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CHARACTERIZATION OF BIOPHYSICAL VEGETATION - SOIL DYNAMICS ALONG AN ECO-CLIMATIC BRAZILIAN TRANSECT WITH MODIS VEGETATION INDICES

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Abstract. Field measurements were conducted on 10 June through 21 July 2002 to collect biophysical data in support of MODIS validation studies. Leaf Area Index (LAI), Plant Area Index (PAI), Absorbed Photosynthetically Active Radiation (fAPAR), biomass, cover components, site characterization and soil characterization were measured. The study areas extended over an eco-climatic transect, from the cerrado in Brasilia National Park through the transition zone in Palmas into the tropical forest near Santarém. We found high relationships between PAI and fAPAR. Furthermore, along the land-cover gradients the biophysical properties as well as soil characteristics significantly varied over the different biome types. The Terra-Moderate Resolution Imaging Spectroradiometer (MODIS) vegetation indices, the normalized different vegetation index (NDVI) and enhanced vegetation index (EVI) products were analyzed for seasonal and spatial patterns of photosynthetic vegetation activity over the same transect. The spatial patterns and relationships of the various landcover types between MODIS VIs and field data during the same period of measurements were investigated, especially in the cerrado biome. This yielded useful insights of the utility of the MODIS VIs.

Keywords: remote sensing, MODIS VI, cerrado, biophysical properties, soil characteristics.

Introduction

The Amazon region consists of a large variety of vegetation communities; grassland, shrub land, woodland, and forest, due to climatic variations, soils, and land use. Many research projects have been conducted in this area. Remote sensing plays an important role for terrestrial biophysical and ecological research and can provide an important tool coupling vegetation change to climate variability and land use. Thus, the interpretation of the remotely-sensed signal provides very important information, but is complex. Canopy spectral reflectance is a function of the biophysical properties of the canopy; canopy structure and leaf, and soil optical properties. (Baret, 1995; Huete, 1988). Many investigators have carried out analyses of optical and biophysical relationships, yet the relative important of these factors has not been adequately addressed (Asner, 1998; Asrar et al., 1984). However, it has been shown that vegetation indices are well correlated with vegetation parameters, for example, Leaf Area Index (LAI), biomass, canopy cover, and Absorbed Photosynthetically Active Radiation (fAPAR) (Tucker, 1979; Asrar et al., 1984). Vegetation indices can be used to quantify spatial and temporal variation in vegetation photosynthetic activity useful in carbon studies. Therefore, the 16-day composite of MODIS VI products; (the normalized different vegetation index (NDVI) and enhanced vegetation index (EVI), were exploited to analyze the spatial and temporal photosynthetic activity of an eco-climatic transect from cerrado into rainforest. Given the importance of soil and biophysical properties, ground measurements were conducted for this study over the period, 10 June 2002 to 21 July 2002.

Purposes of this Study

The purposes of the study were 1) to collect biophysical data and characterize soil and surface properties along the eco-climatic transect 2) to analyze the seasonal and spatial patterns of photosynthetic vegetation activity by utilizing MODIS VI products over the study sites 3) to observe the photosynthetic dynamic behavior of land cover types at the same period that ground measurements took place

Study Sites

There are three main regions of the study sites; centered near Brasilia, Palmas and Santarém. In Brasilia, we set up 3 transects in Brasilia National Park (BNP) over Shrub Cerrado (SC), Wooded Cerrado (WC) and Cerrado woodland (CW) covers; 3 transects in Águas Emendadas Ecological Station (AE) over a humid Cerrado Grassland (CG), Wooded Cerrado (WC) and Cerrado Woodland (CW), and 3 transects in Rio de Janeiro Farm (RJ) over "without fertilizer" or without treatment (WoT), "with treatment" (WT) and "burned" (BU) pastures. They were all N-S 250-m transects, except the 200-m humid Cerrado Grassland and burned pasture transects and 100m cultivated pasture with treatment. In Palmas, two study sites were selected: Cangucu Center (CA) and Santana do Araguaia (SA). There are three 250m transects and a 25m transect in Cangucu Center area; Cerrado Woodland (CW), 8-year cultivated pasture (P8), 3-year cultivated pasture (P3), and 1-year cultivated pasture (P1). In Santana do Araguaia, we set up 2 transects; 100m transect of 20-year cultivated pasture (PA) and 250m Capoeira (CP) transects. All transects were N-S direction as well. In Santarém, we selected the following study sites; Upland and Lowland Primary Forests at km 67 (67U and 67L); Upland Primary Forest at km 89 (89U); 6-7 years old Regeneration site at km 77 (77RE); 12 years old pasture site at km 92 (92PA); Upland Primary Forest at km 103 (103U); and two sites at Selective Logging, km 83 (83SL1 and 83SL2). The regeneration site presented 100-m long transect. The others were 250-m long with N-S direction.

Measurements

Soil samples were collected at 25, 65 and 120 m along the transects for pure spectral signature, moisture, bulk density, texture, and chemical analysis. For moisture and bulk density, we collected at the top 5 cm. Samples for texture and chemical analysis were collected at two depths: 0-5 cm and 5-35 cm. Whenever there was changing in soil color and soil texture along a profile, we separated the samples in different bags. For each depth, we made soils composites with the 25, 65 and 120 m sampling sites. In laboratory, the samples were sieved and separated in three sets for spectroradiometry, texture and chemical analysis. Dry and wet bulb air temperature also measured at 0-m for all transects. At 25, 65 and 120 m, soil temperatures at 5 cm, 15 cm and 30 cm depths were also taken. At the three sites of each transect, dry soil color using Munsell chart and root distribution by sieving the soils were also obtained. Soil root sampling was done only in Brasilia sites.

A 45 cm x 45 cm square were used to sample biomass. There were 9 biomass samples (three samples for each transect) were obtained in Brasilia. In Palmas, 4 biomass samples were obtained: 2 samples in CA and 2 samples in SA. In laboratory, dry and green biomass were separated in order to obtain green/dry biomass ratio. All green matters were photographed using a white background with 50 cm x 66 cm size.

LAI-2000 and an Accupar ceptometer were used for LAI and fAPAR measurements. LAI measurements were obtained in early morning; fAPAR measurements were obtained around noon. At the first 100 meters, measurements were taken at 2-m interval; after 100 meters, measurements were taken at 5-m interval.

ASD airborne or ground top-of-canopy reflectances were obtained whenever weather conditions allowed. For airborne data, the ultra-light was used to fly over the BNP, AE, CA and SA sites. Soil and litter pure spectral signatures were also obtained from collected samples. A great amount of time was spent for plant tissue reflectance measurements. The Sun photometer was set up 8 days in Brasilia to be used for atmospheric correction.

Site Characterization was conducted to identify species higher than 30 cm along 10 m perpendicular to the main transects. Along the transects in Brasilia, Palmas, and one pasture transect in Santarém, percent cover components were measured by using the pin-point method. The measurement was taken every 20 cm for the first 100 meters in each transect and 1 meter interval for 100 – 250 meters. The canopy structure parameters were obtained for the measurements. Additionally, vertical pictures were obtained every 5 m. Panoramic pictures were also obtained every 50 meters (north and south directions).

Results

The moisture content and bulk density values of the sampled soils varied over the landcover types. In BNP and AE, bulk density of shrub cerrado, wooded cerrado, cerrado woodland and cerrado grassland soils ranged from 0.7 to 1.1 g/cm^3, while soil bulk density of RJ pasture transects were higher, 1.30 to 1.39 g/cm^3. At the Santarém transects the soil bulk density ranged from 0.72 to 1.29 g/cm^3. It was also found that soil moisture content was high in forest (31 – 42%) and in cerrado (20-26%) covers and low in pasture sites (12-17%). Furthermore, the soil colors were different along the eco-climate transect.

LAI values for grassland and pasture sites vary from 0.57 to 1.13 while PAI values varied greatly between and within landcover types. The overall total PAI values were twice as high in the gallery forest as the cerrado woodland. Total fAPAR measurements were very similar for pasture and cerrado sites (0.506 to 0.724), with the exception of a recently burned pasture (0.356). In contrast gallery forests had much higher total fAPAR ranging from 0.934 to 0.966. From the results, expected curvilinear relationship of PAI and fAPAR over the entire set of land cover types measured was found and nicely included all landcover types. (Fig.1)

From the cover component measurements, percent green cover of understory in cerrado sites were lower than woodland in Palmas. The total vegetation of the treatment pasture site was higher than pasture without fertilizer. In CA, the 3-year pasture had the highest total vegetation and green cover than 1-year and 8-year pastures. Overall, percent NPV was high in grassland and pasture sites. NPV percentage decreased from cerrado landcover type in Brasilia to Palmas, to forest in Santarém.

MODIS VI products were utilized for seasonal and spatial pattern analyses especially in the Brasilia site. The seasonal pattern of cerrado was well pronounced with distinct dry and wet seasonal trends (Fig.2). However, from visual observation, it was difficult to discriminate cerrado types due to their similar seasoned behavior. However, one can note the sharper seasonality of the more herbaceous shrub and grassland communities (BNPsc, AECG), relative to the more woody cerrado types. The gallery forest (BNPGF) exhibited the least seasonality.

Plots of field measured percent green cover were correlated with the NDVI and EVI extracted from the MODIS composite data over the period of the field campaign (Fig.3). However, there is only slight sensitivity with a small range of VI values depicting a large range of percent green cover values. This was also found in a study by Ferreira et al. (2002) in which he noted slight differences in VI values among the cerrado physiognomies despite a large range of "greenness" conditions. We suspect that simultaneous changes in green cover along with canopy height, structure, shadow, and soils play a role in these VI-biophysical relationships and we plan to include soil optical data and canopy models for a more thorough analyses. Therefore, investigating and analyzing the soil characteristics and remaining biophysical properties with vegetation photosynthetic activity will be carried out further.

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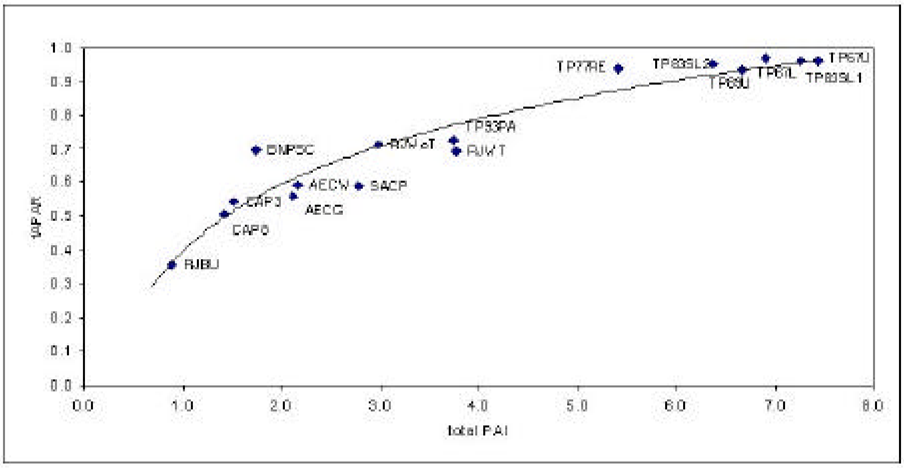

Figure 1 Relationship between LAI and fAPAR of all measured landcover types

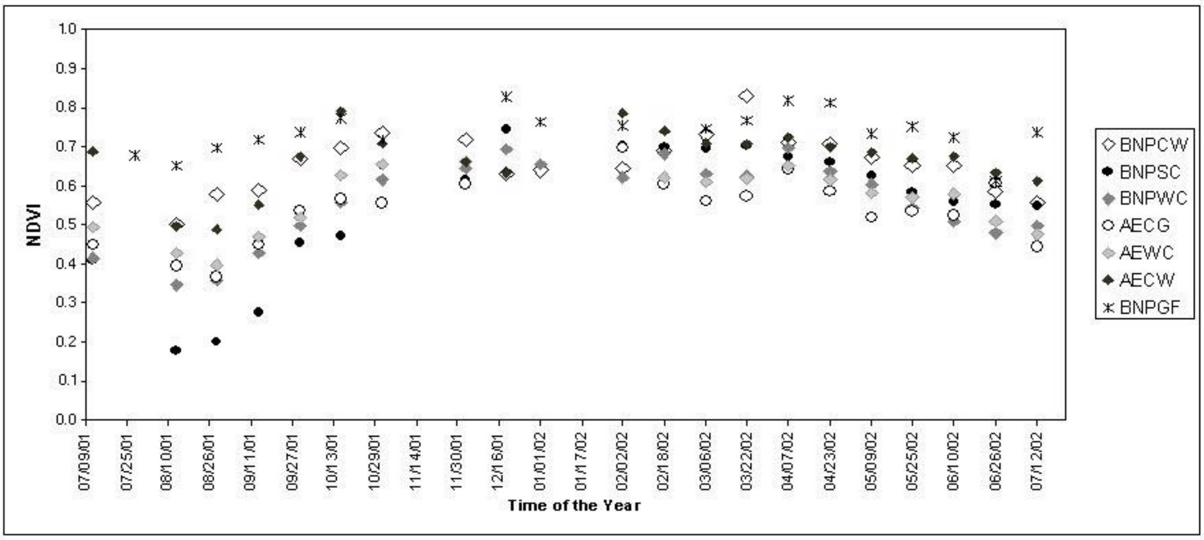

Figure 2 MODIS NDVI Seasonal pattern of cerrado landcover type in Brasillia

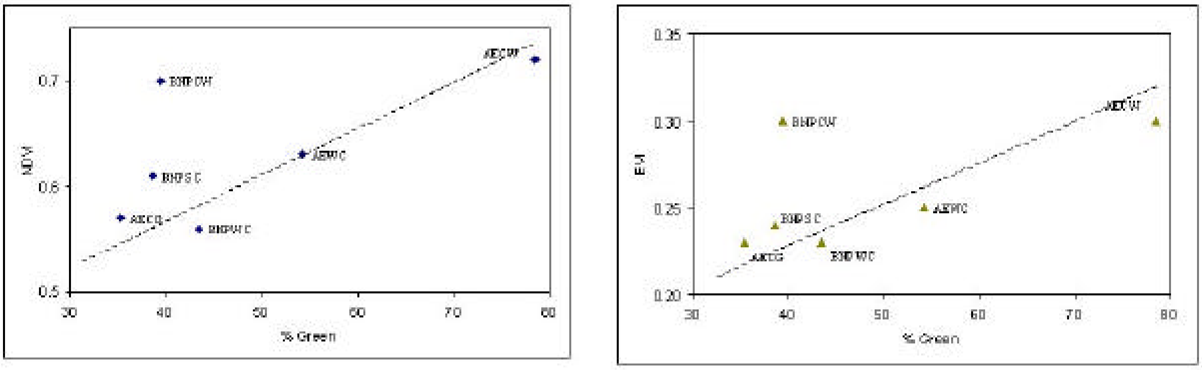

Figure 3 Field measurements of green cover fraction with 10 June 2002 NDVI and EVI composites in Brasillia sites

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