

International Gravimetric Bureau

Bureau Gravimétrique International (BGI)



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<http://bgi.obs-mip.fr>

Terms of Reference

Overview

The Bureau Gravimétrique International (BGI) has been created in 1951 as a scientific service of IAG during the IUGG (International Union in Geophysics and Geodesy) General Assembly for ensuring the collection, validation and archiving of all gravity measurements acquired at the Earth's surface and their distribution to scientific users. The technological and scientific evolutions which occurred over the following decades in the area of gravimetry (improvements in field, airborne and seaborne gravity meters, development of absolute gravity meters, space gravity missions, etc.) provided significant increases of the number, diversity and accuracy of the gravity field observables. Following these evolutions, BGI has contributed to provide original databases and services (products, documentation, tutorials, software...) for a wide international community concerned by the studies of the Earth gravity field. The strategic plan for period 2019-2023 will maintain this objective, ensuring a long term usability and sustainability of the highest-quality of gravity data.

BGI is an official service of the International Association of Geodesy (IAG) and is coordinated with others IAG services (IGeS, ICGEM, IDEMS, IGETS) by the International Gravity Field Service (IGFS). It also directly contributes within IAG to the activities of Commission 2 "Gravity Field" and Global Geodetic Observing System (GGOS). It is recognized by the International Council for Science (ICSU) successively as one of the services of the Federation of Astronomical and Geophysical Services (FAGS) and of the World Data System (WDS).

BGI has its central bureau in Toulouse, France (GET/OMP) and operates with the support of various French agencies (CNES, CNRS/INSU, IGN, IRD, SHOM,

BRGM, IFREMER) and Universities (Toulouse, Paris, Strasbourg, Montpellier, Brest, Le Mans). BGI services also benefits from the close collaboration of other agencies from Germany (BKG), Italy (POLIMI), Greece (AUTH), Czech Republic (VÜGTK), Denmark (DTU) and USA (NGA).

Missions and objectives

The primary task of BGI is to improve the global knowledge of the Earth's gravity field through the collection, homogenization and validation of all available gravity measurements (relative or absolute) and make this information available to a large variety of users for scientific applications. With this aim, BGI holds and maintains for IAG the fundamental global databases of relative and absolute static gravity measurements and develops services to serve the scientific community. The most current services provided by BGI include:

- The supply of gravity data, reference stations, products, software and documentation.
- The validation and the archiving of gravity dataset and products provided to BGI and the attribution to data providers of a traceable international reference through a Digital Object Identifier (DOI).
- The realization and/or evaluation of global models (Earth Geopotential Model, World Gravity Map for instance) as well as regional data compilations carried out for gravity or geoid studies.

BGI also actively contributes to the definition of protocols, practices and recommendations aimed at improving the gravity data acquisition and processing and the realization of gravity surveys and networks. BGI is more specifically involved in the following actions:

- The definition and establishment of the “International Gravity Reference System & Frame (IGRS/IGRF)” promoted through the IAG Joint Working Group 2.1.1.
- The evaluation of new sensors for measuring absolute gravity (cold-atom absolute gravity meters).
- The support to the realization of national absolute gravity networks.

Finally, BGI also contributes with his collaborators to other research and development activities (software developments, research in geophysics and geodesy, etc.), to educational activities in gravimetry (summer schools, tutorials, etc.).

Product and services

Global databases of land and marine gravity data

The databases of relative measurements contain over 12 million of observations compiled and computerized mostly from land and marine gravity surveys. They have been extensively used for the definition of Earth gravity field models and for many applications in geodesy, satellite orbit computation, oceanography, geophysics, etc. They provide today the most precise information available on the Earth gravity field at short wavelengths complementary to airborne and satellite gravity measurements.

Global database of absolute gravity data

The database for absolute gravity measurements was set up in 2008 in cooperation between BGI and BKG (Bundesamt für Kartographie und Geodäsie, Germany) for collecting all available information on absolute gravity measurements acquired on Earth and for ensuring storage and long term availability of gravity data and processing details. It provides today the most complete information on existing absolute gravity stations and measurements (raw or processed data, description of stations, instruments, involved institutions, contacts, etc.). The database (AGrav) can be accessed by a web based interface which provides publicly available meta-data as well as complete datasets for community of users contributing to the archive. A simple exchange format was selected which includes all relevant information and is known by the majority of users avoiding additional effort. In this way the upload of absolute gravity data to the database can be done by the owner institutions, using a web based upload form.

Global database of gravity reference stations

Reference gravity stations established and connected to the former IGSN71 and Potsdam reference systems have been previously collected and archived at BGI. For several decades, these stations have provided the only available information on absolute gravity value for tying local or regional

relative gravity surveys (terrestrial, marine, airborne) in a global reference frame. Even if a significant number of reference stations should have disappeared with time, this original IGSN71 database remains accessible and is still used in some countries for calibration of relative surveys. This global gravity reference network will be advantageously replaced by the International Gravity Reference System & Frame (IGRS/IGRF) based on the increasing network of actual absolute gravity measurements and made available from the above mentioned AGrav database.

Global or regional gravity grids and models

BGI also contributes to the realization of derived gravity products aimed at supporting studies of the Earth gravity field at global or regional scales. The products mostly used by scientific users are the digital global grids from the World Gravity Map (WGM) which represent the first gravity anomalies (Bouguer, isostatic and surface free-air anomalies) computed in spherical geometry taking into account a realistic Earth model (see Figure 1). They include 1 minute resolution terrain corrections computed from the contribution of most surface masses (atmosphere, land, oceans, inland seas, lakes, ice caps and ice shelves). The World Gravity Map is also available as a set of 3 global maps realized for the Commission for the Geological Map of the World (CGMW), UNESCO, International Union of Geodesy and Geophysics (IUGG) and International Union of Geological Sciences (IUGS). Maps available at: <http://ccgm.org/en/16-catalogue>. Other global or regional gravity models and products computed from other contributors may also be made available from the BGI website (contact BGI).

Other services

- Online tools for prediction gravity at a given site.
- Tools and software for data acquisition or validation
- Attribution of DOI (Digital Object Identifier) for relative and absolute gravity data set, products or software provided by contributors.

Key activities

Database & services

The current activities at BGI are mostly dedicated to consolidate and validate the IAG global gravity databases (relative and absolute measurements) and to develop pertinent and updated products and services for supporting long term sustainability and usability of gravity data for scientific purposes.

A new BGI website (to be achieved in 2020) will provide new services and information to both users and contributors. Among the new functionalities, it will include:

- a new version of the user interface for the Absolute gravity database (AGrav) providing improved functionalities and links between BGI and IGETS observations,
- a new version of the user interface for the Reference stations (former IGSN71 network),
- a DOI searching tool for identifying gravity sources in a given area.

Automatic procedures have been designed recently to assign an DOI reference number to any dataset archived in the BGI databases (either from recent or old gravity surveys). National agencies contributing in the acquisition or compilation of gravity measurements (from field, marine or airborne surveys) are thus encouraged to archive their data in a such way in order to update the data coverage and accuracy for each country or region and to better improve the recognition of their contribution in a global frame through the assignment of a DOI. New products are also currently under development at BGI for updating global or regional gravity products (maps and grids) for educational and research purposes.

Support for global gravity products, standards & networks

BGI contributes within IAG, and its components IGFS, GGOS and Commission 2 “Gravity Field”, to several activities and Joint Working Groups aimed at improving the global knowledge and accuracy of the Earth gravity. It currently mostly brings its expertise and databases to the following projects:

IAG Joint Working Group 2.2.1 “Establishment of a global absolute gravity reference system”

This IAG Joint Working Group, launched during decade 2010 and chaired by H. Wziontek (BKG) and S. Bonvalot (BGI), aims at providing an accurate, homogeneous and long-term gravity reference at global scale based on absolute gravity observations. This project which leads to the definition and set-up of a new International Gravity Reference System & Frame (IGRS/IGRF) has within his objectives : (i) The establishment of a global network of core and reference stations where the gravity can be monitored continuously at the microGal level (10^{-8} m.s⁻²) using the state-of-the-art of absolute gravity meters (corner cube or cold-atoms) and possibly in collocation with other geodetic tech-

niques at GGOS Core stations ; (ii) The long-term traceability of the gravity measurements through international inter-comparisons of absolute gravity meters ; (iii) The replacement of the former IGNS71 network by a modern network based on laboratory and field measurements of the absolute gravity. See Wilmes et al. (2016) and Wziontek et al. (2020) for more details.

IAG Joint Working Group 2.1.2 “Unified formats and processing software for high-precision gravimetry”

IAG Joint Working Group 2.2: “Validation of combined gravity model EGM2020”

Evaluation of new gravity sensors

BGI is involved in the evaluation of new gravity sensors such as those based on cold-atom technologies (Pereira et Bonvalot, 2016). It has accompanied the evaluation of the first commercial Absolute Quantum Gravimeter (AQG) developed by MuQuans company (France). It has also participated to the evaluation of a first hybrid absolute gravity meter (composed of accelerometers and cold atom sensor) designed by ONERA (France) for moving platform (shipborne or airborne). An airborne absolute gravity survey, including flights over sea and mountainous areas, has been carried out successfully in France for assessing and comparing the performances and accuracy of this novel instrument with other conventional airborne relative gravity meters and with ground surface marine and land gravity data (study in process). This activity also directly contributes to the new IAG Working Group “Novel Sensors and Quantum Technology for Geodesy (QuGe)” and more specifically to its sub-working group “Quantum gravimetry in space and ground”.

Contribution to gravity surveys & networks

BGI associated research teams also contribute to the realization of gravity surveys and networks in the frame of national or international research projects with national agencies on the French territory or on other continents.

Other contributions

- Contribution to Newton’s Bulletin: BGI contributes jointly with the International Service for Geoid (ISG) to the edition of this Bulletin which publish technical papers on gravity data acquisition and processing.
- Contribution to International summer schools on gravity or geoid in collaboration with ISG and IGFS.

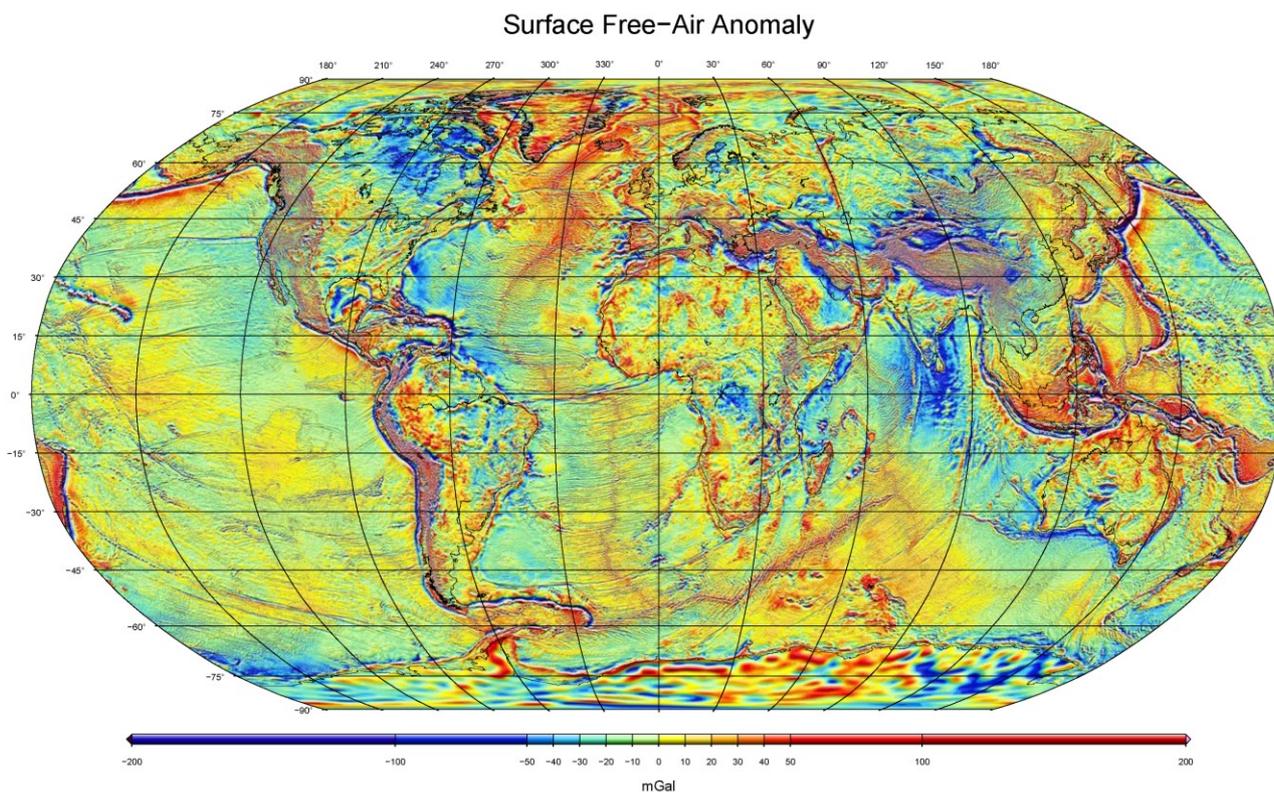


Fig. 1: Example of downloadable gravity product: 2 minutes global grid from the World Gravity Map (source BGI)

Users & contributors information

General terms of use

Data, products or software available at BGI are mostly dedicated to support scientific and academic activities. Digital gravity data or products are distributed free of charge to research or academic institutions or to data contributors according to the conditions given below. Other users, individual or private companies, are invited to specify in their request the expected use of the data and products. See BGI website for diffusion and charging policies.

- Access to non-confidential or non-proprietary relative gravity measurements is provided free of charge to public institutions or data contributors over geographic areas limited to $20^{\circ} \times 20^{\circ}$ or on the base of a maximum number of 10000 data points (land data) and/or 100000 data points (marine data). Retrieval of full data coverage for a whole country is not included in that case. All other requests (for larger datasets, for extended geographic area or for a whole country) as well as massive data retrieval will be subject to an evaluation by BGI who might require a specific protocol of use of the data or ask authorization of the proprietary Institutions. Charges might be applied.

- Access to the Absolute gravity database is provided free of charge. Database consultation and retrieval is done through the Web interfaces at BGI and BKG mirror sites. Confidential data or proprietary data may appear with restricted information (metadata only).
- Access to the Reference gravity stations database (IGSN71 network) is provided free of charge. Note that reference gravity stations (especially those determined and described decades ago) may have been destroyed or modified.
- Access to other additional services is also provided free of charge: global or regional gravity anomaly grids, Prediction of gravity value on Earth, Software, Documentation, etc.

Users of BGI data are invited to make reference to the specific DOI (Digital Object Identifier) provided by BGI along with the distributed data for each query.

Archiving and referencing data to BGI

The contribution of countries, agencies and scientists involved in surface gravity data acquisition (relative or absolute measurements from field, marine or airborne surveys) is essential for improving the global coverage and accuracy

of the Earth gravity field and for contributing to the determination of the new International Gravity Reference Frame (IGRF). The archiving of such incoming gravity sets also enables BGI to better validate the gravity observations in a global reference frame and restore them in standard and unified formats useful for the end users.

Contributors interested in archiving their gravity observations or derived products as non-confidential or as proprietary data (to be defined by the contributors themselves) are invited to contact BGI. A **Digital Object Identifier (DOI)** will be delivered to any institution or author for archiving their own dataset resulting from gravity survey or gravity data compilation. This new service aims at ensuring a proper reference and recognition to the authors and institutions who have acquired or compiled gravity data and a better traceability of improvements in the global gravity data coverage from local or regional surveys. DOI attribution may be also extended to relevant software for gravimetric applications (data processing or modeling) or other related information (maps, grids, reports).

- Contributors with data from land, marine or airborne surveys are invited to contact BGI (bgi@cnes.fr). ASCII data files containing all necessary information and quantities are preferred (station coordinates, gravity measurements and accuracies; gravity corrections; reference geographic, height and gravity systems, etc.).
- Contributors with data from corner cube or cold-atom absolute gravity measurements are invited to contact either BGI (bgi@cnes.fr) or BKG (agrav@bkg.bund.de). Both laboratories and field measurements are welcome to contribute as parts of the reference and core station and of the national infrastructures building the new International Gravity Reference System & Frame.

For any contribution (relative or absolute gravity data), it is reminded that BGI will keep the status of diffusion (with or without restrictions of redistribution) as specified by the proprietary institution.

Structure and membership

Since 2003, BGI is one of the services of the International Gravity Field Service (IGFS) which coordinates within the IAG, the servicing of the geodetic and geophysical community with gravity field-related data, software and information.

The BGI central office (management, secretariat and technical staff) is located in Toulouse, France, in the premises of the Observatoire Midi-Pyrénées. Since 1998, BGI is supported by French agencies and works in close collaborations with universities and research teams involved in gravimetry and geodesy (see list below):

- Centre National d'Etudes Spatiales (CNES)
- Bureau de Recherches Géologiques et Minières (BRGM)
- Centre National de la Recherche Scientifique (CNRS)
- Institut National des Sciences de l'Univers (INSU)
- Institut National de l'Information Géographique et Forestière (IGN)
- Institut de Recherche pour le Développement (IRD)
- Service Hydrographique et Océanographique de la Marine (SHOM)
- Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER)
- Institut de Physique du Globe de Paris (IPGP)
- Ecole et Observatoire des Sciences de la Terre (EOST)
- Ecole Supérieure des Géomètres et Topographes (ESGT)
- Université de Toulouse (GET/OMP)
- Université de Montpellier (Géosciences Montpellier)
- Université de Brest (Géosciences Océan)

It also contribute in France to research groups and networks such as Groupe de Recherches en Géodésie Spatiale (GRGS), Réseau Sismologique et Géodésique Français (RESIF), Pôle de données Système Terre (DataTerra/Form@Ter).

Each supporting organization has a representative member in the BGI Advisory Board. The Advisory Board (who also includes a representative member of IAG) contributes once a year to the orientation and evaluation of the BGI activities. The program of BGI activities is also evaluated and discussed by the IGFS Advisory Board at each IGFS meetings and IUGG General Assemblies. A partnership has been also established between BGI and the Federal Agency for Cartography and Geodesy (BKG), Germany, for the realization and the maintenance of the global database of absolute gravity measurements (AGrav) and with the Research Institute of Geodesy, Topography and Cartography (VUGTK), Czech Republic for metrology applications.

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