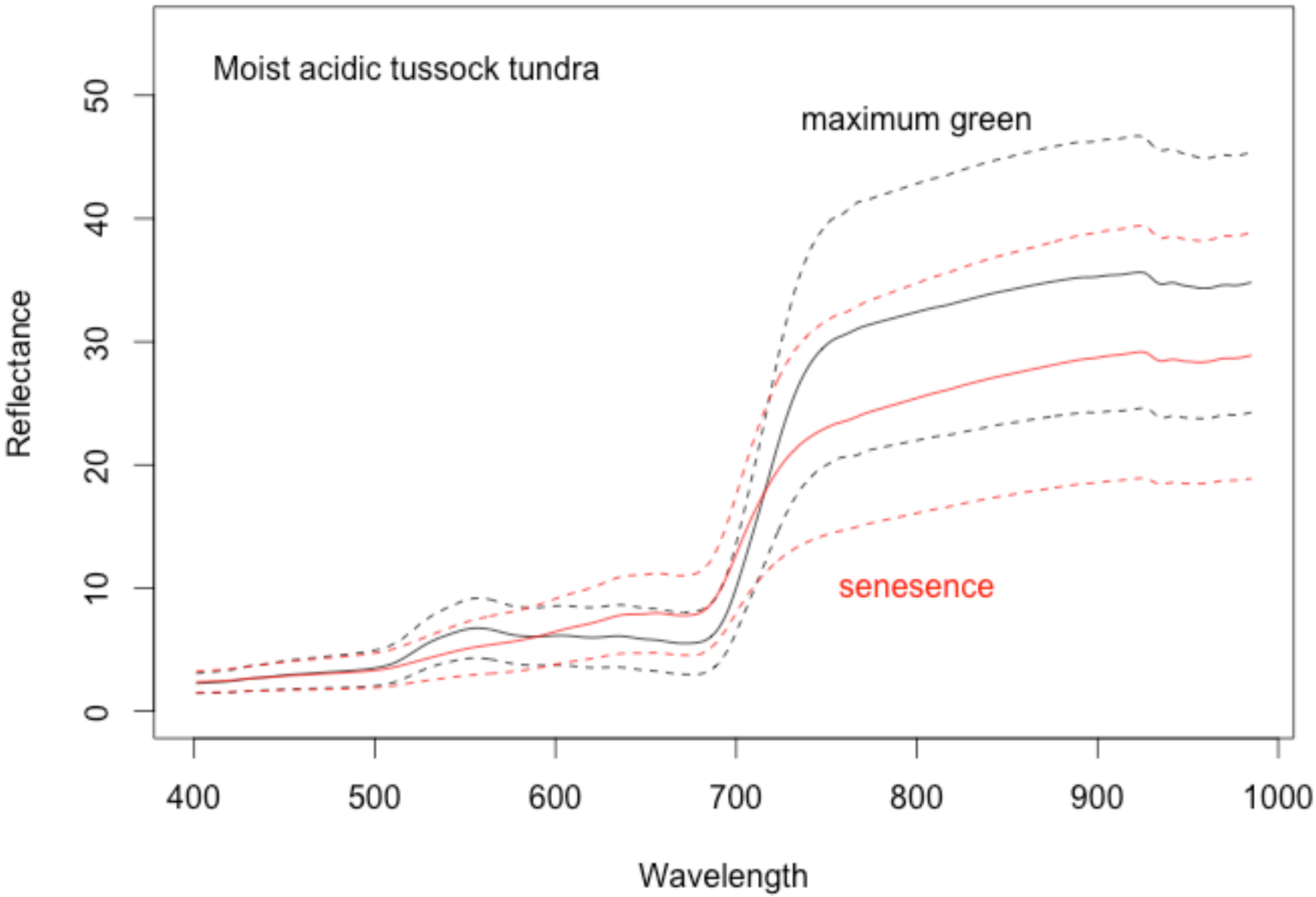
Shrubby tussock tundra dominated by *Salix pulchra*



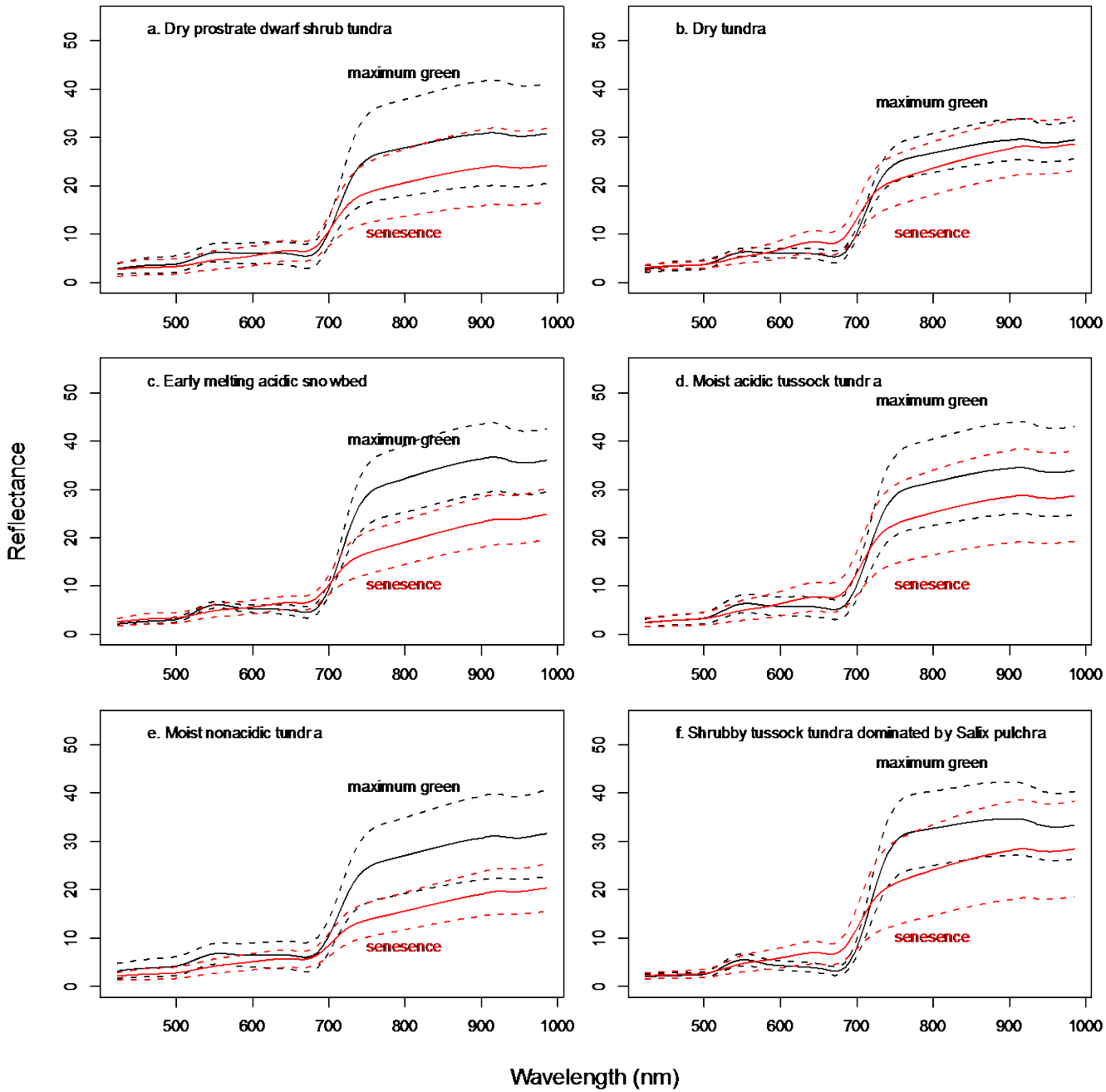
Ground-based reflectance spectra



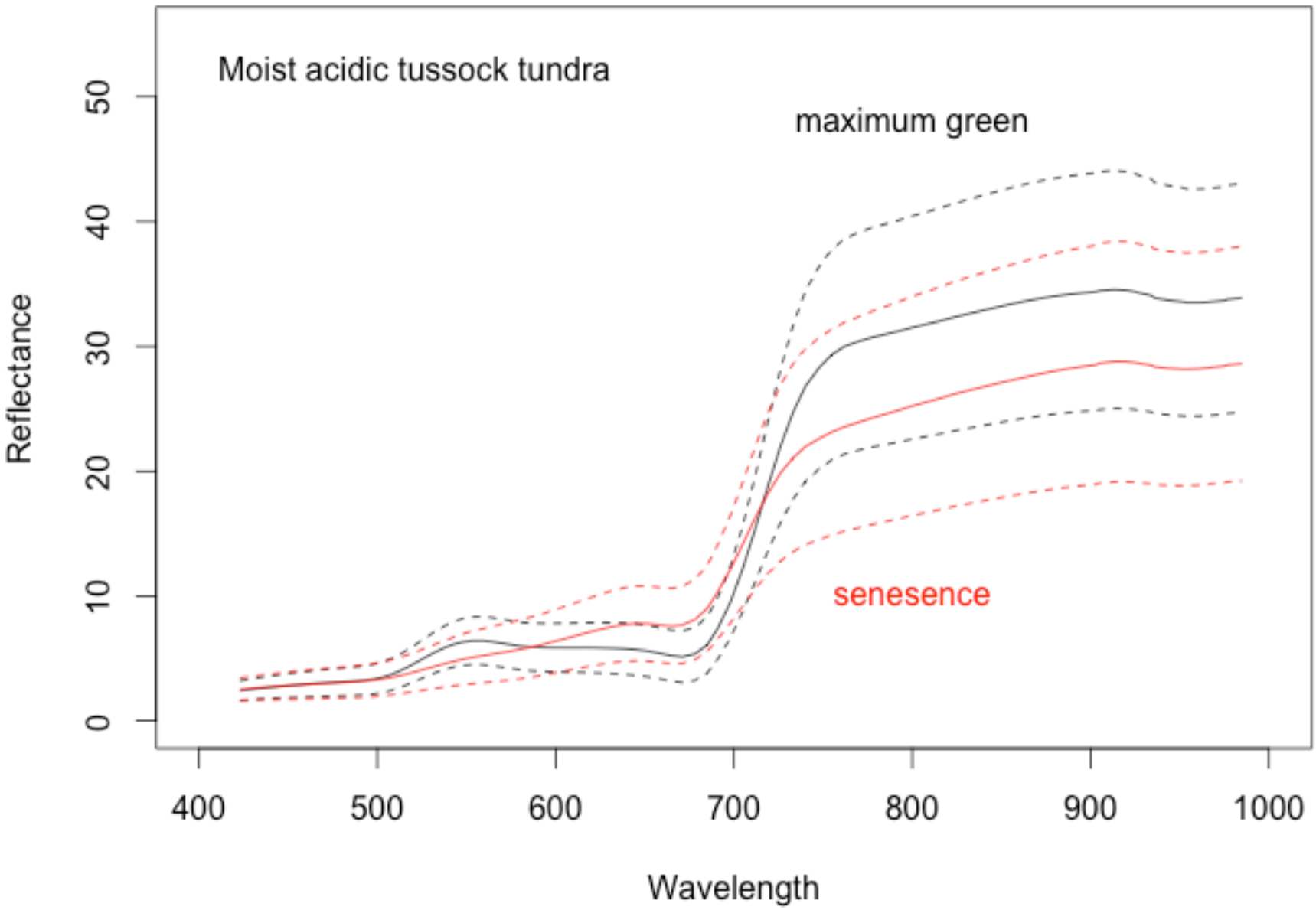
Ground-based reflectance spectra



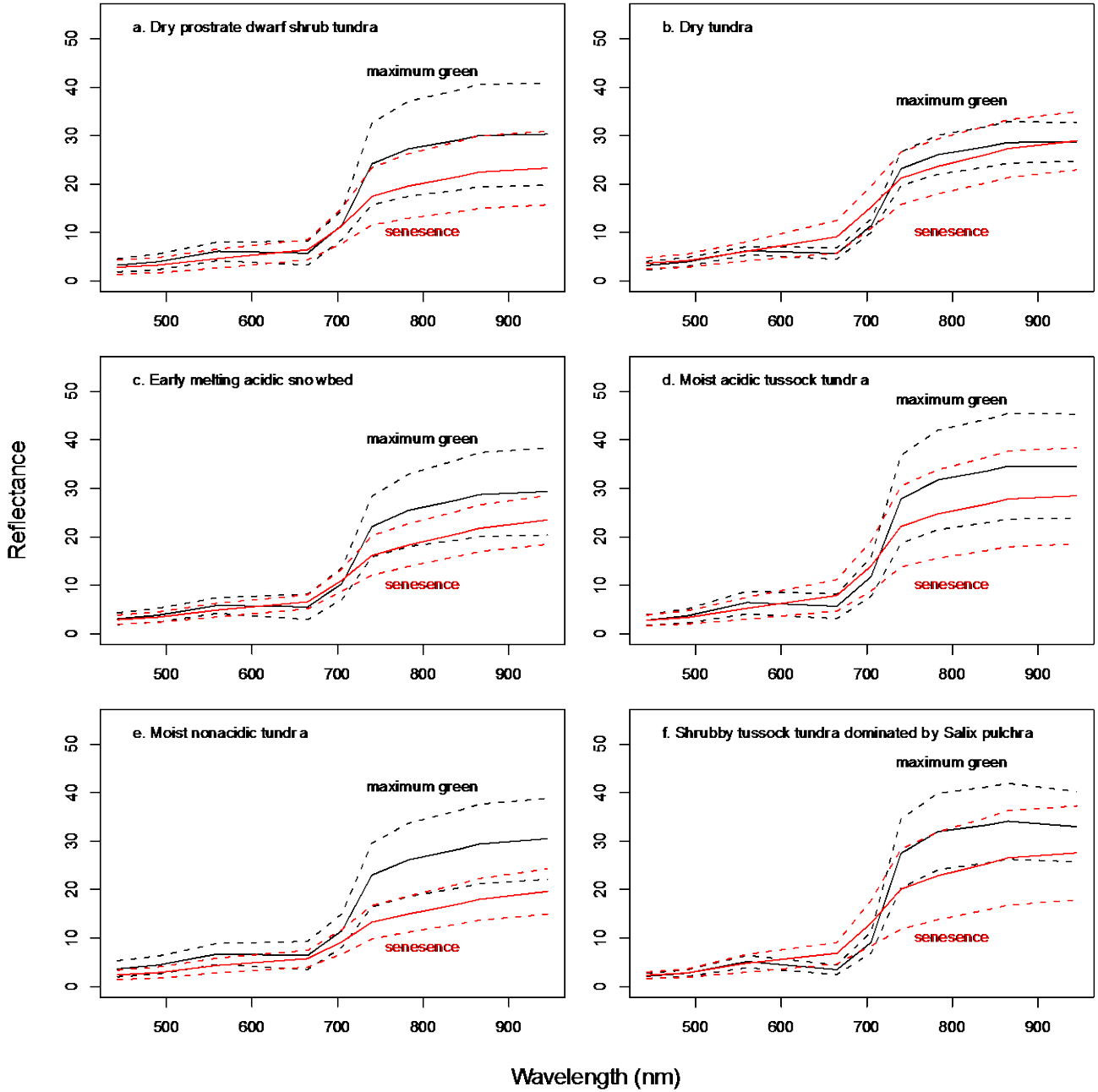
Simulated EnMAP reflectance spectra



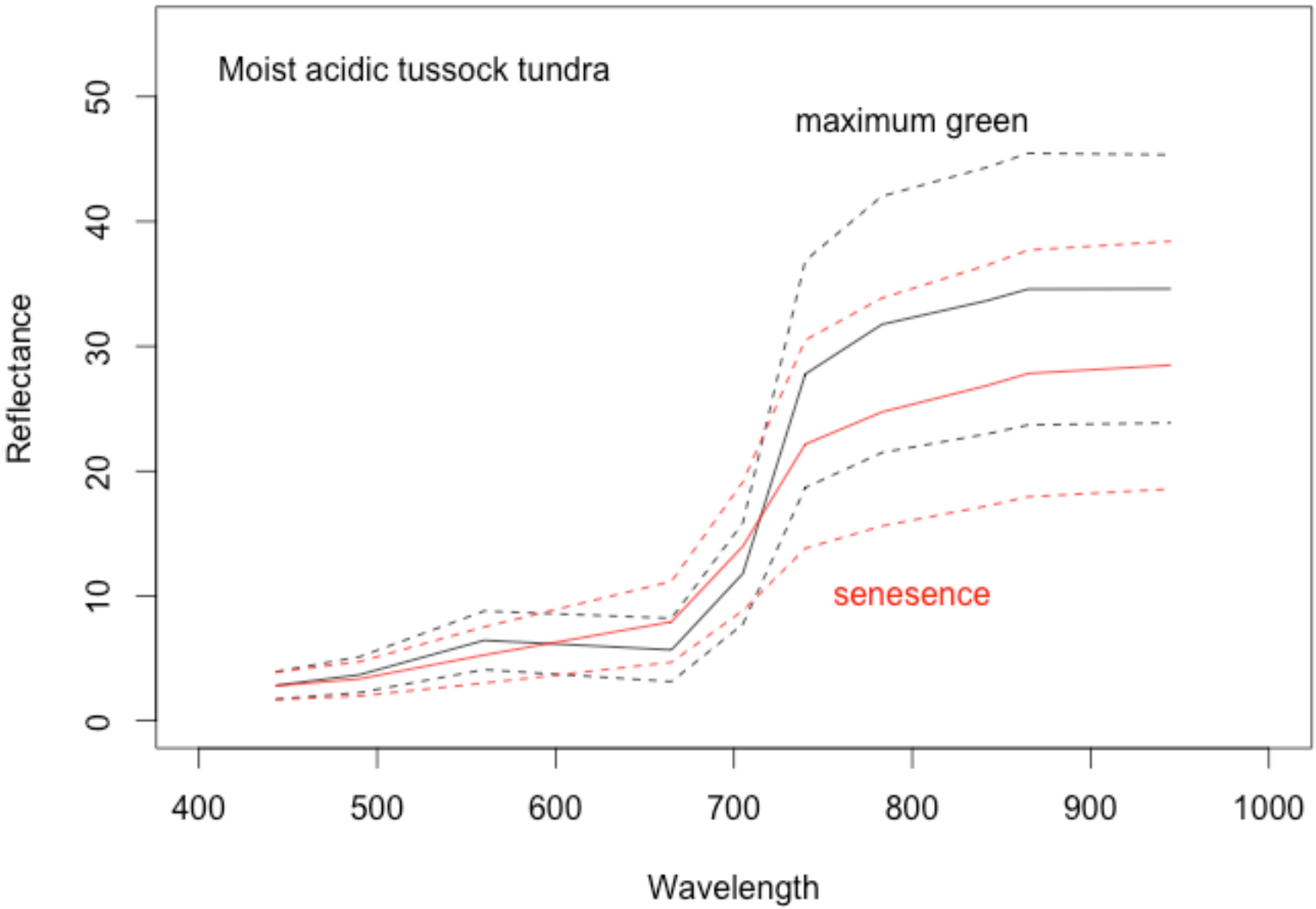
Simulated EnMAP reflectance spectra



Simulated Sentinel-2 reflectance spectra



Simulated Sentinel-2 reflectance spectra

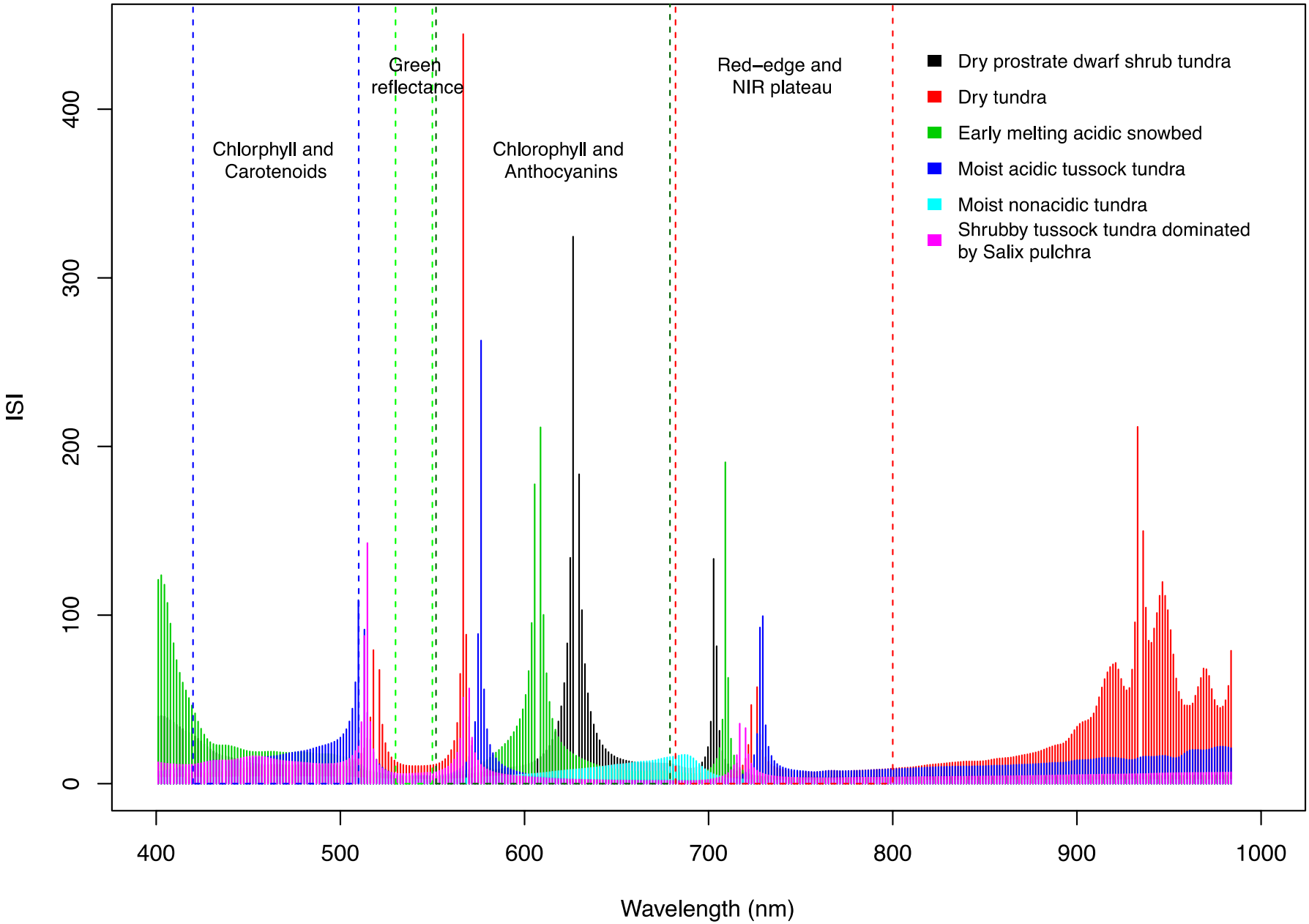


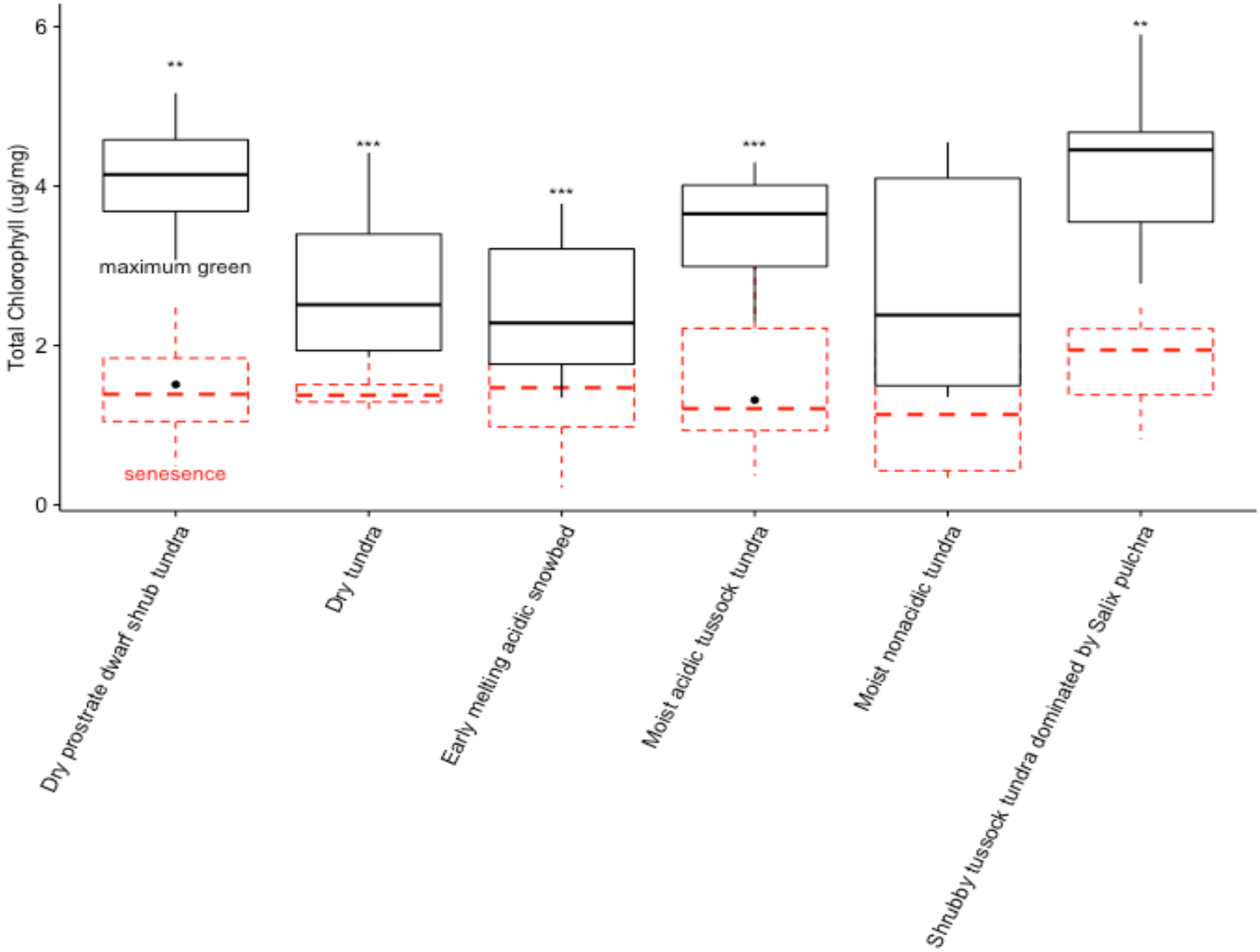
Instability Index (ISI)

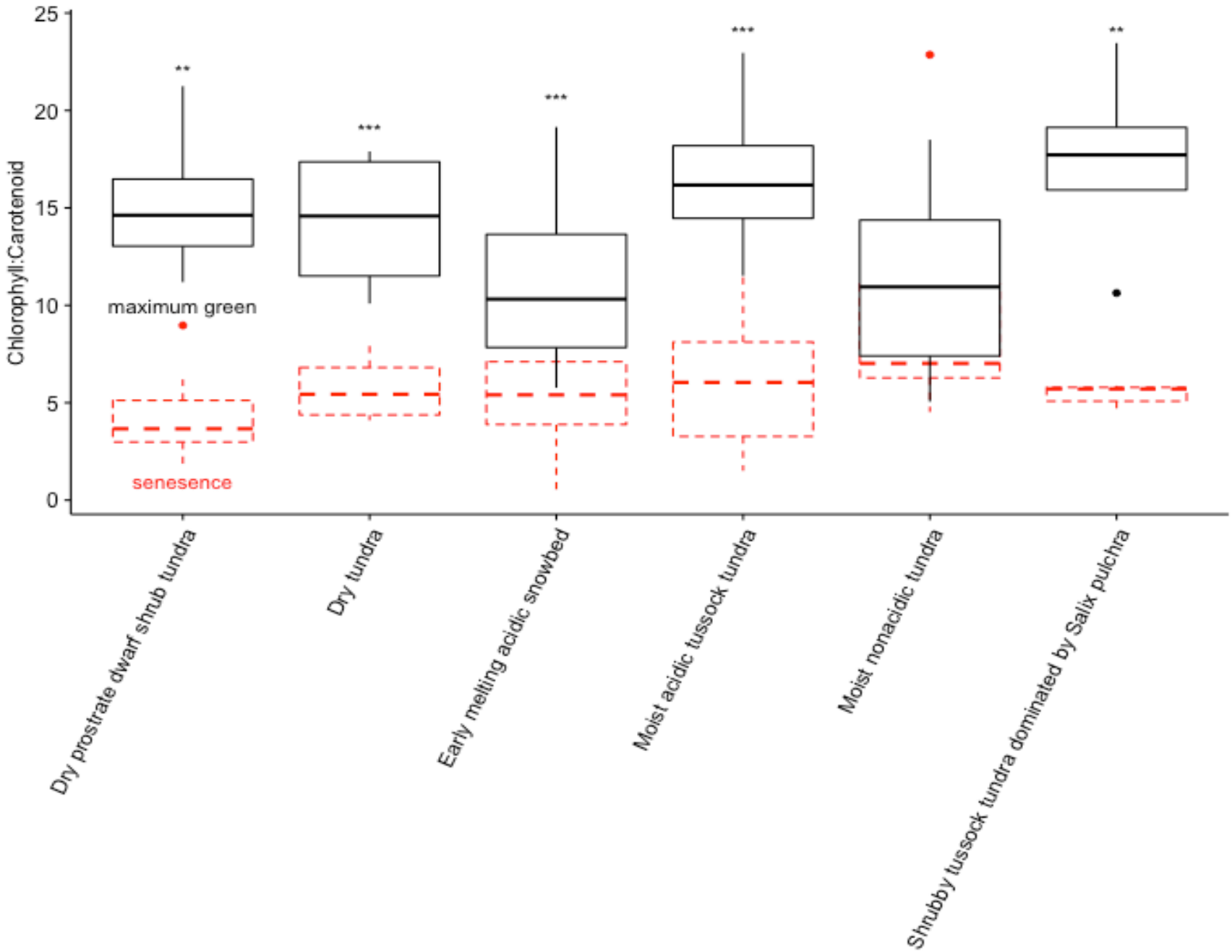
Simple ratio of within class and between class variability (Somers et al. 2009, 2010)

$$ISI_i = \frac{\Delta_{within,i}}{\Delta_{between,i}} = \frac{1.96(\sigma_{1,i} + \sigma_{2,i})}{|R_{mean,1,i} - R_{mean,2,i}|}$$

Minimum in a 3 waveband window identifies wavebands that are the best at differentiating between phenophase


Chlorphyll and
Carotenoids
Green
reflectance
Chlorophyll and
Anthocyanins
Red−edge and
NIR plateau
Dry prostrate dwarf shrub tundra
Dry tundra
Early melting acidic snowbed
Moist acidic tussock tundra
Moist nonacidic tundra
Shrubby tussock tundra dominated
by Salix pulchra
ISI
0
100
200
300
400
400
500
600
700
800
900
1000
Wavelength (nm)


Total Chlorophyll (ug/mg)
6
4
2
0
**
***
***
***
**
maximum green
senesence
Dry prostrate dwarf shrub tundra
Dry tundra
Early melting acidic snowbed
Moist acidic tussock tundra
Moist nonacidic tundra
Shrubby tussock tundra dominated by Salix pulchra


Chlorophyll:Carotenoid
25
20
15
10
5
0
**
***
***
***
**
maximum green
senesence
Dry prostrate dwarf shrub tundra
Dry tundra
Early melting acidic snowbed
Moist acidic tussock tundra
Moist nonacidic tundra
Shrubby tussock tundra dominated by Salix pulchra

Preliminary Conclusions

Can high spectral resolution data capture seasonal changes in pigment concentrations?

Yes. The spectra resolution of EnMAP and Sentinel-2 shows potential for detecting changes in pigment concentrations particularly in the blue wavelengths (Chl and car absorption)

Are there differences in pigment concentration dynamics between vegetation communities?

No. Qualitatively, there are no major differences from peak to late season .

Pigment degradation, rather than necrosis, drives changes in spectral signals from peak to late season in low Arctic tundra ecosystems

Next Steps

What biophysical processes drive the early to peak seasonal transition?

Does LAI significantly differ as well as pigment dynamics?

Can we identify photosynthetic activity?

Differentiation between vegetation communities at key phenophases. Do important wavebands change?

How does this information scale from the plot to the landscape?

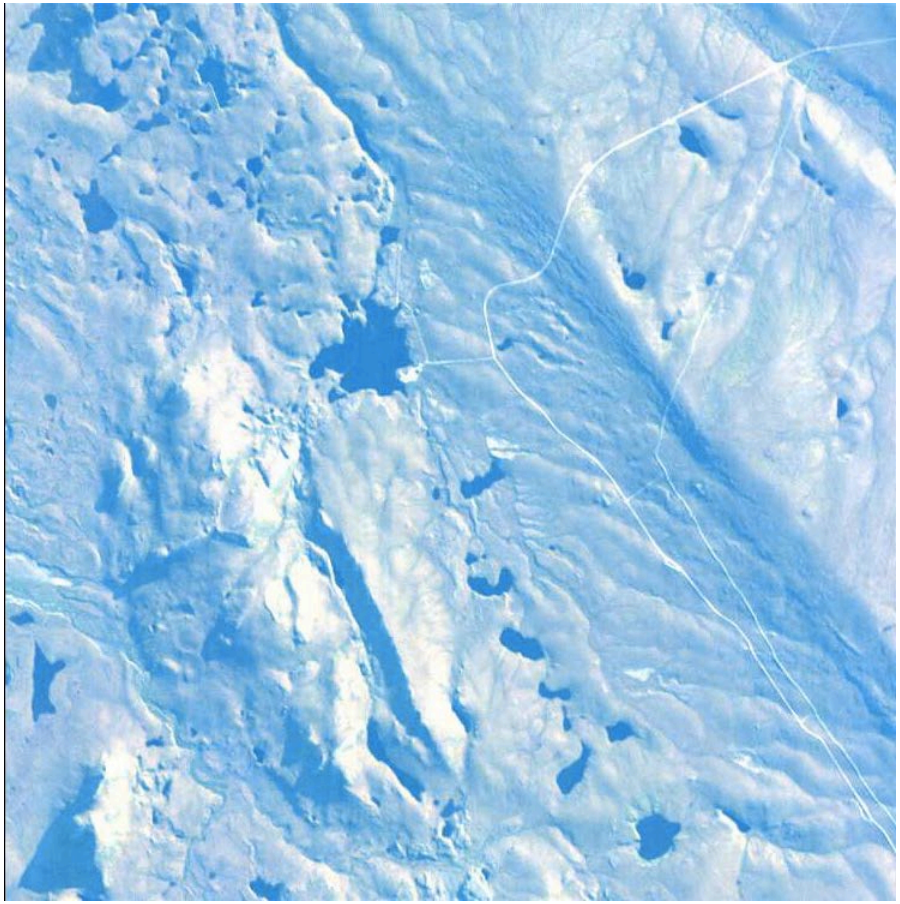
Classification of phenophase and vegetation communities using optimized waveband selection. AISA and CHRIS-PROBA imagery

AISA hyperspectal image

CHRIS-PROBA, ESA

Toolik Research Station

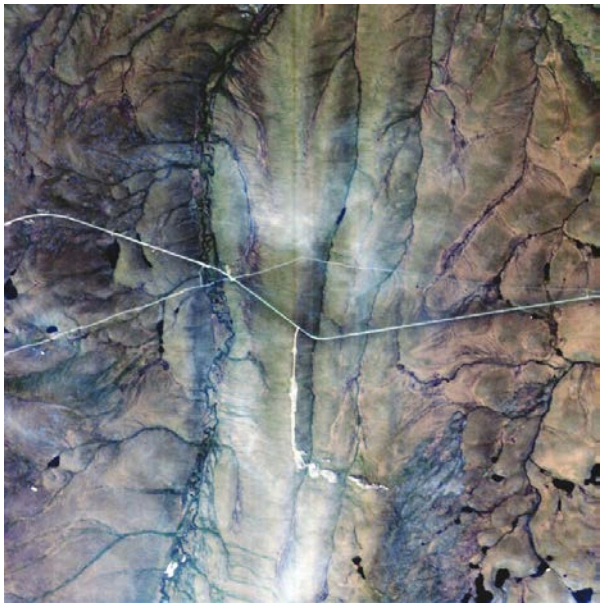
August 8th



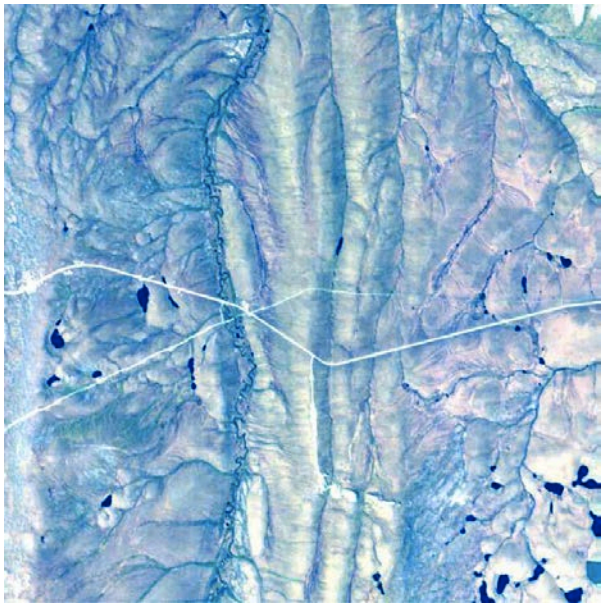
CHRIS-PROBA, ESA

Imnavait Creek watershed

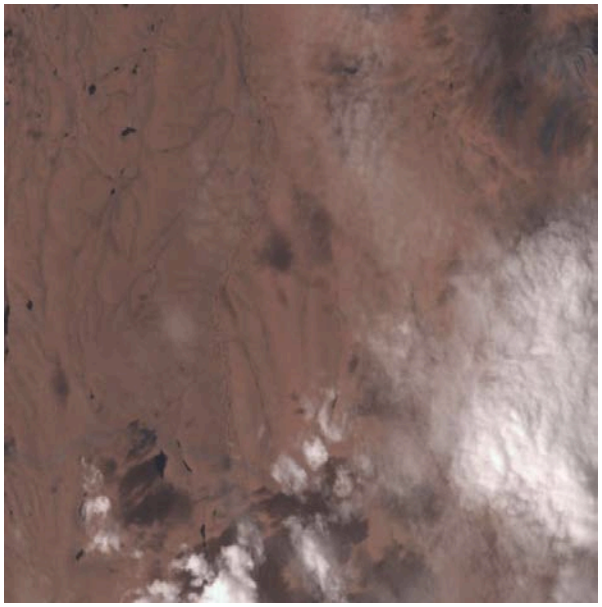
July 5th



August 8th



August 26th



Thank-you

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HELMHOLTZ
GEMEINSCHAFT

a place of mind
THE UNIVERSITY OF BRITISH COLUMBIA

ALASKA GEOBOTANY CENTER
University of Alaska Fairbanks
INSTITUTE OF ARCTIC BIOLOGY

Federal Ministry
for Economic Affairs
and Energy

EnMAP
Hyperspectral Imager

DLR