SIMPOSIO SIRGAS 2021

Del 29 de noviembre al 01 de diciembre de 2021

Evaluation of Global Geopotential Models in Brazilian Coastal Zones

Jayne Gambarine Soares[1]; Tulio Alves Santana[2]; Samoel Giehl[3]; Regiane Dalazoana[4]
[1] Federal University of Uberlândia, Monte Carmelo, Brazil
[2,3,4] Federal University of Paraná, Curitiba, Brazil
[2] Federal Institute of Mato Grosso, Cuiabá, Brazil

Abstract

Research in coastal zones meets the purposes of Geodesy that aims to contribute to the monitoring of variations in the Earth system and the future perspectives of this field, through the conception of the Global Geodetic Observing System (GGOS) and the establishment of the International Height Reference Frame (IHRF). This research seeks to evaluate Global Geopotential Models (GGMs) in Brazilian coastal zones to investigate the behavior of these models in these regions and collaborate with the discussions about the unification of ocean and terrestrial vertical reference, beyond the establishment of IHRF. After delimiting the study area, based on comparisons between global models and local observations of the functional height anomaly of 550 geodetic stations, it was possible to find results that indicate the GGMs that best suit the Brazilian coastal zones. 13 (thirteen) models were selected, using four categories to analyze them, such as: models of the maximum degree of development; the second as the highest degree of development (1420 to 2190); the third as the medium degree of development (up to 720); and the fourth as the lowest degree of development (up to 360). The models that presented the best results were XGM2019e_2159 in the first three categories and GGM05C in the fourth category with models of development up to the degree 360.

Introduction

Over the years, the release of different missions to model the gravity field provided a bigger set of geodetic terrestrial observations and allied to the development of computer science, enabled the estimation of hundreds of Earth models: Global Geopotential Models (GGMs). A GGM is a mathematical approximation to the external gravitational potential of an attractive body, and in this case, the Earth is the body that provokes attraction. (BARTHELMES; INCE; REIBLAND, 2017). Several authors performed research aiming to evaluate the behavior of GGMs in Brazilian regions or the country. This research was based on the relative or absolute evaluation considering geodetic stations that had heights referred to the ellipsoid and the (quasi) geoid simultaneously, that is, evaluation of GNSS (GPS)/Leveling. In this study, it is sought to work with evaluation of global data of GGMs concerning local observations that compose the Brazilian Geodetic System (*Sistema Geodésico Brasileiro* – SGB), from analysis of functional of the gravity field in coastal zones.

Area of Study

The area of study of this research is the Brazilian coastal zone, which was delimited in a radius of 210 km from the Brazilian coastal line. In this region it is possible to find 550 stations of SGB that have a connection between the data of GNSS surveys (with ellipsoidal height) and spirit leveling (with normal height), that is, the stations are a part of two SGB networks: planialtimetric and vertical. Based on the data of the Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística* – IBGE), the 550 stations were visited between the years 1995-2020. These visits consist of an inspection of the geodetic landmarks whose situation and date of visit are included in the station's report.

Figure 1 – Location of the area of study Brazilian Coastal Zone

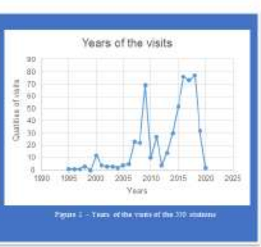

Figure 2 – Years of the visits of the 5?0 stations

Material and Methods

All data from the stations was obtained in the Geodetic Database (*Banco de Dados Geodésicos* – BDG) from IBGE, in vectorial files. The GGMs were extracted from ICGEM (International Center for Global Gravity Field Models). The criteria to select the models considered the results from GNSS (GPS)/Leveling evaluations in the Brazilian territory released by ICGEM, besides the degree of development of the models. It were selected the GGMs with development degree bigger than 300 and RMSE (Root Mean Square Error) smaller than 50 cm. 13 (thirteen) models fit these criteria, among which 8 models have the maximum degree over 1420, 10 the maximum degree over 720, and 2 the maximum degree over 359. The models are: XGM2019e_2159, XGM2016, EIGEN-6C2, GOCO05c, SGG-UGM-1, EIGEN-6C4, EIGEN-6C3stat, EIGEN-6C, GECO, EGM2008, GGM05C, GIF48 and EIGEN-51C. The evaluation by GNSS (GPS)/Leveling can be accomplished using two methods, the absolute and the relative (NICACIO; DALAZOANA, 2018). The absolute method used in this study is established with the direct application of the equation that combines the height, over the surfaces of the quasi-geoid (H^N – Normal Height) and the ellipsoid (h - ellipsoidal Height), and the separation given by the height anomaly (ζ) (GEMAEL, 1999). In this study, information on latitude, longitude, ellipsoidal and normal height of each station was obtained in BDG of IBGE, and the information regarding the height anomaly ($\zeta^{from\ model}$) of the stations was accomplished through the ICGEM calculation service. In the ICGEM service, some definitions are necessary for the functional calculation of the gravity field, such as: coordinates of the points to be calculated; the reference GGM; the desired functional; the degree of development of the model; the reference geodetic system; the tide permanent reference system and the application or not of the term of order zero. For a correct analysis of the results, the permanent tide system in which the data are linked must be compatible, for this reason, it was chosen to adopt the system of mean tide considering the international recommendations for the establishment of the IHRS (IAG, 2015) and GRS80 as the reference ellipsoid. After making all data compatible in the same permanent tide system, the height anomalies (ζ) for the stations were calculated and compared to the values obtained for the 550 stations by ICGEM. From the values of RMSE and standard deviation the 13 GGMs were analyzed.

$$h_{mean-tide} = h_{tide-free} - (1 + k - l)[-0{,}198(\frac{3}{2}\, sen^2\Psi - \frac{1}{2})]$$

Equation of conversion between tide systems

$$\zeta^{calculated}{}_{P} \approx h_P - H^N{}_P$$

Equation of height anomaly

Results

To discuss the results, the GGMs were divided into four categories: the first one considered the models with maximum development degree; the second one considered the highest development degree (1420 to 2190); the third one considered medium development degree (up to 720); and the fourth considered the lowest development degree (up to 360).

GGM05C model (degree 360) presented the lowest RSME (0.582 m) and standard deviation of 0.437 m. Model XGM2019e_2159 (2190), presented RSME of 0.586 m, slightly bigger, although it has the smallest standard deviation, 0.393 m (fig. 3).

When analyzing the development degree between 1420 and 2190, model XGM2019e_2159 is highlighted: it presented the smallest RSME and the smallest standard deviation (fig. 4).

For the development degree up to 720, both had the same RSME value, XGM2019e_2159 and EGM2008, with 0.586 m. Although, it was noted that the standard deviation of the EGM2008 model is bigger when compared to XGM2019e_2159. XGM2019e_2159 presents RSME of 0.398m while EGM2008 has a RSME of 0.425 m (fig. 5). Finally, when analyzing the development degree up to 360, the smallest RSME value, EGM208 and GGM05C with 0.582 m. Considering the standard deviation of GGM05C and EGM2008 models, of 0.437 m and 0.450 m, respectively, it is noted that the most indicated model for studies with this degree is GGM05C due to its smaller error dispersion (fig. 6).

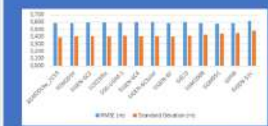

Figure 3 - GGMs RMSE and Standard Deviation with development degree between 359 and 2190

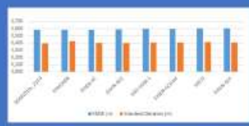

Figure 4 - GGMs RMSE and Standard Deviation with development degree between 1420 and 2190

Figure 5 - GGMs RMSE and Standard Deviation with development degree up to 720

Figure 6 - GGMs RMSE and Standard Deviation with development degree up to 360

Final Considerations

Based on the results reached in each category, the models that are the most efficient were XGM2019e_2159 (in three categories) and GGM05C (in one category).

Model	Maximum Degree	RMSE	Std. deviation
XGM2019e_2159	2159	0,586	0,393
GGM05C	360	0,582	0,437

References