

Commission 2 - Gravity Field

web: www.ceegs.ohio-state.edu/iag-commission2

President: **Christopher Jekeli** (USA)

Vice President: **Ilias Tziavos** (Greece)

Terms of Reference and Objectives

Knowledge of the gravity field in space and its temporal variations is of prime importance for geodesy, navigation, geophysics, geodynamics, and related disciplines. Efficient and accurate modeling of the field spans a broad spectrum of activities that utilize data from ground, airborne, and satellite systems. An important subset of these modeling efforts includes the precise determination of the geoid for applications ranging from traditional height systems to oceanography.

Commission 2 (the Gravity Field Commission), of the International Association of Geodesy is concerned with promoting, supporting, and stimulating the advancement of knowledge, technology, and international cooperation in the geodetic domain associated with Earth's gravity field. This domain comprises several major themes of long-term interest, each under the purview of a sub-commission. The themes cover terrestrial, airborne, shipborne, and satellite gravimetry; terrestrial relative and absolute gravity networks; precise regional and global geoid determination and geopotential modeling; topographic/isostatic modeling; regional and global temporal variations in the gravity field; dedicated satellite gravity mapping missions; and gravity determination from satellite altimetry.

The Gravity Field Commission essentially continues the work of the former Section III of the IAG (Determination of the Gravity Field), but includes some aspects of satellite geodesy (former Section II), and is designed to have stronger links to other components of the IAG, specifically the Inter-Commission Committee on Theory (ICCT) and Commission 1 (Reference Frames). The sub-commissions cover the major themes listed above, which constitute the principal areas in gravity field modeling, determination, and measurement technology, as well as the specific problems and activities related to regional geoid determination. Study Groups, as under the former structure, continue to look at well-defined subjects over shorter duration. They are placed under the sub-commissions. Projects are established under the Commission to organize work on unique and exceptional areas of interest or particular problems requiring specific international cooperation. The regional geoid determination projects, being of paramount importance, are collected under the Sub-commission 2.4, in order to provide close links between them. Connections to

other components of the IAG are created with inter-commission working groups that provide a cross-disciplinary stimulus for work in several topics of interest to the Commission. Finally, the Commission has very strong links to several of the Services in geodesy, particularly the newly established International Gravity Field Service and its component services.

In this modern age of instant change, enabled by electronic forms of information exchange, it is only natural that the structure of Commission 2, its membership, and its connection to other components of the IAG has a dynamic character that will evolve over the current term between IUGG General Assemblies. In fact, this evolution is necessary as the new structure of the IAG takes shape and re-establishes and re-defines its purview over regional and international geodetic activities. The current status of Commission 2, including its structure and membership, may be updated regularly and can be viewed on the internet: www.ceegs.ohio-state.edu/iag-commission2

Structure

Sub-Commissions:

- SC2.1: Gravimetry and Gravity Networks
President: **Shuhei Okubo** (Japan)
- SC2.2: Spatial and Temporal Gravity Field and Geoid Modeling
President: **Martin Vermeer** (Finland)
- SC2.3: Dedicated Satellite Gravity Mapping Missions
President: **Pieter Visser** (The Netherlands)
- SC2.4: Regional Geoid Determination
President: **Urs Marti** (Switzerland)

Commission Projects:

- CP2.1: European Gravity and Geoid
Chair: **Heiner Denker** (Germany)

- CP2.2: North American Geoid
Chair: **Marc Véronneau** (Canada)
- CP2.3: African Geoid
Chair: **Charles Merry** (South Africa)
- CP2.4: Antarctic Geoid
Chair: **Mirko Scheinert** (Germany)
- CP2.5: South American Geoid
Chair: **Denizar Blitzkow** (Brazil)
- CP2.6: Southeast Asian Geoid
Chair: **Bill Kearsley** (Australia)
- CP2.7: Gravity in South America
Chair: **María Cristina Pacino** (Argentina)

Study Groups:

- SG2.1: Comparison of Absolute Gravimeters
Chair: **Leonid Vitushkin** (France)
- SG2.2: Forward Gravity Field Modeling Using
Global Databases
Chair: **Michael Kuhn** (Australia)
- SG2.3: Satellite altimetry: data quality improvement
and coastal applications
Chair: **Cheinway Hwang** (Taiwan)
- SG2.4: Aerogravimetry and Gradiometry
Chair: **Uwe Meyer** (Germany)

Inter-Commission Study Groups:

- IC-SG2.5: Aliasing in Gravity Field Modeling
(Joint with ICCT)
Chair: **C. Christian Tscherning** (Denmark)
- IC SG2.6: Multiscale Modeling of the Gravity Field
(Joint with ICCT)
Chair: **W. Freedden** (Germany)

Inter-Commission Projects:

- ICP1.1: Satellite Altimetry
(Joint with Commission 1 and 3)
(Description: See Commission 1)
Chair **W. Bosch** (Germany)

- IC-P1.2: Vertical Reference Frames
(Joint with commission 1)
(Description: See Commission 1)
Chair: **Johannes Ihde** (Germany)

- IC-P3.1: GGP Global Geodynamics Project
(Joint with Commission 3.
(Description: See Commission 1)
Chair: **David Crossley** (USA)

Inter-Commission Working Groups:

- IC-WG 1: Quality Measures, Quality Control and
Quality Improvement
(Joint with ICCT and Commission 1)
(Description: See ICCT)
Chair: **H. Kutterer** (Germany)

- IC-WG3: Satellite Gravity Theory
(Joint with ICCT and Commission 1)
(Description: See ICCT)
Chair: **N. Sneeuw** (Canada)

Program of Activities

The Gravity Field Commission fosters and encourages research in the areas of its sub-entities by facilitating the exchange of information and organizing Symposia, either independently or at major conferences in geodesy. The activities of its sub-entities, as described below, constitute the activities of the Commission, which will be coordinated by the Commission and summarized in annual reports to the IAG Bureau. An Internet web-site for the Commission will contain all information about the Commission, its basic structure, terms of reference, and membership, as well as links to the internet sites of its sub-entities and parent and sister organizations and services. The Internet address for the Gravity Field Commission (C2) is:
www.ceegs.ohio-state.edu/iag-commission2

Steering Committee

President: Christopher Jekeli
Vice president: Ilias Tziavos
President SC2.1: Shuhei Okubo
President SC2.2: Martin Vermeer
President SC2.3: Pieter Visser
President SC2.4: Urs Marti
Rene Forsberg (representative from the IGFS)
Peter Schwintzer (representative from the Int. Center of
Global Earth Models)
Jacques Hinderer (representative from GGP)

Sub-Commission

SC 2.1 - Gravimetry and Gravity Networks

President: **Shuhei Okubo** (Japan)

Terms of Reference and Objectives

Sub-commission 2.1 promotes scientific investigations of gravimetry and gravity networks by employing a three-step strategy. The first step is focused on gravity determination at some selected sites with absolute gravimeters (point scale). It provides the gravity community with means to assess the level of accuracy of steadily growing numbers of absolute gravimeters through organizing international inter-comparison campaigns of global and of regional scales. In the second step, the Sub-commission proceeds from the 0-D point-wise gravimetry to 1-D gravimetry: accurate and precise gravimetry/gradiometry around land/sea borders where significant bias or errors are still observed. The Sub-commission promotes such research and development by stimulating airborne gravimetry and gradiometry. In the third step, it encourages and promotes special absolute/relative gravity campaigns, techniques and procedures for the adjustment of the results of gravity surveys on a regional scale (2-D). The Sub-commission will encourage regional meetings or workshops dedicated to specific problems, where appropriate.

Reports to Commission 2.

Program of Activities

To meet these goals, the Sub-commission sets up Special Study Groups (SSG's) on Inter-comparison of Absolute Gravimeters, Aerogravimetry and Gradiometry, East Asia and Western Pacific Gravity Network, and Gravity in South America (see below).

Membership

President: Shuhei Okubo
Vice President: Gerd Boedecker
Rene Forsberg (Gravity Networks in Polar Regions)
Matthias Becker (Relative gravimetry)
Leonid F. Vitushkin (Absolute Gravimetry)
Uwe Meyer (Aerogravimetry and Gradiometry)
Yoichi Fukuda (East Asia and Western Pacific Gravity Network)
María Cristina Pacino (Gravity in South America)

Sub-commission

SC 2.2 - Spatial and Temporal Gravity Field and Geoid Modeling

President: **Martin Vermeer** (Finland)

Terms of Reference and Objectives

The subjects of study that the Sub-commission supports and promotes can be summarized, without claim to completeness, as follows. Research work in the spatial domain concentrates on:

- Global and regional gravity modeling
- Topographic/isostatic modeling
- Downward and upward continuation problems
- Boundary value problem approaches
- Spectral techniques like (but not limited to) spherical harmonics
- Height theory and height systems
- Geodetic aspects of satellite radar altimetry

Studies in the temporal domain of the gravity field include, among others, the following:

- Tides
- The effect of postglacial land uplift
- Time derivatives of the J_n
- Short/medium term gravity change due to movements of air and water
- Anthropogenic gravity changes

Reports to Commission 2.

Program of Activities

To meet these goals, the Sub-commission invites the establishment of Special Study Groups (SSG's) on relevant topics, promotes and organizes special sessions at IAG Symposia and other conferences, and reports on the research work in these areas of interest.

Steering Committee

President: Martin Vermeer

Sub-commission

SC 2.3 - Dedicated Satellite Gravity Mapping Missions

President: **Pieter Visser** (The Netherlands)

Terms of Reference and Objectives

The successful launches of the German CHAMP (2000) and US/German GRACE (2002) missions have led to a revolution in global gravity field mapping by space-borne observation techniques and associated activities. These two missions have proven new concepts and technologies, such as space-borne accelerometry and low-low satellite-to-satellite tracking (SST), in combination with more conventional observation techniques, like GPS/SST and satellite laser ranging (SLR). CHAMP and GRACE have already produced the first consistent long- to medium-wavelength global gravity field models and have helped in preparing for the European Space Agency (ESA) GOCE dedicated gravity field mission which will further revolutionize high-accuracy and high-resolution gravity field mapping employing for the first time in history the satellite gravity gradiometry (SGG) observations.

The focus of this sub-commission will be to promote and stimulate the following activities:

- Generation of the best possible static and temporal global gravity field models based on, but not limited to, observations by space-borne techniques (LAGEOS, CHAMP, GRACE,...)
- Preparation for future satellite missions which focus on or support global gravity field mapping (GOCE, COSMIC,...)
- Definition of enabling technologies for the more remote future (GRACE follow-on, GOCE follow-on,...)
- Communication/interfaces with gravity field model user communities (Climatology, oceanography/Altimetry, Glaciology, Solid-Earth, Geodesy,...)

Program of Activities

To meet these goals, the Sub-commission invites the establishment of Special Study Groups (SSG's) on relevant topics, promotes and organizes special sessions at IAG Symposia and other conferences, and reports on the research work in these areas of interest.

Steering Committee

President: Pieter Visser (DEOS/The Netherlands)
Srinivas Bettadpur (CSR/U.S.A.)
Thomas Gruber (IAPG/Germany)
Cheinway Hwang (NCKU/Taiwan)
Radboud Koop (SRON/The Netherlands)
Nico Sneeuw (Univ. Calgary/Canada)

Sub-commission

SC 2.4 - Regional Geoid Determination

President: **Urs Marti** (Switzerland)

Terms of Reference and Objectives

The sub-commission is concerned with the following areas of investigation:

- Regional geoid projects: data sets, involved institutions,
- comparison of methods and results, data exchange, comparison with global models
- gravimetric geoid modeling techniques and methods, available software
- GPS/leveling geoid determination:
 - methods, comparisons, treating and interpretation of residuals
 - common treatment of gravity and GPS/leveling for geoid determination
- geoid applications: GPS heights, sea surface topography, integration of geoid models in GPS receivers, vertical datums
- other topics: topographic effects, downward and upward continuation of terrestrial, airborne, satellite data specifically as applied to geoid modeling

Reports to Commission 2.

Program of Activities

To meet these goals, the Sub-commission invites the establishment of Special Study Groups (SSG's) on relevant topics, and of projects on regional geoid determination. It promotes and organizes special sessions at IAG Symposia and other conferences, and reports on the research work in these areas of interest. Also, the sub-commission plans to facilitate the interaction of the various regional geoid projects by organizing links of communication on the Internet.

Steering Committee

President: Urs Marti
Heiner Denker (Project 2.1)
Marc Véronneau (Project 2.2)
Charles Merry (Project 2.3)
Mirko Scheinert (Project 2.4)
Denizar Blitzkow (Project 2.5)
Bill Kearsley (Project 2.6)

Commission Project

CP2.1 European Gravity and Geoid

Chair: **Heiner Denker** (Germany)

Terms of Reference and Objectives

The primary objective of the project is the development of an improved geoid and quasigeoid model for Europe. The previous European Gravimetric Geoid 1997 (EGG97) is based on high-resolution gravity and terrain data and the global model EGM96. The comparison of the EGG97 model with GPS/leveling data from national campaigns and the continental-scale EUVN project reveals long wavelength discrepancies (at the dm level), while the agreement at shorter wavelengths is at the cm level in many cases. For GPS heighting such long wavelength geoid errors are vital and have to be modeled, e.g., by fitting the geoid model to some GPS/leveling control stations.

Since the development of the EGG97 model, several new data sets and computing techniques have become available. Hence, significant improvements (especially at the long wavelengths) can be expected from an updated European geoid model. Besides the new modeling techniques (e.g., wavelets), improvements are expected from the new CHAMP and GRACE global geopotential models, new terrain data sets (e.g., GTOPO30, SRTM results, national data sets), new and more homogeneous gravity data sets for some regions, new altimetric results, an improved merging of ship and altimetric gravity data, and the use of continental-scale GPS/leveling campaigns. The data collection effort will focus especially on the problem areas in the EGG97 computation, i.e., areas where gravity field data is lacking, sparse, or of low quality.

All relevant work within the project requires close international cooperation between all European countries and different IAG bodies. The contacts and successful cooperation with the respective national and international agencies, established within the framework of the EGG97 model development, will be continued and extended. The project is open to all agencies and universities with an interest in the development of a geoid and quasigeoid model for Europe.

The objectives of the project are summarized below:

- Collection, evaluation and homogenization of land and marine gravity data, altimetric data, GPS/leveling data, digital elevation models, and global geopotential models.

- Creation of databases for different data types.
- Investigation of different techniques for regional geoid and quasigeoid determination.
- Investigation of techniques for the combination of gravimetric and GPS/leveling data.
- Development of a new European geoid and quasigeoid model (gravimetric and/or combined model).

Reports to Sub-Commission 2.4

Steering Committee

Heiner Denker (Chair)	(Germany)
Jean-Pierre Barriot	(France)
Riccardo Barzaghi	(Italy)
Rene Forsberg	(Denmark)
Johannes Ihde	(Germany)
Ambrus Kenyeres	(Hungary)
Urs Marti	(Switzerland)
Ilias Tziavos	(Greece)

Commission Project

CP2.2 -North American Geoid

Chair: **Marc Véronneau** (Canada)

Terms of Reference and Objectives

The primary objective of the Project is the development of a geoid model for North America and surrounding oceans in order to achieve a common vertical datum. Its development will require the determination of the gravity field for an area encompassing Iceland, Greenland, Canada, USA (including Alaska and Hawaii), Mexico and countries forming Central America and the Caribbean Sea, referred to herein as “North America”. The geoid model for North America could be used as the common datum to relate national datums or tailored using; for example, “GPS/Leveling” in order to depict the official national vertical datum as it is done in Canada and USA. The achievement of a geoid model for North America will be accomplished by coordinating activities between agencies and universities with interest in geoid theory, gravity, digital elevation models (DEM), topographical density, altimetry, sea surface topography, leveling and vertical datum.

The determination of a geoid model for North America is not limited to a single agency, which will collect all necessary data from all countries. The Project encourages theoretical diversity in the determination of a geoid model between the agencies. Each agency takes responsibility or works in collaboration with neighboring countries in the development of a geoid model for their respective country with an overlap (as large as possible) over adjacent countries. Each solution will be compared, the discrepancies will be analyzed, and the conclusions will be used to improve on the next model. Thus, the geoid model for North America will be derived from a “mosaic” of geoid models.

Reports to Sub-Commission 2.4

Program of Activities

The Project will support geoid activities in countries where geoid expertise is limited by encouraging more advanced members to contribute their own expertise and software. The Project will encourage training and education initiative of its members (e.g., International Geoid Service (IGeS) geoid school and graduate studies).

The chair of the Project will meet with the equivalent European and South American projects to discuss overlap regions and to work towards agreements to exchange data. Finally, the members of the Project will keep close contact with all related Special Study Groups of the IAG.

The Project is open to all geodetic agencies and universities across North America with an interest in the development of a geoid model for North America. The meetings of the Commission Project 2.2 are open to everyone with interests in geodesy, geophysics, oceanography and other related topics. A list of members is available on the web site of the North American geoid project:

www.geod.nrcan.gc.ca/~marc/Html/GGSCNA/GGSCNA.html

(Username: marc password: private)

Members will communicate primarily using e-mails. However, members of the Project plan to arrange annual meetings. Preferably, these meetings will be held during international conferences where most members will be present; however, some meetings will be held in North America to minimize travel costs. Minutes of meeting will be prepared and sent to all members of the Project.

Membership

Marc Véronneau (chair,GSD/Canada)
Rene Forsberg (KMS/Greenland)
Per Lyster Pedersen (ASIAQ/Greenland)
Antonio Hernández Navarro (INEGI/Mexico)
Dan Roman (NGS/U.S.A.)

Commission Project

CP 2.3 - African Geoid

Chair: **Charles Merry** (South Africa)

Terms of Reference and Objectives:

The principal goal of the Project is very simply to determine the most complete and accurate geoid model for Africa that can be obtained from the available data. Secondary goals are to foster co-operation between African geodesists and to provide high-level training in geoid computation to African geodesists.

The objectives of the Project are summarized below:

- Identifying and acquiring data sets - gravity anomalies, DEM's, GPS/levelling.
- Training of African geodesists in geoid computation.
- Merging and validation of gravity data sets, producing 5' gridded and mean γ .
- Computation of African geoid, and evaluation using GPS/levelling data.

Reports to Sub-Commission 2.4

Membership

Charles Merry (Chair)	(South Africa)
Hussein Abd-Elmotaal	(Egypt)
Benahmed Dahou	(Algeria)
Peter Nsombo	(Zambia)

Commission Project

CP 2.4 - Antarctic Geoid

Chair: **Mirko Scheinert** (Germany)

Terms of Reference and Objectives

Acknowledging the success of the Arctic Gravity Project similar efforts have to be made to compile gravity data for the entire Antarctic. The availability of Antarctic gravity data should be improved by compiling already existing data and by carrying out new gravity observation campaigns. The main scientific goals are to fill in the southern polar gap and thus to improve the terrestrial gravity data coverage. A completed Antarctic gravity data set will substantially contribute to the determination of the global gravity field in combination with the new gravity satellites and will serve as an excellent basis for regional and continental geoid improvement. The Antarctic Geoid Project (AntGP) should be a focus group for geodesists and geophysicists interested in gravity and geoid in Antarctica. Reports to Sub-Commission 2.4

Program of Activities

Activities of the Project include the following:

- Initiating and facilitating the exchange of Antarctic gravity field data.
- Collecting and evaluating existing gravity data (surface, airborne and satellite) and GPS data on tide gauges to compute best possible gravity anomaly and geoid grids.
- Promoting new terrestrial and airborne gravity survey activities.
- Promoting new precise gravity ties to older and new traverses and airborne surveys.
- Promoting the measurement of reference gravity stations, especially using absolute gravity meters.
- Acting as liaison to similar data initiatives in solid-earth geophysics, especially SCAR.

Membership

Mirko Scheinert (Chair) (TU Dresden, Germany)
Alessandro Capra (Italy), Detlef Damaske (Germany),
Reinhard Dietrich (Germany), Rene Forsberg (Denmark),
Larry Hothem (USA), Phil Jones (UK), A.H. William
Kearsley (Australia), Steve Kenyon (USA), Christopher
Kotsakis (Canada), German L. Leitchenkov (Russia),
Jaakko Maekinen (Finland), John Mannin (Australia),
Uwe Nixdorf (Germany), Kazuo Shibuya (Japan),
C.K. Shum (USA), Dag Solheim (Norway), Michael
Studinger (USA),
(corresponding members)
Graeme Blick (New Zealand), John Brozena (USA)
Chenway Hwang (Taiwan)

Commission Project

CP2.5 - South American Geoid

Chair: **Denizar Blitzkow** (Brazil)

Terms of Reference and Objectives

A great effort has been carried out in the last ten years to improve/re-establish the Fundamental Gravity Network in South America, to fill the gravity gaps and to increase GPS observations on the leveling network. Different versions of the geoid (quasi-geoid) were delivered. At the moment it is important to address a renewed focus to reorganize the new gravity surveys, in particular, airborne missions, and to implement new software for the geoid computation. A new geoid model is envisaged to support the SIRGAS altimetric reference system in South America.

The main objectives of the project are:

- To obtain and to maintain files with data necessary for the geoid computations like gravity anomalies, digital terrain models, geopotential models and satellite observations (GPS) in leveling networks.
- To provide a link between the different countries and the International Geoid Services in order to assure access to proper software and geopotential models for local geoid computation.
- To compute a global geoid model for South America with a resolution of $10' \times 10'$ using the available data. To encourage countries to cooperate by releasing data for this purpose.
- To encourage and eventually support local organizations in different countries endeavoring to increase the gravity data coverage; to improve the existing digital terrain models; to carry out GPS observations on the leveling network and to compute a high resolution geoid.

Reports to Sub-Commission 2.4

Program of Activities

The Project will organize and/or encourage the organization of workshops, symposia or seminars on the geoid determination in South America. Links will be established in the project to the following services to facilitate the exchange of data:

- Bureau Gravimétrique International
- International Geoid Service I – Milan

- International Geoid Service II – St. Louis

Membership

Chair: Dr. Denizar Blitzkow (Brazil, dblitzko@usp.br)
Enga. Maria Cristina Lobianco (Brazil)
Enga. Laura Marlene Sánchez Rodríguez (Colombia)
Dr. Melvin Jesus Hoyer Romero (Venezuela)
Geof. Graciela Font (Argentina)
Rodrigo Maturana Nadal, (Chile)
Alfonso R. Tierra C. (Ecuador)

Commission Project

CP2.6 -Southeast Asian Geoid

Chair: **Bill Kearsley** (Australia)

Terms of Reference and Objectives

This new Project is chartered to promote cooperation in and knowledge of geoid and related studies in the region of South East Asia. The target membership consists of representatives from countries in and associated with ASEAN and countries in the Malaysian Peninsula including: The Philippines, Papua New Guinea, Indonesia, Malaysia, Singapore, Brunei, Thailand, Vietnam, Cambodia, Laos and Myanmar. Some of these countries have not yet responded to requests for support. Others (Laos, Cambodia and Myanmar) will be contacted under the auspices of this new Project.

The executive of this Project will be small to ensure efficiency, and the Steering Committee will comprise one member from each participating country. Because of the need to carry national authority, it is proposed that the national member be the officer in the National Geodetic Authority responsible for the National Geoid and/or National Height Datum matters.

Topics of interest in the Project include:

- Gravity and Related Data: Explore ways in which we may
 - share available gravity data (e.g. via International Gravity Bureau; GETECH, University of Leeds; USGS Data Center)
 - share available DEM's along common borders (National Geodetic Authorities)
 - combine resources for terrestrial gravity surveys along common borders
 - combine resources for airborne gravity surveys in the region.
- Geoid Control: Explore ways in which we may cooperate by
 - sharing geometric (GPS/leveling) geoid control data
 - combining efforts in global GPS campaigns (e. g., IGS'92)
 - undertaking joint campaign for the inter-connection of National Height Datums.

Reports to Sub-Commission 2.4

Membership

Bill Kearsley (Chair)

Commission Project

CP2.7 Gravity in South America

Chair: **María Cristina Pacino** (Argentina)

Terms of Reference and Objectives

A gravity reference network was established in South America and adjusted by, at that time, the Canadian Geological Survey. Most of the stations of that old network are destroyed. In many countries, new reference network has been established recently like Chile, Paraguay, Argentina, Ecuador. It is necessary and urgent to tie the network together and carry out an adjustment. On the other hand, many gaps of gravity data have been filled in the last few years in different countries. In spite of that, other gaps still exist, in particular in the mountains and forests.

This project aims to coordinate efforts of gravity data collections and measurement campaigns in South America. The main objectives of the project are:

- To re-measure the existing absolute gravity stations and to encourage new measurements.
- To validate fundamental gravity networks from different countries in order to establish a single and common gravity network for South America.
- To adjust national gravity networks and to link them.
- To contribute to the "Geoid in South America Project" by obtaining and maintaining files with gravity data necessary for the geoid computation.
- To encourage and eventually support local organizations in different countries to increase the gravity data coverage.
- To organize and/or encourage the organization of workshops, symposia or seminars on gravity in South America.

The following links to organizations will be established in the project: Bureau Gravimétrique International; SIRGAS. Reports to Sub-Commission 2.1

Membership

María Cristina Pacino (Chair) (Argentina)
Eduardo Andrés Lauría (Argentina)
Felipe Vasquez Moya (Bolivia)
Daniel Flores Vargas (Bolivia)
Rodrigo Maturana Nadal (Chile)
Rodrigo Barriga Vargas (Chile)
Pedro Sandoval Cavanzo (Colombia)
Luis Llerena (Ecuador)
Juan Carlos Torales (Paraguay)
Juan Munoz Curto (Peru)
Roberto P. Rodino (Uruguay)
Jose Napoleon Hernandez (Venezuela)
Jose Gonzales Briceno (Venezuela)

Study Group

SG 2.1 - Comparison of Absolute Gravimeters

Chair: **Leonid Vitushkin** (France)

Terms of Reference and Objectives

Absolute ballistic gravimeters have become the primary standards of the acceleration unit in the field of free-fall acceleration measurements (in brief, standards of free-fall acceleration). Currently the only way to determine the level of accuracy of the absolute ballistic gravimeters and provide the uniformity in absolute measurements of free-fall acceleration g is by a comparison of the results of their measurements.

The principal task of the Special Study Group consists of the organization (in collaboration with the BIPM and CCM WGG, Consultative Committee on Mass and Related Topics Working Group on Gravity) of the four-year period International Comparisons of Absolute Gravimeters (ICAGs) at the BIPM and Regional International Comparisons of Absolute Gravimeters (RICAGs) at the sites selected on a continental scale. It should be noted that the next ICAG should be held in 2005.

The increasing demand for reliability in absolute gravity measurements requires the development of a technical protocol for future ICAGs following the rules proposed in the international Mutual Recognition Arrangement (signed in 1999 by national metrology institutes) for national measurement standards and calibration and measurement certificates.

The relevance to the SG is that its members are the specialists from the geodetic and geophysical communities, as well as the metrological community and this study group is more open to participation than the more official CCM WGG where the membership is related to the institutes responsible for the traceability in gravimetry. Such intercommunications within the Study Group as well as a linkage between this group and CCM WGG will make it possible to develop the ICAGs and RICAGs technical protocol accepted by both communities.

The sites for regional comparisons of absolute gravimeters (in America, Asia, Europe, and Africa) should be recommended by the geodetic-geophysical community and related to the regional structure of metrology community (Regional Metrology Organizations - RMO, for instance, EUROMET - European Metrology Organization, SIM - Inter-American Metrology System, etc.).

Objectives

- The organization (in collaboration with the Bureau International des Poids et Mesures (BIPM) and Working Group on Gravimetry of Consultative Committee on Mass and Related Topics (CCM WGG) of the four-year period International Comparisons of Absolute Gravimeters (ICAGs) at the BIPM and Regional International Comparisons of Absolute Gravimeters (RICAGs) at the sites selected on continental scale.
- The selection of the sites for regional (on a continental scale) comparisons of absolute gravimeters in collaboration with other working groups of Sub-Commission 2.1 and CMM WGG.

Reports to Sub-Commission 2.1

Membership

Leonid Vitushkin (Chair)(France)
Martine Amalvict (France)
Diethard Ruess (Austria)
Enrique Rodriguez Pujol (Spain)
Ian Robinson (UK)
Philippe Richard (Switzerland)
Simon Williams (UK)
Jaakko Mäkinen (Finland)
Michel Van Camp (Belgium)
Shigeki Mizushima (Japan)
Zhiheng Jiang (France)
Alexandr Kopaev (Russia)
Petr Medvedev (Russia)
James Faller (USA)
Artyom Vitushkin (USA)
Gleb Demianov (Russia)
Olivier Francis (Luxembourg)
Tonie van Dam (Luxembourg)
Alessandro Germak (Italy)
Yuriy Lokshin (Ukraine)
Andrzej Pashuta (Poland)
Arkadii Sinelnikov (Russia)
Evgenii Krivtsov (Russia)
Hsien-Chi Yeh (Taiwan)
Chiungwu Lee (Taiwan)
Jacques Hinderer (France)
Gennadii Arnautov (Russia)
Yuri Stus (Russia)
Matthias Becker (Germany)
Roger Hipkin (UK)
Jan Mrlina (Czech Republic)

Study Group

SG 2.2 - Forward Gravity Field Modeling Using Global Databases

Chair: **Michael Kuhn** (Australia)

Terms of Reference and Objectives:

A vast number of data describing the Earth's shape and structure (elevation, density distribution models for crust and mantle) are currently available. Several of these data are given globally with a continuously increasing resolution. One of the greatest density anomaly, for example, is given nowadays by the topographic and ocean water masses as modeled by global digital elevation models (DEM) with resolutions down to 1 km x 1 km. Apart from these (mostly geometrical) data, there also exist global geological and geophysical information about the Earth's interior, describing mainly the structure of the Earth's crust and mantle. The increasing number of these data allows the use of forward gravity field methods (direct application of Newton's integral) in order to perform gravity field recovery and interpretation. In geodesy first attempts in this field have been made in the framework of the former IAG Special Study Group 3.177 (<http://www.cage.curtin.edu.au/~will/iagssg3177.html>) with very promising results for more detailed studies. Such forward modeling results are of great significance to gravity field modeling and interpretation. Furthermore, the comparison of the forward models with existing gravity field models reveals useful information on the dynamics of the Earth's interior as well as the validity of the forward gravity modeling techniques.

The SG can be seen as a continuation of the IAG SSG 3.177 with a special focus on forward gravity field modeling as well as the modeling of gravity inside the (topographic) masses. Therefore it follows one of the recommendations made in the final report of IAG SSG 3.177.

The main scope of the SG will be the employment of recently released global digital databases with elevation data as well as information on the structure of crust and mantle for gravity field recovery and interpretation. The high resolution of the currently available global data permits the evaluation of high-degree and -order gravity models, while enabling the recovery of the high-frequency content of existing topographic/isostatic models. Furthermore, the forward gravity models can be used to study the behavior of gravity within the (topographic)

masses, which is a crucial point in gravity field determination.

The SG will mainly focus on the following items:

- Construction of forward gravity field models using geophysical data.
 - Construction of forward gravity field models from existing global information on the Earth's shape and structure (e.g. global DEM (topography, bathymetry) such as DTM2000.1, global crustal models like CRUST 2.0, global mantle models on seismic velocity and density).
 - Different approaches can be used and tested, such as the numerical integration of Newton's volume integral or the expression of Newton's gravitational potential in spherical harmonics.
 - Following the ideas of SSG 3.177 these forward gravity models also can be used as synthetic Earth gravity field models.
- Interpretation of forward gravity field modeling results.
 - Comparison of the forward gravity models with existing models from satellite and/or terrestrial gravity measurements (e.g. global gravity field models from CHAMP and GRACE).
 - Construction of synthetic Earth Gravity Models after attempting to identify bandwidths with known or apparent geophysical implications.
 - Geophysical interpretation and numerical assessment of the forward gravity field models with case studies over tectonically active regions (e.g. Isostasy and flexure of the lithosphere, dynamics of the mantle).
- Application of forward modelling results in gravity field determination
 - Modeling of gravity inside the topographic masses, which is required in gravimetric gravity field determination (e.g. geoid determination using Stokes's theory).
 - Study the forward gravity field modeling results under the scope to improve the computation of different gravity reductions/effects such as:
 - computation of terrain reductions,
 - downward continuation of gravity anomalies,
 - orthometric corrections,
 - mean gravity and mean gravity gradient inside the (topographic) masses.
 - Study the possibility to express the Earth's gravity field by forward modeling only.

Reports to Sub-Commission 2.2

Program of Activities

Activities of the SG will include participation by members who will cover at least one of the above mentioned study areas; meetings at larger conferences such as IAG, AGU, EGS in order to report and discuss matters related to the SG; and. Communication by e-mail and a web-page.

Membership

Michael Kuhn (Chair) (Australia)
Dimitris Tsoulis (Vice Chair) (Germany)
Hussein Abd-Elmotaal (Egypt)
Irek Baran (Australia)
Miroslav Bielik (Slovak Republic)
Heiner Denker (Germany)
William Featherstone (Australia)
Jakob Flury (Germany)
Thomas Gruber (Germany)
Simon Holmes (USA)
Michael Kern (Austria)
Jon Kirby (Australia)
Pavel Novak (Czech Republic)
Spiros Pagiatakis (Canada)
Roland Pail (Austria)
Gabor Papp (Hungary)
Nikolaos Pavlis (USA)
Gabriel Strykowski (Denmark)
Gyula Toth (Hungary)
Tony Watts (UK)

Study Group

SG2.3 - Satellite altimetry: data quality improvement and coastal applications

Chair: **Chenway Hwang** (Taiwan)

Terms of Reference and Objectives

In a previous IAG SSG, namely, SSG3.186, members have put effort to develop best methodologies for deriving gravity anomaly, geoid, sea surface topography and bathymetry from satellite altimeter data. Despite some achievements, a number of problems in coastal applications of altimetry are not resolved. For example, altimeter data at the immediate vicinity of shores are eliminated due to bad quality. However, for purposes such as coastal geoid and gravity determinations, shallow-water tide modeling and coastal ocean circulation determination, such "bad" data are badly needed. Do we really need to eliminate these altimeter data? Can we improve the quality of coastal altimeter data and how?

One important application of satellite altimetry is to determine local coastal geoid models. Coastal areas are largely heavily populated. Most countries in the world will need a high-precision coastal geoid model for purposes such as national vertical datum determination and connection (for countries with scattered islands), GPS leveling, coastal circulation study and coastal topography mapping. However, satellite altimetry alone cannot fulfill this need, and satellite and terrestrial gravity data (at land and sea) and elevation data (for terrain effects) should be included. The question is how to best combine these heterogeneous data.

It has been shown that use of retracked altimetry can produce improved results in altimetric applications. Currently, only retracked ERS-1 altimetry is used for purposes such as marine geoid and gravity determinations in only a limited number of coastal areas (e.g., polar regions and the China Seas). Retracked altimetry can be also used in shallow-water tide modeling and sea surface topography determination for oceanography.. Another dense data set, namely, Geosat/GM, has not been retracked for coastal applications. The geodetic and earth science communities will surely benefit from a global set of combined retracked ERS-1 and Geosat/GM altimeter data. One objective of this current SSG will be to freely provide a database of retracked ERS-1 and Geosat/GM for members interested in applications of these retracked altimeter data.

The Study Group activities will include:

- Retrack global shallow-waters ERS-1 and Geosat/GM altimeter data and establish a database for members to use.
- Investigate geophysical, geodetic and oceanographic signals with altimetric products using rates higher than 1 Hz. In addition to the radar altimetry, high-rate laser altimeter data from ICESat, which are not corrupted near coasts, will be used. Impact of using JASON-2 WSOA and CRYOSAT altimeter data will be investigated.
- Improve models of geophysical corrections over shallow waters using, e.g., improved shallow-waters tide models, sea state bias estimates and tropospheric corrections and improve quality of altimeter data over shallow waters by, e.g., waveform retracking, adaptive filtering and outlier detection. Selected "difficult" regions of scientific interest such as the Hawaiian Ridges, the Cayman Trench, and the southeast Asia waters will be investigated. The improved models should be distributed to all members.
- Combine coastal altimetry, satellite gravity, land gravity, marine gravity (shipborne or airborne) to enhance the accuracy of coastal geoid (at sea and land).
- Combine altimetry data, LIDAR and remote sensing data for coastal bathymetry determination. LIDAR onboard an aircraft is able to determine ocean depths up to 50 m. Optical sensor data from, e.g., Landsat, can be used to determine depths at shallow waters, provided that a careful calibration is made. Here altimetry data help to determine bathymetry at the deeper part of the oceans. But how exactly do we combine them?
- Define a standard, including theory and data type, to obtain the current best results in marine gravity, geoid and bathymetry from altimetry data.
- Investigate the possibility of determining coastal ocean circulations from satellite altimetry and numerical modeling.
- Create long-term averaged satellite altimetry database for geodetic purposes.

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P. Knudsen (Denmark)
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JC Li (China)
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Y. Lu (China)
D. T. Sandwell (USA)
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Reports to Sub-Commission 2.2

Membership

Cheinway Hwang (Chair) (Taiwan)
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W. Bosch (Germany)
X. Deng (Australia)
X. Dong (China)

Study Group

SG2.4 - Aerogravimetry and Gradiometry

Chair: **Uwe Meyer** (Germany)

Terms of Reference and Objectives

Within the next four years, the SSG on Aerogravimetry and Gradiometry should concentrate on three major items.

- Now that CHAMP and GRACE are operative and first independent, single satellite models are available for the gravity community, and with the GOCE mission on the horizon, aerogravity campaigns should be designed to close the gap between near-surface measurements (land-based, ship-borne) and satellite observations. Taking the GRACE mission as an example, the design of future aerogravimetry surveys should make sure that long wavelengths (minimum of 250 km profile length) are resolved with stable, best possible accuracy with a resolution that fits to medium wavelength features measured on ground (some ten to hundred km). A new generation of scientific survey aircraft available in the next years such as the planned HIAPER aircraft (USA) and HALO aircraft (Germany) that are mainly designed and planned to be used for atmospheric sciences should also be adopted for large scale aerogravimetric surveys. The aircraft will be of the type of Bombardier Express or Gulfstream V which both are capable to fly distances up to 10000 km. Such type of aircraft allows to fly gravimetry in a sub-continental to continental range. The gravimetry community should soon develop surveys for these aircraft as they will be available in 2006/2007.
- In the meanwhile, large unmapped areas as the Amazon Basin and Antarctica should be covered by systematic aerogravimetry surveys. For the Amazon Basin, a Brazilian scientific and commercial community has already claimed a large interest to cover the northern Amazon Basin. As for Antarctica, a special logistic and long standing experience is needed to cover the continent with aerogravimetric surveys. The institutions involved as BAS, AWI, USGS, etc. already have special science plans developed. IAG should give these institutions some official back-up and help in long term coordination of Antarctic aerogravimetry activities.
- The fast development of gradiometer systems for airborne gravimetry opens a complete new spectrum of accuracy and resolution in local to regional surveys. For the scientific community two problems arise to utilize the new instruments for their aims: most developments are purely made on a commercial base

and gradiometer systems often operate only on a specially designed aircraft, so the system cannot be swapped between aircraft. Here, a new link between industry and science has to be accomplished. The working group members should enforce the use of gradiometer systems on local targets of special interest. One mid-term aim should be the installation of a gradiometer system on HIAPER or HALO in order to fly on GOCE orbits with as much time synchronization as possible also using laser or radar systems for sea surface measurements over the Atlantic.

- The use of the latest satellite gravity observations encouraged the development of new techniques to process traces of satellite data. Some of the new, emerging ideas might be as well very useful in aerogravimetry data processing. Therefore, a set of aerogravity data from different systems should be made available on the internet to test new methods of processing and evaluation. Already existing and available GPS and aerogravimetry processing software should become accessible for comparison.

Reports to Sub-Commission 2.1

Membership

Uwe Meyer (Chair)
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Inter-Commission Study Group

IC-SG2.5 - Aliasing in Gravity Field Modeling (joint with ICCT)

Chair: **C. Christian Tscherning** (Denmark)

Terms of Reference and Objectives

A gravity field observable contains information about all coefficients of its associated spherical harmonic series and of other signals of time-varying character. This makes numerical gravity field procedures prone to aliasing. The effect is most clearly seen when estimating spherical harmonic coefficients, but should also be present when regional models are constructed using Fourier series. In a first phase, only the effects related to the static gravity field will be investigated. If possible, de-aliasing and time-varying effects will be studied in a second phase.

The joint working group will initially through a series of controlled numerical experiments study the effect of aliasing. Simplified as well as realistic global or regional datasets will be generated using coefficients from a spherical harmonic expansion from degree N , $2*N$, $3*N$ etc. to a maximal degree, e.g. 1800.

Program of Work

Phase I: The static gravity field.

- a. Creation of test datasets, including re-use of the positions and attitude angles available from the SC7 datasets for CHAMP, GRACE and GOCE. The generated data will include height anomalies, gravity anomalies or disturbances, gravity gradients or potential differences.
- b. Creation of datasets with added correlated or uncorrelated noise.
- c. Estimation of spherical harmonic coefficients
- d. Estimation (interpolation or extrapolation) of the generated data or of functionals of the anomalous potential.
- e. Study the magnitude and frequency distribution of the aliasing effects
- f. Study the effect of various regularisation procedures including minimum variance and minimum noise variance methods.

The datasets, or software able to create the datasets will be made available on the internet.

The members of the group will be persons having the capability of:

- i. Creating one or more of the datasets.
- ii. Carrying out global or regional gravity field modelling.
- iii. contributing with theoretical analysis of the fundamental aliasing problem or of the results of the numerical experiments.

If phase I is successfully completed, the following will be implemented:

Phase II:

- a. Study of de-aliasing procedures for static gravity field determination: removal of high-frequency information, such as topographic effects or filtering.
- b. Create synthetic data-sets which include time-varying effects (atmosphere, ocean, tides)
- c. Study the effect of combined gravity field modelling and the determination of (contingently time dependent) parameters.
- d. Study the effect of mixing data-types with different spectral content such as gravity and altimetry.

Members:

C.C.Tscherning (President) (Denmark)
F.Sansò (Italy)
J.Bouman (The Netherlands)
Annette Eicker (Germany)
W.Freeden (Germany)
Shin-Chan Han (USA)
Pieter Visser (The Netherlands)
Roland Klees (The Netherlands)
Nico Sneeuw (Canada)

Corresponding members:
Rene Forsberg (Denmark)
Jürgen Mueller (Germany)

Inter-Commission Study Group

IC-SG2.6 Multiscale Modelling of the Gravity Field

(joint with ICCT)

Chair: **W. Freedden** (Germany)

Terms of Reference

Future spaceborne observation combined with terrestrial and airborne activities will provide huge datasets of the order of millions of data. A reconstruction of the gravity field from future data material requires a careful multiscale analysis of the gravity potential, fast solution techniques, and a proper stabilization of the solution by regularization. While global long-wavelength modelling can be adequately done by use of spherical harmonic expansions, harmonic splines and/or wavelets are most likely the candidates for medium and short-wavelength approximation since they are 'building blocks' that enable fast decorrelation of gravitational data. Thus three features are incorporated in this way of thinking about georelevant harmonic wavelets, namely basis property, decorrelation, and fast computation. But this concept of harmonic wavelets demands its own nature in geodesy which by no means can be developed from the classical theory in Euclidean spaces. The working group intends to bring together scientists concerned with the diverse areas of geodetically relevant wavelet theory in general and its applications. An essential field of research is the specific character of geodetic multiresolution methods used in addition or in contrary to standard spectral techniques based on spherical harmonic framework.

Objectives

Theoretical research in the field of spherical and ellipsoidal wavelets as well as wavelet introduction and modelling on geodetically relevant surfaces (like spheroid, geoid, (actual) Earth's surface). Studies of harmonic wavelets in geodetic boundary-value problems (e.g. Runge-Walsh wavelets, layer potential wavelets, etc).

- Studies on spline/wavelet kernel modelling, multiscale pyramid algorithms via kernel functions known from (least squares) collocation and spline approaches, noise cancellation, least-squares adjustment and spline smoothing vs. multiscale thresholding, etc. Development of specific numerical methods: fast wavelet transform (FWT), tree algorithms, data compression, domain decomposition techniques, fast multipole methods (FMM), panel clustering, data transmission, etc.

- Comparison of spherical harmonic and/or wavelet modelling: Combined spectral and multiscale expansion of the gravitational potential, degree variances vs. local wavelet variances, spectral and/or multiscale signal to noise thresholding, etc. Investigation of different wavelet types in geodetic pseudodifferential equations (using numerical methods such as collocation, Galerkin method, least – squares approximation, etc).
- Regularization of inverse problems by multiresolution, locally reflected multiscale vs. globally reflected spectral regularization, multiscale parameter choice strategies, multiscale modelling in SST, SGG. Time dependent multiscale modelling in boundary value and inverse problems, numerical implementation and application to GRACE–, GOCE–data.

Program of Activities

- Organization of meetings and conferences (e.g. Oberwolfach conference on “Geomathematics”, May 2004, Organizers: Freedden (Kaiserslautern), Grafarend (Stuttgart), Sloan (Sydney), Svensson (Lund).
- Organizing of WG meetings or sessions, in coincidence with a larger event, if the presence of working group members appears sufficiently large.
- Email discussion and electronic exchange.
- Launching a web page for dissemination of information, expressing aims, objectives, plus providing a bibliography.
- Monitoring and presentation of activities, either of working group members or interested external individuals.

Members

Members will be determined later.