Commission 2 – Gravity Field

http://www.iag-commission2.ch

President: **Urs Marti** (Switzerland)
Vice President: **Srinivas Bettadpur** (USA)

Terms of Reference

The accurate determination of the gravity field and its temporal variations is one of the Three Fundamental Pillars of modern geodesy (besides of Geometry and Earth rotation). This is essential for applications in positioning and navigation, metrology, geophysics, geodynamics, oceanography, hydrology, cryospheric sciences and other disciplines related to the Earth's climate and environment. IAG Commission 2 was established at the IUGG in Sapporo in summer 2003 for promoting, supporting, and stimulating the advancement of knowledge, technology, and international cooperation in the geodetic domain associated with Earth's gravity field. In the last two periods from 2003 until 2011, Commission 2 has achieved its primary goals and is ready for the next 4-year period. Since most of the scientific themes are of long-term interest, the structure of Commission 2 essentially continues on the same basis as the last period.

Commission 2, at the start of the new period, consists of six sub-commissions (SCs), one inter-commission project (ICP) plus several study groups (SGs) and working groups (WGs), all of them jointly with another Commission or a service (JSG, JWG). The sub-commissions cover the following scientific topics:

- terrestrial, airborne, ship borne gravimetry and relative/absolute gravity networks;
- spatial and temporal gravity field and geoid modeling;
- dedicated satellite gravity missions;
- regional geoid determination;
- satellite altimetry (established in 2007)
- gravity and mass displacements (established in 2011)

The former Commission 2 projects for the continental geoid determination (CP2.1 to CP2.6) have been transferred into new regional Sub-Commissions (in analogy to Commission 1) in order to give them a more permanent status inside the IAG. Their principal goal is to improve the collaboration and the data exchange (gravity, GPS/leveling, digital terrain data) inside a certain region and to aim to a geoid model with a higher resolution than satellite only models.

Commission 2 has strong links to other commissions, GGOS, IGFS, ICCT and other components of IAG. Connections to these components are created through joint working groups (JWGs) and joint study groups (JSGs) that provide a cross-disciplinary stimulus for work in several topics of interest to the commission.

The main tasks of Commission 2 in the next four years are among others:

- Analysis of GOCE data and the release of improved global Gravity field models (satellite only models and in combination with terrestrial data and altimetry)
- Promoting GRACE follow-on missions for assuring the continued monitoring of global gravity and mass flux changes
- Defining and Realizing a new Gravimetric Reference System (IGRS) to replace the outdated IGSN71 and assuring the future of the comparison campaigns of absolute gravimeters
- Establishing of a service for easy accessing Satellite Altimetry data (IAS)
- Transferring the former 'Global Geodynamics Project' (GGP) into a service 'Global Geodynamics) inside the IGFS.
- Assisting the IGFS and its components in improving their visibility and their services
- Assisting GGOS in the realization of a World Height System (WHS)
- Improve the knowledge of the interaction between gravity change and mass transport (Gravity and Mass Displacement)
- Assisting the regional sub-commissions in establishing contacts and in acquiring data.

The necessary WGs and SGs can be established at any time and they can be dissolved when they reached their goals or if they are not active.

Objectives

The main objectives of Commission 2 are as listed in the IAG by-laws:

- Terrestrial, marine and airborne gravimetry
- Satellite gravity field observations
- Gravity field modeling
- Time-variable gravity field
- Geoid determination
- Satellite orbit modeling and determination
- Satellite altimetry for gravity field modeling

Structure

Sub-Commissions

SC 2.1: Gravimetry and Gravity Networks
Chair: Leonid F. Vitushkin (Russia)

SC 2.2: Spatial and Temporal Gravity Field and Geoid Modeling
Chair: Yan Ming Wang (USA)

SC 2.3: Dedicated Satellite Gravity Missions
Chair: Roland Pail (Germany)

SC 2.4: Regional Geoid Determination
Chair: Hussein Abd-Elmotaal (Egypt)
SC2.4a: Gravity and Geoid in Europe
Chair: Heiner Denker (Germany)
SC2.4b: Gravity and Geoid in South America
Chair: Maria Cristina Pacino (Argentina)
SC2.4c: Gravity and Geoid in North and Central America
Chair: David Avalos (Mexico)
SC2.4d: Gravity and Geoid in Africa
Chair: Hussein Abd-Elmotaal (Egypt)
SC2.4e: Gravity and Geoid in the Asia-Pacific
Chair: Will Featherstone (Australia)
SC2.4f: Gravity and Geoid in Antarctica
Chair: Mirko Scheinert (Germany)

SC 2.5 Satellite Altimetry
Chair: Xiaoli Deng (Australia)

SC 2.6: Gravity and Mass Displacements
Chair: Shuanggen Jin (China)

Joint Projects

JP 2.1: Joint Project 2.1 on Geodetic Planetology (JP-GP)
(joint with Commissions 1, 2 and 3 and ICCT)
Chairs: O. Baur (Austria) and S. Han (USA)

Joint Study Groups

JSG 0.1: Applications of time series analysis in geodesy
(joint with ICCT, description see ICCT)
Chair: W.Kosek (Poland)

JSG 0.2: Gravity field modeling in support of height system realization
(joint with ICCT, description see ICCT)
Chair: P. Novak (Czech Republic)

JSG 0.3: Methodology of regional gravity field modeling
(joint with ICCT, description see ICCT)
Chairs: M. Schmidt and Ch. Gerlach (Germany)

JSG.0.4: Coordinate systems in numerical weather models
(joint with ICCT, description see ICCT)
Chair: Th. Hobiger (Japan)

JSG 0.5: Multi-sensor combination for the separation of integral geodetic signals
(joint with ICCT, description see ICCT)
Chair: F.Seitz (Germany)

JSG 0.6: Applicability of current GRACE solution strategies to the next generation of inter-satellite range observations
(joint with ICCT, description see ICCT)
Chairs: M. Weigelt (Germany), A.Jäggi (Switzerland)

JSG 0.7: High-performance computational methods in geodesy (joint with ICCT, description see ICCT)
Chairs: R. Čunderlík, K.Mikula (Slovakia)

JSG 0.8: Earth System Interaction from Space Geodesy
(joint with ICCT, description see ICCT)
Chair: S.G.. Jin (China)

JSG 3.1: Gravity and height change intercomparison
(joint with Comm. 3, description see Comm. 3)
Chair: S. Rosat (France)

Joint Working Groups

JWG 2.1: Techniques and Metrology in Absolute Gravimetry
(joint with IGFS)
Chair: V. Palinkas (Czech Republic)

JWG 2.2: Absolute Gravimetry and Absolute Gravity Reference System
(joint with IGFS)
Chair: H. Wilmes (Germany)

JWG2.3: Assessment of GOCE Geopotential Models
(joint with IGFS)
Chair: J. Huang (Canada)

JWG2.4: Multiple geodetic observations and interpretation over Tibet, Xinjiang and Siberia (TibXS)
(joint with Commission 3)
Chair: Ch. Hwang (Taiwan)

JWG2.5: Physics and dynamics of the Earth's interior from gravimetry
(joint with Commission 3)
Chair: I. Panet (France)

JWG2.6: Ice melting & ocean circulation from gravimetry
(joint with Commission 3)
Chair: J. Schröter (Germany)

JWG 2.7: Land hydrology from gravimetry
(joint with Commission 3)
Chair: A. Eicker (Germany)

JWG 2.8: Modeling and Inversion of Gravity-Solid Earth Coupling
(joint with Commission 3)
Chair: C.Braitenberg (Italy)

JWG 0.1.1: Vertical Datum Standardization
(joint with GGOS, IGFS and Commission 1, description see GGOS)
Chair: L.Sánchez (Germany)

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.

The principal symposium that will be organized by Commission 2 and the IGFS in the next period will be held in Venice in October 2012. A second symposium will be organized by the IGFS in 2014. The other two symposia where a Commission 2 meeting will be held are the IAG scientific assembly 2013 in Potsdam and the IUGG General Assembly 2015 in Prague.

The status of Commission 2, including its structure and membership, as well as links to the internet sites of its sub-entities and parent and sister organizations and services, will be updated regularly and can be viewed on the web site: http://www.iag-commission2.ch.

Steering Committee

- President: Urs Marti (Switzerland)
- Vice President: Srinivas Bettadpur (USA)
- Chair SC 2.1: Leonid F. Vitushkin (Russia)
- Chair SC 2.2: Yan Ming Wang (USA)
- Chair SC 2.3: Roland Pail (Germany)
- Chair SC 2.4: Hussein Abd-Elmotaal (Egypt)
- Chair SC 2.5: Xiaoli Deng (Australia)
- Chair SC 2.6: Shuanggen Jin (China)
- Chair JP 2.1: Oliver Baur (Austria)
- Representative of the IGFS: Rene Forsberg (Denmark)
- Member at large: MC Pacino (Argentina)
- Member at large: Yoichi Fukuda (Japan, past president)

The steering committee will meet at least once per year. These meetings are open for all interested IAG members.

Sub-Commissions

SC 2.1: Gravimetry and Gravity Networks

Chair: Leonid F. Vitushkin (Russia)

Terms of Reference and Objectives

IAG Sub-commission 2.1 "Gravimetry and gravity networks" promotes scientific studies of the methods and instruments for terrestrial, airborne, shipboard and planetary gravity measurements, establishment of gravity networks and improvement of strategy in the measurement of gravity networks provided by growing number of absolute gravity determinations and the sites for such determinations. The Sub-commission provides the geodesy-geophysics community with the means to access the confidence in gravity measurements at the well-defined level of accuracy through organizing, in cooperation with metrology community, Consultative Committee on Mass and Related Quantities and its Working Group on Gravimetry (CCM WGG), Regional Metrology Organizations (RMO) the international comparisons of absolute gravimeters on continental scale. The Sub-commission proceeds from such point-wise gravimetry to precise gravimetry/gradiometry which should cover, in particular, the land-sea border areas to resolve still existing problem of significant biases and errors in determination. The Sub-commission promotes such research and development by stimulating airborne and shipboard gravimetry and gradiometry. 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.

The Sub-commission supports the development of the International Gravity Reference System (IGRS) for GGOS technically and through organization of comparisons of absolute gravimeters at the sites of IGRS in cooperation with relevant metrological bodies.

The Sub-commission in collaboration with metrology community promotes the implementation of the system of metrological support (calibration, verification, comparisons) of absolute gravimeters belonging to geodesy-geophysics community.

In collaboration with JWG 2.2 "Absolute Gravimetry and Absolute Gravity Reference System" the Sub-commission works on the standardization of absolute gravity data, software for absolute gravity measurement and appropriate information. The Sub-commission will encourage regional meetings or workshops dedicated to specific problems, where appropriate.

To meet these goals, the SC 2.1 sets up the Joint Working Group JWG 2.1: “Techniques and Metrology in Absolute Gravimetry” and appointed the Steering Committee consisted of the members which are the specialists in the fields of gravimetry related to the activities of SC2.1 and the contact persons for European, East Asia and Western Pacific, South America and North America Gravity Networks)

Program of Activities

- selection in collaboration with Commission 2 – IGFS JWG 2.2 and CCM WGG of the sites for regional comparisons of absolute gravimeters, as the basis for IGRS
- supporting the CCM and RMO Key Comparisons of absolute gravimeters on four-yearly and two year scale, correspondingly
- providing the results of comparisons of absolute gravimeters to data base AGrav at BKG-BGI
- supporting the scientific investigations of absolute and relative (including the superconducting) gravimeters on static and moving platforms
- organization of the Third IAG Commission 2 Symposium "Terrestrial Gravimetry. Static and mobile measurements – TGSMM-2013"

Steering Committee

Chair: Leonid Vitushkin (Russia)
Vice Chair: Hideo Hanada (Japan)
Matthias Becker (Germany, Relative Gravimetry and European Gravity Networks)
Herbert Wilmes (Germany, Absolute Gravimetry Data and Absolute Gravity Reference System)
Vojtech Palinkas (Czech Republic, Techniques, Metrology and Comparisons of Absolute Gravimeters)
David Crossley (USA, Superconductive Gravimetry)
Uwe Meyer (Germany, Aerogravimetry and Gradiometry)
Dag Solheim (Norway, Shipboard Gravimetry)
Yoichi Fukuda (Japan, East Asia and Western Pacific Gravity Networks)
Maria Cristina Pacino (Argentina, South America Gravity Networks)
Mark Eckl (USA, North America Gravity Networks)

SC 2.2: Spatial and Temporal Gravity Field and Geoid Modeling

Chair: Yan Ming Wang (USA)

Terms of Reference

Sub-Commission 2.2 (SC2.2) promotes and supports scientific research on modeling the Earth's gravity field, including determination of the geoid which is partially inside the Earth's topography.
In today's satellite age, satellite gravity missions deliver very accurate long to medium wavelength of the gravity field, and the Global Positing System provides positions with cm or better accuracy anywhere on planet Earth. On the other hand, gravity and other related data have been collected and monitored by using airplanes, moving vehicles, relative/absolute gravity projects and networks, and other means. The SC2.2 aims at bringing together scientists concerned with all aspects of the diverse areas of geodetically relevant theory and its applications. Its goal is to advance theories and computational methods to ensure that the static and time varying gravity fields are modeled with the required accuracy.

Objectives

Research related to gravity field determination, e.g., studies of the geodetic boundary value problem (free and fixed boundary value problems); development and refinement of gravity/topographic reduction theories; exploration and implementation of numerical methods of partial differential equations for Earth's gravity field determination (e.g., domain decomposition, spectral combination and others).
In more details, this includes:

- Studies of the effect of topographic density variations on the Earth's gravity field, including the geoid.
- Rigorous yet efficient calculation of the topographic effects, refinement of the topographic and gravity reductions.
- Studies on harmonic downward continuations.
- Non-linear effects of the geodetic boundary value problems on geoid determination.
- Optimal combination of global gravity models with local gravity data.
- Exploration of numerical methods in solving the geodetic boundary value problem (domain decomposition, finite elements, and others).
- Studies on data requirements, data quality, distribution and sampling rate, for a cm- accurate geoid.
- Studies on the interdisciplinary approach for marine geoid determination, e.g., research on realization of a global geoid consistent with the global mean sea surface observed by satellite altimetry.
- Studies on airborne, shipborne gravimetry and the application of satellite altimetry in geodesy.
- Studies on W_0 determination, and on global and regional vertical datum realization.
- Studies on ocean, solid-Earth and polar tides.
- Studies on time variation of the gravity field due to postglacial rebound and land subsidence.
- Studies on geocenter movement and time variation of J_n and its impact on the geoid.

Program of Activities

- Organizing meetings and conferences.
- Inviting the establishment of Special Study Groups on relevant topics.
- Reporting activities of SC2.2 to the Commission 2.

SC 2.3: Dedicated Satellite Gravity Missions

Chair: Roland Pail (Germany)

Terms of Reference

Sub-commission 2.3 promotes scientific investigations concerning the dedicated satellite gravity field missions CHAMP, GRACE and GOCE, the development of alternative methods and new approaches for global gravity field processing also including complementary gravity field data types, as well as interfacing to user communities and relevant organizations.

Objectives

The successful launches of the German CHAMP (2000), the US/German GRACE (2002) and the ESA GOCE (2009) missions have led to a revolution in global gravity field mapping by space-borne observation techniques. Due to the fact that they are the only measurement system which can directly observe mass and mass transport in the Earth system, they provide valuable contributions to many geoscientific fields of application, such as geodesy, hydrology, oceanography, glaciology, and solid Earth physics. These missions have proven new concepts and technologies, such as high-low satellite-to-satellite tracking (SST) using the GPS constellation, low-low SST based on micro-wave ranging, and satellite gravity gradiometry (SGG), as well as space-borne accelerometry. GRACE has produced consistent long- to medium-wavelength global gravity field models and its temporal changes. GOCE provides high-accuracy and high-resolution static gravity field models. In combination with complementary gravity field information from terrestrial data, satellite altimetry, an even higher spatial resolution can be achieved. Additionally, based on challenging user requirements, concepts of future gravity field missions are developed and investigated.

Program of Activities

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

- generation of static and temporal global gravity field models based on observations by the satellite gravity missions CHAMP, GRACE, and GOCE, as well as optimum combination with complementary data types (SLR, terrestrial and air-borne data, satellite altimetry, etc.).
- investigation of alternative methods and new approaches for global gravity field modelling, with special emphasis on functional and stochastic models and optimum data combination.
- identification, investigation and definition of enabling technologies for future gravity field missions: observation types, technology, formation flights, etc.
- communication/interfacing with gravity field model user communities (climatology, oceanography/altimetry, glaciology, solid Earth physics, geodesy, ...).
- communication/interfacing with other IAG organizations, especially the GGOS Working Group for Satellite Missions and the GGOS Bureau for Standards and Conventions

Steering committee

- Chair: Roland Pail (Germany)
- Srinivas Bettadpur (USA)
- Sean Bruinsma (France)
- Frank Flechtner (Germany)
- Thomas Gruber (Germany)
- Gerhard Heinzel (Germany)
- Cheinway Hwang (Taiwan)
- Torsten Mayer-Gürr (Austria)
- Federica Migliaccio (Italy)
- Ulrich Meyer (Switzerland)
- Pieter Visser (the Netherlands)

SC 2.4: Regional Geoid Determination

Chair: Hussein Abd-Elmotaal (Egypt)

Terms of Reference and Objectives

Sub-Commission 2.4 is concerned with the following areas of investigation:

- Regional gravity and geoid sub-commissions: data sets, involved institutions, comparison of methods and results, data exchange, comparison with global models, connection of regional models
- Gravimetric geoid modeling techniques and methods, available software, new alternative geoid determination techniques
- 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.

Program of Activities

Sub-Commission 2.4 is going to initiate and coordinate regional gravity and geoid sub-commissions. It will encourage and support the data exchange between agencies and will assist local, regional and national authorities in their projects of gravity field determination. It will help in organizing courses and symposia for gravity field determination.

Steering Committee

Chair: Hussein Abd-Elmotaal (Egypt)
Chair SC2.4a: Heiner Denker (Germany)
Chair SC2.4b: Maria Cristina Pacino (Argentina)
Chair SC2.4c: David Avalos (Mexico)
Chair SC2.4d: Hussein Abd-Elmotaal (Egypt)
Chair SC2.4e: Will Featherstone (Australia)
Chair SC2.4f: Mirko Scheinert (Germany)

SC 2.4a: European Gravity and Geoid

Chair: Heiner Denker (Germany)

Terms of Reference

The primary objective of the sub-commission is the development of improved regional gravity field models (especially geoid/quasigeoid) for Europe which can be used for applications in geodesy, oceanography, geophysics and engineering, e.g., height determination with GNSS techniques, vertical datum definition and unification, dynamic ocean topography estimation, geophysical modelling, and navigation.

The modelling will be based mainly on terrestrial gravity and terrain data in combination with the latest available global geopotential models. In this context, the upgrade of the terrestrial data sets as well as the inclusion of the CHAMP and GRACE based global geopotential models lead to significant improvements. The evaluation of the present European Gravimetric Geoid 2008 (EGG2008) by GNSS and levelling data indicates an accuracy potential of 1 – 3 cm on a national basis, and 2 – 5 cm at continental scales, provided that high quality and resolution input data are available within the area of interest. Further improvements are expected from the utilization of the GOCE based geopotential models as well as from further upgrades of the terrestrial data base.

Structure

The regional sub-commission for Europe SC2.4a has national delegates from most of the countries in Europe and reports to sub-commission 2.4. The existing contacts and successful cooperation with the respective delegates and national and international agencies shall be continued and extended.

Program of Activities

- Utilization of new geopotential models based on the GOCE mission.
- Identification and acquisition of new terrestrial data sets including gravity, terrain, and GPS/levelling data.
- Merging and validation of all data sets.
- Refinement of the mathematical modelling and numerical tests.
- Investigation of different data combination approaches.
- Computation of new geoid and quasigeoid models.
- Evaluation of the results by GNSS/levelling data.
- Study of applications, such as vertical datum definition and unification, dynamic ocean topography estimation, etc.

SC 2.4b: Gravity and Geoid in South America

Chair: Maria Cristina Pacino (Argentina)
Co-Chair: Denizar Blitzkow (Brazil)

Terms of Reference and Objectives

The Sub Commission 2.4b entitled Gravity and Geoid in South America, as part of the Commission 2 of IAG, was established as an attempt to coordinate efforts to establish a new Absolute Gravity Network in South America, to carry out gravity densification surveys, to derive a geoid model for the continent as a height reference and to support local organizations in the computation of detailed geoid models in different countries.

Besides, a strong effort is being carried out in several countries in order to improve the distribution of gravity information, to organize the gravity measurements in the continent and to validate the available gravity measurements.

The main objectives of the project are:

- To re-measure existent absolute gravity stations and to encourage the establishment of new stations.
- To validate fundamental gravity network 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 together.
- To obtain and to maintain files with data necessary for the geoid computation like gravity anomalies, digital terrain models, geopotential models and satellite observations (GPS) on the levelling network of different countries.
- To provide a link between the different countries and the IGFS in order to assure access to proper software and geopotential models for local geoid computation.
- To compute a global geoid model for South and Central America 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 endeavouring to increase the gravity data coverage, to improve the existing digital terrain models, to carry out GPS observations on the levelling network and to compute a high resolution geoid.
- To organize and/or encourage the organization of workshops, symposia or seminars on gravity and geoid determination in South America.
- To test and to use future geopotential models derived from the modern missions (GRACE and GOCE) as well as any new combined model (e.g. EGM2008).
- To support the IAG Sub-Commission 1.3b (Reference Frame for South and Central America, SIRGAS) in the activities related to the unification of the existing vertical datums.
- Establish close connections with SC2.4c (Gravity and Geoid in North and Central America) to have a good overlap of data coverage in Central America and the Caribbean.

SC 2.4c: Gravity and Geoid in North and Central America

Chair: David Avalos (Mexico)

Terms of Reference and Objectives

The primary objective of this Sub-commission is the development of a regional gravity field and geoid model covering the region of North America and Central America in order to achieve a common vertical datum. The region involved will encompass Iceland, Greenland, Canada, the U.S.A. (including Alaska and Hawaii), Mexico, countries forming Central America, the Caribbean Sea and the northern parts of South America.

The intention is to ensure that a suitable North American Geoid is developed to serve as a common datum for everyone in the region. All countries in the region would be served by having access to a common model for translating oceanographic effects to terrestrial datums for various scientific, commercial, engineering and disaster preparedness applications. Likewise, it shall serve as the basis for a forthcoming International Great Lakes Datum model in 2015 (IGLD 15).

The achievement of a geoid model for North and Central America will be accomplished by coordinating activities among agencies and universities with interest in geoid theory, gravity, gravity collection, gravity field change, geophysical modeling, digital elevation models (DEM), digital density models (DDM), altimetry, dynamic ocean topography, leveling and vertical datums. Of particular interest will be relating geoid and ocean topography models to ocean topography and tidal bench marks, taking advantage of the recent satellite altimetry and geopotential field products.

The determination of a geoid model for North and Central America is not limited to a single agency, which will collect all necessary data from all countries. The Sub-commission encourages theoretical diversity in the determination of a geoid model among 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.

Program of Activities

The Sub-commission will support geoid activities in countries where geoid expertise is limited by encouraging more advanced members to contribute their own expertise and software. The Sub-commission will encourage training and education initiative of its delegates (e.g., IGeS geoid school, graduate studies and IPGH technical cooperation projects). Starting on 2011 the Sub-commission will

organize regular meetings with representatives of Central American and Caribbean countries to promote an increase of expertise as well as to create a wide network of specialists.

The chair of the Sub-commission 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 Sub-commission will keep close contact with all related Study Groups of the IAG. The Sub-commission is open to all geodetic agencies and universities across North and Central America with an interest in the development of a geoid model for the region. The meetings of the Sub-commission 2.4c are open to everyone with interests in geodesy, geophysics, oceanography and other related topics.

The delegates will communicate primarily using e-mail. However, the sub-commission plans to arrange annual meetings. Preferably, these meetings will be held during international conferences where most delegates will be present; however, some meetings will be held within the region to minimize travel costs. Minutes of meetings will be prepared and sent to all delegates of the Sub-commission.

Delegates

- Chair: David Avalos (Mexico)
- Rene Forsberg (Denmark)
- Marc Véronneau (Canada)
- Dan Roman (USA)
- Laramie Potts (USA)
- Vinicio Robles (Guatemala)
- Carlos E. Figueroa (El Salvador)
- Anthony Watts (Cayman Islands)
- Oscar Meza (Honduras)
- Alvaro Alvarez (Costa Rica)
- Wilmer Medrano (Nicaragua)
- Christopher Ballesteros (Panama)

SC2.4d: Gravity and Geoid in Africa

Chair: Hussein Abd-Elmotaal (Egypt)

Terms of Reference

The African Gravity and Geoid regional sub-commission (AGG) belongs to the Commission 2 of the International Association of Geodesy (IAG). The main goal of the African Gravity and Geoid regional sub-commission is to determine the most complete and precise geoid model for Africa that can be obtained from the available data sets. Secondary goals are to foster cooperation between African geodesists and to provide high-level training in geoid computation to African geodesists.

Objectives and Activities

The objectives and activities of the regional sub-commission are summarized as follows:

- Identifying and acquiring data sets - gravity anomalies, DTMs, GPS/leveling.
- Training of African geodesists in geoid computation.
- Merging and validating gravity data sets, producing homogenous gravity anomalies data set ready for geoid computation.
- Computing African geoid**.**
- Evaluating the computed geoid using GPS/leveling data.

Steering Committee

- Chair: Hussein Abd-Elmotaal (Egypt)
- Charles Merry (South Africa)
- Ahmed Abdalla (Sudan)
- Benahmed Daho (Algeria)
- J.B.K. Kiema (Kenya)
- Joseph Awange (Kenya)
- Ludwig Combrinck (South Africa)
- Prosper Ulotu (Tanzania)

Delegates

- Addisu Hunegnaw (Ethiopia)
- Adekugbe Joseph (Nigeria)
- Albert Mhlanga (Swaziland)
- Francis Aduol (Kenya)
- Francis Podmore (Zimbabwe)
- Godfrey Habana (Botswana)
- Hassan Fashir (Sudan)
- Ismail Ateya Lukandu (Kenya)
- Jose Almeirim (Mozambique)
- Karim Owolabi (Namibia)
- Peter Nsombo (Zambia)
- Saburi John (Tanzania)
- Solofo Rakotondraompiana (Madagascar)
- Tsegaye Denboba (Ethiopia)

SC 2.4e: Gravity and Geoid in the Asia-Pacific

Chair: Will Featherstone (Australia)

Context

Depending on one's definition of the Asia-Pacific (AP) region, this SC could cover as many as 48 counties. Moreover, these countries are very diverse in terms of language, political persuasions, governments and wealth. This poses a significant challenge for the exchange of gravity and geoid data and expertise.
Not only unique to the AP region, the management and administration of gravity and the geoid can be vastly different in each country, making the coordination of such a group challenging. Taking Australia as an easy example, the gravity database is administered by a different government division to the administration of the national quasigeoid model.

Terms of Reference and Objectives

Promote the cooperation in and knowledge of gravity, geoid and closely related studies in the Asia-Pacific region.
The executive committee should be small to ensure efficiency, but the larger committee should comprise one member from each participating country. Because of the need to carry national authority, the national member is logically the officer in the country's geodetic authority responsible for its quasi/geoid and/or vertical datum matters.
Because of the synergy that exists between the objectives of this SC and those of the Geodesy Working Group of the UN Permanent Committee for GIS Infrastructure for Asia and the Pacific (PCGIAP), it is logical to liaise with this working group.

Program of Activities

Liaise with the Geodesy Working Group of the PCGIAP and other nations in the Asia-Pacific region, initially through the production of a flier that outlines the benefits of cooperation and data sharing.

Audit, document and catalogue the gravity and geoid-related that exists – including airborne campaigns. It is also important to establish a protocol for sharing the data. National authorities may be reluctant to give all the data available and at the precision available. It should be possible for geoid evaluation purposes, however, to decrease the resolution and accuracy of data shared along common borders without either comprising the precision of the geoid significantly, or the security of the national data shared.

Topics of interest

a) Gravity and Related Data

Explore ways in which we may

- share available gravity data (e.g. via International Gravity Bureau)
- share available DEMs along common borders (National Geodetic Authorities)
- combine resources for terrestrial gravity surveys along common borders
- combine resources for airborne gravity surveys in the region.

b) Quasi/geoid Control

Explore ways in which countries of the region may cooperate by

- sharing geometric (GNSS/leveling and vertical deflections) geoid control data
- combining efforts in global GNSS campaigns
- undertaking joint campaign for the connection of regional vertical datums.

c) Education & Research

Encourage and sponsor, for the region,

- meetings and workshops, in cooperation with the International Geoid Service, to foster understanding in the evaluation and use of gravimetric quasi/geoids, and in their application to efficient height determination with GNSS.
- technical sessions in scientific and professional conferences
- research into matters of common concern/interest.

SC 2.4f: Gravity and Geoid in Antarctica (AntGG)

Chair: Mirko Scheinert (Germany)

Terms of Reference and Objectives

Antarctica is the region which still possesses the largest data gaps in terrestrial gravity. Especially with regard to the latest satellite gravity field mission GOCE the polar data gap in terrestrial gravity deteriorates the model solutions. Generally, also the existing Antarctic gravity data coverage is heterogeneous and exhibits inconsistencies. However, globally distributed gravity data are needed for the global high-resolution determination of the Earth's gravity field. Regionally densified Antarctic gravity data shall be used for a validation of global gravity field models and, finally, for a regional improvement of the Antarctic geoid. Nevertheless, due to the vast extension of the Antarctic continent, its hostile environment and the difficult logistic conditions it is a long-lasting task to close the Antarctic data gaps in terrestrial gravity. AntGG shall pursue this objective and shall facilitate the necessary coordination to release gridded gravity datasets for Antarctica. It plays an important role to improve the cooperation between all interested scientists of geodesy and of neighboring disciplines, mainly geophysics.

Program of Activities

- Promoting the collection of surface and airborne gravity data in Antarctica
- Promoting new gravity surveys in Antarctica, especially airborne gravimetry
- Promoting the establishment and (re-)measurement of reference gravity stations utilizing absolute gravity meters
- Promoting the scientific exchange of latest developments in technology (esp. airborne gravimetry) and data analysis
- Evaluation of existing and new surface and airborne gravity data, validation of global gravity field models in Antarctica
- Investigation of optimum strategy for the combination of gravity data of different sources, release of gridded gravity anomaly dataset(s) for Antarctica
- Focus group for all scientists interested in Antarctic gravity and geoid, and cooperation with similar data initiatives, especially within the Scientific Committee on Antarctic Research (SCAR)

Delegates

Chair: Mirko Scheinert (Germany)
Don Blankenship (USA)
Alessandro Capra (Italy)
Detlef Damaske (Germany)
Fausto Ferraccioli (UK)
Christoph Förste (Germany)
René Forsberg (Denmark)
Larry Hothem (USA)
Wilfried Jokat (Germany)
Gary Johnston (Australia)
Steve Kenyon (USA)
German L. Leitchenkov (Russia)
Jaakko Mäkinen (Finland)
Yves Rogister (France)
Kazuo Shibuya (Japan)
Michael Studinger (USA)
Yuande Yang (China)

Associates

Matt Amos (New Zealand)

SC 2.5 Satellite Altimetry

Chair: Xiaoli Deng (Australia)

Terms of Reference

For long-term geodetic and climate change studies, a series of repeat-track radar altimeter satellite missions (e.g., Geosat/GFO, TOPEX/Jason-1/-2/-3, ERS-1/-2/Envisat, Cryosat-2, Altika, and Sentinel-3) have made and will continue to monitor ocean surface height globally. Missions of the CryoSat-2 InSAR/SAR altimetry and ICEsat-1/-2 laser altimetry are significantly improving observations of the cryosphere, sea-ice and ice-covered oceans. CryoSat-2 altimetry in its conventional LRM and SAR modes, will be the best chance to improve the marine gravity field by a factor of two in the near future. The future planned Surface Water and Ocean Topography (SWOT) wide-swath synthetic aperture radar interferometry (InSAR) altimetry mission is about to map high spatial resolution oceanic sub-mesoscale variability and surface water hydrology. Another potential technology under development is the so-called GNSS-R altimetry or reflectometry. With these existing and new technological advances in altimetry, the purpose of this IAG sub-commission is to promote innovative research involving the use of historic and future altimeter observations on the studies of local, regional, and global geophysical processes, with emphasis on emerging cross-disciplinary applications using satellite altimetry, and in combination with other data sets, including *in situ* hydrography data (XBT/MBT/Argo) and GRACE/GOCE. The research results and potential data products will benefit IAG's Global Geodetic Observing System (GGOS) and the International Altimetry Service (IAS).

Objectives

General objectives of the Sub-Commission 2.5 will include:

- To establish a close link between this sub-commission and international altimeter services to bridge the gaps on new research and application data products or services not currently available, in terms of establishing scientific forums to discuss new result results, and as expert users, suggesting to altimeter services to develop more efficient procedures and new data products involving cross-disciplinary applications using satellite altimetry;
- To promote innovative applications of satellite altimetry, including evaluations and cross-disciplinary applications of future satellite altimetry;
- To continue developing techniques to improve altimeter data quality towards new data products in coastal zones including coastal ocean, estuaries, and coastal land;
- To promote cross-disciplinary research to improve the determinations of the shapes and temporal variations of land/ice/ocean surfaces, such as studies of coastal ocean variability, regional sea level change, mountain glaciers/ice-sheet ablations/accumulations, permafrost degradation, coastal and ice-shelf ocean tides, vertical displacements at major tectonic-active zone and due to other geophysical processes;
- To improve the marine geoid, mean dynamic ocean topography, temporal variations induced by solid Earth processes and global terrestrial water cycle; and
- To establish a specific connection with relevant altimetry observing systems in IAG's GGOS and IAS.

Program of Activities

This sub-commission will organize independent workshops or special sessions in major meetings to promote altimetric applications in interdisciplinary earth sciences, and to increase the visibility of IAG in altimetric science. Special study groups will be established to investigate important issues.

Steering Committee

- Chair: Xiaoli Deng (Australia)
- Vice Chair: C.K. Shum (USA)
- Ole Andersen (Demark)
- Cheinway Hwang (Taiwan)
- Walter Smith (USA)
- David Sandwell (USA)
- Per Knudsen (Demark)
- Wolfgang Bosch (Germany)

SC 2.6:Gravity and Mass Displacements

Chair: Shuanggen Jin (China)

Terms of Reference

The variation of gravity field is related to the physic processes and dynamics of the Earth's interior, Earth system coupling and in particular interactions between atmosphere, hydrosphere, cryosphere, land surface and the solid Earth. Nowadays the gravity field, derived from terrestrial and space gravimetry (e.g. CHAMP, GRACE, and GOCE…) with unprecedented accuracy and resolution, provides a unique opportunity to investigate gravity-solid earth coupling, the structure of the globe from the inner core to the Earth's crust, physics and dynamics of the Earth's interior, and mass flux such as within the ocean-land water cycle. It also contributes to a better understanding of the interactions in the Earth's interior and its response to climate change.

Objectives:

- To model and inverse gravity-solid Earth coupling, e.g. crust thickness, isostatic Moho undulation, mass loadings, basin formation, thermal effects on density, gravity tensor and gravity field related deformation as well as interactions with the Earth' interior.
- To understand the physics and dynamics of the Earth's interior using gravity and other geophysical measurement techniques.
- To quantify Earth's mass flux and their interactions and, in particular, to study gravity role in the understanding of the ocean-land-cryosphere cycle.
- To promote/communicate with gravity-related communities (Oceanography, Hydrology, Cryosphere, Solid-Earth, Geodesy...)

Program of Activities

The Sub-commission will establish Work Groups (WGs) on relevant topics, and model and inverse gravity-Earth System coupling, structure and dynamics of the Earth's interior and their interactions. A Steering Committee will work closely with members and other IAG Commissions/Sub-Commissions to obtain mutual goals. Also it will promote and jointly sponsor special sessions at IAG Symposia and other workshop/conferences.

Steering Committee

- Chair: Shuanggen Jin (China)
- Co-Chair: Jürgen Kusche (Germany)
- Carla Braitenberg (Italy)
- Annette Eicker (Germany)
- Isabelle Panet (France)
- Jens Schroeter (Germany)
- Séverine Rosat (France)

JP 2.1: Geodetic Planetology (JP-GP)

Chairs: Oliver Baur (Austria) and Shin-Chan Han (USA)

Terms of Reference

Precise knowledge about the thermal evolution, composition, shape and dynamics of extra-terrestrial bodies is increasingly accessible from science data collected by space-geodetic methods. With growing opportunities from the past, current and future satellite missions to the planets of the solar system and other bodies in outer space, it is timely to explore various space-geodetic theory and methodologies to enhance the scientific return of the planetary missions for improved understanding of the planets or satellites.

In the last decades, geodetic planetology has experienced considerable advance. Data collected by spacecraft orbiting the Earth's moon (e.g., Lunar Prospector, SELENE/Kaguya, Lunar Reconnaissance Orbiter), Mars (Mars Global Surveyor, Mars Odyssey, Mars Reconnaissance Orbiter), Venus (Magellan), and Mercury (Messenger) revealed increasingly detailed structures of the gravity field, shape, surface and atmosphere of these celestial bodies. Forthcoming missions to the Earth's moon (GRAIL), Mercury (BepiColombo), Jupiter (JUNO), and the Jovian system (EJSM-Laplace) will ensure ongoing progress. The space-geodetic methods used in planetary geodesy include range and range-rate orbit tracking, VLBI, altimetry, and photogrammetric remote sensing; these observation techniques are well-known from terrestrial applications.

The main motivation to constitute a Joint Project on Geodetic Planetology (JP-GP) within the IAG is the scientific proximity of planetary geodesy to the activities of the IAG Commissions, the ICCT and the IAG services. This proximity particularly holds to Commission 1 (Reference Frames), Commission 2 (Gravity Field), Commission 3 (Earth Rotation and Geodynamics), and the ICCT. High-accuracy determination of reference frames is the basis for the quantification of dynamic processes on and beneath a body's surface, the detection of variations in its rotational behavior and precise orbit determination of satellites. The gravity field is a key quantity to assess information on a body's composition and interior structure; furthermore, knowledge about the gravity field allows for the tailored orbit design of artificial satellites, for instance with regard to robotic and human landing. Rotation characteristics of celestial bodies include length-of-day variations, polar motion, precession, nutation or libration. These areas of research require sophisticated physical and mathematical modeling in the framework of a concise theoretical background. In summary, promoting geodetic planetology is an inter-disciplinary effort, and hence demands for collaboration with all IAG components.

Within the 4-year horizon 2011-2015, the JP-GP will start to initiate and promote geodetic research of extra-terrestrial

bodies. Furthermore, in terms of sustainable follow-on activities, the project envisages the establishment of an Inter-Commission Committee on Geodetic Planetology for the next period 2015-2019. Towards that goal, the JP-GP aims to:

- support scientific activities related to the gravity field and orbit determination, topography, physical shape (geoid), interior structure and rotation characteristics of planetary bodies, together with the establishment and maintenance of reference frames;
- encourage the cooperation between the terrestrial geodesy and planetary geodesy communities by promoting the exploitation of synergies;
- provide an international platform for the transfer of knowledge and experience on geodetic theory and data analysis including radio science, altimetry, and stereo images;
- coordinate interdisciplinary research activities.

Organization

The JP-GP is joint with the ICCT and the Commissions 1, 2, and 3, with Commission 2 being the lead commission. The activities of the JP-GP are coordinated by a Steering Committee consisting of the President, the Vice President, representatives from the Commissions 1, 2, and 3 (one representative from each commission), and a representative from the ICCT.

Objectives

The main objective of the JP-GP is to initiate and promote geodetic research of extra-terrestrial bodies. In particular, the JP-GP will

- act as a framework for geoscientific discussion and cooperation concerning the study of the planets of the solar system and other bodies in outer space;
- promote the integration of advanced space-geodetic methods for planetary purposes, including the development of tailored methodologies for data exploitation and interpretation;
- support interdisciplinary activities of the ICCT in geodetic theory and data analysis;
- help to develop future geodetic technologies and mission designs for planetary geodesy;
- explore the possibility of sustainable collaboration with the IAU/IAG Working Group on Cartographic Coordinates and Rotational Elements (WGCCRE)
- establish an Inter-Commission Committee on Geodetic Planetology for the period 2015-2019.

Output

The outputs after the 4-year time frame 2011-2015 are:

- Establishment of geodetic planetology within the IAG;
- Organization of a Workshop with interdisciplinary emphasis;
- Establishment of an Inter-Commission Committee on Geodetic Planetology for the period 2015-2019.

Steering Committee

Chair: Oliver Baur (Austria)
Vice Chair: Shin-Chan Han (USA)
Commission 1 Representative: Tonie van Dam (Luxembourg)
Commission 2 Representative: Urs Marti (Switzerland)
Commission 3 Representative: Richard Gross (USA)
ICCT Representative: Nico Sneeuw (Germany)

Members

Markus Antoni (Germany)
Brent Archinal (USA)
Ali Ardalan (Iran)
Georges Balmino (France)
Veronique Dehant (Belgium)
Shuanggen Jin (China)
Anno Löcher (Germany)
Jürgen Müller (Germany)
Nico Sneeuw (Germany)
Dimitrios Tsoulis (Greece)
Pieter Visser (Netherlands)

Joint Working Groups

JWG 2.1: Techniques and Metrology in Absolute Gravimetry

(Joint with the IGFS)

Chair: Vojtech Palinkas (Czech Republic)

Terms of Reference

Absolute ballistic gravimeters have become the primary measurement standards for the determination of free-fall acceleration. Currently the only way for the realization of the gravity reference is realized by the comparisons of the absolute gravimeters, which has to be organized and accomplished in such a way that the high requirements in gravity measurements in geosciences and metrology are fulfilled. Principal tasks of the Working Group are thus closely connected with the four-yearly International Comparisons of Absolute Gravimeters (ICAGs) and relevant Regional International Comparisons of Absolute Gravimeters (RICAGs) in the frame of regional structures of metrology community Regional Metrology Organizations (RMO) at the sites selected on a continental scale.

The Working Group will participate on the organization of comparisons under close cooperation with the BIPM Working Group on Gravimetry of Consultative Committee on Mass (CCM) and Related Quantities (CCM WGG) and

the IAG Joint Working Group on Absolute Gravimetry and Absolute Gravity Reference System (JWG2.2). The connection between ICAGs and RICAGs has to be established by means of reliable absolute gravimeters participating in both kinds of comparisons. An important benefit of a distributed network of Regional Comparison Sites would be that it makes an invaluable contribution to establishing a Global Gravity Reference System. The sites should be related to RMO, for example, EURAMET – European Metrology Organization, SIM – Inter-American Metrology System, APMP - Asia-Pacific Metrology Program, etc.).

The Joint Working Group aims to deal with technical and metrological aspects in absolute gravimetry and theirs realization within a system of comparisons. The increasing demand for reliability and confidence in absolute gravity measurements requires further progress in the comparisons under certain aspects: organization, measurement optimization, combination of different methods of measurements, data analysis, estimation of uncertainties or investigations of systematic effects. In keeping with the above mentioned, the technical protocol of the comparisons has to be developed according to the rules of the international Mutual Recognition Arrangement for national measurement standards and for calibration and measurement certificates issued by National Metrology Institutes.

The WG will work in a close cooperation with metrology community on the implementation of the system of calibration and verification of absolute gravimeters at relevant National Metrology Institutes and designated institutes as other possibility, besides the comparisons, to determine the metrological characteristics of absolute gravimeters.

The relevance to the Working Group is that its members are the specialists as well from geodetic and geophysical communities, as from the metrological community, and this working group focuses more to participation of individual scientists than the more official CCM WGG where the membership is related to the institutes responsible for the traceability in gravimetry. Such inter-communications within the Working Group as well as a linkage between this group and CCM WGG will make it possible to develop the ICAGs and RICAGs to be supported by both communities.

Objectives

- The participation in the organization (in collaboration with CCM WGG and JWGAG2.2) of the four-year period ICAGs and additional RICAGs at the sites selected on a continental scale.
- The elaboration of criteria and recommendations for a distributed network of Comparison Sites.
- The progress of the comparisons of absolute gravimeters in terms of optimization, measurement methods, data analysis, investigations of systematic effects and uncertainties.
- The development of the technical protocol of the comparisons.
- The collaboration with metrology community for the implementation of the system of calibration and verification of absolute gravimeters.

Members

- Chair: Vojtech Palinkas (Czech Republic)
- Henri Baumann, (Switzerland)
- Matthias Becker (Germany)
- Reinhard Falk (Germany)
- James Faller (USA)
- Olivier Francis (Luxembourg)
- Alessandro Germak (Italy)
- Jacques Hinderer (France)
- Zhiheng Jiang (BIPM)
- Jacques Liard (Canada)
- Jaakko Makinen (Finland)
- Sebastien Merlet (France)
- Christian Rothleitner (Luxembourg)
- Diethard Ruess (Austria)
- Sergiy Svitlov (Ukraine)
- Ludger Timmen (Germany)
- Michel Van Camp (Belgium)
- Leonid Vitushkin (Russian Federation)
- Herbert Wilmes (Germany)
- Shuqing Wu (China)

Corresponding Members

- Martin Amalvict (France)
- Ernst Boyarsky (Russian Federation)
- Nicholas Dando (Australia)
- Gleb Demianov (Russian Federation)
- Andreas Engfeld (Sweden)
- Filippo Greco (Italy)
- Vladimir Kaftan (Russian Federation)
- Jan Krynski (Poland)
- Chiungwu Lee (Taiwan)
- Nicolas Le Moigne (France)
- Shigeki Mizushima (Japan)
- Jan Mrlina (Czech Republic)
- Andrzej Pachuta (Poland)
- Alfredo Esparza Ramires (Mexico)
- René Reudink (The Netherlands)
- José Manuel Serna Puente (Spain)
- Dru Smith (USA)
- Yury Stus (Russian Federation)
- Simon Williams (United Kingdom)
- Daniel Winester (USA)
- Alexander Yankovsky (Russian Federation)

JWG 2.2: Absolute Gravimetry and Absolute Gravity Reference System

(Joint with the IGFS)

Chair: Herbert Wilmes (Germany)

Terms of Reference and Objectives

IAG Sub-Commission 2.1 "Gravimetry and Gravity Networks" promotes scientific investigations of gravimetry and gravity networks and terrestrial, airborne, shipboard and planetary gravity measurements. One of the outputs of the SC 2.1 activities is the result of gravity measurements, i.e. the gravity data.

The International Gravity Field Service IGFS coordinates the servicing of the geodetic and geophysical community with gravity field related data, software and information.
The IAG's scientific community demands more detailed information on the Earth's gravity field and its changes, and precise terrestrial absolute gravity (AG) observations are an important contribution to monitoring and understanding mass transports e.g. by hydrological and atmospheric variations or by changes in the solid Earth's geometry.

The role of absolute gravimetry increases with the growing number of absolute ballistic gravimeters and the rising number of AG measurements worldwide. The philosophy of gravity measurements has changed from rare AG determinations at a few principal network stations to repeated absolute gravity observations at global networks in combination with geometric geodetic observations. At selected sites, the AG observations are complemented by the high sensitivity of continuously observing superconducting (relative) gravimeters.

GGOS, the IAG Global Geodetic Observing System integrates different geodetic techniques, models and approaches to ensure a long-term, precise monitoring of the Earth's shape, the Earth's gravity field and the Earth's rotational motion. Consistent and precise absolute gravity measurements from a global network would be a valuable contribution to the GGOS infrastructure.

Up until now the Working Group of Absolute Gravimetry has been contributing to the development of the absolute gravity database AGrav which reached operational status and became a fixed part of the BGI (International Gravimetric Bureau) services. The database provides an overview of existing AG stations, observations, instruments and institutions, and facilitates the cooperation. Multidisciplinary cooperation and the combination of gravity data with other geodetic observation types is going to be essential for our future work.

The realisation of a global gravimetric reference relies upon well calibrated instruments and standards which in the case of absolute gravity determination is realized by the repeated comparison of the measuring instruments. Comparisons are carried out as four-yearly International Comparisons of Absolute Gravimeters (ICAGs) and as additional Regional International Comparisons of Absolute Gravimeters (RICAGs). Whereas these comparisons are prepared and carried out by JWG 2.1 this project at hand makes use of the comparison results and the data of the calibrated instruments. Triggered by BIPM's decision to close the comparison site at its premises, future ICAG and RICAG sites will develop to a distributed network with global distribution. Together with additional absolute gravity reference and comparison sites such a network gains the potential to build up a new International Gravity Reference System where the precise gravity reference is available and gravity field variations are monitored. This working group will contribute to this realisation and to the establishment of the necessary standards. The new International Gravity Reference System will be developed to replace the former IGSN71 (International Gravity Standardization Network 1971).

The proposed Working Group on Absolute Gravimetry will focus upon the following objectives:

- Continue the operation and improvement of the AGrav database for global absolute gravity measurements
- Provide AG metadata and data for GGOS to be used for the combination of AG measurements with geometric measurements (GNSS, SLR, VLBI) and for specific investigations
- Extend the AG database to store the comparison results from ICAG and RICAG sites
- Establish a new International Gravity Reference System based upon a distributed network of AG comparison and reference sites which can replace IGSN71
- Contribute to the agreement about the necessary standards and corrections
- Contribute to the Global Geodynamics Project GGP by the storage of repeated AG observations necessary for the determination of superconducting gravimeter drift and calibration parameters

Membership

- Chair: Herbert Wilmes (Germany)
- Jonas Ågren (Sweden)
- Martine Amalvict (France)
- Henri Baumann (Switzerland)
- Nicholas Dando (Australia)
- Mark Eckl (USA)
- Reinhard Falk (Germany)
- Domenico Iacovone (Italy)
- Jan Krynski (Poland)
- Jacques Liard (Canada)
- Jaakko Mäkinen (Finland)
- Urs Marti (Switzerland)
- Vojtech Palinkas (Czech Republic)

- Diethardt Ruess (Austria)
- Victoria Smith (UK)
- Gabriel Strykowski (Denmark)
- Ludger Timmen (Germany)
- Michel van Camp (Belgium)
- Leonid Vitushkin (Russia)
- Hartmut Wziontek (Germany)

Corresponding Members

- Mauro Andrade de Sousa (Brazil)
- Roger Bayer (France)
- In-Mook Choi (Korea)
- Andreas Engfeldt (Sweden)
- Yoichi Fukuda (Japan)
- Jose Manuel Serna Puente (Spain)
- Olga Gitlein (Germany)
- Mirjam Bilker Koivula (Finland)
- Alessandro Germak (Italy)
- Jacques Hinderer (France)
- Janis Kaminskis (Latvia)
- Steve Kenyon (USA)
- Jakub Kostelecky (Czech Republic)
- Dennis McLaughlin (USA)
- Tomasz Olszak (Poland)
- Bjorn Ragnvald Pettersen (Norway)
- Rene Reudink (the Netherlands)
- Heping Sun (China)
- V.M. Tiwari (India)

JWG 2.3: Assessment of GOCE Geopotential Models

(Joint with the IGFS)

Chair: Jianliang Huang (Canada)
Co-Chair: Christopher Kotsakis (Greece)

Terms of Reference and Objectives

The GOCE mission by European Space Agency is mapping the Earth's gravity field with the same level of accuracy as GRACE and a higher spatial resolution. GRACE and GOCE are complementary in terms of spectral sensitivity. A series of GOCE and GRACE&GOCE-based global gravity models have been released since 2010. Assessment of these models is commonly based on comparisons with other independent data that are direct and indirect observations of the Earth's gravity field. Such data include geoid heights from GPS and spirit leveled heights, airborne and surface gravity measurements, marine geoid heights from mean oceanographic sea surface topography models and altimetry observations, orbits from other geodetic and altimetry satellites etc. In response to the call of having an independent, coordinated and inclusive team for the assessment of the new GOCE models, a Joint Working Group (JWG) has been approved by IGFS and the IAG Commission 2 during IUGG 2011 in Melbourne, Australia. Its objectives are to develop new standard validation/calibration procedures, and to perform the quality assessment of GOCE- GRACE&GOCE-based satellite-only and combined solutions for the static Earth's gravity field.

The Joint Working Group reports to IGFS and the Commission 2.

Program of Activities

- The JWG creates opportunities through communication and conferences for international cooperation to develop and propose new standard methods for evaluating global EGMs using external data. A specific research area of interest will be the issue of how to handle the different spectral content of satellite-based global gravity field models and terrestrial gravity data.
- The JWG assesses new GOCE and GRACE&GOCE models.
- The JWG organizes a special session in the next IAG Commission 2 conference in Venice, Italy, in 2012.
- The JWG publishes assessment papers in a dedicated issue of the Newton's Bulletin in 2013.

Membership

- Hussein Abd-Elmotaal (Egypt)
- Jonas Ågren (Sweden)
- Ben Ahmed Daho Sid Ahmed (Algeria)
- Riccardo Barzaghi, on behalf of IGeS (Italy)
- Denizar Blitzkow (Brazil)
- Minkang Cheng (USA)
- Sten Claessens (Australia)
- Artu Ellmann (Estonia)
- Christoph Foerste (Germany)
- Thomas Gruber (Germany)
- Ali Kilicoglu (Turkey)
- Jiancheng Li (China)
- Pavel Novak (Czech Republic)
- Maria Cristina Pacino (Argentina)
- Dan Roman (USA)
- Gabriel Strykowski (Denmark)
- Viliam Vatrt (Czech Republic)
- Matthias Weigelt (Germany)

Corresponding members

- P. G. Vipula Abeyratne (Sri Lanka)
- Heiner Denker (Germany)
- Cheinway Hwang (Taiwan)
- Chris Jekeli (USA)
- Jaroslav Klokocnik (Czech Republic)
- Charles Merry (South Africa)
- Peter Morgan) (Australia)
- Nikolaos K. Pavlis (USA)
- Marcelo Santos (Canada)
- Claudia Tocho (Argentina)

JWG 2.4: Multiple geodetic observations and interpretations over Tibet, Xinjiang and Siberia (TibXS)

(Joint with Commission 3)

Chair: Cheinway Hwang (Taiwan)
Vice Chair: Wenbin Shen (China)

Terms of Reference and Objectives

Tibet, Xinjiang and Siberia (TibXS) are regions with active plate tectonics. Evidences from satellite gravimetry and altimetry show the hydrological evolutions over these regions are sensitive to global climate change. For example, inter-annual lake level changes over Tibet and Xinjiang from satellite altimetry are found to be connected to El Nino Southern Oscillation (ENSO). Lakes in central Asia originating in Xinjiang and lakes in eastern Siberia show sharp changes in lake levels that can be explained by climate change. Recent terrestrial gravity, GRACE and GPS observations suggest that the crust over the Tibetan plateau is thickening, and the Himalayan glaciers appear to be thawing. Satellite altimetry is a potential tool to study vertical displacement and permafrost thawing and changes in the active layers in Siberia and Tibet. With more satellite gravimetry and altimetry data to come, decadal changes over TibXS in many aspects can be investigated in connection to global climate change and dynamics of the crust and the upper mantle.

Under the support of IAG commission 2, two international workshops on multiple geodetic observations and interpretations have been held in Urumqi (2009; http://space.cv.nctu.edu.tw/altimetryworkshop/TibXS2009/TibXS2009.htm) and Xining (2011; http://space.cv.nctu.edu.tw/altimetryworkshop/TibXS2011/TibXS2011.htm). The results presented in these workshops have been or will be published in two special issues of the journal Terrestrial, Atmospheric and Oceanic Sciences (TAO). In response to the call to continue the geodetic studies over TibXS, this working group is established and reports to IAG Commission 2 over 2011-2015. The objective is to investigate the long-term records from different geodetic sensors to understand the geodynamic process and climate change over TibXS. This WG will report to IAG Commission 2.

Program of Activities:

- This WG will organize international workshops to investigate the results from multiple geodetic observations over TibXS.
- This WG will establish a link between the geodetic community and the geophysical community to interpret the geodetic results.
- This WG will assess satellite results from GRACE, COSMIC and its follow-on, altimetry and SAR and other remote sensing platforms over TibXS using in situ observations such as superconducting gravimeter and absolute gravimeter data, GPS data, lake gauge and glacier stake and snow pit measurements.
- This WG will publish papers dedicated to the subjects of the WG in journal special issues.

Members of the Standing Committee

- B F Chao (Taiwan)
- Kosuke Heki, (Japan)
- Jeff Freymuller, (USA)
- CK Shum (USA)
- He-Ping Sun (China)
- Qi Wang (China)

Members

- Xiaoli Deng (Australia)
- Xiao-Li Ding (Hong Kong)
- Xiaodong Song (USA)
- Wenke Sun (China)
- Nikolay Shestakov (Russia)
- VM Tiwari (India)
- Carla Braitenberg (Italy)

JWG2.5: Physics and dynamics of the Earth's interior from gravimetry

(Joint with Commission 3)

Chair: Isabelle Panet (France)

Terms of Reference

To develop approaches for the determination of the physical properties of the Earth interior and its dynamics, from the joint use of gravity and other geophysical measurement techniques. Insights from earthquakes signals and normal modes will be considered. The objective is to better constrain the structure in the mantle and the core as well as their interactions.

Goals

The following, non-restrictive list of goals is proposed (to be discussed in the WG):

Methodological goals:

- to develop methods for extracting a geodynamic signal of interest, related to Earth mantle and/or core, from noisy data (satellite gravity data and other measurements). Some important points: separation from the geofluid variations, in the case of temporal gravity variations, separation from surface contributions, in the case of static gravity.
- to review and develop approaches for the combination of heterogeneous geophysical and gravity data at different spatial and/or temporal scales.

Application goals:

- to review the existing methods and propose approaches for the joint use of seismic and surface/satellite gravity data to infer Earth structure at various scales. The use of magnetic data will also be considered.
- to review and estimate expected amplitudes of core signals in gravity and other geophysical observations,
- to review and address the observation of Earth normal modes in gravity and other geophysical measurements,
- to address the extraction of solid Earth deformations from satellite gravity data combined with surface displacement measurements,
- to address the determination of mantle viscosity from satellite gravity combined with other measurements, from the analysis of post-seismic deformations of large earthquakes / GIA, ...

Members

Chair: Isabelle Panet (France)
Shuanggen Jin (China)
Valentin Mikhailov (Russia)
Séverine Rosat (France)
Bert Vermeersen (The Netherlands)
Tonie Van Dam (Luxembourg)
Virendra Tiwari (India)
Lei Wang (USA)
Kosuke Heki (Japan)
Fred Pollitz (USA)

JWG2.6: Ice melting and ocean circulation from gravimetry

(Joint with Commission 3)

Chair: Jens Schröter (Germany)

Terms of Reference

The working group will primarily address the contribution of ice melting to the global and regional sea level. Specifically observation of the Earth's ocean- water and ice sheet variations at all spatial and temporal scales will be considered from GRACE data and other sensors, e.g., Altimetry, ICESat, InSAR and GPS. Furthermore the fate of the melt-water in the ocean, its distribution and impact on ocean circulation will be studied.

Goals

- to estimate individual mass and volume change of major ice sheets and ice caps using a synthesis of different techniques
- separate geometric change on long time scales (e.g. GIA) as well as elastic response/loading/self attraction of sea water from the estimates of volume change in land ice and ocean
- use estimates of land storage of water from JWG 2.7 to close the global water cycle and to improve removal of leakage of land signals into ocean estimates
- close the ocean's regional volume budget by observing sea level from altimetry, steric expansion of sea water from ocean measurements and ocean modeling and mass change from a combination of GRACE and other observations (e.g. GPS, tide gauges, ocean bottom pressure recorders...)
- consider the impact of increased inflow of melt-water into the ocean on ocean circulation, sea level and mass/heat transports
- and finally describe and understand trends and contributions to global and regional sea level rise

Members

- Chair: J. Schröter (Germany)
- J. Bamber (UK)
- D. Chambers (USA)
- JL. Chen (USA)
- M. Horwath (Germany)
- J. Kusche (Germany)
- SB. Luthcke (USA)

- E. Rignot (USA)
- I. Sasgen (Germany)
- C.K. Shum (USA)
- D. Stammer (USA)
- CR. Wilson (USA)
- DG Vaughan (UK)
- I. Velicogna (USA)
- B. Wouters (The Netherlands)
- HJ. Zwally (USA)

JWG2.7: Land hydrology from gravimetry

(Joint with commission 3)

Chair: Annette Eicker (Germany)

Terms of Reference

The working group will be dedicated to the development of new strategies and algorithms for using time-variable gravity data from GRACE and data from complimentary sensors in the understanding of the terrestrial water cycle. This includes the development of tools and products to encourage adoption of geodetic data by the hydrological community, application and validation of GRACE to investigate water storage changes and the improvement of model reliability and predictability (calibration, assimilation). This Working group was proposed by SC2.6 (Gravity and Earth System).

Goals

The following, non-restrictive list of goals is proposed (to be discussed in the WG):

- to tailor GRACE products towards the specific requirements of hydrological applications (regional solutions, spatial/temporal constraints,…)
- to review existing approaches and develop new strategies for GRACE post-processing (filtering issues, bias correction associated with the leakage problem)
- to discuss the separation of the GRACE mass signal into different storage compartments
- to compare the satellite data with model output and complementary data sets (super-conducting gravimeters, ground water observation,…)
- to review and develop strategies to compare and combine heterogeneous data sets given on different temporal and spatial scales
- to compare and develop approaches to use GRACE and alternative sensor data to calibrate hydrological modeling and to assimilate the observations into the models
- to develop strategies for innovative use of GRACE products for hydrometeorology

Members

Annette Eicker (Germany)
Petra Döll (Germany)
Jean-Paul Boy (France)
Andreas Güntner (Germany)
Laurent Longevergne (France)
Himanshu Save (USA)
Benjamin Zaitchik (USA)

JWG2.8: Modeling and Inversion of Gravity-Solid Earth Coupling

(Joint with commission 3)

Chair: Carla Braitenberg (Italy)

Terms of Reference

To model and invert gravity-solid Earth coupling, e.g. explore situations in which gravitative forces have been an important agent in the evolution of the lithosphere. The topics of interest range from the evolution of crustal thickness, isostatic Moho response, lithospheric thickness, lithospheric slab pull, lithospheric cooling, gravity field related deformation. Explore where and to what extent density variations in crust and mantle affect mass loading and geodynamics. We consider the effect of density changes in time through thermal heating and cooling, including magmatic loading, underplating and basin evolution. Methodological aspects include the development of forward and inversion algorithms in a spherical Earth, the use of the gravity tensor and the new GOCE observations. This Working Group belongs to the initiatives coordinated by Sub-Commission 2.6.

Goals

- Create a platform in which density models can be tested through geodynamic models. This needs the interaction of the geodynamic modeler with the geophysical modeler, and allows a consistency check of the density models from the point of view of observations of the potential field and of geodynamics. Viceversa the geodynamic models producing density variations are checked against consistency with density models constrained by further geophysical observations.
- Create a reference database covering the subject of gravity-solid earth coupling (mass loading, underplating, isostatic Moho, crustal thickness, lithospheric thickness, dynamic topography versus mass loading).
- Create a database on methodology of gravity forward and inversion calculations, spherical calculations
- Create a kit of software tools that have been tested and verified by the working group and that will be shared among the members of the working group. It shall cover the different aspects of the goals of the WG. If several software-programs are made available they can be benchmarked against each other.
- Set up a social networking page for the members of the working group.

- Organize a practical-theoretical school on Modeling and Inversion of Gravity-Solid Earth Coupling

Members

Carla Braitenberg (Italy)
Jon Kirby (Australia)
Shuanggen Jin (China)
Erik Ivins (USA)
Xiapoping Wu (USA)
Valeria Barbosa (Brazil)
Jörg Ebbing (Norway)
Holger Steffen (Canada)
Daniele Sampietro (Italy)
Sabine Schmidt (Germany)
Rezene Mahatsente (Germany)

Corresponding members

Séverine Rosat (France)
Leonardo Uieda (Brazil)
Rebekka Steffen, (Canada)
Carlos Chaves (Brazil)
Andres Tassara (Chile)
Mario Gimenes (Argentina)