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LAKE BATHIMETRY EXTRACTED FROM SUPERVISED CLASSIFICATION AND IN SITU ESTIMATION ALONG JEQUIA LAGOON.ALAGOAS.BRAZIL

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Abstract. Thematic Mapper (TM) image recorded in 1990 and containing a visible wavelenght range (450-600 nm) was used to processe data relating the reflectance along the water surface and light penetration of light. EASI PACE-PCI and DIMPLE digital image procesing programs were used within this work. Data from the TM-Band 4 was also used. The ´ in situ´ depth measurements were realized during the same period. Samples of bottom sedimetns were collected.

A Maximum Likelihood Classification (MLC) and a Density Slicing (DS) were performed to estimated bathimetric zones related to turbidity levels. The results indicate silting (high deposition) processes on the main inlet and outlet therefore lower depth levels of the Jequia lagoon and a depther site on the middle of that lake. The in situ depth data also show similar results.

1. INTRODUCTION

The main goal of this research is to present the results of a digital (processed) and in situ bathymetry estimated for the Jequia lagoon located (Figure 1.1) along the southern coast of Alagoas state, northeast of Brazil, during two field work. Comparisons between the two set of data are also discussed within this paper. Those results are part of a doctorated study developed on the mid 90s.

The *Jequia* lagoon has a water surface area of about 16 km^2, a width varying from 200 m to 1000 m and a depth varying from 1 to 11 m. The lagoon in connected to the *Atlantic Ocean through a* tidal channel has a length of 7,5 km and width varying from 50 to 200 m. The *Jequia* lagoon, presents mostly clastic continental sediments as the major water quality parameter considered on this work. Several suspended sediment plumes floating on the Jequia lagoon were recognized during field work and processing LANDSAT-TM data.

Sugar-cane fields, farming crops, roads, urban sites and bare soil are the land-used targets ourrounding the lagoon. Those targets were masked from the lagoon.

2. METHODOLOGY

The *Jequia* multispectral image used within this work was recorded on a computer compatible tape (CCT) from the Thematic mapper sensor captured from LANDSAT 5, managed by the Brazilian National Institute of Spatial Research (INPE) in partnership with NASA. Seven TM bands were recorded during the peak of water excess around 9:45 a.m., on June 11, 1990 and are free from geometric and radiometric corrections.

The Thematic mapper tapes were processed in sections of 1024 x 1024 pixels, by the PCI Image Analysis System Softwares on a Sun UNIX based computer station at the Remote Sensing Laboratory of the Department of Human Sciences of the University of Quebec at Chicoutimi.

The overall imagery size was 6 120 pixels per 3 088 lines centered at -9,6563 degrees of latitude and -36,2322 degrees of longitude. The target of interest in this study present specific spectral signatures or albedo within the TM bands along the visible wavelength ranges of TM1, TM2 and TM3, and one near infra-red band, TM4. Subscenes sets presenting 700 pixels per 700 lines were selected and generated from an image of 3 089 pixels per 3 600 lines

The methodology used comprises two main steps: a pre-processing procedures which include the selection of the TM bands containing the most suitable spectral information regarding the depth along the water column of the lagoon, the correction of atmospheric scattering and the removing of striping zones.

The second step comprises the analysis and interpretation of the overall irradiance for the targets within the water column of the lagoon. The procedures applied in this step involve the application of simple image arithmetic, decorrelation of data through the principal component transformation, the categorization of data using density slicing classification and a standard Gaussian (normal distribution) classifier.

Within the first step we isolated the area of the Jequia lagoon from its sorrounding to avoid mixed pixels. Training sites were selected based on field observations and a Gaussian Maximum likelihood classification and a pseudo-color encoding procedures on the LANDSAT-TM computerized image was then perform to generate the digital bathimetry mapped for each individual TM-band.

An error matrix was performed to achieve the classification efficiency and a principal component image was also performed to highlight or enhance the non-correlated or redundant depth-related-turbidity data.

In situ measurements along the lagoon were realized with a scaled rope during sediment sampling. The data was plot on the SURF program which performed the depth zones. The depths were grouped to suspended matter in four main zones I, II, III and IV (Figure 2)

3. RESULTS AND DISCUSSION

Innumerable published researches of single and multiband processed data presenting reflectance patterns of water targets depending on depth turbidity, turbulence and salinity levels. We refer to the work of Nichol (1993); Lavery *et al*. (1993); Lathrop *et al*. *(*1989); Khorram and Cheshire (1985); Khorram (1981) and Johnson and Harris (1980). Bhargava, S. D., and Mariam, W. D. (1991); Bierwirth, P.N et al.(1993); JI, W. et al. (1992).Lemieux, H. G., et al. (1993); Mertes, K.A. L., Smith, O. M., and Adams, B. J. (1993); Moore, K. G. (1980) and Tassan, S. et al.(1993).

The estimation of the in situ bathymetry of the *Jequia* lagoon was performed using data gathered by lifting down a rope attached to the dredge equipment at each sediment sample site. Six main bathymetric zones were mapped. Zone II represents the deepest zone, with depth range from 11-16 meters. Zone IV represents the shallow one with average depth of 30 cm to 1 meter, and the two others' zones comprising intermediate zones with average depth of 2-8 meters.

The TM1 band showed the highest suspended sediment signature. It also produced the highest light penetration values reaching depths of 10m in the water column. The TM2 band is assumed to map the lagoon depth down to 5m. The overall albedo is considered to be recorded within TM3 band. The absorption and scattering effects in the water column of the *Jequia* lagoon is deduced based on the expected effect produced by the targets within the attenuated irradiance of energy. These effects are assumed to be the related to the variation of grain size, mineral type and concentration of sediments.

The highest correlated data within the five TM bands mapped was applied a supervised Gaussian classifier. The raw data was used to produce a MLC and DS images are ilustrated in Figure 3 and 4. The targets categorized using both data sets produced similar images. The classifications results depict the lower depths of site IV and I and a deep basin in the middle of the lagoon, on site II.

The depth variation from shallow Zones I and IV (3-5 m) to deepest Zones III and II (6-12) play also a significant role within the residual irradiance recorded by the LANDSAT TM sensor. This parameter might create constraints on any comparison between the residual irradiance detected by the TM sensor, and the residual spectra-reflectance(irradiation) recorded by the spectro-radiometer in laboratory for a constant depth. The results indicate a high attenuation due to the significant absorption and scattering effects from the targets within Zones I and IV and a low attenuation effects produced by the targets within the water column of the deepest Zones II and III of the lagoon.

Therefore the higher overall residual irradiance is controlled mainly by the partial irradiance estimated within the shallow Zones IIIa and IV. The interpretation of the model suggests at least two uniform layers of water for Zones I, IIb and IIIa and a very mixed one for Zone IV. It is assumed two deepest layers along Zones I and IIb and a shallow one within zone III. These results show good agreement with the bathymetric data.

The estimation of the digital bathymetry of *Jequia* lagoon using LANDSAT-TM data, was also performed using the band rationing and band subtraction procedures. The

selection of TM bands to map the bathymetry of the lagoon was based on the assumption that light penetration within water columns is wavelength dependent (Iqball, 1983).

4. CONCLUSION

The bathimetric results indicates a very advanced silting process mainly on the outlet of the Jequia lagoon. Historic data on period silting have been stated by the fishing community of Jequia. Outlet site is near the Jequia town which presents a very tempting potential to tourism and fishery activities. Due to those natural potential and historic deforestation, we consider the study area as a very sensitive environment, susceptible to quick degradation, or at least subjected to a rapid and accelerated silting of the entire lagoon if sustainable measures are not taken in account within Jequia regioanl or territory planning.

Therefore the intensive land-use along the sorrounding area of the lagoon must require a continuous monitoring program before any development or expansion program might be established. The Jequia lagoon should be managed through integrated seasonally preservation and/or conservation sustainable projects coupled with education programs. wit

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