‘Radiography of the Amazon’ DSM/DTM data: comparative analysis with SRTM, ASTER GDEM

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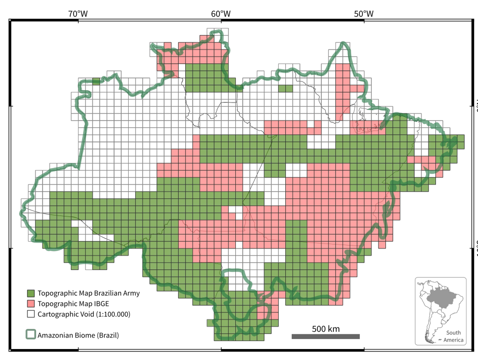
Abstract—**This paper presents a preliminary comparison of Digital Elevation Models SRTM, Topodata and ASTER GDEM with data from the 'Radiography of the Amazon' project (RAM), for a small study area north of Barcelos city, Amazonas State, Northern Brazil. The RAM project is run by the Division of Geographical Service of the Brazilian Army, and intents to map ca. 1.8 million sq.km. of the Amazon region using InSAR in the P and X bands.The analysis showed that ASTER GDEM presents a high level of noise and artefacts from the automatic image processing chain, with low correlation to the morphology depicted in the other DEMs. RAM Digital Surface Models (i.e., canopy height) have a good correlation with SRTM and Topodata DEMs, although with higher elevation due the use of X-band Radar, which does not penetrates the forest canopy. RAM Digital Terrain Models exhibits the topography under the forest allowing the identification of morphological features that could be hidden under the vegetation. Future studies should be carried out to determine, for instance, the level of detail of DTM-derived drainage networks as well as to evaluate the noise of 5m-resolutions DTMs and possible filtering or smoothing procedures.**

I. INTRODUCTION

The Brazilian Legal Amazon Region encompasses 5.2 million square kilometres. Around 1.8 million square kilometres do not have cartographical information in scales larger than 1:250,000, being known as a ‘cartographic void’ [1] (Fig.1). In order to address this issue, the Brazilian Government created the Amazon Cartography project, with three sub-projects: Land Cartography (also known as Radiography of the Amazon), Geological Cartography and Nautical Cartography [2].

The Land Cartography subproject, under the responsibility of the Division of Geographical Service (DSG) of the Brazilian Army, intents to map the cartographic void of the Amazon region using airborne InSAR in the P (75 cm), L (23 cm) and X (3,1 cm) bands. Mapping will be carried out at 1:100,000 and 1:50,000 scales, covering 1,142,000 km^2 in areas of dense tropical forest and 658,000 km^2 in non-forest areas (natural open fields and anthropized areas) [1].



1. Current status of cartographic mapping in the Legal Amazon Region (adapted from [2])

InSAR Mapping with P, L and X bands allows generation of Digital Terrain Models (DTMs - elevation at ground level), Digital Surface Models (DSMs - elevation of forest canopy) and derived products such as vegetation height and geomorphological classifications [3][4].

In this work we present a preliminar comparison between data from the 'Radiography of the Amazon’ project (RAM) with SRTM, Topodata and ASTER GDEM, for a study area north of Barcelos city, Amazonas State, northern Brazil (area location in Fig. 2).

II. MATERIALS AND METHODS

The Brazilian Army allowed research-level access to RAM data after a formal request was submitted to the Division of Geographical Service. RAM products are distributed according to 1:50,000 scale topo sheets, in 32-bit GeoTIFF files, with spatial resolution of *ca.* 5 meters. In this work we used DTMs and DSMs downloaded from the Brazilian Army Geographic Data Base (BDGEx) [5].

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SRTM V3.0 data was downloaded from the LPDAAC Data Pool [6] with spatial resolution of 3 arcsec (*ca*. 90m). Topodata is a refinement of original 3-arcsec SRTM to 1-arcsec (*ca*. 30m) with kriging [7][8]; data is distributed by the Brazilian National Institute of Space Research (INPE) [9]. ASTER GDEM version 2 [10] was downloaded from ERSDAC [11], with nominal spatial resolution of 30m. All data was analysed in GRASS-GIS [12], through Python scripts using the Pygrass library [13] to access GRASS' datasets.

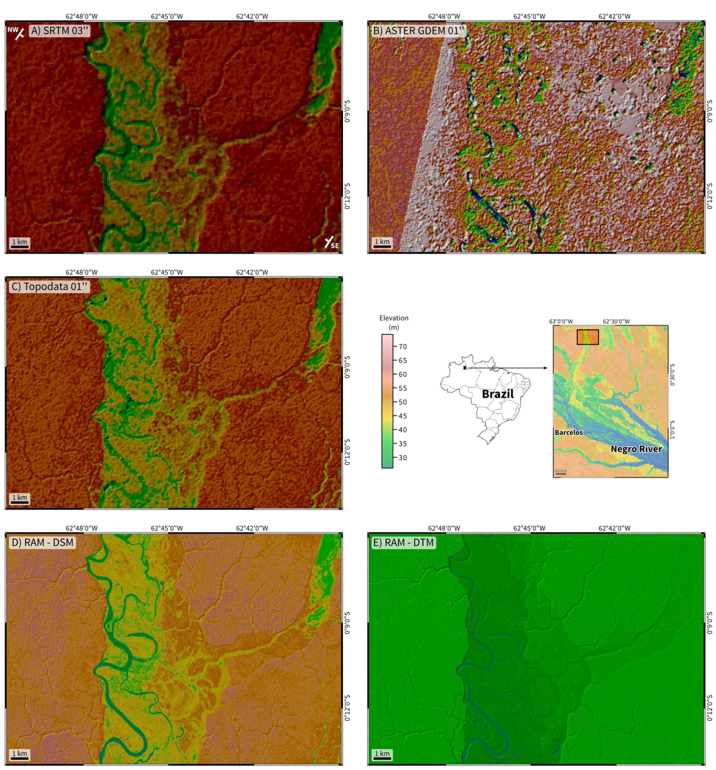
I. DESCRIPTIVE STATISTICS OF ANALYSED ELEVATION DATA

Data	Min	Max	Mean	Median	Std.Dev.	Assim.	Kurt.
SRTM	28.24	64.38	51.72	54.16	6.62	-1.02	0.35
GDEM	-62.00	160.0	61.68	62.00	15.37	-0.62	4.67
Topodata	13.15	66.07	51.81	54.12	6.52	-0.92	0.09
DSM RAM	26.22	74.12	52.83	55.35	7.85	-1.20	1.34
DTM RAM	25.19	39.39	33.80	35.26	3.26	-0.77	-0.91

III. RESULTS

Fig. 2 shows the elevation of the analysed data, descriptive statistics are presented in Table I, histograms of elevation in Fig. 3, and NW-SE topographic profiles in Fig. 4 (location of profiles in Fig. 2A).

SRTM (Fig. 2A) and Topodata (Fig. 2C) provide a good representation of the landforms in the study area, while ASTER GDEM (Fig. 2B) shows artefacts inherent to the automatic processing of optical imagery and do not depict the local landscape correctly.

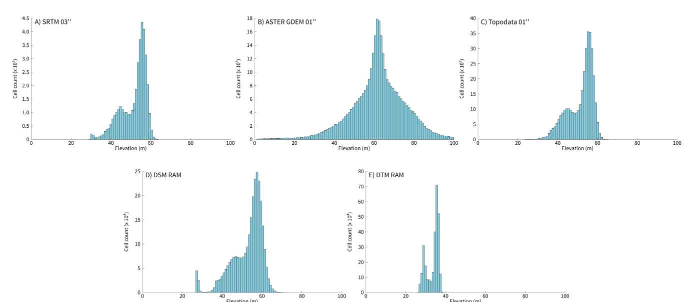


2. Shaded relief images of analysed data (illuminant at 315º, inclination 25º). The colorscale is the same for all images.

Distribution of elevation values (Fig. 3) is, generally, asymmetric with two modes representing the forest canopy and the alluvial plain in the central portion of the study area. The exception to this behaviour is ASTER GDEM, with unimodal distribution and high standard deviation (Fig. 3B).

RAM Digital Surface Model (Fig. 2D) shows a histogram of elevation values similar to SRTM and Topodata, without artefacts (Fig. 3D). The higher spatial resolution allow for a greater detail in the fluvial landforms and it is possible to observe sutil variations of elevation of the forest canopy.

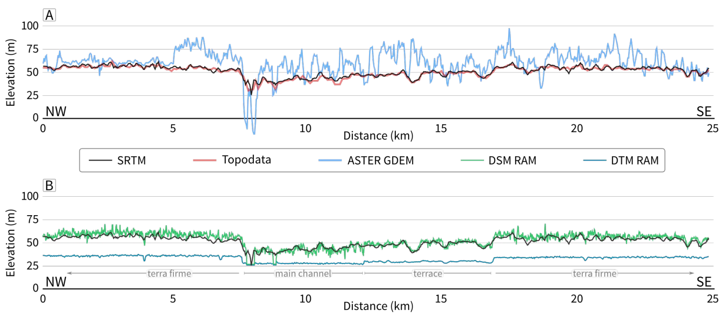
RAM Digital Terrain Model (Fig. 2E) has the smaller standard deviation and range of the analysed data. The distribution of elevation highlights the differences between flood-prone and dry areas (*terra firme*).



3. Histograms of elevation values.

The topographic profiles are useful to visually compare the relations among the analysed data. In Fig. 4A, it is possible to see the similarity between SRTM (black line) and Topodata (red line), although in some places the interpolated data shows an inverse behaviour or underestimate the original data (note the fluvial valley at about 8 km from the origin of the profile, for instance). ASTER GDEM (blue line) is only locally similar to SRTM and do not provide a real representation of the landscape.

Profiles for RAM data are presented in Fig. 4B. DSM data (green line) shows a good visual correlation with SRTM (black line). As one could expect, SRTM values are, in general, lower than RAM DSM, since SRTM was acquired with C band (5.6 cm), which allows for some penetration of the Radar signal in the canopy. RAM DTM (blue line)shows not only the main morphological division between flood-prone and dry areas, but also a subdivision of the lower sector, with a main channel and a fluvial terrace.



4. Topographic profiles (NW-SE) of analysed data. Location of profiles is shown in Fig. 2A.

IV. Discussions and Conclusions

This paper presented a preliminary comparison of Digital Elevation Models SRTM, Topodata and ASTER GDEM with data from the Brazilian Army's 'Radiography of the Amazon' project (RAM).

The analysis showed that ASTER GDEM presents a high level of noise and artefacts from the automatic image processing chain, with low correlation to the morphology depicted in the other DEMs.

RAM Digital Surface Models (i.e., canopy height) have a good correlation with SRTM and Topodata DEMs, although with higher elevation due the use of X-band Radar, which does not penetrates the forest canopy.

RAM Digital Terrain Models exhibits the topography under the forest allowing the identification of morphological features that could be hidden under the vegetation.

Future studies should be carried out to determine, for instance, the level of detail of DTM-derived drainage networks as well as to evaluate the noise present in 5m-resolutions DTMs and possible filtering and/or smoothing procedures.

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