INTERACTIVE ANALYSIS OF POLARIMETRIC SIR-C AND LANDSAT-TM DATA FOR THE SPECTRAL AND TEXTURAL CHARACTERIZATION OF THE LAND COVER IN SW AMAZONIA, BRAZIL

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ABSTRACT

The objective of this study, is to analyze SIR-C, L-band data at several polarizations, combined with TM-Landsat data, to chracterize land use/land cover features in SW Amazonia (Acre State, Brazil). Segmentation techniques of TM-Landsat and textural classifiers for SIR-C were used for the identification of six land use/land cover classes. The spectral and textural characteristics of forest, regrowth and pasture types are briefly discussed. This interactive analysis of the optical and microwave sensor data will certainly contribute to monitor the dynamics of land use in Amazonia.

1. INTRODUCTION

In the frame of studies related to global change, there is a need to monitor tropical forests, not only to estimate the yearly deforestation rate, but also to follow the dynamics of land occupation by man. The frequent cloud coverage in certain tropical areas made data collection with optical spaceborne sensors an impossible task. Imaging radar offers the potential to map vegetation and land use classes in such areas, because its' independence of weather conditions.

A cooperation program between the National Brazilian Institute of Space Research (INPE) and the German Aerospace Research Establishment (DLR) is under development, with the objective to evaluate the capabilities of Remote Sensing techniques to control the environmental impact of deforestation in Amazonia and to map rainforest formations and land use (Keil et al., 1995). As a result of this cooperation, the main objective of the present study is to evaluate the spectral and textural capabilities of SIR-C (Shuttle Imaging Radar) data at different polarizations (HH, VV, HV, LL and Total Power), specially at L-band, to characterize the changes of land cover in a section of West Brazilian Amazonia, in Acre State. An interactive analysis of Landsat-TM data, using the six optical bands, was also performed to identify the main land cover units along the Rio Branco-Sena Madureira road (Acre State).

2. AREA UNDER STUDY

The area under study includes a section along the road Rio Branco - Sena Madureira (BR-364). This area is covered by different tropical vegetation formations and disturbed areas like pastureland and natural secondary succession. Since the opening of the BR-364 in the early 70's, large deforestation activities took place, mainly for cattle raising activities, but also for colonization projects. In the last few years, since the suspension of governmental incentives, the speed of forest clearance decreased. According to Santos et al. (1994) the annual rate of gross deforestation in Acre State in the timeframe 1991 to 1992 was of about 327 km^2, and it is believed that this value is valid until today, due to the strong environmentalist pressure. The plantation of pasture, the improvements obtained in burning and logging, as well as the vegetal successions of deforested areas, strongly influence the equilibrium of the ecosystem in SW Amazonia.

3. MATERIALS AND METHODS

The main database of reference were Landsat TM images, bands 1 - 5 and 7, from July 1994. A SIR-C dataset of the April '94 Mission was used. The SPRING software package, developed at INPE, as well as EBIS, from DLR, were used. In July 1994 a field survey was performed with assistance of the Technological Foundation of Acre (FUNTAC) and University of Acre (UFAC). During the field campaign, several land use classes were observed, and several vegetation profiles (arboreal and bush individuals along sections of 60 m x 2 m size) were made at natural vegetation regrowth including: the description and collection of flora composition, DBH above 3 cm, total height, percentage of crown cover. In this study, the general allometric equation for secondary forest,

$$\ln Y = -2.17 + 1.02 \ln (\mathbf{DBH})^2 + 0.39 \times \ln \mathbf{Height}$$

according to Uhl et al. (1988), was used to estimate the biomass values, mainly of regrowth areas. An overview of the entire area, as well as 35 mm photos were obtained during an overflight.

The TM images were analyzed considering the following steps: atmospheric and geometric corrections, image segmentation based on the algorithm for the growth of regions (similarity threshold = 6; area threshold = 10); labeling of segment samples of thematic classes: Forest (F), Initial (IR) and Intermediate (AR) Regrowth, Overgrown Pasture (OP), Fresh Pasture (FP), Pasture with Bare Soil (PS); application of the ISOSEG Classifier; and generation of a thematic map. The SIR-C data were analyzed according to the following procedure: speckle reduction filtering (MAP filter) and merging of SAR data at different polarizations (HH, VV, HV, LL and Total Power) with TM images, application of a new version of the EBIS texture classifier (Evidence Based Interpretation of Satellite Images, developed at DLR) and also plotting of the mean backscatter values as a function of wavelength and polarization for each land cover identified, and generation of a thematic map. EBIS is a algorithm used for classifying textures, based on co-occurrence feature vectors, that are modeled as multinomial density functions (Lohmann, 1991). Additionally to the classes mentioned above, for the SIR-C data, the floodplain forest (V) was included.

4. RESULTS

Figures 1 and 2 are histograms showing the behavior of land use classes at both SIR-C/L-band and TM-Landsat data. In the signature plots of these figures, the original data have been used in association with the variance values of the training areas. The combination of bands TM 3 and 5 present the best performance, as compared to the other bands for the general discrimination of the set of thematic classes, i.e. discrimination of forest, regrowth and pasture areas. During the thematic classification, we could observe that TM images alone did not allow the discrimination of "Terra Firme" (Uplands) from "Várzea" (Floodplain) Forests. In contrast to that, L-band images, due to the several polarizations available and textural characteristics, allowed a very good discrimination among these two important forest types. It is known that it is possible to separate different forest types as well as logged forest using texture information, and in this case, the different moisture and relief conditions of these two environments, are the main reasons for its' discrimination.

Regrowth areas are best discriminated with TM band 4 data, in the succession "Initial" and "Intermediate", while SIR-C/L-band data does not allow this discrimination. The same finding applies for the discrimination among "regrowth" and "overgrown pasture" classes. For the identification "initial" regrowth and overgrown pasture, TM band 3 was a better indication. The misclassification in SIR-C data (L band) is mainly due to larger amounts of shrubs and palms, like *Maximiliana maripa* and *Orbignia martiniana,* which abound in these former pastures and lead to higher backscatter values (sometimes as corner reflectors) as well as to texture variances.

For the discrimination among "pasture with bare soil" and "fresh pasture" classes, the L-band image presented a similar performance as TM-Landsat data. The soil type and the physical-structural conditions are also an important factor for this discrimination analysis.

Generally, optical sensors are most sensitive to plant structure at micrometer scales, whereas radar interacts mainly at centimeter scales. Of special interest to radar are the vertical stems of plants and the trunks of trees, because wave propagation and backscattering through these media are polarization-dependent (NASA, 1989). Being so, the different polarizations provide different views of the canopy's structure. From another overview, Figure 1, shows that the HV polarization of L-band is more sensitive to the vegetation growth and it is appropriated for land occupation/management studies.

As far as backscattering from vegetated surface is concerned, three scattering components must be considered: vegetation, soil and also the interaction component of the L-band data studied here. Leaves and stalks of vegetation are relatively transparent to radiation and so the significance of the soil and the interaction component predominate. The variability found in the sample areas in each of the thematic classes of L-band data, shows a certain sensitivity of this sensor to the horizontal and vertical polarizations, but a lower sensitivity to Total Power (TP) polarization.

Taking into account the actual interest of the scientific community on specific studies of regrowth areas, it is to say that at these areas, the contribution of the horizontal polarization is moderately higher than the vertical one. The first one is of interest to define parameters such as the spectral and textural amplitude of the physiognomic-structural variations of secondary succession areas (Figure 3). Considering the vegetation data inventoried g the field survey and using the allometric tion mentioned, a regrowth value of 128,09 ton/ha calculated, which can be considered as typical for e areas at intermediate stage, taking into account the d management conditions. For initial regrowth the t was 45,78 ton/ha, which refers to areas that red normally 2 clearcuts. At this "initial" phase, the owth is characterized by a canopy with thin icillate branching and horizontal crowns, in vertical ction and horizontal crowns on two well-defined a. In the lower stratum there is a higher concentration herbaceous species, normally with large leaves. At the ermediate regrowth", the canopy is more ogeneous with large crowns, with at least 3 not well ed strata. The lower stratum here is frequently sing, including species that present a higher tolerance shadow. Presently there are more detailed studies ing made in this direction, including the association ong biomass content and textural information of R-C/L-band, merged with TM-Landsat data.

5. CONCLUSIONS

Within the objectives of this study, it was verified that the segmentation technique for region growth is an adequate way to separate at TM-Landsat scene the land use/land cover classes. These classes are spectral and textural information sources at the interactive process of image classification. After a certain similarity threshold is adopted, the sensitivity of this segmentation algorithm would be useful for the identification of thematic classes from SIR-C, L-band data. Based on that, it is possible to analyze the contributions of textural information for the different polarizations, associating the amplitude of radiometric variations with the physiognomic-structural characteristics of the targets under investigation. The experience obtained in this study indicates that, in order to obtain an improvement of the thematic classes studied, multiseasonal radar data must be used to monitor the phenological conditions of pasture, regrowth areas and some types of tropical forests. The option for textural classification of the EBIS version in the image processing environment was considered as adequate for the analysis of radar data.

6. REFERENCES

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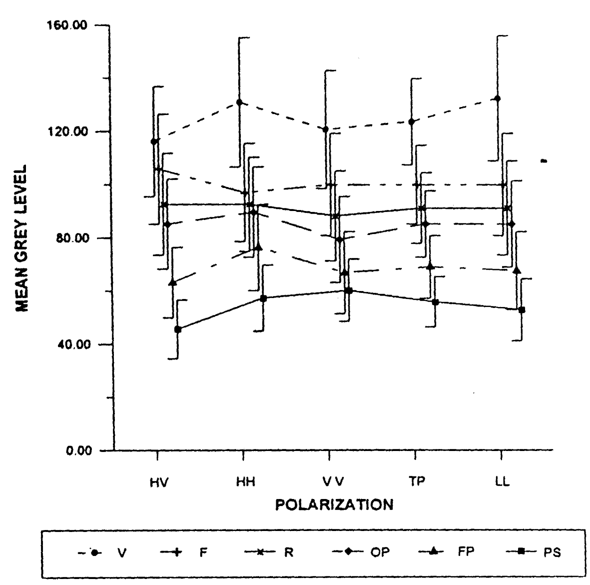

Figure 1 - Histogram of land use/land cover classes for the different polarizations of SIR-C/L-band.

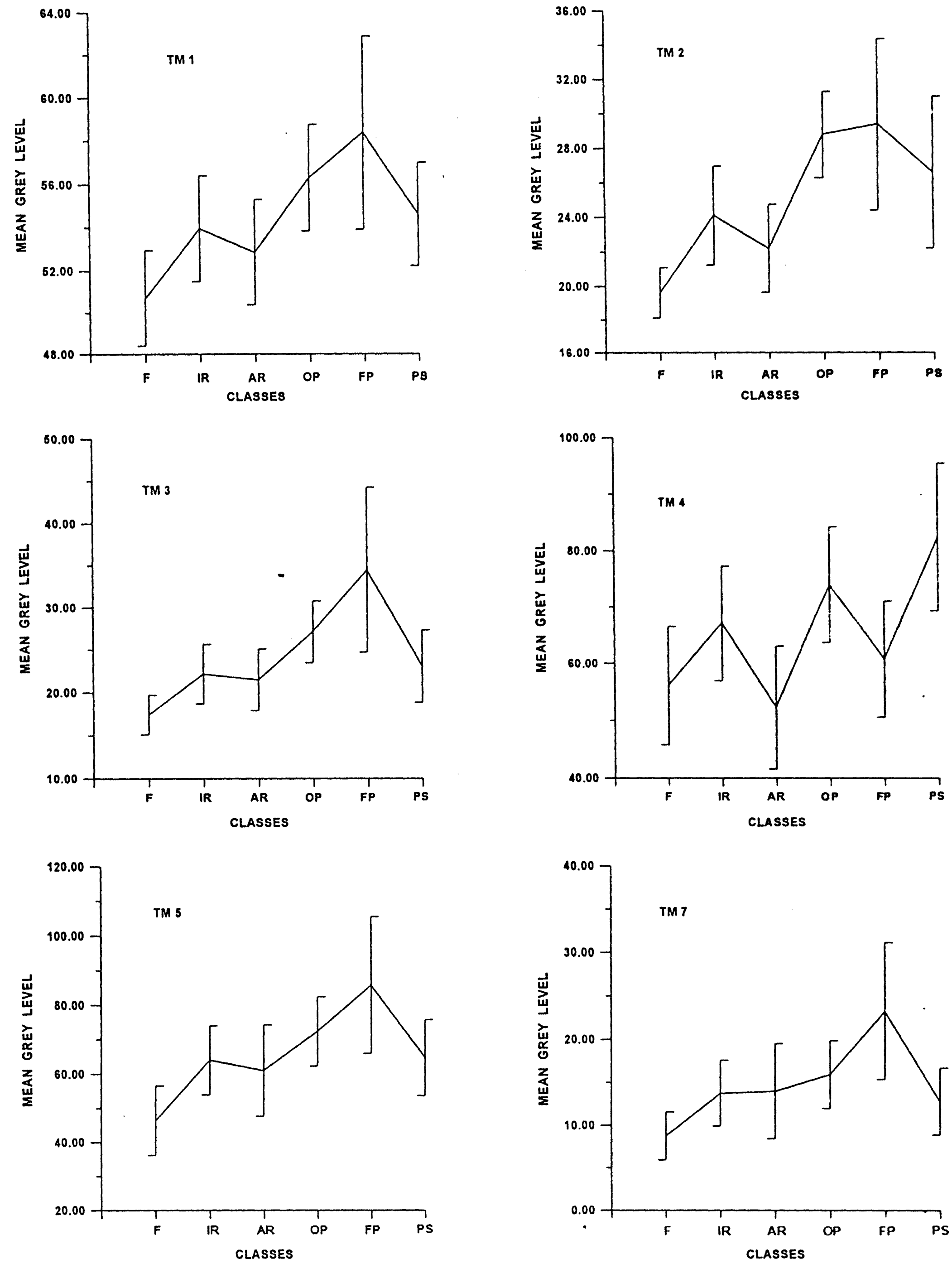

Figure 2 - Spectral responses for land use/land cover classes in the section Rio Branco - Sena Madureira. Forest (F), Initial Regrowth (IR), Intermediate Regrowth (AR), Overgrown Pasture (OP), Fresh Pasture (FP), Pasture with Bare Soil (PS).

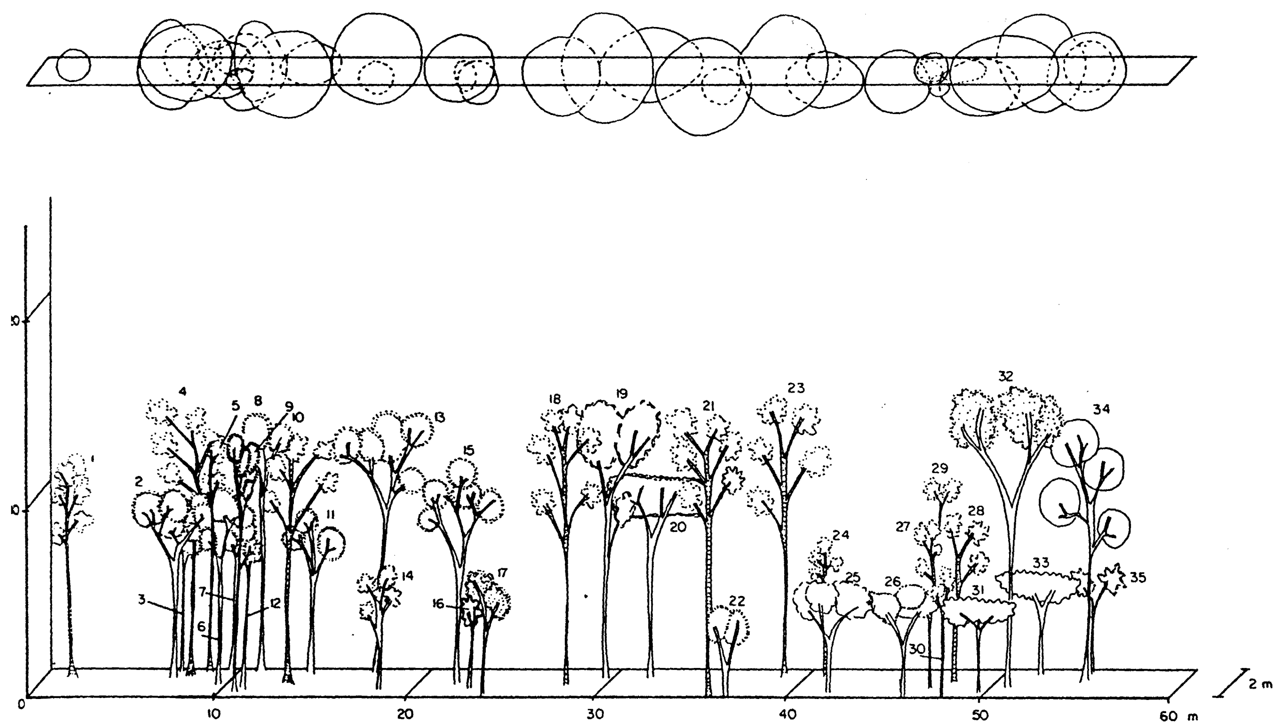

Figure 3 - Intermediate regrowth profile at a section close to road Rio Branco - Sena Madureira. 1) *Cecropia leucocoma*; 2) *Apeiba echinata*; 3) *Apeiba echinata*; 4) *Cecropia leucocoma*; 5) *Cecropia leucocoma*; 6) *Apeiba echinata*; 7) *Apeiba echinata*; 8) *Apeiba echinata*; 9) *Guadua sp.*; 10) *Cecropia leucocoma*; 11) *Apeiba echinata*; 12) *Sapium sp.*; 13) *Apeiba echinata*; 14) *Cecropia sp1*; 15) *Apeiba echinata*; 16) *Rollinia sp.*; 17) *Sapium sp.*; 18) *Cecropia leucocoma*; 19) *Sapium sp2*; 20) *Urtica sp.*; 21) *Cecropia leucocoma*; 22) *Piper sp.*; 23) *Cecropia leucocoma*; 24) *Cecropia leucocoma*; 25) *Vismea guianensis*; 26) *Inga sp.*; 27) *Cecropia leucocoma*; 28) *Cecropia leucocoma*; 29) *Cecropia leucocoma*; 30) *Cecropia leucocoma*; 31) *Acalipha sp.*; 32) *Sapium sp1.*; 33) *Acalipha sp.*; 34) *Zantoxyllum rhoifollium*; 35) *Inga sp1.*