Commission 3: Earth Rotation and Geodynamics

REPORT OF ACTIVITIES
(2003–2005)

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

1. Overview

The reorganization of the IAG took effect at the IUGG meeting in Sapporo in 2003. The new Commission 3 is dealing with Earth rotation and geodynamics activities.

An Advisory Board of Commission 3 has been created to serve during the period 2003-2007 in order to provide comments and advices to the officers (President and Vice-President) and to represent the interests within the commission. The Advisory Board confers via email, and has no formal meetings. The Advisory Board consists of the following members (their responsibilities is also given below):

President:	Véronique Dehant
Vice-President:	Mike Bevis
Past Presidents:	Clark R. Wilson and Martine Feissel-Vernier
Heads of Sub-commissions:	
Sub-commission 3.1 Earth Tides:	G. Jentzsch (Germany)
Sub-commission 3.2 Crustal Deformations:	M. Poutanen (Finland)
Sub-commission 3.3 Geophysical Fluids:	R. Gross (USA)
Head of Inter-commission Project:	
Inter-commision project 3.1 GGP:	D. Crossley (USA)
Inter-commision project 3.2 WEGENER:	S. Zerbini (Italy)
Commission 3 representatives:	
To inter-commision commitee on Theory:	T. Van Hoolst (Belgium)
To inter-commision commitee on Planetary Geodesy:	O. Karatekin (Belgium)
To inter-commision project 3.1 GGP:	D. Crossley (USA)
To inter-commision project 3.2 WEGENER:	T. Van Dam (Luxembourg)
To IERS:	C. Wilson (USA)
To IAU commission 19:	M. Rothacher (Germany)
Member at large:	
Kosuke Heki (Japan)	

The commission is co-sponsoring two WGs

1. on “Theory of crustal deformations” of ICC on Theory (Chair: Heki Sensei),

2. on “Differential INSAR” of Commission 4 (Chair: Xiaoli Ding).

The objectives of Commission 3 are:

- 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.

The activities in scientific research related to Commission 3 are mostly developed in the sub-commission report, with one important exception, the new research in the frame of precession and nutation. This research has been initiated by the Descartes Prize received by the Nutation Consortium in 2003. The money (300 000 €) has been dedicated to young scientist proposals. A call for proposals has been sent out at the beginning of 2004 and 15 proposals have been selected for either PhD students or postdocs. Additionally, money has been dedicated to travel support for participation in meetings for disfavored countries.

In addition to this, the activities of these last two years include
1. Participation in special meetings related to geodynamics and Earth rotation, such as Journées Systèmes de Références Spatio-temporels in Paris, ECGS Chandler Wobble Workshop in Luxembourg (on ‘Forcing of polar motion in the Chandler frequency band: a contribution to understanding interannual climate variations**’).**
2. Participation in the IAG Project Global Geodetic Observing System (GGOS). Some of the Descartes fellows have a GGOS flag on their project.
3. Linking the Sub-Commission together: we have encouraged joint sub-commission meetings. The three Presidents of the sub-commissions have agreed to have a common Symposium in 2008 in Jena, Germany.
4. Linking Commission 3 with its sister commission of the IAU, Commission 19 on ‘Earth Rotation’. This link has been done using the website of both commissions and through the sharing of information, easy to do for this term as the presidents of both commissions are the same person (V. Dehant).
5. Encouraging and stimulating the services related to Commission 3. This has again been performed by using money of Descartes Prize as several proposals have the objectives to help the IERS Product Center on Global Geophysical Fluids.

In addition to this, following the adoption of new resolutions on the definition of the way to pass from the terrestrial reference frame to the celestial reference frame, using the Non Rotating Origin (NRO), the Royal Observatory of Belgium has decided to dedicate some money to perform 3D representations which explain it. These 3D representations

are on the web. Still some explanations must be added. The new link between the frames takes full advantage of precision available with modern VLBI and other space techniques. The new precession-nutation models are an important element of high precision geodesy that enables the study of geodynamics.

One important concern related to our commission is the impact of the 2005 tsunami on geodynamics. Sessions at AGU and EGU meetings have been totally dedicated to that subject. The IAG General Assembly in Cairns contains as well many papers on that subject.

The web pages of Commission 3 are: http://www.astro.oma.be/IAG/

2. Report of Sub-commission 3.1 on 'Earth Tides'

Author: G. Jentzsch

After taking over the presidency from Shuzo Takemoto in July 2003, Gerhard Jentzsch asked Spiros Patiatakis to become Vice-President of ETsC, and Olivier Francis to continue as the secretary. They prepared the 15th International Symposium in Ottawa, August 2004. The symposium was a successful event, although only about 80 participants took part. Currently, they are preparing the proceedings which will appear as a special volume of the Journal of Geodynamics, scheduled for the last volume in 2005.

In April 2004, Gerhard Jentzsch participated in the celebration of the 70th birthday of Houtze Hsu in Wuhan, China. He was invited to present a talk which was printed in a comprehensive volume on 'Progress in Geodesy and Geodynamics' (1100 pages), already completed at the event. H.T. Hsu was a former president of the ETC, and he opened China for Earth tide research. He especially tied strong connections to European scientists and their institutions.

The Earth Tides sub-commission had three working groups which continue:
- Earth Tides in Geodetic Space Techniques, co-chaired by H. Schuh and Wu Bin,
- Analysis of Environmental Data for the Interpretation of Gravity Measurements, co-chaired by C. Kroner and G. Jentzsch, and
- Gravitational Physics, chaired by L. Mansinha.

A new working group was created:
- Precise Tidal Prediction, chaired by Y. Tamura

During the last EGU General Assembly in Vienna, April 2005, the sub-commission had a joint GGP and ETsC meeting. There we decided that between March 27 and 31, 2006, (during the week prior to the EGU conference) a combined meeting of the working group on 'Environmental Data ...' and the new WG on 'Tidal Prediction' together with a GGP workshop should be organized in Jena. The sub-commission will apply for funding of this meeting.

The 16th International Symposium on Earth Tides will be held in Jena in 2008. Taking into account that more than 50% of all presentations were not on Earth tides, but on geodynamics and environmental effects as well as on instrumental topics, the sub-commission already agreed in Ottawa to extend the scope of the next symposium: there will be a joint symposium of the three sub-commissions of commission 3 (Earth Tides, Crustal Deformation, Geophysical Fluids) and the inter-commission project GGP (Global Geodynamics Project).Other inter-commission study groups can be included if possible. This symposium is scheduled for the first week in September 2008.

3. Report of Sub-commission 3.1 on 'Crustal Deformation'

Author: M. Poutanen

Members of the directing board:
Markku Poutanen (Chair)
Jim Davis
Kosuke Heki
John Manning
Janusz Sledzinski
Susanna Zerbini

General objectives of the Sub-Commission 3.2 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.

The SC3.2 comprises sub-entities or working groups corresponding either to different geographical regions or different important and actual topics involved in the field of the SC 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. Sub-entities or working groups will be established by the directing board according to the needs or activities. Currently, there exists the Permanent Working Group on 'Geodynamics of the Central Europe'.

Permanent Working Group on '*Geodynamics of the Central Europe'*, (reported by Janusz Sledzinski, Poland) has continued studies on geotectonic regions of Central Europe. The formal membership list of the WG includes 29 scientists from 12 European countries. The programme of the WG (Plan of Action for 2003-2006) includes the following subjects:

- Geodetic and geodynamic programmes

European programmes:

  - CERGOP = Central Europe Regional Geodynamics Project,
  - CEGRN = (Central European GPS Reference Network) Consortium,
  - Post-UNIGRACE action (Unification of gravity system in Central and Eastern Europe).

Local geodynamic projects:

  - Projects realized by the subgroups of the CERGOP Study Group CSG.5 on "Geotectonic Analysis of the Region of Central Europe"; they concern the following regions: Eastern Alps and the North and Eastern Adriatic Sea, Romania Plate, Pannonian Basin, Plitvice Lakes, Croatia, Tatra Mountains, Northern Carpathians, and Balkan Peninsula;
  - Projects realized in bilateral/multilateral agreements of CEI countries, e.g. Czech-Polish-Slovak Cross-Border Studies of Regional Geodynamics (Sudetes, Beskydy, Tatra, Pieniny Mts).

- Working Group on University Education Standards;
- Working Group on Satellite Navigation Systems;
- Cooperation CEI Section C "Geodesy"– European Geophysical Society (EGS) / European Geosciences Union (EGU).

CEI WGST Section C "Geodesy" declares further close cooperation with the International Association of Geodesy in any form that would be considered as the most effective. The research and interpretation of recent crustal movements detected by satellite techniques are recognized as most important and urgent action within the mentioned workpackages of the CERGOP-2. The Section C "Geodesy" will provide the velocity vectors (displacement vectors) from the regions of Central Europe covering the area of CEI countries. The results of the CERGOP and other CEI projects will be release for the IAG scientific groups dealing with geodynamic investigations. The full report can be found on SC3.2 web page (see below).

Contacts between SC3.2 and WEGENER (Working group of European Geoscientists for the Establishment of Networks for Earth science Research, chaired by L. Bastos) continued. Zerbini is also a member of the WEGENER governing board. Zerbini and Poutanen participated in the board meeting of WEGENER held in Vienna in April 2005.

Discussions and planning on a joint symposium of SC3.1, 3.2 and 3.3 started. Preliminarily, the meeting is planned to be held in September 2008 in Jena. Chairman of the SC3.1, Gerhard Jentzsch is the chairman of the organizing committee.

Markku Poutanen participated on the planning of the Antarctic geodynamics plan POLENET: Polar Earth Observing Network for IPY. It is an international plan, chaired

by Terry Wilson of OSU, and proposed as an IPY project for the International Polar Year programme. One of the goals is to study present-day motions on Antarctica.

Markku Poutanen is the chairman of the Task Force set by Presidium of the Nordic Geodetic Commission to prepare the plan for the NGOS – Nordic Geodetic Observing System. The plan will follow the guidelines and principles of the GGOS (Global Geodetic Observing System) of IAG. NGOS will be a regional implementation of GGOS. The report of the NGOS task force can be found in http://www.nkg.fi.

Web pages of the IAG SC3.2 are under construction. Current version of the pages can be found in http://IAGSC32.fgi.fi.

4. Report of Sub-commission 3.1 on 'Geophysical Fluids'

Author: R. Gross

Directing Board

President: Richard Gross (USA)
Vice President: Aleksander Brzezinski (Poland)
Member: Ben Chao (USA)

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.

Report

Investigating the impact of geophysical fluids on the Earth's gravity, rotation, and shape continues to be a very active area of research as judged both by the number of special sessions devoted to this topic at the major EGS, EGU, and AGU conferences that were held during 2003 to 2005 and by the successful Chandler wobble workshop that was held during April 21–23, 2004 in Luxembourg at which geophysical fluid excitation of the Chandler wobble was a major topic of discussion. Special sessions on geophysical fluids will continue to be organized at future EGU and AGU conferences. In addition, at the invitation of Gerhard Jentzsch, President of IAG Sub-Commission 3.1 on Earth Tides, Sub-Commissions 3.2 and 3.3 and the Inter-Commission Project on the Global Geodynamics Project will participate in and co-organize the next Earth Tide Symposium to be held in Jena, Germany in 2008. Holding such a joint symposium will strengthen interactions between these Sub-Commissions and Inter-Commissions of the IAG.

Sub-Commission 3.3 continues to be a very active participant in the Global Geophysical Fluids Center (GGFC) of the IERS. The President of Sub-Commission 3.3 (R. Gross) is the head of the GGFC Special Bureau for the Oceans, and a member of its Directing Board (B. Chao), who was the former head of the GGFC, is the head of the GGFC Special Bureau for the Mantle. The data sets archived at the GGFC Special Bureaus continue to expand, providing a continuing source of data for present and future investigations of the impact of geophysical fluids on the Earth's gravity, rotation, and shape.

5. Report of intercommission project 3.1 on 'GGP'

Author: D. Crossley

Directorate

D. Crossley (Chair), J. Hinderer (Secretary).

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 (Crossley) and Secretary (Hinderer). 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 (the Global Geodynamics Project) 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 Sapporo, 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 following items constitute 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. GGOS. GGP would like to establish a membership within the GGOS 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.

Study 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 that 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.

Report

In 2004 the main GGP activity was the project session held at the 15th International Symposium on Earth Tides, in Ottawa, August 2-6. The associated Newsletter #14 appeared in the fall of 2004 and was posted on the GGP website (http://www.eas.slu.edu/GGP/ggphome.html). Important points noted in the Newsletter were:

1. Station Review. We have seen the closing down of the Boulder stations (BO) due to a hardware malfunction that also required a software upgrade that has not yet been implemented. For the moment the only North America SG station still recording is in Cantley Canada, and recently we heard that this station is also in imminent danger of disappearing, unless funding can be arranged through the Geological Survey of Canada. Contrary to the NA situation, a new station has come on line in Korea, and a new installation in Taiwan is in the planning phase. We are pleased that station BH (Bad Homberg, Germany) is now providing data to GGP and the remote station in Concepcion, Chile is working well.
2. Updated GGP agreements now require a delay of no more than 6 months between members and within 1 calendar year after its collection, all reporting SG stations are required to send their data to the International Center for Earth Tides (ICET) in Brussels.
3. GGP is moving towards more timely release of earthquake (rapid sample data), see below.
4. GGP is also working out the details of collecting AG (absolute gravimeter) data at the SG station sites. The purpose if to provide AG data for (a) the calibration of the SGs, and (b) to determine the secular changes in gravity at a station so that the SH drift can better be monitored. The reason GGP is considering this development is due to the reservations some members of the community seem to have with the current procedures for collecting absolute gravimeter data through the BGI database.

Since the August GGP Workshop, and spurred on by the very large earthquakes in Sumatra on December 26 2004 and March 28 2005, GGP has move to make raw data available online (http://www.eas.slu.edu/GGP/sumatra.html). The format for the data has been standardized as modified PRETERNA format, just as for the 1 minute data, and now about 15 datasets are available for December 2004 and January 2005. It is hoped this will be expanded in future to permit more continuous data to be sent to the IRIS (seismology) database. Some differences of approach exists within GGP as to whether to go directly to IRIS or work through our normal ICET procedures, now managed from GFZ (Potsdam).

The special issue of the Journal of Geodynamics (vol 38, Nos. 3-5, 2004) was devoted to papers arising from the previous years' Sapporro GGP Workshop, on the occasion of the first 6 year period of GGP (1997-2003). This special issue contained 19 papers from about 60 authors. At the present time, papers are being assembled from the 2004 Earth Tides meeting and will again be published in a future issue of the Journal of Geodynamics.

The next GGP Workshop is scheduled to be held during the imminent EGU meeting in Vienna, April 2005. Issues to be addressed remain those largely on the table last year. GGP has now successfully completed its first year as an interdisciplinary project of the newly organized IAG.

Of particular interest the gravity community at large is the need to create an absolute gravity database. GGP will continue to seek a viable means to collect AG data from the SG station sites, and this should be a good point of intersection for the combined resources of GGP and Commission 2.

6. Report of intercommission project 3.2 on 'WEGENER'

Author: S. Zerbini

Members

B. Ambrosius (Netherlands), T. Baker (United Kingdom), L. Bastos (Portugal), M. Becker (Germany), -, C. Bruyninx (Belgium), L. Combrinck (South Africa), J. Dávila (Spain), K. Feigl (France), H.-G. Kahle (Switzerland), I. Kumkova (Russia), J. LaBrecque (USA), - -T., Mourabit (Morocco), J.M. Nocquet (France), M. Pearlman (USA), R. Reilinger (USA), F. Rocca (Italy), W. Spakman (Netherlands), S. Stein (USA), S. Tatevian (Russia), K. Yelles (Algeria), S. Zerbini (Italy).
Representative of Commission 1 (to be assigned);
Representative of Commission 3: Tonie van Dam.

Terms of reference

The evolution of geodetic techniques in the past decade, with unprecedented achievements in the precise detection and monitoring of 3D movements at the millimeter level has opened new prospects for the study of Earth kinematics and hence dynamics. However, those achievements also raised new issues that have to be properly taken into account in the processing and analysis of the data, demanding a careful inter-disciplinary approach.

Areas in Europe, primarily in the broad collision zone between Europe, Africa and Arabia, provide natural laboratories to study crucial and poorly understood geodynamic processes. These have been systematically monitored in the last decade by different research groups using a variety of space geodetic and other techniques. However, in general data analysis has been done from the perspective of one discipline and processing procedures have not always followed a standard approach.

The existence of these geodata, never completely explored, justifies a new insight by using a really integrated approach that combines data from different observational techniques and input from other disciplines in the Earth Sciences. This should lead to the development of interdisciplinary work in the integration of space and terrestrial techniques for the study of the Eurasian/African/Arabian plate boundary deformation zone, and adjacent areas, and contribute to the establishment of a European Velocity Field.

With that purpose it is important to promote stronger international cooperation between Earth-Scientists interested in the study of that plate boundary zone. Towards that goal the WEGENER project aims to:

• Actively encourage the cooperation of all geoscientists Eurasian/African/Arabian plate boundary deformation zone, by promoting the exploitation of synergies;
• Be a reference group for the integration of the most advanced geodetic and geophysical techniques by developing the adequate methodologies for a correct data integration and interpretation;
• Act as a forum for discussion and scientific support for geoscientists from all over the world interested in unraveling the kinematics and mechanics of the Eurasian/African/Arabian plate boundary deformation zone;
• Promote the use of standard procedures for geodetic data, in particular GPS data, quality evaluation and processing.

The need to involve different research areas demands for collaboration with different IAG Commissions and in particular with Commission 1 and Commission 3. Commission 1 is responsible for regional and global reference frames, for the coordination of space techniques and for satellite dynamics. WEGENER can contribute significantly to each one of these areas and, in particular, to regional and global reference frames by making available, in its study area, quality-tested regional data sets acquired with different space and terrestrial techniques, as well as relevant quality-tested solutions. Additionally WEGENER can contribute by carrying out studies, already being developed by WEGENER member groups, on the definition of effective integrated observational strategies. Commission 3, is responsible for earth rotation and geodynamics. WEGENER will provide its main contribution in the field of geodynamics by studying, regionally, both short and long-term crustal motions.

Objectives

The primary goals of the WEGENER project are:

• Continue as a framework for geodetic/geophysical/geological cooperation in the study of the Eurasian/African/Arabian plate boundary zone;
• Foster the use of space-borne, airborne and terrestrial hybrid techniques for earth observation;
• Define effective integrated observational strategies for these techniques to reliably identify and monitor crustal movements and gravity field variations over all time-scales;
• Facilitate and stimulate the integrated exploitation of data from different techniques in the analysis and interpretation of geoprocesses;
• Organize periodic meetings with special emphasis on interdisciplinary research and interpretation and modeling issues;

• Reinforce cooperation with African and Arabian countries and colleagues, which can both contribute to understanding the kinematics and dynamics of the Eurasian/African/Arabian plate boundary zone and promote the growth of such research in these countries.

Activities

• We have begun to establish a GEO Data and Analysis Center (GEODAC) at the University of Porto (http://geodac.fc.up.pt). The main objective of GEODAC is to provide a platform to the whole interested scientific community for European GPS data archiving/linking, reprocessing of old data series in a unique reference frame, and an open data bank which will include, when available, environmental parameter series. GEODAC is promoting the use of state-of-the-art methodologies and latest results/solutions by supporting the scientific community when requested. Although in a testing phase (access only by password), GEODAC already contains most of the functions that were planned to be implemented. Examples are the computation of atmospheric loading corrections for stations that are not provided by the IERS Special Bureau for Loading, and realistic error bars for the trends in continuous GPS data analysis. At present, GEODAC is processing data of the GPS stations of the Iberian area. GPS data from episodic campaigns performed in Iberia, Italy and Morocco are already stored and available for access.. Log utilities to describe the properties of the GPS stations according to the IGS template were implemented. A forum where the GEODAC users can post questions and suggestions was also created. A link to other geodata sources, namely NEIC (National Earthquake Information Center) was already established. Additionally, GEODAC can support teams that do not have many processing capabilities. -
• Standards for GPS networks establishment, data acquisition and guidelines for data processing and reliability checks have been defined;
• Strategies for a full exploitation of different geodata (GPS, gravimetry, seismic, etc.) have been defined;
• We have organized every two years General Assemblies to serve as high-level international forum, in which scientists from all over the world can look at a multidisciplinary interpretation of geodynamics, and strengthen the collaboration between countries. The last conference took place in September 2004 in Tangier (Morocco). The next one will be in June 2006 in France.