LC20: Hyperspectral analysis of landcover in Rondônia

D.A. Roberts[1], L.G. Soares[2], I. Numata[3], I. McCubbin[4], O.A. Chadwick[5]

[1] US PI, Dept of Geography, University of California at Santa Barbara, Santa Barbara, CA 93106, E-mail: dar@geog.ucsb.edu

[2] SA PI, INPE, Sao Jose Dos Campos, E-mail: lenio@ltid.inpe.br, [3] Student UC, E-mail: numata@geog.ucsb.edu;

[4] Participant, JPL, E-mail: Ian.B.McCubbin@jpl.nasa.gov; [6] UC, E-mail: oac@geog.ucsb.edu

ABSTRACT

Remote sensing is a critical component of LBA ecology, contributing to the basin wide study primarily through land-cover classification, land-cover change, and biophysical retrievals. Accurate maps of land-cover, land cover change and canopy biophysical properties are needed as inputs for hydrological and biogeochemical models, as a means for quantifying above ground carbon stocks, scaling up flux tower measurements beyond tower sites and to direct field sampling. Currently a wide array of spaceborne image data are available to the project including multitemporal Landsat TM, AVHRR, some SAR and more recently, MODIS, SeaWiFS, Ikonos and ASTER. While many of these data sets are invaluable, they do not have the capability of separating many important land-cover classes, nor the capability of more accurate biophysical retrievals offered by hyperspectral systems. Examples of land-cover classes that cannot be distinguished reliably with image data available to the project include green pasture, early regeneration and tree crops. Past research in Eastern Amazônia, and more current research in Rondônia has shown that some of these ambiguities are non trivial. For example, in the vicinity of Ji Parana, spectral ambiguity between green pasture and second growth forest results in interannual fluctuations between these two cover classes of up to 10%, with the highest proportion of second growth occurring in early dry season images. No such ambiguity will occur in hyperspectral data. Tree crops, which cannot be separated from some second growth forests without extensive supporting field data, should also be spectrally distinct in hyperspectral data. Improved biophysical retrievals include LAI retrievals for forested areas at ranges that typically saturate NDVI.

LBA ecology is also limited by the availability of high quality spectral reflectance data at branch to canopy scales. In order to best interpret canopy reflectance, it is critical that data exist at an appropriate spatial scale for remotely sensed data. Because of the difficulty of acquiring a sufficient number of spectra from towers, an airborne campaign is virtually the only way to develop such a library. Not only can such a library improve the quality of land-cover maps, but it can be convolved to other sensors, and thereby used to improve analysis using broad band systems that cover a larger area and include archived data sets.

For this research, we propose to address a number of critical problems in land-cover mapping and biophysical retrievals through the use of high resolution AVIRIS. We propose a 4 to 8 week deployment, starting in late June/early July, at the start of the dry season and prior to the onset of significant burning. We propose target sites in Rondônia that include well characterized sites such as Fazenda Nova Vida, tower sites such as Jaru, and a selection of targets that cover a range of land-cover categories (crop, pastures of ranging quality, second growth at different ages and primary forest). Site selection would be guided by extensive GIS layers and Landsat time series we have developed for the state of Rondônia. A key focus will be on well characterized sites. Expected products include a regionally specific spectral library for Rondônia that includes all major dominant cover types, land-cover maps using techniques developed at UCSB, and new biophysical maps such as LAI retrievals. UCSB will work closely with Brazilian collaborators and other LBA researchers to develop optimal test sites throughout the state. This project contributes to LBA educational initiatives through graduate student support of a Brazilian PhD and a remote sensing short course on hyperspectral remote sensing, to be taught in Rondônia and potentially at INPE.

SCIENTIFIC OBJECTIVES

Develop a regionally specific spectral library for Rondônia

- *Few spectra exist acquired for vegetation acquired at an appropriate spatial and spectral resolution to constitute a library
- *Such spectra are critical for improved land-cover mapping and can be used for multi-sensor calibration/validation

Develop improved maps of land cover using techniques developed primarily for hyperspectral applications

- *New techniques, combined with hyperspectral data have the potential of discriminating land-cover types that are not separable using broad band sensors.

Develop improved biophysical maps with a specific focus on

- *Flux towers, pastures
- *Pasture chronosequences

Evaluate pasture/second growth quality for pasture chronosequences using hyperspectral measures

- * Several hyperspectral measures, such as depth of the liquid water band are more sensitive to changes in canopy biophysical properties that standard indices such as NDVI

Evaluate canopy biophysical changes along forest edge chronosequences associated with fragmentation

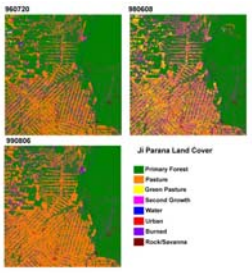
Research training in hyperspectral remote sensing

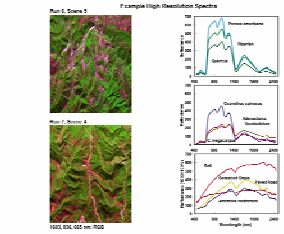
BACKGROUND

Some land-cover types are not distinct with broad band data

- *Green pasture vs second growth
- *Second growth & perennial crops
- *Savanna, exposed rock & pasture
- *Annual crops

The figure on the right shows a time series of land-cover maps derived from Ji-Parana. Major changes in the area mapped as second growth are probably a result of phenology and the timing of image acquisition, not shifts in second growth.





High quality spectra of most Brazilian land-cover is sparse

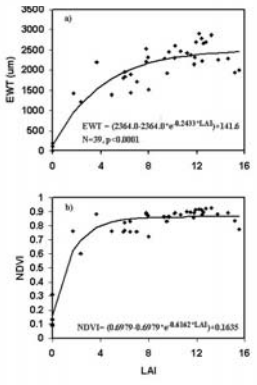
- *Primarily leaves, soils, shrubs, very few trees

The figure to the left shows example spectra derived from a low altitude AVIRIS flight over the Santa Monica Mountains, California. The spectra, measured at ~ 4 meter spatial resolution are of comparable quality to laboratory spectra.

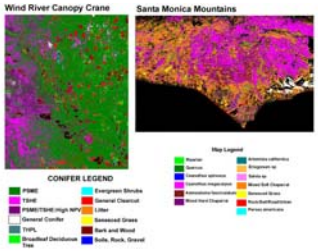
Hyperspectral systems have the potential of improved biophysical retrievals

- *Improved LAI (liquid water)
- *Red-edge parameters
- *Pigment fits

The figure on the right shows a plot of Equivalent Water Thickness (EWT) against Leaf Area Index (LAI) from the Wind River Canopy Crane Research site and vicinity. While the relationship appears to be non-linear, NDVI reaches an asymptote at significant lower LAI (~4 vs > 9). From Roberts et al., Ecosystems, in review.



Hyperspectral data have the potential for improved land-cover mapping



The figures on the left show conifer dominants and chaparral dominants mapped using AVIRIS. The approach used was Multiple Endmember Spectral Mixture Analysis (MESMA), in which a simple spectral mixture model is extended to allow the number and type of endmembers to vary on a per/pixel basis. The spectral library can be developed strictly from the field, or as some combination of spectra from the field and imagery. Image-derived spectra have the advantage in that they include tall objects and are at an appropriate spatial scale (~3-5 m).

Recent advances, focusing on the development of optimal spectral libraries have achieved accuracies exceeding 87% in chaparral in Santa Barbara, California.

APPROACH

- **Preliminary image analysis**
  - **SCAR-B, 1995**
  - **20 m resolution, mostly cloud/smoke contaminated, some good examples (Cuiaba)**
  - **Important as examples for the short course**
- **Target identification**
  - **All flux towers and well characterized field sites (ie, Jaru, Fazenda Nova Vida)**
  - **All major land-cover classes and crop types in Rondônia**
  - **Chronosequences of pastures and second growth across gradients in site quality.**
  - **Chronosequences of forest edges**

SUPPORTING DATA

Digital PRODES base maps

Extensive historical/current TM/ETM, MSS(100+scenes)

Standardized reflectance products

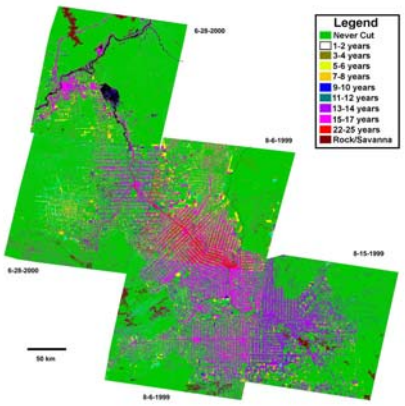
Spectral Mixture Models

Land-cover classification

Airborne Videography 1997, 1999

Local/Field knowledge

Supporting GIS layers
Soils, DEM, Planoflora



Example of supporting data, showing the age of forest clearing determined from the Landsat time series data. These data, combined with the land-cover map, were used in the field to improve flight line location. A key objective was to acquire data over a wide range of cover types and ages of pasture and second growth

TECHNICAL PLAN

AVIRIS deployment
Twin Otter, 5 meter resolution, 2.9 km swath
Late June to early August 2003.

Field Support (2003)
Ground reflectance targets
Endmember Identification
Field measurements
GPS, CCD images, spectra along pasture transects across a range of ages, soil types
Leverage off of well characterized sites

Reflectance retrieval
Green et al., 1993

Develop first generation spectral library

Develop first generation land-cover maps
Quantify spectral separability of dominants
Map dominants with MESMA

First generation biophysical maps
EWT retrieval, SMA

Second field campaign, summer 2004

EXAMPLE FLIGHT LINES

INTEGRATION AND SYNTHESIS

Hyperspectral short course, to be taught in Rondônia and potentially INPE

Image acquisition, processing and analysis over well characterized regions: Machadinho (Lu, Brondizio, Batistella), AltaParaiso (Salas/Pedlowski), Fazenda Nova Vida (CENA), all Rondônia flux tower sites (Jaru, Nossa Senhora)

Spectral library development, documentation and sharing, improved spectral land-cover definitions

Regional comparison of second growth and pasture with variable land-use histories

Inter-regional comparison of second growth and pasture with collaborators working in Altamira (Polzoni)

Reanalysis of ETM products through improved spectral libraries and reflectance retrieval

Evaluation of the effects of forest fragmentation on edge biophysical properties