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Comparative analysis of landform units corresponding to the third taxon in different geomorphological mappings in the state of Paraná

Análise comparativa das unidades do relevo correspondentes ao terceiro táxon em distintos mapeamentos geomorfológicos no estado do Paraná

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Abstract

The growing debate on geomorphological cartography in Brazil has led to the formulation of the Brazilian Relief Classification System (SBCR), currently under development through collaboration between the community of geomorphologists, represented by UGB, IBGE and the Geological Survey of Brazil (SGB/CPRM). The SBCR is based on the hierarchical organization of taxa for geomorphological representation. In this sense, this paper aims to contribute to the debate through the comparative analysis of the landform units corresponding to the 3rd taxon of two geomorphological mapping works covering the state of Paraná, both at a scale of 1:250,000: the geomorphological units of the Environmental Information and Database (BDiA) of IBGE and the morphosculptural subunits of the Geomorphological Mapping of Paraná. The comparison revealed that the first identified 16 units, while the second mapped 50. Only four units share the same name in both mappings (Coastal Plain, Serra do Mar, Curitiba and Apucarana Plateaus), but with limited spatial correspondence (96%, 55%, 33% and 18%, respectively). The mapping of Paraná highlighted the predominance of plateaus in the state, designating 43 of the 50 units as "plateau", without resorting to the terminologies of “patamares”, depressions and “serras” used in the BDiA/IBGE. The geomorphological units of the BDiA are excessively generalized in comparison to the geomorphological mapping of Paraná.

Keywords:
Geomorphological cartography, Landform classification, Geomorphological taxonomy, Landform units, Geomorphology of Paraná.

Resumo

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O debate atual sobre a cartografia geomorfológica no Brasil e o desenvolvimento do Sistema Brasileiro de Classificação de Relevo (SBCR) têm evidenciado a necessidade de padronização dos critérios de representação do relevo. Nesse contexto, o presente estudo analisa comparativamente as unidades correspondentes ao terceiro táxon de dois mapeamentos geomorfológicos que recobrem a área do estado do Paraná, ambos na escala 1:250.000: o mapeamento do Banco de Dados e Informações Ambientais (BDiA) e o Mapeamento Geomorfológico do Paraná. A comparação, realizada por meio de sobreposição espacial e análise estatística de atributos geomorfométricos (declividade e amplitude altimétrica), revelou contrastes significativos entre as abordagens. O BDiA identificou 16 unidades, enquanto o mapeamento paranaense delimitou 50 subunidades morfoesculturais. As unidades do BDiA apresentam maior generalização, com áreas médias três vezes superiores e maior heterogeneidade interna, refletindo a influência de uma perspectiva regional herdada do Projeto RADAMBRASIL. Já o mapeamento paranaense demonstrou coerência morfológica e detalhamento na diferenciação dos padrões de formas. As assinaturas geomorfométricas confirmaram a tendência do BDiA em integrar padrões distintos de relevo, comprometendo a distinção morfológica local. Verificou-se que é necessária a definição de critérios que equilibrem abrangência e especificidade na representação do terceiro táxon, bem como a padronização terminológica e conceitual.

Palavras-chave:
Cartografia geomorfológica, Classificação do relevo, Taxonomia geomorfológica, Unidades de relevo, Geomorfologia do Paraná.

I. INTRODUCTION

Geomorphological taxa constitute a hierarchical classification system that is fundamental to geomorphological cartography, allowing the representation of terrain at different levels of detail, considering morphological, morphogenetic, morphodynamic, and morphochronological aspects. In Brazil, this classification approach was promoted by the RADAMBRASIL Project in the 1970s and 1980s, which developed specific methodologies for surveying the country's natural resources, contributing to the field of geomorphology with the development of specific geomorphological cartography techniques.

The two most commonly used methods of geomorphological mapping in Brazil share a common taxonomic organization. One proposes six taxonomic levels (Ross, 1992), while the other, derived from the methodological legacy of the RADAMBRASIL Project, is organized into four taxa, with subsequent advancement to more detailed representations through symbologies (IBGE, 2009).

Geomorphological mapping in Brazil has been developded in recent years by technical advances in geomorphometry, the science of quantitative analysis of the Earth's surface (Pike, 2000), whose main objective is to extract descriptive measurements and features of the terrain (Mark; Smith, 2004; Wilson, 2012;

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Xiong et al., 2022). These techniques are applicable in various fields of knowledge, such as geomorphological mapping and the classification of landforms.

Current debates on geomorphological cartography have recognized the need to formulate a Brazilian Landform Classification System (SBCR), which resulted in its development through joint collaboration between the Brazilian geomorphological community, represented by the Brazilian Geomorphology Union (UGB), the IBGE, and the Geological Service of Brazil (SGB/CPRM).

The advances already established within the SBCR indicate that the representation of the terrain will be maintained through hierarchical taxa; that the first taxon should be represented by macrocompartments of the Brazilian landforms, with the following classes: mountains, plateaus, plains, depressions and coastal tablelands (CEN/SBCR, 2022); and that the second taxon is represented by Morphostructural Domains and Subdomains (IBGE, 2025). Thus, the current state of the art of the SBCR focuses on the debate about what should be represented in the third taxon, which will require a great effort from the Brazilian geomorphology community.

Although these geomorphological units constitute the most widely used category in regional mapping in Brazilian states, such as Mato Grosso (Werle; Silva, 1996), São Paulo (Ross; Moroz, 1997), Paraná (Santos et al., 2006), Espírito Santo (Coelho et al., 2012), and Rio Grande do Norte (Diniz et al., 2017), their delimitation is commonly based on criteria with a high degree of subjectivity (Silveira; Silveira, 2021). In addition, the two methods most commonly used in Brazil, Ross (1992) and IBGE (2009), although organized into taxa to represent landforms, have different approaches and names for the third hierarchical level.

The first method refers to the third taxon as morphological units or patterns of similar landforms, which represents a morphology resulting from the influences of more recent erosive processes. Its representation contains units that have smaller areas, are more recent in age, and have erosive processes that favor the dissection of the terrain. The patterns of forms can be of two genetic lineages: accumulation forms, represented by plains of different genesis, and denudation forms, which are characterized by different intensities of dissection of the terrain under the influence of temporary and perennial drainage channels (Ross, 1992).

In the second method, the third taxonomic level is designated as geomorphological units, defined as an arrangement of altimetric and morphologically similar forms in their various types of modeling. Their genesis and similarity of forms can be explained by paleoclimatic factors and by structural and lithotype constraints.

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The sets of landforms that make up these units constitute compartments identified as plains, depressions, plateaus, tablelands, terraces, plateaus, and mountain ranges (IBGE, 2009, p. 29).

In this context, the present study aimed to evaluate the representation of the third geomorphological taxon through a comparative analysis of geomorphological mapping studies that met the following requirements: use of a method based on the hierarchical representation of landforms in the state of Paraná; representation equivalent to the third taxon; and availability of the database in digital vector format.

Two studies met the requirements, both on a scale of 1:250,000: the morphocultural subunits of the Geomorphological Mapping of Paraná (Santos et al., 2006), which used the Ross (1992) method up to the representation of the 3rd taxon, considering, in the delimitation of classes, information on the dominant landform pattern, such as dissection, tops, types of slopes, valleys, altimetric gradient, and slope; and the geomorphological units contained in the Environmental Database and Information (BDiA) (IBGE, 2023), whose classification of taxa is based on the IBGE (2009) method.

Thus, the objective of this study was to perform a comparative analysis between the geomorphological units corresponding to the third taxon in these two different available maps, with an emphasis on the geomorphometric characteristics linked to categorization.

Geomorphology of the state of Paraná

Paraná is located in the southern region of Brazil, bordering the state of São Paulo to the north, the Atlantic Ocean to the east, the state of Santa Catarina to the south, the Republics of Argentina and Paraguay to the southwest and west, respectively, and the state of Mato Grosso do Sul to the northwest. The state covers an area of 199,575 km².

Its configuration is dominated by plateaus, with five distinct geomorphological compartments recognized and named as natural landscape units by Maack (1968): 1) Coastal Plain, 2) Serra do Mar Paranaense, 3) First Paranaense Plateau, 4) Second Paraná Plateau, and 5) Third Paraná Plateau, described as morphoscultural units compatible with the second taxon in the geomorphological mapping of the state of Paraná, published by Santos et al. (2006).

The Coastal Plain extends from the Serra do Mar mountain range to the Atlantic Ocean coastline and consists of continental sedimentary deposits associated with slopes (fans, talus, colluvium, and fluvial sediments) and coastal deposits (coastal plain with coastal ridges and estuarine mudflats), due to fluctuations in relative sea level during transgression and regression cycles that occurred in the Quaternary period (Angulo, 2004).

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The Serra do Mar mountain range in Paraná is currently interpreted, in light of the concept established by the SBCR for the first taxon (CEN/SBCR, 2002), as a class of mountain, being the only set of this class of landform present in the state of Paraná (Silveira; Silveira, 2023). It is bordered to the west by the First Paranaense Plateau and to the east by the Coastal Plain. Despite its more restricted area, it stands out in the landscape due to its prominent mountainous portion, with average altitudes between 1300 and 1800 m, the highest altitude being at Pico Paraná (1877 m), located in the Serra do Ibitiraquire (Nascimento et al., 2013). The highest elevations are supported by a Coastal Granitoid Belt (Almeida; Carneiro, 1998), surrounded by other diverse lithological units, mostly high-grade metamorphic.

The First Paraná Plateau is bordered to the west by the Devonian Escarpment (also known regionally as the Purunã and Serrinha Escarpment), which in Paraná forms a *cuesta* line of relative morphological expression related to Devonian formations (Ab'Saber, 1949), and to the east by the mountains of the Serra do Mar. To the north are the rocks of the Açungui Group (Fiori; Gaspar, 1993), with a strongly dissected terrain, with altitudes between 400 and 1200 m, developed on the metamorphic rocks of the Açungui Group. In the portion over crystalline bedrock, there are rocks cut by the swarm of mafic dikes of the Ponta Grossa Arch (Raposo, 1995), with average elevations ranging from 850 to 950 m, gently undulating terrain, and the presence of flat areas along the main rivers, associated with the formation of alluvial plains (Santos et al., 2006).

The Second and Third Plateaus are located on the Paraná Sedimentary Basin, a large sedimentary region of the South American continent covered in the central region by thick lava flows, resulting from intense fissure volcanism, associated with swarms of mafic dikes that can be very thick, with large extensions and a preferential NW direction (Raposo, 1995), cutting through the sedimentary section and multiple dikes and sills, whose sedimentary and magmatic record was organized by Milani et al. (2007).

The Second Plateau is situated on the Paleozoic sedimentary rocks of the Paraná Basin. It takes the form of a plateau modeled by sub-horizontal monoclinal structures, dipping to the west (Santos et al., 2006), dissected by the drainage network that runs in the same direction. This unit extends from the reverse side of the Devonian cuesta (Purunã), over the sandstones of the Furnas Formation, where the average summit altitudes are between 1100 and 1200 m, to its western limit, at the foot of the Triassic-Jurassic cuesta front (or Serra Geral), with altitudes ranging between 400 and 500 m. According to Ab'Saber (1949), the Serra Geral escarpment constitutes a typical system of circumdenudation escarpments.

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The Third Plateau is developed on the Mesozoic volcanic rocks of the Serra Geral Group (Licht; Arioli, 2018; Besser et al., 2021) and on the sandstone rocks of the Caiuá Group (Fernandes; Tcacenco-Manzano, 2023, Besser et al., 2021). The geomorphological unit of the Third Plateau predominates in Paraná, with average summit elevations between 1,100 m and 1,250 m on the reverse side of the Serra da Esperança escarpment, falling to altitudes between 220 m and 300 m near the Paraná River channel (Santos et al., 2006).

II. Materials and Methods

For this comparative analysis, we considered the geomorphological mappings of Santos et al. (2006) and BDiA (IBGE, 2023), both consistent with the third taxon of geomorphological representation. The first methodological step consisted of quantifying the spatial properties and qualitative comparisons of the geomorphological units. The second stage focused on the statistical analysis of the third taxon classes based on geomorphometric attributes (slope and altimetric amplitude) derived from the Digital Terrain Model (DTM). Operationally, the processing was performed using QGIS 3.36 software.

The geomorphological units of the BDiA constitute, in the third taxon, arrangements of altimetric and physiognomically similar forms, including information on formative processes, predominant drainage patterns, current morphogenesis, and general characterization of the unit (IBGE, 2023).

The data from the BDiA geomorphological mapping, as it constitutes a national mapping, was cut to the boundaries of the state of Paraná and subsequently processed to dissolve the "nm_regiao" field from the attribute table, corresponding to the geomorphological units.

Regarding the geomorphological mapping of Paraná (Santos et al., 2006), this was developed using the methodology adopted by Ross and Moroz (1997) for the state of São Paulo, based on the proposal of Ross (1992), aiming to continue the systematization of a geomorphological cartography of the state of Paraná at a scale of 1:250,000, representing the first three taxa.

Vector files from the third taxon, represented by morphostructural subunits, were used, providing information on the dominant landforms, including dissection, summits, slope types, valleys, altimetric gradient, and slope gradient, with the similarity of landforms related to structural and lithological conditions being the basic elements for their definition (Santos et al., 2006).

For the quantitative analyses, the maps were overlaid using the "Intersection" tool. In addition to calculating the area (absolute and proportional) of the compared units, statistics on the mean, standard

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deviation, and minimum values of the polygons corresponding to the representation of the 3rd geomorphological taxon in both maps were computed.

Areas with overlapping units of less than 1% were excluded from the comparative analysis, assuming that such values represent noise resulting from the delimitation scale of both mappings (1:250,000).

Subsequently, statistical analyses of the geomorphological units were quantified based on geomorphometric attributes calculated from a DTM with a spatial resolution of 20 m. The DTM was interpolated using the Topogrid method (Hutchinson, 1989) from elevation points, contour lines, and vectorized hydrographic segments from 96 topographic maps at a scale of 1:25,000 (eastern portion of Paraná) and another 313 maps at a scale of 1:50,000.

Two geomorphometric attributes were calculated: slope in percentage (Horn, 1981) and the altimetric amplitude measured within a 1 km radius for each DTM cell (using the *r.neighbors* tool). These are the main terrain attributes that express the concept of the 3rd taxon units, defined by "differences in appearance between them based on topographic roughness or terrain dissection index, as well as the shape of the summits, slopes and valleys of each pattern" (Ross, 1992, p. 19).

Thus, using these attributes, the objective was to extract the geomorphometric signatures of the units of the 3rd taxon from each mapping, in order to measure and analyze the generalization criteria employed in the representation of homogeneous landform patterns. The concept of geometric signatures comes from Pike (1998), defining them as a set of measurements that describes landforms sufficiently to distinguish disparate geomorphological landscapes. Descriptive statistics (minimum, maximum, mean, median, and quartiles) were considered, with boxplots, to highlight the comparison of morphological characteristics between the units.

III. RESULTS AND DISCUSSION

The geomorphological mapping of the Environmental Database and Information (BDiA) (IBGE, 2023), elaborated using the IBGE method (2009) and data from the RADAMBRASIL Project (IBGE, 2018a; 2018b), identified 16 geomorphological units present in the Paraná state (Figure 1), considering the third hierarchical level of landform representation, while the geomorphological mapping of Paraná published by Santos et al. (2006), based on the Ross method (1992), mapped 50 morphostructural subunits in the state of Paraná in the third taxon (Figure 2). The number of geomorphological units represented and their area dimensions, equivalent to the same taxonomic level evaluated, reveal a substantial difference in the two geomorphological mapping works.

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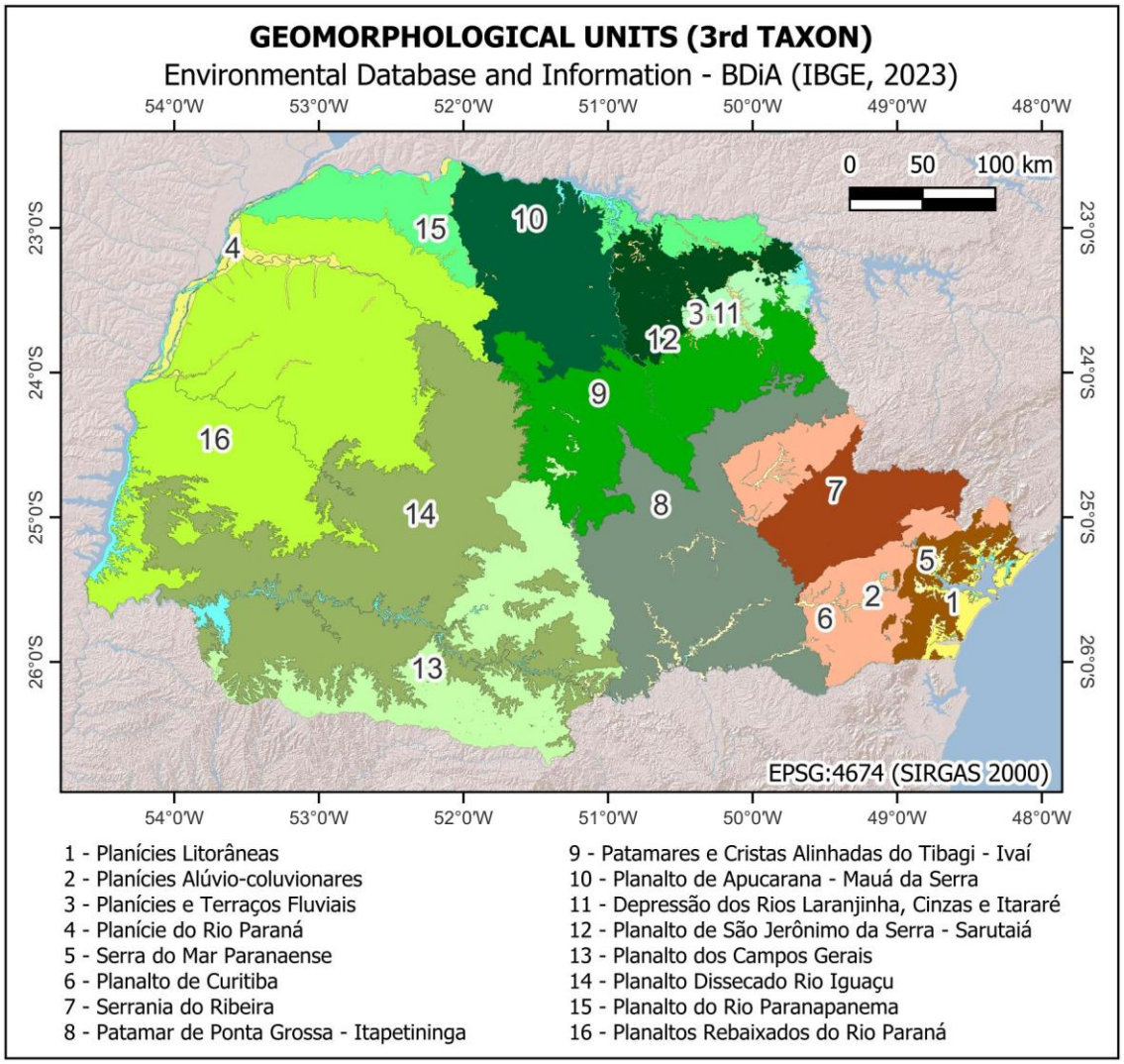

Figure 1 – Geomorphological units (3rd taxon) of the BDiA (IBGE, 2023) in the state of Paraná.

In the dimensional comparison between the two studies (Table 1), it was found that the BDiA units have significantly larger areas in the representation of the 3rd taxon, with an average area of 12,237 km² and a standard deviation of 9,690 km², while the units from the Paraná mapping have an average area of 3,918 km² and a standard deviation of 3,047 km². Thus, both the average area and the standard deviation of the BDiA units are approximately three times greater than those of the Paraná mapping.

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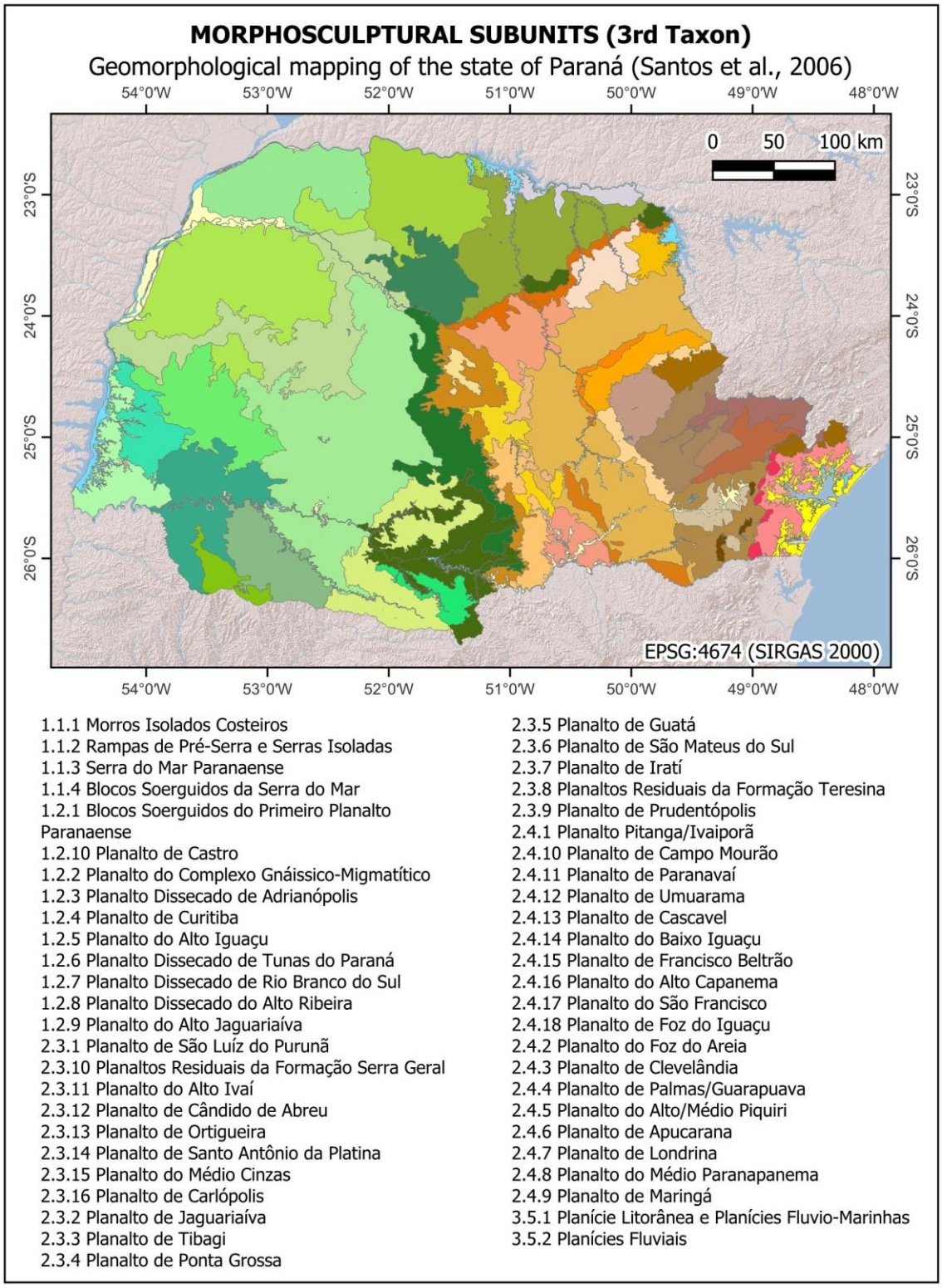

Figure 2 – Morphosculptural subunits (3rd taxon) of the geomorphological mapping of the state of Paraná (Santos et al., 2006).

Table 1 – Area of mapping units in the third taxon: geomorphological units of the BDiA (IBGE, 2023) and morphosculptural subunits (Santos et al., 2006).

BDiA - IBGE (2023)			
Geomorphological region	**Geomorphological unit**	**Code**	**Area (km²)**

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Planícies Deltáicas, Estuarinas e Praiais	Planícies Litorâneas	1	1554,3
Formas Agradacionais Atuais e Subatuais Interioranas	Planícies Alúvio-coluvionares	2	1603,6
	Planícies e Terraços Fluviais	3	615,7
Planícies do Rio Paraná	Planície do Rio Paraná	4	2150,5
Escarpas e Reversos da Serra do Mar	Serra do Mar Paranaense	5	3591,8
	Planalto de Curitiba	6	10379,0
Planalto de Paranapiacaba	Serrania do Ribeira	7	7703,7
Patamar Oriental da Bacia do Paraná	Patamar de Ponta Grossa - Itapetininga	8	22879,5
	Patamares e Cristas Alinhadas do Tibagi - Ivaí	9	17532,9
	Planalto de Apucarana - Mauá da Serra	10	12975,8
	Depressão dos Rios Laranjinha, Cinzas e Itararé	11	2573,7
	Planalto de São Jerônimo da Serra - Sarutaiá	12	6137,4
Planalto das Araucárias	Planalto dos Campos Gerais	13	17006,4
	Planalto Dissecado Rio Iguaçu	14	38917,5
Planalto do Rio Paraná	Planalto do Rio Paranapanema	15	8548,0
	Planaltos Rebaixados do Rio Paraná	16	41636,9
Geomorphological mapping of the state of Paraná - Santos et al. (2006)			
Morphosculptural unit	**Morphosculptural subunit**	**Code**	**Area (km²)**
Serra do Mar	Morros Isolados Costeiros	1.1.1	280,0
	Rampas de Pré-Serra e Serras Isoladas	1.1.2	439,9
	Serra do Mar Paranaense	1.1.3	2063,3
	Blocos Soerguidos da Serra do Mar	1.1.4	445,6
Primeiro Planalto Paranaense	Blocos Soerguidos do Primeiro Planalto Paranaense	1.2.1	267,5
	Planalto de Castro	1.2.10	2452,4
	Planalto do Complexo Gnáissico-Migmatítico	1.2.2	716,1
	Planalto Dissecado de Adrianópolis	1.2.3	2150,6
	Planalto de Curitiba	1.2.4	3713,1
	Planalto do Alto Iguaçu	1.2.5	1316,6
	Planalto Dissecado de Tunas do Paraná	1.2.6	2096,9
	Planalto Dissecado de Rio Branco do Sul	1.2.7	649,8
	Planalto Dissecado do Alto Ribeira	1.2.8	3828,2
	Planalto do Alto Jaguariaíva	1.2.9	1301,3
Segundo Planalto Paranaense	Planalto de São Luíz do Purunã	2.3.1	1529,4
	Planaltos Residuais da Formação Serra Geral	2.3.10	4175,8
	Planalto do Alto Ivaí	2.3.11	1680,1
	Planalto de Cândido de Abreu	2.3.12	577,2
	Planalto de Ortigueira	2.3.13	3594,3
	Planalto de Santo Antônio da Platina	2.3.14	1746,6
	Planalto do Médio Cinzas	2.3.15	2437,4
	Planalto de Carlópolis	2.3.16	1141,3
	Planalto de Jaguariaíva	2.3.2	2386,6
	Planalto de Tibagi	2.3.3	669,9
	Planalto de Ponta Grossa	2.3.4	16659,5
	Planalto de Guatá	2.3.5	1348,3
	Planalto de São Mateus do Sul	2.3.6	1725,4
	Planalto de Iratí	2.3.7	784,9
	Planaltos Residuais da Formação Teresina	2.3.8	684,8
	Planalto de Prudentópolis	2.3.9	2612,3
Terceiro Planalto Paranaense	Planalto Pitanga/Ivaiporã	2.4.1	5634,3
	Planalto de Campo Mourão	2.4.10	11273,4
	Planalto de Paranavaí	2.4.11	7492,4
	Planalto de Umuarama	2.4.12	15348,2
	Planalto de Cascavel	2.4.13	6350,8
	Planalto do Baixo Iguaçu	2.4.14	6788,4

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	Planalto de Francisco Beltrão	2.4.15	4645,1
	Planalto do Alto Capanema	2.4.16	1407,1
	Planalto do São Francisco	2.4.17	3052,2
	Planalto de Foz do Iguaçu	2.4.18	3653,6
	Planalto do Foz do Areia	2.4.2	6913,4
	Planalto de Clevelândia	2.4.3	1457,8
	Planalto de Palmas/Guarapuava	2.4.4	6645,4
	Planalto do Alto/Médio Piquiri	2.4.5	21787,5
	Planalto de Apucarana	2.4.6	3996,8
	Planalto de Londrina	2.4.7	9305,9
	Planalto do Médio Paranapanema	2.4.8	1525,6
	Planalto de Maringá	2.4.9	7955,7
Planícies	Planície Litorânea e Planícies Fluvio-Marinhas	3.5.1	2005,6
	Planícies Fluviais	3.5.2	3223,3

Source: IBGE (2023) e Santos et al. (2006).

In the BDiA, the Planaltos Rebaixados do Rio Paraná constitute the largest unit, with 41,636 km², while the Planícies e Terraços Fluviais represent the smallest, with only 615 km². In the Paraná mapping, the Planalto do Alto/Médio Piquiri stands out as the largest unit, with 21,787 km², and the Blocos Soerguidos do Primeiro Planalto Paranaense correspond to the smallest, with 267 km². It is evident, therefore, that the units presented in the BDiA (IBGE, 2023) are considerably larger and more generalized compared to those in the Paraná mapping, since each unit of the first mapping encompasses several units of the second (Table 2). An example to be highlighted is the Patamares e Cristas Alinhadas do Tibagi-Ivaí unit, which contains ten morphostructural subunits from the mapping by Santos et al. (2006).

Table 2 – Overlay of the geomorphological units of the BDiA (IBGE, 2023) with the morphosculptural subunits (Santos et al., 2006).

Geomorphological Unit	Morphosculptural subunit	%	Geomorphological Unit	Morphosculptural subunit	%
Planalto do Rio Paranapanema	Planalto de Paranavaí	54%	Patamar de Ponta Grossa - Itapetininga	Planalto de Guatá	6%
				Planalto de Prudentópolis	12%
	Planalto de Maringá	16%		Planalto de Tibagi	3%
	Planalto do Médio Paranapanema	17%		Planalto de Jaguariaíva	11%
	Planalto de Londrina	13%		Planalto de Ponta Grossa	45%
Planície do Rio Paraná	Planícies Fluviais	84%		Planalto de Irati	4%
	Planalto de Umuarama	6%		Planalto de São Mateus do Sul	8%
	Planalto de Paranavaí	5%		Planalto de São Luíz do Purunã	7%
	Planalto de Maringá	4%		Planaltos Residuais da Formação Teresina	3%
Planalto de São Jerônimo da Serra - Sarutaiá	Planalto de Santo Antônio da Platina	15%		Planaltos Residuais da Formação Serra Geral	4%
	Planalto do Foz do Areia	15%	Planícies Alúvio-coluvionares	Planícies Fluviais	57%
	Planalto de Londrina	70%		Planície Litorânea e Planícies Fluvio-Marinhas	28%
Serra do Mar Paranaense	Serra do Mar Paranaense	65%		Planalto de Castro	14%
	Rampas de Pré-Serra e Serras Isoladas	11%	Patamares e Cristas Alinhadas do Tibagi - Ivaí	Planalto de Santo Antônio da Platina	3%
	Blocos Soerguidos da Serra do Mar	14%		Planalto de Ortigueira	20%
	Morros Isolados Costeiros	9%		Planalto de Ponta Grossa	37%
Planícies e Terraços Fluviais	Planalto de Santo Antônio da Platina	3%		Planaltos Residuais da Formação Serra Geral	15%
	Planalto de Campo Mourão	4%		Planalto de Carlópolis	2%

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	Planalto de Umuarama	14%		Planalto do Médio Cinzas	3%
	Planalto de Ponta Grossa	8%		Planalto de Cândido de Abreu	3%
	Planalto do Médio Cinzas	35%		Planalto de Apucarana	6%
	Planalto de Maringá	6%		Planalto do Alto Ivaí	9%
	Planalto de Londrina	29%		Planalto Pitanga/Ivaiporã	2%
Planalto de Curitiba	Planalto Dissecado do Alto Ribeira	3%	Planalto de Apucarana - Mauá da Serra	Planalto de Maringá	49%
	Planalto Dissecado de Tunas do Paraná	7%		Planalto de Apucarana	19%
	Planalto do Complexo Gnáissico-Migmatítico	7%		Planalto de Londrina	32%
	Planalto de Curitiba	35%	Planaltos Rebaixados do Rio Paraná	Planalto de Cascavel	16%
	Planalto do Alto Jaguariaíva	13%		Planalto de Campo Mourão	29%
	Planalto do Alto Iguaçu	12%		Planalto de Umuarama	40%
	Blocos Soerguidos do Primeiro Planalto Paranaense	2%		Planalto de Paranavaí	7%
	Planalto de Castro	22%		Planalto de Foz do Iguaçu	8%
Planalto dos Campos Gerais	Planalto do Alto Capanema	4%	Planalto Dissecado Rio Iguaçu	Planalto do São Francisco	5%
	Planalto do Alto/Médio Piquiri	4%		Planalto do Alto Capanema	2%
	Planalto de Palmas/Guarapuava	39%		Planalto do Alto/Médio Piquiri	53%
	Planalto de Clevelândia	8%		Planalto do Baixo Iguaçu	15%
	Planalto do Foz do Areia	13%		Planalto do Foz do Areia	10%
	Planalto de Francisco Beltrão	9%		Planalto de Foz do Iguaçu	2%
	Planalto Pitanga/Ivaiporã	23%		Planalto de Francisco Beltrão	8%
Serrania do Ribeira	Planalto Dissecado do Alto Ribeira	46%		Planalto Pitanga/Ivaiporã	4%
	Planalto Dissecado de Adrianópolis	27%	Planícies Litorâneas	Rampas de Pré-Serra e Serras Isoladas	4%
	Planalto Dissecado de Tunas do Paraná	18%		Planície Litorânea e Planícies Fluvio-Marinhas	96%
	Planalto Dissecado de Rio Branco do Sul	9%	Depressão dos Rios Laranjinha, Cinzas e Itararé	Planalto de Carlópolis	27%
				Planalto do Médio Cinzas	73%

Source: IBGE (2023) e Santos et al. (2006).

The oversizing of geomorphological units in relation to morphosculptural subunits consists of grouping distinct landform patterns. The methods employed in the two mappings detected different morphological patterns. From the quantification and statistics of slope and altimetric amplitude (Table 3), it is possible to verify the values of the distinct geomorphometric attributes present in the units of the 3rd taxon, in which the BDiA has larger intervals and greater generalization of patterns.

This generalization of the BDiA (IBGE, 2023) is exemplified by the Planaltos Rebaixados do Rio Paraná, which coincide almost entirely with the Planaltos de Campo Mourão (29%), Cascavel (16%), Foz do Iguaçu (8%), Umuarama (40%) and part of the Planalto de Paranavaí (7%) of Santos et al. (2006) (Table 2). The first three develop on Mesozoic volcanic geological units of the Serra Geral Group, while the last two are based on the sandstones of the Caiuá Group (Besser et al., 2021), resulting in distinct morphological characteristics, such as altimetric amplitude and slope. Silveira et al. (2025) identified different average slope lengths in these

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subunits, and Silveira et al. (2018) detected the differentiated distribution of geomorphons on them. These differences reinforce the separation of units with distinct geomorphological patterns.

The Planalto do Rio Paranapanema of the BDiA intersects 54% with the Planalto de Paranavaí (Table 2), developed on the sandstone rocks of the Caiuá Group. Secondarily, it overlaps with the Planaltos do Médio Paranapanema, Maringá and Londrina Plateaus (17%, 16%, and 13%, respectively). These last three plateaus are situated on volcanic geological units, presenting differentiated morphological characteristics. For example, the average length of the slopes, recorded by Silveira et al. (2025), tends to be less extensive in the volcanic plateaus than in the plateaus on the Caiuá sandstones. Furthermore, the morphometric values (Table 3) are distinct and the morphodynamic behavior of soil water erosion is more pronounced in the Planaltos de Paranavaí and Umuarama, where moderate to high vulnerability to erosion occurs, while in the three volcanic units low vulnerability predominates (Santos et al., 2007).

The results of the geomorphometric signatures of the units equivalent to the Planaltos Rebaixados do Rio Paraná and the Planalto do Rio Paranapanema are illustrated in Graph 1 (altimetric amplitude) and Graph 2 (slope), which denote the distinct morphologies in relation to the morphostructural subunits.

Table 3 – Statistics of geomorphometric attributes of geomorphological units of the 3rd taxon.

Geomorphological unit (3rd taxon)		Altimetric amplitude (radius of 1 km)						Slope (%)					
		Minimun	Q1	Median	Mean	Q3	Maximun	Minimun	Q1	Median	Mean	Q3	Maximun
IBGE (2023)	Planícies Litorâneas	0,0	4,1	7,4	19,5	16,3	322,0	0,0	0,3	0,7	1,8	1,6	101,5
	Planícies Alúvio-coluvionares	0,4	16,0	31,3	38,3	48,5	315,6	0,0	0,9	2,0	3,6	4,0	89,2
	Planícies e Terraços Fluviais	2,5	31,2	42,7	47,2	56,8	233,2	0,0	2,1	4,3	6,4	8,3	99,8
	Planície do Rio Paraná	0,0	2,1	5,4	9,3	11,3	79,2	0,0	0,2	0,5	1,1	1,2	42,6
	Serra do Mar Paranaense	4,0	162,7	232,8	244,7	312,8	1046,6	0,0	21,0	32,9	34,9	46,4	244,5
	Planalto de Curitiba	0,5	44,2	64,4	75,3	92,2	550,7	0,0	4,8	10,8	14,4	20,7	169,2
	Serrania do Ribeira	10,8	122,7	159,6	177,6	216,5	658,4	0,0	19,8	32,8	33,6	45,8	288,0
	Patamar de Ponta Grossa - Itapetininga	2,4	49,5	67,1	75,2	88,9	433,3	0,0	4,6	8,9	11,4	15,2	180,6
	Patamares e Cristas Alinhadas do Tibagi - Ivaí	3,7	79,9	104,2	115,0	138,4	459,0	0,0	9,5	16,4	19,3	26,1	219,6
	Planalto de Apucarana - Mauá da Serra	2,1	50,3	66,7	73,5	89,2	366,0	0,0	4,4	8,0	10,1	13,3	115,6
	Depressão dos Rios Laranjinha, Cinzas e Itararé	2,8	40,1	52,3	57,2	68,8	228,9	0,0	3,5	6,9	9,0	12,4	89,4
	Planalto de São Jerônimo da Serra - Sarutaiá	6,7	69,2	87,8	103,5	117,3	647,6	0,0	6,9	12,3	15,1	20,2	148,4
	Planalto dos Campos Gerais	0,0	52,4	72,7	83,6	102,5	413,7	0,0	5,0	9,7	12,5	17,0	141,8
	Planalto Dissecado Rio Iguaçu	4,8	83,7	108,2	115,2	139,0	500,8	0,0	8,9	15,5	18,0	24,9	178,2
	Planalto do Rio Paranapanema	1,0	33,5	43,6	45,0	54,4	262,4	0,0	2,8	4,6	5,5	7,1	74,6
	Planaltos Rebaixados do Rio Paraná	1,3	41,6	52,8	55,2	65,5	265,7	0,0	3,5	6,1	7,3	9,6	84,0
Santos et al. (2006)	Morros Isolados Costeiros	12,3	189,2	252,8	259,2	321,1	642,0	0,0	25,1	36,4	37,0	47,8	145,8
	Rampas de Pré-Serra e Serras Isoladas	5,3	62,7	87,7	96,6	122,6	330,3	0,0	4,8	14,8	17,4	26,9	108,3
	Serra do Mar Paranaense	32,2	194,2	253,2	266,0	325,2	854,4	0,0	23,6	34,8	36,9	47,8	227,5
	Blocos Soerguidos da Serra do Mar	52,7	220,7	292,3	317,7	386,3	1046,6	0,0	27,1	39,5	42,8	53,7	244,5
	Blocos Soerguidos do Primeiro Planalto	22,4	95,2	151,5	157,8	216,3	395,3	0,0	12,9	23,0	25,3	34,9	139,3
	Planalto de Castro	0,5	32,5	47,0	57,8	69,6	283,6	0,0	2,6	6,2	9,1	12,3	134,5
	Planalto do Complexo Gnáissico-Migmatítico	12,6	69,7	101,3	114,3	142,2	465,1	0,0	11,8	22,3	24,0	33,6	124,6
	Planalto Dissecado de Adrianópolis	18,5	188,4	244,7	251,3	307,2	658,4	0,0	28,9	41,8	41,9	54,1	166,7
	Planalto de Curitiba	2,4	49,2	63,4	69,1	81,0	507,9	0,0	5,8	11,6	14,0	19,9	172,4
	Planalto do Alto Iguaçu	2,1	27,5	35,6	36,0	43,9	115,7	0,0	2,4	4,6	6,2	8,4	72,1
	Planalto Dissecado de Tunas do Paraná	14,0	104,0	138,5	150,4	185,4	508,2	0,0	17,1	29,1	30,4	42,1	147,4
	Planalto Dissecado de Rio Branco do Sul	55,8	151,4	181,3	186,2	217,9	418,8	0,0	23,6	36,4	36,5	48,7	126,8
	Planalto Dissecado do Alto Ribeira	16,3	106,5	131,2	136,4	160,4	423,7	0,0	15,6	27,1	28,2	39,1	288,0
	Planalto do Alto Jaguariaíva	12,5	67,9	83,4	100,4	112,6	396,7	0,0	8,2	15,4	18,2	25,2	126,6
	Planalto de São Luíz do Purunã	3,2	47,4	65,0	75,5	88,7	369,3	0,0	3,9	7,3	10,2	12,9	120,5
	Planaltos Residuais da Formação Serra Geral	9,6	103,9	143,1	152,3	193,9	459,0	0,0	12,1	20,6	23,2	31,4	219,6
	Planalto do Alto Ivaí	8,0	94,2	125,1	131,1	159,5	399,5	0,0	11,9	22,4	25,6	35,9	152,4
	Planalto de Cândido de Abreu	7,1	50,0	62,5	68,8	79,7	314,3	0,0	5,2	9,7	11,3	15,5	103,1

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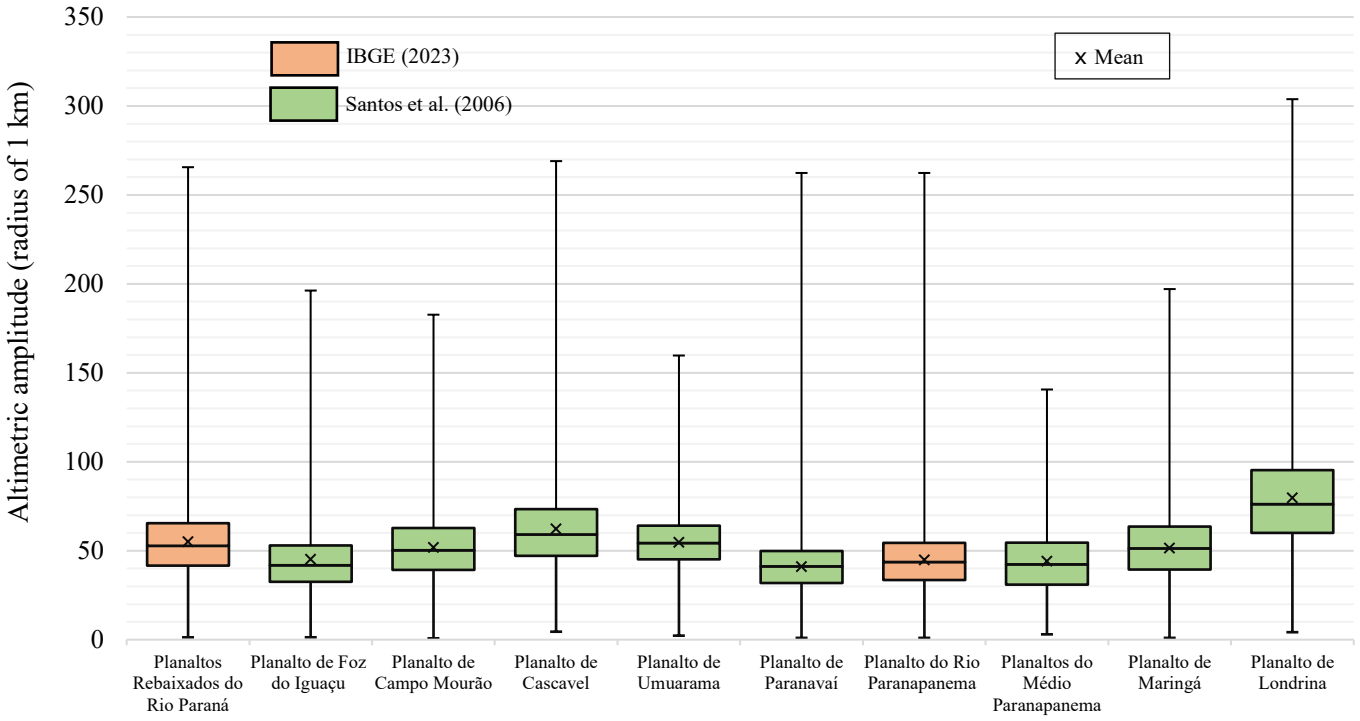
	Planalto de Ortigueira	12,7	77,7	106,2	114,4	141,0	404,3	0,0	9,6	16,6	19,5	26,8	151,8
	Planalto de Santo Antônio da Platina	8,4	105,4	149,5	159,5	203,6	647,6	0,0	11,0	20,2	22,9	32,3	148,4
	Planalto do Médio Cinzas	3,8	39,6	52,2	57,6	69,8	304,0	0,0	3,4	6,9	9,2	12,6	89,4
	Planalto de Carlópolis	6,7	53,4	71,1	83,5	103,5	311,9	0,0	5,3	10,3	13,0	18,0	98,4
	Planalto de Jaguariaíva	7,7	66,5	85,1	94,9	112,6	358,8	0,0	6,0	10,7	13,6	17,4	146,8
	Planalto de Tibagi	10,5	50,2	61,7	64,1	74,9	187,3	0,0	4,5	8,0	9,3	12,6	86,4
	Planalto de Ponta Grossa	3,7	60,6	78,6	83,0	100,1	352,0	0,0	6,1	11,2	13,3	18,2	156,7
	Planalto de Guatá	5,8	63,1	75,7	76,6	89,4	160,9	0,0	6,3	11,6	13,1	18,2	80,5
	Planalto de São Mateus do Sul	2,4	33,7	42,6	44,6	52,4	170,5	0,0	2,6	5,2	6,6	8,9	77,9
	Planalto de Iratí	10,8	51,9	67,8	72,7	89,4	220,0	0,0	4,9	10,1	12,5	17,9	85,1
	Planaltos Residuais da Formação Teresina	5,8	53,7	84,1	97,9	130,4	400,5	0,0	5,6	11,1	14,6	19,8	134,6
	Planalto de Prudentópolis	2,8	39,3	52,7	60,8	71,7	317,4	0,0	3,4	7,2	9,6	13,1	128,4
	Planalto Pitanga/Ivaiporã	7,8	60,6	74,6	84,5	94,0	439,2	0,0	5,8	10,6	12,6	16,8	162,2
	Planalto de Campo Mourão	0,7	39,2	50,3	51,9	62,8	182,7	0,0	3,1	5,6	6,7	9,0	68,6
	Planalto de Paranavaí	0,0	31,9	41,2	41,2	49,8	262,4	0,0	2,6	4,3	4,9	6,3	74,6
	Planalto de Umuarama	2,3	45,2	54,3	54,8	64,1	159,7	0,0	3,9	6,6	7,4	9,8	61,9
	Planalto de Cascavel	4,5	47,1	59,1	62,3	73,4	269,0	0,0	4,2	7,0	8,2	10,6	80,9
	Planalto do Baixo Iguaçu	10,2	79,5	98,1	102,4	121,8	282,7	0,0	8,0	13,2	15,6	21,1	103,9
	Planalto de Francisco Beltrão	10,1	72,7	91,1	93,5	111,4	255,0	0,0	8,0	13,2	15,1	20,4	96,2
	Planalto do Alto Capanema	22,8	115,3	143,7	144,5	171,9	314,3	0,0	13,4	22,4	23,5	32,2	106,9
	Planalto do São Francisco	5,7	69,3	91,5	94,9	116,6	244,4	0,0	6,6	10,9	12,9	17,1	78,0
	Planalto de Foz do Iguaçu	1,3	32,5	41,8	45,3	53,0	196,2	0,0	2,7	4,7	5,7	7,3	84,0
	Planalto do Foz do Areia	0,0	100,8	134,1	148,6	182,3	500,8	0,0	10,3	18,8	21,1	29,5	178,2
	Planalto de Clevelândia	8,4	75,7	107,9	115,7	144,4	362,9	0,0	7,7	14,9	18,0	25,5	120,9
	Planalto de Palmas/Guarapuava	0,0	40,6	53,1	59,1	70,6	363,0	0,0	3,6	6,8	8,8	11,7	141,8
	Planalto do Alto/Médio Piquiri	8,2	85,8	110,0	114,0	138,6	331,8	0,0	9,3	16,0	18,3	25,3	109,6
	Planalto de Apucarana	4,8	71,4	90,2	94,5	113,6	254,6	0,0	7,2	11,9	13,8	18,4	100,8
	Planalto de Londrina	4,2	60,0	76,2	79,8	95,3	303,8	0,0	5,5	9,8	11,5	15,6	91,8
	Planalto do Médio Paranapanema	2,8	30,9	42,3	44,3	54,5	140,6	0,0	2,6	4,6	5,8	7,7	56,8
	Planalto de Maringá	0,5	39,4	51,3	51,6	63,6	197,1	0,0	3,1	5,5	6,4	8,7	101,4
	Planície Litorânea e Planícies Fluvio-Marinhas	0,0	5,0	10,2	35,7	52,5	391,0	0,0	0,4	1,0	3,9	2,6	101,5
	Planícies Fluviais	0,0	3,9	10,5	22,6	30,3	316,7	0,0	0,3	0,9	2,5	2,5	133,7

Source: The authors.



Graph 1 – Statistics of altimetric amplitude in the Planaltos Rebaixados do Rio Paraná and Planalto do Rio Paranapanema.

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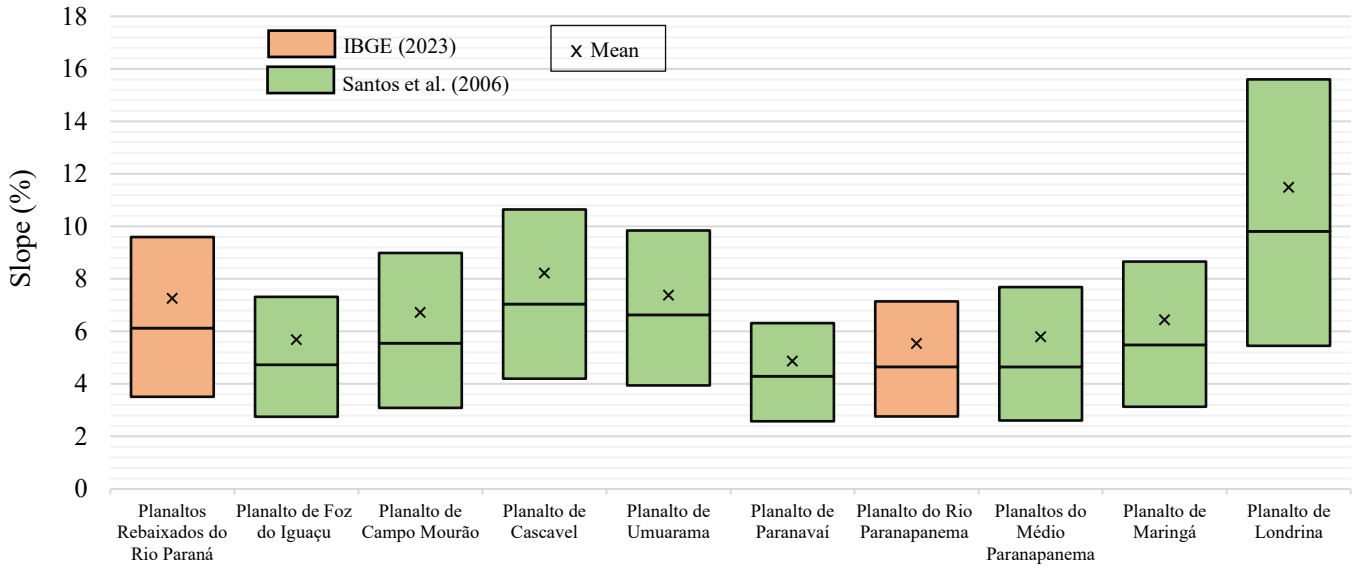

Graph 2 – Slope (%) statistics in the Planaltos Rebaixados do Rio Paraná and Planalto do Rio Paranapanema (between the 1st and 3rd quartiles).

The Planalto Dissecado Rio Iguaçu geomorphological unit of the BDiA predominantly coincides with the Planaltos do Alto/Médio Piquiri (53%) and Baixo Iguaçu (15%) (Table 2), in addition to encompassing the Foz do Areia, Francisco Beltrão, São Francisco, Pitanga/Ivaiporã, Upper Capanema and Foz do Iguaçu Plateaus. The eight morphostructural subunits identified in the Paraná mapping show significant morphological differences, such as drainage orientation and divides, degrees of dissection, predominance of slope and altimetric gradient, demonstrating that the grouping into a single unit carried out by the BDiA represents an overgeneralization.

Figure 3 exemplifies the generalization of the BDiA mapping, since the morphostructural subunits that intersect and subdivide the so-called "Planalto Dissecado Rio Iguaçu" have geomorphometric signatures with great variation. The "Planalto de Foz do Iguaçu" subunit, from Santos et al. (2006), is the most homogeneous considering the slope values, while others present a greater amplitude – as is the case of the Planalto do Foz do Areia. Note that each subunit has a morphometric pattern that distinguishes it from the others and, thus, justifies the detail in the mapping.

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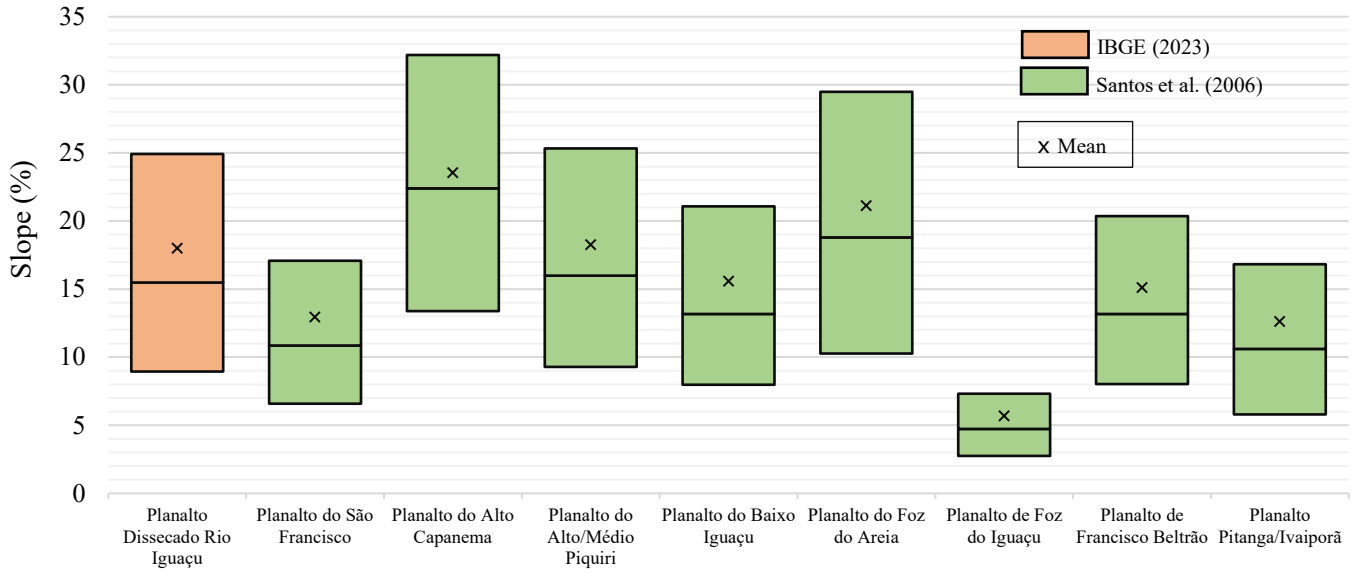

Graph 3 – Slope (%) statistics in the Rio Iguaçu Dissected Plateau (between the 1st and 3rd quartiles).

The Planalto de São Jerônimo da Serra-Sarutaiá, mapped in BDiA, overlaps with three units of the Paraná geomorphological mapping: the Santo Antônio da Platina, Foz do Areia and Londrina Plateaus. The latter shows the greatest spatial correspondence, representing 70% of the intersection area, while the other two correspond to 15% each (Table 2).

The Planalto dos Campos Gerais, identified by BDiA, overlaps the Palmas/Guarapuava Plateau (38%), the Pitanga/Ivaiporã Plateau (22%), the Foz do Areia Plateau (13%), the Francisco Beltrão Plateau (9%), and the Clevelândia Plateau (8%), in addition to small portions of the Alto Capanema and Alto/Médio Piquiri Plateaus (4% each) (Table 2). It is important to highlight that the toponym "Campos Gerais" is not traditionally applied to the geographical region where the aforementioned geomorphological unit of the IBGE (2023) is located, this name being inherited from the RadamBrasil reports (IBGE, 2018a).

In Paraná, the region known as the Campos Gerais, established in the literature since Maack (1968), is located along the Devonian Escarpment in the central-eastern portion of the state (Melo et al., 2014). Situated under the Furnas and Ponta Grossa Formations, both of the Paraná Group, they occupy almost the entire strip that follows the eastern edge of the Campos Gerais, extending inland in the central and northern portion. The remaining area of the Campos Gerais has rocks of the Itararé Group, in addition to small sections with exposures of the Guatá Group (Guimarães et al., 2014). In short, the location of the Campos Gerais in Paraná is on the Second Plateau (*Segundo Planalto*) and not on the Third Plateau (*Terceiro Planalto*), where the unit so named by the IBGE (2023) is located.

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The Planalto de Apucarana-Mauá da Serra of the BDiA overlaps with the Maringá (49%), Londrina (32%), and Apucarana (18%) Plateaus (Table 2). Despite the similar name "Planalto de Apucarana" in both mappings, the units show limited spatial coincidence, evidencing that, although they share the same toponymy, they do not represent the same geomorphological characteristics.

This divergence possibly stems from the fact that both regions contain natural grasslands; however, in a manner established in regional literature, the grasslands of the Third Plateau were designated by Maack (1968) as "Campos de Guarapuava," while those of the Second Plateau were named "Campos Gerais," in recognition of their historical identity. Therefore, the toponymy employed in the BDiA can generate ambiguities regarding the spatial location of the unit.

Similarly, the Planalto de Curitiba of the BDiA uses the same name as one of the morphostructural subunits of the Paraná mapping, but covers a substantially larger area, approximately three times greater (10,343 km² compared to 3,469 km²), with only 35% overlap between them (Table 2). The Planalto de Curitiba of the BDiA completely overlaps the Planalto do Alto Iguaçu Plateau (13%), Planalto de Curitiba (33%), the Planalto de Alto Jaguariaíva (13%), the Planalto de Castro (22%), the Gneissic-Migmatitic Complex (7%), and the Blocos Soerguidos do Primeiro Planalto (3%), in addition to partially intersecting the Planalto Dissecado de Tunas (7%) and the Alto Ribeira (3%). The geomorphometric signature of these units is presented in Graph 4, with an example of the altimetric amplitude.

The Serra do Mar constitutes the third geomorphological unit of the BDiA that shares the same name as a morphostructural subunit in the Paraná mapping. However, the BDiA unit encompasses a set of classes: Serra do Mar, Blocos Soerguidos da Serra do Mar, Rampas de Pré-Serra and Morros Isolados Costeiros, with overlap values of 65%, 14%, 12%, and 9%, respectively (Table 2). This set of units distinguishes different landforms present in the Serra do Mar, termed in Silveira et al. (2025) as Serras Montanhosas, which configure the faulted block mountains described by Ab'Saber (2006).

It was observed that the Serra do Mar unit, mapped in the 3rd taxon by IBGE (2023), corresponds 65% to the unit defined with the same name by Santos et al. (2006) in the 2nd taxon, evidencing the excessive generalization of the BDiA representation for the 3rd hierarchical level of this geomorphological unit set composed of mountain ranges (Silveira et al., 2025).

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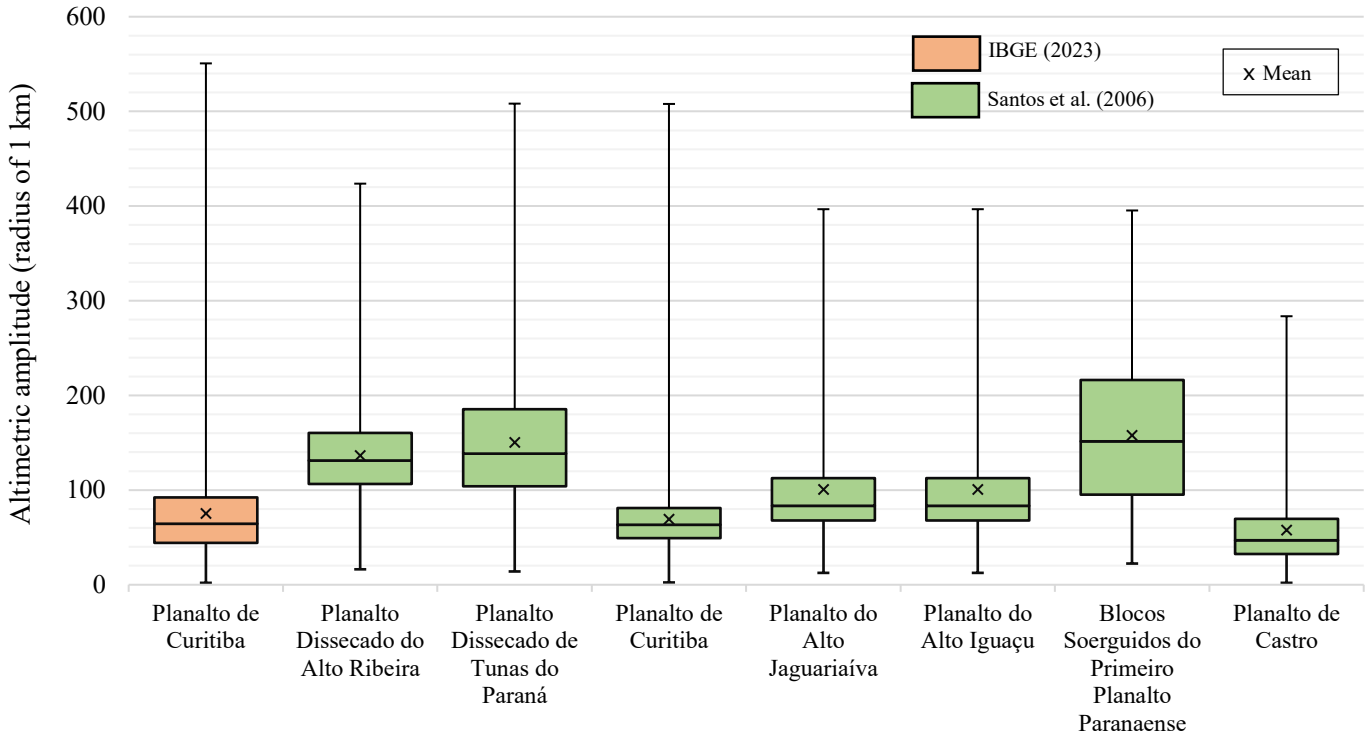

Graph 4 – Statistics of altimetric amplitude in the Curitiba Plateau.

The unit called Planícies Litorâneas in the BDiA coincides 96% with the Planície Litorânea and Planícies Fluviomarinhas of the Paraná mapping and 4% with the unit Rampas de Pré-Serra and Serras Isoladas. The formation of the Paraná fluviomarine plain is associated with transgressive/regressive cycles of the Quaternary in the last two glacial periods (Angulo, 2004), while the Rampas de Pré-Serra constitute colluvial slopes, a term proposed by Bigarella and Mousinho (1965), used in gently sloping valley bottom forms, associated with the coalescence of colluvial deposits from the slopes that interdigitate and/or cover the alluvial deposits.

Three other aggradational geomorphological units are identified by IBGE (2023): the Planícies Alúvio-coluvionares and Planícies do Rio Paraná, included in the Planícies Fluviais unit in the mapping by Santos et al. (2006), and the Planícies and Terraços Fluviais, which coincide with morphostructural subunits of the Planaltos de Médio Cinzas (35%), Londrina (29%), Umuarama (14%), Ponta Grossa (8%), Maringá (6%), Campo Mourão (4%) and Santo Antônio da Platina Plateau (3%) (Table 2). In the case of the plains, it was found that the BDiA database showed less generalization.

In addition to the designations of Planaltos, Serra and Planícies, used in representing the units of the 3rd taxon in both mapping studies, BDiA also uses other relief terminologies: Serrania, Depression and Patamares.

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The unit identified as Serrania do Ribeira intersects entirely with the morphostructural subunits Planaltos Dissecados do Alto Ribeira (46%), de Adrianópolis (27%), Rio Branco do Sul (9%) and partially coincides with the Planalto Dissecado de Tunas do Paraná (18%). These units are part of the region called Vale do Ribeira, developed on rocks of the Itaiacoca, Capiru, Votuverava Groups, Açungui Supergroup and Granitoids (Besser et al., 2021). The designation of "serrania" may be considered in the representation of the 3rd taxon, as it proves adequate in detailing the typology of intraplanatic landform, equally pertinent to the designation of dissected plateau.

Considering that the Serra do Mar and Serrania do Ribeira are the areas with the most dissected terrain pattern in the state of Paraná, Graph 5 presents the statistics of slope values for the 3rd taxon classes that overlap in the analyzed mappings.

The Depressão dos Rios Laranjinha, Cinzas and Itararé overlaps with two units mapped in Paraná: the Planaltos do Médio Cinzas e de Carlópolis, with 73% and 27% of their areas overlapping, respectively. These two units, classified by Santos et al. (2006), demonstrate the generalization in the treatment of the 3rd taxon of the unit mapped by IBGE (2023), which does not distinguish the different morphologies between them. However, the designation of "depression" to characterize a unit in the 3rd taxon is appropriate, although it could be complemented as "intraplateau depression," allowing the name to more faithfully reflect the unit's configuration. Thus, the Planalto do Médio Cinzas could be classified as an intraplateau depression, resulting from the erosive retreat of the Serra Geral do Paraná Escarpment or Mesozoic Escarpment (Maack, 1968), presenting lower altimetric levels than its surroundings, a characteristic that does not apply to the Planalto de Carlópolis.

The Patamar de Ponta Grossa – Itapetininga unit encompasses nine units from the Paraná mapping: the São Luiz do Purunã (7%), Jaguariaíva (11%), Tibagi (3%), Guatá (6%), São Mateus do Sul (8%), Prudentópolis (12%), Irati (4%), Ponta Grossa (45%) plateaus and Planaltos Residuais da Formação Serra Geral (4%) (Table 2). This Plateau unit covers half of the south-central area of the Second Paraná Plateau, represented in the 2nd taxon by Santos et al. (2006), also including areas of the proximal reverse slope of the Purunã cuesta. Therefore, it is an excessively generalized unit to represent the 3rd taxon, as it does not distinguish the different morphologies that characterize each of the morphostructural subunits identified in the Paraná mapping.

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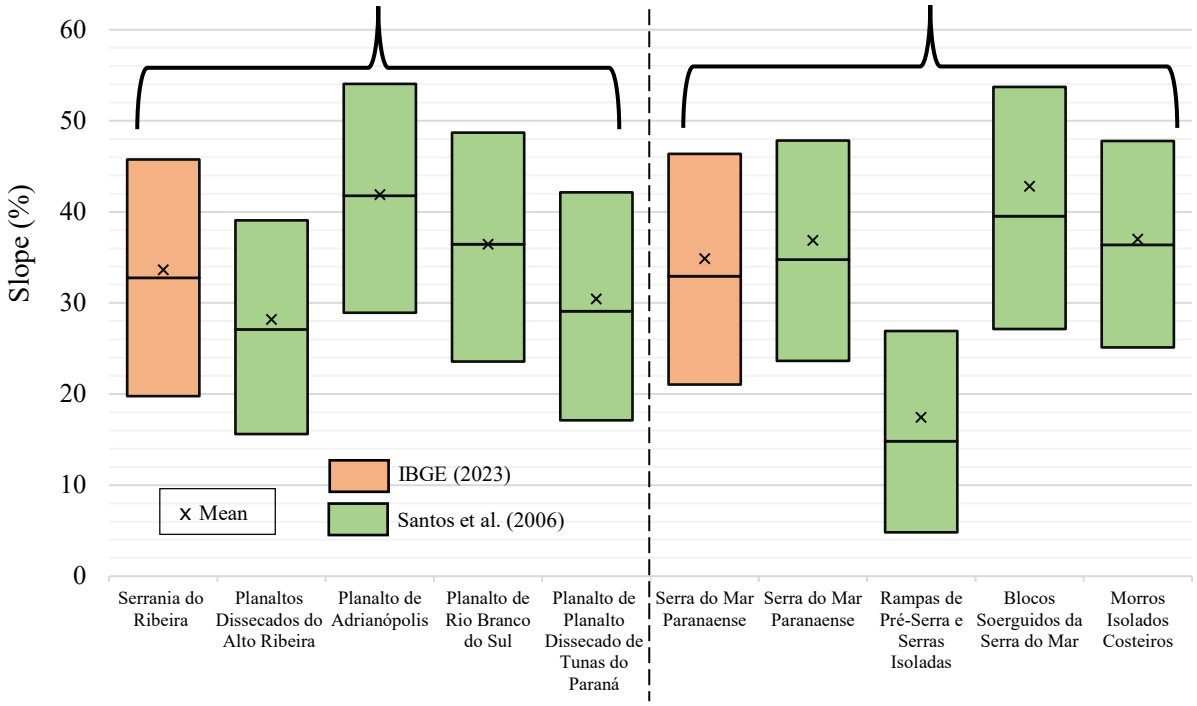

Graph 5 – Slope (%) statistics in the Serrania do Ribeira and Serra do Mar Paranaense (between the 1st and 3rd quartiles).

The Patamares e Cristas Alinhadas do Tibagi – Ivaí unit of the BDiA overlaps with the morphostructural subunits Planaltos de Ortigueira (20%), Ponta Grossa (37%), Carlópolis (2%), Médio das Cinzas (3%), Planaltos Residuais da Formação Serra Geral (15%), Cândido de Abreu (3%), Pitanga/Ivaiporã (2%), and Apucarana (6%) (Table 2). The latter is located in the Third Paraná Plateau, indicating that the delimitation of the Patamares e Cristas Alinhadas do Tibagi – Ivaí does not coincide with the boundary of the Serra Geral Cuesta and is not exclusively restricted to the Second Paraná Plateau, although it encompasses its central and northern portion. This BDiA unit also demonstrated excessive generalization in the representation of geomorphological units with distinct morphological patterns.

The designation of "patamar" used in naming these last two geomorphological units of the BDiA (IBGE, 2022a), inherited from the RADAMBRASIL Project (IBGE, 2018a; 2018b), conflicts with the classic term "planalto" used by Santos et al. (2006), which has historically been used by authors such as Ab'Saber (1964), who named the region the Planalto Meridional, and Maack (1968), who characterized it as the Segundo Planalto (Second Plateau). However, it would be possible in the third taxon, plateaus on terraces represent typologies of forms used in the more detailed representation of intraplateau units.

The disparity between the national approach of BDiA and the detailed mapping of Paraná is influenced by differences in the techniques employed and the methodological approach. The former relies on the regional perspective provided by radar images, which was the basic material used by the RADAMBRASIL

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Project (IBGE, 2018a; 2018b) in identifying geomorphological units were delimited, assumed, and designated under a regionalist approach. While the mapping by Santos et al. (2006) used geomorphometric attributes processed from the SRTM90 DEM to identify distinct morphological patterns, even though it later names the resulting units with regional toponyms, its delimitation is based on the distinction of form typology. The geomorphological units classified in BDiA fail to distinguish the patterns of shape typology, thus tending towards generalization, resulting in polygons with average areas three times larger than the Paraná mapping, which presented a more detailed and specific approach supported by the similarity of shape patterns for the identification of the 3rd taxon.

The lack of terminological standardization identified in the analyzed maps constitutes an obstacle to scientific communication and technical application. Therefore, the 3rd taxon should be more focused on establishing criteria to distinguish the typologies of landforms and on developing terminology appropriate to the relief compartments, rather than fixating on establishing regionalist designations.

Terms such as " patamar" "depression" and "serra" which are not found in the first taxon, can be represented as representative compartments of the third hierarchical level, complementary to the higher taxa in distinguishing relief patterns. Various other terminologies representative of the 3rd taxon, which appear in the distinct landscapes of the Brazilian landforms, can also be used.

IV. CONCLUSÕES

A comparative analysis between the geomorphological mapping of BDiA and the mapping of the state of Paraná revealed significant differences in the representation of the third geomorphological taxon, although both are equivalent in hierarchical level and cartographic scale. The BDiA mapping presented significantly more generalized units, with average areas three times larger than the second mapping analyzed.

The discrepant sizing between the units in the two mappings reflects the distinct techniques employed and different conceptions about the taxonomic representation of landforms. While the BDiA is based on a regional perspective inherited from the RADAMBRASIL Project, the Paraná study is based on the differentiation of specific morphological patterns, identified through geomorphometric attributes derived from digital elevation models.

Geomorphometric signatures of attributes such as altimetric amplitude and slope confirmed that the BDiA units tend to integrate contrasting form patterns. The statistics of these parameters revealed higher

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amplitudes and deviations in the BDiA units, while the Paraná mapping showed greater internal homogeneity, reinforcing the coherence of its delimitation based on form typologies.

By overgeneralizing the geomorphological units in the BDiA, the identification of local morphological patterns was compromised. This generalization groups areas with significantly distinct characteristics from a morphological, morphogenetic, and morphodynamic perspective into a single unit. Therefore, it is necessary to establish criteria that define the distinction between geomorphological typologies, as well as the appropriate areal amplitude for the third taxon, avoiding both excessive fragmentation and inadequate generalization.

The limited spatial correspondence between units with the same name in the two mappings further demonstrated the absence of terminological standardization, which constitutes an obstacle to scientific communication. Particularly problematic is the use of toponyms that contradict historically consolidated names in the regional geographical literature.

The mapping of Paraná highlighted the predominance of plateaus in the state, even in the representation of the units of the 3rd taxon, designating 43 of the 50 geomorphological units as "planalto" (plateau) without resorting to the terminologies of “patamares”, “depressions” and “serras”, which were used in the naming of the units identified in the BDiA. The use of these terminologies may be valuable in the third taxon, as it allows for the distinction of intraplateau typologies.

Identifying the inconsistencies between the two mappings contributes to reflections that lead to the improvement of methods and techniques used in geomorphological mapping in the country, indicating the need to develop taxonomic systems that balance the standardization necessary for studies of national scope with the detailed representation of regional geomorphological characteristics, which is both comprehensive and sensitive to local variations, converging with the current efforts employed by the Brazilian geomorphological community in the formulation of the Brazilian Landform Classification System.

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