LARGE SCALE ESTIMATION OF LAI AND ABOVEGROUND BIOMASS USING LIDAR AND HYPERSPECTRAL DATA

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INTRODUCTION

The understanding of the vegetation stocks and fluxes of carbon is important for many applications and due to their importance, numerous reporting tools have been developed to monitor these two variables. Stocks of carbon are highly related to the aboveground biomass (AGB) which also represents the amount of carbon that may be released to the atmosphere in the case of disturbances such as natural and anthropogenic fires, cyclones and land use and land cover change. Fluxes of carbon from the vegetation are related to the photosynthetic activity and production of vegetation which is determined primarily by leaf area index (LAI).

Savannas store 30% of terrestrial carbon and have the potential to play an important role in the global carbon cycle (Chen, et al., 2003). The Australian savannas account for 12% of the world global savannas and cover about 25% of the continental area of Australia (Beringer et al. 2003)

Northern Australian Tropical Transect (NATT) stretches over 800 km of heterogeneous landscape in the Northern Territory. NATT is selected as the study area to assess the spatial variability of vegetation parameters such as AGB and LAI using large scale airborne and spaceborne surveys with the support of ground based structural and spectral measurements.

Figure 1. The shaded region shows the location of the Australian tropical savannas

Study Area

Six different sites were selected for the collection of ground based data in one hectare plots along the NATT. The sites were the location of existing flux towers. Vegetation structural and spectral data such as tree height and diameter along with spectral reflectance at leaf and canopy level were collected during September 2008.

Airborne and spaceborne hyperspectral and lidar data were acquired at the same time of ground measurements.

Table 1. Location of the study sites with the dominant species

Sites	Dominant Species
1- Howard Springs (12° 29'39.12"S, 131° 09'09"E)	Eucalyptus Miniata, Erythrophleum Chlorostachys
2- Adelaide River (13° 04'36.84"S, 131° 07'04.08"E)	Eucalyptus tectifica, Planchonia careya
3- Daly un-cleared (14° 09'33.12"S, 131° 23'17.16"E)	Terminalia grandiflora, Eucalyptus tetradonta
4- Daly 5 year (14° 07'50.16"S, 131° 22'58.08"E)	Eucalyptus miniata, Eucalyptus tetradonta
5- Dry Creek (15° 15'31.62"S, 132° 22'14.04"E	Eucalyptus tetradonta, Eucalyptus terminalis
6- Sturt plains (17° 09'2.76"S, 133° 21'1.14"E)	Eucalyptus pruinos, Acacia cowlean

Figure 2. Location of ground based survey sites and airborne survey tracks

ANALYSIS APPROACH

The aim of this research is to integrate different data sets from different scales such as ground based leaf and canopy level measurements, airborne measurements and spaceborne measurements and different sensors and method to estimate the vegetation parameters of interest. For this purpose object based image analysis method has been adopted in order to establish a robust method for large-scale and detailed estimation of LAI and AGB. The below steps are parts of the overall method.

Individual tree delineation: This step is required for the estimation of the parameters for individual trees. On the other hand ground based data were collected from individual trees. The general methods of tree delineation are based on the use of low radiometric values between individual trees crowns in dense canopies. The study area has a heterogeneous pattern of high density and low density canopies which makes it difficult to apply a global method to the whole area. The segmentation method to be used here is using structural features from LiDAR data such as canopy height model (CHM) and spectral information such as species type for accurate delineation of individual trees.

ANALYSIS APPROACH

Species classification: Airborne hyperspectral data and Spectral Angle Mapper (SAM) is in use in this research to classify the pixel into the species types collected using the ASD handheld spectroradiometer. These data are to be used in tree delineation and classification of the individual trees.

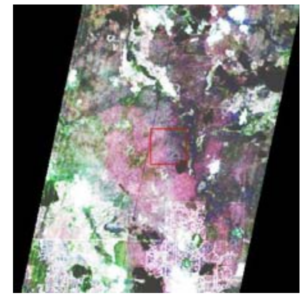


Figure 3. Hyperion image showing Howard Springs ground plot location

Sensitivity analysis: Due to the sheer amount of information produced by hyperspectral data needs proper handling of the data. The 5-Scale reflectance model is used for the analysis of the spectral response of the reflectance spectra to the variations of different vegetation parameters such as leaf water content, leaf nitrogen content, leaf chlorophyll content and canopy LAI in order to choose a spectral subset or transformation of hyperspectral data.

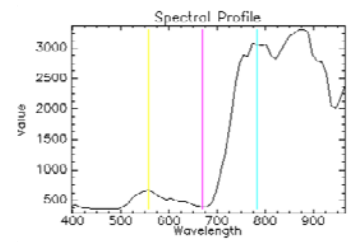
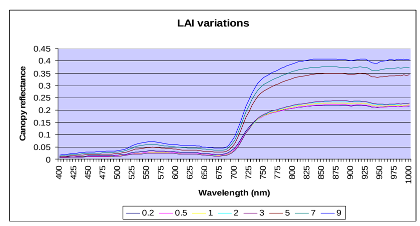


Figure 4. Example reflectance spectrum extracted after atmospheric correction of the AISA hyperspectral data

Feature extraction: Individual segments of trees will be used to extract spectral and structural feature from lidar and hyperspectral sensors. Lidar data will be used to extract 3D distribution of tree elements. Spectral features will be extracted based on the results of the sensitivity analysis stage.

Model development and validation: The next step is to develop a predictive model of vegetation parameters using Artificial Neural Networks (ANN) technique. Different subsets of the ground based data will be used to establish the relationship between extracted structural features from lidar and spectral features from hyperspectral data to validate the developed model.



Figures 5. The results of a sensitivity analysis of 5-Scale canopy reflectance model to assess the effect of the LAI variations on the reflectance curve

SUMMARY AND OUTCOMES

The method of individual tree based estimation of LAI and AGB based on the salient structural and spectral features extracted from lidar and hyperspectral is described here. This enables large-scale estimation of the vegetation parameters for an important environmental transect (NATT). Spatial variability of different vegetation properties will be assessed based on the data collected along the transect. This will help in the understanding of the large scale relationship between environmental gradient factors such as precipitation and temperature and the estimated vegetation parameters. The results will be transferable to other savanna areas with some modifications.

AKNOWLEDGEMENT

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REFERENCES

Chen et. Al., (2003) Carbon balance of a tropical savanna of northern Australia. Ecologia, 137, 405-416. Beringer (2003) Fire impacts on surface heat, moisture and carbon fluxes from a tropical savanna in northern Australia. International Journal of Wildland Fire, 12, 333-340.

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