Proceeding of the 10th International Symposium on Spatial Accuracy Assessment in Natural Resources and Environmental Sciences
Florianopolis-SC, Brazil, July 10-13, 2012.

The Positional and Thematic Accuracy for Analysis of Multi-Temporal Satellite Images on Mangrove Areas

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Abstract

This article presents standard procedures on the positional and thematic accuracy for analysis of multi-temporal satellite images on mangrove areas. The Landsat TM 5 imagery for the years: 1986, 1997, and 2010 were used to identify and quantify the anthropogenic pressure, through the process of urbanization on coastal marine ecosystems surrounding neighborhoods at the city of Florianópolis – SC, Brazil. Geometric correction of these images reached a positional accuracy ¼ pixels. On the thematic accuracy, a supervised classification, using a maximum likelihood classifier, was validated using Kappa Index statistics (Conglaton and Green, 1999). The results show that high classification accuracies were reached. However, marine processes, such as coastal erosion on the shoreline and dynamics of ecosystems (e.g., natural succession of species of different vegetation types, as well as the seasonal variation of reflectance of plants) are factors to consider when assessing the reliability of image classifications.

Keywords: Mangrove Areas, Multi-Temporal Analysis, Land Cover Classification.

1. Introduction

The urban growth of coastal cities, has forced the occupation of areas with fragile ecosystems, not favorable for this use due to its biological, physical and socioeconomic aspects in recent decades. An important tool for locating and quantifying the urban pressure on coastal marine ecosystems are the Remote Sensing products, mainly when associated with GIS analysis. Usually the accuracy of cartographic products is represented by two components: positional and thematic components. Positional accuracy determines how closely the position of discrete objects shown on a rectified image (map), or a spatial database agrees with the true position on the ground. While thematic accuracy, refers to the non-positional characteristic of a spatial data entity, the so-called attributes (which are derived from radiometric information).Thus, this article aims to analyze the thematic and positional accuracies, and the resulting imprecision in multi-temporal analysis images from the Landsat TM 5 sensor in mangrove areas. Where, the derived products on the multi-temporal analysis had associated uncertainty which

influenced on the analysis. The existence of aligned pixels within the limits of the class theme represents the noise of the positional accuracy.

2. Study Area

Urban growth was not very expressive in Florianopolis until the second half of the twentieth century. Therefore, after the 60 decades, Florianópolis was affected by socio-spatial transformations as result of developmental policies, which conducted this city to suffering a severe process of urbanization. Urban growth was first directed to the north of the island, however, in the late 80s/90s the new spatial planning policies at the municipal level as well as construction of infrastructure such as the Southern Expressway, intensified urbanization population in the South of the Island. This was the case of towns on the boudaries of the mangrove Rio Tavares (Costeira do Pirajubaé, Carianos, Rio Tavares and Campeche) where there are infrastructure, settlements and anthropogenic activities advancing coastal marine ecosystem over the years. Figure 1 shows the spatial location of the study area.

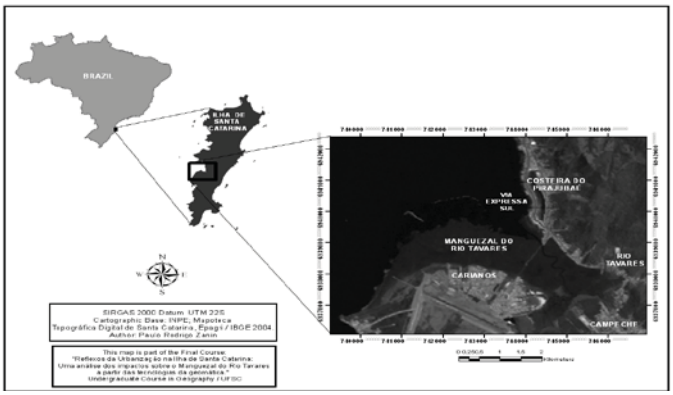

Figure 1: Location of the study area.

3. Material and Methods

It was used images from Landsat 5 TM sensor (bands 1, 2, 3, 4, 5, and 7) for the years of 1986, 1997 and 2010, released by INPE to perform the land cover classification. It was also used a Garmin GPS Xtrex Vista receiver for the georeferencing of these images and sample areas identification on the field for supervised classification. The classes of land use and land cover used in the supervised classification of Landsat TM 5 images of the sensor were defined according to the Technical Manuals of IBGE (1992) and IBGE (2006) with some generalizations and specializations. The informational calsses chosen were: Water, Urbanized, Mangrove, Campestral, Ombrophilous Dense Forest, Landfill and Sandy Deposits.

The material of remote sensing over GPS data were processed in Idrisi Andes Version 15.0, to obtain the classification of the land use and land cover and analyze the changes in the environment means arithmetic overlay. It was used the software ArcGIS 9.2 to generate the layout of the maps.

Initially it was performed geometric corrections (absolute and relative), through ground control points, of the images sets into the actual Brazilina Reference System

(SIRGAS 2000). It was identified representative areas of each thematic class through field supervision using GPS receiver for location of these samples. From these field work, it was generated a reference image which was used on the supervised classification in order to training and test a Maxima Likelihood classifier. After the validation process, using Kappa Index and independent samples, it was obtained the three thematic images for each year of the analysis. And finally, it was used these thematic image for the temporal analysis, means arithmetic overlay, in different time intervals (1986-1997, 1997-2010, 1986-2010), The analysis of positional and thematic accuracies consisted in an empirical verification of results obtained from field surveys.

4. Results and Concluding Remarks

In relation to the positional accuracy, two factors were decisives: the GPS receiver accuracy (+/- 10 m), but due to favorable weather conditions and topographical factors, each point achieved an accuracy of +/- 3 to 4m, and the root mean square (RMS) error for georeferencing. These geometric corrections obtained RMS of approximately ¼ of a pixel in the three images, as Table 1. For the multi-temporal analysis, result in inaccuracies on the featuring boundaries after the overlay process. Therefore, thematic maps generated arithmetic overlay will produce pixels on the feature edges that do not represent real changes, but they represent only results from a pour registration.

Table 1: RMS for images 1986, 1997, 2010.

Year	1986	1997	2010
RMS	0.2083	0.17789	0.2374

Thematic accuracy usually could be derived from the comparison of samples on the ground (references) and their homologues on the thematic image derived from the classification procedure. Between thematic classes were made some generalizations and specializations of thematic classes in order to elicit relevant information to this research, with acceptable precision. Current accuracy assessment methods are based on non-spatial statistics derived from the confusion or error matrix, which compares the output of a classifier and known test data. Although these measures are in widespread use, none of them considers the spatial distribution of erroneously classified pixels, either implicitly or explicitly. (Vieira *et al.*, 2004)

Since the validation of the classification, which identifies representative of each class stating the level of confusion between the samples and the classification was obtained by the kappa index of Agreement validation (Conglaton and Green, 1999). Table 2 shows that all classification performances have reached very high accuracy level ($0.8 < k < 1.0$). For the 1986 image of the Kappa index was 0.9987, the image of 1997 reached 0.9908 classification and the classification of 2010 was the rate of 0.9863. Table 2 shows the summary of the error matrix.

Table 2: Summary of the Error Matrices (Percentage of hits).

Classes Thematic	1986	1997	2010
Water	100%	100%	100%
Mangrove	100%	100%	100%
Urbanized Areas	98.43%	100%	90%
Campestral	99.15%	97.54%	95.96%
Ombrophilous Dense Forest	100%	98.75%	94.57%
Landfill and deposit sandy	100%	92.94%	100%

After performing the classifications and validation of the classification, it was observed in field that there was confusion among some classes: Arboreal mangrove and Ombrophilous Dense Forest, more specifically on the training patterns for the Maciço da Costeira lowland forests. Another misclassified pixels, on a smaller proportion, was among the Urbanized Areas and areas of landfill with spectral response different from zero. Some areas of sand deposits were misclassified due to the presence seasonal water surface layer of water on them. There was also confusion between Mangrove areas and Campestral, particularly in areas of transitional vegetation.

Although high accuracy levels were reached, according to the validation indices kappa (Conglaton and Green, 1999), of special significance are spectral and physiological changes that occur as a plant matures. Therefore, there will be phenological stages of a crop that will be extremely important for its identification, and other ones in which it will be almost impossible to discriminate between crops, since their spectral profiles are very similar. (Vieira, 2000)

The variation on the spectral behavior of the plants, according to their phonological changes, influenciate the accuracy of thematic images, resulting in inaccuracy in multitemporal analysis. Another factor influencing the multi-temporal imprecision based on the reflectance of the targets, refers to the intertidal, as for being a coastal area, sandy deposits submerged in a layer of shallow water, with enough depth or emerged, showed different spectral responses.

This article reached the proposed objective. For positional accuracy, the geometric correction of images obtained RMS less than $^1/_4$ pixel for all images, that resulted in inaccuracies of a pixel in the multitemporal analysis. All the three classifications reached kappa indexes considered excellent, however, the phenological spectral changes of the plants over the years and variations on sea level according to the tidal affect the accuracy of classification of past images, resulting in imprecision in multitemporal analysis. Thus, Landsat TM images are very useful in order to locate and identify areas of mangrove removal.

Acknowledgements

We would like to thanks the Geosciences' Department - CFH / UFSC for the use of their software in this study. We would like to thanks to the Commander of Florianópolis Air Base, Mr. Paulo Roberto de Schã Barros, who authorized the work in the military field.

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