MINISTÉRIO DA CIÊNCIA E TECNOLOGIA
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

ANALYSIS OF ALOS/PALSAR POLARIMETRIC SIGNATURES AND SCATTERING MECHANISMS OF FOREST TYPES IN TAPAJÓS REGION, BRAZIL

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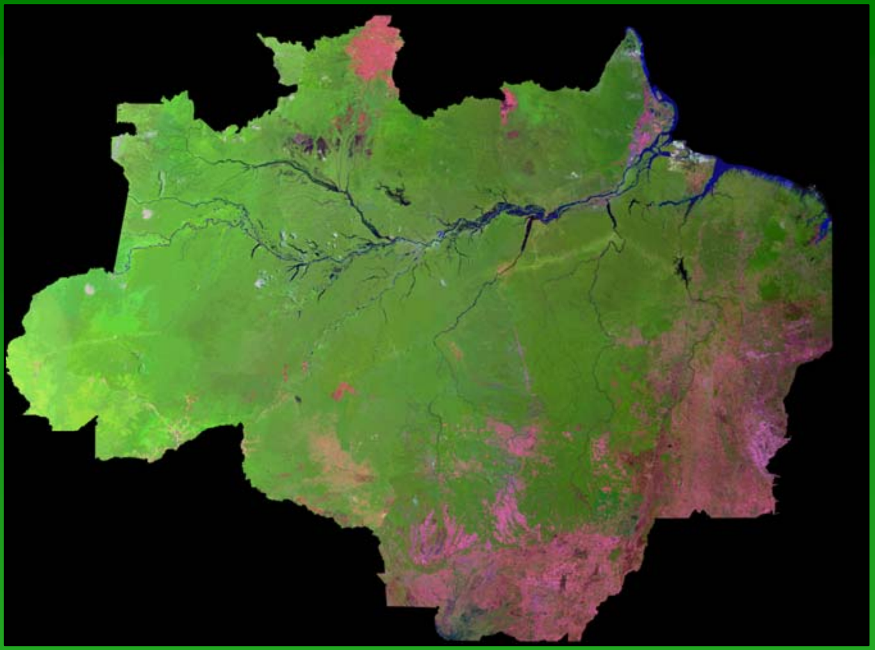
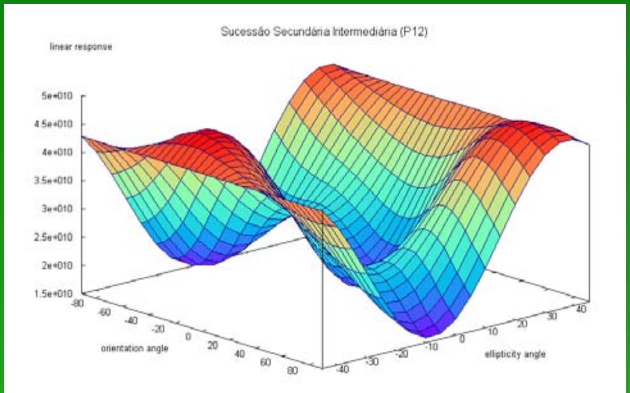
1. INTRODUCTION



Gross deforestation rate = ~11,000 km^2 / year

Due to the increase of economic activities in Amazon tropical rainforest, remote sensing is becoming a fundamental tool to characterize the causes of degradation (conversion of forest to agriculture and cattle raising, selective logging, charcoal production, etc.), but also to make a forecast model to preview the impact of human activities over these large and fragile ecosystems.

2. OBJECTIVES



to analyze the graphic representation of polarimetric signatures of PALSAR data (L-band) in primary forest, secondary succession (initial, intermediate and advanced levels of recovery) and forests with timber exploitation.

to make an exploratory analysis of scattering mechanisms of tropical forest typology in accordance with the alternative procedure of SAR image classification based on target decomposition.

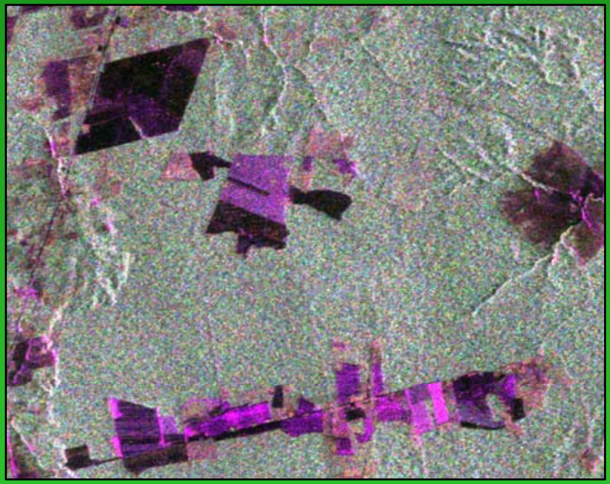
3. STUDY AREA

Tapajós region (NW Pará State, Brazil);

- low rolling relief;
- dominated by Dense and Open *Ombrophilous* Forests;
- land use: few cash crops, cattle raising and selective logging activities.

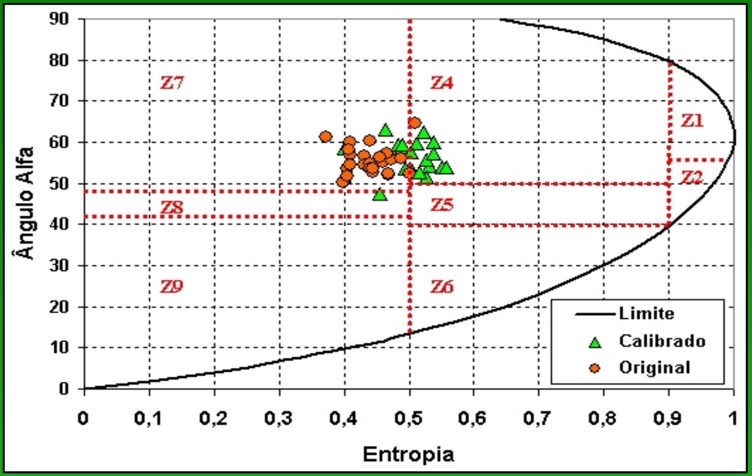
4. METHODOLOGICAL APPROACH

At this study we used the ALOS/PALSAR polarimetric images (HH, HV, VH and VV), ascending mode, acquired in April 23rd 2007, with a spatial resolution of 4.50m in range and 9.50m in azimuth and incidence angle 24.333º.

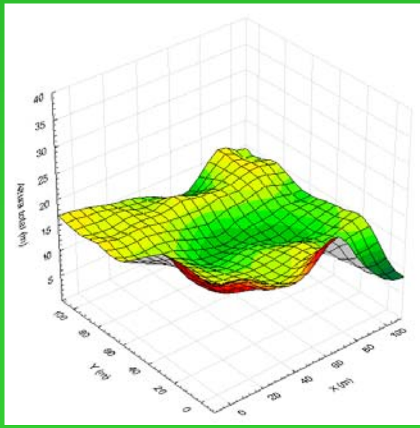


1°step: At the first analysis, a graphic representation of the parallel polarization response of five forest typologies was generated. The cross section of a certain type of forest cover (σ) is plotted on a tri-dimensional graphic, as a function of all combinations of orientation angles (ψ) and ellipticity (χ), related to the polarization ellipsis. In order to construct a polarization response of a given ROI at the SAR image, we used a mean value, at the complex format of all pixels.

2°step: At the second exploratory analysis the entropy values and the mean alpha angle (resulting from the decomposition of eigenvalues and eigenvectors of the coherence matrix) of the same ROIs were plotted in the bi-dimensional spatial classification. This procedure allowed the target classification and it is possible to investigate the scattering mechanisms of forest typology at 9 specific zones.



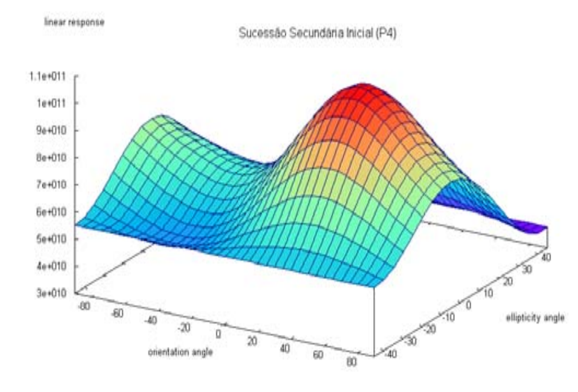
3°step: After the inclusion of the SAR response of each ROIs into the $(H,\overline{\alpha})$ bi-dimensional spatial classification, a statistical test based on a linear regression model (F test of $b_1 = 0$ versus $b_1 \neq 0$; t test of $b_0 = 0$ versus $b_0 \neq 0$; and t test of $b_1 = 1$ versus $b_1 \neq 1$; b_0 , was applied to verify the existence of significant differences between classifications (combination of all possible pairs of classification derived from each ROI).

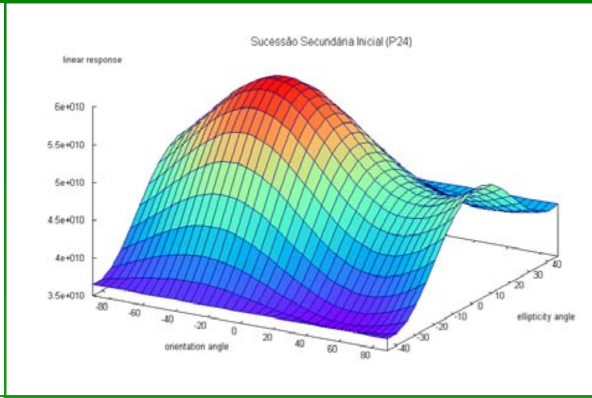


Forest inventory

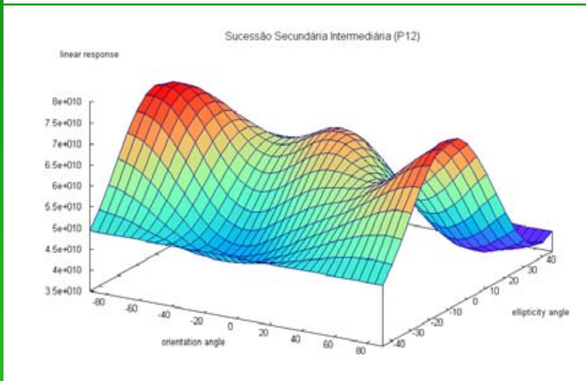
4. RESULTS

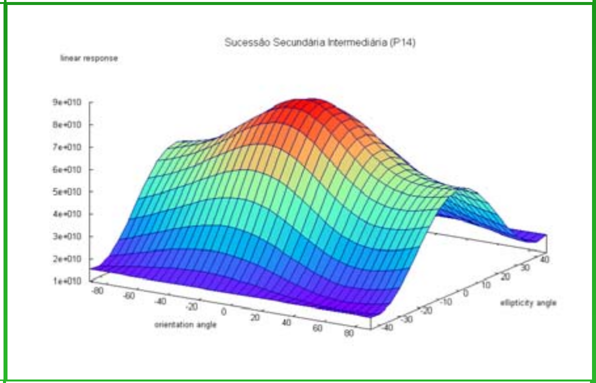
Initial Regrowth



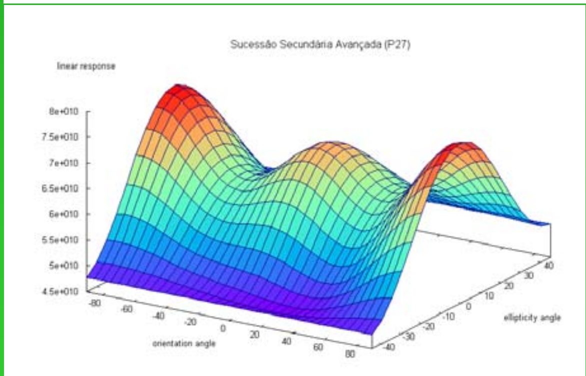


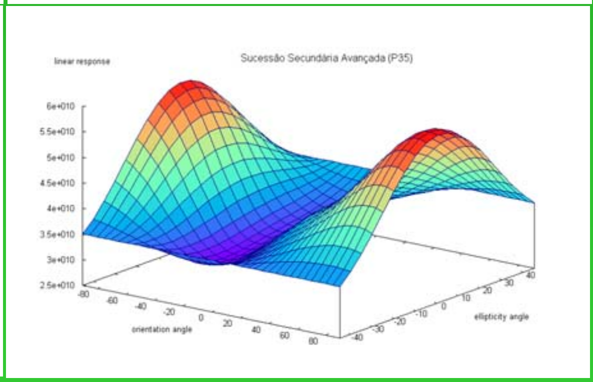
Intermediate Regrowth





Advanced Regrowth

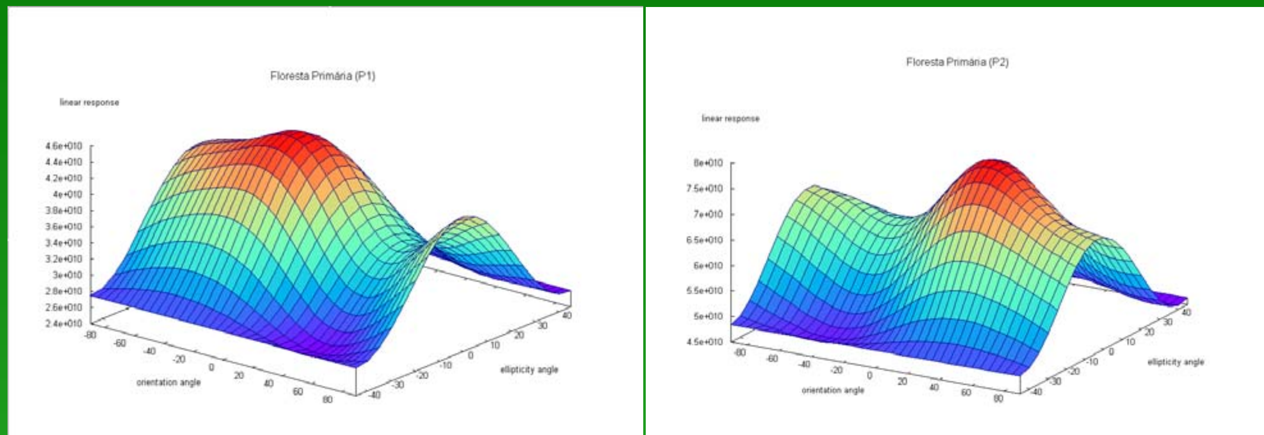


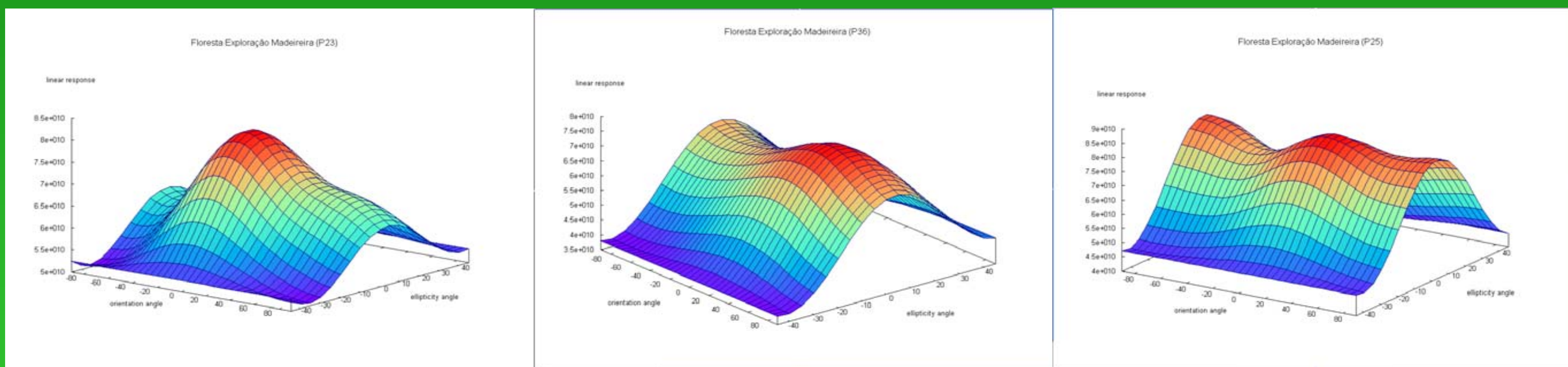


The co-polarization responses of regrowth show a similarity to the theoretical characteristics of short and thin conducting cylinders (i.e. rays at shorter lengths than the **λ**). This suggests that the scattering by small branches is an important contribution for the backscattering of these types.

4. RESULTS

Primary Forest

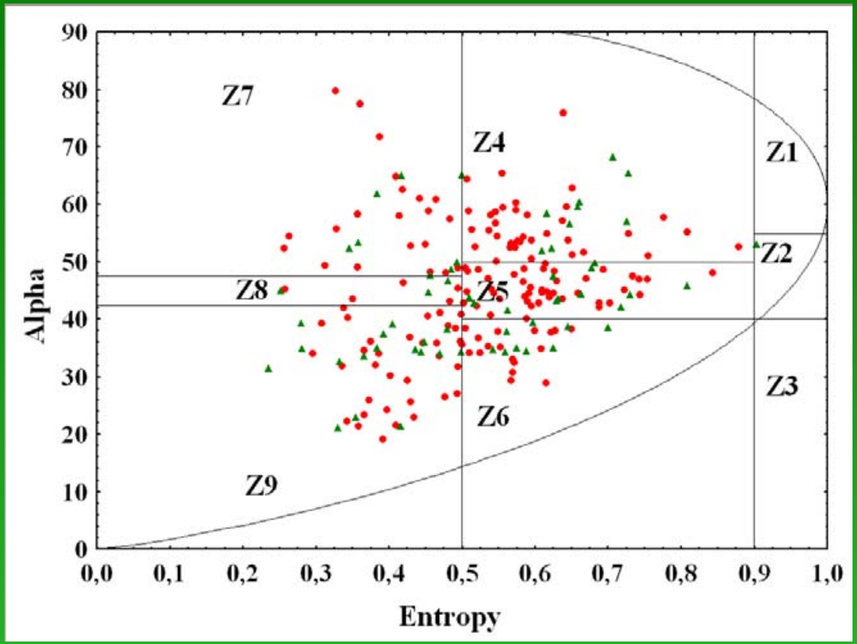




Forest with Selective Logging

Section P23 (selective logging) presents most diffusers oriented vertically ($\psi = 0^{o}$);

The highest pedestals occur at PALSAR co-polarized signatures of secondary succession if compared to those of forest areas, at the contrary what we expected. At the studies of tropical zones it was observed that a higher age, diversity of species and a stronger variability of forest structure, results at an increase of the pedestal size on the polarization responses.



L-band PALSAR α-H distribution for scattering mechanism: green color are pixels of primary forest, forest with old selective logging and advanced regrowth; red color are initial and intermediate secondary succession.

ROIs representatives of primary forest, forest with timber exploitation and advanced secondary succession, show a concentrated pixel distribution at zones Z4, Z5 and Z9;

The response of these classes (structure containing 3 or 4 strata) is based mainly on multiple and volumetric scattering at zones of medium entropy. Additionally, there is also some influence of a surface scattering but derived from a zone of low entropy;

The initial secondary succession is positioned in the low entropy (Z9) and also configured by double-bounce mechanisms (medium entropy multiple scattering – Z4), affected by the propagation of the canopy, as a result of the growth uniformity of pioneer species where there is a predominance of only homogeneous stratum.

ANOVA				
	gl			
Regression	1			
Residual	7			
Total	8			
	Coeficient	*St deviation*	*Stat t*	*P-value*
Intersection	0.889210	3.869940	0.22977	0.8248
X	0.919970	0.263440	3.49214	0.0101
			-0.3038	**0.7701**

	P-value	
CLASSES	**β0**	**β1**
PF / SL	0.6581	0.5479
PF / ASS	0.4317	0.2661
PF / IntSS	0.6793	0.5616
PF / ISS	0.6063	0.4988
SL / ASS	0.3293	0.1725
SL / IntSS	0.4301	0.2754
SL / ISS	0.8466	0.7983
ASS / IntSS	0.5085	0.3579
ASS / ISS	0.9092	0.8799
IntSS/ ISS	0.8248	0.7701

Low *p* values were observed which correspond to the largest differences found in polarimetric responses among pairs of ROIs, but they are not yet significant;

Since there are physiognomic-structural differences in forested targets (with or without timber exploitation) and those at younger secondary successional stages, one can infer that, at this significance level (5%), this classification procedure by target decomposition of the PALSAR data was not enough robust to detect such a variability.

5. CONCLUSIONS AND RECOMMENDATIONS

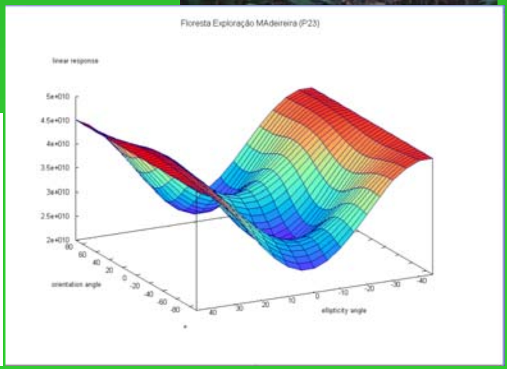
The analysis of polarimetric signature of PALSAR data and the classification by target decomposition, allow the following conclusions:

(a) at different forest types studied there is a predominance of scattering processes with medium entropy, with volumetric and multiple scattering, influencing mainly those structures formed by more strata;

(b) areas under natural recovery (initial or intermediate) present mechanisms of surface type (low entropy) and double-bounce affected by canopy propagation (medium entropy);

(c) the classification method by target decomposition based on entropy values and of mean alpha angle was not robust (significant level of 5%) enough to detect the floristic-structural variability existing among certain land cover classes.

more detailed analysis of trees arrangements and its proportions as dominant and co-dominant in the vertical structure must be done;



the analysis of PALSAR cross-polarized mode data is approach under development.

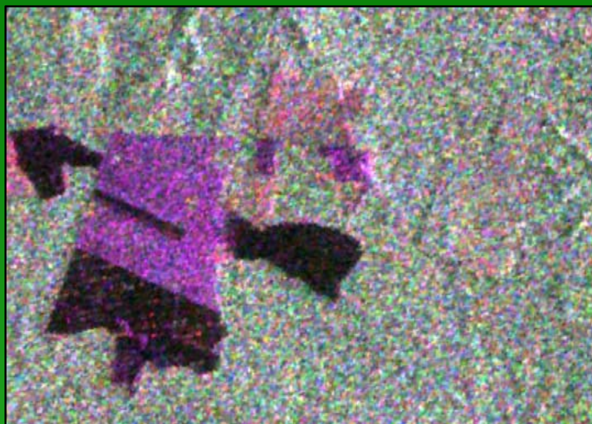
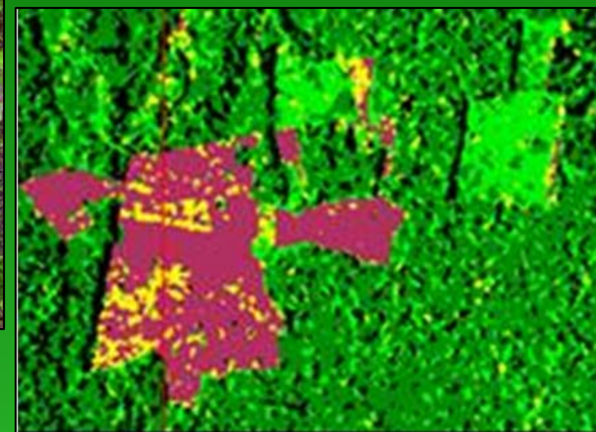


Imagem PALSAR / ALOS
Amplitude_HH(R)_VV(G)_HV(B)

Wishart _EM Classifier)



LEGEND

- PASTURE / CROP
- BARE SOIL
- RECENT DEFORESTATION
- SECONDARY SUCCESSION
- PRIMARY FOREST

Our interest to investigate the potential of PALSAR data in this stratification of forest typologies is to obtain a higher efficiency on thematic classification and modeling of biomass from the different land cover classes in tropical regions.