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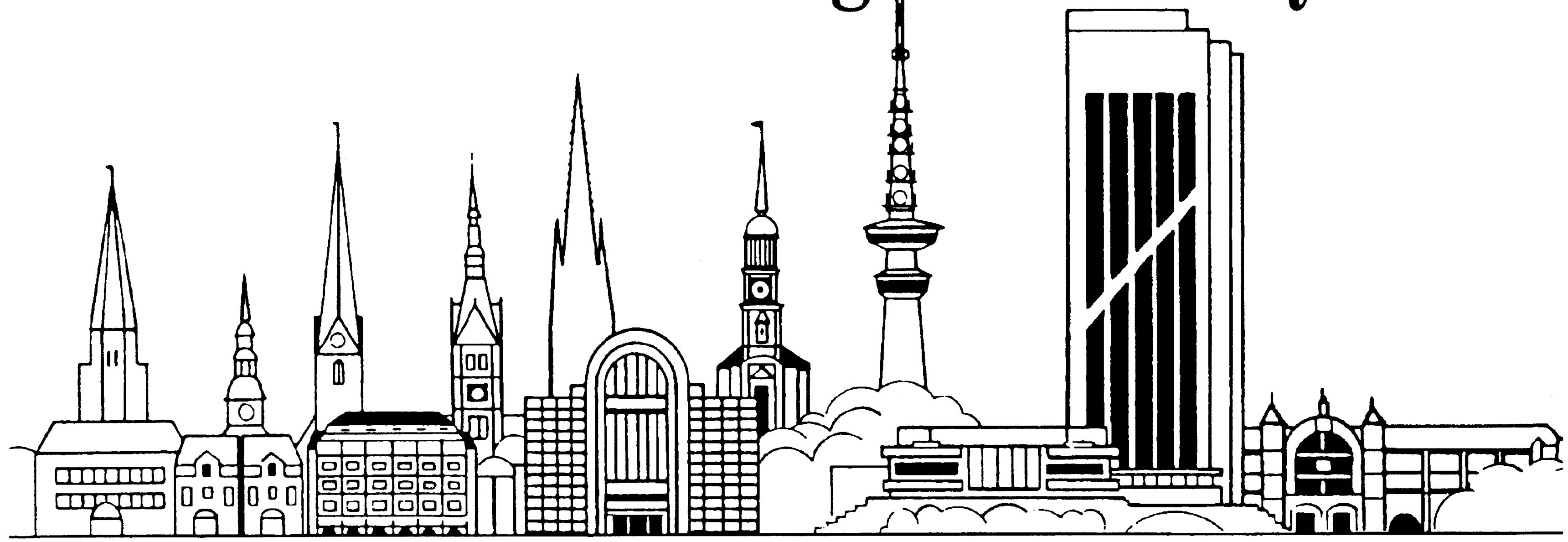

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SESSIONS

GETTING STARTED

AUTHORS

The use of microwave and optical data for estimating aerial biomass of the savanna and forest formations at Roraima State, Brazil

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ABSTRACT

The objective of this study is to analyze the behavior of forest and savanna biomass with respect to backscatter signals of radar image and spectral parameters of optical data, using a multiple regression model. It is also discussed briefly the approach and results of generation of fraction-image "vegetation", "soil" and "shade" derived from a linear spectral mixture model applied to TM/Landsat image. The shade component is the variable with the highest coefficient of correlation to biomass, for forest and savanna types, but once this component is present in the regression model, the backscatter variable does not contribute significantly to explain biomass.

Keywords: Tropical rain forest, Savanna, Biomass, JERS-1 data, TM/Landsat data, Amazonia, vegetation inventory.

INTRODUCTION

Monitoring of the contact zones with Tropical rainforest/Savanna formations in Brazilian Amazonia is an important task nowadays. The results of forest inventory and landscape monitoring is a strong support for a more accurate analysis of global changes and biodiversity studies. The present study is part of a larger proposal to study biomass distribution using JERS-1 and TM/Landsat images in transition zones between both formations. Within this context, the objective of this study is to analyze the behavior of biomass from these vegetation types referring to backscatter signals of radar and spectral parameters of the optical data, using a multiple regression analysis. Furthermore a physiognomic-structural characterization of forest and savanna is made and the biomass presented, taking into account men induced actions in the landscape.

AREA UNDER STUDY

The test site is located at central-north Roraima State (Brazil), geographical coordinates 2° 30" to 2° 50" N and 61°00" to 61°30" W, representing a zone of abrupt changes between both physiognomic formations. The climate of this region, according to Köppen, is of type Awi, presenting a tropical rain dominance and a well defined dry season, with an average yearly rainfall of 1,800mm.

DATA ACQUISITION AND METHODS

JERS-1 amplitude image of path/row 419/296, May 31st '96 was obtained from NASDA through an agreement with INPE, to perform this study. A TM/Landsat image at bands 1 to 5 and 7, referring to path/row 232/58 from January 17th '96, was used as a complementary source of information. Both scenes were processed by software packages ENVI version 2.6 and SPRING version 3.2 . The TM scene processed by a linear spectral mixture model became the data base to identify land use/land cover classes and to establish the sample areas to collect field data. The TM image was merged to JERS-1 scene, and when the error of fitting was less than 1 pixel, it was considered adequate to extract the backscatter signals from this radar scene, from previously selected sample areas, considering the following equation [2]:

$\sigma^o = 10 \log_{10} \{ (\sum DN^2) / n\} + CF$ where, DN = digital number of a pixel (16 bits), n = number of pixel of the sample area, CF = offset calibration factor (-68.5 dB).

The TM fraction-images (proportions of vegetation, soil and shade) and backscatter values have been used to define the spatial attributes of each class (primary forest, secondary succession, grass/ and shrub savanna, park savanna) and a multiple regression analysis was performed. The biomass is the dependent variable (y) and the spectral-textural parameters are independent variables. During the field survey, dendrometric parameters (DBH and height) were measured to estimate biomass of forest formations by allometric equations (18 sample areas). The biomass of savanna types at 21 sample areas, was estimated by clear cutting and weighting the wood and the foliar material of different strata [4]. Statistical tests using linear and multiple regression models were used to understand the relationship between biomass values and those values obtained from orbital data.

RESULTS

At the test site the contact zone between both formations is abrupt; it was necessary to compare separately each formation and its' relation to optical and radar data (Fig. 1). The analysis of these datasets showed that the shade component is the variable that best correlates to the biomass for both formations. In the multiple regression for forest formation, with "shade proportion" (%shade) and backscatter (dB) being the independent variables, the model for biomass estimation presents a coefficient of determination of 0.7834. The estimated equation is: **Biom = 130.48 + 19.79 (dB) + 1.17 (% shade)**. The coefficient of the backscatter variable is not significant (t = 0.91), and when only the shade proportion is used in the regression model {**Biom = -47.11 + 1.38 (% shade)**} , the determination coefficient is 0.7714, showing that JERS-1 backscatter does not contribute significantly for biomass estimation once the other variable is already in the model (Fig. 1a). However, in case TM data is not available, and only the backscatter is used to explain biomass, its coefficient is significant (t = 4.57), and the determination coefficient is 0.57 at the model (Fig. 1b). Almost the same conclusion is valid for savanna formation (Fig. 1c,d), with the backscatter variable not contributing significantly for biomass estimation. The regression with only shade proportion is however poorer (r^2 = 0.2276). Using only the backscatter variable, the regression is not significant at 95% level.

The primary forest has backscatter values of – 7.62dB, while at regrowth areas they are around – 8.27dB. The spatial attributes of the savanna formations, referring to backscatter, are between –14.85 to –11.89 dB, which distribution is directly related to increase in the density of arboreal/shrub strata, and consequently of the biomass. These backscatter values are similar to those found in others studies at Amazonia [1], [3] and [4]. Based on these backscatter datasets, becomes evident the possible contribution of L band (~23cm) to delineate areas of primary forest, regrowth and savanna. However, the variations of the radar backscatter within each class does not allow any intra-class.

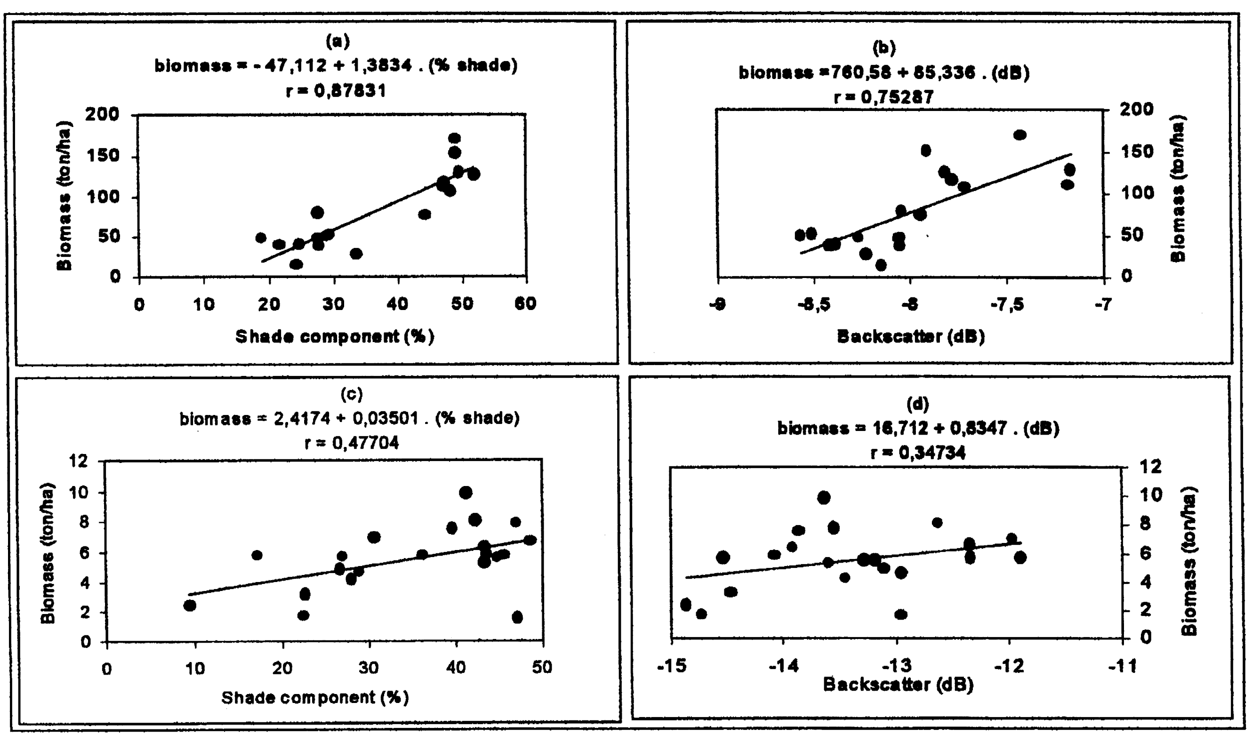

Figure 1. Relationship between biomass and shade component or backscatter to forest (a,b) and savana (c,d) formations

The general information given above, allow the following commentaries: a) the low performance of JERS-1 to estimate biomass of primary and secondary forests is due to saturation of the L band signal for values above 100 ton/ha [1], [4], the structural complexity of branching of individuals and diversity of floristic composition and growth. This explains that there is no direct relationship between backscatter and biomass increase; b) the no significant performance of JERS data to discriminate physiognomic variations of savanna due to the vegetation cover has a low height, with occurrence of bush/arboreal individuals sparsely distributed and the vegetation that is strongly influenced by the water content in the soil and that consequently presents a low biomass volume (variation of biomass 35%).

For the case of TM/Landsat scene, the fraction of "vegetation", "soil" and "shade", considered at the smallest image resolution element, are some of the parameters which are determinant for the response at optical data, associated to the variation of vegetal structure and soil conditions. The spatial attributes of these components for each vegetation class can explain the response of forest and savanna formations at an abrupt contact zone (Fig. 2). Those areas of secondary succession have a lower content of shade if compared to primary forest due to an equal growth of pioneer species, with a more regular canopy, at the succession process. Nevertheless, in both cases there is a higher proportion of the vegetation component over the other fraction-images. With the advance of the succession process, there are spectral/textural changes that are characteristic of this vegetation cover. As for the savanna areas, there is a strong response from the soil component, due to a low grass/bush coverage. This is specially true for the dry season, when there is a low photosynthetic activity and a high soil exposition rate.

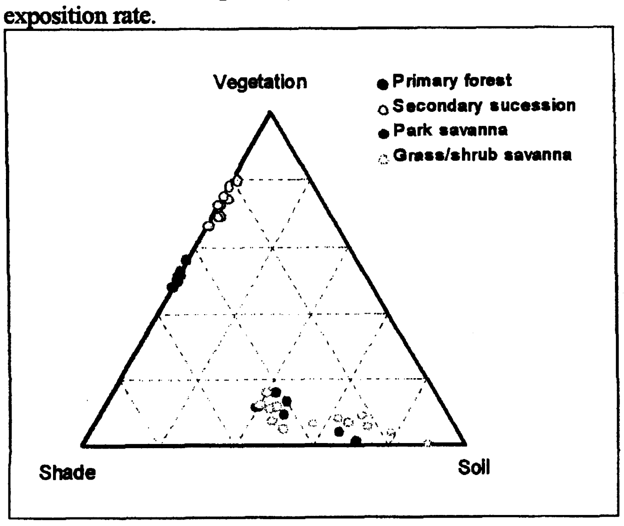

Figure 2. Diagram of vegetation, soil, and shade proportions from a spectral mixture model for forest and savanna types.

CONCLUSIONS

In the abrupt contact zones studied, the presence of the variable backscatter in the multiple regression, when variable shade is included in this model, there is no significant contribution to biomass estimation. Using solely JERS-1 data, the borders of forest and savanna formations can be mapped, but it is not able to discriminate subtle features intra-class. However, data merging of JERS-1 and TM/Landsat to discriminate forest and savanna features improves information for inventory and monitoring purposes.

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