Investigating the impact of spatially-explicit sub-pixel structural variation on the assessment of vegetation structure from imaging spectroscopy data

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Outline

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Introduction

Project outline

Estimating LAI from VIs

Sub-pixel structural variation

DIRSIG Simulation

System Study

HyspIRI PSF

Airborne data

Field data
Introduction

Project outline

AVIRIS Data → Extracting VIs → Down sampling VIs → Estimating LAI from VIs → VIs

LAI → Down sampling LAI

Airborne data → Sub-pixel structural variation

DIRSIG Simulation → System Study → HyspIRI PSF
Introduction
Vegetation structural measurements

- Tree height
- Canopy width
- Height to living crown
- Diameter at breast height (DBH)
- Leaf area index (LAI)
Introduction
Vegetation indices (VIs)

*Spectral indices* are transformations applied to remotely sensed data to enhance some characteristic of the surface.

*Vegetation indices* are a type of spectral index for estimating forest biophysical variables.

The most widely used of these transformations is the “normalized difference vegetation index” (NDVI).
Methods

Study area

The National Ecological Observatory Network (NEON), Pacific Southwest Domain (D17)

1. San Joaquin Experiment Range (Core site)
2. Soaproot Saddle (Relocatable site)
Methods

Field collection

1 San Joaquin Experiment Range, June 9 - 14, 2013
12 sites (AOP #): 4, 8, 36, 112, 116, 361, 824, 952

AOP 36

AOP 116

AOP: Airborne Observation Platform
Methods
Field collection

Soaproot Saddle, June 16 - 20, 2013
8 sites (AOP #): 43, 63, 95, 143, 299, 331, 555, 1611

AOP 43
AOP 1611

AOP: Airborne Observation Platform
Methods

Airborne collection

AVIRIS data collected during HyspIRI preparatory airborne campaign, summer 2013:

- **June 12, 2013**: f130612t01r09 (San Joaquin)
- **June 12, 2013**: f130612t01r07 (Soaproot)
- **June 26, 2013**: f130626t01r13 (San Joaquin)
- **June 26, 2013**: f130626t01r07 (Soaproot)
Methods
Field collection

Measurements at NEON’s 20 × 20m AOP:
1. Stem maps
2. Height
3. DBH
4. Species
**Methods**

Field collection

Measurements at each spot within $80 \times 80 m$ site:

1. LAI (AccuPAR LP-80)
2. Ground based lidar (SICK LMS-151, RITTL)
3. Spectra (SVC HR-1024i)
4. Grass biomass (only in San Joaquin)
5. GPS position
6. Pictures
Methods

Definitions of vegetation indices

Simple Ratio VI (SR):

\[ SR = \frac{R_{800}}{R_{670}} \]

Normalized Difference Vegetation Index (NDVI)

\[ NDVI = \frac{R_{800} - R_{670}}{R_{800} + R_{670}} \]

Modified Chlorophyll Absorption Ratio Index (MCARI), Improved version of MCARI (MCARI2)

\[ MCARI = [(R_{700} - R_{670}) - 0.2(R_{700} - R_{550})](R_{700}/R_{670}) \]

Triangular Vegetation Index (TVI), Modified TVI (MTVI1)
Methods
Mapping LAI to VIs

AOP site 43
Methods
Mapping LAI to VIs

AOP site 43
Methods
Mapping LAI to VIs

AOP site 43

Area = 40 x 40 = 1600 m²
Methods
Mapping LAI to VIs

AOP site 43

Area = (14 x 14) x 9 = 1764 m²
Methods

Mapping LAI to VIs

AOP site 43

Area = (14 x 14) x 9 = 1764 m²

Area = 40 x 40 = 1600 m²
Methods
Mapping LAI to VIs

A theoretical semi-variogram.
http://planet.botany.uwc.ac.za/nisl/GIS/spatial/chap_1_48.htm
AOP site 43
Methods
Mapping LAI to VIs

AOP site 43
Results

LAI estimation

Linear function: $LAI = a \cdot VI + b$

SR

$R^2 = 0.51$

MCARI

$R^2 = 0.33$
Exponential function: \( \text{LAI} = a \cdot \exp(b \cdot \text{VI}) \)

- **NDVI**
  - \( R^2 = 0.52 \)

- **MTVI2**
  - \( R^2 = 0.51 \)

- **MCARI2**
  - \( R^2 = 0.51 \)
Results
LAI estimation

Exponential function: \( \text{LAI} = a \cdot \exp(b \cdot \text{VI}) \)

TVI
MTVI1
MCARI1
Results

Error analysis

Error on calculated VIs

Site 143
Results

Error analysis

Error on measured LAI

Site 43, spot 13
Conclusions:

1. Both LAI and VI are scalable based on consistent results:
   LAI: $20m \rightarrow 40m$, VI: $14m \rightarrow 42m$

2. SR, NDVI, MCARI2 can be potentially used to estimate LAI from HyspIRI data, although fit improvements are required.
Conclusions/Outlook

Future work

1. Improved estimation of VIs:
   - Use other combinations of bands to calculate VI, find the best bands for HyspIRI data to estimate LAI

2. Improved estimation of field LAI:
   - Use high resolution NEON spectrometer and discrete lidar data to “unmix” coarser scale imaging spectroscopy data
   - Based on height (short photosynthetic vegetation) and spectra
Conclusions/Outlook

Project outline

- Estimating LAI from VIs
- Sub-pixel structural variation
- DIRSIG Simulation
- System Study
- HyspIRI PSF
- Airborne data
- Field data
Conclusions/Outlook

Stage 1: Estimating LAI from VIs

AVIRIS Data \rightarrow Extracting VIs \rightarrow Down sampling VIs \rightarrow Estimating LAI from VIs

LAI \rightarrow Down sampling LAI

Airborne data \rightarrow DIRSIG Simulation \rightarrow System Study \rightarrow HyspIRI PSF

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Stage 2: Sub-pixel structural variation

Ground based LiDAR
- Position
- DBH
- Volume
- Biomass

Canopy structure
- Structural variation
  - LAI(VIs)
  - Grass biomass
  - Assess the impact

Volume

Biomass
- NEON’s high res data

AVIRIS data

NEON’s high res data
Stage 2: Sub-pixel structural variation
Stage 3: DIRSIG Simulation

DIRSIG: The Digital Imaging and Remote Sensing Image Generation
Stage 4: System Study

- Simulated HyspIRI pixel
- Virtual scenes
- Simulated AVIRIS pixel
- HyspIRI PSF
- AVIRIS PSF
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NEON AOP team
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