Commission 3 - Geodynamics and Earth Rotation

Web: www.astro.oma.be/IAG/index.html

President**: Véronique Dehant** (Belgium)
Vice President: **Mike Bevis** (USA)

Terms of Reference

In the frame of geodesy, geodynamics deals with the natural forces and processes, of the Earth's interior and crust as observed by means of geodetic measurements. The Earth rotation deals with all the Earth orientation parameters, i.e. polar motion, length-of-day variations, precession and nutation, which allow transformation from a terrestrial reference frame to a celestial reference frame or vice versa. These parameters are varying with time and are related to geodynamical processes as well as external tidal forcing. Commission 3 is a part of the International Association of Geodesy for short-term or long-term research that focuses on collecting, analyzing, and modeling observational data in the frame of geodynamics and Earth rotation. This includes in particular, Earth Tides (Sub-Commission 1), tectonics and Crustal Deformations (Sub-Commission 2), as well as the effects of the Geophysical Fluids (Sub-Commission 3) in geodynamics (e.g., post-glacial rebound, loading) and Earth rotation. Geodynamics and rotation studies of the Earth can be extended to those of other terrestrial bodies (planets and moons). Commission 3 has the possibility to promote a project, and in particular the project called Global Geodynamics Project (GGP), which involves measuring and analyzing temporal changes in the Earth's gravity field over a long period and using a global network of measurements. Commission 3 relies on IAG services such as the International Earth Rotation and Reference Systems Service (IERS) or the International Center for Earth Tides (ICET). Commission 3 is closely related to the IAU (International Astronomical Union) Commission 19 on Earth Rotation.

Objectives

To develop cooperation and collaboration in computation, in theory, and in observation of Earth rotation and geodynamics, and to ensure development of research in geodynamics and Earth rotation by organizing meetings, symposia, and general assemblies, by creating working groups on specific topics, and by encouraging exchange of ideas and data, comparisons of methods and results improving the accuracies, content, methods, theories, and understanding of Earth rotation and geodynamics.

To serve the geophysical community by linking them to the official organization providing the International Reference Systems/Frames and Earth orientation parameters (IERS and related bodies), and organizations providing all the other data on which geodynamics and Earth rotation studies can be performed.

Structure

Sub-Commissions:

SC3.1: Earth Tides
President: **Gerhard Jentzsch** (Germany)

SC3.2: Crustal Deformation
President: **Markku Poutanen** (Finland)

SC3.3: Geophysical Fluids
President: **Richard Gross** (USA)

Inter Commission Projects:

IC-P1.1: Satellite Altimetry
(Joint with Commission 1 and 2)
(Description: See Commission 1)
Chair: **Wolfgang Bosch** (Germany)

IC-P3.1: GGP Global Geodynamics Project
(Joint with Commission 2).
Chair: **David Crossley** (USA)

Inter Commision Working Groups:

IC-WG1 Theory of crustal deformations
(Joint with ICCT and Commission 1)
(Description: See ICCT)
Chair: **Kosuke Heki** (Japan)

Representatives

1. to ICC on “Theory”: Tim Van Hoolst
2. to ICC on “Planetary Geodesy”: Ozgur Karatekin
3. to the Integrated Global Geodetic Observing System (IGGOS) IAG Project: Véronique Dehant
4. to IAU Commission 19 on “Earth Rotation”: Marcus Rothacher (also, Véronique Dehant who is President of IAU Commission 19)
5. to IERS Directing Board: Clark Wilson
6. to ICET Directing Board: Gerhard Jentzsch

Steering Committee members

President: V. Dehant
Vice President: M. Bevis
President SC3.1: G. Jentzsch
President SC3.2: M. Poutanen
President SC3.3: R. Gross
President ICP.31: D. Crossley
T. Van Hoolst
O. Karatekin
M. Rothacher
C. Wilson (past President)
M. Feissel-Vernier (past President)

Program of Activities

1. Participation in special meetings related to geodynamics and Earth rotation.
   Action item for Commission 3 EC: to stimulate participation in these meetings and to ask IAG for co-sponsorship.
2. Participation in the IAG Project Integrated Global Geodetic Observing System (IGGOS).
   Action item for Commission 3 EC and Commission 3 IGGOS representative: to link the IGGOS program with the members and the Commission 3 sub-entities.
3. Encouraging and stimulating the services related to Commission 3.
   This is particularly true for Sub-Commission 3.1 on Earth tides and 3.3 on geophysical fluids that should stimulate research related to the ICET and to the IERS Product Center on Global Geophysical Fluids, respectively.
4. Linking the Sub-Commission together, in particular provide them with a forum for exchange of information.
   Action item for Commission 3 President: create a forum for exchange of information between Sub-commissions, as for instance between Sub-commissions 3.1 and 3.3.
5. Linking Commission 3 with its sister commission of the IAU.
   Action item for Commission 3 President and IAU representative: to provide information from one entity to the other (construction of web-site links), to create joint WG if necessary.
6. See program of the three Sub-Commissions as well.

Sub-Commission

SC 3.1- Earth Tides.

President: **Gerhard Jentzsch** (Germany)
Vice President: J. Hinderer

Terms of Reference

The objective of the Sub-Commission is to promote international cooperation and coordination of investigations related to the observation, preprocessing, analysis and interpretation of earth tides. By earth tides, we understand all phenomena related to the variation of the Earth's gravity field and to the deformation of the Earth's body induced by the tide generating forces, i.e. the forces acting on the Earth due to differential gravitation of the celestial bodies as the Moon, the Sun and the nearby planets. The relation between earth tides and Earth rotation is certainly an important perspective of the work of the Sub-Commission. The Sub-Commission collaborates with all international and national organizations concerned with the observation, preprocessing, analysis and interpretation of earth tides. The Sub-Commission encourages and promotes campaigns to develop, compare and calibrate instrumentation for earth tide observations, techniques of operation, procedures for data preprocessing and data analysis. The Commission makes standard software for the prediction of earth tide phenomena and for the processing of earth tide observations available to the scientific community by the www. The Sub-Commission supports the activities of the International Center for Earth Tides (ICET) in collecting, analyzing and distributing earth tide observations. The ICET is considered as the executive office of the Earth Tide Sub-Commission. The Sub-Commission provides an Electronic Information Service with data and software files on its website. The Sub-Commission organizes yearly Earth Tides Symposia when the IAG or IUGG are not organizing general assemblies (next meeting is in Ottawa, 2-6 August 2004). The Sub-Commission creates WGs when necessary and adopts resolutions when necessary. The Sub-Commission has a medal that is delivered to a scientist for her/his outstanding contribution to international cooperation in earth tide research, on the occasion of the International Symposium on Earth Tides.

Steering Committee

President:G. Jentzsch
Vice President: J. Hinderer
B. Ducarme (Director ICET)
D. Crossley (GGP)
S. Takemoto (Past-President)
L. Manshina (WKG1)
Wu Bin (WKG2)
C. Kroner (WKG3)

Working Groups

WG: 3.1.1 Gravitational Physics

The general goal of the WG is to tackle among others the following scientific problems:

- The Problem of Aberration: Modern tidal position catalogs assume that the true position of the tide causing body is responsible for the tidal forces, rather than the apparent position, as in optical astronomy. The problem may have consequences, as it may imply relative velocities between the gravity and optical signals. This is a case for experts in Celestial Mechanics and in Earth Tides.
- The Gravitational Shielding: There is currently no accepted theory of gravity that incorporates or predicts gravitational shielding. The problem is possibly different from the absorption of gravitational radiation by matter. The Earth Tide community should think about, and search for, the consequences of shielding.

WG: 3.1.2 Earth Tides in Space Geodetic Techniques

The general goal of the WG is to strengthen the links between researchers of the tidal community and those who work in space geodetic techniques in both directions:

- The tidal experts provide precise models for the displacements of observation sites on the Earths crust due to the tides and for the tidal variations to the gravitational field of the Earth;
- The space geodetic techniques are used to validate and possibly to improve the tidal models, e.g. the tidal parameters.

Terms of Reference

- Cooperation with the analysis coordinators of the new IAG international services, e.g. IGS, IVS, ILRS, IDS, ... and the Working Groups which exist within these services,
- Comparison of tidal parameters obtained from the different techniques,
- Comparison of results obtained by space geodetic techniques and ground-based tidal measurements,
- Exploring new satellites measurements (CHAMP and GRACE) for Earth tides,

- Using GPS and ground-based gravimeter to study regional ocean tides.

Program:

- Extension of the recommendations concerning the tidal influences given in the IERS Conventions (2000) to facilitate their practical use for space geodetic techniques; upgrade of 'supplements' to the IERS Conventions; establishment of subgroups of experts in order to help the IERS Convention Directing Board;
- Evaluation and comparison of the potential of different space geodetic techniques to monitor tidal effects and to determine tidal parameters; Techniques such as VLBI, SLR, LLR, GPS and GLONASS, DORIS and PRARE, satellite altimetry will be covered;
- Determination of parameters of the tidal models by space geodetic techniques; This requires a priori corrections due to atmospheric and oceanic influences on the Earth's surface and on the geopotential and precise models for tidal influences on the Earth orientation parameters; The effect of pole-tide has also to be considered.

WG 3.1.3 Analysis of Environmental Data for the Interpretation of Gravity Measurements

The general goal of the WG is to identify the environmental parameters should be monitored and the procedure to monitor them, and to recommend the corrections and the related procedures that are necessary in the frame of tidal studies at all timescales.

Objectives

- Systematic investigation of effects of environmental parameters on the gravity vector, such as air pressure, air humidity, wind, seasonal effects of vegetation, ground water level variations, soil moisture;
- Understanding of the relation between the individual sources and their effects on the gravity vector, both in different periods, and different amplitudes;
- Development of models for the correction of environmental effects and recommendations for the recording of environmental parameters, and recommendations for the application of the corrections.

Program

- Exchange of information by meetings with printed papers in the Bulletin d'Information Marees Terrestres;
- Recommendations and proposals concerning the parameters to be recorded, their sampling and resolution; these parameters are temperature, humidity, precipitations (rain and snow), ground water table variations, snow accumulation, …
- Identify efforts to realize a continuous monitoring of these parameters;
- Identify correlation among these parameters;
- Develop models for the correction of gravity and tilt measurements, and possibly for prediction of these corrections;
- For this, special events could be studied and particular experiments (to be identified) could be done.

Sub-Commission

SC 3.2 Crustal Deformation.

President: **Markku Poutanen** (Finland)

Terms of Reference

There are many geodetic signals that can be observed and are representative of the deformation mechanisms of the Earth's crust at different spatial and temporal scales. The time scales range from seconds to millions of years in the case of plate tectonics and from millimeters to continental dimension for the spatial scales.

Space geodetic measurements provide nowadays the means to observe deformation and movements of the Earth's crust at global, regional and local scales. This is a considerable contribution to global geodynamics by supplying primary constraints for modeling the planet as a whole, but also for understanding geophysical phenomena occurring at smaller scales.

Gravimetry, absolute, relative and nowadays also spaceborn, is a powerful tool providing information to the global terrestrial gravity field and its temporal variations. Superconducting gravimeters allow a continuous acquisition of the gravity signal at a given site with a precision of 10^{-10}. This is important in order to be able to detect and model environmental perturbing effects as well as the weak gravity signals associated with vertical crustal movements of the order of mm/yr. These geodetic observations together with other geophysical and geological sources of information provide the means to understanding the structure, dynamics and evolution of the Earth system.

Objectives

General objectives of the Sub-Commission 3.2 will include:

- to study tectonic motions, including plate deformation;
- to study postglacial rebound, but also glacial dynamics and glacial isostatic adjustment in the currently glaciated area of the Earth, as well as the water and ice mass balance;
- to study local crustal movements, some of which could be potentially hazardous;
- to study sea-level fluctuations and changes in relation to vertical tectonics along many parts of the coastlines and in relation to environmental fluctuations/changes affecting the geodetic observations;
- to promote, develop and coordinate international programs related to observations, analysis and data interpretation for the three fields of investigation mentioned above;
- to promote the development of appropriate models.

There are particular objectives for the different entities, in the frame of the general objectives.

One should also notice, that the objectives of the integrated global geodetic observing system (IGGOS) includes e.g.

- the integral effect on Earth rotation of all angular momentum exchange inside the Earth, between land, ice, hydrosphere and atmosphere, and between the Earth, Sun, Moon, and planets,
- the geometric shape of the Earth's surface (solid earth, ice and oceans), globally or regionally, and its temporal variations, whether they are horizontal or vertical, secular, periodical or sudden, and
- by adding the Earth's gravity field-stationary and time-variable-mass balance, fluxes and circulation.

According to these objectives, SC3.2 should have close contacts to the IGGOS activities, because many of the items are shared in the plans of IGGOS and SC3.2.

Structure and activities

The Sub-Commission on Crustal Deformation comprises sub-entities or working groups corresponding either to different geographical regions or different important and actual topics involved in the field of the Sub-Commission studies. These sub-entities are dealing with main scientific objectives having common general aspects and, in parallel to these objectives, follow the development of technology and measurement techniques capable to best fulfill the scientific objectives.

The SC3.2 will promote itself, but also encourage its working groups and other related groups or institutions to organize meetings or larger scientific conferences for selected scientific or technological subjects. Outcome of these meetings will be published in Proceedings, either separate one or as special issues of scientific journals.

Sub-entities or working groups will be established by the directing board according to the needs or activities. This list will be completed later, and more groups are to be added. Currently, the following group exists

- Geodynamics of the Central Europe, chaired by Janusz Sledzinski (Poland).

Steering Committee

Chair: M. Poutanen
J. Davis
K. Heki
S. Zerbini
J. Manning
J. Sledzinski

Related Working Groups

"Working group of European Geoscientists for the Establishment of Networks for Earth science Research (WEGENER)", chaired by L. Bastos, and earlier being as a sub-entity of Commission XIV is now a separate group. However, close contacts between WEGENER and SC3.2 will be continued.

Sub-Commission

SC3.3- Geophysical Fluids.

President: **Richard Gross** (USA)
Vice President: **A. Brzezinski** (Poland)

Terms of Reference

Mass transports in the atmosphere-hydrosphere-solid Earth-core system, or the "global geophysical fluids", will cause observable geodynamic effects on a broad time scale. Although relatively small, these global geodynamic effects have been measured by space geodetic techniques to increasing, unprecedented accuracy, opening up important new avenues of research that will lead to a better understanding of global mass transport processes and the Earth's dynamic responses. Angular momentums and the related torques, gravitational coefficients, and geocenter shift for all geophysical fluids are the relevant quantities. They are studied theoretically and observed based on global observational data, and/or products from state-of-the-art models some of which assimilate such data.
The objective of the Sub-Commission is to serve the scientific community in providing research and data analysis associated with the geophysical fluids, in areas related to the variations in Earth rotation, gravitational field and geocenter that are caused by mass transport in the geophysical fluids. The geophysical fluids of the Earth system include the atmosphere, ocean, solid Earth, and core, and geophysical processes associated with ocean tides and hydrological cycles.

Steering Committee

President: R. Gross
Vice President: A. Brzezinski
Ben Chao

Inter Commission Project

IC-P 3.1 Global Geodynamics Project (GGP). (joint with Commission 2)

Chair: **David Crossley** (USA)
Secretary: **Jacques Hinderer** (France)

Terms of Reference

The GGP project began on 1 July 1997 and Phase 1 ended on 1 July 2003. A continuation of the project, GGP Phase 2, was approved to continue until July 1, 2007. The main purpose of GGP was, and remains, to record the Earth's gravity field with high accuracy at a number of worldwide stations using superconducting gravimeters (SGs). An important requirement is the frequent monitoring of absolute gravity at each site to co-determine secular changes. Phase 2 envisages project in which SGs are deployed in regional arrays for limited time periods.

A list of publications related to GGP and SGs is available at the GGP website, as are a number of newsletters published for the benefit of the community. The main website is http://www.eas.slu.edu/GGP/ggphome.html.

The data is being used in an extensive set of studies of the Earth, ranging from global motions of the whole Earth such as the Chandler wobble to surficial gravity effects such as atmospheric pressure and groundwater. The SG stations are run independently by national groups of scientists who send data each month to the GGP database at the International Centre for Earth Tides (ICET) in Brussels.

GGP data is recorded and processed to standards agreed between the SG groups. For some of the GGP sites, the most recent data is temporarily restricted and will become available one or two years after collection. For other GGP sites, the data is available as soon as it has been sent to ICET, without restriction. Interested scientists can contact ICET, or the GGP website, for details. Useful site links and some technical terms involved in gravimetry are also on this site.

GGP has recently endorsed a joint operation between ICET and GFZ as a means of developing the database of SG measurements. ICET provides the front-end organization to which the data is sent, and GFZ provides the technical aspects of maintaining and developing the database. GGP will thereby contribute data to ICET, for as long as ICET remains a service of the Earth Tide Commission and FAGS.

Organization

The activities of the GGP are coordinated by a directorate consisting of a Chairman and Secretary The directorate guides the members who are responsible for all aspects of the GGP such as setting the timetable for the project, setting standards for the data acquisition systems and data exchange protocols and recommending procedures for the database operations. The membership agrees to meet at least once a year, either independently of in conjunction with an appropriate scientific meeting.

Recent Evolution

GGP is currently an inter-union, interdisciplinary project endorsed by SEDI (Study of the Earth's Deep Interior). We have conducted a survey of its members on possible affiliation with IAG, as discussed at the GGP Business Meeting in Sapporro, Japan, on July 6, 2003. Only 15 of approximately 80 members on the mailing list replied to our survey. We interpret this response to indicate that the majority of members do not object to the ideas proposed in our survey. The IAG has approved the proposal.

The following items constitutes GGP Proposal to Commissions 2 and 3 of the IAG:

1. Identity. GGP considers itself to be an unrestricted international scientific ***project*** that also provides a ***service*** to the community. Therefore any affiliation with IAG needs to preserve these two aspects and to allow GGP to continue its current scientific and administrative structure.

2. Affiliation. GGP would like to be affiliated with IAG as an Inter-Commission ***project***, on the understanding that the definition of project (IAG Bylaw 1.2.3) in no way limits the time period over which GGP can operate. We have voted to seek affiliation under the general scientific directives of both Commission 2 (the Gravity Field) and Commission 3 (Earth Rotation) because the mandate of GGP encompasses the terms of reference of both Commissions.

3. Reporting. GGP prefers a mechanism whereby it reports only to one commission, in this case Commission 3 (Earth Rotation), on the assumption that there will be close communication between the commissions on matters concerning GGP.

4. IGGOS. GGP would like to establish a membership within the IGGOS framework and to participate in that organization for the purpose of the exchange of worldwide gravity data.

Scientific Objectives

GGP monitors changes in the Earth's gravity field at periods of seconds and longer. The GGP is named to indicate the application of gravity data to the solution of a number of geodynamic problems; additionally GGP may become a source for absolute gravimeter data as well as other geodynamic data.

The measurements were originally planned over a time span of 6 years at a small number of permanent observatories where a superconducting gravimeter (SG) had been installed. The 6-year period was chosen as the minimum length of data required to separate annual and 14 month Chandler wobble components in the gravity record. A pilot phase of GGP commenced 2 years earlier, in July 1995, so GGP is effectively in its 9'th year of operation.

The SG has been, for the past two decades, the most sensitive, stable instrument for the measurement of the vertical component of the Earth's gravity field. Each of the currently operating SGs is the focus of a national effort to provide a continuous gravity record for geodetic and geophysical research. The GGP is an opportunity for the various SG groups to participate in a global campaign to monitor the gravity field and to exchange the raw data.

Precise global measurements of the Earth's gravity field are essential to answer a number of important questions in geophysics, which we outline in more detail in the next section: (a) Do internal gravity waves (inertial waves if the fluid is neutrally stratified) exist in the Earth's liquid core and are their gravitational effects at the Earth's surface detectable? (b) What is the gravity effect of the global atmospheric loading and mass re-distribution on the solid Earth? (c) Through global tidal analysis, can we refine estimates of the nearly diurnal free wobble of the Earth and models of oceanic loading on the solid Earth? (d) What changes in gravity are associated with slow and silent earthquakes, tectonic motions, sea-level changes and post-glacial rebound? (e) Can we monitor the location of the rotation pole of the Earth on a time scale of minutes? (f) Can SG recordings of the earth's normal modes enhance the global long period seismic and spring gravimeter networks?

Benefits

The aims of GGP are twofold:

- To reassure users of SG data that extreme care has been taken in the sampling and pre-processing of the available data and that all pre-processing steps and other site-specific information such as atmospheric pressure, environmental data and a record of all site disturbances are available to users, and
- To enable global signals to be extracted by various stacking procedures that would not be possible with single station recordings.

Superconducting Gravimeter (SG) Groups

The GGP is open to all organizations with access to the appropriate instrumentation, i.e. a SG. Each independent organization that manages a SG will be called a SG group; there may be several SG groups in any one country. SG groups seek their own sources of financing.

The GGP Agreements encourage SG groups to (a) upgrade existing SG facilities to a common standard of data acquisition, (b) participate in continuous gravity observations by maintaining the SGs in good operating conditions at fixed locations and (c) exchange raw gravity (and other important supplemental) data through the Internet.

Global Data Acquisition and Distribution

As described later, the scientific goals of the GGP include a wide range of signals from periods of seconds to years, covering seismic normal modes, tides, core modes and wobble modes of the Earth to other long period variations in Earth's gravity field such as tectonic deformation.

Many of the Earth parameters of critical interest in global dynamics exist in gravimetric signals at or below the ambient noise level. Examples include internal gravity waves in the fluid core and post-glacial uplift and plate motions. The SG has a frequency-domain sensitivity at the nanogal level and many periodic signals of interest are expected to be in this range. Because the time-domain variability of gravity 'noise' is usually two to three orders of magnitude greater than this, global signals identified on the record of an individual instrument at the nanogal level cannot be considered reliable until confirmed with similar signals from other instruments. For many purposes, these instruments must be distributed widely around the Earth because global gravimetric signals have theoretically predictable spatial and temporal global variations.

Access to worldwide gravimetric data is essential for progress in global geodynamics for several reasons. First, SG data can be used to recover long-period free oscillations of the Earth with unprecedented precision. In real time, an array of SG instruments, as considered in GGP Phase 2, would provide a means for detection of slow and silent earthquakes, co-seismic slip, and tectonic signals. Second, sub-milliarcsecond orientation can be obtained through measurement by an SG network for space-based measurements such as Satellite Laser Ranging and the US-proposed GLRS project to position points on the Earth's surface to the sub-centimeter level through the use of Earth-based retro-reflectors and satellite-based lasers. Third, Earth models that incorporate core resonances require access to gravimetric data at the nanogal level to successfully account for motion in the deep interior in all of the orientation calculations. GGP is striving to make such data available as rapidly as possible to the scientific community, so that all the above tasks can be accomplished.

A number of tectonics-related problems require global gravity field data for their resolution. In particular the problems of long-term secular changes in elevation, caused not only by post-glacial rebound and sea level changes but also by active plate-tectonic related deformation, need long-term gravity variations at continental scales. The long-period stability of SGs is variable, with the best instruments having instrument drift as low as about 1 microgal per year. Wherever this level of stability can be maintained by even a small number of SG stations in a regional network, particularly where confirmed with absolute gravimeters, then GGP will provide useful data for these tectonic problems.

In the past an individual with access to his/her local instrument and a computer could make major progress in the solution of both analytical and data analysis problems. However, the complexity of many problems in global geodynamics is such that measurements on a global scale are needed to make even minimum progress. Concerted effort by cooperating scientists is needed to make any significant advance. Without uniform high precision global data it will be impossible to move toward the solution of the problems of the Earth's deep interior. GGP has responded to this need by agreeing to a monthly transfer of data from all instruments to the ICET / GFZ database in Brussels. This data represents the success of the overall project.

Specific Tasks of GGP

The SG is capable of recording temporal gravity variations from seconds to years and thus the GGP has application to large number of scientific tasks. As indicated above, at long periods (months - years), we highly recommend the use of a SG supplemented by an absolute gravimeter to fully characterize secular trends in gravity.

1. Earth tides and the nearly diurnal free wobble: the estimation of precise tidal parameters (e.g. gravitational delta factors) can contribute to the development of better models for correcting for ocean loading phenomena. In addition, the stacking of global delta factors provides important information on the diurnal free wobble of the Earth which is essential for theoretical work on the structure of the Earth's core.
2. Core modes: the search for internal gravity waves in the Earth's liquid core necessitates global, long-period, long-duration recordings to separate local gravity variations from a global coherent signal. If we are able to detect these waves, this will give direct information on the mechanical equilibrium of the fluid in the core, and thus information on the operation of the geodynamo.
3. Atmospheric interactions: stacking global gravity and pressure data is essential to clarify the nature of the long period phenomena in the atmosphere and for evaluating the effects of global atmospheric surface pressure and mass redistribution on the Earth's gravity field.
4. Hydrology: it has become clear during the first phase of GGP that rainfall, soil moisture, snow cover, and groundwater variations can all affect local gravity. The study of hydrology is therefore a fruitful area for GGP. With the advent of new satellite missions (CHAMP, GRACE, GOCE) it is possible to look at common signals in both ground and satellite data sets, particularly using the European stations of the GGP array.
5. Earth rotation and polar motion: the measurement of the gravity effect of polar motion (orientation of the Earth's rotation axis) requires a global coverage of stations. It should be possible to continuously monitor the location of the rotation pole on the time scale of minutes and therefore provide an independent verification of the same measurement now made with space techniques; connections with the International Earth Rotation Service (IERS) service here will be valuable.
6. Gravity changes due to tectonic motions: the monitoring of long-term changes due to tectonic motions, sea-level changes affecting the survival of coastal cities, post-glacial uplift and the deformation associated with active tectonic events.
7. Enhancing absolute gravity measurements: SGs are a valuable aid to international programs for the determination of absolute gravity values on a global scale as they provide a short-term, relative gravity reference level and they ‘fill in’ the gravity field behavior between AG measurements.
8. General research tool: GGP provides a high quality, continuous global data set will be a valuable resource for future geodetic and geophysical studies that involve the Earth's gravity.

GGP and Geodesy

There are important connections between the above goals and other scientific programs of national concern. In particular, the geodetic community clearly recognizes the importance of simultaneous geodetic (positional) information and gravity changes at fiducial stations that contain very high quality instrumentation. There are two primary areas in common between GGP and other geodetic programs:

1. Space techniques. Two space techniques that require detailed models of Earth deformation are satellite tracking and Very Long Baseline Interferometry (VLBI). At the proposed sub-centimeter level of accuracy, for projects in the 1990's such as the current Satellite Laser Ranging (SLR) and the proposed Geodynamics Laser Ranging System (GLRS) mission, precise knowledge of the Earth's dynamics, including resonances in the liquid core, are required. A global net of SGs will give the required information on dynamics of the liquid core.
2. Sea level changes. A satisfactory solution to the problem of defining the origins of sea-level changes requires input from different sources. The necessity of differentiating between the effects of height variations caused by post glacial rebound or plate tectonics and changes in sea level resulting from global warming demands the establishment of a global geodetic/geophysical observatory network, such as FLINN (Fiducial Laboratories for an International Natural Science Network), an IUGG-sponsored project initiated at the Coolfront Workshop in 1989. A central feature of such a network is the monitoring of the gravity field at a smaller group of fiducial stations equipped with SGs as well as precise positioning instrumentation (e.g. SLR, VLBI or GPS) and having accurate connections to the reference tide gauges.

Steering Committee

Chair: D. Crossley (USA)
Secretary: J. Hinderer (France)