MAPPING AMAZON RIVER FLOODPLAIN REACH WITH SRTM-DEM USING THE HAND DESCRIPTOR AND OBJECT BASED IMAGE ANALYSIS

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ABSTRACT:

The study of the Amazon River floodplain is of great importance for many subjects, and the first challenge that needs to be overcome in these studies is accurately defining the area of floodplain occurrence. An important source of data for this kind of study is the SRTM Digital Elevation Model. The objective of this work is to evaluate the use of SRTM data and HAND descriptor (Rennó et al, 2008) to map the Amazon River floodplain, using object based image analysis. For this, an Amazon River floodplain reach, Óbidos, Pará State was selected to apply the classification method. The classification was carried out using a two level segmentation and three level classification procedures. SRTM-DEM, HAND-DEM and HAND-DEM derived slope and curvature images were used as information layers. The results of the Monte Carlo analysis used to evaluate the level of agreement between the classifications and a reference map reveal that object based classification methods shows promise for floodplain mapping.

1. INTRODUCTION

The study of the Amazon River floodplain is of great importance for many subjects, such as deforestation (Renó et al, 2011), water circulation (Barbosa, 2005; Junk, 1996), fishery production and water quality (Junk, 1996). The first challenge that needs to be overcome in these studies is accurately defining the area of floodplain occurrence. Data from optical sensors was used in the past (Mertes et al., 1995; Novo & Shimabukuro, 1997) to map the Amazon wetland vegetation, but these sensors, due to cloud and smoke cover, have limited application (Hess et al, 2003).

Active sensors, such as SAR systems, can bypass most of these restrictions, and provide useful data for mapping the Amazon floodplain. Hess et al (2003), for example, using SAR imagery from JERS-1, generated a map of the Amazon mainstem floodplain. They estimated that approximately 17% of the 1.77 million km² study area covering the central Amazon basin was occupied by wetlands, that is, areas regularly inundated for at least part of the year.

Another important source of data derived from SAR systems is the SRTM Digital Elevation Model (DEM) created using InSAR techniques (van Zyl, 2001). This DEM constitutes the source of topographical data with the best resolution and most accurate currently available for many parts of the world (Rennó, 2008).

Using the SRTM-DEM as reference, Rennó et al (2008) proposed the Height Above Nearest Drainage (HAND) descriptor. This descriptor generates a DEM such that the height indicated in each cell is the height of that cell in relation to the point of the drainage network nearest to it. In the HAND-DEM, rivers and lakes have their height zeroed, and the model presents strong correlation to the local topography (Rennó et al, 2008).

The objective of this work is to evaluate the SRTM data and HAND descriptor to map the Amazon River floodplain, using object based image analysis. For this, an Amazon River floodplain reach, near Óbidos, Pará State (Figure 1) was selected to apply the method.

Figure 1. Localization of the study areas

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2. STUDY AREA

According with Mertes et al (1996), the floodplain in the area near Óbidos is more confined and straight than most areas of the Amazon River floodplain, with the presence of broad, shallow, patchy lakes. The height difference between the floodplain and the non-floodable areas is significant as well, approximately 10 m on average.

This specific portion of the SRTM-DEM is also practically free of acquisition errors, which would negatively impact the classification. These factors should make the task of delineating the floodplain easier. The SRTM-DEM of this area is shown in Figure 2.

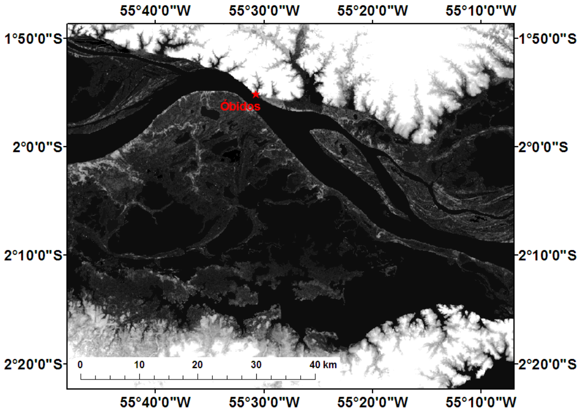

Figure 2. SRTM-DEM of the Óbidos study area.

3. METHODOLOGY

The methodology applied in this study can be summarized in three main steps: HAND-DEM processing, floodplain mapping and classification validation.

3.1 HAND-DEM

Firstly, a HAND-DEM of the study area was prepared as described in Rennó et al (2008), using a plugin for ENVI developed in IDL by Dr. Rennó. This process does not require input from the user for the most part, beyond providing the source SRTM-DEM to be converted to a HAND-DEM.

It is necessary, however to indicate the contributing area threshold value to be used by the descriptor, so the drainage network created in this way accurately reflects the real one. This value signifies the numbers of DEM cells which contribute to the flow accumulating in the cell being considered.

This process separates channel cells, which will have zero height in the finished HAND-DEM product, from non-channel cells, which will have their HAND-DEM height based on the nearest channel cell. For this work, a threshold of 10.000 cells was used for the study area.

Then, the slope and curvature images for this area were created based on the HAND-DEM. Both images were created using the Spatial Analyst module available in ArcGIS. The curvature image used was the one created by the 3x3 mask averaging method, so it contains the curvature information in the horizontal and vertical directions. These images, along with the original SRTM-DEM, composed the data layers used in the object based classification procedure.

3.2 Floodplain Mapping

To differentiate floodplain areas from higher terrain, a hierarquical class description based on a two-scale segmentation and a three-level classification was programmed as a processing routine within the eCognition image analysis environment. This description is summarized in Figure 3.

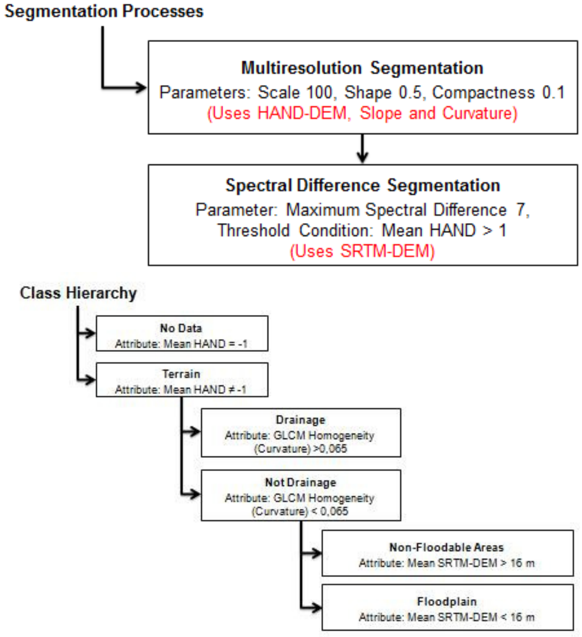

Figure 3. Class description procedures

The segmentation of the images of the study areas were done in two steps. This because the eCognition software is not able to execute the Spectral Difference Segmentation algorithm over the original pixels of the images. Furthermore, it serves to optimize the processing time,

The Spectral Difference Segmentation algorithm, which merges objects if their means differ by a value smaller than the parameter defined by the user. This algorithm was preceded by the Multiresolution Segmentation algorithm.

The Multiresolution Segmentation algorithm merges pairs of adjacent pixels (or objects) according to a homogeneity criteria created by combining the scale, shape and compactness parameters defined by the user.

The classification process followed a tiered strategy, first separating the areas that could not be properly processed by the HAND descriptor (incomplete small basins in the borders of the images) into the No Data class.

In the second level, the process classifies the Drainage objects, which are readily separable using the texture attribute GLCM Homogeneity, as the drainage network has always the same height (zero), and thus is flat throughout the image.

Finally, the third level uses the mean SRTM-DEM height of each remaining object to classify it as either a part of the floodplain or part of the non-floodable areas.

3.3 Classification Validation

The wetlands map based on JERS-1 data created by Hess et al (2003), adapted to include the drainage network, was used to validate the classification. The portion of this map correspondent to the study area is shown in Figure 4.

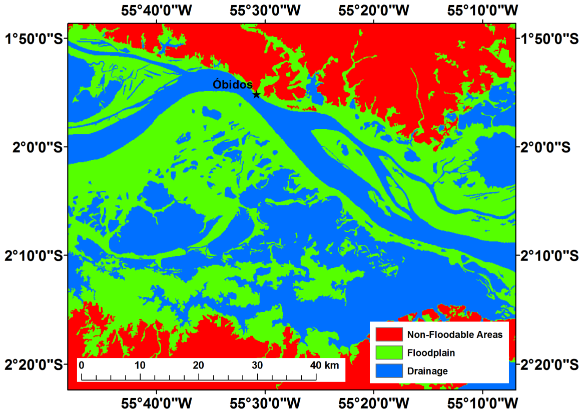

Figure 4. Reference map of the Óbidos study area.

A Monte Carlo analysis with 5000 iterations was carried out to create a 95% credibility interval for the value of the kappa coefficient. Each iteration consisted of calculating kappa for a different, randomly chosen, 150-pixel sample from each class of the map.

This 95% credibility interval means that 95% (corresponding to 4750 iterations) of the 5000 iterations of the kappa index calculated are in the range of the interval. The narrower this interval is, the more representative of the actual correspondence between the reference map and the classification. Also, a higher credibility interval means a higher level of agreement is expected between the reference map and the classification.

4. RESULTS

The floodplain maps of the study areas are shown in Figure 5, and Table 1 presents the results of the Monte Carlo analysis.

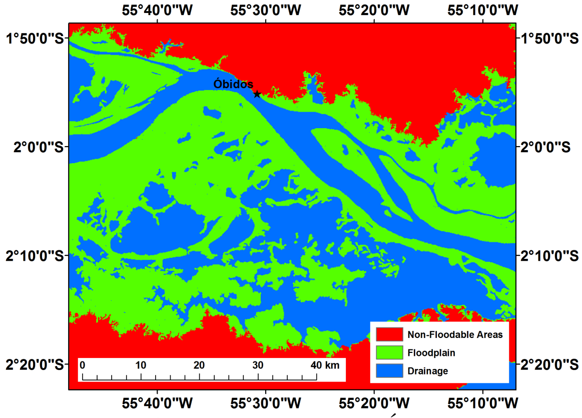

Figure 5. Floodplain map of the Óbidos area.

Study Area	Credibility interval (95%)	Maximum kappa value	Minimum kappa value
Óbidos	0.810 – 0.890	0.783	0.923

Table 1. Results of the Monte Carlo analysis for the study area.

The results of the Monte Carlo analysis show that the credibility interval is narrow enough to be considered representative of the true agreement between the reference map and the classification, presenting a width of 0.08. The lower and the higher values for kappa found on the 5.000 iterations of the analysis are also reasonably close, with a difference of 0.14 between them.

For the Óbidos study area, the high level of agreement between the classification and the reference map was expected, as this area consists of a strongly confined floodplain, with a large difference in height to the non-floodable areas. The small number of tributaries and the comparatively large area of the lakes in the floodplain also contribute to the high values of kappa calculated, because smaller features are harder to correctly classify.

The results obtained show that the object based classification procedure created a map with a high level of agreement with a previously published map. However, the relative lack of difficulty in the classification process means that the Óbidos study area may not be representative of the actual problems one must face when mapping the floodplain of the entire course of the Amazon River. This means that tests on several other areas are necessary to fine tune the classification procedures so that they can work on the entire river.

5. CONCLUSIONS

The results provided by the Monte Carlo analysis show that object based classification approach can generate a product that displays a high level of agreement with a previously published floodplain map of the study area. This is possible because this method allows the interpreter to more directly input the criteria used in the classification.

The results also reveal that the combination of SRTM-DEM data with the HAND descriptor is a promising approach to floodplain mapping. The authors intend to extend its use to more areas on the Amazon River and eventually to the entire course of the river.

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