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Software G Search: a tool for access to gravimetric database in Rio Grande do Sul state, Brazil

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Abstract Summary.

Gravimetric data of Rio Grande do Sul state, are currently available, dispersed, and in different databases across various institutions.,The study aims to unify this information into a single source accessible through a software developed in Python. Thus, geodesic stations containing absolute gravity data from IBGE, DNPM, Petrobras, IG/UFRGS, UFPR, and IAG/USP were integrated, covering, besides Bouguer and Free-Air anomalies, absolute gravity values, and georeferenced data. The procedures and work steps included, analysis of data consistency, data validation, linear interpolation, and segmentation using the Fast Fourier Transform (1D FFT) to separate regional and residual anomalies. The software, *G Search*, currently is in its testing phase, and its preliminary results offers a generateds topographic and Bouguer anomaly maps with interactive visualization, optimizing queries and analyses. This software provides a valuable tool facilitating geological, environmental, and urban planning studies. Follow-ups will incorporate different data sources from past and current studies in the region (LGA/Unipampa), enhancing spatial resolution for the user. Further adjustments are still needed to improve the interface and data accuracy.

Introduction

Geophysical studies employing gravimetric methods both terrestrial and airborne are widely used in crustal investigations, geological research (exploratory and academic), and shallow geophysics (including geotechnics, environmental studies, and archaeology). In Brazil, the state of Rio Grande do Sul hosts multiple gravimetric stations with records of gravity anomaly values and absolute gravity (G) measurements (Geodetic Stations). These stations have been established by organizations and academic/research institutions, including the *IBGE* (Brazilian Institute of Geography and Statistics), *DNPM* (National Department of Mineral Production), *Petrobras*, *IG/UFRGS* (Institute of Geosciences at the Federal University of Rio Grande do Sul), *UFPR* (Federal University of Paraná), and *IAG/USP* (Institute of Astronomy, Geophysics, and Atmospheric Sciences at the University of São Paulo).

Although these stations provide valuable regional data, these measurements are sparse. Therefore additional gravimetric measurements are required for detailed and semi-detailed investigations. To meet this need, *Base Gravimetric Stations* play a crucial role in reducing the relative values acquired by gravimeters during field campaigns. However, for geoscientists the primary users of these datasets—data integration poses significant challenges. The information is often scattered across various platforms, and inconsistencies in formatting, missing metadata (e.g., absolute G values, coordinates, altitude), and incomplete records hinder efficient compilation and practical application in surveys. As a result, users are frequently compelled to "reconstruct" base stations from fragmented data, which can compromise the reliability and applicability of the method.

In light of these challenges, this study aims to consolidate all gravimetric data available for Rio Grande do Sul into a unified, centralized database using specialized software. Specifically, the project focused on developing a Python-based tool designed to facilitate fast and efficient access to gravimetric station data, including georeferencing and other critical parameters.

The integration of this information into a single database is expected to significantly enhance operational efficiency and provide essential support for researchers and professionals. It will also enable broader distribution and more effective use of the data by streamlining access, promoting standardization, and facilitating geospatial analyses within a Geographic Information System (GIS). Ultimately, this centralized system will improve the application of gravimetric methods in Rio Grande do Sul, supporting advanced research and informed decision-making in fields such as geology, environmental management, and infrastructure planning. It will foster seamless collaboration, reduce redundancy, and empower stakeholders to leverage high-quality, standardized data for innovative solutions.

Materials and methods

The execution of this study involved the following steps:

i) Compilation and integration of gravimetric databases from the state of Rio Grande do Sul: The study area is bounded by the geographic coordinates 27°S to 34°S latitude and 49°W to 58°W longitude, as illustrated in Figure 1.

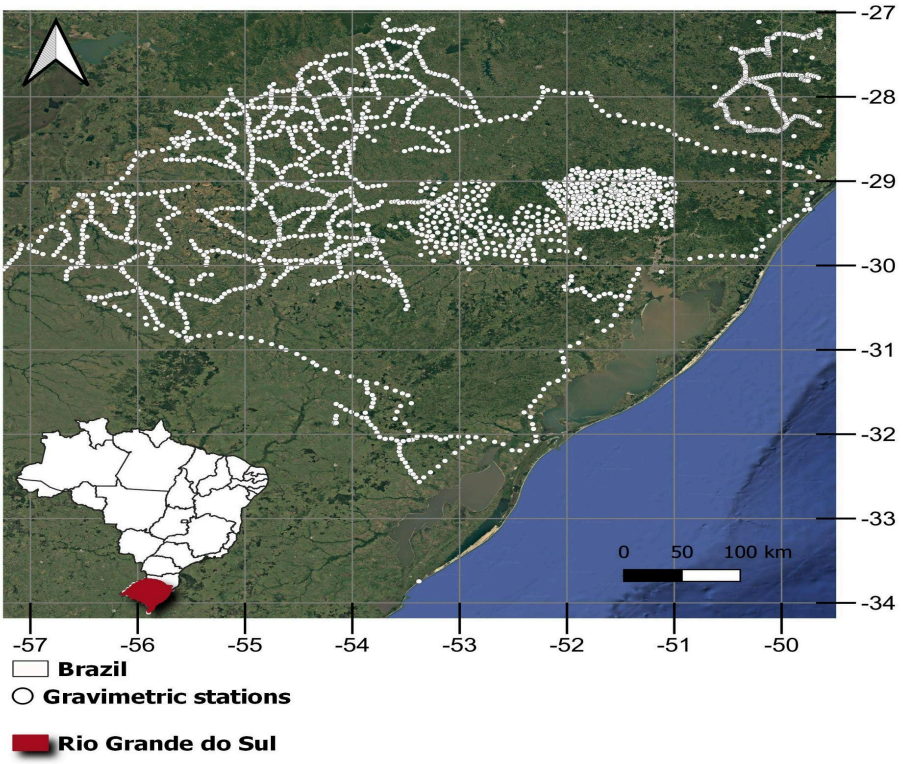

Figure 1. Gravimetric stations location and distribution map in the Rio Grande do Sul state.

The georeferenced Bouguer and Free-Air anomaly values used in this research are publicly available and were obtained from multiple sources, including the National Gravimetric Database (BDNG), the Brazilian Institute of Geography and Statistics (IBGE), the National Department of Mineral Production (DNPM), Petrobras, the Institute of Geosciences at the Federal University of Rio Grande do Sul (IG/UFRGS), the Federal University of Paraná (UFPR), and the Institute of Astronomy, Geophysics and Atmospheric Sciences at the University of São Paulo (IAG/USP).
ii) Validation and consistency analysis of the data, which involved a detailed review of the datasets from different institutions: This process included verifying the consistency of Bouguer and Free-Air anomaly values, absolute gravity (G), and georeferencing information.

iii) Integration of the unified database into software developed in Python: For the processing and analysis of the gravimetric data, linear interpolation was chosen due to its simplicity and computational efficiency, although other techniques could have been employed. After constructing the Complete Bouguer Anomaly (CBA) map, the dataset was segmented for spectral analysis using the one-dimensional Fast Fourier Transform (1D FFT). The segmentation was carried out over specific intervals to isolate both regional and residual anomalies.

The FFT was used to compute amplitude (A) and wavenumber (k) values. These were then plotted to distinguish between different types of anomalies. Inflection points—where the anomaly trends change—were identified, and linear regression lines were fitted to each trend. From the regression parameters, the cutoff frequency and bandwidth were calculated, which were subsequently used to filter the anomalies. Regional and residual anomalies were then extracted and visualized.

The compilation and analysis of data from diverse sources posed a significant challenge due to varying formats and organizational structures. This heterogeneity was addressed by standardizing the datasets, converting them into a unified map, and applying segmentation techniques for spectral analysis. The implementation of 1D FFT proved effective in identifying key anomalies, contributing to a better understanding of the geological framework of the region.

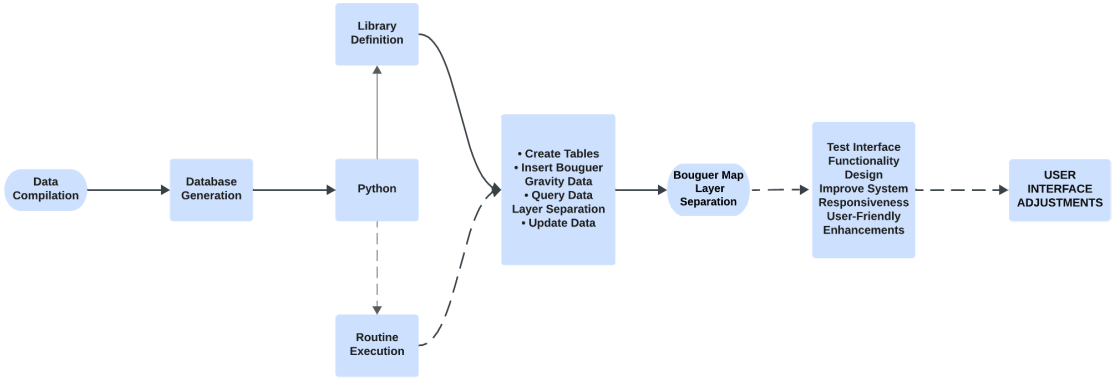

Figure 2. Activities steps flow adopted for the development of this work.

Results

The software developed in this study provides a robust tool for integrated geophysical analysis, combining advanced technical visualizations with a user-friendly interface. By processing georeferenced gravimetric data, the system generates two key outputs: an interpolated topographic map and a Bouguer anomaly map scaled for seismic interpretation—both of which are essential for identifying subsurface density variations.The graphical interface organizes the outputs across different tabs and includes a histogram of elevation distribution to support statistical analysis. Interpolation is performed using the cubic method (*griddata*), which produces smooth and continuous surface representations. In addition, the system incorporates automatic geolocation, enabling data filtering based on proximity to urban centers.

This tool is particularly valuable for recognizing geological patterns and supports applications in urban planning and environmental studies. It delivers a professional, interactive, and efficient

representation of complex geophysical datasets, making it accessible even to non-specialist users. An example of the software's output is presented in Figure 3.

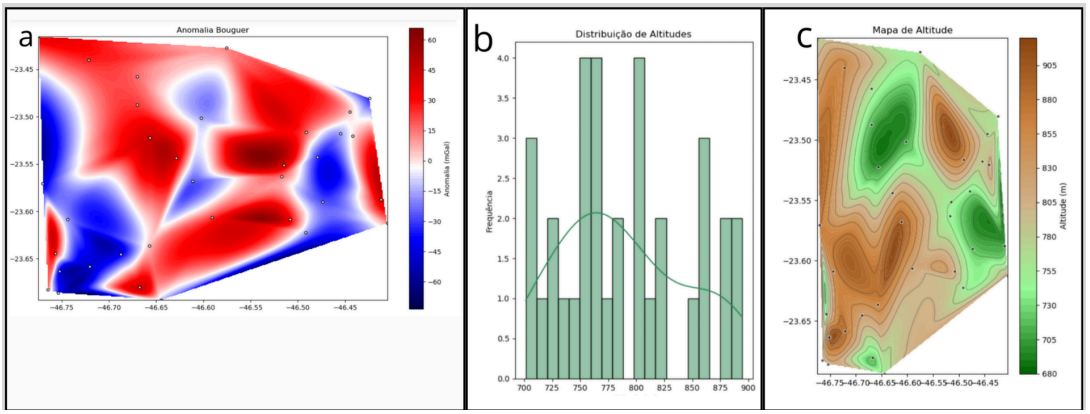

Figure 3: Results visualizations generated by the user search into the currently software:(a) Bouguer anomaly map, (b) histogram of elevation distribution and (c) interpolated topographic map.

Conclusions

In its current phase, the G Search software has demonstrated its value as an essential tool for accessing and consulting gravimetric data in the state of Rio Grande do Sul. It contributes both to regional studies—such as the acquisition and validation of gravimetric stations—and to the use, implementation, or relocation of Base Stations.Future developments include the planned integration of studies and data acquired in the region by the Applied Geophysics Laboratory of Unipampa (LGA/Unipampa), which will enhance the spatial resolution of gravimetric anomaly maps in the region and support more detailed geological investigations.G Search facilitates the organization and compilation of gravimetric datasets, optimizing the time required for data processing and improving the efficiency of both fieldwork and academic research.

Although the interface has undergone improvements, further refinements are needed regarding data precision, the quality of graphical representations (e.g., color schemes and scale settings), and the accessibility of commands. Continued development and user feedback will be essential for increasing the tool's reliability and usability in geophysical studies.

References

MCKINNEY, 2018. Wes. Python para análise de dados: Tratamento de dados com Pandas, NumPy e IPython. Novatec Editora, 588 p.

TELFORD, William Murray, 1990. GELDART, Lloyd P.; SHERIFF, Robert E. **Applied geophysics**. Cambridge university press, 748 p.

IBGE. Banco de Dados Geodésicos. Disponível em: BDG (ibge.gov.br). Acesso em: 15 de agosto de 2023.

BNDG - Banco Nacional de Dados Gravimétricos — Agência Nacional do Petróleo, Gás Natural e Biocombustíveis (www.gov.br). acesso em: 15 de agosto 2023.