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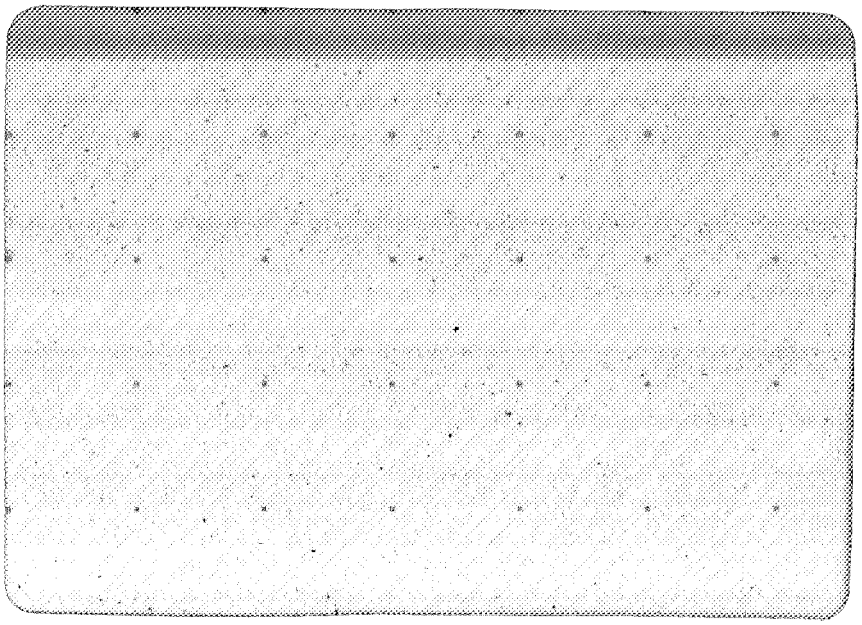

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12. Revised by

José Raimundo B. Coelho

9. Authorship

Marco Antonio Raupp

Roberto Pereira da Cunha

René Antonio Novaes

Responsible author

13. Authorized by

Marco Antonio Raupp
Director General

14. Abstract/Notes

Most of remote sensing activities in Brazil have been conducted by the Institute for Space Research (INPE). This report describes briefly INPE's activities in remote sensing in the last years. INPE has been engaged in research (e.g. radiance studies), development (e.g. CCD-scanners, image processing devices) and applications (e.g. crop survey, land use, mineral resources, etc.) of remote sensing. INPE is also responsible for the operation (data reception and processing) of the LANDSATs and meteorologic satellites. Data acquisition activities include the development of CCD-Camera to be deployed on board the Space Shuttle and the construction of a remote sensing satellite.

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BRAZIL'S REMOTE SENSING ACTIVITIES IN THE EIGHTIES

Marco Antonio Raupp *

Roberto Pereira da Cunha *

Renê Antonio Novaes *

A B S T R A C T

Most of the remote sensing activities in Brazil have been conducted by the Institute for Space Research (INPE). This report describes briefly INPE's activities in remote sensing in the last years. INPE has been engaged in research (e.g. radiance studies), development (e.g. CCD-scanners, image processing devices) and applications (e.g. crop survey, land use, mineral resources, etc.) of remote sensing. INPE is also responsible for the operation (data reception and processing) of the LANDSATs and meteorologic satellites. Data acquisition activities include the development of CCD-Camera to be deployed on board the Space Shuttle and the construction of a remote sensing satellite.

1. INTRODUCTION

The Brazilian territory embraces an area of 8.5 million of square kilometers which is comparable in size, for instance, to the countries of North America (see Table 1). A large part of the Brazilian territory (ca 5 million km^2) includes areas of difficult access and adverse climate (e.g. the Amazon rain forest). Inventoring or monitoring of the natural resources of such large areas is a task which requires a considerable time and implies high costs. Remote sensing can reduce time and costs of the survey of natural resources, thus in Brazil remote sensing data have been used to obtain a knowledge of its natural resources in a short time and to reduce the costs of surveying. Mapping in Brazil has advanced significantly after the introduction of remote sensing techniques in the seventies (Tables 2 and 3). Two Brazilian government agencies have contributed to this: the Institute for Space Research (INPE) and the RADAMBRASIL Project (former Radar in the Amazon Project). We will focus on INPE's remote sensing activities only due to the coordination role INPE plays in the field in Brazil. This report thus gives a summary of INPE's activities in remote sensing with special attention to the last two years (i.e. 1984, 1985). INPE's main activities in remote sensing have been: data reception and processing; image processing for applications (hardware and software development); research (scene radiance, spectral and spatial characteristic studies)

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* SELPER members. The Institute for Space Research (INPE) is also a SELPER member.

and development (methodology and hardware); applications (mineral resources, agriculture, land use, etc.) and training (specialization, graduate courses).

2. BRAZILIAN REMOTE SENSING PROGRAM

The Brazilian Remote Sensing Program developed by INPE includes (1) reception, processing and distribution of satellite data and (2) research and development of techniques and methodologies for the study of earth resources (mineral resources, land use, crop inventory, cartography, urban planning, etc.) as well as training.

On the area of remote sensing INPE has the following facilities:

a) A ground tracking and reception station for LANDSAT data. This station is located at Cuiabá (Mato Grosso State), the center point of South America for coverage purposes.

b) A data processing station located at Cachoeira Paulista (São Paulo State).

c) A set of data distribution centers spread over the country.

d) Meteorologic satellite reception stations (GOES-TIROS-N) at Cachoeira Paulista.

e) Three image processing user oriented systems (General Electric - IMAGE-100; Bendix - MDAS; INPE - SITIM).

f) A twin engine aircraft, EMBRAER - Bandeirante, EMB-110 equipped with special camaras for remote sensing data acquisition.

g) A data base with approximately one hundred thousand LANDSAT imageries from South America.

h) A library with approximately 3200 books, 20 journals signatures and 3000 maps.

i) Laboratories for sensor development and spectroradiometric measurements.

3. ORGANIZATION

The structure of INPE's Space Applications area consists of: (1) Department of Remote Sensing (DSR), (2) Department of Application of Satellite Data (DDS), (3) Department of Image Processing (DPI) and (4) Department of Image Production (DGI). These departments develop the following activities:

a) Basic research for remote sensing (e.g. energy matter interaction studies).

b) Study and analysis of new sensors or products (TM, SPOT, SIR-A, SIR-B, etc.).

c) Technological transfer and training in remote sensing.

d) Image processing (image generation and digital analysis for applications).

e) Hardware development (e.g. image analysis systems for applications).

f) Data reception and processing (e.g. LANDSAT MSS and TM).

g) Applications in geology, agronomy, forestry, environmental analysis and cartography.

Research, development and applications are carried out by approximately 200 people (09 PhD, 45 M.Sc., and 63 B.Sc. level). Hardware facilities include a Burroughs - B6800, Digital PDP-1134, and Vax 780 computers. Hardware development has yielded an image analysis system based on 16 bits microprocessor and an interactive image processing system based on a minicomputer (e.g. SISCO MB 8000).

4. APPLIED ACTIVITIES

4.1. GEOLOGY

Remote Sensing activities in geology at INPE have been concentrated on geologic mapping, structural studies, mineral prospection, as well as training of geologists from universities and industry. INPE has developed a program of geologic mapping at the millionth scale in order to demonstrate the utility of remote sensing data and techniques as an alternative tool for geologic survey. This effort resulted in the publication of several maps from different parts of the country. Currently, structural studies are been conducted in the Espinhaço and Canastra belts,

Minas Gerais State, and in the semiarid Northeastern Brazil region. This last area was also focus of a geologic comparison study with West Africa (Gondwana Project) involving LANDSAT and radar data from both sides of the Atlantic.

The geologists utilize visual and automatic image processing techniques to develop methodologies, as well as preprocessing techniques in the study of lithologic discrimination and targets for detailed mineral prospection. Some examples of remote sensing applications in geology are:

Oil - INPE has developed joint projects with two Brazilian oil companies (Petrobrás and Paulipetro). In these projects remote sensing data area used as an auxiliar tool in the oil exploration.

Ore deposits - several studies have been conducted by INPE as auxiliary information or direct indications of areas for mineral prospection. This includes titanium deposits (Ilmenite, Northeast Brazil), lead zinc deposits (geobotany, Minas Gerais State), bauxite deposits associated with alkalic rocks (Itatiaia and Poços de Caldas, Rio de Janeiro and Minas Gerais States). Tin deposits were investigated through the study and selection of circular granites in the Rondônia and Goiás States. Iron deposits have been under investigation in the Amazon State.

4.2. AGRICULTURE, FORESTRY AND SOILS

Grain exporting and food production are major goals of the Brazilian government. Sugarcane, for example, has been indicated as an alternative source of energy in the development of the country. As a result, INPE is currently dedicating a considerable effort in crop survey and forescast using remote sensing techniques. Sugarcane has deserved a special project which concentrates on assessments of cultivated areas and productivity (size, distribution of the crops, etc.). Studies of irrigated rice and wheat crops through remote sensing techniques are given promising results encouraging the use of these techniques as auxiliary tool in the inventory and production forecast of those cultures in the Rio Grande do Sul State. Soybean project is currently undergoing in a feasibility study in the Paraná State. Monitoring of deforestation includes area estimation, as well as, the evaluation of the effective use of deforested areas. Large forested areas in the Amazon Region, for example, have been clear cut for the purpose of cattle raising projects (i.e. pasture lands), receiving government tax subsides. The satellite data have been used alternative as way to monitory their progress. Deforestation is also a main concern of the Brazilian Government in the sense that the Amazon Region is ecologically a priority area. INPE has developed studies to estimate rate and percentage of deforestation in the Amazon Region. INPE has conducted researches projects looking for area size, age and volume of timber.

4.3. LAND USE, URBAN PLANNING, ENVIRONMENTAL ANALYSIS AND CARTOGRAPHY

A rapidly growing country needs, in a short time, data and information for resources management. INPE has conducted studies on desertification, geomorphology, water resources (e.g. irrigated lands and dams), mining activities (e.g. coal mines), phytomass estimation (i.e. vegetation indexes), flooded areas, etc. Most of these studies have been requested by government and private agencies due to their extreme difficulties in gathering information using conventional methods. In this sense, INPE has contributed very sucessfully through the elaboration of reports, maps, etc., as well as training of personnel from different government agencies (water resources department, city services, etc.). Cartography is another area experimenting considerable advance after the introduction of satellite data in the process of mapping (e.g. 1:250 000 sheets, navigation charts, etc.).

5. HARDWARE AND SOFTWARE DEVELOPMENT

A prototype of a CCD camera (1728 elements) was developed and tested by INPE. The first images have shown satisfactory results. A study for the construction of a new CCD camera is currently been developed. This new sensor is been designed envisaging an experiment on board the Space Shuttle and will serve as an assessment of sensor caracteristics and specification for the future Brazilian remote sensing satellite (i.e. BRESEX Experiment and MECB mission).

Two radiometers have been built by INPE, one of CCD-type covering the visible-near infrared portion of the spectrum and the other in the microwave region (10 GHz). These radiometers

were designed to acquire radiometric data to attend different applications (e.g. reflectance studies, emissivity, etc.). Hardware development has also included the construction of image analysis systems based on Brazilian microcomputers (e.g. SITIM).

Software development has concentrated on research and applications in three main areas: (1) software development for image production (e.g. radiometric and geometric corretions, etc.); (2) software for image analysis (e.g. image enhancement techniques and classification algorithms) and (3) software for geographic information systems.

6. CONCLUDING REMARKS

Brazil is a large country with diversified characteristics and natural resources. Remote Sensing techniques are been continually studied to show their real utility and have been used in different applications in Brazil. In order to full-explore and transfer this knowledge to the country, INPE has dedicated its effort in research (e.g. scene radiance studies), development (e.g. methodologies and image processing systems) and applications (e.g. mineral resources, forestry, agronomy, land use, etc.). Nevertheless, and not usually, weather conditions unpair the full utilization of remote sensing data, particularly in tropical regions, because of high percentages of cloud cover. Some applications which require a high frequency of observations become seriously compromised.

INPE is considering and planning several alternatives for remote sensing data acquisition, among them are Brazilian Remote Sensing Experiment (BRESEX) which consists of a CCD-Camera to be deployed on board the Space Shuttle and the Brazilian Space Mission (MECB), which includes the construction of a remote sensing satellite. Also, are under study the international remote sensing programs such as the Radarsat Project.

COUNTRY	AREA IN SQ.KM	AREA IN NUMBER OF*	
		LANDSAT IMAGES	SPOT IMAGES
USSR	22.402.200	655	6223
CANADA	9.976.139	291	2771
CHINA	9.956.961	291	2766
USA	9.369.885	274	2603
BRAZIL	8.511.965	248	2364
FRANCE	547.026	16	152
SPAIN	504.782	15	140
W. GERMANY	248.690	7	69
GREAT BRITAIN	244.103	7	68
NETHERLANDS	33.939	1	9
ARGENTINE	2.766.889	81	769
MEXICO	1.958.201	57	544
COLOMBIA	1.138.914	33	311
BOLIVIA	1.098.581	32	305
VENEZUELA	912.050	27	253

* maximum

TABLE 1

SOME EXAMPLES OF COUNTRY SIZES AROUND THE WORLD

SCALE / REGION	≤1:25,000	≤1:50,000	≤1:100,000	≤1:200,000
AFRICA	1%	25%	25%	95%
AUSTRALIA	19%	35%	35%	100%
ASIA	15%	50%	85%	90%
EUROPE	75%	100%	100%	100%
NORTH AMERICA	40%	55%	55%	90%
SOUTH AMERICA	10%	20%	30%	30%

TABLE 2

TOPOGRAPHIC MAPS - WORLDWIDE COVERAGE

TYPE	SCALE	COVERED AREA (%)
Geologic	> 1: 250 000	100%
	1: 250 000	62%
	< 1: 250 000	16%
Soil	1:1: 000 000	85%
	1: 500 000 - 1:1 000 000	9%
	1: 100 000 - 1: 500 000	3%
	1: 100 000	0.1%
Vegetation	1: 100 000	72%
	1: 500 000 - 1:1 000 000	35%
	1: 250 000	27%
	1: 100 000	7%
Geomorphologic	1: 1 000 000	85%
Land Use	1: 1 000 000	79%
	1: 500 000 - 1:1 000 000	11%
	1: 100 000	0.1%

TABLE 3

THEMATIC MAPS - BRAZILIAN TERRITORY