Commission 3 – Geodynamics and Earth Rotation

http://www.earthsciences.osu.edu/IAG-C3

President: Michael Bevis (USA)
Vice President: Richard Gross (USA)

Structure

Sub-commission 3.1:	Earth Rotation and Earth Tides
Sub-commission 3.2:	Tectonic Deformation
Sub-commission 3.3:	Geophysical Fluids
Sub-commission 3.4:	Cryospheric Change and Earth Deformation
IC Project 3.1:	Global Geodynamics Project (GGP)
IC Project 3.2:	Working Group of European Geoscientists for the Establishment of Networks for Earth Science Research (WEGENER)

Overview

The main innovations in the structure of Commission 3 were the generalization of terms of reference of Sub-commission 3.1, so that it now addresses Earth rotation as well as Earth tides, and initiation of an entirely new Sub-commission, 3.4, which focuses on Earth deformation associated with the changing loads imposed upon our planet by changes in the cryosphere. This latter topic might seem to be a subset of the subject area addressed by Sub-commission 3.3, which focuses on 'geofluids' and Earth's various responses to the mass fluxes associated with these fluids. However, in practice the geodesists studying glacial isostatic adjustment and also elastic adjustments near present-day ice sheets tend to have a rather different set of shared interests. Sub-commission 3.2 now focuses mainly on *tectonic* deformation, which nevertheless constitutes a very broad subject area.

Terms of Reference

Geodynamics in the broader and most traditional sense addresses the forces that act on the earth, whether they derive from outside or inside of our planet, and the way in which the earth moves and deforms in response to these forces. This includes the entire range of phenomena associated with Earth rotation and Earth orientation such as polar motion, length of day variation, precession and nutation, the observation and understanding of which are critical to the transformation between terrestrial and celestial reference frames. It also includes tidal processes such as solid Earth tides and ocean loading tides.

During the last few decades many geophysicists have come to use geodynamics in a more restricted sense to address processes such as plate tectonics and postglacial rebound that are dominantly endogenic processes. Because the Earth as a mechanical system responds to both endogenic and exogenic forces, and these responses are sometimes coupled, Commission 3 studies the entire range of physical processes associated with the motion and the deformation of the solid Earth. The purpose of Commission 3 is to promote, disseminate, and, where appropriate, to help coordinate research in this broad arena.

Sub-commission 3.1 (Earth Rotation and Earth Tides) addresses the entire range of Earth rotation phenomena including tidal deformation. Sub-commission 3.2 (Tectonic Deformation) addresses the entire range of tectonic phenomena including plate tectonics, intraplate deformation, the earthquake deformation cycle, a-seismic phenomena such as episodic tremor and slip, and volcanic deformation. Sub-commission 3.3 (Geophysical Fluids) addresses the space-time variation of atmospheric pressure, seafloor pressure and the surface loads associated with the hydrological cycle, and Earth's (mainly elastic) responses to these mass redistributions. Sub-commission 3.4 (Cryospheric Change and Earth Deformation) addresses the Earth's instantaneous and delayed responses to ice mass changes, including seasonal (cyclical) mass changes and progressive changes associated with climate change. This group will study postglacial rebound at all spatial scales, and also the elastic deformation taking place in the near-field of existing ice sheets and glaciers.

The areas addressed by the various Sub-commissions sometimes overlap. Commission 3 also has overlapping interests with other entities within the IAG, and with Commissions in other Associations such as the International Astronomical Union (IAU). The recent space mission GRACE has expanded our common interests with IAG Commission 2 (Gravity) since temporal changes in gravity are associated with both the drivers of Earth deformation (e.g. changing ice and loads) and with Earth's response to these and other forcing.

Objectives

The objectives of Commission 3 are to develop cooperation and collaboration in computation, in theory, and in observation of geodynamics and Earth rotation, and to ensure development of research in these areas 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 geodynamics and Earth rotation. The Commission also serves the geophysical community by helping the IAG to link scientists 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.

Activities

The activities of Commission 3 during the last quadrennial are given in detail in the Sub-commission reports given below. Other major activities of Commission 3 during 2007–2011 include:

- Participation in IAG's Global Geodetic Observing System (GGOS). Many of the members of Commission 3 are members of the GGOS Steering Committee and the GGOS Executive Committee.
- Participation in special workshops and conference sessions related to geodynamics and Earth rotation such as the Journées Systèmes de Références Spatio-temporels that were held in greater Paris (2007, 2010) and in Dresden (2008). Of special interest to Commission 3 during the past 4 years are the many great earthquakes and associated tsunamis that have occurred recently and their impact on geodynamics and Earth rotation. Sessions at major conferences have been dedicated to these topics.
- Strengthening the link between the Sub-commissions and Inter-commission Projects. A Symposium on "New Challenges in Earth Dynamics" was held in Jena, Germany in September 2008 that included broad participation by all components of Commission 3. Another symposium planned to be held in Egypt in 2012 is also expected to involve all of the Commission 3 components.

- Strengthening the link between Commission 3 and the IAG Services. The IAG Services provide the data and products needed to study geodynamics and Earth rotation and it is important that Commission 3 and the Services be closely linked to each other. This is being accomplished by Commission 3 members participating in GGOS and in the IERS Global Geophysical Fluids Center.
- Strengthening the tie between IAG Commission 3 and IAU Commission 19 (Rotation of the Earth). Discussions have been held with the President of IAU Commission 19 about the possibility of holding a joint workshop on Earth rotation like the joint GGOS/IAU workshop on "Observing and Understanding Earth Rotation" that was held in Shanghai, China during October 25–28, 2010.

Sub-Commission 3.1: Earth Rotation and Earth Tides

President: Gerhard Jentzsch (Germany)
Vice-President: Spiros Pagiatakis (Toronto)

During the IUGG General Assembly in Perugia, 2007, Gerhard Jentzsch was asked to continue his presidency. And again, Gerhard Jentzsch asked Spiros Patiatakis to act as Vice-President of this Sub-Commission. Since Olivier Francis did not want to continue as Secretary we decided that we would pass on without nominating a secretary.

1. Symposium on New Challenges in Earth Dynamics, including the 16th International Symposium on Earth Tides, together with the other two sub commissions

Because of the re-organisation the old 'Earth Tide Commission' was renamed and the scope was extended to 'Earth Rotation and Earth Tides'. The new definition and the development of the terms of reference covered the first months after the IUGG 2007.

A main task was the preparation of the 16th International Symposium on Earth Tides to be held in Jena in September 2008 together with the other Sub-Commissions of Commission 3 and including inter-commission projects and study groups. The symposium was a successful event: 116 colleagues from 24 countries took part. The motto of the symposium was "New Challenges in Earth Dynamics".

During the symposium, the Earth Tide Commission Medal was awarded to two well known colleagues:

Bernard Ducarme and Tadahiro Sato

The documents as well as the nominating essays written by Walter Zürn for Tadahiro Sato and David Crossley for Bernard Ducarme are published in volume 144 of the Bulletin d'Information Marées Terrestres. This was the third and last time this medal was awarded: The name of the commission has changed, and, thus, the name of the medal has to be changed as well (see below).

The proceedings were split up in two parts: The *first part* contains speeches, reports and organizational details as well as the resolutions and the more technical papers collected for the Bulletin d'Information Marées Terrestres (BIM); the first volume no. 144 was already published in December 2008, no. 145 followed in Dec. 2009, and no. 146 was available in Dec. 2010. The *second part* of the proceedings contains papers published by the Journal of Geodynamics: a special issue containing 40 papers was prepared by guest editors Jentzsch, Jahr, and Kroner. The special issue, Vol. 45, Nos. 3-5, appeared in Dec. 2009.

The resolutions approved at the end of the symposium touch different topics:

1. The Earth Tide Commission Medal should be renamed as *Paul Melchior Medal* to acknowledge first the fact that the Earth Tide Commission does not exist any more under this name. More important are the tremendous activities Paul Melchior put into the development of tidal research, especially his activities world-wide, to name this medal after him.
2. The next symposium to be held in Egypt in 2012 (invited by the National Research Institute for Astronomy and Geophysics) should also combine all sub-commissions and inter-commission committees.

3. One scientific point concerns the estimation of ocean tide models which often give the tide height only. Since also the angular momentum of tidal currents is needed to model tidal effects, in future beside tide heights also barotropic tidal currents should be taken into account.
4. Organisational points concern the Global Geodynamics Project (GGP): Its transition from an Inter-Commission project to an IAG Service should be discussed to prepare a proposal to be decided during the next IUGG (2011). Second, the running of the GGP data base should cover several tasks for the benefit of the community of users, like standardisation to 1-minute data, calibration history of the SGs, and providing corrected 1-minute data as well as the results of the tidal analyses to all users.

Following these resolutions, the family of Paul Melchior was asked to agree to name the medal after Paul Melchior – the answer was positive. Concerning the next symposium to be held in Egypt, invited by the National Research Institute for Astronomy and Geophysics (NRIAG), the negotiations were carried on. Prof. Dr. Khaled Zahran is the responsible scientist. The intention is to hold the meeting in Cairo, outside the period of high temperatures.

2. ICET and next meeting

Another task was the move of the International Center for Earth Tides to another place, because the Royal Observatory of Belgium did not agree to continue to host ICET after Bernard Ducarme's retirement at the end of 2007. After discussions with several potentially interested institutions, during the last meeting of Sub-Commission 3.1 in Perugia, 2007, it was decided to accept the offer of the University of French Polynesia, Tahiti, to host ICET; Jean-Pierre Barriot is the responsible scientist.

From Oct. 03 to 11, 2010, Jentzsch visited the new ICET in Tahiti to see the progress and to talk to the local staff. In all, the impression is promising, but there is still a lot to do until the previous standard is reached again. The problems concern the work with the data as well as the Bulletin (BIM), which appears now electronically with only a few printed copies.

In connection with ICET we also had to discuss the future of the GGP data base as an integral component of the IAG GGOS program: There exists a cooperation agreement between ICET and GFZ – Potsdam to host and maintain this data base within the GFZ/ISDC. But after some changes involved colleagues have some concerns about the future support. Therefore, during the last symposium Gerhard Jentzsch was asked to discuss the matter with the president of GFZ or the management board. Up to now several letters were written, but without any answer. Also before the IAG in Buenos Aires in 2009 there was no official answer to be reported during the splinter meeting of Sub-Commission 3.1.

On 30th of June, 2011, the Sub-Commission 3.1 will have a splinter meeting during the IUGG General Assembly in Melbourne. During this meeting a new president has to be elected; Jentzsch will not more be available due to retirement.

3. Working groups of SC3.1

The SC3.1 has three working groups which continued during the period 2005-2011:

- Earth Tides in Geodetic Space Techniques, co-chaired by H. Schuh and Wu Bin,
- Analysis of Environmental Data for the Interpretation of Gravity Measurements, chaired by C. Kroner,
- Precise Tidal Prediction, chaired by Y. Tamura.

4. Future work

The future work will have two main tasks:

1. First, we will have to support the new International Center to help to develop its new feature following modern needs and using the available digital and internet facilities. Here, we have to consider that Tahiti is quite far away and not so easy to reach like Brussels was. Further, new ICET has to develop research goals and, thus, gain experiences and to make them available to the community.
2. The second task is the next symposium: It will be the first symposium in Africa, and a small but quite active group in Cairo will be responsible (supported by the National Research Institute for Astronomy and Geophysics). With this symposium in Egypt we hope to advertise for research in geodynamics and long-period crustal dynamics, also in countries not so much involved up to now.

Further, we need a new president to be elected during the meeting in Melbourne, 2011.

Sub-Commission 3.2: Tectonic Deformation

President: Markku Poutanen (Finland)

Members of the board:

Markku Poutanen (Finland), President
Jeffrey Freymueller (USA), vice president
James Davis (USA), Cryospheric Change and Earth Deformation
Kosuke Heki (Japan), Asia-Pacific area coordinator
Janusz Sledzinski (Poland), Geodynamics of the Central Europe
Susanna Zerbini (Italy), WEGENER and GEO

Overview

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. This include the entire range of tectonic phenomena including plate tectonics, intraplate deformation, the earthquake deformation cycle, aseismic phenomena such as episodic tremor and slip, and volcanic deformation. The time scales range from seconds to years and from millimetres 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.

One of the key issues nowadays is the definition and stability of global and regional reference frames. Tectonic deformations in all time and spatial scales as well as mass transfer will affect reference frames. The work done in SC3.2 will deal in information essential to the reference frames.

Events 2008-2011

Earth Tides Symposium

The Commission 3 of the IAG together with sub-commissions on Earth Tides (3.1), Crustal Deformation (3.2), Geophysical Fluids (3.3) and the Global Geodynamics Project (GGP) organized for the first time a joint meeting in Jena, Germany, September 1-5, 2008. It included the 16th International Symposium on Earth Tides. The assembly provided a unique opportunity to exchange new results and strategies to meet the current challenges of Earth's dynamics from different viewpoints. Subcommission 3.2 was responsible of plans and arrangements of one session, as well as arranging the review of papers in session submitted for the proceedings.

A special issue containing 40 papers was published in Journal of Geodynamics special issue, Vol. 45, Nos. 3-5, 2009. A non-reviewed publication containing speeches, reports and the technical papers appeared in the series of Bulletin d'Information Marées Terrestres 144, 145 and 146 in 2008-2010.

DynaQlim - GGOS workshop

The Global Geodetic Observing System (GGOS) of the International Association of Geodesy (IAG) and the International Lithosphere Program (ILP) Regional Co-ordination Committee DynaQlim organized a joint workshop "Understanding Glacial Isostatic Adjustment" in Espoo, Finland June 23-26, 2009. Local Organisers were the ILP National Committee, and DynaQlim, IAG Subcommission 3.2. Tectonic deformations, Finnish Geodetic Institute, Geological Survey of Finland, and University of Helsinki. The objective of the workshop was to review the current state of the science in modeling glacial isostatic adjustment, to review the use of geodetic measurements to both constrain and to test GIA models, to identify obstacles to improving GIA models, and to identify the improvements to the global geodetic observing system that are required to advance our understanding of glacial isostatic adjustment.

The major outcome of the workshop was a report summarizing the current state of the science, a description of future research directions, and a description of the future observations that are needed to improve our understanding of glacial isostatic adjustment. This summary was published in Gross, R., M. Poutanen (2009): Geodetic Observations of Glacial Isostatic Adjustment. EOS, Vol. 90, No. 41, p. 365. The proceedings will be published in the Physics and Chemistry of the Earth, in 2011.

Steering Committee meeting 2009

A meeting of the steering committee was arranged during the IAG Assembly in Buenos Aires, Sept. 2, 2009. Present: Markku Poutanen, Jeff Freymueller, Kosuke Heki and Janusz Sledzinski. Susanna Zerbini consulted.

1. Short report by MP about last year activities.
2. Janusz Sledzinski gave a report on Central European Initiative activity.
3. Discussion on ways to activate the work of the SC.

Based on the discussion in the SC meeting two tasks were initiated:

a) Attempt to co-organize a session in the IUGG General Assembly in Melbourne 2011 and arranging a special issue in a peer reviewed journal. There are now two SC3.2 related sessions in the Melbourne GA where SC3.2 members are as co-organizers:

   J-G04: Structure and Deformation of Plate Interiors.

   - Organiser: IAG
   - Co-sponsor: IASPEI, IAVCEI
   - Lead Convenor: John Dawson
   - Co-convenors: Sierd Cloetingh, Kevin Furlong, Markku Poutanen

J-G06: Tectonic Geodesy and Earthquakes

- Organiser: IAG
- Co-Sponsors: IASPEI
- Lead Convenors: David D. Jackson, Jeff Freymueller
- Co-Convenors: Valentin Mihkailov

b) Co-operation with IAG Working Group "Regional Dense Velocity Fields", chaired by Carine Bruyninx. There has been some preliminary discussion with MP and Carine Bruyninx about the idea, and it was agreed to continue discussion.

Permanent working group 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. Till 2008 the programme of activities was coincided and overlapped with actions performed by the Section C, Geodesy, of the WG Science and Technology of the Central European Initiative (CEI). In 2008 CEI has abolished. The formal membership list of the IAG WG includes 27 scientists from 12 European countries. The activities of the WG concentrated on the following subjects:

- European geodetic and geodynamic programmes:
  - CERGOP = Central Europe Regional Geodynamics Project;
  - CEGRN = (Central European GPS Reference Network) Consortium,
- Local geodynamic projects
  - subgroups of the CERGOP Study Group CSG.5 Geotectonic Analysis of the Region of Central Europe in the following regions:
    - Eastern Alps and the North and Eastern Adriatic Sea; Romania Plate; Pannonian Basin; Plitvice Lakes, Croatia; Tatra Mountains; Northern Carpathians; Balkan Peninsula.
- Cooperation of CEI Section C Geodesy and European Geosciences Union (EGU)

Future plans

A new president for SC3.2 will be elected during the GA in Melbourne.

One should seek ways to activate the work of subcommission in the framework defined by the Commission 3. Establishing regional working groups similar to WG in Central Europe may help in this. Close contacts with related groups outside IAG, like WEGENER (Working group of European Geoscientists for the Establishment of Networks for Earth science Research) and DynaQlim (Upper Mantle Dynamics and Quaternary Climate in Cratonic Areas) will be continued.

Sub-Commission 3.3: Geophysical Fluids

President: *Aleksander Brzezinski (Poland)*
Vice-President: *Mike Thomas (Germany)*
Members: *David Salstein (USA) - Atmosphere*
Rui Ponte (USA) - Oceans
Richard D. Ray (USA) - Tides
Benjamin F. Chao (Taiwan) - Hydrology
Richard Peltier (Canada) - Mantle
Tim van Hoolst (Belgium) - Core
Erricos Pavlis (USA) - Gravity/Geocenter
Tonie van Dam (Luxembourg) - Loading

Terms of Reference

Charter

Mass transport in the atmosphere-ocean-cryosphere-mantle-core system, or the "global geophysical fluids", cause observable geodynamic effects on broad time scales. 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 of the Earth's dynamic response. Angular momenta and the related torques, gravitational field coefficients, and geocenter shift for all geophysical fluids are the relevant quantities. They are studied theoretically and are observed using global-scale measurements and/or products from state-of-the-art models, some of which assimilate such measurements.

Objectives

The objective of the Sub-Commission is to serve the scientific community by supporting research and data analysis in areas related to variations in Earth rotation, gravitational field and geocenter caused by mass transport in the geophysical fluids, which include the atmosphere, ocean, continental water, mantle, and core along with geophysical processes associated with ocean tides and the hydrological cycle.

- The Sub-Commission is aware that its objectives overlap with the objectives of the IAG Global Geodetic Observing System (GGOS) with its central theme "Global deformation and mass exchange processes in the Earth system" and the following areas of activities
- deformation due to the mass transfer between solid Earth, atmosphere, and hydrosphere including ice;
- quantification of angular momentum exchange and mass transfer.

Program of Activities

Sub-Commission 3.3 follows the program defined by Commission 3. In addition, SC 3.3 interacts with the sister organizations and services, particularly with the Global Geophysical Fluids Center (GGFC) of the International Earth Rotation and Reference Frames Service (IERS) and its components: three operational Special Bureaus - for the Atmosphere SBA, Oceans SBO, and Hydrology SBH, Special Bureau for combination products and the non-operational components. Due to the overlapping of the tasks, SC 3.3 should also have close contacts to the GGOS activities.

Report on Activities 2007-2011

The Sub-Commission 3.3 participated, together with the Sub-Commissions 3.1 "Earth Rotation and Earth Tides", 3.2 "Crustal Deformation", and the Inter-Commission Global Geodynamics Project (GGP), in organization of the Earth Tide Symposium 2008 "New Challenges in Earth's Dynamics" in Jena, Germany, 1-5 September 2008. This joint symposium was an important event strengthening interactions between these 3 Sub-Commissions and the GGP. The Organizing Committee of ETS2008 decided to continue the idea of joint symposium with the next ETS, to be held in Egypt.

Important exchanges of information at meetings during the period occurred at the IERS Workshops, 2007 in Sevres, France, and 2009 in Warsaw, Poland, at the conferences of the series Journées Systèmes de Référence Spatio-Temporels, 2007 in Meudon, France, 2008 in Dresden, Germany, and 2010 in Paris, France, at the American Geophysical Union meetings, and the European Geosciences Meeting, Vienna, where special sessions were held on "Observing and understanding Earth rotation variability and its geophysical excitation" (2008, 2009, 2010, 2011), "Geophysical models for the analysis of space-geodetic techniques" (2008) and "Geodetic observations: model advances and time series effects" (2009). We should also mention a Joint GGOS/IAU Science Workshop 2010 "Observing and understanding Earth rotation" in Shanghai, P.R. China.

There has been considerable development of the global circulation models of geophysical fluids in recent years. Progress has been attained in modelling the atmospheric circulation, examples being new reanalysis model ERA40 and an experimental model with hourly resolution (Salstein et al., 2008a). The IERS GGFC Special Bureau for the Atmosphere www.aer.com/scienceResearch/diag/sb.html continues its effort to provide atmospheric data relevant to the study of the Earth's variable rotation. The time series are updated on regular basis and are available in near-real time. The IERS GGFC Special Bureau for the Oceans http://euler.jpl.nasa.gov/sbo/ provide data relating to non-tidal changes in oceanic processes such as the global Ocean Angular Momentum (OAM) mass and motion terms. The OAM series based on the ECCO ocean global circulation model are updated up to the recent months and are available for users in two versions, derived by analysis with and without data assimilation. The user should be aware of the fact that the OAM series based on the model with data assimilation, which should be better than the standard series, in general, appear to be corrupted by the tidal effects which have not been removed perfectly form the satellite altimetry observations; see (Gross, 2009) for details. The IERS GGFC Special Bureau for the Hydrology www.csr.utexas.edu/research/ggfc/ provides data sets and numerical model results related to the changing distribution of water over the planet, especially over land. Other important data sets concerning the influence of geophysical fluids on the Earth's dynamics are provided by the GGFC http://geophy.uni.lu/ and its remaining components, Special Bureau for combination products and the non-operational components.

One important problem in estimation of the influence of external fluids, the atmosphere, the oceans and the land hydrology, on Earth rotation and other geodynamical phenomena is associated with the inconsistencies in the treatment of mass conservation problem in models of those components; see the report of Maik Thomas below for further details. The results obtained from the satellite Gravity Recovery and Climate Experiment (GRACE) are of crucial importance for solving this problem. This experiment measures changes of the Earth's gravity field with monthly time resolution. From the GRACE observations one can estimate the mass redistribution on the planet surface including contribution from the three components mentioned above. Some recent results comparing results using GRACE data and those based on outputs of the available models of geophysical fluids (e.g., Nastula et al., 2007; Brzezinski et al., 2009) are quite promising.

Below we present brief reports provided by the members of the Sub-Commission 3.3: by Maik Thomas – on the related research projects in Germany, concerning the modelling of the atmosphere (David Salstein), the oceans (Rui Ponte), and the gravity and geocenter (Erricos Pavlis).

Report on research concerning geophysical fluids (Maik Thomas, Germany)

In order to consistently represent mass transports in the global hydrological cycle and to estimate variations in global geodetic parameters due to water mass redistributions a model combination for the atmosphere-hydrosphere system has been established at the German Centre for Geosciences (GFZ). The model combination consists of the hydrological land surface discharge model (LSDM; Dill, 2008) and the ocean model for circulation and tides (OMCT). Both models are consistently forced with operational data from the European Center for Medium Weather Forecasts (ECMWF). The ECMWF-LSDM-OMCT model combination is running on a daily operational basis producing global mass variations and Earth rotation parameters in near real time (Dobslaw et al., 2010). These operational time series as well as short-term predictions for Earth rotation parameters based on ECMWF's forecasts are available via the corresponding sub-bureaus of the GGFC (Dill and Dobslaw, 2010).

In close cooperation with the German research unit "Earth rotation and global dynamic processes" an Earth system model for physically consistent simulations of atmospheric, oceanic and hydrological induced variations of Earth rotation, deformation and gravity field has been developed in a research project supported by DFG with participating German scientists from geodesy, meteorology and oceanography (Hense et al., 2009). The dynamical system model couples numerical models of the atmosphere, of ocean tides and circulation as well as of continental discharge considering consistent mass, energy and momentum fluxes between these near-surface subsystems of the Earth in order to allow for explanations and interpretations of geodetically observed variations of global parameters of the Earth.

Report on research concerning the atmosphere (David Salstein, USA)

During this period we continued the archives of the atmospheric angular momentum series at the IERS Special Bureau for the Atmosphere. We used GRACE and other gravity and hydrological data as information for excitations of polar motion by hydrology, supplementing the other geophysical fluids (Nastula et al., 2007). We examined the high frequency series from hourly fields using an experimental series from U.S. NASA (Salstein et al., 2007). We assessed the quality of data sets including the surface pressure for various geodetic applications, including surface pressure fields needed for the GRACE mission (Salstein et al., 2008). We analyzed the partition between the tropospheric and stratospheric angular momentum series, and found a negative correlation between the angular momentum in these two regions (Zhou et al., 2008). Lastly, we partitioned the regional excitations of polar motion, due to equatorial atmospheric angular momentum into their temporal bands, and discovered where the atmospheric impact has the greatest variability on polar motion. (Nastula et al., 2009).

Report on research concerning the ocean (Rui Ponte, USA)

Among the activities pursued in the period 2007-2011, we have continued to produce global estimates of the ocean circulation and mass fields need for calculation of ocean angular momentum (OAM) and related quantities, in collaboration with our ECCO partners (Wunsch et al., 2009). Other efforts were focused on evaluating the quality of available atmospheric pressure fields (Salstein et al., 2008) and including their effect on ocean circulation estimates (Ponte and Vinogradov, 2007), and on using GRACE data for assessing and improving the quality of OAM variables (Nastula et al., 2007; Ponte et al., 2007; Quinn and Ponte, 2008). A detailed discussion of the uncertainties associated with GRACE-derived ocean mass trends was provided by Quinn and Ponte (2010). Observations from GRACE also permitted a new study of how wind stress torques are balanced quickly by bottom pressure torques acting on bottom topography (Ponte and Quinn, 2009). Vinogradova et al. (2010) call attention to the importance of accounting for self-attraction and loading effects when determining the annual cycle in ocean bottom pressure. The potential for extracting information about the oceanic mass fields from observations of sea level was addressed in Vinogradova et al. (2007).

Report on research concerning the gravity/geocenter (Erricos Pavlis, USA)

My main contribution to SC 3.3 is in the development and maintenance of time series of "geocenter" variations with respect to each ITRF. A series is updated weekly with a new vector estimate referenced to the middle of the week, based on the analysis of LAGEOS 1 & 2 and ETALON 1 & 2 satellite laser ranging (SLR) data. We simultaneously solve for the second-degree terms of the gravitational field, so series of those harmonics are also available for the same time period. Up until a year ago the series were still with respect to ITRF2000. However, with the reanalysis of all SLR data since 1983 in view of the ITRF2008 project, a new series was obtained which is referenced to ITRF2005S (i.e. the version of ITRF2005 that has the correct scale).

Another area of contribution is the improved modeling of geodetic data used to monitor geophysical fluids and their motions. An area that required improved models for increased accuracy SLR analyses was that of the atmospheric delay modeling. The 1973 model used up until recently has now been replaced by a model that was derived in part to support the above activities and it has been adopted by the ILRS and IERS as the standard for optical wavelengths (Pavlis et al., 2008). Going further, we have now established an approach (Hulley and Pavlis, 2007) that utilizes meteorological fields to more accurately approximate the atmospheric delay with data beyond the observing SLR station and to account for horizontal atmospheric gradients.

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Sub-Commission 3.4: Cryospheric Change and Earth Deformation

President: James L. Davis
Vice-President: Detlef Wolf

Introduction

Subcommission 3.4 (Cryospheric Change and Earth Deformation) was started in 2007, and is intended to focus on those methods and techniques in Geodesy that focus on the deformational response of the Earth to changes in glacier mass balance. This area is thus an important component of the geodesy of the Earth system. Although, for consistency's sake, there is some minor overlap with other subcommissions, the focus on Earth deformation brings in a variety of geodetic observations and techniques, including ground- and space-based observations of global and regional deformation, gravity, sea level, and ice thickness.

The members' activities are a mixture of observational and theoretical, covering short-term (i.e., ongoing melting) and longer-term (i.e., glacial isostatic adjustment) solid-Earth response to cryospheric changes. (See also the Terms of Reference, below.) Members of the sub-commission include: J. Davis, R. Dietrich, P. Elósegui, H. Geirsson, E. Ivins, S. A. Khan, M. King, O. Kristiansen, G. A. Milne, I. Sasgen, D. Wolf, and X. Wu.

Terms of Reference

Past and present changes in the mass balance of the earth's glaciers and ice complexes induce present-day deformation of the solid earth on a range of spatial scales, from the very local to global. The earth's deformational response to cryospheric change is complex due to a number of factors, including: complexities in the viscoelastic structure of the earth; the spatial and temporal variability of the mass changes; and the interaction between the cryosphere and the ocean, which lead to a redistribution of cryospheric mass in a highly dynamic system. These complexities pose both observational and modeling challenges. The purpose of Sub-commission 3.4 is to promote, and where appropriate, to help coordinate research involving geodetic observation and modeling of earth deformation due to past and ongoing cryospheric changes, with emphasis on present-day deformation taking place in the near field of existing ice sheets and glaciers and the extent to which this deformation is a response to climate change.

Activities 2007–2011

GIA Observation and Modeling

The modeling of glacial isostatic adjustment (GIA) is becoming more complex as both the Earth models [e.g., Klemann et al., 2008; Simpson et al., 2010] and ice history [e.g., van den Berg et al., 2008; Milne et al., 2008] evolve. At the same time, new geodetic observations are acquired and new methods for extracting the geodetic information are being developed [e.g., Tamisiea et al., 2007; Pagli et al., 2007; Hill et al., 2008; Tamisiea et al., 2008]. Observations continue to be used to test and assess available GIA models [e.g., Khan et al., 2008; Groh et al., 2009; Sasgen, 2010].

Present-day mass glacier mass changes and GIA

One of the most difficult tasks facing us is the separation of present-day mass changes and GIA signals. During this period, the GRACE data set achieved much attention, and was used alone or in combination with ground-based data sets to study GIA or separate GIA from present-day effects [e.g., Boehm et al, 2008; Dietrich et al., 2008; Ivins and Wu, 2008; Ivins et al., 2008; Sasgen et al, 2007a; Sasgen et al, 2007b; Sasgen et al, 2008]. In fact, joint inversion studies seem to be generally on the increase [e.g., Tamisiea et al., 2007; Sasgen et al., 2007b, 2008; Dietrich et al., 2008; Hill et al., 2008, 2010; Wu et al., 2009, 2010a,b; Ivins et al, 2010a; Wu, 2010], reflecting the need to disentangle the signatures of GIA from present-day mass change effects. Importantly, relevant ground-based data sets continue to improve [e.g., Dietrich et al., 2008; Groh et al., 2009; Lidberg et al., 2007, 2009, 2010; Milne et al., 2008; King et al., 2009; Scherneck et al., 2010; Whitehouse et al., 2010]. Several sub-commission 3 members published or edited reviews on the topic [King et al., 2010; Wolf et al., 2010].

Deformation due to present-day glacier melting

Ground-based observations on regional or local scales presented us with new specific information on the mass balance of glaciers and how they are impacted by the climate [e.g., Árnadóttir et al., 2008; Khan et al., 2007; Khan et al., 2008; Pagli et al., 2007]. Of great importance is the POLENET project [Wiens et al., 2007]. Now called A-NET (Antarctic network), the network consists of 40 GNSS sites in Antarctica. Its "antipodal sister" is G-NET, consisting now of 46 GNSS sites. Data from these networks are being used to measure solid-Earth deformation in response to melting on seasonal [Bevis et al., 2009a; Kendrick et al., 2010] and longer [e.g., Kahn et al., 2007; Pagli et al., 2007; Bevis et al., 2009b; van Dam et al., 2010; Kahn et al., 2010a, b, c].

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Inter-Commission Project 3.1: Global Geodynamics Project (GGP)

Chairman: David Crossley (USA)
Secretary: Jacques Hinderer (France)

Overview

GGP is listed only under Commission 3 Structure, but it is a Joint Project of Commissions 3 and 2; this report is therefore sent to both Commissions.

1. Introduction

Our report was prepared with knowledge of the report of Gerhard Jentzsch, President of Sub-Commission 3.1 - Earth Rotation and Earth Tides, to the IAG. We thank Gerhard for his remarks that covered several topics involving GGP, thus enabling us to reduce duplication here. Gerhard notes that changes to the IAG structure in 2007 have impacted the functioning of the former Earth Tide Commission (ETC), the International Centre for Earth Tides (ICET), and also GGP.

After the last IUGG Assembly in Perugia 2007, the main task given to GGP was to plan a transition from an Inter-Commission project to an IAG Service, and to prepare a proposal for adoption at the IUGG in 2011. Some progress was achieved on this task up to the IAG meeting in Buenos Aires (2009), with positive encouragement from within IAG. Unfortunately momentum has been lost in the last two years due to issues arising from the move of ICET from the Royal Observatory of Belgium (ROB) in Brussels to the University of French Polynesia (UPF) in Tahiti.

GGP originally (in 1997) chose the database at ICET in Brussels as the vehicle for storing and processing superconducting gravimeter (SG) worldwide data. Through an arrangement between ROB and GFZ (Potsdam), the latter organization became the physical location of the database, but ICET at ROB was the responsible gateway. This arrangement worked well until the retirement of B. Ducarme from ROB (end of 2007), after which ICET was moved to UPF under the Directorship of J.-P. Barriot (see the report of G. Jentzsch).

2. The actual situation for GGP

Before going further, it is appropriate to remind all GGP members, and IAG, that the organization of GGP is skeletal. It consists of a Chair (D, Crossley) and a Secretary (J. Hinderer). There is no other structure – no secretaries, no technical help, and no students dedicated to GGP tasks. We like to think GGP has achieved many things in the past 14 years; if so its success has been due to two factors:

a) the willingness of the various SG groups to send data to ICET on a regular basis. In the early years of GGP, there was extensive discussion of the structure of GGP data, the standards for the data, and the frequency with which it should be made available to other scientists. In 2011 times have changed, and with many new SG users joining the community, some with no background in tidal gravimetry. There are also new requests for quicker release of SG data, so some of the original agreements need to be revisited.

b) the willingness of some organizations to host GGP Workshops, either stand-alone, or as part of meetings such as the Earth Tides Symposia. Examples (not exhaustive) are the ROB (ICET) in Brussels (Melchior/Ducarme/Francis), the University of Jena (Jentzsch /

Kroner), Japanese institutions in Mizusawa and Kyoto (Sato / Tamura / Takemoto), and the Hsinchu SG group in Taiwan (Hwang). Their organizational effort has provided the structure upon which GGP has met and discussed SG data.

The tasks that GGP *can do* are limited to: maintaining the GGP website, planning and scheduling (not frequently even organizing) GGP meetings and workshops, reviewing the statistics of the SG stations sending data to the GGP database, and promoting the use of SG data in the community (e.g. through GGOS meetings) towards achieving various scientific goals.

The tasks that GGP *cannot do*, on a regular basis, are the processing and correction of GGP data from ICET (except for special in-house projects), moderating the interaction between the SG groups and the GFZ database, responding to community demands for help in tidal processing, and doing regular tidal analysis to check the quality of all GGP data. Until 2007 most of these tasks were done by ICET in Brussels.

3. GGP events 2007-2011

As covered in Jentzsch's report, many GGP papers were presented as part of the 16'th International Symposium on Earth Tides in Jena in 2008, the proceedings of which can be found in the Bulletin d'Information Marées Tèrrestre (BIM) on the GGP website http://www.eas.slu.edu/GGP/BIM recent issues. Issues 144-146 contain the formalities and papers from the symposium; BIM issues are also available through ICET at http://www.bim-icet.org. Other papers were published in the Journal of Geodynamics (volume 48, 2009). A full report of GGP Business is available through GGP Newsletters #19 and 19a, available at http://www.eas.slu.edu/GGP/ggpnews.html.

A Second Asian SG Workshop was organized in Taiwan by Cheinway Hwang and colleagues in June 2010, and a full report of covering that meeting is contained in Newsletter #20 (available as above). A number of papers from that meeting can be found at http://space.cv.nctu.edu.tw/SG2/programs.html.

GGP Business Meetings and discussions were held at the EGU Meetings from 2008-2010. In 2010 an EGU Session G9.2 "Mass transport involving ground gravity and deformation observations" was organized by C. Kroner and GGP to highlight oral papers on the topic of ground gravity and deformation measurements. We thank C. Kroner for also giving several review talks of GGP science, for example at the 2nd IGFS Meeting in Fairbanks, Alaska, October 2010, and similarly to J.-P. Boy for giving a GGP overview at the AGU Fall meeting in December 2010.

We should not forget the introduction of the new iGrav SG by GWR Instruments (San Diego, CA), the only SG supplier. With almost the same performance as the Observatory instrument (OSG) in a smaller package, it promises to be a popular instrument, due to transportability.

4. Status of the GGP database

As of March 27, 2011, the ICET database contained the following data from stations operating since 2007. The stations are divided into 3 categories.

a) First generation stations – those operational before the official start of GGP (97/7/1). Most stations still operating have kept up to date with sending their data (WU, ST, WE, and CA). Esashi SG stopped at the end of 2008 and was moved to Mizusawa.

b) Second generation stations – those started during the first GGP campaign (97-03). Almost all of these stations have operated well (CB, MB, MC, ME, BH, MO, NY, and SU) with the data almost up to date. We have no data from Matsushiro (MA), and station Tigo Concepcion (TC) had some troubles due to the Chile earthquake in 2010. The SG at Vienna has been moved to the Conrad Observatory (Austria) and was restarted in 2009.

c) Third generation stations – newer stations since 2007. Only 3 of these (HS, PE, and KA) have sent any appreciable amount of data. MunGyung (MG) stopped in 2010 but we never received the previous data. We are waiting on data from AP, BF, CO, DJ, WA, WG, and GE. We hope by the time of the IUGG (June 2011), that at least some of these stations will have responded.

ICET (Ducarme/Barriot) have been processing and correcting 1 minute data covering the period 2007/1/1 – present. This is available at the ICET/GFZ site http://ggp.gfz-potsdam.de/

5. GGP and ICET

In order for GGP to become an IAG service, it was essential that several tasks be organized in a solid and responsible manner for the benefit of IAG, and particularly GGOS as the umbrella project for geodetic and gravity data.

These tasks were identified by Jentzsch as the standardization of 1-minute data, the correction of 1 minute data by ICET, the provision of a calibration history for all the gravimeters within GGP, and the provision of annual tidal analyses of the GGP data by ICET. It was also recognized that the SG data flow had peaked in the early 2000s and some of the new SG stations were unfamiliar with high precision gravity data and their processing. For a number of reasons, the percentage of SG data being sent to ICET has declined in the last few years, despite the efforts of GGP to assist new groups in sending the data to GFZ. As indicated in section 4, it is the newer stations that (as a group) have sent the least data.

GGP data has always been sent directly to GFZ. As indicated above, prior to 2007 other aspects of the GGP data were handled by ICET. Since 2007, and until early 2010, there had been no correction of GGP data by ICET. The automatic program envisaged and presented by J.-P. Barriot in 2007 to do this task has not yet been released to GGP.

The raw 1 minute decimated data usually sent to GFZ includes spikes, disturbances and offsets, which if left in the data renders it unsuitable for tidal analysis. ROB removed these disturbances in a semi-manual way (using TSOFT) and put the processed data on the GFZ website as 'corrected 1-minute data'. ICET at ROB provided a regular tidal analysis of all stations using the corrected 1 minute data as a means of checking the quality of each SG and site. These reports were presented and published at various SG meetings.

In 2010 B. Ducarme resumed the responsibility of correcting the GGP data at ICET in the same manner as prior to 2007. At the 2nd Asian SG Meeting in Taiwan, the ICET report by B. Ducarme and J.-P. Barriot (*attached at the end of this report*) was presented showing a report of tidal analysis of stations that had sent data to ICET. This is a valuable task, as it enables a local tidal model to be used at each station to remove solid Earth and ocean tides from any data set.

If stations do not send 1 minute data to ICET, then their data will not be corrected by this procedure, and the tidal analysis cannot be done. Ducarme (personal communication) has indicated that such analyses will continue at least up to the IUGG meeting in Melbourne (June

2011). J.-P. Barriot detached one technician of his staff who is now able, after training in Brussels, to do the correction of the 1 minute data. However this additional support could be reduced in the future due to the lack of corresponding financial support and it will be necessary then to revisit the ICET commitments.

A smaller, but valuable, role of ICET was as a centre of tidal expertise for those scientists wishing to do tidal analysis, or ocean tide loading, as part of other studies. Frequently scientists were invited to ROB to learn tidal analysis for themselves. Such a service was never envisaged at UPF, (despite the desire of many scientists clamouring to go to Tahiti for such help). GGP has tried to respond to email requests for tidal services, but there have not been the resources to do this in every case. We have always recognized the manpower situation in Tahiti, but the situation with ICET needs resolving to better serve GGP, GGOS, and the scientific community.

6. GGP and GFZ

The GGP database at GFZ also needs some attention. Traditional data uploading and downloading functions are still working well, with most GGP users using the older ICET-oriented portal at GFZ, rather than the newer ISDC portal. Some inconsistencies exists between theses databases. Again the response time of GFZ to GGP inquiries is not always ideal, but the continued involvement of Bernd Ritschel in assisting GGP is much appreciated. G. Jentzsch has also made references to this point, and the lack of response from inquiries to GFZ.

There has been some discussion that a new home for the GGP database could be found within an organization that is able to handle this increasing volume of worldwide gravity data. The recent organization of the absolute gravity database (AGRAV) suggests a potential direction.

7. A seismological view of GGP

Our seismology colleagues are interested in SG data for some purposes (e.g. the Slichter triplet detection). It is instructive to read some remarks from a document online originating from UC Berekely:
"SG data has played a key role in the study of the Slichter mode, but the disadvantages of these instruments are also apparent: (1) Since SGs are very expensive and have strict site condition requirements, they are still sparsely distributed globally; (2) Only a small part of SG data are directly shared on-line, and these data always have a delay of 6 months; (3) the SG data format is not used by seismologists, and the transfer function is not always known. Compared with SGs, STS-1 seismometers also have good performance at ultra low frequency and the wide distribution of the STS-1 makes it an optimal instrument for global stacking. Also, the transfer functions are well known. For these reasons, we are trying to develop a standard procedure to search for the Slichter mode using STS-1 data."

8. Prospects and Challenges

The future of the relationships between GGP, ICET, and GFZ seems fluid. Despite the continued cooperation between B. Ducarme and J,-P. Barriot to ensure ICET a success in Tahiti, there are uncertainties about this direction. Without the full services of ICET, our report remains incomplete, and reduces the prospect of GGP as an IAG Service.

GGP discussion has centered on the following issues:

1) We need to work with the newer stations to increase the geographical coverage of GGP data in the GGP database - for example Onsala (Sweden), Schiltach (Black Forest), GETOC (Wuhan), Lhasa (China), Yebes (Spain), and Apache Point (New Mexico).
2) The current delay in stations sending data to GGP, even delays of only a few months, is a major hindrance to the better and more widespread use of the data. We need to address this topic more urgently and try to get data released immediately it is sent to the GFZ database at the end of each month.
3) More stations should be encouraged (and shown how) to send their raw data directly to IRIS. This has been a long time without finalization. Only Membach and Strasbourg do this regularly.
4) Some GGP members are suggesting a modernized data base with the daily provision of raw data (much like a gravity version of IRIS). This could be monitored for quality control.
5) There have been efforts to work more closely with the AG community with respect to the intercomparisons of AG instruments. GGP has recently completed a survey of possible SG sites where AGs can be regularly sited for a variety of studies.
6) To be an IAG service, GGP needs to deliver a reliable product. The 1 second data probably should go to IRIS (as above). The 1 minute data needs correcting for tidal analysis (ICET, as above). Perhaps GGP could provide a processing of the data for longer term studies (e.g. hydrology, tectonics, polar motion), but this would require a somewhat different kind of processing than regularly done at ICET. The lack of manpower is a major problem.

Considering all these points, GGP will present a proposal to IAG at the IUGG in Melbourne that hopefully will address some of these points.

GGP Data Preprocessing and Analysis Status at ICET

B. Ducarme and J.-P. Barriot

The last update of the GGP data had been made before the last Earth Tides symposium in 2008. The new revision gave the opportunity to process in most of the stations two years of additional data. We welcome the contribution of Hsinchu (HS) and Pecny (PE), who joined recently GGP. A total of 433 months (n in Table 1) from 14 stations have been processed since the beginning of 2010. These stations are marked in blue. Perhaps additional data have been uploaded since our processing as the data base is permanently in evolution. Stations marked in red are late in uploading their raw data. Four stations operated by the Japanese group (CB, ES, KA, NY) did not upload raw data since 2007. MA and TC stopped sending data after 2008/06. The instruments marked with a star are no more operated.

The new data have been analyzed and the results carefully compared with the previous tidal analysis results when available. The responsibles of the 14 reprocessed stations received a report of our investigations. Global tidal analyses have been processed. In some stations the end of the data had to be rejected from the global analysis due to degraded signal to noise ratio (last column of Table 1).The number of days used for the global analysis N and the standard deviation STD computed with ETERNA (ANALYZE) are given in Table 1. As the stability of the sensitivity of the superconducting gravimeters is generally better than 0.1%, the STD is a measure of the signal to noise ratio in the station. For 9 stations among the 14 updated ones the STD is lower than 1nm/s^2.

Status of the processed stations

BH: In Bad Homburg the new SG044 is operational for more than 900 days. The STD of this instrument is one of the lowest among all the GGP stations. The new SG C044 is perfectly fitting the results of the CD030-L. There is a slight calibration difference, close to 0.1%, between CD030-L and CD030-H.The phase differences of the different instruments agree within the associated RMS errors.

CA: Cantley started in 1989. It is the longest series of observations. It suffered from technical problem and the STD was multiplied by a factor of two during several months in 2006/2007. This portion of the data was rejected from the global analysis. The change of electronics on January 22 2008 did not affect the calibration. The amplitude factors agree perfectly. The new time lag of 16.3s applied since that epoch provides phases which seem a bit too large compared to previous results. If a precise determination of the true time lag is obtained it will be possible to normalize the data prior to 2008/01/22 to get homogeneous results.

HS: Hsinchu is a new station which has a large STD. The modelling of the tidal factors using recent ocean tides models is questionable as it provides ratios $\delta_{obs} / \delta_{mod}$ close to 1.01 in the diurnal band and close to 0.995 in the semi-diurnal band. The misfit is thus not related to calibration.

MA: Matsushiro remained a good station and the two last years of data are in perfect agreement with previous data.

MB: Membach continued to run very well as usual. From It is interesting to note a more or less continuous drift of sensitivity of the order of 0.03% to 0.04% between 1998 and 2009.

This variation could probably not be detected by calibration. It confirms that the stability of the superconducting gravimeters is better than 0.1%.

MC : The end of Medicina is a bit noisier than usual. After the change of electronics on 2007/06/12 the calibration factor was modified as well as the time lag. The new time lag of 11.1s is good as the phase lag on M2 is not modified. However a large jump of the amplitude factors of the order of 0.4% is appearing, while the ratio of the new and old calibrations is 1.0043. It is clear that the sensitivity of the voltage output has not been modified. It is the new calibration value which seems questionable as the results obtained with the previous calibration were fitting very well the other GGP stations in Europe as shown in Ducarme et al., 2009.

ME: Metsahovi is also a station which started well before 1997. A comparison of 5 successive analyses covering each 2 years between 2000 and 2009 has shown no shift of sensitivity at the level of 0.05%. The registration prior to the GGP period is in agreement with the GGP data within 0.1%. An adjustment factor of 0.9996 could be introduced for a better fit.
MO: Moxa is an excellent station with very low STD.

PE: Pecny is a new station with exceptionally low STD.. The 1000 registration days provide the same tidal factors as the 6 years of excellent results with the modified ASK228 but the RMS errors on the tidal factors are already lower.

ST: Strasbourg remains an excellent station even if January and December 2009 are perturbed.

SU: In Sutherland the dual sphere instrument was replaced by SG052 after July 2008. The RMS error on the unit weight of the new SG C052 is better than the RMS error of the CD instrument. There was no difference in the tidal factors between CD037-L and CD037-H.
The provisional calibration of the new SG C052 seems to be very slightly too large compared to both components of CD037, but the series of the new instrument is still too short to draw firm conclusions.

TC: Only 7 additional months have been processed in Tigo and there is no special remark.

WE: The dual sphere instrument of Wettzell is excellent. After the change of electronics on April 17, 2007 new calibration values and new time lags have been determined. The amplitude factors δ and the phase differences α of the L and H sensors are now in perfect agreement. In the previous series there was a difference in the δ values between L and H sensors at the level of 0°05%, while the phase differences were in agreement within the associated RMS errors.. It should be noticed that the amplitude factors are now increased by more than 0.1% with respect to the previous values. It confirms the conclusions of Ducarme et al., 2009 based on the previous results. The authors showed that, after tidal loading corrections, the δ_c values for O1 and M2 at Wettzell were 0.1% lower than the mean of 15 European stations. To get homogeneous results it should be necessary to apply a normalisation factor 1.0017 on the previous series of channel L and 1.0012 on channel H.

WU: Wuhan station remains in good shape since its repair at the beginning of 2005. Due to the failure two years of data have been eliminated from the global analysis i.e. 2003-2004. The STD is well below 1nm/s^2.

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Table 1: Status of preprocessed and analyzed GGP data

n: number of preprocessed months since 2008

N: number of days effectively used in the global tidal analysis

STD: standard deviation of the global analysis (ETERNA)

Code	Location	SG Instr.	ICET Code	RAW	Corrected	n (months)	N (days)	STD (nm/s^2)	remarks
BA	Bandung, Indonesia	T008	00084100	030600	030622*		1104	2.938	
BE	Brussels, Belgium	T003	07790200	000900	000901*		6692	1.641	
BH	Bad Homburg, Germany	CD030_L CD030_U SG044	01300734 02300734 00440734	070400 070400 090800	070422* 070422* 090822	 31	2222 2218 909	0.783 0.835 0.558	
BO	Boulder, USA	C024	00246085	031000	031022*		1850	1.109	
BR	Brasimone, Italy	T015	00150515	991200	991222*		1428	2.954	
CA	Cantley, Canada	T012	00126824	091100	091122	23	4212 ¶5777	1.221 1.210	
CB	Canberra, Australia	C031	00314204	070400	070422		3429	1.019	
ES	Esashi, Japan	T007	00072849	070400	070322		2274	1.491	→ 20040225
HS	Hsinchu, Taiwan	T048	00482695	081200	081222	33	898	2.249	
KA	Kamioka, Japan	T016	00162828	070500	070522		901	1.310	
KY	Kyoto, Japan	T009	00092823	030600	030622*		1533	3.691	→ 20020731
MA	Matsushiro, Japan	T011	00112834	080600	080622	25	3954	1.008	
MB	Membach, Belgium	C021	00210243	091000	091022	20	4282	0.789	
MC	Medicina, Italy	C023	00230506	100300	100300	34	4458	0.876	
ME	Metsahovi, Finland	T020	00200892	091100	091122	24	4303 ¶4829	1.254 1.154	
MG	MunGuyng, S. Korea								
MO	Moxa, Germany	CD034_L CD034_U	01340770 02340770	100400 100400	100422 100322	27 27	3576 3646	0.679 0.626	
NY	Ny Alesund, Norway	C039	00390005	070400	070422		2413	2.954	
PE	Pecny, CZ	OSG050	00500930	100300	100322	35	1046	0.557	
PO	Potsdam, Germany	T018	00180765	980900	980912*		2250	0.856	
ST	Strasbourg, France	C026	00230306	091200	091222	25	4492	0.744	
SU	Sutherland, South Africa	CD037_L CD037_U SG052	01373806 02373806 00523806	080700 080700 090900	080722* 080722* 090922	08 08 13	2665 2502 385	1.113 1.038 0.713	
SY	Syowa, Antarctic	T016	00169960	030100	030122*		1279	1.387	→ 20001231
TC	Tigo, Concepcion, Chile	RT038	00387621	080600	080622	07	1805	1.158	
VI	Vienna, Austria	C025	00250698	061200	061222*		3402	0.530	
WA	Walferdange, GDL								
WE	Wettzell, Germany	SG103 CD029_L CD029_U	01030731 01290731 02290731	980900 090800 090800	980921* 090822 090822	 29 29	¶726 3784 3750	2.639 0.629 0.642	
WU	Wuhan, China	T004	00322647	090500	090522	35	3300	0.924	
					TOTAL	433			

* instrument stopped

¶ with data before 1997/07

→ end of the global analysis

Inter-Commission Project 3.2: Working Group of European Geoscientists for the Establishment of Networks for Earth Science Research (WEGENER)

Chair: Susanna Zerbini (Italy)

Members

B. Ambrosius (Netherlands), A. ArRajehi (Saudi Arabia), L. Bastos (Portugal), M. Becker (Germany), R. Bingley (United Kingdom), C. Bruyninx (Belgium), L. Combrinck (South Africa), J. Dávila (Spain), J. LaBrecque (USA), S. Mahmoud (Egypt), M. Meghraoui (France), T. Mourabit (Morocco), J.M. Nocquet (France), H. Ozener (Turkey), M. Pearlman (USA), R. Reilinger (USA), W. Spakman (Netherlands), S. Tatevian (Russia), K. Yelles (Algeria), S. Zerbini (Italy).
Representative of Commission 1: Alessandro Caporali (Italy)
Representative of Commission 3: Tonie van Dam (Belgium)

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 millimetre 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 to:

- Provide 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

- A GEODynamic Analysis Center (GEODAC) was established at the University of Porto (http://geodac.fc.up.pt). The main objective of GEODAC is to provide automatic analysis of GNSS time series to estimate the station velocity based on the Maximum Likelihood Estimation method and assuming a power-law plus white noise model. It is well known that such an approach provides realistic error bars because it takes into account the temporal correlations that exist in the signal. After free registration, the user can upload his GNSS time-series which will be processed and afterwards the results are presented in figures and tables. The web service uses proprietary software developed at the University of Porto (Bos et al., 2008).
- Strategies are being discussed and developed to integrate geological, geophysical, and geodetic observations to address a broad range of questions related to tectonic, atmospheric, oceanic, and climatic issues of interest to the earth science community (e.g., Zerbini et al. 2007; Zerbini et al. 2010).

- WEGENER members actively fostered the co-operation with the African countries in the framework of AFREF (AFrican REference Frame) and other specific scientific projects. Such collaborations extend to the entire continent since that it is necessary to understand the geodynamics of the different African tectonic units (Nubia, Somalia and other blocks in the East African Rift) in order to properly constrain the interaction between these tectonic plates with Eurasia and Arabia In this respect, new GNSS stations have been installed in several countries by the WEGENER community (e.g., Ethiopia, Eritrea, Morocco, Egypt, Cape Verde, S. Tomé e Príncipe, Malawi, Tanzania, Mozambique, Mauritius). WEGENER PI-driven projects are providing new constraints on fault slip rates throughout the Arabia-Africa-Eurasia zone of plate interaction (e.g., Ferry et al., 2007; Nemer et al., 2008; Sbeinati et al., 2010; Ferry et al., 2011; Reilinger et al., 2009, Vernant et al., 2009, Alchalbi et al., 2009), on the earthquake deformation cycle (Hearn et al., 2009, Ergintav et al., 2009), as well as the kinematics and dynamics of plate-scale interactions (e.g., ArRajehi et al., 2010, McClusky et al., 2010, Perouse et al., 2010), In addition, WEGENER members are collaborating with AFREF Scientific Committee in the definition and implementation of procedures to compute the first AFREF solution. Results for the first two epochs were presented at IAG meetings (e.g., Fernandes et al, 2009).
- In the framework of the IAG GGOS project, WEGENER contributes to the activities of subtask DA-09-02-c (Global Geodetic Reference Frames) of the Group on Earth Observations (GEO).
- Every two years General Assemblies are organized to serve as a high-level international forum, in which scientists from all over the world can discuss multidisciplinary interpretation of geodynamics, and strengthen the collaboration between Countries.
  1. The 14th General Assembly with the title "WEGENER: an interdisciplinary approach to Earth science research and modelling" was hosted by the Institute of Physical Geodesy at the Conference Center of the Technische Universität Darmstadt on September 15-18, 2008 (http://www.ipg.tu-darmstadt.de/projekte/wegener2008/home/index.de.jsp). There were 86 participants from 18 nations. The program was articulated around five major sessions: Current plate motions and inter- and intraplate deformations. Focusing on Europe, the Mediterranean and surrounding regions; Contribution of new Earth observation systems and methodologies; The Global Geodetic Observing System (GGOS) and its regional implementations; Open Session: Geosciences from Northern Africa to Central and Northern Europe; Special Session: The Mediterranean: A geohazards focus area. More than 70 oral presentations were made. A special issue of the Journal of Geodynamics compiles 16 selected manuscripts derived from such presentations (JoG, vol. 49, 2010).
  2. The 15th General Assembly that celebrated the 30th anniversary of the project was held in Istanbul, Turkey, on September 14-17, 2010 and was hosted by the Geodesy Department of Kandilli Observatory and Earthquake Research Institute of the Bogazici University at the Albert Long Hall Conference Center (http://www. koeri.boun.edu.tr/jeodezi/wegener2010/ . There 96 participants from 15 countries. The program was organized according to the following four main sessions: 30 Years of WEGENER - The Evolution of our Knowledge about the Africa-Eurasia Plate Boundaries; Current Plate Motions, Inter- and Intraplate Deformation with a Focus on Europe, the Mediterranean, Northern Africa and the Middle East; Earth Observation Systems and Reference Frames, Observation Techniques, Methods and Data Analysis; Open Session with Proposed Focus on International Organization of Geodetic Initiatives Contributing to Earth Sciences. The Journal of Geodynamics agreed upon publishing a special issue

which will include selected manuscripts derived from presentations made during this 15th General Assembly.

- A Wegener session "Geodesy and natural and induced hazards: Progress during 30 years of the WEGENER initiative" co-convened by S. Zerbini, M. Meghraoui and R. Reilinger has been organized and will be held in Vienna, Austria, on April 4 and 5, 2011, during the EGU General Assembly 2011. About 50 abstracts were received. The presentations will describe multidisciplinary studies of natural and human-induced hazards using geodetic techniques (GPS, InSAR, LiDAR, space/air/terrestrial gravity, ground-based geodetic observations), complementary geologic and geophysical observations, and modeling approaches. Also fundamental studies of natural and induced physical phenomena, strategies to develop early warning and rapid response systems, and development programs will be presented.

To keep close contacts among the Directing Board members and to coordinate the activities, directory board meetings are held in association with the annual EGU and AGU meetings. The 16th assembly will take place in September 2012 and will be hosted by the EOST - Institut de Physique du Globe de Strasbourg, France.

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