K&C Science Report – Phase 1
Application of ALOS/PALSAR in support to Brazilian Forest Monitoring Program

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***Abstract*— This paper presents a preliminary assessment of ALOS/PALSAR - Kyoto and Carbon Initiative radar images for the Brazilian Forest Monitoring Program. Using deforestation polygons mapped by DETER project, two ALOS/PALSAR ScanSAR images were analyzed considering the capability to detect deforestation patterns. Approximately 50% of polygons could be detected by ALOS/PALSAR images without orthoretification or radiometric calibration. Additional research efforts to develop better image products and multi-temporal approach should improve the deforestation detection capability. Considering the importance and the extension of Amazon forest and the cloud cover conditions, ALOS/PALSAR data has a strong potential to complement the Forest Monitoring Program. Having radar data operational at DETER project would also prepare the Forest Monitoring Program to integrate further radar data from planned Brazilian satellites – MAPSAR and CBERS-7.**

***Index Terms*—ALOS PALSAR, K&C Initiative, forest monitoring, DETER.**

I. INTRODUCTION

A. *Deforestation and SAR data over Brazilian Amazon*

Early deforestation stages as slash-and-burn practices were previously identified at SAR image, L band, JERS sensor as spectrally distinct from original forest cover over Brazilian Amazon [1]. L Band seemed to be very sensitive to variations between deforestation increase and primary forest [2].

Polarimetric radar data from Mapsar showed also to be very useful to detect recent deforestation over Tapajós National Forest (Pará), in the Brazilian Amazon [3]. Among polarimetric data, HH-HV showed to be the more adequate polarization to general forest mapping, it is possible to discriminate primary forest, secondary forest, bare soil, agriculture and degraded forest [4]. Preliminary investigations using ALOS PALSAR images, using only HH polarization, over Amazonia, showed distinct responses from slash-and-burn practices and also different degradation stages of the forest [5].

Comparisons between optical and radar images suggested that SAR L-band images are an important and complementary information source to land change cover mapping, specially over frequent cloud cover areas as Amazonia region [6].

This paper describes the project developed at Kyoto & Carbon (K&C) Initiative [7] where we assess the use of ALOS PALSAR K&C images for the DETER qualification procedure as initial steps to introduce ALOS PALSAR products at Brazilian Forest Monitoring Program.

B. *ALOS Imagery for forest monitoring in Brazil*

At INPE's Brazilian Amazon Deforestation Monitoring Program, the DETER System (the Real-Time Deforestation Detection System) [8] identifies and maps deforested areas in tropical Amazon forests. This system uses images from MODIS sensors on the NASA TERRA satellite and WFI on the Brazilian INPE CBERS-2B satellite. With spatial resolution limited to 250 meters, the images from these sensors allow detection of deforestation in areas greater than 0.25 km^2 (or 25 ha). In DETER, all deforestation identified in an image and not previously detected by Legal Amazon Deforestation Monitoring Project (PRODES) [9] is considered new deforestation, regardless of chronological time. The PRODES map, containing deforestation from prior years, together with non-forest areas (such as savannah, bodies of water and rocky outcrops) is used to eliminate old deforestation being identified and counted again. Identification of deforestation is performed through photo-interpretation of

the MODIS image, taking into account only the portion of the image that supposedly still contains forest cover.

Every 15 days, when observation conditions are favorable, DETER produces a digital map with all deforestation occurrences observed during the preceding period. These digital maps containing Alert polygons and tables describing them are sent every 15 days to IBAMA (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis), along with the cloud cover map for the period, thus indicating the area to be effectively monitored. The maps for the two halves of each month are integrated and, together with the cloud cover maps and images for the period, are placed on the Internet (http://www.obt.inpe.br/deter/) for consultation, where they remain available for download.

For every month, associated to DETER data, a technical report assessing DETER information and results is also published on the Internet. Based on cloud free and medium spatial resolution images (20 –30m), a sample of DETER Alert polygons is qualified. Multi-temporal and visual analysis classify DETER Alert polygons as light progressive forest degradation, moderate progressive forest degradation, high intensity forest degradation, clear cutting, or non-confirmed deforestation. Qualification results provides basic information about types of deforestation mapped by DETER and data accuracy, considering also the information about polygons area. From May to August, 2008, an average of 91% of DETER Alert polygons were confirmed as deforestation [10]. Data from field observation is also periodically obtained to improve DETER methodology and data evaluation [11]. In September 2008 INPE team went for a field expedition along the southwest of Para. With IBAMA collaboration, DETER Alert polygons were checked from a helicopter flight.

This qualification of DETER Alert polygons using optical remote sensing imagery is strongly limited by the cloud cover over the Amazon region.

A preliminary but essential application for ALOS PALSAR K&C images for deforestation monitoring could reside in qualifying DETER Alert polygons procedures. It is not expected that PALSAR imagery would provide information about different deforestation intensity, as it is usually detected by optical images and multi-temporal approach. However, radar backscatter data provides information about general forest cover condition:

- Deforested areas older than one year (PRODES mapping) presented dark patterns at L-band SAR;
- Less than one year deforestation (PRODES mapping) are detected at L-band SAR as lighter areas;
- Very recent deforestation mapped by DETER Program is discernible at L-band SAR as lighter polygons.
- Besides the clear-cut pattern, forest degradation is also detected with PALSAR Fine resolution data.

II. Description of the Project

A. Relevance to the K&C drivers

The use of ALOS imagery operationally at DETER system, as an improvement of the forest monitoring system, is in according to the Conservation thematic driver outlined in the K&C Science Plan [12]. To effectively monitor deforestation, specially over frequent cloud cover areas, ALOS information will be very helpful to define policy and plans of actions, either for carbon emission reduction or conservation strategies.

B. Work approach

This project was conducted in two parts. Initially, we had to assess ALOS PALSAR K&C imagery for deforestation detection. Secondly, some methodological development was needed to specify image processing to define the products and procedures. By the time that we finish the studies and the products and procedures tested and validated, we will be able to introduce PALSAR data operationally in the Forest Monitoring Program.

Although ALOS PALSAR Fine Mode provided an excellent spatial resolution to detailed study sites, ScanSAR data were preferred because these images cover larger extensions, essential capability when considering the Amazon forest as area of interest. Parallel to the image processing development to improve radiometric and geometric precision, we compared the ability of ScanSAR images to deforestation detection obtained from DETER system.

C. Satellite and ground data

For this analysis, the ALOS-PALSAR ScanSAR image of August 30, 2008 (WB1, HH polarization, slant range KC_003-21406N09S21WB1SLT1) was georeferenced (resampled to spatial resolution of 50 m) based only on the image acquisition parameters (geo_factors) with SARSCAPE software, converted to 8 bits tiff file to be integrated with deforestation data sources using geographical information systems developed by INPE (SPRING and TERRAVIEW). Every clear-cut polygon was visually interpreted over the PALSAR image, seeking to identify differences in the radar signal as lighter digital values, linear boundaries, or patterns different from the forest background and the darker pattern from older deforested areas. Comparing to radar forest backscatter, clear-cut areas present lighter patterns in PALSAR images.

DETER Alert polygons from May to August 2008 checked during the fieldwork (September, 2008) were superposed to a PALSAR K&C image from August (Figure 1). All of the analyzed DETER polygons referred to clear-cut deforestation, comprising areas that will be mostly converted to pasture, located at municipalities of Itaituba, Novo Progresso and Altamira (PA) (Figure 2).

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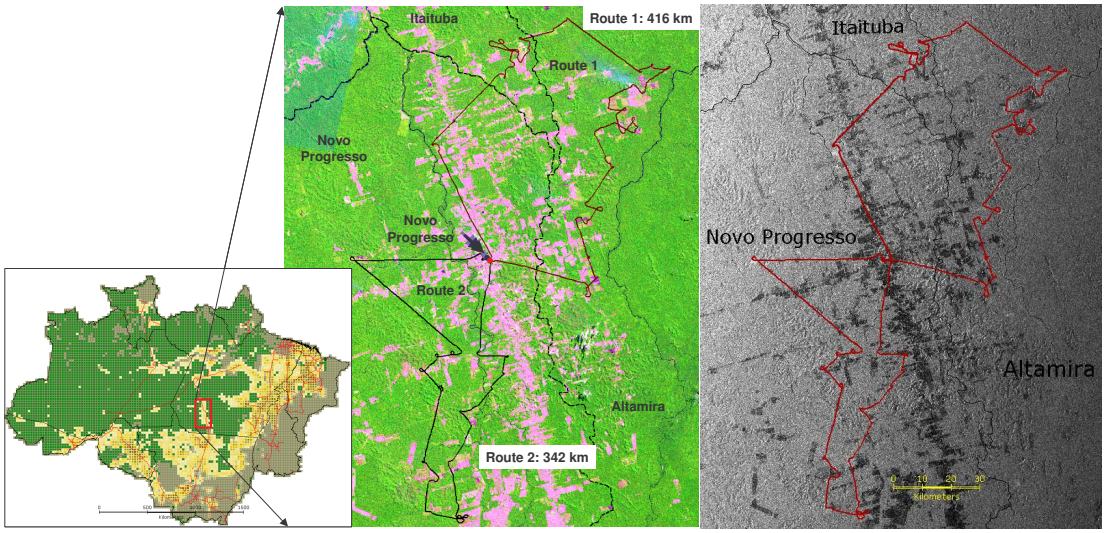

Figure 1. INPE Fieldwork location. Helicopter flight route over (a) Landsat-TM colour composition, and (b) ALOS ScanSAR image (WB1-HH–083008). Municipalities of Altamira, Novo Progresso and Itaituba – state of Pará, Brazil.

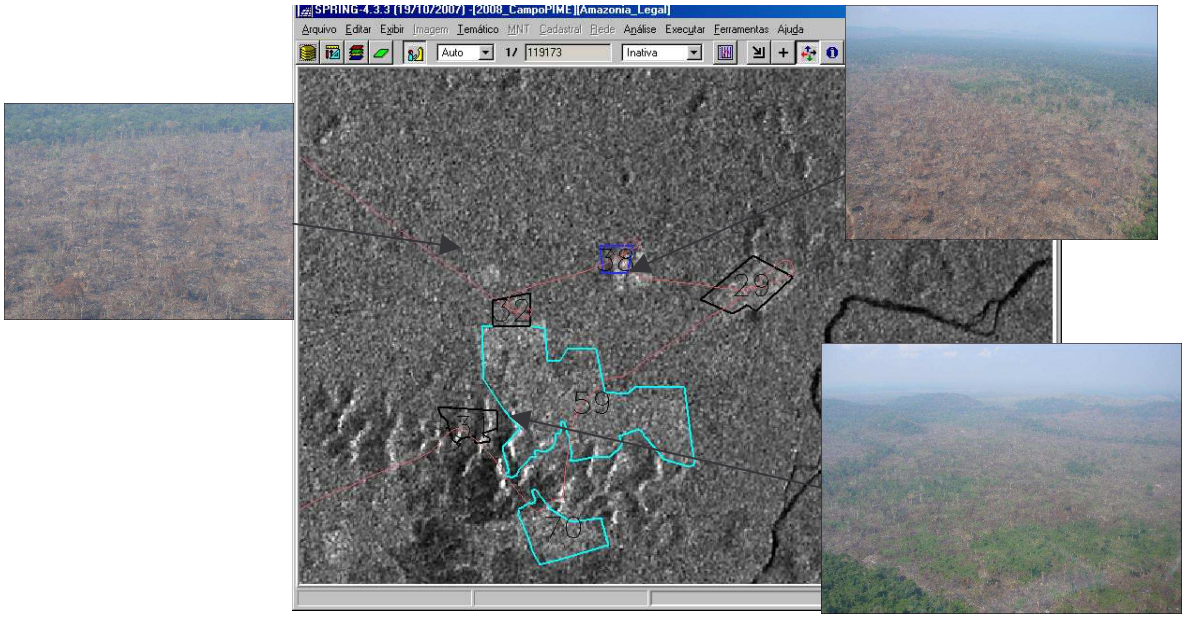

Figure 2. Example of Clear-cut Deter Alert polygons over ALOS ScanSAR image (WBS-HH–083008). Deter polygons from June (light blue), July (dark blue) and August (black) in a region close to Curuá River (Altamira-PA).

A second analysis were performed observing only DETER Alert Polygons for September 2008, over ALOS PALSAR ScanSAR image from October (10-15-2008), with the same methodological procedure. This analysis simulated the use of ALOS PALSAR at an operational approach.

III. Results and Summary

Considering the methodological part of this project, we first managed to develop a tool to store and recover every image from K&C project. An automatic procedure was implemented to regularly access JAXA ftp sites and organize the ALOS PALSAR K&C available images in a database. Using a web portal, credentialed users can consult the downloaded images by date, polarization or central geographical coordinate (Figure 3). The image swath can be visualized and the selected images can be ordered to the database manager. As soon as JAXA authorizes, this portal can be open to the Brazilian scientific community to freely access this PALSAR image database.

The analysis of ALOS ScanSAR images for deforestation detection indicated the need of additional methodology, described after the Deter comparison results.

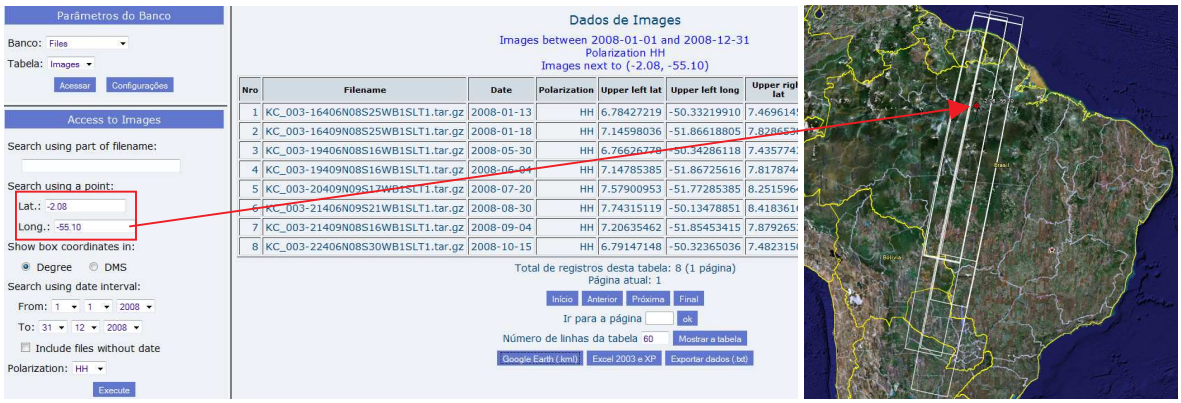

Figure 3. Web Portal to select ALOS PALSAR K&C images, verifying scenes coverage (http://www.dpi.inpe.br/sima/bancos/)

Considering only clear-cut DETER Alert polygons verified in the fieldwork (a total of 67 polygons, from May to August, 2008), ALOS-PALSAR images could register difference in image response for only 55.22% of the clear-cut polygons (Table 1).

Table 1 – ALOS-PALSAR ScanSAR image assessment for DETER clear-cut polygons verified during the fieldwork.

	Deter Clear-cut	ALOS detection	%
May	12	6	50.00
June	17	7	41.18
July	14	10	71.43
August	24	14	58.33
Total	67	37	55.22

Some factors could contribute to this result:

- The image was not properly radiometrically calibrated, there was significant difference in image illumination that difficult the interpretation.
- Clear-cut DETER polygons located in flat terrain are easier to detected than in those in hilly areas. Small hills are very frequent in the study area.
- Variation in size and shape of clear-cut polygons interferes in the radar image response.

It was observed that DETER Alert polygons detected by the ALOS (Table 2) image had an average of 4.33 km^2, in contrast to the polygons not detected in the ALOS image, that presented average areas of 2.65 km^2.

Table 2 – ALOS-PALSAR ScanSAR image assessment for DETER clear-cut polygons verified during the fieldwork.

	DETER polygons average area (km^2)	
Month	Detected	Not detected
May	7.00	3.86
June	5.51	3.21
July	2.46	1.68
August	2.35	1.83
Average	4.33	2.65

Observing DETER Alert Polygons for September 2008 over ALOS PALSAR image from October (10-15-2008), only 76 polygons from 565 where placed over the scene. Even with DETER polygons smaller than registered previously, 45% of the polygons were identified over PALSAR image (Table 2). Most of the deforestation polygons presented darker response in the PALSAR image, suggesting older clear-cut areas.

Table 3 – ALOS-PALSAR ScanSAR image (October) assessment for DETER clear-cut polygons registered for September 2008.

ALOS (10-15-2008)	DETER Polygons (Sept-2008)	%	Area (km^2)
Detected	34	44.74	0.92
Undetected	42	55.26	0.75
Total	76		

ALOS PALSAR ScanSAR images covered the north part of Amazonia, where cloud cover makes the deforestation detection difficult (Figure 3). To be used in an operational basis, ScanSAR images should be accessed and processed as soon as possible to enable DETER qualification, what is planned for the continuity of this work.

Deforestation detection by SAR L Band has also a temporal dynamic that interferes on image interpretation. Recent deforestation shows brighter pattern than the what is found on intact forest cover and it progressively becomes darker areas. This change the backscattering pattern occurs within approximately 5 months time. Such temporal variation was not enough quantified and understood, and it will be subject of further research.

Considering the results showing the potential ALOS PALSAR for deforestation detection, and the temporal variability of deforestation backscattering patterns, it is necessary to adapt the methodology for an operational forest monitoring. Change detection, multi-temporal approach should be defined, in order to compare a new radar image with previous images of the same season.

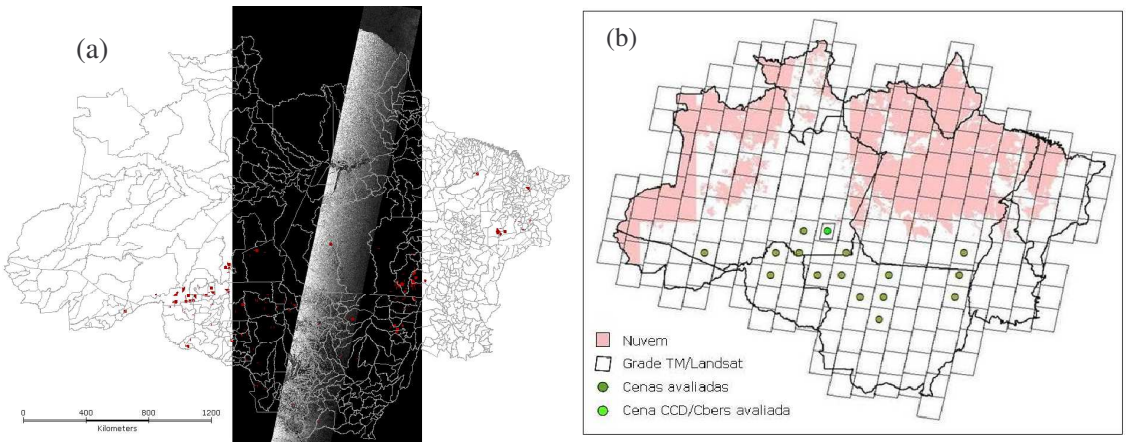

Figure 4 (a) ALOS PALSAR WB1 image (10-15-2008) coverage and DETER Alert Polygons for September 2008 (red vectors). (b) DETER Alert polygons for September qualification report: cloud cover (pink) and DETER polygons qualification sites (green dots).

IV. Final Commnents

ALOS K&C Initiative gave us the opportunity to consider the use of radar data to overcome the cloud cover problem in the Brazilian forest monitoring system. Radar data availability in a regular basis enables the development of an operational procedure to use L Band for deforestation detection.

The results obtained so far indicate that ALOS PALSAR imagery has a potential to detect only part of the deforestation polygons that are normally published as deforestation alerts. However, as the deforestation detection has to be operational and expedited, we need an uncomplicated approach, based on ScanSAR – HH polarization data, the methodology is not completely defined. We plan to build an ALOS PALSAR mosaic images for the four seasons and work with multi-temporal analysis to detect deforestation.

Another benefit from being part of ALOS K&C Initiative and conduct this project, it the construction of a radar culture, not only at the scientific level, but also in an operational basis with implications on the public awareness about the technological capability of remotely sensed monitoring of the deforestation process in Brazil. This is especially important considering that the Brazilian Spatial Program is planning to develop radar sensors onboard of Brazilian satellites in the next decade.

Acknowledgements and Image Copyrights

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