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Inaccuracies on morphometric characterization of watersheds on GIS ambient

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Abstract

The morphometric characterization of watersheds is done, nowadays, with the integration of relief information in Geographic Information System (GIS) interface, extremely applicable on planning and management of water resources. The study objective was to analyze the vegetation and relief influence on the morphometric characterization of "Pedras Negras" stream, at Petróplolis-RJ, comparing the hydrographically conditioned digital elevation models (HCDEMs), generated from sensor VNIR of ASTER (Advanced Spaceborn Thermal Emission and Reflection Radiometer) data, with the model obtained from the processing of IBGE's topographic maps on the scale of 1:50.000. The study area is characterized for gneissic stone outcrops up to 2263 meters elevation, and surrounded by Atlantic forest, which has full vegetation with trees that reach 40 meters high. The processing and treating of the models had guaranteed the hydrographic conditioning, resulting in models with no spurious depressions, with stream flow originated from riverheads and a detailed and ramified drainage system. The percentage variation of the morphometric data valued by DEMHC ASTER compared with those valued by DEMHC IBGE were superior to 10% for main river length results (22.5%), total length drainage system (24%), watershed contribution area (10.9%), shape factor (-41.3%), drainage density (14.7%) and the river axial length (20.9%). The expressive variations between the models came from the vegetation behavior, which inclines and shadows the river border, causing inaccuracy on the river channel reconnaissance. The DEMHC ASTER presented an average slope variation of (20.9%) compared with IBGE maps, showing a tendency of the models to soothe the relief, loosing curacy on the determination of riverhead points and tributary rivers points also. In a general way, we can see good congruity between DEMHC ASTER and IBGE for hydrologic studies, where the most appropriate on the current study was to work with DEMHC generated from IBGE's maps.

Keywords: Geographic Information System, Watershed, digital elevation models, morphometric characterization.

1. Introduction

The generation of watershed maps had become a quick and simple process with the digital elevation models in GIS ambient. The morphometric characterization of a watershed is one of the first, and most common, executed procedures in hydrological or environmental analysis, which have as an objective make clear all the questions related to the understanding of local and regional environmental dynamics.

The analysis of the watershed morphometric characteristics its fundamental at the development of the environmental researches. According to Tonello et al. (2006), the physics and biotic characteristics of a watershed have a important part in the hydrologic cycle, influencing, between others, the infiltration, the quantity of water produced as flowing, the evapotranspiration, and the surface and subsurface flow. Currently, the watershed morphometric characterization is done integrating relief information in GIS ambient.

This procedure can be done by the manual or automatic way (Cardoso *et al*., 2006). The relief information are represented by a numerical structure of data that corresponds to the spatial distribution of high and land surface, called Digital Elevation Model (DEM). Those models are obtained, nowadays, by the interpolation of level curves extracted from a topographic map or images of remote sensors.

The Digital Elevation Model (DEM) is a quantitative model, on digital format, of land surface (Bourrough e McDonnell, 1998) and it has been an important topic on geography and related sciences, due to its use as a reference surface to material gravitational flow studies and to a large fan of uses and applications (Oksanen and Sarjakoski, 2005).

The available structures to generating of digital elevation models and the interpolation methods, as well as the discussion about advantages and disadvantages of it usage, can be found on specialized literature (Burrough and McDonnell, 1998; Wilson and Gallant, 2000), despite of it shows no consensus (Fernandes and Menezes, 2005).

The quality of generated DEMs can range a lot, depending on the original data and the interpolation method applied. Many DEMs use depends on the representation of surface shape and drainage structure. To those uses, absolute measures of high, can't allowed a complete quality evaluation of the DEM. On the other hand, an efficient detection of spurious features on the generated models can result on the improvement of DEMs generation techniques or even at original data errors detection (Hutchinson and Gallant, 2000).

Therefore, this paper has an objective evaluate the Atlantic forest and uphill relief influence on the morphometric characterization of *Pedras Negras* stream watershed, at *Petrópolis-RJ*, comparing DEMHC generated from data obtained by sensors VNIR of AST|ER (Advanced Spaceborn Thermal Emission and Reflection Radiometer) with the model generated from topographic maps of IBGE.

2. Material and methods

The study area refers to the *Pedras Negras* stream watershed, located in National park of *Serra dos Órgãos, Petrópolis – RJ*. The geographic coordinates of watershed influx are X = 698897.20 m / Y = 7505624.87 m, at "Córrego Alegre" 23S projection system. The National Park of "Serra dos Órgãos" was grounded in 1939 to protect the exceptional landscape and biodiversity of this section of Serra do Mar at the mountain region of Rio de Janeiro. In *Teresópolis, Petrópolis, Magé* and *Guapimirim* we have 20.024 ha of protected area. The park contains over 2.800 species of cataloged plants by science, 462 species of birds, 105 of mammals, 103 amphibians and 83 reptiles including 130 endangered animals and a lot of endemic species (<http://www4.icmbio.gov.br/parnaso/>).

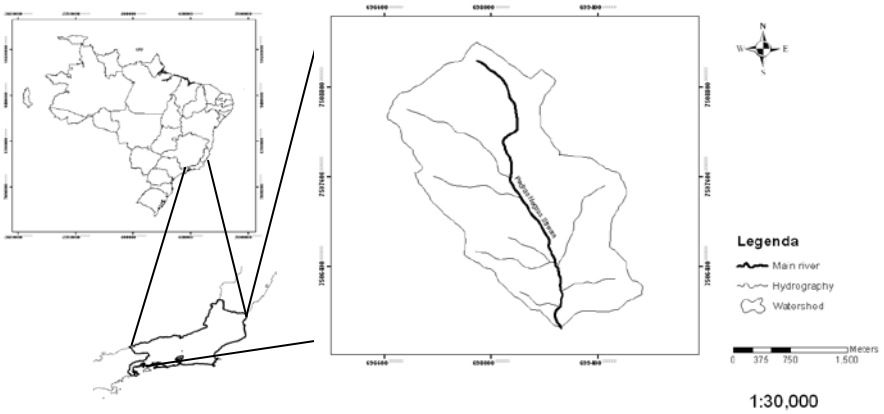


Fig. 1: *Pedras Negras* stream watershed delimitation, on *Petrópolis, RJ*, council.

The study area has a preserved and singular physical and biological characteristic, where the relief is marked by gneissic stone outcrops, with elevation up to 2263 meters, and the Atlantic forest vegetation with trees that reaches 40 meters high. To determinate the *Pedras Negras* stream watershed morphometric characteristics, was utilized the digital data base available by the American platform, which can be accessed by the link http://asterweb.jpl.nasa.gov/gdem.asp, that consists in altimetry information (digital elevation model), 30x30 resolution, of remote sensors of ASTER mission – Advanced Spaceborn Thermal Emission and Reflection Radiometer – promoted by NASA.

The conditioning of digital elevation models consists in supply one of the basics hydrological analysis challenges which is the morphometric characterization and the delineation of watershed associating the drainage system to the altimetry data. A succession of changes is made at DEM, like the deepening of the river channel, the river borders smoothing, and removal of spurious depressions (Fig. 2)

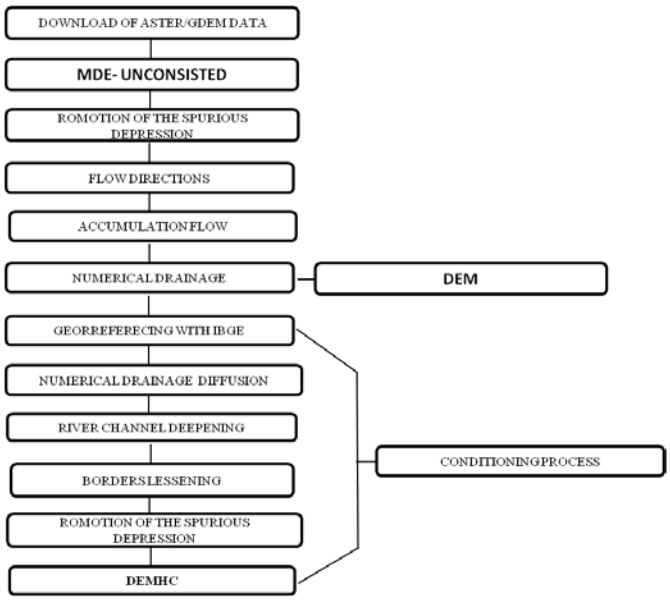


Fig. 2: Diagram representing treatment and conditioning procedures of DEM

It is important to rebound that, aiming to obtained a more detailed drainage and a hydrographically conditioned (DEMHC), was utilized the IBGE's mapped hydrography available at the link <http://www.ibge.gov.br>.

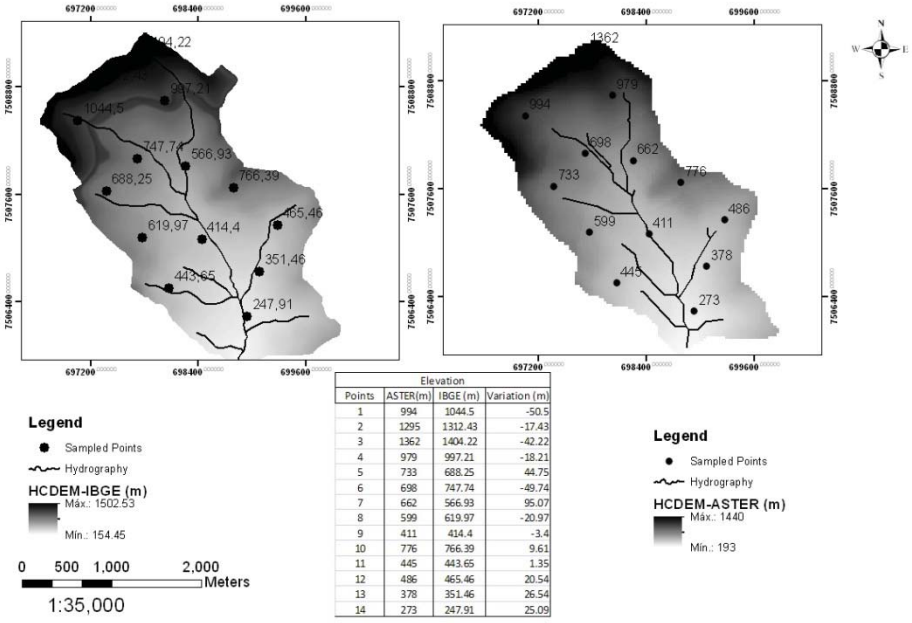
With raster and features information of the defeated model thought ArcGis® software, it became possible to determinate the following watershed of *Pedras Negras* stream physical characteristics: drainage area (A), perimeter, main river length (Lp) and total stream length (Lt), compactness coefficient (Kc), shape factor (Kf), drainage density (Km Km^{-2}) and minimum, medium and maximum slope (Imin, Imed and Imax) (VILLELA AND MATOS, 1975).

3. Results and discussion

The processing and treatment performed at topographic maps and ASTER have guaranteed the hydrographic conditioning, resulting in a model free of spurious depressions and with stream flow originated from riverheads and a detailed and ramified drainage system. The choice of the study area was due to it singular characteristics as source of errors on the MDE generation by ASTER satellite altimetric survey of relief.

The sampled points along the stream (Fig.3) shows a height difference between DEMHC ASTER and DEMHC IBGE, close to 40 meters. The reason for the presented difference refers to the large vegetation density which shadows the river and the tree height, which interfere at MDE generation obtained by ASTER satellite.

Therefore, the difference on elevation height is generated by the interference of a dense border forest, which restrains the relief surface recognition. The ASTER digital elevation models generated, for the researched area, height elevation values with range of 25 to 45 meters compared with DEM generated from IBGE maps. The importance of DEMs perfection to hydrological studies is obtain from GIS platform morphometric characteristics with precise values.



Elevation			
Points	ASTER(m)	IBGE (m)	Variation (m)
1	994	1044.5	-50.5
2	1295	1312.43	-17.43
3	1362	1404.22	-42.22
4	979	997.21	-18.21
5	733	688.25	44.75
6	698	747.74	-49.74
7	662	566.93	95.07
8	599	619.97	-20.97
9	411	414.4	-3.4
10	776	766.39	9.61
11	445	443.65	1.35
12	486	465.46	20.54
13	378	351.46	26.54
14	273	247.91	25.09

Fig. 3: Comparative map of DEMHC ASTER and IBGE maps sampled points

The points sampled next to the riverheads, are between 1200 and 1350 meters high and in a really irregular relief area. The relief characteristics presented next to the riverheads are errors source on the generation of DEM ASTER, due to the shadow hillsides, which influences on the spectral bands formation, for elevation height calculation.

With the digital elevation model hydrographically consisted (DEMHC) from ASTER and IBGE model, was realized the morphometric characteristics calculation and established the range between the two models (Fig.4)

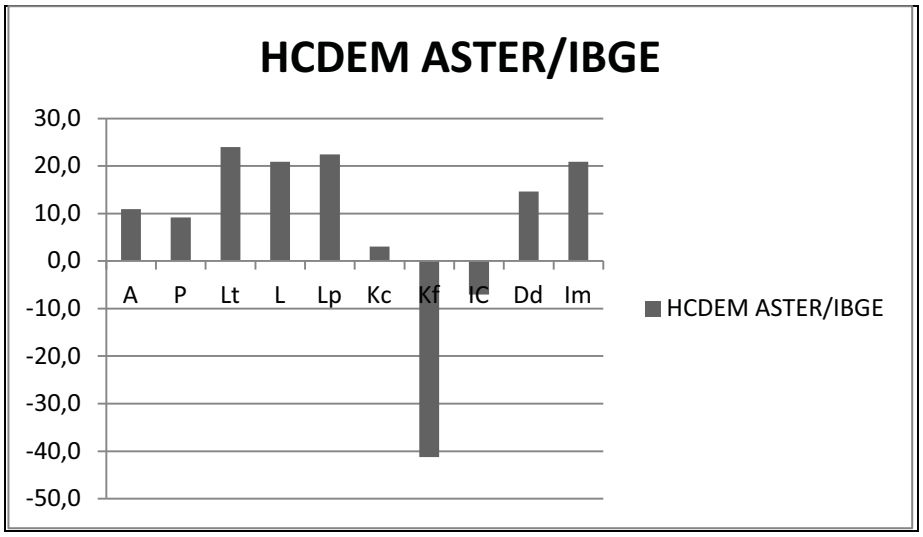


Fig. 4: Morphometric characteristics range between DEMHC ASTER and IBGE maps

The morphometric characteristics comparison between DEMHC ASTER and DEMHC IBGE maps resulted in considerable ranges. They reach over 20% for total stream length (Lt), main stream length (Lp), axial length (L), shape factor (Kf) and average slope (Im), being these, main parameters to watershed physiographic analysis.

According to VILLELA and MATOS (1975), the shape factor relate the watershed shape with a rectangle, corresponding the reason between average width and axial length (from outfall to the further point of thalweg length), with possibility of being influenced by some aspects, especially by geology. They can also act over some watershed hydrological process. The slope is related with surface flow velocity, affecting, therefore, the time that rain water takes to concentrate on the river channels that constitutes watersheds drainage system, since that flood, infiltration and erosion maximums depends on how fast the surface flows occur over watershed lands. Therefore, a range of 41.25% for shape factor and 20.9% for slope represents a concern to hydrological studies, when you are working with DEMHC ASTER.

The range of area and perimeter values, respectively, were 10.94% and 9.15%, and they are considered relevant to large watershed studies, since that it implies in gain or loss of drainage area along the hydrograph.

The accuracy of the morphometric characteristics results is directly related to its data bases, being necessary a selective analysis about its possible errors sources before using the GIS platform to hydrological studies.

4. Conclusion

1) The mosrphometric characteristics obtained from digital elevation model ASTER and IBGE had presented range greater than 20% for total stream length (Lt), main stream length (Lp), axial length (L), shape factor (Kf) and average slope (Im) parameters;

2) The area to be study to a large watershed must be realized, when possible, from digital elevation models generated from IBGE maps information;

3) The Atlantic forest full vegetation and relief influence are source of erros to DEM ASTER;

4) In a general way, we can see good congruence between DEMHC ASTER generated from remote sensing data, with DEMHC IBGE maps, standard at this study, evaluated in relation to the obtained morphometrics characterization Therefore, these models are a practical and viable alternative to decrease costs and execution time of the projects, helping on planning water resources planning and management.

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