The mega capture of the Negro River, Central Amazônia, Brazil: a novel feature revealed by SRTM data

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Abstract. In Central Amazônia, Brazil, the Solimões and Negro rivers converge to form the Amazonas, the largest river in the world. Interferometric-derived topographic data, generated during the Shuttle Radar Topography Mission (SRTM), indicate that the present-day lower course of the Negro River is the result of a mega fluvial capture governed by neotectonics. The data indicated that the ancient confluence of the Negro River with the Solimões River was located where today is the mouth of Manacapuru River, 60 km west of the present location in the vicinity of the city of Manaus.

***Index terms*: SRTM, Fluvial capture, Amazônia**

I. INTRODUCTION

Digital elevation data produced by interferometric synthetic aperture radar (InSAR) during the 2002 Shuttle Radar Topographic Mission-SRTM [1] opened unprecedented opportunities for scientists dealing with regional terrain analysis. By highlighting subtle terrain features, this new class of space-borne data is of particular interest for studies in densely vegetated tropical areas, where details of the topography are blurred in currently used orbital remote sensing images. This paper reports a novel terrain feature revealed in digital elevation data of the SRTM in the Central Amazônia. Such a terrain feature was not visible before neither in optical Landsat-TM images nor in L-band synthetic aperture radar images of the Japanese Earth Resources Satellite (JERS-1).

II. STUDY AREA

The study area is located in Central Amazônia, Brazil, not far from the confluence of the Negro and Solimões rivers (Figure 1). These rivers form the Amazonas, the largest river in the world, responsible for about 15% of all freshwater discharged in the oceans [2].

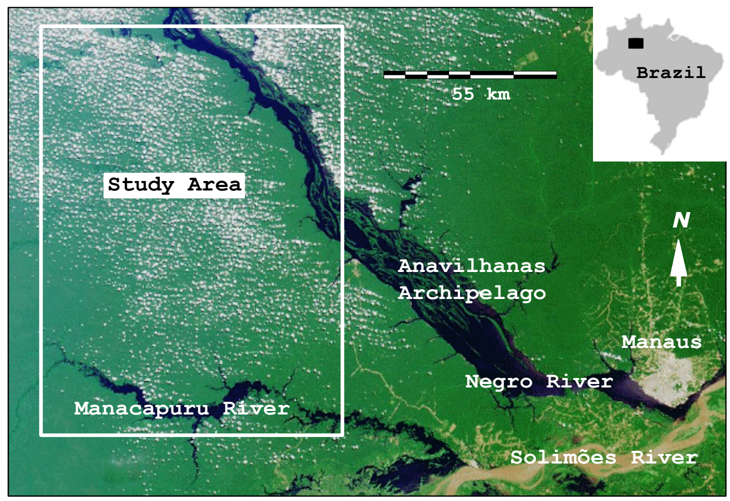

Figure 1. Location of the study area in Central Amazônia, Brazil.

Geologically, the area pertains to the Amazonas Sedimentary Basin, with a sedimentary pile is about 5,500 m thick, ranging from Ordovician to Tertiary in age and covered by Quaternary alluvial deposits [3]. Proterozoic basement crustal blocks comprise the Ventuari-Tapajós Province, which occurs in a prominent NW-SE trend [4]. Major faults limiting these basement blocks are rejuvenated as a result of neotectonics. Mid Atlantic Ridge spreading and concurrent resistance by Nazca and Caribbean plates govern the present-day stress regime over the entire Amazonas Basin [5].

The neotectonic activity in the Amazônia is confirmed by the occurrence of frequent earthquakes. One of these earthquakes was registered on December 14, 1963 with magnitude 5.1 m_b, and epicenter on the left bank of the Negro River, in the region of the Anavilhanas Archipelago. Focal mechanism solution indicated an axis of maximum compressional stress nearly horizontal, oriented N31W [6]. Coinciding with the tectonic fabric of the underlying Ventuari-Tapajós Province, this orientation coincides with a strike-slip fault that controls the lower course of the Negro River in the region of the Anavilhanas Archipelago [7]. This feature also extends northwestward and controls flooded forest lowlands and rapids in several tributaries on the right margin of the Negro River [8], confirming the role of the neotectonits controlling present-day drainage network in Central Amazônia.

III. SRTM DATA IN THE STUDY AREA

Figure 2 compares terrain features in the study area using three different remote sensing systems: (a) interferometric digital elevation models produced by SRTM; (b) L-band synthetic aperture radar images of the JERS-1 satellite, and (c) band 4 images of the Landsat-Thematic Mapper. Gray levels in the Landsat image are associated with the near-infrared response of the green foliage of the rain forest. In the JERS-1 image, intermediate gray levels represent the intensity of the radar return from the forest canopy, whereas the light gray levels result from radar double-bounce effect in areas of flooded forests along drainages. Conversely, in the SRTM image gray levels are associated with terrain morphology, varying from dark gray (lower relief) to light gray (higher relief). In the three images black is associated with free water surface.

Conversely, in the SRTM image gray levels are considered to be associated with regional terrain morphology, expressed between dark gray (lower relief) and light gray (higher relief). The topographic information depicted in the SRTM scene highlights the relicts of an ancient riverine system flowing southward nd connecting the present-day courses of the Negro and Manacapuru rivers. Such a terrain feature is not discernible in the L-band radar image and only barely suggested in the near-infrared image.

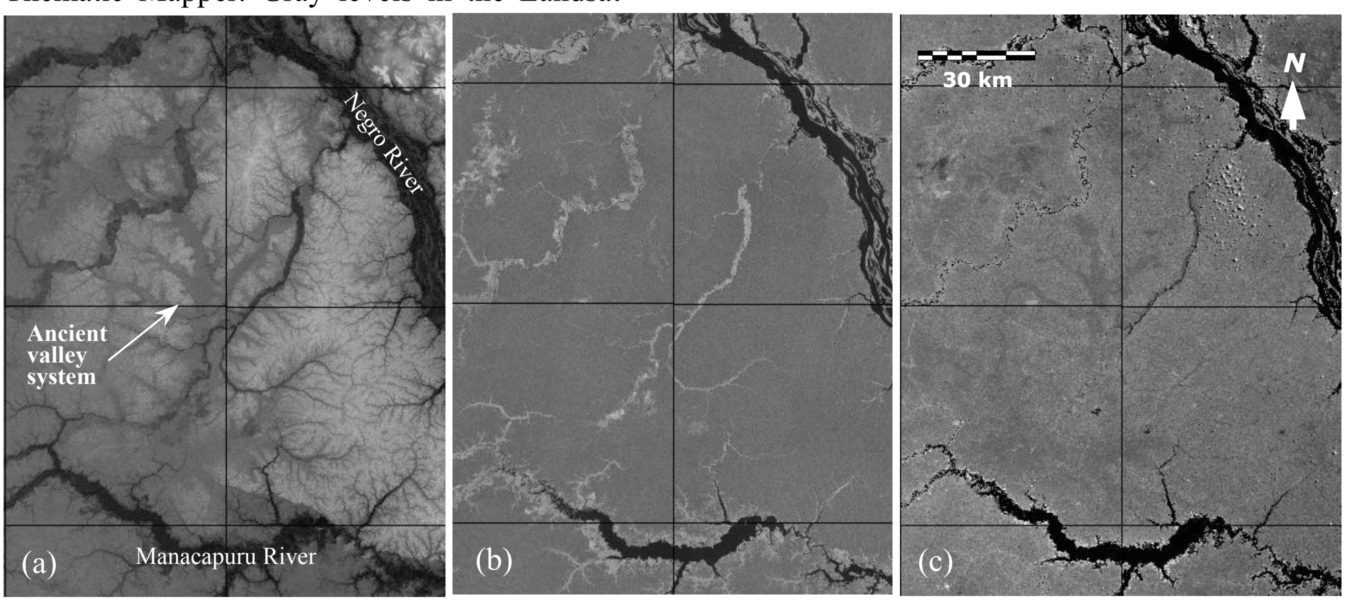

Figure 2. SRTM digital elevation model showing the relicts of an ancient drainage system (a), which is not visible in an L-band synthetic aperture radar image of the JERS –1 satellite (b) and only barely suggested in a Landsat TM band-4 image (c). See Figure 1 for location.

the ancient drainage system (I), which possibly represents the former course of the Rio Negro. Elevation data showed that the ancient drainage system is bordered by interfluves nearly 40 m higher than the bottom of the valleys.

IV. RESULTS AND DISCUSSION

The SRTM digital elevation model was matched with a Landsat color composite to produce a 3-D perspective view that realistically replicated terrain morphology (Figure 3). This procedure better highlighted

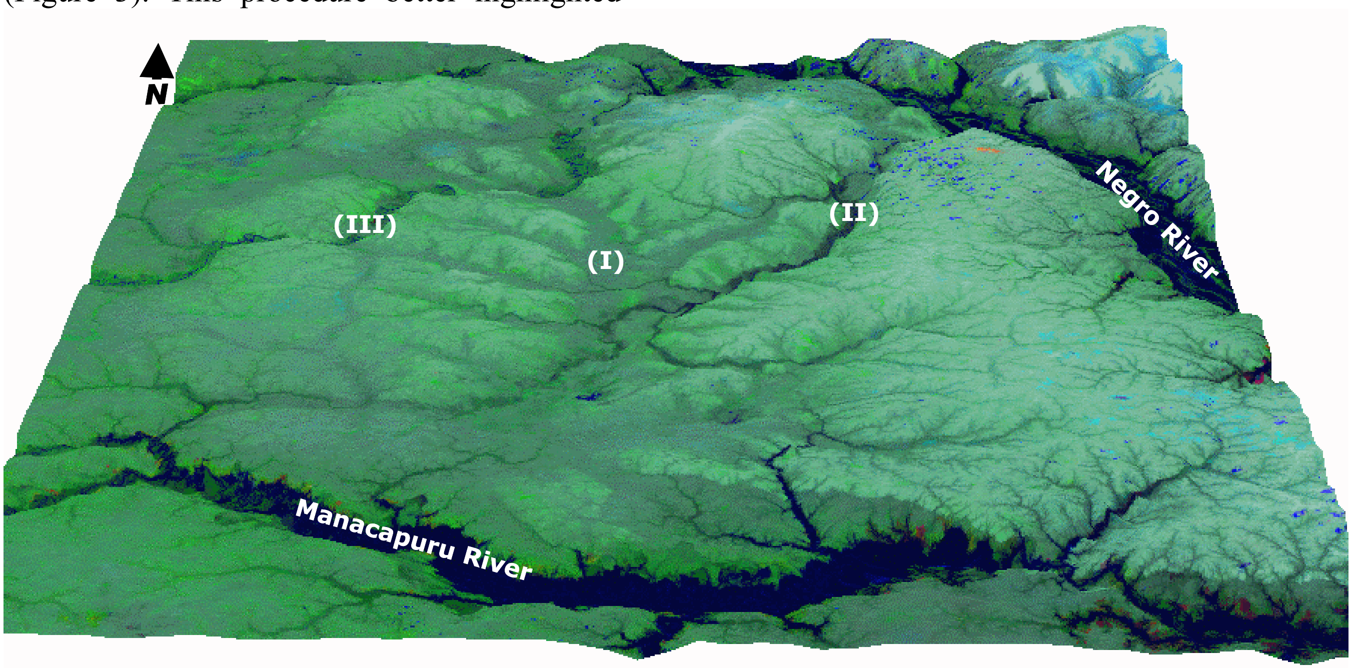

Figure 3. Perspective view of the study area (vertical exaggeration is 70x) depicting the relicts of a large ancient drainage system (I) flowing southward and connecting the present-day valleys of the Negro and Manacapuru rivers. The Padauari (II) and Carabinani (III) rivers, tributaries of the Negro River, flow northeastward eroding the ancient valley systems. See Figure 1 for location.

As indicated in Figure 3, present-day drainage (exemplified by the Padauari (II) and Carabinani (III) rivers) flows northeastward, in an opposite direction to the ancient drainage system that flowed southward. Such an inversion in flow direction reinforces the role of neotectonics as a prime agent modeling landscapes in the region. A possible scenario suggests that the ancient drainage system was blocked as a result of a regional tilting to NE. Field evidence of this regional tilt may be found in the Solimões River, not far from the mouth of the Manacapuru River, where the Solimões excavates uplifted Tertiary deposits [9]. Furthermore, the distribution of the Tertiary-Quaternary sedimentary covers in the Central and Western Amazon Regions also indicates the effect of a northeastward regional tilting, as they are progressively younger from southwest to northeast [10]. The regional uplifting is also witnessed by the fact that the present-day drainage is eroding the ancient river valley.

As a result of the regional tilting, the southward flow of the ancient course of the Lower Rio Negro was redirected southeastward, following the NW-SE orientation of the basement structural features, described in the region [4]. As a consequence of this mega fluvial capture, a new regional drainage network was established in the area. Governed by a new regional base level, tributaries on the right margin of the Rio Negro flow apparently against the regional topographic slope, carving out deep valleys in an increasingly undulated topography, as indicated in the SRTM digital elevation model (Figure 3).

V. CONCLUSIONS

Evidence of a dramatic change in the course of one of the largest rivers of the Amazônia governed by neotectonics is in accordance with previous studies (*e.g*. 11, 12), which suggest that the region has suffered frequent changes in landscape throughout the Neogene-Quaternary and that geological factors may have played a decisive role in the evolution of its biodiversity.

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