Abstract

Imaging spectroscopy data have been successfully used to map a wide range of canopy and leaf-level biochemical and biophysical properties across a diverse set of ecosystems. These maps provide critical insights into the spatial patterns and drivers of biodiversity and ecosystem processes, and can be used to refine inputs to both ecosystem and climate models. However, the availability of such datasets has been mostly limited to single acquisitions over relatively small extents compared to those acquired by multispectral sensors. The Hyperspectral Infrared Imager (HyspIRI) mission would provide the first global, object-level measurements and will significantly expand the current datasets.

Leaf-level Spectral & Trait Variation

- Principal Components Analysis shows greater variation in leaf-level spectra than in five leaf traits (leaf mass area, water content, total chlorophyll, carotenoids & leaf thickness).
- Leaf Reflectance: 5 components explain 99% variance.
- Leaf Traits: 3 components explain 99% variance.

Canopy-level Spectral Variation

Data dimensionality for June 2013 AVIRIS imagery of selected sites were calculated using the Hyperspectral Signal Subspace Identification with Minimum Error (HySime) algorithm (Boucau-Dias & Nascimento, 2008). HySime selects a set of eigenvectors that minimize the least squares error (both minimizing the power of the signal projection error & the power of the noise projection).

The number of dimensions estimated corresponds closely to the number of spectral endmembers or data clusters within the image.

Estimating Leaf Functional Traits

- Leaf traits were estimated using leaf reflectance spectra and partial least squares regression (PLSR).
- # of included components was selected based on minimization of the PRESS statistic.
- Final models were cross-validated using a leave-one-out procedure.
- When traits were estimated as a multi-response model, R² and RMSE values were not significantly different.

Examples of Predicted vs. Measured Leaf Trait Values (m37, June data)

Canopy-level Trait Variation

- Maps show canopy leaf mass area (LMA, g/m²), total chlorophyll concentration (CHL, µg/cm²), and equivalent water thickness (EWT, cm) estimated for the Soaproot Saddle site.
-chl & LMA were calculated using optimized normalized difference indices from Maimer et al., 2008 (710 & 925 nm, 2260 & 1490 nm, respectively).
-EWT was calculated by spectral feature fitting (Roberts et al., 1997).
-RGB composite of scaled variables shows the spatial variation in dominant canopy leaf traits.

Addressing Challenges in Retrieving Canopy Biochemistry

Radiative transfer modeling (RTM) is a powerful tool for estimating plant functional traits (e.g., LAI, pigments, water content) at canopy scale. Still, the effects of pixel composition and canopy structure reduce the accuracy and precision of these estimates. To successfully use RTMs over a wide range of ecosystems and in spectrally diverse species, such as will be collected by HyspIRI, we must find a reliable method for addressing these effects. Our future research will evaluate several approaches to account for pixel composition and canopy structure.

Proper Approaches

- Explicitly test the effect of different structural parameters within RTM simulations.
- Estimate sub-pixel composition and cover using spectral un-mixing.
- Constrain RTM inversions for both pixel- and object-levels using prior information (e.g., image clusters, structural types, plant functional types).

References


Acknowledgements

We would like to thank our many field volunteers and lab assistants for their help collecting and processing field data. We would also like to thank the AVIRIS team at JPL for collecting and pre-processing the image data.

RESEARCH FUNDED BY NASA HYSPIRI AIRBORNE HYPERSONIC IMAGING SPECTROMETER Mission: "DETECTING & MEASURING FLUXES OF GASES & PARTICLES IN ECOSYSTEMS, WITH SPECIAL REFERENCE TO FIRST-ORDER BIOMASS BURNING INDUCED CHANGES AND ADVANCED CANOPY LIBERATION TRANSFER MODELS."