OPEN JOURNAL SYSTEMS
ISSN:2237-2202

Available on line at Directory of Open Access Journals
Journal of Hyperspectral Remote Sensing v.7, n.5 (2017) 284-291

www.periodicos.ufpe.br/revistas/jhrs

Journal of Hyperspectral Remote Sensing

SRTM and ASTER models digital elevation (MDE) products: Assessment comparative in Sobradinho Reservoir – Bahia, Brazil

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Received 19 September 2017; accepted 20 October 2017

Abstract

The Sobradinho Reservoir is one of the most important in the northeast of Brazil, therefore, the perennial and adequate monitoring of this area reflects in good practices in the economy and quality of life. Thus, understanding the best altimetric database for the region is essential to initiate and assist in other monitoring processes, since the relevance of altimetric studies in several areas is observed. Therefore, this work aims to evaluate, through a comparative analysis, the SRTM models (30 and 90 meters) and ASTER (30 meters) for the Sobradinho Reservoir region. SRTM images (30 and 90 meters) and ASTER were acquired, where it was executed its mosaic and altimetric classification through the software ERDAS imagine 9.1. In the analysis, it is verified that the values of the digital elevation models ASTER do not agree with the academic literature for the region. The SRTM model of 90 meters resolution maintains values within the observed in the literature, however, in the water body of the reservoir occurs the error called sinks. The SRTM 30-meter resolution maintains the best data quality, error-free and according to the literature. Through this manuscript, it is recommended to use the SRTM digital elevation model of 30 meters resolution for the Sobradinho Reservoir region, due to the excellent results found.
Keywords: Remote Sensing, Geoprocessing; Water resources.

1. Introduction

The Remote sensing from microwave mappings coupled with photogrammetry and radargrammetry techniques resulted in stereoscopic products, that is products derived from the comparison of pairs of images in the same area. Radar interferometry, in turn, where the active emission of the signal for antennas (central antenna for two antennas at known points) provides new alternatives for efficient imaging of environments next to said stereoscopy, in which the representation reproduced in these processes are the Digital elevation models, also called MDE - DEM. Digital elevation models (MDEs) represent, for geoprocessing, a high degree of essentiality in the analysis of urban or natural environments, providing support for slope information, drainage network, disaster planning and prevention, among others. Several studies based on the MDE data were carried out for agriculture geopotentiality (Silva et al., 2015), desertification (Ferreira et al., 2014), geomorphological and geophysical characteristics (Kazzuo-Vieira, 2009; Camargo et al., 2011), observing that, with The combination of climatological knowledge, temperature and geomorphological / geological results was satisfactory in the expected results.

Among the various digital elevation models available stand out the ASTER and SRTM MDEs, both carried out by partnerships between the US government and other countries (NASA - National Aeronautics and Space Administration and METI / MITI - Ministry of Economy, Trade and Industry / Ministry of International Trade and Industry of Japan for ASTER and NASA - National Aeronautics and Space Administration, DLG - Deustches Zentrum für Luft- und Raumfahrt ASI - Agenzia Spaziale Italiana for SRTM), being used for several functionalities over the years.

The ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) sensor was launched in 1999 aboard the TERRA satellite, where its characteristics, for example, of narrower bands and

more in the medium and thermal infrared region gave the possibility of studying More detailed responses of surface targets, influencing and arousing the interest of the scientific community (Yamaguchi et al., 2001). The ASTER is an image radar that presents a spatial resolution of 30m in its topography, formatted to a 1 x 1 degree at each pixel of its image; The radar operates with 3 independent subsystems, with its own telescope: the visible and the near infrared (VNIR) have 3 bands with 15m spatial resolution and an extra telescope imaging backwards, allowing the stereoscopic vision of the near infrared band; mid-infrared (SWIR) with 6 bands and 30 m spatial resolution and thermal band (TIR) with 5 channels and 90m spatial resolution. The SRTM - Shuttle Radar Topography Mission project was launched in February 2000, showing the final product for 80% of the Earth's surface, corresponding to images three arcseconds or approximately 90 meters resolution (we will call the SRTM-3 90-meter product), available for the entire globe and a second arc (we will call the product 30 meters of SRTM -1) or approximately 30 meters of spatial resolution, available only for the North American territory until the year 2014, after that period the images were made available For all traced territory (ASTER, 2002; SRTM, 2005; Teixeira, 2005).

According to Nikolakopoulos, Kamaratakis and Chrysoulakis (2006) and emphasized by Luedeling et al. (2007), errors in DEM were detected during analyzes and studies on environments, in which two cases are widely recognized: the accuracy of the positioning of the radar in relation to the relief, where regions above 20 ° or mountainous can share these errors and in water bodies, in which the reflection of the water sheet interferes in the quality of obtaining the data. In this problem, it stresses the importance of choosing a digital elevation model for these areas that comes close to the information obtained during on-site measurements or in subsequent works, beyond the areas easily detected by radar, higher regions, bathymetry, and border areas of rivers and reservoirs. This work aims to analyze the digital elevation models ASTER and SRTM - 1/3 for the Sobradinho Reservoir - BA, one of the largest artificial reservoirs in latin america and of extreme importance for the maintenance of life in the In the Brazilian semiarid northeast and its surrounding region, aiming to observe which is the most adequate to contribute with due support in geoprocessing works,

2. Materials and methods

The study was carried out in the Sobradinho Reservoir (Figure 1), State of Bahia, located in the Northeast of Brazil and included in the Middle San Francisco region. According to Dantas (2005), the area dominates the semi-arid climate, the vegetation of Caatinga and negative water balance. With a total area of 4214.3 km² and maintaining 280 km in length, the strategic location allows, according to Santos (2012), local climate maintenance, population supply and economic investments from irrigation. The municipalities of Petrolina, Juazeiro, Jaguarari, Campo Formoso, Umburanas, Sento Sé, Remanso, Casa Nova and Sobradinho constitute the area surrounding the reservoir.

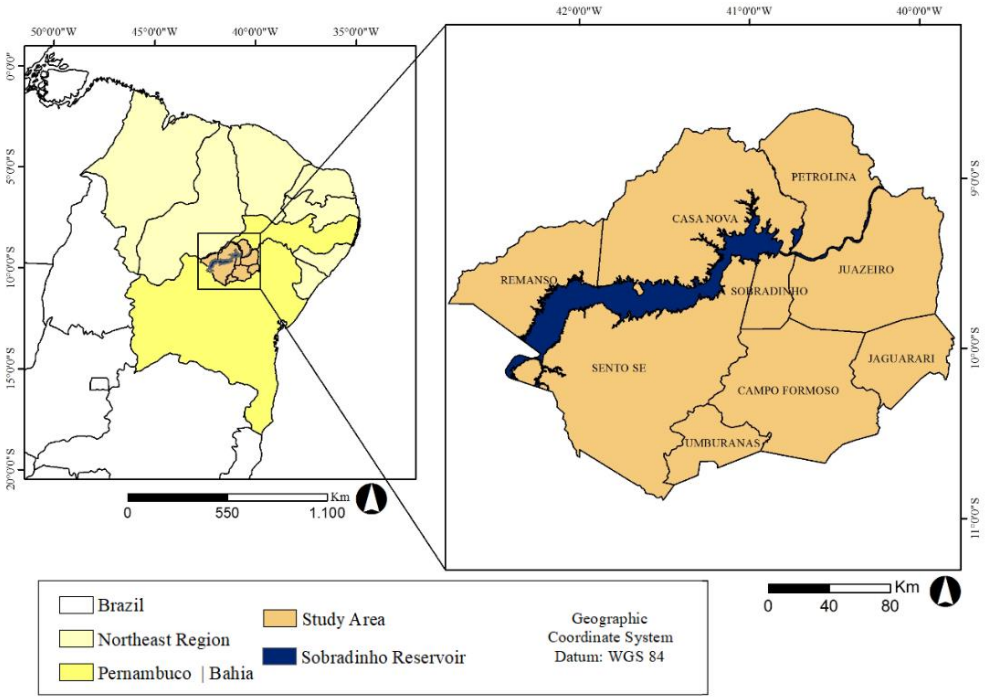

Figure 1 - Sobradinho Resevoir – BA, Brazil.

Collected Data

Were used in this study SRTM, DEMs and ASTER. The generation of the Digital Elevation Model will be carried out using the Shuttle Radar Topography Mission (SRTM) data, with spatial resolution of 30 m (SRTM - 1), available on the website of the U.S. Geological Survey (USGS), these images can be acquired for free at earthexplorer.usgs.gov/. SRTM images with spatial resolution of 90 meters (SRTM - 3) were also obtained, available free of charge by EMBRAPA - Brazilian Company of Agricultural Research in the Brazil portal in Relief: www.relevobr.cnpm.embrapa.br/. The ASTER images - Advanced Spaceborne Thermal Emission and Reflection Radiometer, with spatial resolution of 30 meters were obtained free of charge at earthexplorer.usgs.gov/ website. The shapefiles of municipalities and states of Brazil were derived from the IBGE and can be obtained free at the IBGE portal http://mapas.ibge.gov.br/ maps.

Images from the years 1974 and 2004 were obtained from the MMS / RBV (Landsat Multispectral Scanner System - Return Beam Vidicon) and TM (Thematic Mapper), point 233 and 67/66 orbit (13/11 / 1973) and point 234 with 67/66 orbit (09/10/1973) for Landsat 1; Point 218 and orbit 67/66 (07/31/2004) and point 217 with orbit 67 (24/07/2004) / 66 (08/07/2004), on board the Landsat 5 satellite, obtained from the geological United States - USGS.

Mosaics and reprojection

We acquired 12 SRTM images - 1 (Table 1), 18 images for SRTM - 3 (Table 2) and 12 ASTER images (Table 3).

Table 1 - Acquisition of images SRTM 30 meters resolution.

SRTM 30 meters resolution scenes	
s09_w040_1arc_v3	s10_w042_1arc_v3
s09_w041_1arc_v3	s10_w043_1arc_v3
s09_w042_1arc_v3	s11_w040_1arc_v3
s09_w043_1arc_v3	s11_w041_1arc_v3
s10_w040_1arc_v3	s11_w042_1arc_v3
s10_w041_1arc_v3	s11_w043_1arc_v3

Table 2 – Acquisition of images SRTM 90 meters resolution.

SRTM 90 meters resolution scenes		
sc-24-za	sb-24-yc	sc-24-vd
sc-24-zc	sc-23-zb	sc-24-xa
sd-23-xb	sc-23-xd	sc-24-xc
sd-23-xd	sc-23-zd	sc -24-ya
sc-24-vc	sc-24-va	sc-24-yb
sc-24-yd	sc-24-vb	sc-24-yc

Table 3 – Acquisition of images ASTER 30 meters resolution.

ASTER 30 meters resolution scenes	
ASTGTM2_S09W040	ASTGTM2_S10W042
ASTGTM2_S09W041	ASTGTM2_S10W043
ASTGTM2_S09W042	ASTGTM2_S11W040
ASTGTM2_S09W043	ASTGTM2_S11W041
ASTGTM2_S10W040	ASTGTM2_S11W042
ASTGTM2_S10W041	ASTGTM2_S11W043

Where we made to all of its images, reprojection WGS 64 south and a mosaic by ERDAS software imagine 9.3, licensed by Department of Geographical Sciences, Federal University of Pernambuco.

Vectorization of the obtained data

The vectorization or vector drawing is defined by Tori (1987), where Cartesian coordinates and geometric parameters can be converted into an image consisting of pixels, that is, a point map. The same author calls this process "image analysis". They can be used in several environments, either in the architecture or in the image processing via remote sensing (Soares et al., 2005; Rocha, 2009). In the work, the entire border of the São Francisco River was vectorized for 1974 and the edge of the Sobradinho Reservoir for the year 2004.

Image analysis

The final assembly of the maps, the inclusion of shapefiles, raster cuts by the shape and the creation and superposition of layers were done through the software ArcGIS 9.3, licensed product of the Department of Geographical Sciences of the Federal University of Pernambuco.

3. Results and discussion

The Sobradinho reservoir is dated from the 70, one of the oldest reservoirs in activity under semi-arid territory. This title made him the target of several physical studies, in order to better understand the environment and its interactions with the environment. Dantas (2005), presents to the region one of the most relevant works regarding the information collected; in his analysis, the author brings arising CHESF data flow, total area, length, minimum area for normal operative and minimum altitudes, maximum and full project (380.5, 392.5 and 393.5 meters to the aforementioned, respectively). The corroboration and affirmation of these data nowadays comes from the Ministry of the Environment - MMA (2010) and the National Operator of the Electric System - ONS (2015), in which these bodies point out new information, such as distance from the reservoir to the bridge that links Juazeiro to Petrolina, distance to Foz and the percentage / quota value ratio of the reservoir, revealing the percentage of 100% corresponding to 392.5 meters, 90% to 391.83 and 80% to 390 meters, Emphasizing the quota denominated maximorum, of 393.5 meters. The areas around the reservoir range from 394 meters to over 1000. In the possession of this information, we used the ASTER and SRTM images of the second arch and three second arcs for the study area. We divide in twelve (12) altimetric intervals, with colors varying from green to red, where the greenish colors indicate the lower values of quota and, the red ones, larger. Figure 2 shows the comparison of the SRTM - 1 [a] and ASTER [b] digital elevation models, both of 30 - meter spatial resolution.

It is observed the excellence of the stereoscopes and interferometric products in the environment chosen for the analysis by the similarity of the terrestrial data obtained for both digital models. Nikolakopoulos, Kamaratakis and Chrysoulakis (2006), when comparing digital elevation models to the city of Crete, Greece, concluded through statistical analysis that the difference of the two models is below 50 meters. The region allocated to the south has the highest altimetric values, reaching information above 1000 meters; the north of the reservoir there is a variation between 400 and 650 meters of height. The altimetric data included in the reservoir vary between the digital elevation models: in image A (Figure 2), the values comprise the altimetric dimensions of 380 to 395 meters along the reservoir as a whole, in agreement with the values found in the literature. On the other hand, the image B corresponding to ASTER has a predominance of values between 370 and 380 meters, values below those found and diffused to the water environment. Also, are noticed in the picture B two essential details that make a significant image A: the upper reservoir the size of the image A (SRTM -1) and the abrupt change of elevation values near the dam, in which the highest values (380 to 390 meters) exempting the border areas, are found.

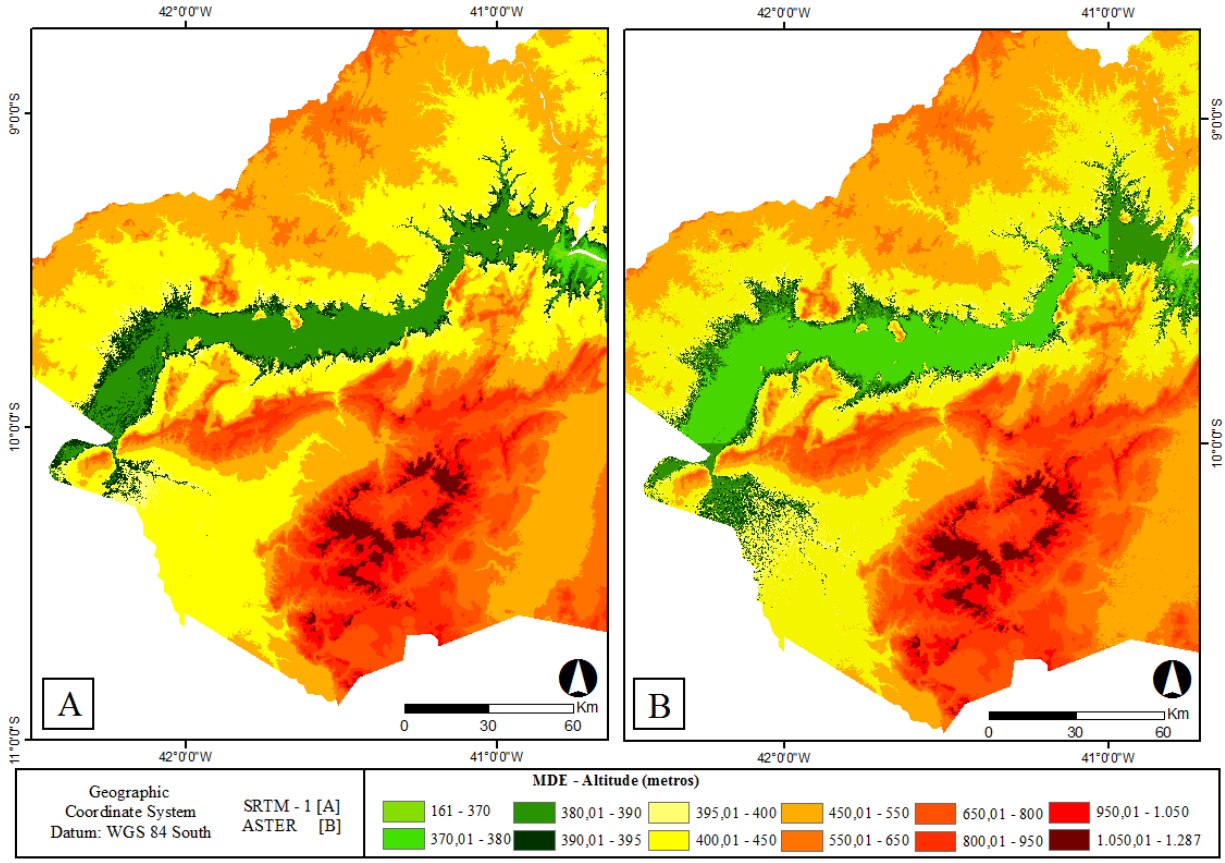

Figure 2 - Digital elevation models SRTM 1 [A] and ASTER [B] for Sobradinho region – Bahia, Brazil.

In the Figure 3 shows the comparison between the SRTM arc second (SRTM-1) and three-second arcs (SRTM -3) elevation model, respecting the criteria adopted for Figure 2. It is noteworthy that the repetition of the second arch image was due to its positive response to ASTER, as well as values included in the reservoir. About the product SRTM, Medeiros et al. (2009) indicate the accuracy of vertical and horizontal absolute are of 16 meters for SRTM - 1 and 20 meters for SRTM - 3, resulting in 90% reliability in the product.

Although the spatial resolution of the SRTM - 3 over the altimetry of the study area is similar to that found in the SRTM - 1, where the southern region presents the highest values of altitude while in the North 400 to 650 meters are displayed. With respect to the height data inside the reservoir, the predominance of several points above 400 meters is shown in Figure 3 (image B), being represented by the yellow color. These points escape the actual data of the Sobradinho Reservoir and are the result of the reflection of the water body in the radar. Mendes and Cirilo (2001) define these points as sinks, being characterized as surrounded areas with higher elevations, giving the impression that several joint depressions were formed. The SRTM - 1, with the absence of serious errors, stands out in relation to SRTM 3, since the sinks of SRTM 3 make all the altimetric work for the reservoir impossible.

In possession of this information, we performed the vectorization of the edge of the Sobradinho Reservoir for its full and pre-filling period. In this way, with the geoprocessing techniques overlay the data obtained from the layers in the SRTM - 1, due to the satisfactory results obtained on the digital terrain model. The Figure 4 shows the relation of difference between quotas in the previous period of installation of the Sobradinho Reservoir and the Reservoir in the period of its greatest floods.

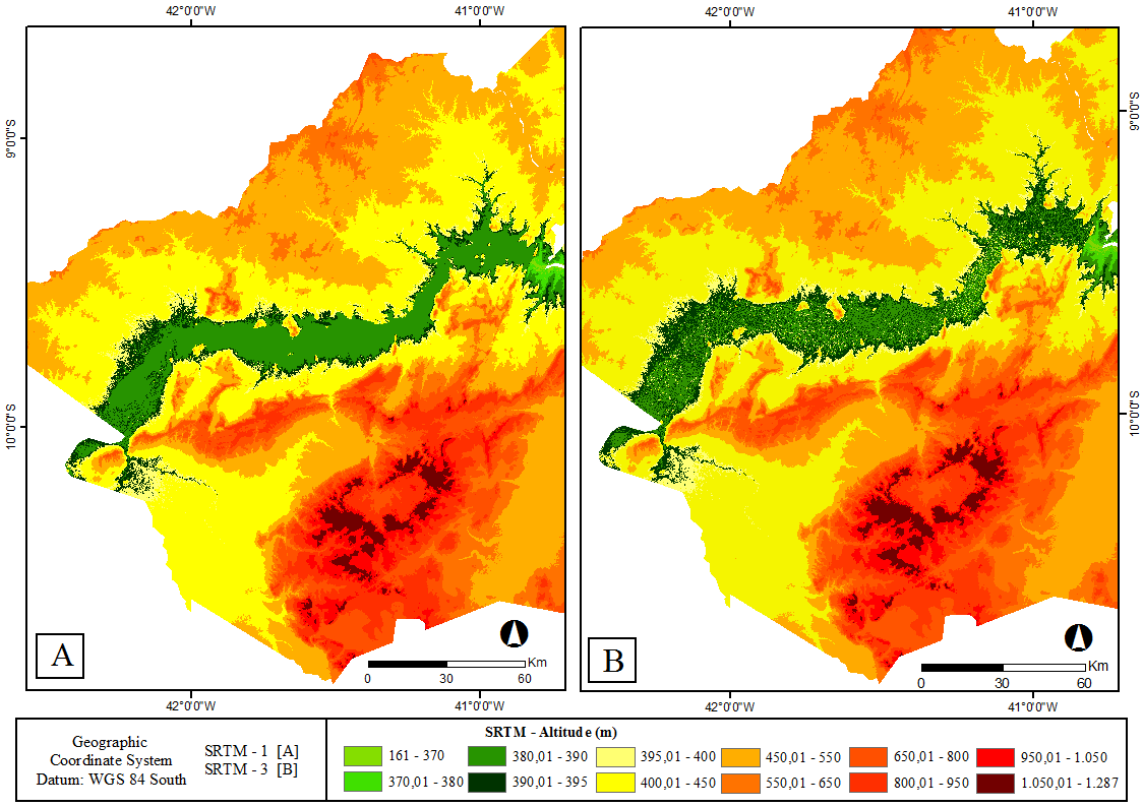

Figure 3 - Digital elevation models SRTM 1 [a] to SRTM 3 [b] for Sobradinho region, Bahia, Brazil.

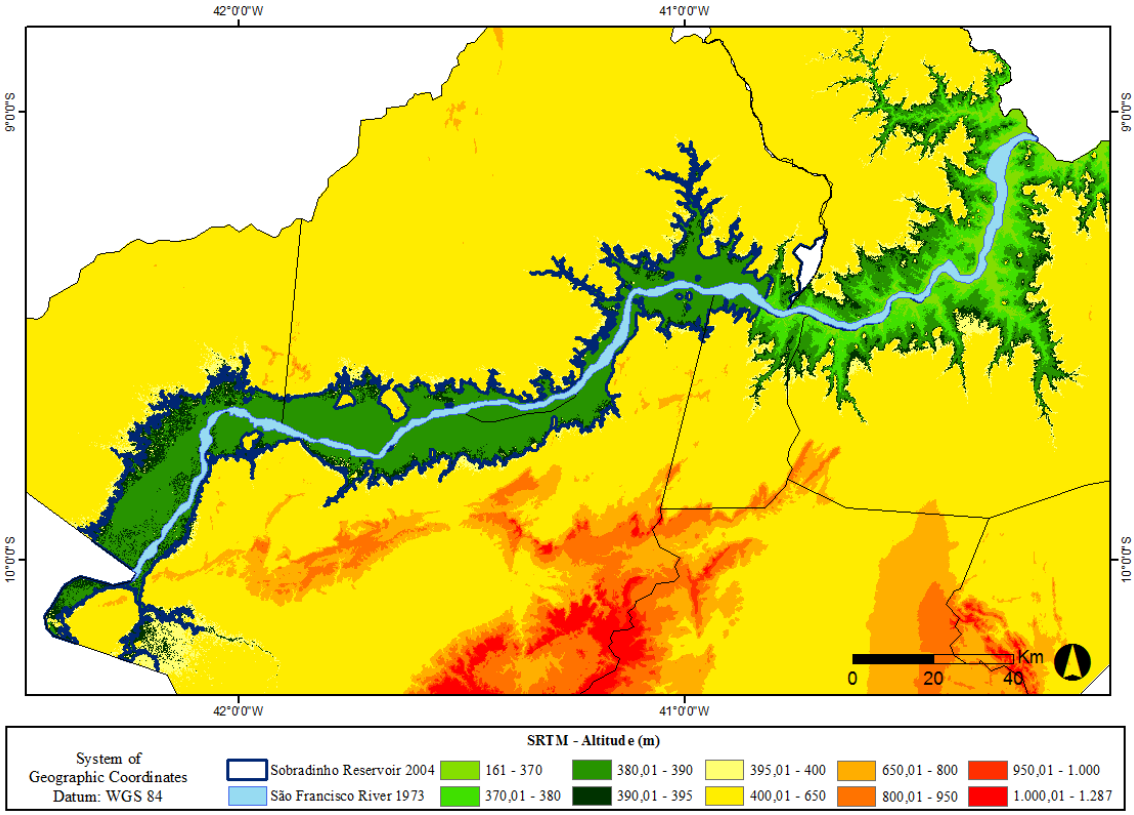

Figure 4 - Vectorization of the Sobradinho Reservoir (2004) and the São Francisco River (1974) combined with the SRTM - 1 digital elevation model (resolution 30 meters).

Knowing the characteristics of the reservoir and surrounding area, we divided the altimetry into 10 intervals for the analysis of figure 4: The greenish tones refer to the lower values; these colors are present in the reservoir and after dam areas. The lighter the green tone, the lower the height, therefore, the darker shades of green show the larger dimensions within the reservoir area. The colors yellowish to red refer to the areas with average elevation varying to high; are the other areas surrounding the reservoir. When we analyzed the São Francisco River in 1974, we observed that its height varies from 350 meters near areas near the municipality of Petrolina and 385 meters in the regions where the Sobradinho reservoir is now installed. It is noticed small areas with 390 meters, however, absent of predominance

For the analysis of the reservoir in the year 2004, it is worth mentioning initially that the values obtained in the SRTM - 1 images can understand the data already studied over the years for the environmental altimetry. The green color in figure refers to the height range 380 - 390m, and predominates throughout the area of the reservoir. The darkest color of the green shows the highest elevations within the reservoir, referring to the altimetric interval 390 - 395.01m, where in that interval the regions of the edge and of downstream are revealed, highlighting the environments of downstream, where there are the greatest evidences.

The Remote Sensing through SRTM 1 images opens a new gap for studies related to altitude and water bodies, especially in semi-arid environments, where the control and management of these resources give quality of life and economic control to society. We emphasize the importance of the field visits to verify these data from remote sensing; in addition, we highlight the relevance of the researcher in observing if the data found in a temporal bibliographic review of the region under study are in agreement with those of the analysis for validation purposes. We detected that the altimetric difference between the period of the São Francisco River in 1974 and the Reservoir of Sobradinho in 2004 for the area belonging to the reservoir today varies in the values of 10 to 15 meters, however, the dam gave the possibility of the perennial level of water is protected at the highest.

4. Conclusions

Through the analysis performed on the job at hand, we can conclude that for deriving the geoprocessing studies involving interactions with digital elevation models in the region of the Sobradinho Reservoir and its surroundings, indicates if the images arc second SRTM (SRTM - 1) due to its satisfactory answer in the aquatic sphere as in the earth, meeting with the data reported in the literature. It is advised as a methodological proposal to obtain information close to reality, an earlier comparison of MDEs, revising them with the exposed records of the region under study, since relevance was seen in terrestrial data in ASTER and SRTM. Furthermore, we observe the historical rescue that remote sensing can bring to scientific research, restoring environments that have suffered direct anthropic impacts such as reservoirs, for example.

We observed, with the result of the vectorization, that the region of the São Francisco river chosen for the installation of the Sobradinho reservoir maintained a variation of 5 meters under its altitude, comprising values of 380 to 385 of altitude. The lowest altimetric values are observed near the city of Petrolina, in which they reached measurements close to 350 meters. The region of Sobradinho in the year 2004 varied between 12 to 13 meters, covered the quota of 380 to 393 meters. In the post-reservoir region, we found the lowest values of the area, similar to the period of 1974. In general, the SRTM 1 image for the study area is absent from sinks and goes according to the data collected throughout the bibliography, competing satisfactorily in what was proposed.

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Acknowledgments

We thank FACEPE (Foundation for Science and Technology Support of Pernambuco) for making the scholarship available to the first author. To the Innovate project (Interplay among multiple uses of water reservoir via innovative coupling of water cycles in terrestrial and terrestrial ecosytems), where the work forms part and contributes as a whole. To the laboratory of Remote Sensing and Geoprocessing - SERGEO and to the Analysis and processing of images, allocated to the Federal University of Pernambuco, for providing space for research and reflection.

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