

# Grids & Datums

## FEDERATIVE REPUBLIC OF BRAZIL

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The northern coast of Brazil was explored by Vicente Pinzón, a Spaniard, in 1500 although theoretically already allotted to Portugal by the 1494 Treaty of Tordesillas. Brazil was not formally claimed by discovery until the Portuguese navigator Pedro Álvares Cabral accidentally touched there also in 1500. The native Indians spoke languages that scholars have classified into four families: the *Gê* speakers, originally spread along the coast and into the central plateau and scrub lands; the *Tupís* speakers, who displaced the *Gê* on the coast and hence were the first met by the Portuguese; the *Carib* speakers in the north and in Amazônia, who were related distantly to the people who gave their name to the Caribbean; the *Arawak* speakers in Amazônia, whose linguistic relatives ranged up through Central America to Florida; and, according to sociologist Donald Sawyer, the *Nambicuará* in northwestern Mato Grosso. Brazil's history prior to becoming an independent country in 1822 and a republic in 1889 is intertwined mainly with that of Portugal. Unlike the other viceroyalties of Latin America, which divided into twenty countries upon attaining independence, the Viceroyalty of Brazil became a single nation, with a single language transcending all diversities and regionalisms. Brazil is the only Portuguese-speaking Latin American country, and its Luso-Brazilian culture differs in subtle ways from the Hispanic heritage of most of its neighbors (*Library of Congress Country Studies*, 2008).

century, the *Instituto Geográfico e Geológico do Estado São Paulo* produced the first 1:100,000 scale base map of the nation. In 1909, the *Diretoria do Serviço Geográfico do Exército*, (Directorship of the Army Geographic Service), produced some 1:10,000 scale sheets, and in 1913 or 1914, terrestrial photogrammetry was first used in Brazil. In 1917, the *Serviço Geográfico Militar*, (Military Geographic Service) was founded. In 1922, the first map compiled using aerial photogrammetric procedures was published of the Distrito Federal (*Topographic Mapping of the Americas, Australia, and New Zealand*, M.A. Larsgaard, 1984).

The *Conselho Nacional de Geografia* (National Council of Geography) is responsible to the *Instituto Brasileiro de Geografia e Estatística* – *IBGE* (Brazilian Institute of Geography and Statistics). Founded in 1937, this civilian agency is the primary national source of public information and data on geodesy and mapping.

With such an enormous country and long history, there have been extensive surveys and mapping projects with concomitant grids and datums established in Brazil. According to **TM 5 – 248, Foreign Maps**, “In 1925 the Brazilian Government adopted the Hayford International ellipsoid of 1909 ( $a = 6,378,388$  m,  $1/f = 297$ . – Ed.). Prior to 1925 the Clarke spheroid of 1866 had been used ( $a = 6,378,206.4$  m,  $b = 6,356,583.8$  m. – Ed.).” In 1952,

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Brazil is bordered by Argentina 1,261 km (*PE&RS*, December 1999), Bolivia 3,423 km (*PE&RS*, July 2001), Colombia 1,644 km (*PE&RS*, November 1997), French Guiana 730 km (*PE&RS*, April 2003), Guyana 1,606 km (*PE&RS*, March 2006), Paraguay 1,365 km (*PE&RS*, December 2007), Peru 2,995 km (*PE&RS*, May 2006), Suriname 593 km (*PE&RS*, March 2002), Uruguay 1,068 km (*PE&RS*, November 2002), and Venezuela 2,200 km (*PE&RS*, December 2000). With a coastline of 7,491 km, the lowest point in Brazil is the Atlantic Ocean (0 m) and the highest point is Pico da Neblina (2993.78 m). Brazil is slightly smaller in area than the United States.

Three years after independence from Portugal, the *Comissão do Império do Brasil* (Imperial Commission of Brazil) was formed in 1825 – the first official mapping agency of the country and also of South America. Two state agencies appeared before the end of the century; the *Comissão Geológica do Estado do São Paulo*, (Geological Commission of the State of São Paulo), in 1866, and the *Comissão Geográfica e Geológica*, (Geographical and Geological Commission), the official mapping agency for the state of Minas Gerais in 1892. In the late 19<sup>th</sup>

a cooperative agreement was signed between the Brazilian Army and the U.S. Army Map Service and the Inter-American Geodetic Survey (IAGS). The following paragraph is a compilation of all known astronomical positions in Brazil, mostly published by the various Anuários of the *Diretoria do Serviço Geográfico do Exército*. Some of these may indeed represent small datums established for local city uses but are not generally considered major datums within the country.

The “Abrolhos Lighthouse” is approximately:  $\Phi_0 = -17^{\circ} 57' 32''$ S,  $\Lambda_0 = -38^{\circ} 38' 42''$ W, and is likely the origin for a local hydrographic survey. Located on Santa Bárbara Island and part of an archipelago, it is a popular tourist destination for viewing whales. The “Barreira do Monte 1941” origin is:  $\Phi_0 = -08^{\circ} 00' 31.1'' \pm 0.2''$  S,  $\Lambda_0 = -34^{\circ} 51' 15.2'' \pm 0.6''$ W, and is in the State of Pernambuco. The “Base Este do Forte de Coimbra 1945” origin is  $\Phi_0 = -19^{\circ} 55' 17.00''$ S,  $\Lambda_0 = -57^{\circ} 47' 33.75''$ W and is located on the Paraguay River in the State of Mato Grosso. The site of many historical battles dating from the 18<sup>th</sup> century, it maintains an artillery garrison to this day. The “B of Base Luis Correia” origin in the State of Piauí is approximately

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$\Phi_o = -02^\circ 53' 01''S$ ,  $\Lambda_o = -41^\circ 39' 58''W$ . The “Centro da Base Mato Grosso 1937” origin is:  $\Phi_o = -20^\circ 27' 01.7''S$ ,  $\Lambda_o = -54^\circ 38' 58.3''W$ , and  $H_o = 578.38$  m. The “Extremo B2 da Base da Fortaleza 1944” origin is:  $\Phi_o = -03^\circ 42' 31.4''S$ ,  $\Lambda_o = -38^\circ 34' 36.6''W$  and is located in the State of Ceará, a popular coastal destination of Brazilian tourists. The “Extremo S.E. da Base 1939” at point  $B_2$  origin is:  $\Phi_o = -21^\circ 42' 11.7''S$ ,  $\Lambda_o = -43^\circ 24' 55.4''W$ ,  $H_o = 68.50$  m, and is in the State of Minas Gerais. The islands of Fernando de Noronha are located 540 km off the Recife coast; the archipelago is made up of 19 islands, and only two of them are inhabited; the largest island has an area of 16.2 km<sup>2</sup>. There are a few versions about the discovery of the island; the most accepted version is that Italian navigator Américo Vespúcio came across Noronha in 1503, when at service of the Portuguese King, he commanded a fleet that explored the Brazilian coast. In past centuries, Fernando de Noronha was invaded by the Dutch, the French and the British, all wanting to establish a base in a strategic spot. In the 19th century, the island became a penal colony; during this period, the forests were cut down to prevent prisoners from using the trees to build boats and escape. More recently during the Brazilian Military Period, Noronha was used to isolate political prisoners. In 1942, Noronha

became a Federal Territory. After the Federal Constitution of 1988, Noronha was turned into a District of the State of Pernambuco. The origin is approximately  $\Phi_o = -03^\circ 54' 00''S$ ,  $\Lambda_o = -32^\circ 25' 00''W$ . The State capital of Ceará is Fortaleza, and the origin of “Fortaleza 1942” is at “Porta da Base” where:  $\Phi_o = -03^\circ 45' 46.7''S$ ,  $\Lambda_o = -38^\circ 31' 23.4''W$ . The “Grupo Escolar de Piquete 1926” origin point is located in the municipality of Guaratinguetá, São Paulo where:  $\Phi_o = -22^\circ 36' 58.10''S$ ,  $\Lambda_o = -45^\circ 10' 44.22''W$ ,  $H_o = 657.31$  m. “Itararé” is also located in São Paulo State and its approximate coordinates are:  $\Phi_o = -24^\circ 06' 45''S$ ,  $\Lambda_o = -49^\circ 19' 44''W$ ,  $H_o = 740$  m. “Leste N.E. Base” has similar coordinates as “Itararé” in that:  $\Phi_o = -24^\circ 06' 55''S$ ,  $\Lambda_o = -49^\circ 17' 55''W$ . The “Pico do Jaraguá” origin is located on the highest mountain in the city of São Paulo where:  $\Phi_o = -23^\circ 27' 08.054''S$ ,  $\Lambda_o = -46^\circ 45' 51.201''W$ . The “Extremo Nordeste da Base de Leste 1904” origin has its latitude listed as:  $\Phi_o = -30^\circ 20' 52.00''S$  and is located in Porto Alegre, the capital of the State of Rio Grande do Sul. The “Macuco 1946” origin in Minas Gerais State is:  $\Phi_o = -22^\circ 27' 03''S$ ,  $\Lambda_o = -44^\circ 26' 37''W$ ,  $H_o = 449.04$  m. “Observatório da Comissão 1906” at the point listed as Observatório da Comissão da Carta Geral do Brasil *Pillar in West Room* is:  $\Phi_o = -30^\circ 02' 14.885''S \pm 0.074''$ ,  $\Lambda_o = -51^\circ 13' 12.660''W \pm 0.36''$ , and

at the point listed as *Mark on the Terrace* is:  $\Phi_o = -30^\circ 02' 14.762''S \pm 0.07''$ ,  $\Lambda_o = -51^\circ 13' 12.660''W \pm 0.36''$  and has an azimuth to Cav-alhada as:  $\alpha_o = 38^\circ 40' 16.35'' \pm 0.35''$ , both being located in Pôrto Alegre. The “Observatório Nacional do Rio De Janeiro 1890” origin is:  $\Phi_o = -22^\circ 53' 42.15''S$ ,  $\Lambda_o = -43^\circ 13' 22.5''W$ ,  $H_o = 35.18$  m. “Pilar Astronômico 1926” origin north of Sorocaba, São Paulo is:  $\Phi_o = -23^\circ 25' 34''S$ ,  $\Lambda_o = -47^\circ 35' 44''W$ . “Pilar Astronômico de Ponta Grossa 1948” origin is listed as:  $\Phi_o = -25^\circ 11' 09''S$ ,  $\Lambda_o = -50^\circ 08' 37''W$ , but to my surprise I noticed the point is actually shown in *TM 5 – 248, Foreign Maps* on page 226! The scaled coordinates from that exemplar Brazilian map are:  $\phi_o = -25^\circ 11' 31.8''S$ ,  $\lambda_o = -50^\circ 08' 47.3''W$ , and the point is labeled “Datum,” with  $H_o = 794$  m. “Pilar do Forte 1937” origin is:  $\Phi_o = -22^\circ 22' 39''S$ ,  $\Lambda_o = -41^\circ 46' 14''W$ . In the city of Salvador, Bahia, the “Pronto Socorro 1937” origin is:  $\Phi_o = -12^\circ 59' 31.43''S$ ,  $\Lambda_o = -38^\circ 31' 34.95''W$ , and the azimuth from north to Hospício is:  $\alpha_o = 67^\circ 52' 47.20''$ . Located in the vicinity of Santa Vitória do Palmar, Rio Grande do Sul, “Sul S.O. Base 1912” (Extremo S.O.) origin is  $\Phi_o = -33^\circ 29' 25.85''S \pm 0.10''$ ,  $\Lambda_o = -53^\circ 19' 41.12''W \pm 0.33''$ . In the State of Santa Catarina, “Três Barras Extremo N.E. da Base 1952” at the Pilar N.E. da Base de Três Barras origin is:  $\Phi_o = -26^\circ 07' 46.0''S \pm 0.5''$ ,  $\Lambda_o = -50^\circ 18' 28.80''W \pm 0.53''$ ,  $H_o = 775.627$  m. In Rio Grande do Sul, the “Val de Serra 1947” origin is:  $\Phi_o = -29^\circ 28' 14.30''S \pm 0.03''$ ,  $\Lambda_o = -53^\circ 42' 03.27''W \pm 0.24''$ . Thanks to John W. Hager for all of these Astro stations!

The major geodetic datums found in Brazil include: Aratu Datum, Córrego Alegre Datum of 1949, Provisional South American Datum of 1956, South American Datum of 1969, SIRGAS and WGS84. The Córrego Alegre Datum of 1949 **original** origin coordinates are:  $\Phi_o = -19^\circ 50' 15.14''S$ ,  $\Lambda_o = -48^\circ 57' 42.75''W$ ,  $H_o = 683.81$  m, and azimuth to Chapada das Areias:  $\alpha_o = 128^\circ 21' 48.96''$ . The origin coordinates of Córrego Alegre **were later revised** to be:  $\Phi_o = -19^\circ 50' 14.91''S$ ,  $\Lambda_o = -48^\circ 57' 41.98''W$ , the defining azimuth was unchanged, and the components of the deflection of the vertical,  $\xi = \eta = 0$ , and the geoid height was constrained to zero ( $N = 0$  m). As stated previously, the ellipsoid of reference was the International Hayford 1924. According to *TR 8350.2*, the 3-parameter transformation values from Córrego Alegre Datum of 1949 to WGS84 are:  $\Delta X = -206$  m  $\pm 5$  m,  $\Delta Y = +172$  m  $\pm 3$  m,  $\Delta Z = -6$  m  $\pm 5$  m, and this is based on a 17-station solution. Two major grid systems were associated with the Córrego Alegre Datum of 1949, both being based on the Gauss-Conform Transverse Mercator projection. The 3° belt system started with Belt I at  $\lambda = -28^\circ 30'W$  and continued east to Belt XVI at  $\lambda = -73^\circ 30'W$ . No False Easting or False Northings were used and the Scale Factor at the Central Meridian was equal to unity. The 6° belt system started with Belt I at  $\lambda = -30^\circ W$  and continued east to Belt VIII at  $\lambda = -72^\circ W$ . The False Easting for each belt was 500 km at the Central Meridian, the False Northing was 5,000 km at the Equator, and the Scale Factor at the Central Meridian was 0.999333333. Note that Northing is X, and Easting is Y. On certain small scale maps Brazil uses the Rectangular Polyconic projection, primarily for their 1:1,000,000 International Map of the World Series. I have a copy of those projection tables in Portuguese given to me by my first cousin, Professor Daryl Domning of Howard University when he was doing research on Amazon River Manatees in Manaus during the 1970s. Also included are tables for the Lambert Conformal Conic projection with standard parallels at  $0^\circ 40'N$  and  $3^\circ 20'N$ , and the Polar Stereographic with standard parallels at  $76^\circ S$  and  $80^\circ S$ .

The Provisional South American Datum of 1956 (PSAD56)

origin is at La Canoa, Anzoátegui Province, Venezuela where:  $\Phi_o = +08^\circ 34' 17.170''N$ ,  $\Lambda_o = -63^\circ 51' 34.880''W$ , and the defining azimuth to station Pozo Hondo:  $\alpha_o = 40^\circ 22' 45.96''$ . The PSAD56 ellipsoid of reference is also the International 1924. Note however, that *TR 8350.2* does not list any datum transformation parameters for PSAD56 to WGS84 in the country of Brazil although it presumably has been used in the northern reaches of the Amazon Basin.

The astronomic origin coordinates of the South American Datum of 1969 (SAD69) at station Chuá are where:  $\Phi_o = -19^\circ 45' 41.34''S \pm 0.05''$ ,  $\Lambda_o = -48^\circ 06' 07.80''W \pm 0.08''$ , and the astronomic azimuth to Uberaba:  $\alpha_o = 271^\circ 30' 05.42''$ . The corresponding adjusted geodetic coordinates of Chuá are:  $\phi_o = -19^\circ 45' 41.6527''S$ ,  $\lambda_o = -48^\circ 06' 04.0639''W$ ,  $H_o = 763.28$  m, and the geodetic azimuth to Uberaba:  $\alpha_o = 271^\circ 30' 04.05''$ . The components of the deflection of the vertical,  $\xi = +0.31''$ ,  $\eta = -3.52''$ , and the geoid height was constrained to zero ( $N = 0$  m). The SAD69 ellipsoid of reference is the International 1967 where:  $a = 6,378,160$  m, and  $1/f_j = 298.25$ . According to *Resolução da Presidência da República nº 23, de 21/02/1989*, the following official Brazilian National transformation parameters are from SAD69 to WGS84:  $\Delta X = -66.87$  m  $\pm 0.43$  m,  $\Delta Y = +4.37$  m  $\pm 0.44$  m,  $\Delta Z = -38.52$  m  $\pm 0.40$  m. By altering the characterization of the Brazilian Geodetic System and according to *Resolução da Presidência da República nº 24, de 25/02/2005*, the following official Brazilian National transformation parameters are from SAD69 to SIRGAS2000:  $\Delta X = -67.35$  m,  $\Delta Y = +3.88$  m,  $\Delta Z = -38.22$  m. Note that the GRS80 ellipsoid parameters are:  $a = 6,378,137$  m, and  $1/f_j = 298.257222101$ .

The Aratu Datum to WGS84 mean three-parameter transformation is:  $\Delta X = -158$ m,  $\Delta Y = +315$ m,  $\Delta Z = -148$ m, however there are numerous variants used in the offshore basins by Petrobras as well as by various oil company producers, according to the current *EPSG Database, version 6.18*. Brazil now uses the UTM Grid on their current map sheets.



The contents of this column reflect the views of the author, who is responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the American Society for Photogrammetry and Remote Sensing and/or the Louisiana State University Center for Geoinformatics (C<sup>4</sup>G).