CSTARS CENTER FOR SPATIAL TECHNOLOGIES AND REMOTE SENSING
DEPT. OF LAND, AIR AND WATER RESOURCES

HOW DO OPTICAL PROPERTIES FROM IMAGING SPECTROSCOPY DATA RELATE TO STRUCTURAL ATTRIBUTES FROM LIDAR?

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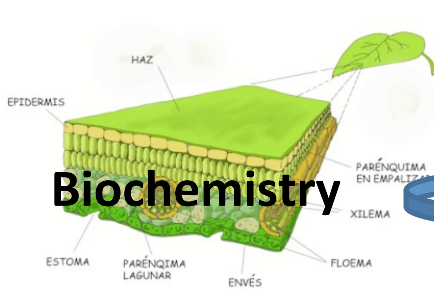
FUNDED BY: NASA HYSPIRI PREPARATORY PROJECT

HyspIRI Science and Applications Workshop, October 2014

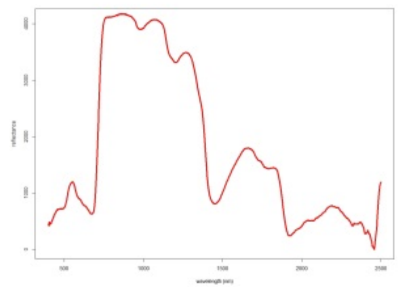
BACKGROUND

Leaf-level



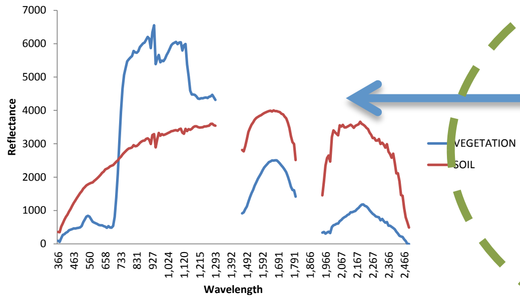
Biochemistry

Leaf Spectra



MODELS

Canopy-level



Vegetation structure

Canopy Spectra

Background

To assess the relationship between optical properties and vegetation structure

↓

To analyze the effect of vegetation structure in canopy spectra

↓

To account for these effects to improve the estimation of leaf chemistry and structure from canopy spectra

Objectives

Main goal

To assess the relationship among structural metrics from LIDAR and optical spectral information from the Airborne Visible Infrared Imaging Spectrometer (AVIRIS)

Specific objectives:

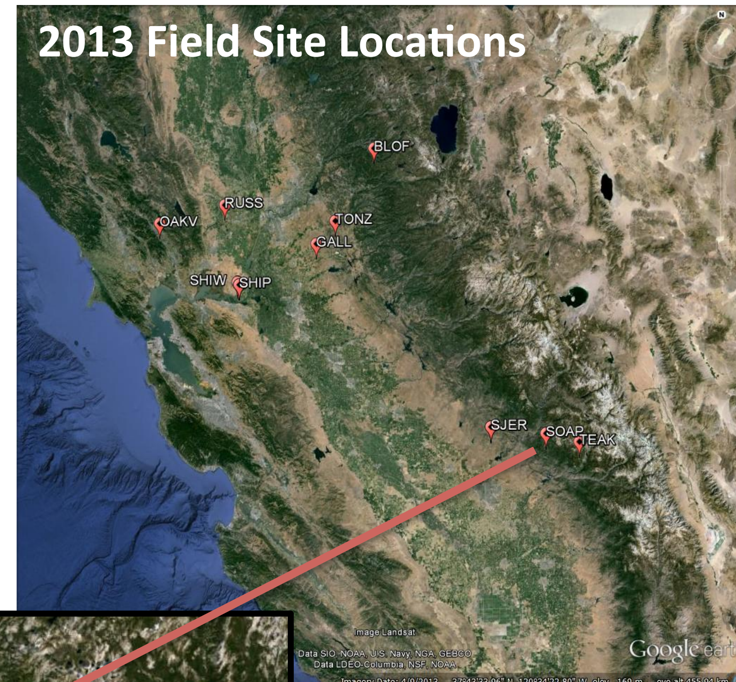
1. Analyze the effect of stratification, by vegetation types, on the relationship among variables (Conifer versus Hardwood)
2. Identify the most significant region of the spectrum related to vegetation structure
3. Explore the best band combination indexes that show the strongest relationship with vegetation structure

STUDY AREA

STUDY AREA: Soaproot Saddle

- Located in Central California
- Mid elevation (around 1100 m)
- Strong Mediterranean climate
- Hot, dry summers and mild, wet winters
- Mixed conifer/broadleaf forest:

  Pinus ponderosa (ponderosa pine); Quercus kelloggii (black oak); Quercus chrysolepsis (canyon live oak)



Introduction

Objectives

Study area

Material and methods

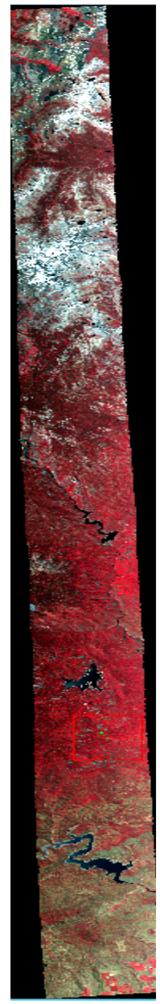
Results

Conclusions

Material and Methods

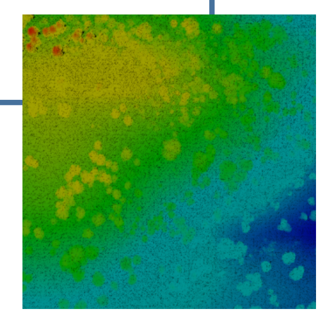
AVIRIS data:

- Surface reflectance
- Spatial resolution: **18 m**
- Spectral resolution: **224** bands (350-2500nm)
- Acquisition date: **June-2013**



NEON LIDAR data:

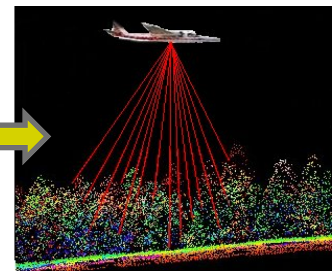
- Point density: **1.7 ppm2**
- Small - footprint
- Multi return
- Acquisition date: **June-2013**

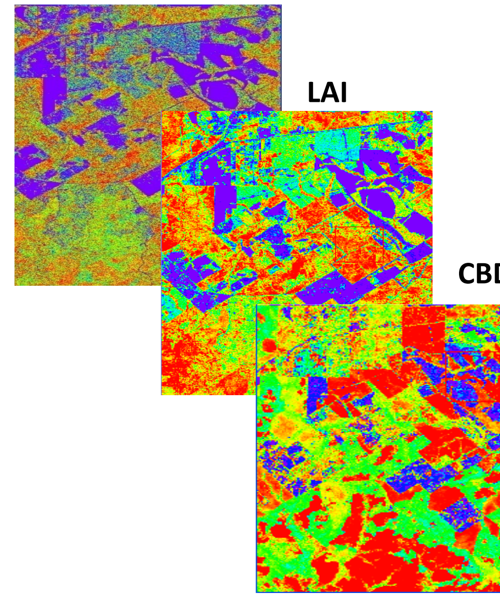


MATERIAL AND METHODS

LIDAR VARIABLES

LIDAR





1 **Height related variables:** Height max (H_max), Height mean (H_mean), Height median (H_median), Height standard deviation (H_std), Canopy Height Model standard deviation (CHM)

2 **Biomass related variables**: Leaf Area Index (LAI), Fractional Canopy Cover (FC), Fractional Canopy cover from 1st return (FC_1ret), Vegetation Vertical Profile integral (VVP)

MATERIAL AND METHODS

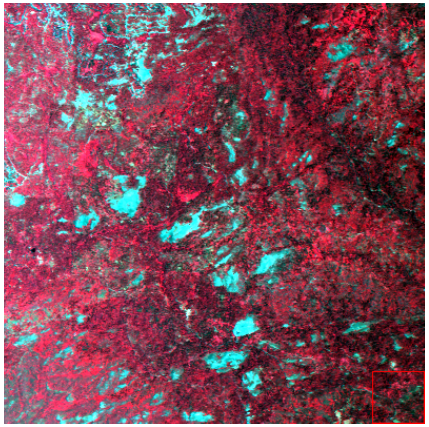
AVIRIS DATA

Pre-processing data:

- Sun Canopy Sensor correction →remove topography effects
- Textural analysis → Study area stratification

Variables selection:

- Multiple endmember spectral mixture analysis (MESMA)
  → GV, NPV, soil, Shade fraction
- Optical indices and spectral figures
  → NDVI, NDVI705, mNDVI705, EVI
  → NDWI, NDII
  → EWT, CAI
  → Wtr1EdgeWvl, Wtr2EdgeWvl, Wtr1EdgeMag, Wtr2EdgeMag, Wtr1AbAr, Wtr2AbAr



Introduction

Objectives

Study area

Material and methods

Results

Conclusions

INTERCORRELATED LIDAR VARIABLES

	LAI	FC	FC_1ret	VVP	H_max	H_mean	H_median	H_std	CHM
LAI	**1.00**	**0.94**	**0.92**	**0.87**	0.21	0.04	0.03	0.40	0.29
FC	**0.94**	**1.00**	**0.98**	**0.94**	0.24	0.06	0.05	0.41	0.32
FC_1ret	**0.92**	**0.98**	**1.00**	**0.94**	0.22	0.05	0.05	0.38	0.29
VVP	**0.87**	**0.94**	**0.94**	**1.00**	0.38	0.17	0.16	0.48	0.38
H_max	0.21	0.24	0.22	0.38	**1.00**	0.82	0.79	0.77	0.74
H_mean	0.04	0.06	0.05	0.17	0.82	**1.00**	**0.99**	0.38	0.38
H_median	0.03	0.05	0.05	0.16	0.79	**0.99**	**1.00**	0.35	0.34
H_std	0.40	0.41	0.38	0.48	0.77	0.38	0.35	**1.00**	**0.95**
CHM	0.29	0.32	0.29	0.38	0.74	0.38	0.34	**0.95**	**1.00**

Green Biomass | **Height** | **Complexity**

RELATIONSHIP OPTICAL VARIABLES AND GREEN BIOMASS

	ALL PIXELS	CONIFER	HARDWOOD
ALL PIXELS	Wtr2AbAr(0.46)	Wtr2AbAr(0.43)	CAI(0.66)
HOMOGENEOUS	NDVI 705(0.41)	NDII(0.59)	Wtr2AbAr (0.44)
HETEROGENEOUS	Wtr2AbAr (0.48)	Wtr2AbAr (0.45)	NDVI 705 (0.55)

- Stratification by vegetation types and spectral homogeneity may improve the correlations
- Water dependent indexes, NDII and CAI have highest correlation in homogeneous conifer and in hardwood forest respectively
- Water absorption feature indexes show acceptable correlations in most scenarios

RELATIONSHIP OPTICAL VARIABLES AND HEIGHT

	ALL PIXELS	CONIFER	HARDWOOD
ALL PIXELS	SHADE (0.29)	GV (0.34)	NULL
HOMOGENEOUS	SHADE (0.21)	SHADE (0.14)	mNDVI705 (0.28)
HETEROGENEOUS	SHADE (0.29)	GV/SHADE (0.26)	SHADE (0.32)

- Stratification by vegetation types and spectral homogeneity may improve correlations
- Shade fraction has the highest correlation in most scenarios
- Discrimination by spectral homogeneity improves correlations in hardwood forests

RELATIONSHIP OPTICAL VARIABLES AND COMPLEXITY

	ALL PIXELS	CONIFER	HARDWOOD
ALL PIXELS	SHADE (0.35)	SHADE (0.39)	NULL
HOMOGENEOUS	SHADE (0.20)	SHADE (0.25)	mNDVI705 (0.18)
HETEROGENEOUS	SHADE (0.40)	SHADE (0.31)	SHADE (0.34)

- Stratification by vegetation types and spectral homogeneity may improve correlations
- Shade fraction has highest correlation in most scenarios
- Discrimination by spectral homogeneity improves correlations in hardwood forests

Introduction

Objectives

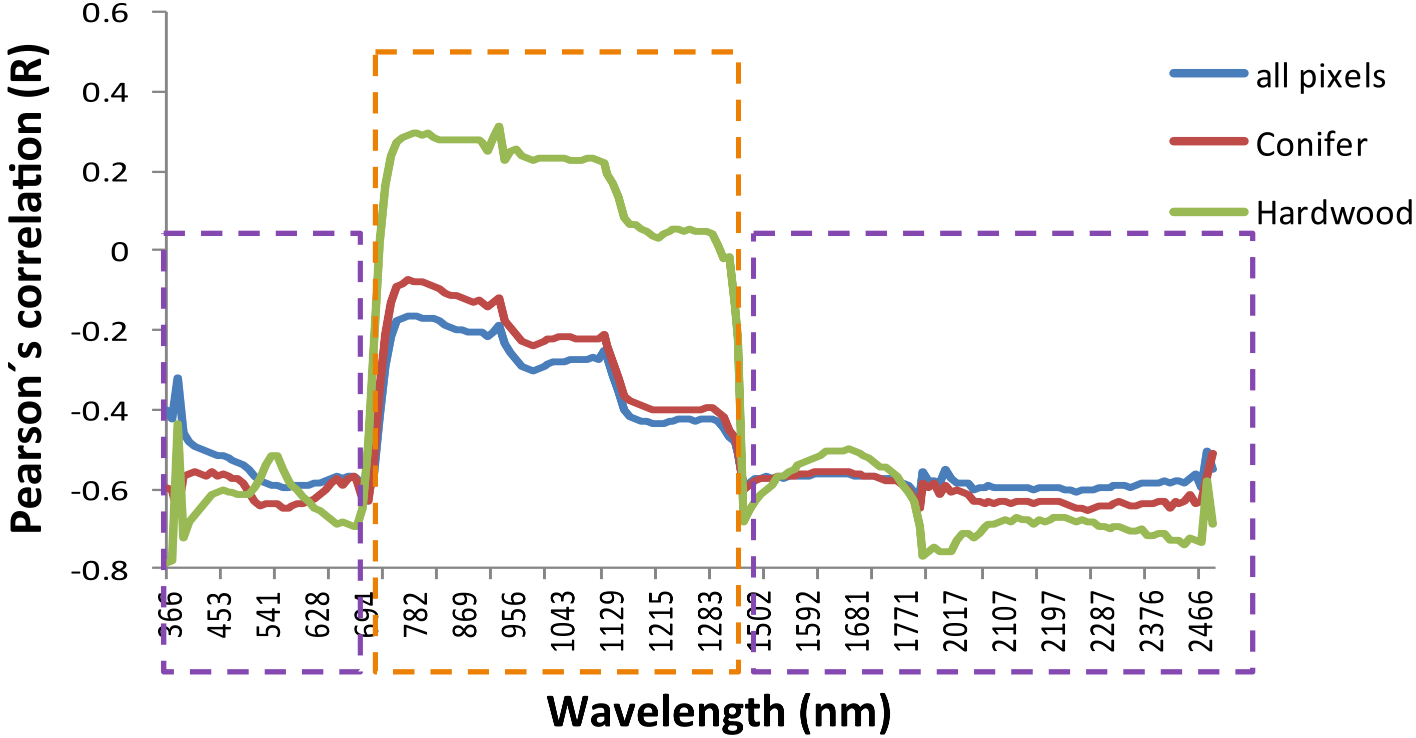
Study area

Material and methods

Results

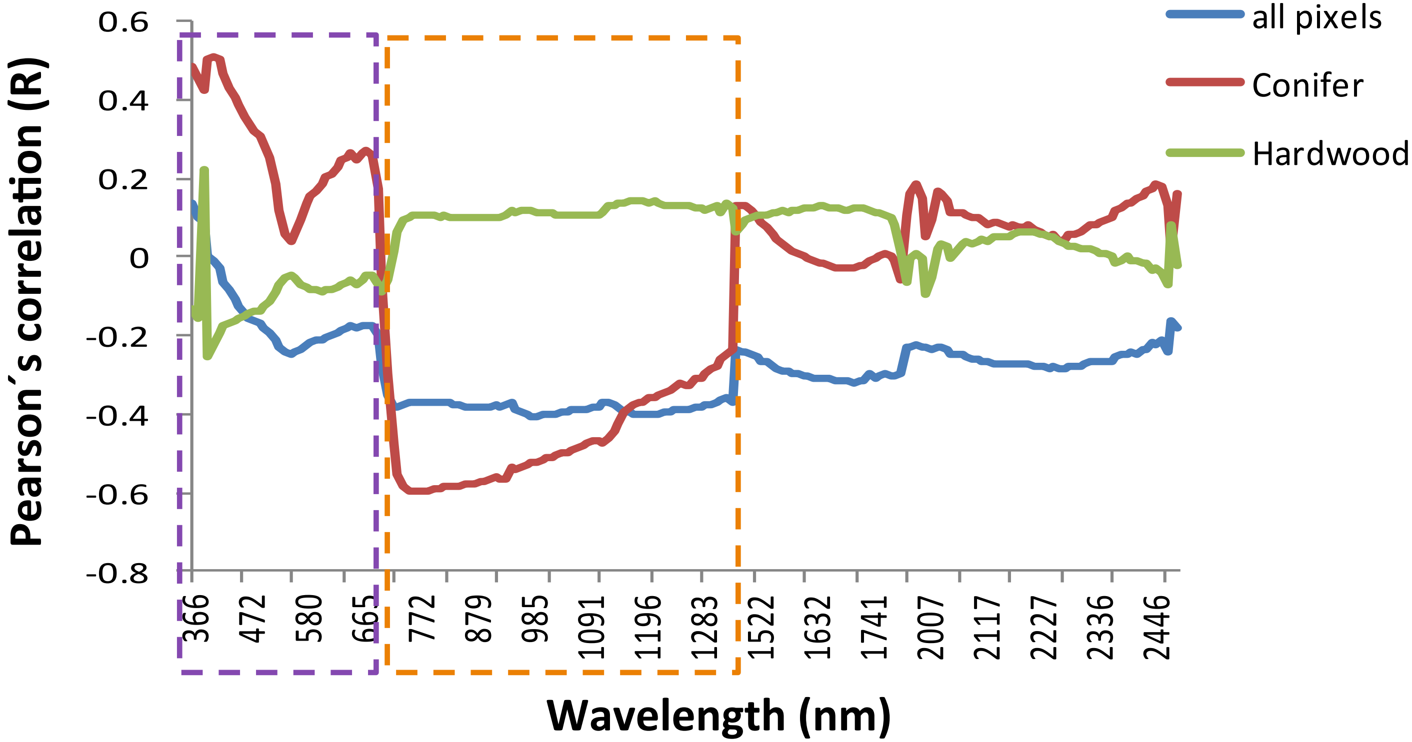
Conclusions

RELATIONSHIP SPECTRAL BANDS AND GREEN BIOMASS



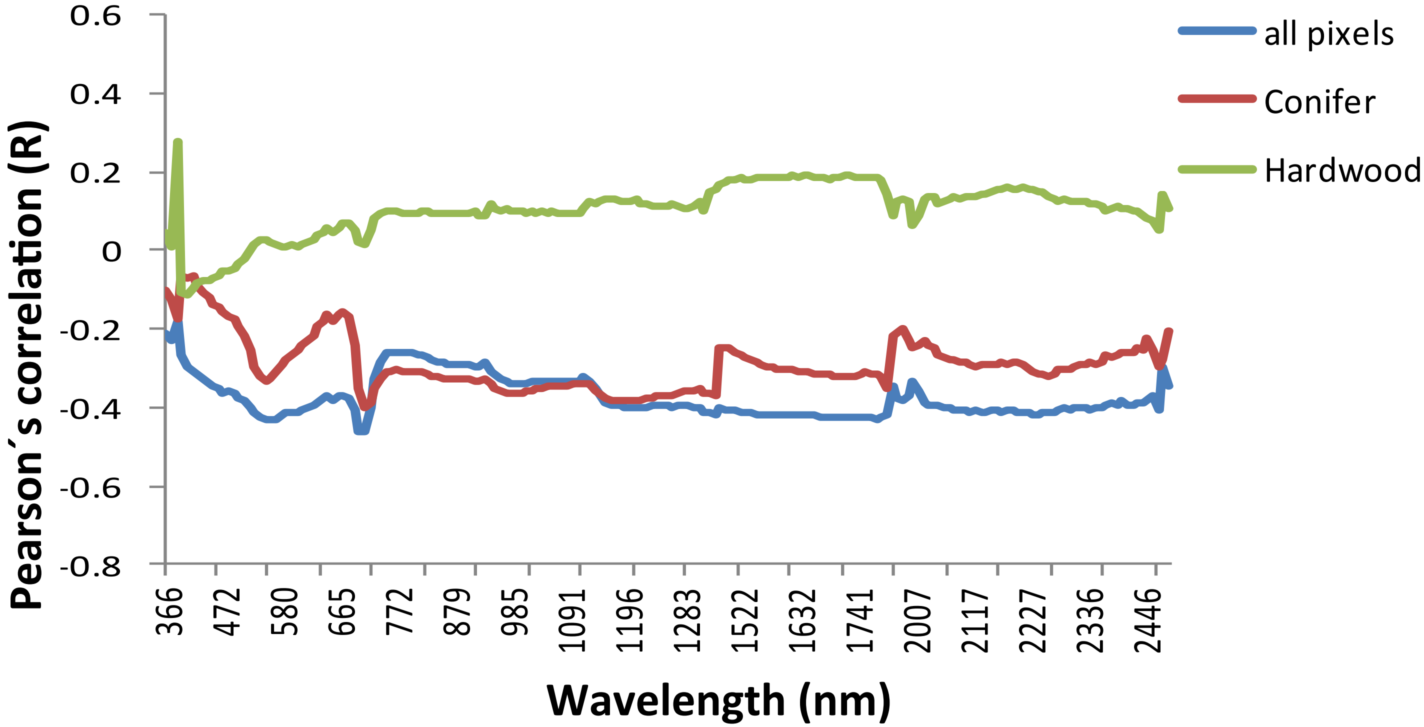
- Correlations change with vegetation type across the spectrum
- Green Biomass in Conifer forests is related to reflectance in the visible and SWIR parts of the spectrum, while in hardwood forest the NIR also has acceptable correlations

RELATIONSHIP SPECTRAL BANDS AND HEIGHT



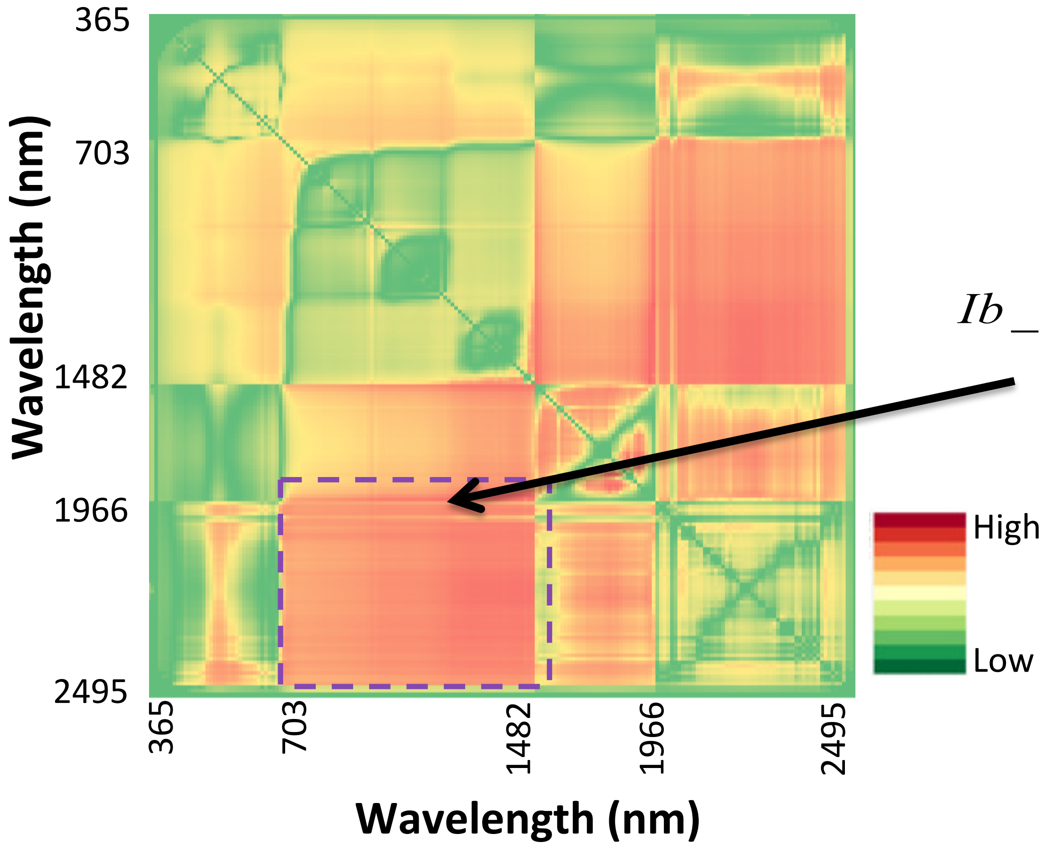
- Correlations change with vegetation type across the spectrum
- The visible and NIR part of the spectrum have highest correlations with height in Conifer forests
- Hardwood forests lack a clear part of the spectrum with high correlations with height

RELATIONSHIP SPECTRAL BANDS AND COMPLEXITY



- No part of the spectrum had high correlations with complexity
- The highest correlations are found in conifer forest

INDEX OPTIMIZATION - GREEN BIOMASS (ALL PIXELS)

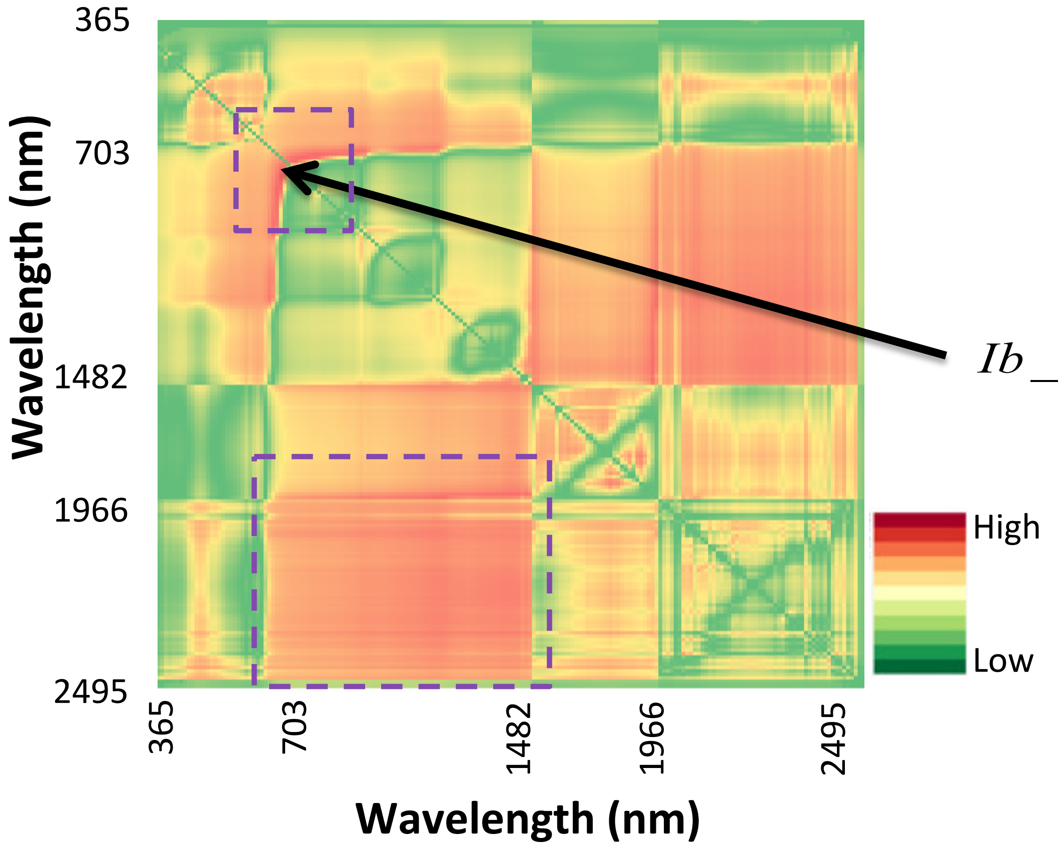


R2 = 0.49

$$Ib\_all = \frac{\rho_{1148} - \rho_{1800}}{\rho_{1148} + \rho_{1800}}$$

- The best band combination is in NIR and SWIR parts of the spectrum

INDEX OPTIMIZATION - GREEN BIOMASS (CONIFER)

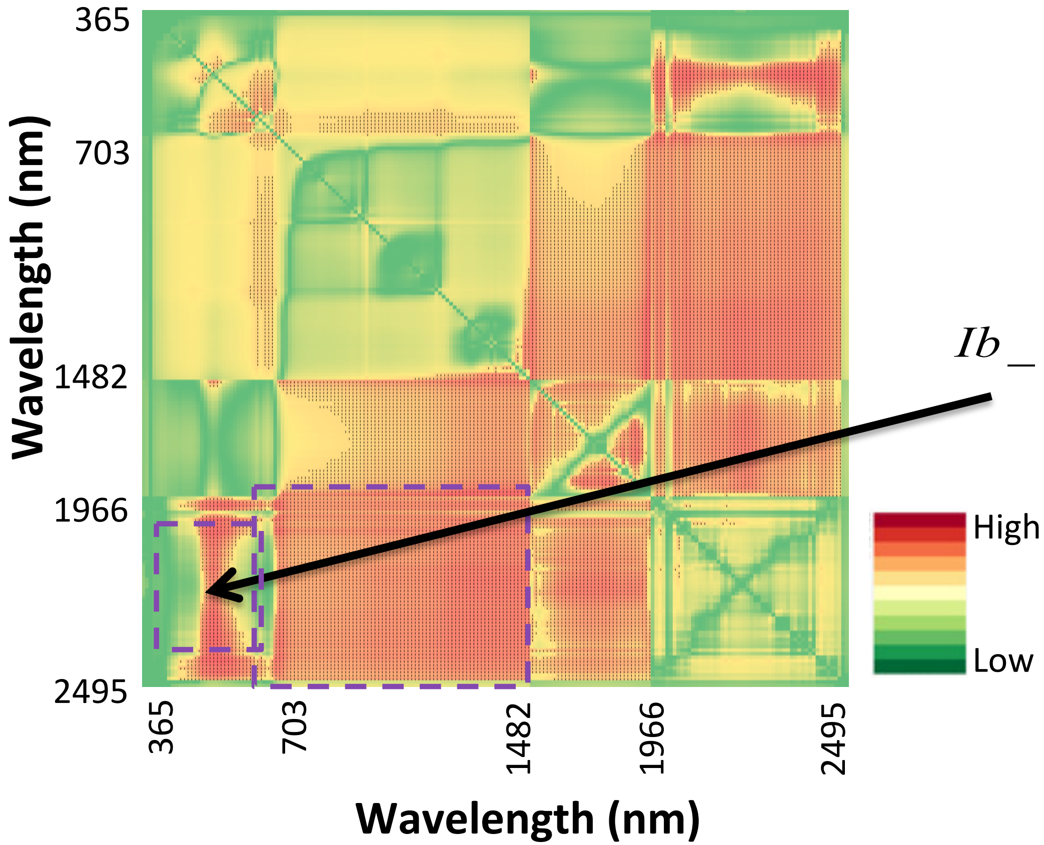


R2 = 0.48

$$Ib\_con = \frac{\rho_{733} - \rho_{791}}{\rho_{733} + \rho_{791}}$$

- The best band combination is around bands 733-791 nm
- The combination of NIR and SWIR regions also show acceptable correlations

INDEX OPTIMIZATION - GREEN BIOMASS (HARDWOOD)

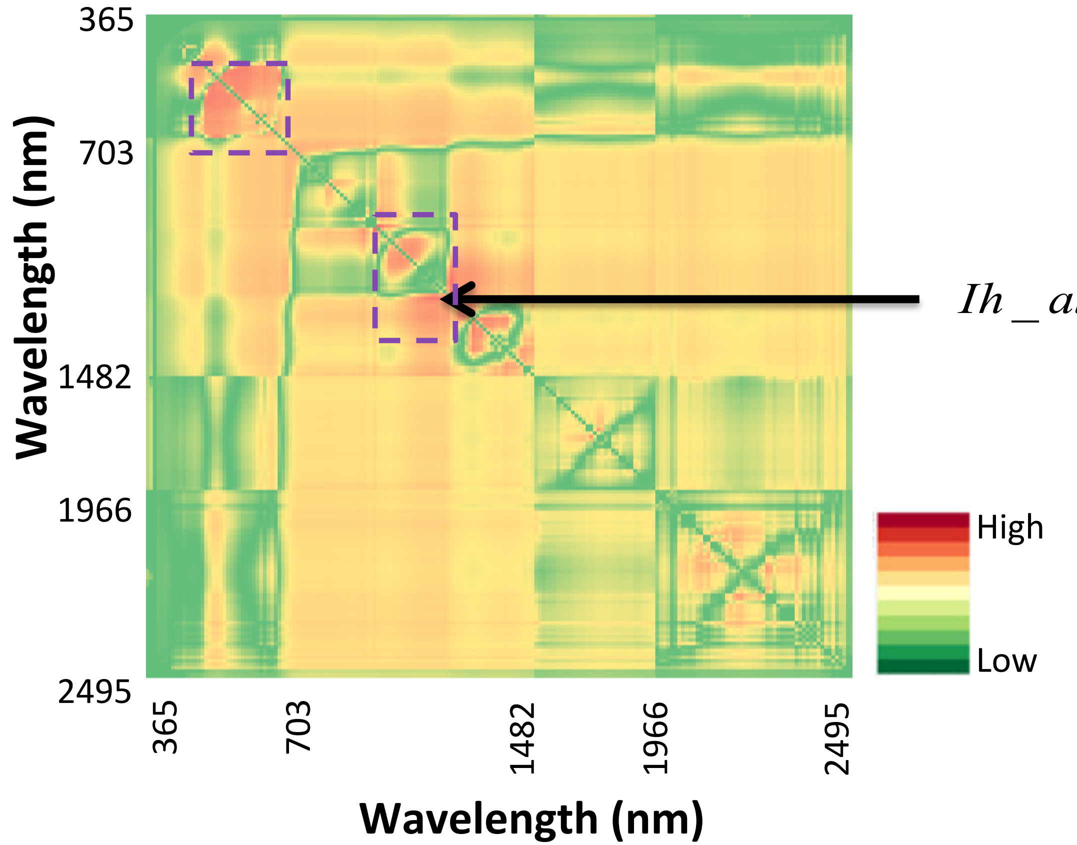


R2 = 0.68

$$Ib\_har = \frac{\rho_{569} - \rho_{2425}}{\rho_{569} + \rho_{2425}}$$

- The best band combination is in the visible and SWIR part of the spectrum
- NIR in combination with SWIR region also show satisfactory correlations

INDEX OPTIMIZATION – HEIGHT (ALL)

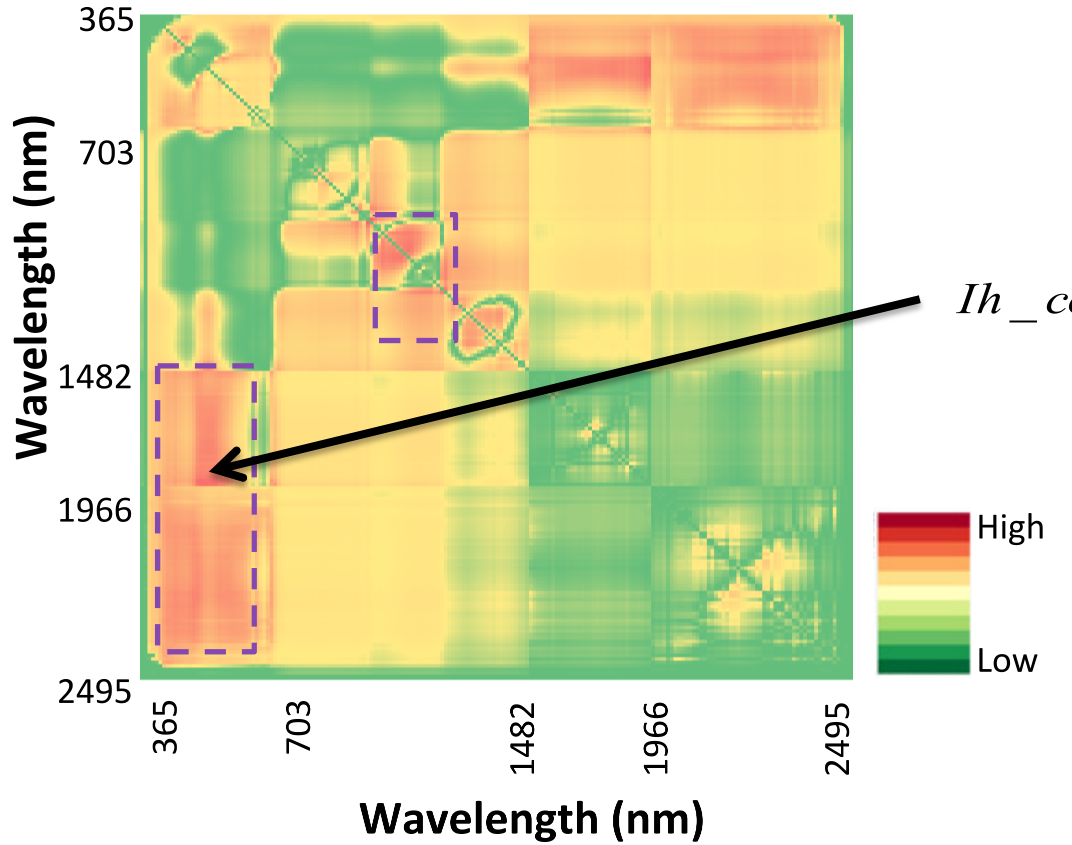


R2 = 0.34

$$Ih\_all = \frac{\rho_{1138} - \rho_{1148}}{\rho_{1138} + \rho_{1148}}$$

- There is no part of the spectrum that shows high correlations
- The best band combination is around bands 1100 nm. Also the combination of bands around 600 nm present appreciable correlations

INDEX OPTIMIZATION – HEIGHT (CONIFER)

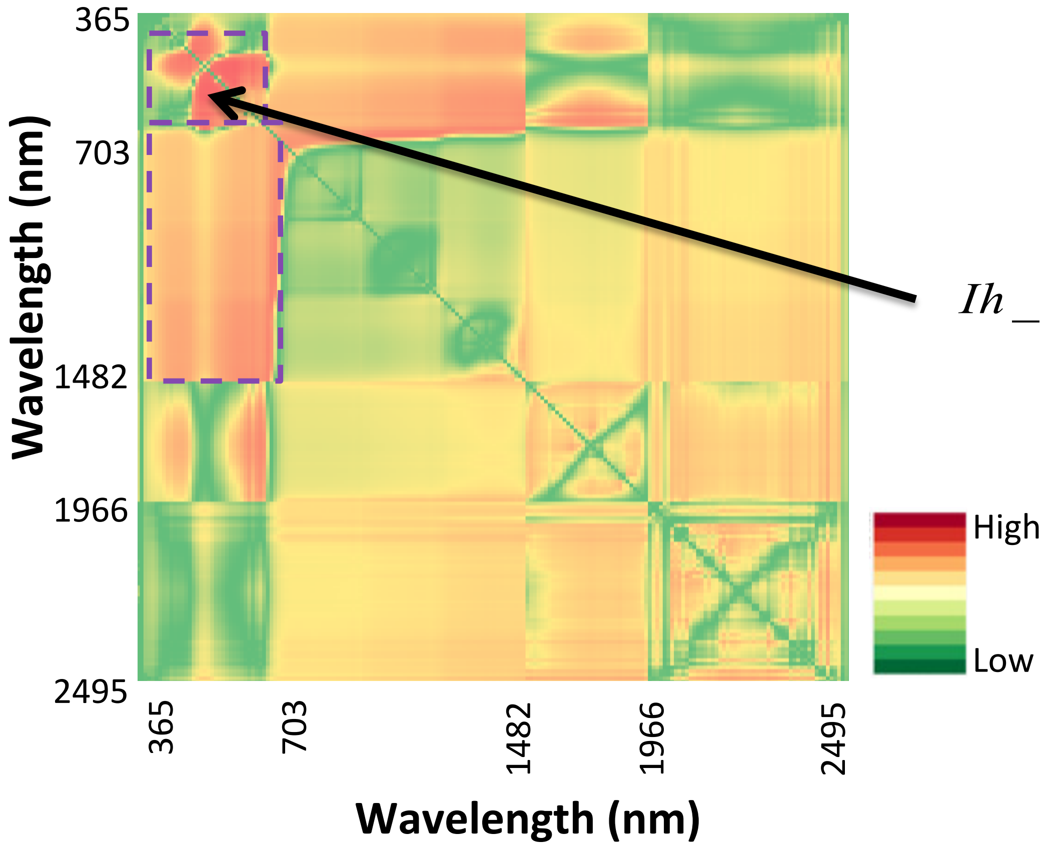


R2 = 0.34

$$Ih\_con = \frac{\rho_{540} - \rho_{1800}}{\rho_{540} + \rho_{1800}}$$

- The best band combination is in the SWIR part of the spectrum
- The combination of bands around 1100 nm shows acceptable correlations

INDEX OPTIMIZATION – HEIGHT (HARDWOOD)

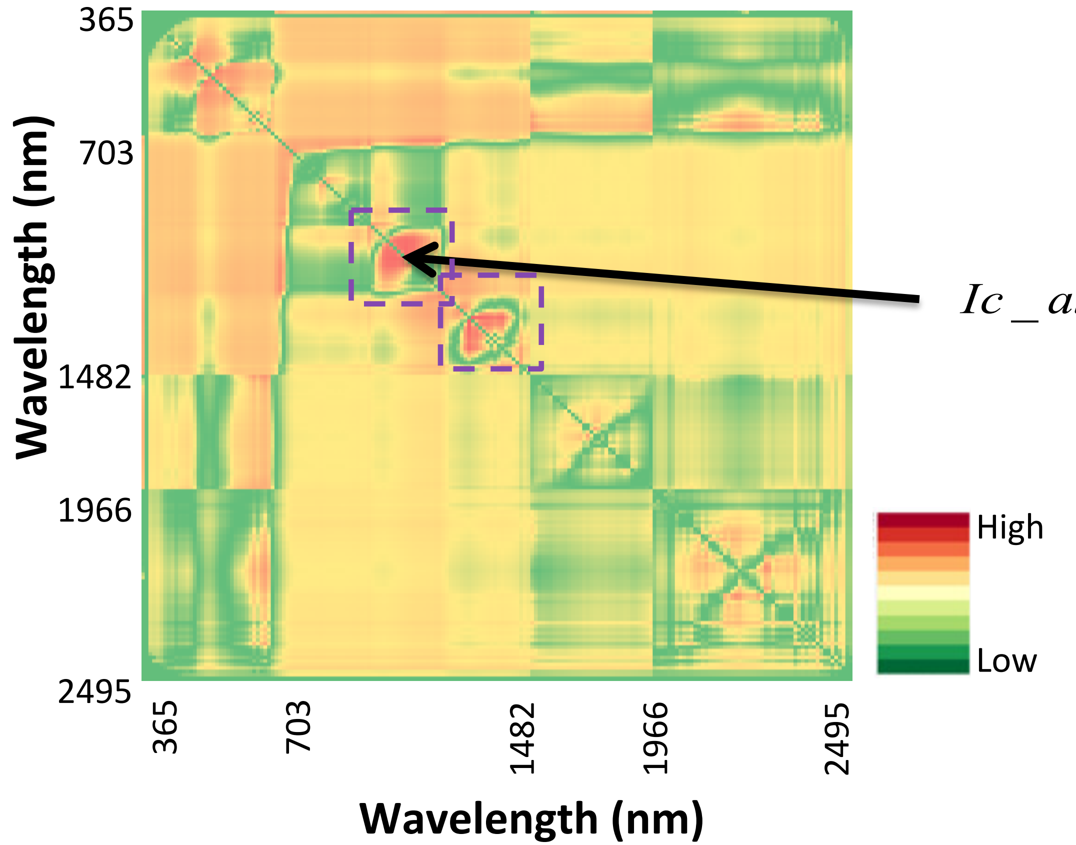


R2 = 0.46

$$Ih\_har = \frac{\rho_{550} - \rho_{628}}{\rho_{550} + \rho_{628}}$$

- The best band combination is in the visible and NIR part of the spectrum specially using bands situated around 600 nm

INDEX OPTIMIZATION – COMPLEXITY (ALL)

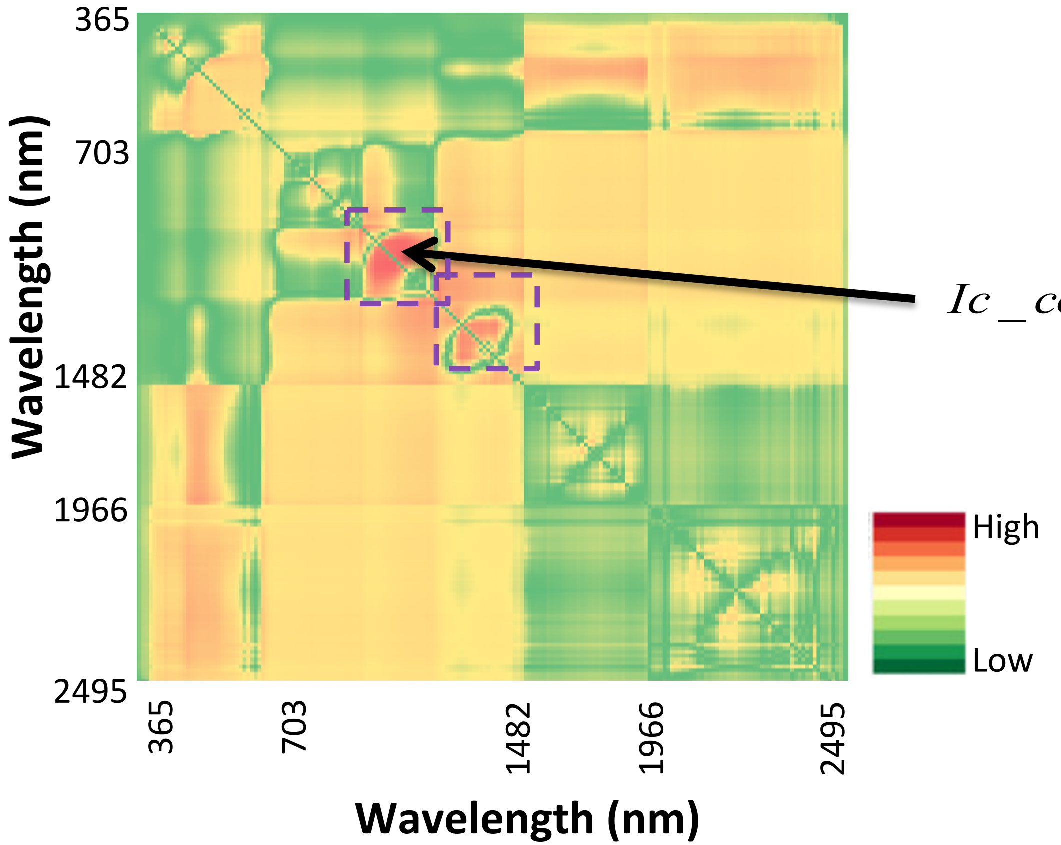


R2 = 0.30

$$Ic\_all = \frac{\rho_{1205} - \rho_{1215}}{\rho_{1205} + \rho_{1215}}$$

- The best band combination is around band 1100 coincident with a water absorption feature

INDEX OPTIMIZATION – COMPLEXITY (CONIFER)

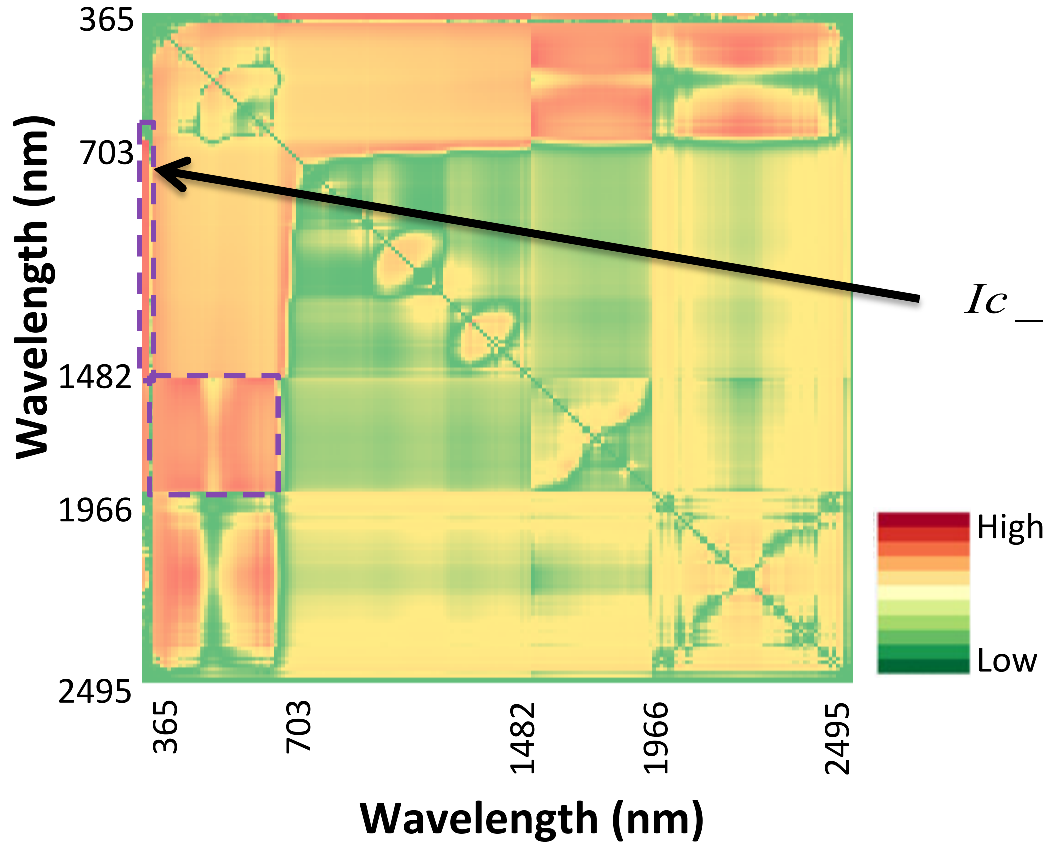


R2 = 0.33

$$Ic\_con = \frac{\rho_{1014} - \rho_{1043}}{\rho_{1014} + \rho_{1043}}$$

- The best band combination is around band 1100 coincident with a water absorption feature

INDEX OPTIMIZATION – COMPLEXITY (HARDWOOD)



R2 = 0.36

$$Ic\_har = \frac{\rho_{375} - \rho_{713}}{\rho_{375} + \rho_{713}}$$

- The best band combination is with bands 375 and 713 nm
- The region between 1482 and 1966 nm also present acceptable correlations

Introduction

Objectives

Study area

Material and methods

Results

Conclusions

CONCLUSIONS I

1 Stratification by vegetation type (conifer versus hardwood) allow obtaining stronger relationship between vegetation structure and optical metrics

2 The optical metric most strongly correlated with height and complexity is the shade fraction

3 The optical metric most strongly correlated with green biomass is a water absorption features (Wtr2AbAr)

4 The regions of the spectrum more correlated with vegetation structure present differences between conifer and hardwood forest probably due to the high dissimilarity between this two types of forest in terms of vegetation structure

Introduction

Objectives

Study area

Material and methods

Results

Conclusions

CONCLUSIONS II

5 The best band combination indices improve the correlations in all of the studied scenarios

6 Results show the potential of imaging spectroscopy to evaluate the relationship between optical properties and vegetation structure

7 Future research will investigate how to use these optical metrics to quantify the effect of the vegetation structure in the canopy spectra to improve the estimation of leaf properties within imaging spectroscopy data


THANKS FOR YOUR ATTENTION
QUESTIONS?