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The objective of this study is to identify flooded areas using digital LANDSAT-TM data. The test site is a section along the Parnaíba river (NE of Brazil). By means of digital processing, one analyses the spectral separability of the classes, which are characterized by the presence of water surface with different intensities of a pixel in the near infrared band (4). A Density Slicing algorithm is applied for this purpose. The multitemporal analysis of the data is accomplished through the merging of the band 4 images corresponding to normal and flood periods. After this procedure, a maximum likelihood algorithm is applied in both images. The Density Slicing is also applied in multitemporal difference of the image (band-4-normal minus band-4-flood). A comparative analysis of the digital processing techniques using TM data to study flooded areas is presented.

OBSERVAÇÕES / REMARKS

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## LANDSAT-TM DATA TO MAP FLOODED AREAS

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### ABSTRACT

The objective of this study is to identify flooded areas using digital LANDSAT-TM data. The test site is a section along the Parnaíba river (NE of Brazil). By means of digital processing, one analyzes the spectral separability of the classes, which are characterized by the presence of water surface with different intensities of a pixel in the near infrared band (4). A Density Slicing algorithm is applied for this purpose. The multitemporal analysis of the data is accomplished through the merging of the band 4 images corresponding to normal and flood periods. After this procedure, a maximum likelihood algorithm is applied in both images. The Density Slicing is also applied in multitemporal difference of the image (band-4-normal minus band-4-flood). A comparative analysis of the digital processing techniques using TM data to study flooded areas is presented.

### 1. INTRODUCTION

The River flooding is an important natural hazards which affect man and his spatial organization. The most aparent way in which Remote Sensing may assist is by providing imagery of floods as they happen. Any sensor capable of discriminating between water and land areas would seem to present possibilities. The synoptic coverage of LANDSAT imagery allows rapid appraisal of the areal extent of flood inundation for entire river systems. Deutsch and Ruggles (1978), Novo (1983) and Pinto et alii (1985) using LANDSAT-MSS data have been made success to study flood events.

During April and May 1985, the Parnaíba River Valley experienced one of the largest floods on record. Tremendous areas of low-lands were inundated along the Parnaíba River mainstream and along a number of major tributaries. Florenzano et alii (1988) using visual interpretation of images made a flood inundation mapping for these areas. Here one discuss the results obtained using digital LANDSAT-TM data for evaluate flood boundary in test-site localized along the Parnaíba River (figure 1).

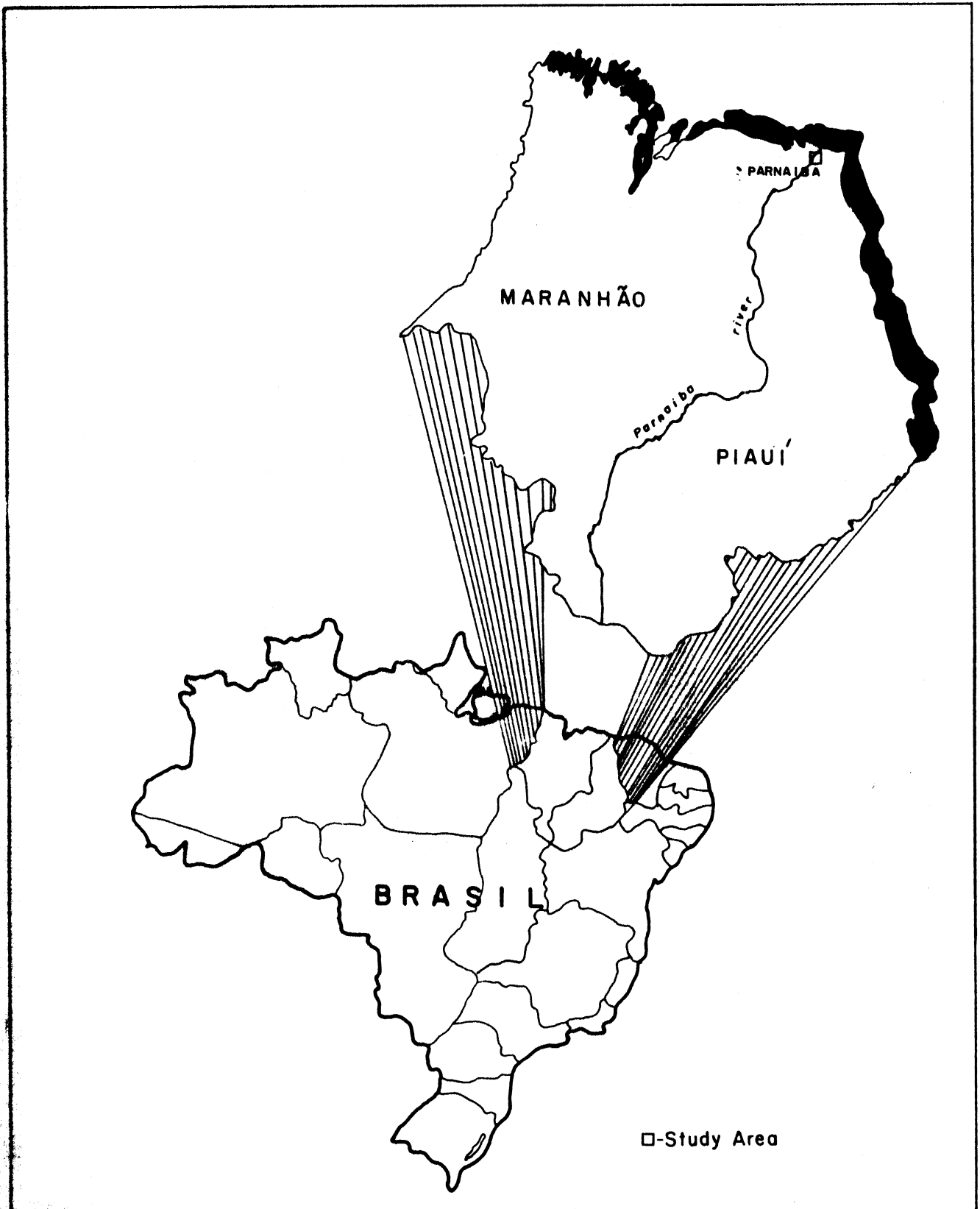


Figure 1. Study area location.

## 2. METHODOLOGY

For the digital analysis LANDSAT-TM band 4 (CCT), of both normal (08.06.86) and flood periods (05.31.85) were used.

The TM data were enlarged at scale 1:50,000 in the display of the digital processing system. By means of digital processing, one analyzes the spectral separability of the classes, which are characterized by the presence of water surface with different intensities of a pixel in the near infrared band (4). A density slicing algorithm were used for this purpose. The maximum and minimum gray level of each class were established using a single-cell algorithm.

The multitemporal analysis of the data is accomplished through the merging of the band 4, images corresponding to normal and flood periods. In other words, TM-4 images covering the flooded areas (cyan) were composed of images of the same area collected under normal conditions (red) to prepare temporal composites. The resulting composite exhibits different colors where change has occurred and gray tones for areas of no change. After this procedure, a maximum likelihood algorithm is applied in both images. The choice of the homogeneous training samples was carried out by using the density slicing classification and multitemporal composite analysis.

Comparative analysis between digital supervised classifications and visual interpretation of the analogic data (Florenzano, 1988) was carried out.

Subtraction of one image from another of the same scene gives the potential for detecting change if the two images are taken at different times as carried out in this study using band 4 of the flood minus band 4 of the normal periods.

Finally, a density slicing is applied in multitemporal difference image.

## 3. DISCUSSION OF RESULTS

Two methods of computer classification were used and compared: Density slicing classification and the Maximum Likelihood Decision Rule (MAXVER algorithm).

The resulting classes from density slicing classification are indicated in table 1.

TABLE 1. DENSITY SLICING FLOOD TM 4 IMAGE

Class	Class Level	Area (Km <sup>2</sup> )	%
Water	8 - 29	34,68	14,7
Flood water/ Wet areas	30 - 37	14,99	6,3
Wet areas	38 - 59	86,98	37,0

This result demonstrates the spectral separability between the thematic classes and agrees with the analogic interpretation image (Florenzano et alii, 1988).

The supervised classification (MAXVER) was applied on the multi-temporal color composite (band 4, normal and flood periods). The table 2 shows the result of this approach.

TABLE 2. MAXVER APPLIED MULTITEMPORAL BAND 4 DATA

Class	Area (Km <sup>2</sup> )	%
Water	14.18	6.0
Flood water	19.07	8.1
Wet areas 1	45.69	19.4
Wet areas 2	74.28	31.5
Others	69.52	35.0

The rationale for using the multitemporal TM band 4 image for flooded areas identification can be found in table 3.

TABLE 3. CONFUSION MATRIX: MULTITEMPORAL BAND 4 DATA

Class	Water	Flood Water	Wet Areas 1	Wet Areas 2	Others
Water	99.6	0.4	0.0	0.0	0.0
Flood water	0.0	90.8	8.7	0.5	0.0
Wet areas 1	0.0	18.2	69.8	10.9	1.0
Wet areas 2	0.0	0.0	14.2	78.1	7.7
Others	0.0	0.0	0.2	6.8	93.0

The confusion matrix shows the results of the supervised analysis classification using band 4 data for two dates. For this case, the mean performance of the classification is 87.5%.

The thematic classes distribution in the study area from supervised classification are showed in the figure 2.

To simplify the comparison between the both classifications (MAXVER and Slicing) the classes were clustered in two categories: water (water and water flood) and wet areas (wet areas 1 and wet areas 2). The water category occupied basically the same percentage in both classifications (14.7% - Slicing; 14.1% - MAXVER) due to the easy spectral separability of the water in the near-infrared band (TM 4).

On the other hand, the wet areas are characterized by heterogeneous surfaces and in this way the percentage of area occupied for this class presents significant difference (50.8% - MAXVER; 43.3% - Slicing). Beside that, in the practice for the multitemporal analysis must be considered that many of the differences between two images will be a result of variations in sun angle and orientation on overall illuminations levels.

The other digital processing used in this study was the multitemporal difference of the image (band 4 flood - band 4 normal). In this algorithm a off-set value equal 128 was used to eliminate negative digital numbers, as follows:

$$\text{DIF.IMAGE} = \text{FLOOD IMAGE} - \text{NORM.IMAGE} + 128$$

The Density Slicing algorithm was applied in the difference image. The result obtained was not satisfactory when compared with the other two classifications systems (MAXVER and Slicing applied in the flood band 4), mainly with the reference of the water category. The reason for this insatisfactory result is due to the misclassification between the water and other changeless targets.

The accuracy of the mapping of the inundated area by digital analysis was not evaluate because ground observations weren't available.

#### 4. CONCLUSIONS

This study demonstrates the versatility of TM-LANDSAT data for flood events analysis. The multitemporal TM data permits to evaluate the sections of the flood plains inundated.

In this case, the use of digital analysis provides the quantification of the flooded area directly on the multitemporal images. The supervised classification algorithm (MAXVER) presented satisfactory results when compared with the others two algorithms (Slicing on the flood band 4 and Slicing on the difference image).

The analysis of multitemporal color composite (normal and flood periods) demonstrated that no other TM band used alone produced a more accurate classification.

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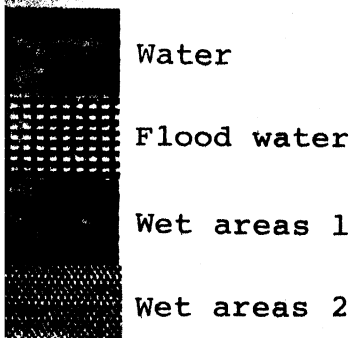


Figure 2. Print-out map produced by the computer (MAXVER classification)