Global Measurement of Non-Photosynthetic Vegetation: Need and an Effort to Assess Potential Accuracy

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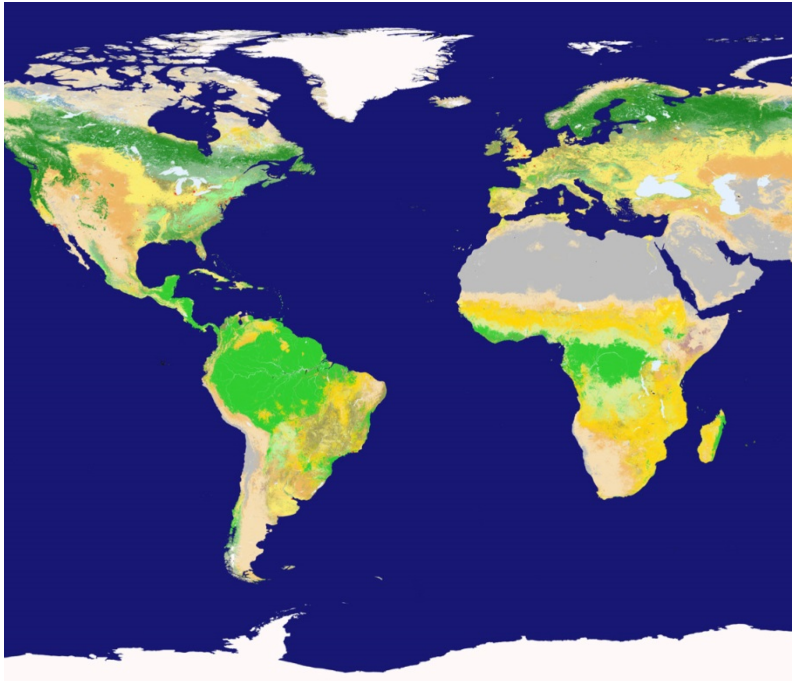
Non-Photosynthetic Vegetation (NPV)

- NPV includes dead and senesced vegetation, plant litter, and non-photosynthesizing branch and stem tissues
- NPV cover changes in response to seasonal and long-term drought, mortality caused by disturbance events, and wildfire
- NPV cover is an important indicator of crop residue cover and soil susceptibility to erosion

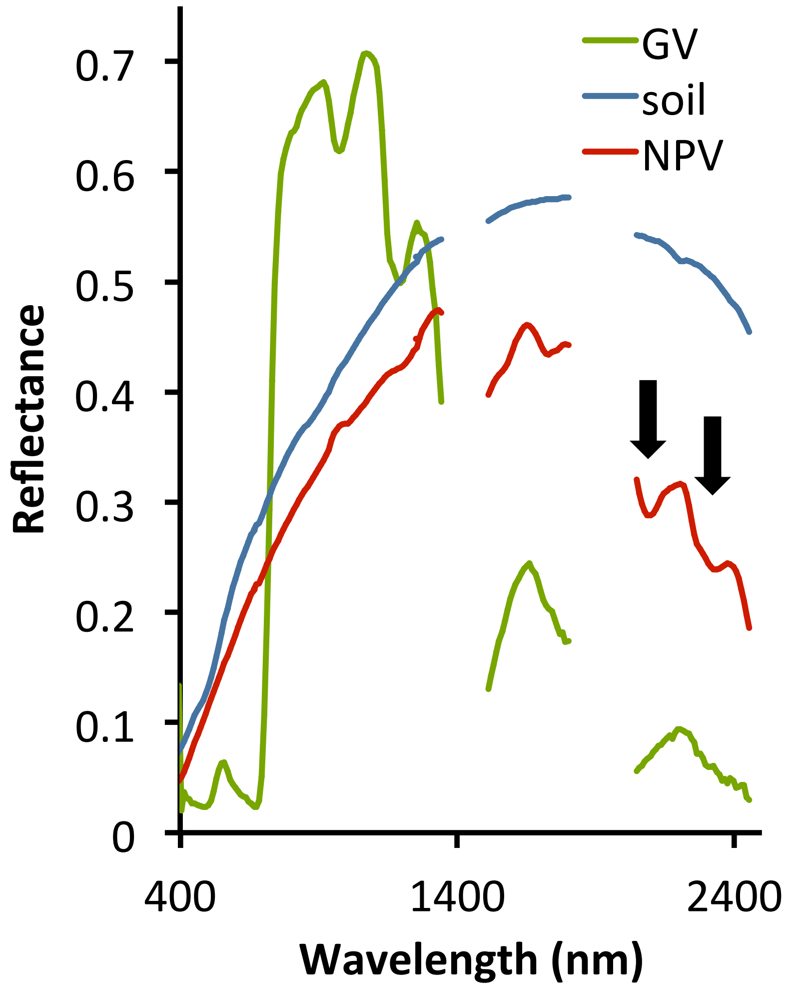
Need for Global NPV Cover Measurement

- NPV is associated with large fluxes of carbon
  - Droughts, insect attack, wind damage, deforestation, wildfire
  - Soil carbon flux in agricultural systems
- NPV is the dominant form of land cover in many grassland, semi-arid, and agricultural ecosystems at least some of the year
- Our current measurement capabilities are targeted almost entirely at green vegetation (GV)



MODIS Land Cover (BU/GSFC)

- NPV is spectrally similar to soil, but is distinguishable using SWIR lignocellulose absorption
- Imaging spectroscopy is capable of resolving lignocellulose absorption and mapping fractional NPV cover (% NPV per pixel)



National Academies Decadal Survey

- Response to RFI2: *Global Measurement of Non-Photosynthetic Vegetation*
- Objective: "Map seasonal NPV cover for all vegetated ecosystems globally at a spatial resolution required for quantifying stand/patch scale variation (≤ 30 m)"
- Quantified Earth Science Objective (QESO)
  - <u>What is the achievable accuracy of fractional NPV cover mapping?</u>
- We simulated HyspIRI VSWIR spectra using field spectra covering 400-2500 nm to examine achievable accuracy for NPV cover mapping

Daughtry

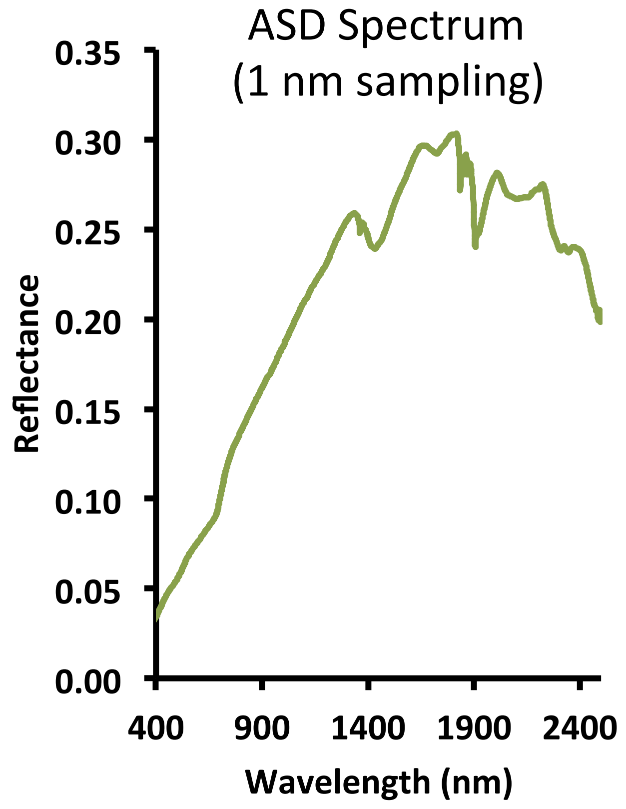
- 600 spectra from 7 agricultural sites in Maryland
- Mixtures of GV, soil, and residues
- Percent cover estimated using sampled field photos

Kokaly

- 19 spectra from Wyoming rangeland plots
- Mixtures of GV, soil, and senesced grass
- Shrub cover measured; grass, forb & soil cover visually estimated
- Aggregated to % GV, NPV, and soil cover

Simulating HyspIRI VSWIR Spectra

1. **Reflectance field spectra were convolved to 10, 15, 20, and 30 nm band spacing and FWHM**
2. Reflectance spectra were converted to simulated radiance using a MODTRAN-generated lookup table
3. Noise was added using a radiance-dependent HyspIRI VSWIR noise function
4. Reflectance was retrieved from the radiance spectra using ATREM



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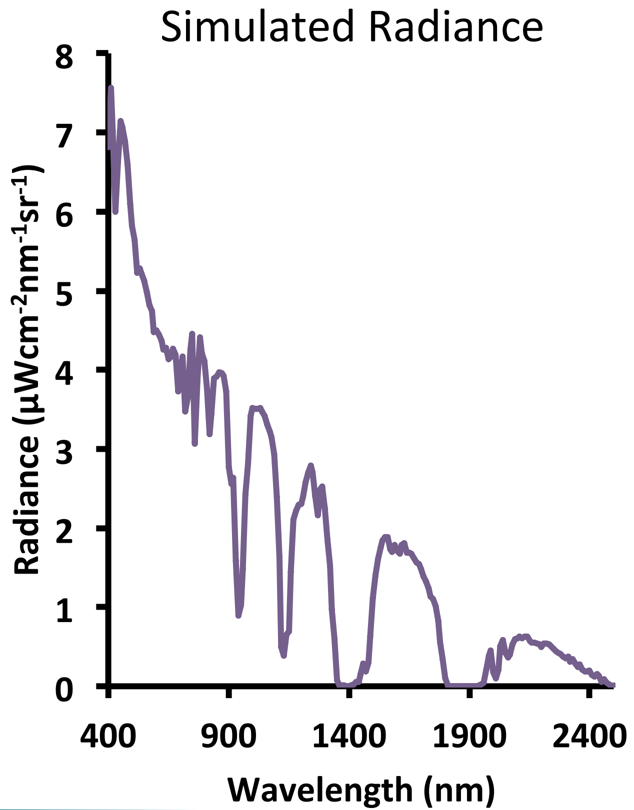

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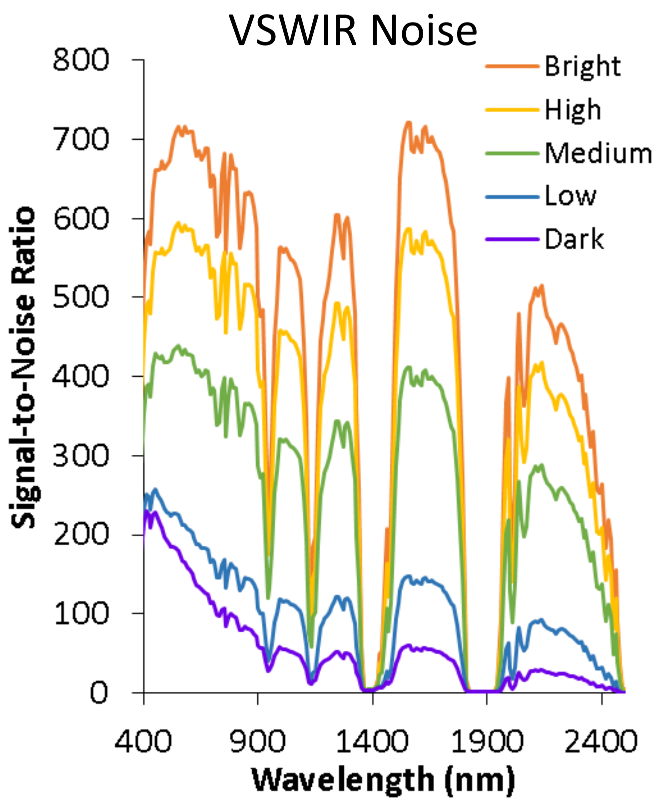

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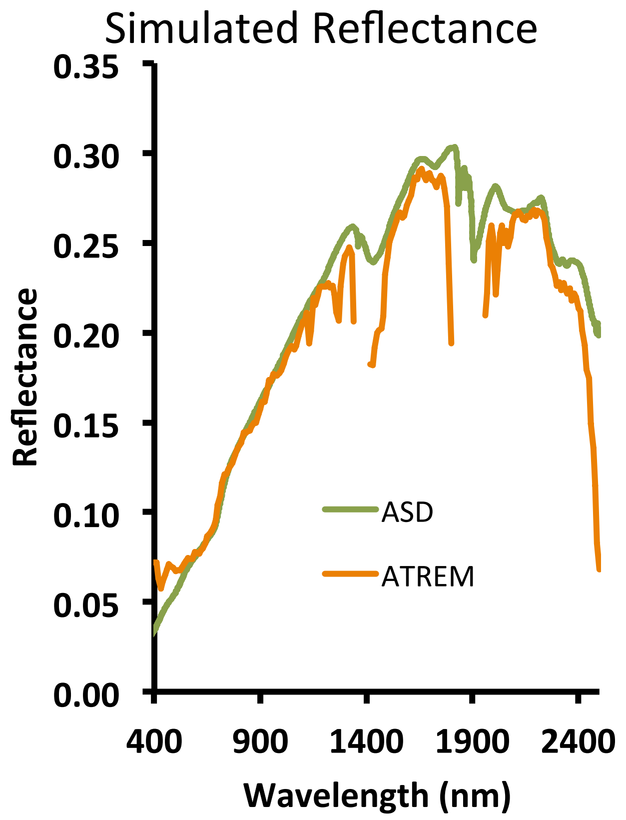
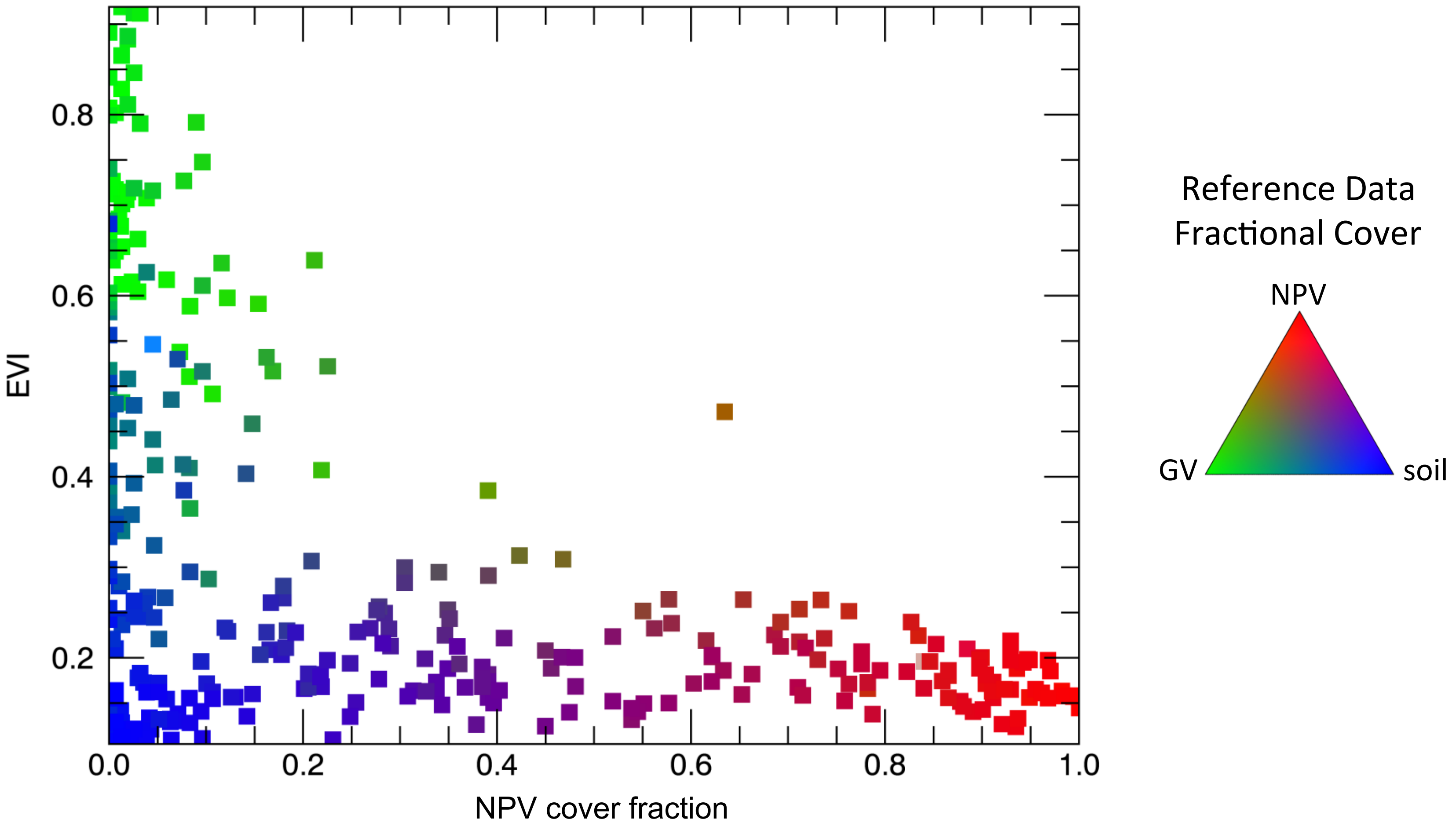


NPV Cover Modeling

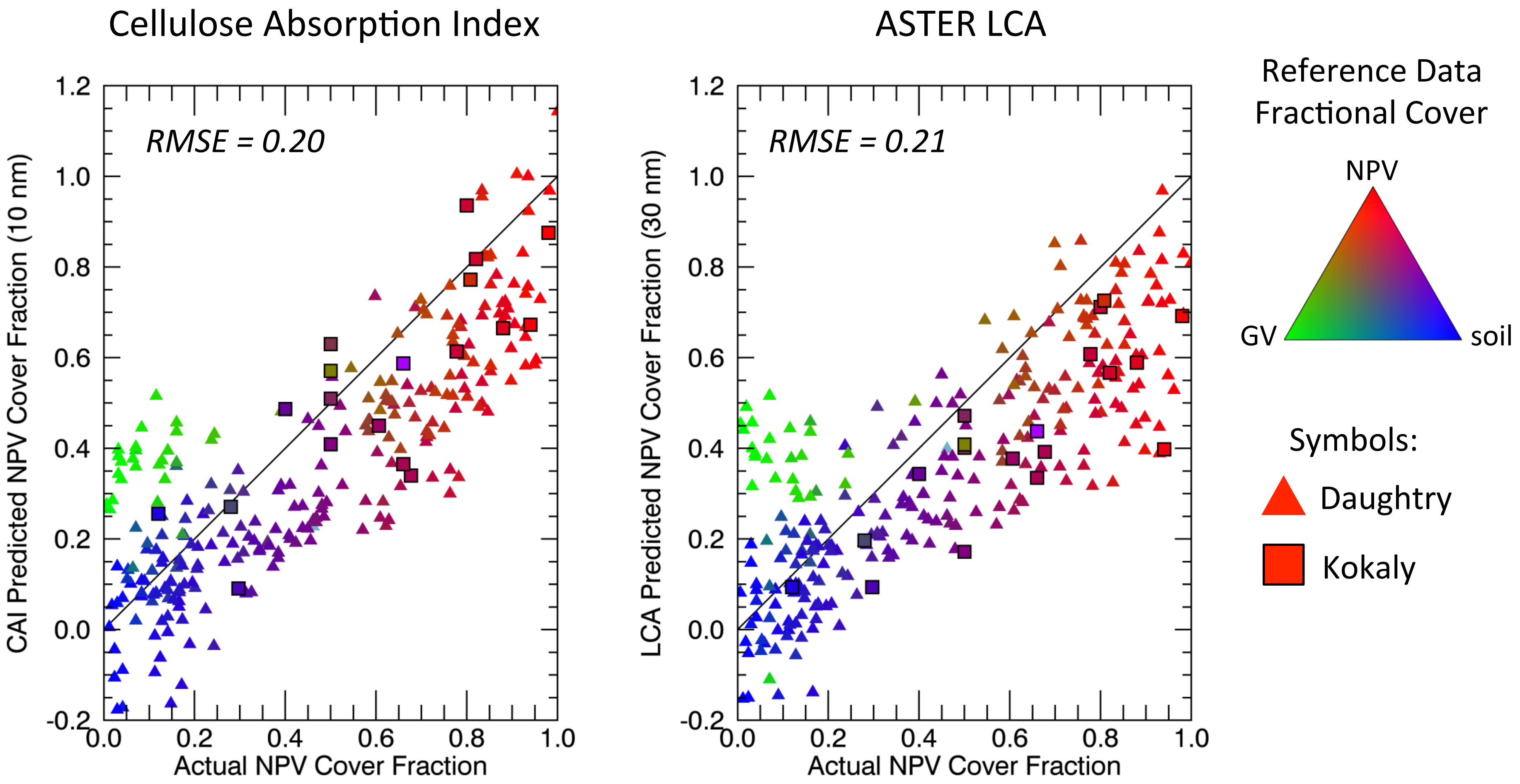
- Simulated HyspIRI reflectance spectra were split into training and validation libraries by site
  - Training Library: 4 Daughtry sites
  - Validation Library: 3 Daughtry sites + Kokaly site
- NPV cover metrics:

NDVI	Normalized difference vegetation index	**hSINDRI**	Hyperspectral SWIR normalized residue index
EVI	Enhanced vegetation index	**LCA**	ASTER ligno-cellulose absorption index
NDII	Normalized difference infrared index (SWIR2)	**MESMA**	Multiple endmem. spectral mixture analysis
CAI	Cellulose absorption index (Daughtry 2001)	**SFA**	Spectral feature analysis (Kokaly & Skidmore)
CAI2	Cellulose absorption index (Serbin et al 2009)	**PLS**	Partial least squares regression

- Relationships from training library were applied to validation library and error was assessed

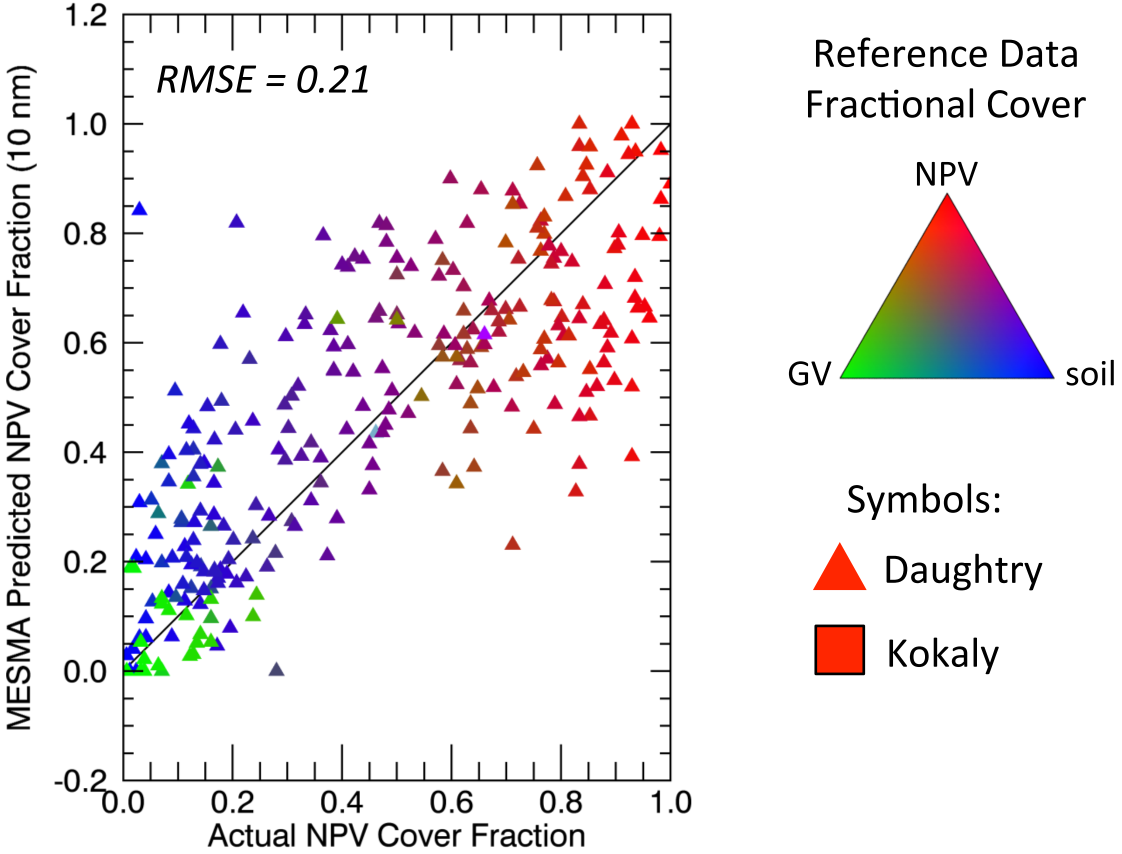


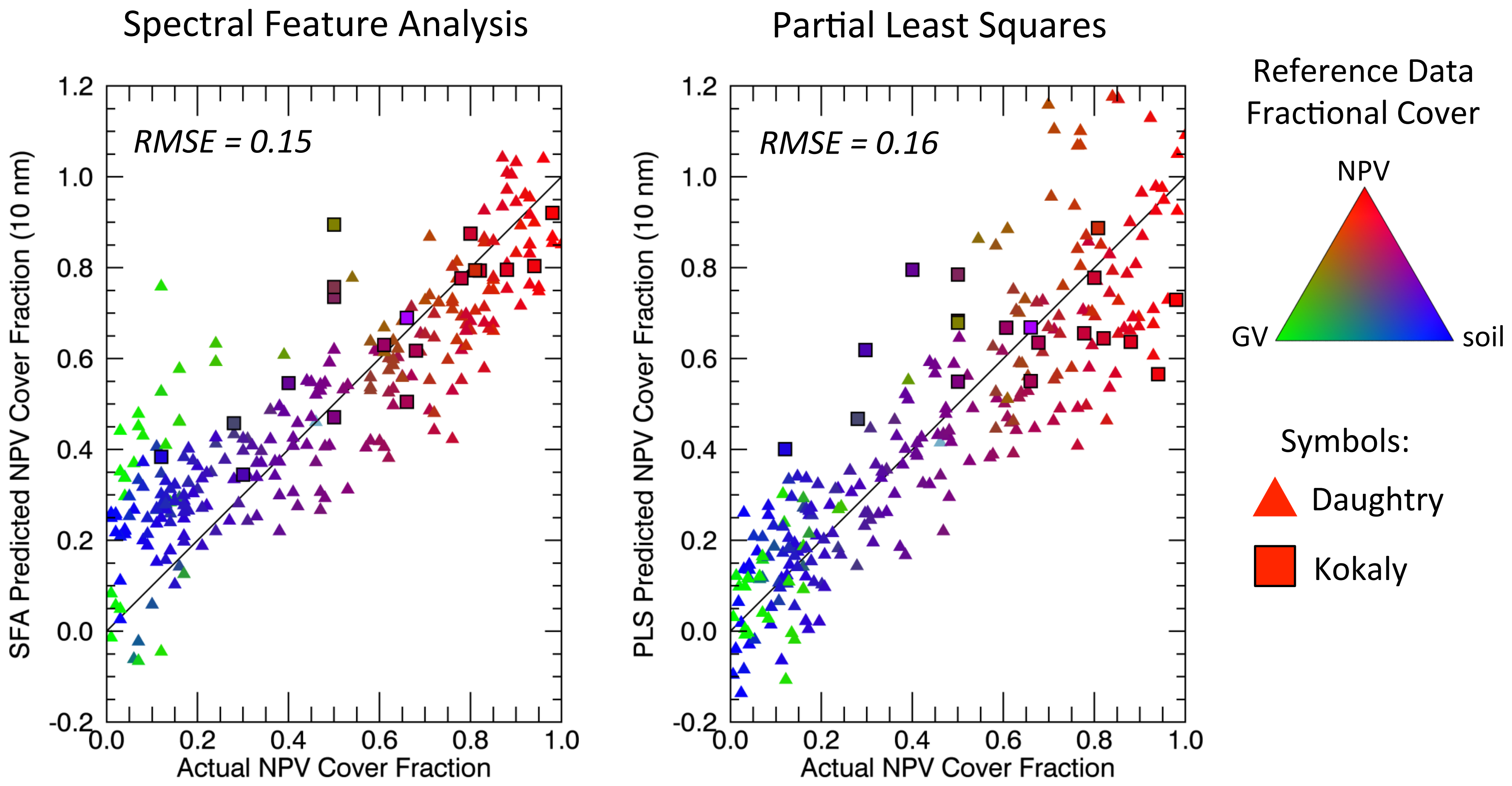
0.8
0.6
0.4
0.2
EVI
0.0
0.2
0.4
0.6
0.8
1.0
NPV cover fraction
Reference Data
Fractional Cover
NPV
GV
soil



Cellulose Absorption Index
ASTER LCA
RMSE = 0.20
RMSE = 0.21
CAI Predicted NPV Cover Fraction (10 nm)
LCA Predicted NPV Cover Fraction (30 nm)
Actual NPV Cover Fraction
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
1.2
Reference Data
Fractional Cover
NPV
GV
soil
Symbols:
Daughtry
Kokaly

MESMA (preliminary model)

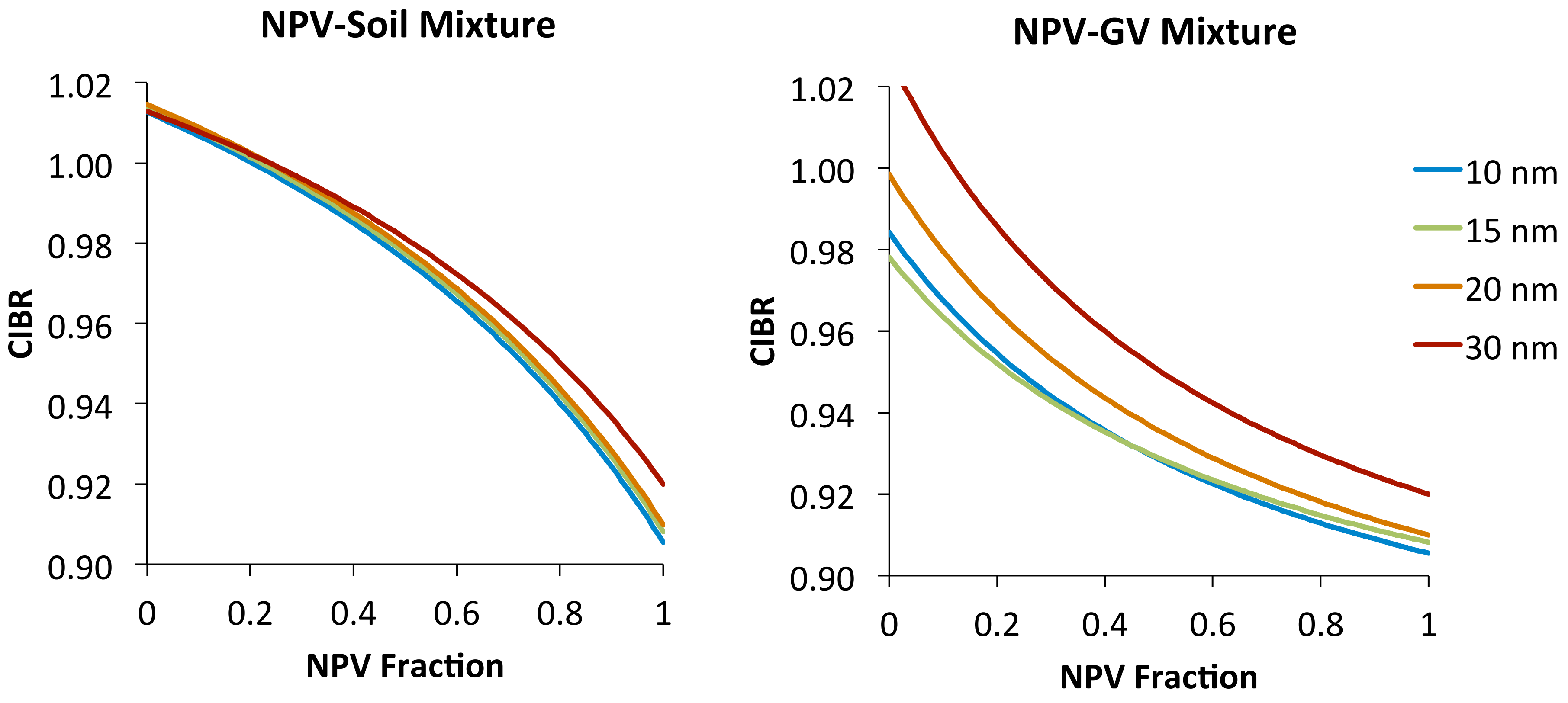




Spectral Feature Analysis
RMSE = 0.15
SFA Predicted NPV Cover Fraction (10 nm)
Actual NPV Cover Fraction
Partial Least Squares
RMSE = 0.16
PLS Predicted NPV Cover Fraction (10 nm)
Actual NPV Cover Fraction
Reference Data
Fractional Cover
NPV
GV
soil
Symbols:
Daughtry
Kokaly

Spectral Resolution

- Depth of lignocellulose absorption feature in mixtures starts to decrease at 20 nm

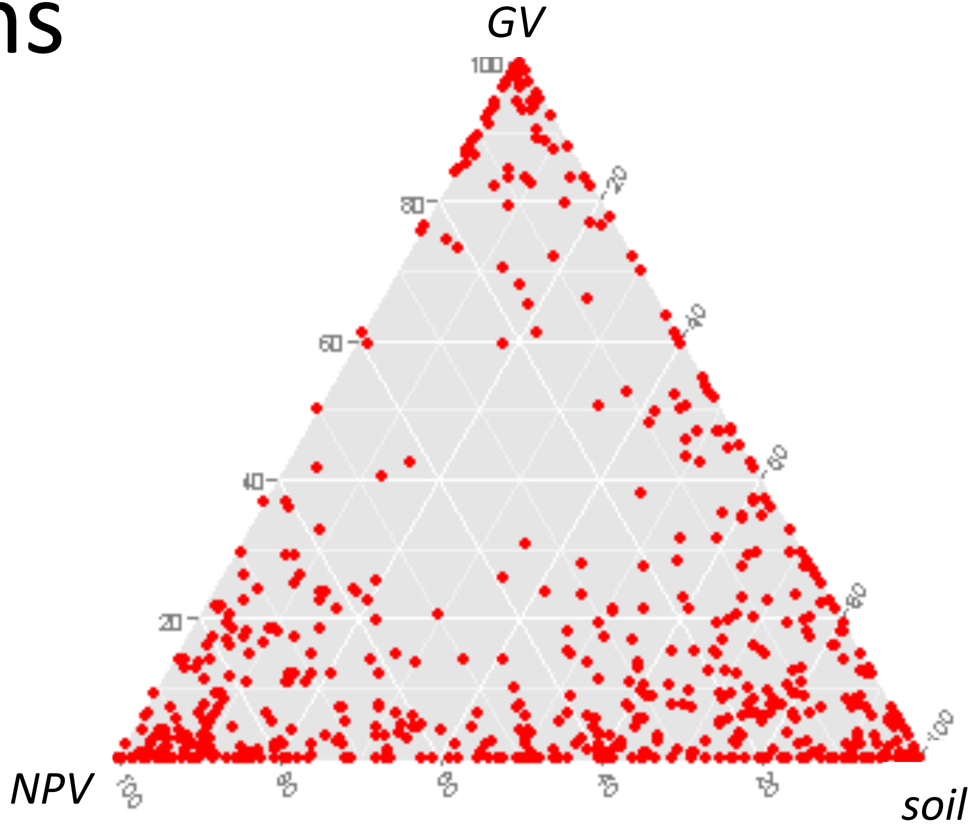


NPV Cover RMSE and Spectral Resolution

Spectral Resolution	SFA	PLS	CAI	Prelim. MESMA
10 nm	0.15	0.16	0.20	0.21
15 nm	0.15	0.16	0.21	0.21
20 nm	0.16	0.16	0.19	0.24
30 nm	0.17	0.16	0.22	0.19

Library Limitations

- Training and validation data include error in field-assessed cover
  - Daughtry & Hunt (2008): "6-35%"
- Library is heavy on soil-NPV mixtures
  - Average fractional cover: 42% soil, 36% NPV, 22% GV
- GV cover in library is low LAI
- Modeled atmosphere and solar geometry are not varied



Conclusions

- An imaging spectrometer mission would uniquely provide the ability to measure global NPV cover, a need unmet by current satellite missions
- Initial investigation into achievable accuracy found a RMSE of 15%
  - Methods that rely entirely on lignocellulose absorption can overestimate NPV fraction in spectra with high GV cover
  - Lower error is likely with fine-tuning of methods
- We need to improve the diversity of NPV, soil, and GV cover in this analysis. Have spectra and field-assessed cover? **Join our effort!**
- 10-15 nm spectral resolution would be ideal for mapping NPV cover, although placement of band centers was not evaluated

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