ERS-1 Multitemporal Backscatter Analysis of Different Types of Land Cover in Brazilian Amazonia

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Abstract - Three ERS-1 images acquired in 1992, 1993 and 1996 respectively, over the Tapajós National Forest, Brazilian Amazonia, were used and the results show that the pasture areas backscatter had a random behavior in all three images. Agricultural areas also had a random behavior in the three images, however their average backscatter was higher than the pasture average backscatter. The behaviors of regrowth at age ranged from 1 to 8 years affected by fire and regrowth at the same age but not affected by fire were different. Three different types of regrowth whose ages ranged from 9 to 15 years showed three different behaviors. Regrowths whose age vary from 18 to 22 years old showed behavior according to their previous land use. Three different types of primary forests also were analyzed and three different behaviors were found. This study shows that the previous land use can interfere in the multitemporal backscatter behavior of the land cover, and it was also inferred that multitemporal analysis can be useful for the building of automatic radar images classifiers, once different types of land covers present different behaviors.

1 – INTRODUCTION

Discussion about Climate Changes and Carbon Budget must consider the importance of the Amazon rainfall forest and its role in the carbon flux in the atmosphere. Because Amazon forest is the largest continuous forest on Earth, the knowledge of the amount of carbon sunk by the growing and emitted by the logging of vegetation can help scientists improve the forecasts of Global Changes from numeric models. The estimation of the biomass over the Amazon forest is not well known and this can be in part attributed to the uncertainty in the biomass estimate of deforested forests [1]. [2] pointed to a deforestation rate ranged from 50,000 to 80,000 Km^2y^{-1} for the period of 1978-1988 while [3] and [4] suggest a much lower rate ranging from 15,000 to 21,000 Km^2y^{-1} . To improve such estimation classifications that consider the age of the regrowth can be useful. To classify the Amazon forest remote sensing is an important tool. Due to the constant cloud cover over the low latitude regions the radar

remote sensing can be an alternative to optical remote sensing. Forest classification considering the age of the secondary forest can be obtained by radar data. The sensibility of the radar to biomass was realized by [5] and a detailed multitemporal investigation about the backscatter of many types of land cover, including regrowths ranging from 1 to 23 years old, primary forest and agricultural areas was conducted by [6] using L Band data. The goal of this assignment is to investigate the backscatter of the same land cover type analyzed by [6], but this time applying C Band ERS-1 data. Such an investigation can be useful to elaborate automatic classifiers that make use of temporal images in tropical forests environment.

2 - METHODOLOGY

Three ERS-1 images acquired in 31/07/1992, 24/09/1993 and 14/04/1996 and a data set of twelve Landsat/TM images annually acquired from 1984 were used. A GIS and ground truth data were also used to verify the prior land use of the studied sites. The study area is the National Forest of Tapajós and its surroundings, in the state of Pará, Brazilian Amazonia. The 1992 and 1993 ERS-1 images were corrected considering the mean of the 1996 image. Therefore, each pixel of those images was multiplied by the ratio among the Digital Number mean of the 1996 image and Digital Number mean of the image being corrected. After correction possible unbalances caused by weather conditions and other sources were minimized.

It was possible to identify many types of land cover and verify their temporal behavior from the Landsat and ground truth data set. Thus, classes as bare soil, agricultural areas, undisturbed primary forest, primary forest affected by fire, primary forest affected by selective logging and regrowths with ages ranging from 1 to 23 years old could be investigated. Table 1 presents the previous land use of all cover types and the number of pixels sampled for each one.

The backscatter of those classes were assessed for each ERS-1 image and the results of each site sampled were plotted in a graph. The backscatter coefficients and their correspondent 95% confidence interval are shown in Fig.1. The abscissa axis refers to the sampled site. The name of each site is related to the land cover type and the year when it was sampled. Thus, Sample5-92-def corresponds to Sample 5, sampled in 1992 ERS-1 image whose vegetation was in a deforestation process, and Sample10-92-9 corresponds to Sample 10, sampled in 1992 ERS-1 image whose vegetation was 9 years old.

3 – DISCUSSION

Pasture areas backscatter had a random behavior in all three images. While one pasture area is growing another one can be nourishing the cattle or be already stressed by it. Therefore, the difference between the biomass in different stages of the pasture can define this behavior.

Agricultural areas also had a random behavior in the three images, however their average backscatter was higher than the pasture average backscatter. Backscatter values depend on the stage of the crop, the biomass amount and the orientation of the crop in relation to the sensor.

Regrowth at age ranging from 1 to 5 years old exhibited increase in their backscatter. This increase can be related to the biomass growing. The backscatter behavior of samples 7, 9 and 11 was similar and the abrupt fall in Sample7-93-2 is explained by a fire occurred in 1992. The low value in Sample9-92-def can be related to a deforestation process that it was suffering.

Secondary forests at age ranged from 4 to 8 years presented two different behaviors and this can be attributed to previous land use. While Sample 12 is an abandoned regrowth, Sample 8 is located in a region where human activities as logging and burn are very common. The abrupt fall in Sample8-93-5 is related to the 1992 fire.

Samples 10, 13 and 1 represent regrowths at age ranged from 9 to 15 years. Each one has a distinct behavior and a distinct land use as well. Sample 10 is located in the region affected by human activities and this sample was burned in 1992. Sample 13 suffered selective logging made by local residents, who used the wood to build houses, fences, bridges, etc. Sample 1 did not suffer any human action and its backscatter is a little lower than the others.

Sample 2 and 3 are the same age (12 to 22 years), and while Sample 2 suffered selective logging, Sample 3 did not. Different behavior between them is easily realized. The Sample which did not suffer human activities exhibits an apparent stability in its backscatter.

The three types of primary forests analyzed also showed different behavior. Forest with selective logging presented

higher backscatter than the others. Forest affected by 1992 fire presented lower backscatter than the others. Finally, undisturbed forest showed stable backscatter.

4 – FINAL CONSIDERATIONS

This ERS-1 multitemporal analysis, although making use of only three images, revealed the feasibility to discriminate land cover types based on the backscatter coefficient. Regrowth and primary forest affected by human activities present increase in the backscatter values while regrowth and primary undisturbed forest exhibit stable values for this coefficient. Such an investigation can find better results with a larger number of images and employing both ERS-1 and RADARSAT images. Losses caused by the ERS-1 VV polarization can be minimized by the RADARSAT HH polarization and its variable incidence angles. Improvement in the knowledge of carbon flux in the atmosphere can be obtained by classifiers that consider not only the single spectral signature of a specific land cover, but also the multitemporal analysis which can allow researchers get better accuracy of the regrowths ages. This assignment expects to contribute with researchers that work with classifiers and need to find new ways of getting information about forest environment.

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TABLE 1
 LAND USE HISTORY FOR SAMPLED AREAS

ÁREA	PIXELS	84	85	86	87	88	89	90	91	93	95	96	97
Sample 1	1424	RG	RG	RG	RG	RG	RG	RG	RG	RG	RG	RG	RG
Sample 2	918	RG	RG	RG	RG	RG	RG	RG	RG	RG	RG	RG	RG
Sample 3	1970	RG	RG	RG	RG	RG	RG	RG	RG	RG	RG	RG	RG
Sample 4	348	F	F	F	F	F	F	F	F	F	AP	AP	AP
Sample 5	419	RG	RG	RG	RG	RG	RG	RG	RG	AP	AP	AP	AP
Sample 6	1028	F	F	F	F	F	F	F	AP	AP	AP	AP	AP
Sample 7	779	F	RD	RG	RG	AP	AP	RG	RD	RG	RG	RG	D
Sample 8	660	F	F	RD	AP	AP	RG	RG	RG	RG	RG	RG	RG
Sample 9	490	F	F	F	F	F	F	F	F	RG	RG	RG	RG
Sample 10	1960	RD	RG	RG	RG	RG	RG	RG	RG	RG	RG	RG	RG
Sample 11	1175	AP	AP	AP	AP	AP	AP	AP	AP	RG	RG	RG	RG
Sample 12	2309	RG	RG	RG	RD	RG	RG	RG	RG	RG	RG	RG	RG
Sample 13	1066	RD	RG	RG	RG	RG	RG	RG	RG	RG	RG	RG	RG

RG= regrowth, RD= recently deforested, F= forest, AP= agricultural or pasture areas, D= deforestation

Fig.1. Backscatter behavior of samples