EVALUATION OF SIR-C/X-SAR DATA FOR THE IMPROVEMENT OF GEOMORPHOLOGY AND SOIL MAPS IN ACRE STATE, BRAZIL

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ABSTRACT

An evaluation of a X-SAR scene from the SIR-C mission is made with special interest for the improvement of geomorphology and soil maps in Acre State, SW Amazonia, Brazil. Potential operational applications of X-SAR data are discussed, indicating the possibility of the use of relatively straightforward procedures and methods.

1. INTRODUCTION

Experience with the analysis and evaluation of airborne X-SAR data in the tropics, specially for natural resources mapping, go back to the late 60's and early 70's. There are many good examples on the utility of these imaging systems, after aerial surveys performed in remote areas of Asia (Indonesia, Borneo), Africa (Nigeria, Togo, Ivory Coast) and Latin America (Nicaragua, Colombia, Venezuela and Brazil) (Koopmans, 1983, Trevett, 1986). Brazil established, worldwide the most ambitious mapping program of natural resources, setting up Projeto Radam. During the early 70's the X-SAR GEMS (Goodyear Environmental Mapping System), mounted in a *Caravelle* aircraft imaged the entire country to produce, among others, semi-controlled radar mosaics, to be evaluated for Geology, Geomorphology, Soils, Forest/Landuse, and Potential Landuse by Brazilian scientists (Bittencourt Neto, 1979). The results are available as reports and thematic maps, at 1:1,000,000 SCALE, for the entire country.

Since 1990, there is a cooperation program between (German Aerospace Research Establishment) and INPE (National Brazilian Institute for Space Research) in Acre State, SW Amazonia, to evaluate the usefulness of different sensor systems to map the dynamics of changes in the tropical rainforest, due to human interference (Hönsch 1993, Kux et al., 1993, 1995, Keil et al. 1995a,

1995b). In the frame of this cooperation program, testsite Acre was selected as a project area for ecology and tropical rainforest monitoring, using multifrequency and multipolarization SAR data of the SIR-C (Shuttle Imaging Radar)/X-SAR mission. Different datasets from different sensor systems TM-Landsat, ERS-1, airborne C-band SAR) have been used for comparison with multifrequency (L, C and X-band) and multipolarization (HH, VV, HV, VH) data of this mission.

In this context, the objective of this paper is to analyze the information content of X-SAR data separately and to discuss on how existing geomorphologic and soil maps of this region could be improved. A companion paper, presented at this Symposium by Santos et al. (1996) refers to the joint analysis of SIR-C, L band, and TM-Landsat data to characterize the land cover of an adjoining area.

2. MATERIALS AND METHODS

The X-SAR scene analyzed (Fig.1) was taken in April 18th, 1994, at descending orbit, VV polarization, with a nominal resolution of 25x25 m, and an incidence angle, at the middle of swath, of 27,4°. The following pre-processing was made at DLR/DFD: tone adjustment between near and far range, and application of a MAP filter, with a 3x3 window, to reduce *speckle* noise without

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blurring. Due to the good quality of the scene, the visual analysis was made directly on the computer screen. A field and an aerial survey were made in this region, to control the findings of interpretation.

3. OVERALL DESCRIPTION OF THE AREA UNDER STUDY

The area under study is localized at the border between Amazonas and Acre States, west of the city Sena Madureira, with approximate geographical coordinates of S 8°32' - W 68°17', S 8°34' - W 68°35' to S 9°15' - W 68°09', S 9°17' - W 68°27'. The geology of this region is made up essentially by the Cenozoic Solimões Formation (mainly very friable sandstones and siltstones and recent sediments) that covers entirely the area under study. The climate is humid, presenting two distinct seasons (humid / dry) along the year. The annual rainfall is around 2,000-2,500 mm (PMACI I, 1990). The main vegetation cover is of two types: Tropical Lowland Forest with Palms and Bamboo (open forest) and Dense Tropical Forest, on higher sections, such as on the Plateau (I). Along the floodplain of the main river, Rio Purús, a wet Forest dominates, locally known as "Igapó forest".

4. MAIN GEOMORPHOLOGICAL UNITS

The criteria used to discriminate 8 main geomorphological units (Figure 1) were: texture, tone, context and previous experiences from aerial and ground surveys in this region. The higher section (I) is part of the Lower West-Amazonian Plateau, defined in Brazil (1976) as part of a much larger relief unit, that has been strongly eroded at its' edges. The average height of (I) is around 250-300 m, only about 100 m above the Rio Purús floodplain (III). The plateau is covered, at least partially, by Al-, Fe-, Mn holding laterites, known in Brazil as *Canga*. The main soil types of this section are Red Yellow Latosols and Podzols (PMACI I).

At NW of the plateau (units II, VII and VIII) there are highly dissected areas of relatively small hills, covered by Open Tropical Rainforest, dominated by Bamboo. Nelson (1994) presented the first map showing the extension of bamboo-dominated forests in Acre, indicating also areas of death of entire bamboo formations during the second half of the 80's. Taking into account the completely different physiognomy of bamboo (specially of the canopy due to a different architecture of trunks, twigs and leaves) as compared to the canopy of the Tropical Rainforest in Acre, the relief units VII and VIII (dominated by bamboo) present very distinct smoother texture features and tones, as compared to unit VI (no bamboo dominance), although the relief height and geological substratum are the same at these 3 units. This

indication was confirmed by an independent analysis of TM-Landsat data.

The floodplain of Rio Purús is apparently the best defined relief unit of the area under study. This is certainly due to differences of soils and vegetation with high (III) and lower (IV) moisture content. Furthermore, the Upper Rio Purús Terrace (IV), 10-15 m above (III), comes out sharply, due to subtle changes in the geometry of the channels of the tributaries, after leaving units (VI) and (V) to (IV). The scene under study would also allow to establish a classification of fluvial features such as, abandoned meanders, oxbows (open and vegetation covered, etc.), that are important for environmental planning purposes.

5. DISCUSSION

The excellent experiences with X-band SAR data obtained worldwide, and specially in the tropics, as mentioned at the beginning of this paper, will certainly be a strong argument towards an operational spaceborne SAR system at this frequency, which is missing presently. Such a system would allow both to map the geomorphology and soils of unknown areas or upgrade already existing ones. If optical data (TM-Landsat) is available, merging of SAR and TM data and RGB/IHS transformations become feasible, as it was shown by Kux et al (1995) in Acre with airborne C-Band SAR, thus allowing further informations related to vegetation, land use and hydrology.

The floodplain of all the major rivers in Amazonia is very dynamic, and changes can occur in a timeframe of a few years. An X-SAR, together with other sensors, would contribute to show the changes that are taking place. Furthermore it should be mentioned that floodplains, like that of Rio Purús shown here, are regions of extremely high primary production, and due to that, an area of potential high dispute among humans and animals, for living grounds. Again, X-SAR data could help to detect those areas that are being occupied and those that deserve environmental protection (e.g. breeding areas for wildlife).

This study, together with its' companion paper of Santos et al. (this Symposium), present the first results obtained from the analysis of SIR-C/X-SAR testsite in Acre. Further studies, using the polarimetric and multi-frequency information to be obtained from data of this Mission, will certainly give new insights to problems like, inasmuch canopy moisture can be better detected at shorter wavelengths (X-band) as compared to longer wavelengths (L-band) or on how to improve information related to soil erosion, from surface roughness, ratioing images from different frequencies and polarizations. Soil erosion problems are found almost anywhere in Acre,

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where there is human occupation, due to the very friable underground

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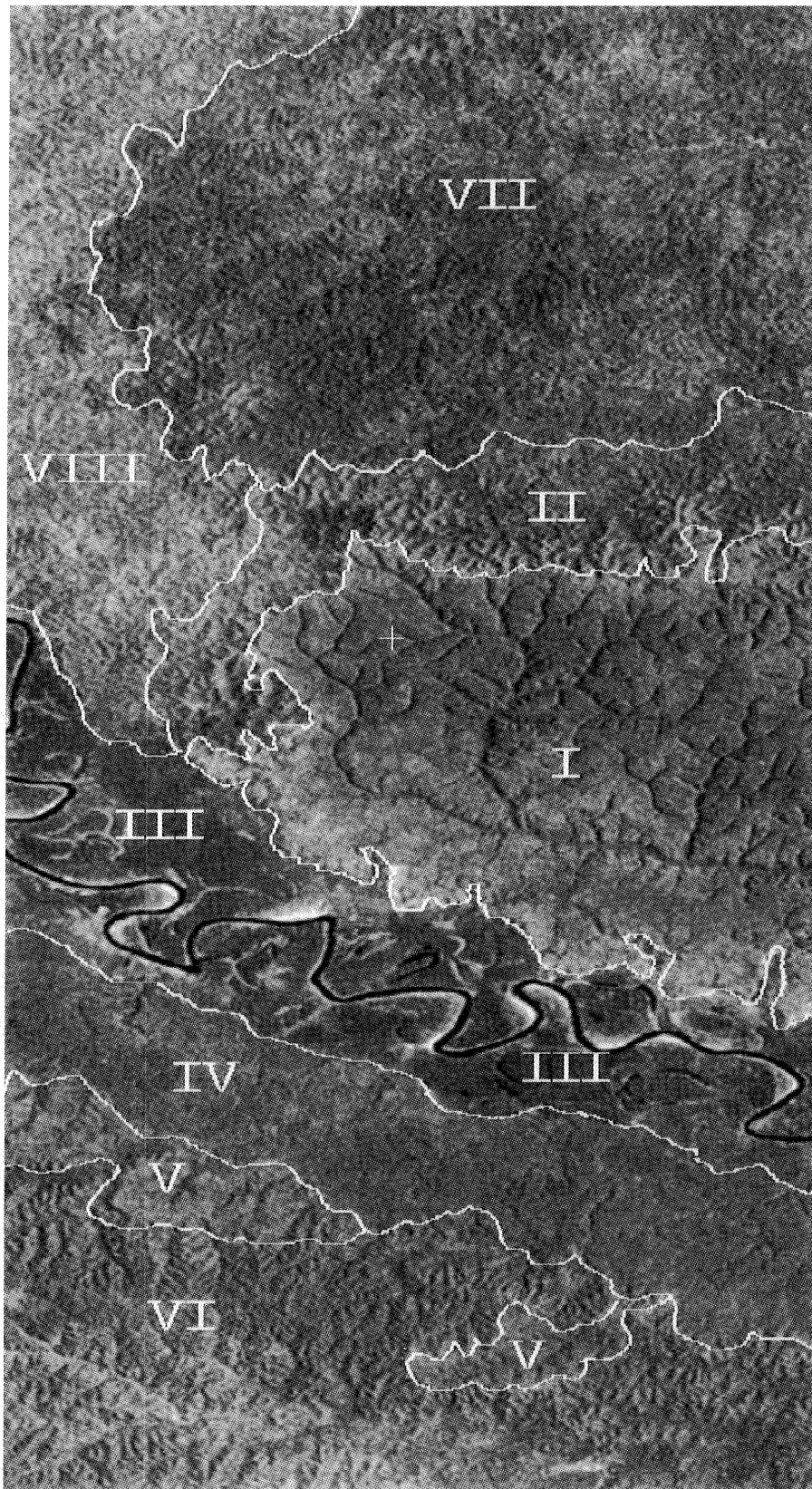International Archives of Photogrammetry and Remote Sensing. Vol. XXXI, Part B7. Vienna 1996

Fig.1 - Geomorphological units

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