

# Interim Activity Report for IAG Commission 2, The Gravity Field

by

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Commission President

March 2006

## Executive Summary

Commission 2 consists of four sub-commissions, seven projects, and three study groups organized in the following structure:

1. Sub-Commission SC2.1: Gravimetry and Gravity Networks (president: Shuhei Okubo)
  - a) Commission Project CP2.7: Gravity in South America (María Cristina Pacino)
  - b) Study Group SG2.1: Comparison of Absolute Gravimeters (Leonid Vitushkin)
2. Sub-Commission SC2.2: Spatial and Temporal Gravity Field and Geoid Modeling (president; Martin Vermeer)
  - a) Study Group SG2.2: Forward Gravity Field Modeling Using Global Databases (Michael Kuhn)
  - b) Study Group SG2.3: Satellite altimetry: data quality improvement and coastal applications (Cheinway Hwang)
3. Sub-Commission SC2.3: Dedicated Satellite Gravity Mapping Missions (president: Pieter Visser)
4. Sub-Commission SC2.4: Regional Geoid Determination (president: Urs Marti)
  - a) Commission Project CP2.1: European Gravity and Geoid (Heiner Denker)
  - b) Commission Project CP2.2: North American Geoid (Marc Véronneau)
  - c) Commission Project CP2.3: African Geoid (Charles Merry)
  - d) Commission Project CP2.4: Antarctic Geoid (Mirko Scheinert)
  - e) Commission Project CP2.5: South American Geoid (Denizar Blitzkow)
  - f) Commission Project CP2.6: Southeast Asian Geoid (Bill Kearsley)

In addition, there are various Inter-Commission study groups, working groups and projects, as follows.

- a) Inter-Commission Working Group IC-WG1 (Joint with ICCT & Commission 1): Quality Measures, Quality Control, and Quality Improvement (H. Kutterer)
- b) Inter-Commission Working Group IC-WG2 (Joint with IGFS): Evaluation of Global Earth Gravity Models (Jianliang Huang)
- c) Inter-Commission Working Group IC-WG3 (Joint with ICCT & Commission 1): Satellite Gravity Theory (Nico Sneeuw)

- d) Inter-Commission Study Group IC-SG2.6 (Joint with ICCT): Multiscale Modeling of the Gravity Field (Willi Freeden)
- e) Inter-Commission Project IC-P1.1: (Joint with Commissions 1 & 3): Satellite Altimetry (Wolfgang Bosch)
- f) Inter-Commission Project IC-P1.2: (Joint with Commission 1) Vertical Reference Frames: (Johannes Ihde)
- g) Inter-Commission Project IC-P3.1: (Joint with Commissions 1 & 3): Global Geodynamics Project (David Crossley)

These entities have their primary affiliation as indicated and the reporting of their activities is contained in other corresponding documents (available reports from some of these are also attached as Appendices).

This report covers the period of activity of the primary entities in Commission 2 for the year 2005. Each of the chairs of the entities was asked to summarize activities in six general areas:

- 1) publications of members, including journal papers, conference papers and presentations, and bulletin reports;
- 2) organizations of workshops, conference sessions, group meetings;
- 3) participation in observation campaigns and major computational efforts;
- 4) other noteworthy accomplishments, including significant interaction with groups outside the Commission;
- 5) future plans and activities;
- 6) issues and concerns, and recommended improvements in the Commission.

Reporting for the Commission was organized by Sub-Commission, with entities submitting activity summaries to their corresponding Sub-Commission. Each president of a Sub-Commission then collected and submitted a brief report to the Commission President. This report then summarizes these for the Executive Committee of the IAG. All entities of the Commission achieved significant progress in their stated objectives during the past year. Besides the highlights of the Commission mentioned here, further details may be found on the web sites of individual sub-commissions (see [www.ceegs.ohio-state.edu/iag-commission2](http://www.ceegs.ohio-state.edu/iag-commission2)) and in the Appendices to this report.

1. The quadrennial scientific assembly of the International Association of Geodesy was held in Cairns, Australia, 22-26 August 2006. This was a joint symposium with the International Association for the Physical Sciences of the Ocean (IAPSO) and the International Association for Biological Oceanography (IABO), and with the theme "Dynamic Planet 2005." Our Session G2, Spatio-Temporal Gravity Field Determination from a Synthesis of Terrestrial, Satellite, Airborne and Altimetry Measurements, commanded a substantial (if not the largest) turnout within IAG in terms of scientific contribution: 100 papers presented at the symposium, 47 papers written for the proceedings, 28 papers accepted for the Springer-Verlag volume.

The Proceedings of the GGSM2004 Symposium held in Porto, Portugal, in August/September of 2004 was finally published by Springer Verlag containing 63 peer-

reviewed papers. The Proceedings volume for the Cairns conference, also by Springer Verlag, is in press.

2. Sub-Commission 2.1 (Gravimetry and Gravity Networks) reports great progress in the establishment and enhancement of the Absolute Gravity Standard Station Network in East Asia and South-East Asia (AGSSN-ESEA), which was successfully finished in 2005. The network comprises stations in China (10), Indonesia (4), Malaysia (2), Taiwan (1), Australia (2), Antarctica (1), Thailand (2), Philippines (1), Japan (8). The Seventh International Comparison of Absolute Gravimeters ICAG-2005 (19 gravimeters from 16 countries) was organized at the BIPM by our Study Group 2.1 and other groups. The final report of the results will be forthcoming in June of this year (2006). The Chair of SG2.1 has also initiated the organization of an IAG-sponsored Symposium on "Terrestrial Gravimetry. Static and Mobile Measurements" to be held in St. Petersburg 20-22 August 2007 with support from the Russian Academy of Sciences. Commission Project 2.7 also reports significant progress in the establishment of gravity networks in Ecuador with new data becoming available in Colombia, Chile and Brazil (the latter with two new absolute gravimeters obtained by the National Observatory of Brazil).

3. The work of Sub-Commission 2.2 (Spatial and Temporal Gravity Field and Geoid Modeling) was primarily reported via the numerous papers and posters presented at the IAG Scientific Assembly (Dynamic Planet 2005) in Cairns, Australia. Specific reports from the membership in response to this call for progress concerned the airborne gravity campaign over the Southern U.S. and Gulf coast, continuing efforts to determine the geoid in Egypt, and gravity data availability in Australia. Also, an extensive list of accomplishments in Study Group 2.3 shows much progress in modeling gravity in coastal areas from retracking of satellite altimetry. A workshop on applying altimetry to coastal gravity estimation is planned to be held in Beijing, China, this summer.

4. Sub-Commission 2.3 (Dedicated Satellite Gravity Mapping Missions) also reports tremendous progress in the analysis of gravity data from the two satellite missions CHAMP and especially GRACE including the phenomenal time-varying gravity signatures associated with major mass displacements. Again, many of the details were presented at the Cairns conference. The membership is actively involved in the preparations for GOCE and COSMIC, as well as in the collaboration with the Global Geodetic Observing System (GGOS). A newly formed Inter-Commission Study Group (IC-WG2) is preparing activities related to evaluating upcoming global gravity models.

5. The various geoid projects under Sub-Commission 2.4 (Regional Geoid Determination) are progressing with different levels of success. The European geoid is on schedule for a 2007 completion and work is making headway in the unification of the geoid in North America. Data collections in Antarctica are continuing with a look toward the International Polar Year (2007/2008) and the South American geoid is being enhanced with improved gravity data sets as noted already above (SC2.1). The geoid in Africa is hindered by a lack of funding for data collection and work will largely concentrate on regional detailed models in the wake of the new EGM06 model. The chair for the geoid project in South East Asia reports difficulty in the exchange of data in

this area of the world; recently established contacts with the U.N. may help in this respect.

In summary, the Commission 2 is continuing to carry out quality and highly successful geodetic and gravity-related activities in modeling and data analysis. Aside from various routine scientific conferences, we look forward to a significant symposium to be organized by the International Gravity Field Service, where many of our members are helping to develop sessions.

The Appendices are reports provided by the sub-commission presidents and chairs of individual entities and form a part of this report. They provide the details of activities within the sub-structure of the Commission.

Appendix 1: Report of **Sub-Commission SC2.1**, by S. Okubo (includes reports for SG2.1 and CP2.7)

Appendix 2: Report of **Sub-Commission SC2.2**, by M. Vermeer

Appendix 3: Report of **Sub-Commission SC2.3**, by P. Visser

Appendix 4: Report of **Sub-Commission SC2.4**, by U. Marti

Appendix 5: Report of **Study Group SG2.3**, by Cheinway Huang

Appendix 6: Report of **Commission Project CP2.1**, by H. Denker

Appendix 7: Report of **Commission Project CP2.2**, by M. Véronneau

Appendix 8: Report of **Commission Project CP2.3**, by C. Merry

Appendix 9: Report of **Commission Project CP2.4**, by M. Scheinert

Appendix 10: Report of **Commission Projects CP2.5**, by D. Blitzkow

Appendix 11: Report of **Commission Project CP2.6** by B. Kearsley

Appendix 12: Report of **Inter-Commission Working Group IC-WG3**, by N. Sneeuw

Appendix 13: Report of **Inter-Commission Study Group IC-SG2.6**, by W. Freedon

Appendix 14: Report of **Inter-Commission Working Group IC-WG2**, by J. Huang

Appendix 15: Report of **IGFS**, by R. Forsberg

## Appendix 1

### Activity Report of Sub-Commission 2.1

(Gravimetry and Gravity Networks)

Compiled by S. Okubo, President of SC 2.1

#### **Absolute Gravity Network in East Asia and Western Pacific: Reported by Y. Fukuda, Member of SC2.1.**

Absolute gravity measurements provide nationwide fundamental basis for local and regional gravity surveys and consequently a reference for the height system of the nation as well. Moreover the absolute gravity measurements contribute to the studies of crustal movements, sea level changes as well as secular gravity changes due to various phenomena in and on the Earth.

To establish/enhance the Absolute Gravity Standard Station Network in East Asia and South-East Asia (AGSSN-ESEA), we have been conducting absolute gravity measurements using FG-5 absolute gravimeters in the region under the collaboration with Geographical Survey Institute of Japan and several institutions of the countries. The absolute gravity campaign is carried out in consort with the Asia-Pacific Space Geodynamics (APSG) Project in IAG and the work plan in the Permanent Committee on GIS Infrastructure for Asia & the Pacific (PCGIAP)

During the period from 2005 to 2006, we have determined absolute gravity values in the order of  $\mu\text{Gal}$  at Wulumuqi, Xi'an and Xining in China, Pontianak in Indonesia, Bangkok and Cheng-Mai in Thailand, and Manila in Philippines.

Our efforts to establish AGSSN-ESEA has successfully finished in 2005. So far, AGSSN-ESEA consists of stations described below (Takemoto et al. 2006).

- 1) Wuhan, Nanning, Shanghai, Beijing, Kunming, Lhasa, Hong-Kong, Wulumuqi, Xi'an and Xining in China,
- 2) Bandung, Yogyakarta, Cibinong and Pontianak in Indonesia,
- 3) Kuala Lumpur and Kota Kinabalu in Malaysia,
- 4) Hsinchu in Taiwan,
- 5) Perth and Canberra in Australia,
- 6) Syowa Station in Antarctica.,
- 7) Bangkok and Cheng-Mai in Thailand,
- 8) Manila in Philippines,
- 9) Kyoto, Esashi, Matsushiro, Kamioka, Muroto, Aso, Mizunami and Naha in Japan.

In the next few years, we will conduct complementary measurements as well as domestic campaigns especially aiming at the comparison of the absolute gravimeters, calibration of the superconducting gravimeters and so on. We also plan to reoccupy some of the stations of AGSSN-ESEA for the studies of secular gravity changes.

One non-scientific but important remark is worthy to be described here. We have bitter experiences that the gravimeters were damaged during cargo transportation probably due to rude handling, even though we asked extremely careful handing to transportation companies. Practically, safety transportation as well as swift customs clearance of the instruments are very important issues to conduct the measurements successfully. Thus the exchanges of the know-how regarding those issues should be encouraged apart from the scientific problems.

## **Publications**

Fukuda, Y., T. Higashi, S. Takemoto, S. Iwano, K. Doi, K. Shibuya, Y. Hiraoka, I. Kimura, H. McQueen, R. Govind (2005): Absolute Gravity Measurements in Australia and Syowa Station, Antarctica, IAG Symposia 129, C. Jekeli, L. Bastos and J.Fernandes (eds), Springer, 280-285.

Fukuda Y., S. Iwano, H. Ikeda, Y. Hiraoka and K. Doi (2005): Scale of the Superconducting Gravimeter CT#043 with an Absolute Gravimeter FG5#210 at Syowa Station, Antarctica, Polar Geoscience, 18, 41-48.

Tamura, Y., T. Sato, Y. Fukuda and T. Higashi (2005): Scale Factor Calibration of a Superconducting Gravimeter at Esashi Station, Japan, Using Absolute Gravimeters, Journal of Geodesy, 78, 481-486.

Takemoto, S. et al., (2006): Establishment of an Absolute Gravity Network in East- and Southeast-Asia, J. Geodetic Soc. Japan, 52, in press (in Japanese with English abstract).

## **Study Group 2.1.1: Study Group on Comparisons of Absolute Gravimeters Reported by Leonid Vitushkin ( Chairperson of SG 2.1.1 and CCM WGG).**

1. The Seventh International Comparison of Absolute Gravimeters ICAG-2005 was organized at the BIPM by the IAG SG2-1-1, the Working Group on Gravimetry of Consultative Committee on Mass (CCM WGG) and the BIPM. The steering committee of the ICAG-2005 consisted of L.Vitushkin (BIPM), M.Becker (IPG DTU, Germany), O.Francis (ECGS, Luxemburg), A.Germak (INRIM (former IMG), Italy), Z.Jiang (BIPM), Wangxi Ji (NIM, China).

2. For the first time the Technical Protocol for the ICAG was developed by the Discussion Group on Technical Protocol (Chaired by A.Germak from INRIM, Italy) and the pilot laboratory – BIPM, following the rules for the key comparisons in the framework of the Mutual Recognition Arrangement signed by the directors of the National Metrology Institutes from about 60 countries.

The technical protocol specifies in detail the procedure to be followed for the comparison, data processing and presentation of the comparison results with the uncertainties.

3. As decided at the 1<sup>st</sup> CCM WGG-SGCAG meeting, the members of these working groups, after consultations at their institutes, have informed the chairman of the decision taken concerning the status of the ICAG-2005 making the choice between pilot study and key comparison [1].

In view of the large support for the pilot study status for the ICAG-2005, the steering committee recommended to the CCM that this comparison should have the status of a

pilot study. This recommendation was accepted at the last CCM meeting held at BIPM in Sèvres on 27<sup>th</sup> and 28<sup>th</sup> April, 2005.

Then the steering committee recommended that the ICAG-2005 pilot study should be organized following the rules for a key comparison. In a pilot study wider participation is possible along with greater flexibility.

For participation in a pilot study, the requirements are less stringent and participation can be from Associates of the General Conference on Weights and Measures (*Conférence Générale des Poids et Mesures*, CGPM), as well as from Members of the Metre Convention (*Convention du Mètre*). Analysis of the results can be used to benchmark the performance of participants and can be used as evidence of calibration and measurement capabilities (CMCs) for laboratories that participate in the CIPM MRA in those cases where there has been no Key Comparison.

The final choice of the participants was fixed by the steering committee.

4. Nineteen absolute gravimeters from sixteen countries (Austria, Belgium, Canada, Chinese Taipei, Czech Republic, Finland, France, Germany, Italy, Japan, Luxemburg, Russia, Spain, Switzerland, Ukraine, USA) and the BIPM have participated in the comparison. Among these gravimeters there were two gravimeters of the JILA type (made by JILA, USA), two FG5-1##, ten FG5-2##, one A10 (all made by Micro-g Solutions, USA), FGC-1 (a new cam-driven JILA gravimeter), the gravimeter IMGC-2 (Italy), GABL-G (Russia), TBG (Ukraine).

The supporting relative measurements of gravity gradients and links between the gravity stations of the BIPM gravity network have been organized by Zhiheng Jiang, Matthias Becker and Leonid Vitushkin.

The BIPM constructed two new outdoor sites for relative and absolute measurements and provided nine gravity stations at two pillars and at the special 80-tonne basement in the buildings of the BIPM. Two absolute gravimeters were used to monitor the stability of the gravity field during the comparison. The BIPM calibrated the frequency of the lasers and Rb-clocks of all the gravimeters.

The absolute measurements were performed from 3 to 25 September 2005.

Two types of results of the comparison will be analyzed. The first type are results reported by the operators and second type are the raw data (measured pairs of time and space intervals of the falling body), which will be reprocessed using the same software. In some cases the raw data can not be provided by the operators because it is

not accessible due to the design of the gravimeters. For the first time all the teams were required to calculate the uncertainty budgets of their absolute gravimeters.

It is worthy of note that the results of gravity field measurements obtained from the control gravimeters (those of Belgium and BIPM) were stable within the measurement uncertainty during all the comparison.

**5.** Currently all the operators have presented their results to the pilot laboratory and all the raw data have been reprocessed by O.Francis (ECGS). The least squares adjustment of all the results of the measurements at eleven sites of gravity network will be the next stage in the evaluation of the results.

Then Draft A of the Report on the comparison will be prepared and distributed among the participants and will remain confidential among the participants. After the discussion of this draft the next Draft B and a final version of the report will be prepared. Starting with Draft B, the report is no longer considered confidential.

It was a clear delay in the result evaluation because of the late presentation by the operators of the results of absolute measurements with the uncertainty budgets.

**6.** A one-day meeting "Instrumentation and Metrology in Gravimetry" was organized at the BIPM on 19 September 2005. About 50 participants from 15 countries and the BIPM attended the meeting.

**7.** The 2nd Joint meeting of CCM WGG and IAG SGCAG will be organized at METAS (Swiss Federal Office of Metrology and Accreditation, <http://www.metas.ch>) on 7-8 June 2006.

The results of the International Comparison of Absolute Gravimeters ICAG-2005 which was held at the BIPM in September 2005, the proposals on further development of the Technical Protocol for ICAG's and for regional comparisons of absolute gravimeters, and the organization of regional comparisons (choice of the sites, periodicity, technical protocol, the use of the results of regional comparisons (link to the ICAGs ), etc.) will be discussed, in particular, at the meeting.

**8.** After preliminary discussions among the president of Commission 2, the chairman of SGCAG and CCM WGG, and Academician Vladimir Peshekhonov (St Petersburg, Russia) the agreement was reached on the organization of the IAG conference "Terrestrial Gravimetry. Static and Mobile Measurements. TG-SMM-2007" on 20-22 August 2007 in St Petersburg, Russia. This conference will be supported also by Russian Academy of Sciences.



## **Gravity in South America.**

**Report ed by M. C. Pacino (Chair of Commission Project 2.7)**

**Fundamental Gravity Network of Ecuador.** A total of 33 gravity stations have been established in a cooperation between EPUSP, IBGE (Brazil), IGM and INOCAR (Ecuador). The network has been adjusted recently and the results are presented in the master dissertation of Carlos Alberto Correa e Castro Jr. A problem that still exist in Ecuador is the inexistence of absolute gravity stations.

**Future efforts.** A new set of gravity data is now available in Colombia and Ecuador due to an effort of Laura Sanchez and Alfonso Tierra to validate the data in the two countries. The next version of the geoid model will benefit of this effort.

A new gravity survey is expected to be accomplished in south of Chile, along Carretera Austral. The survey will be carried out in a joint cooperation between EPUSP, IBGE and IGM.

As a result of the fact that National Observatory of Brazil has two absolute gravimeters it is planned to re-observe existing absolute gravity stations in Brazil and in South America in the new future as well as the establishment of new stations.

## **Publications**

Pacino M.C. (2005). Argentina Report. XVIII General Assembly of IPGH. SIRGAS meeting – GTIII. Caracas, 17 – 19 November.

Pacino M.C. (2005) Absolute Gravity Measurements in South America. IAG-IAPSO-IABO Joint Meeting. 22 – 26 November, Cairns.

Pacino M.C., Font G., Del Cogliano D., Natali P., Moirano J., Lauria E., Ramos R. (2005). Activities related to the materialization of a new vertical reference system for Argentina. IAG-IAPSO-IABO Joint Meeting. 22 – 26 August, Cairns.

# Activities of IAG Subcommittee 2.2: Spatial and Temporal Gravity Field and Geoid Modelling

Martin Vermeer

March 7, 2006

## 1 Reporting period

This report covers the Subcommittee's history for the year 2005.

## 2 Terms of Reference

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

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

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

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

## 3 Steering Committee and membership

|                                       |   |
|---------------------------------------|---|
| Martin Vermeer (Chair) – Finland      | <code>marti.vermeer@tkk.fi</code>           |
| Bernard Ducarme – Belgium             | <code>bernard@ksb-orb.oma.be</code>         |
| Michael Kuhn – Australia              | <code>kuhnm@vesta.curtin.edu.au</code>      |
| Dimitrios Tsoulis – Germany... Greece | <code>tsoulis@topo.auth.gr</code>           |
| Bernhard Heck – Germany               | <code>heck@gik.uni-karlsruhe.de</code>      |
| Zdenek Martinec – Germany             | <code>zdenek@gfz-potsdam.de</code>          |
| Christopher Kotsakis – Canada         | <code>kotsakis@geomatics.ucalgary.ca</code> |

As for the Subcommittee's members, we have a mailing list of interested people in which no distinction is being made between full and corresponding members. These are almost 40 people that your chairman knows to be or have been active in the field of the Subcommittee. During the reporting period only part of these people actually responded to the initial invitation or otherwise participated in the work.

## 4 Activities

### 4.1 Subcommission

At the IAG Scientific Assembly “Dynamic Planet 2005” in Cairns, Australia, August 22-26, 2005, the Subcommission organized a splinter meeting, which was reasonably well attended.

A report on this meeting can be found on the website:

<http://users.tkk.fi/~mvermeer/IAGSC2.2.html>.

The current report includes contributions by the following people.

- Michael KUHN of Curtin University, Perth, Australia, mentioned that the data of the Australian Earth Gravity Model are freely available; three publications related to it are [KS05a, KF05, BKC<sup>+</sup>05].
- Hussein ABD-ELMOTAAL has been active in Egyptian geod determination.
- Heiner DENKER reported independently on the European Gravity and Geoid Project [DBB<sup>+</sup>05], a regional application in practice of the subject area of our Subcommission. During the reporting period, the update of the gravity and terrain databases was continued.

The project is progressing well, and final geoid/quasigeoid computations are planned for 2007.

- Dan ROMAN and colleagues from the US National Geodetic Survey, and others (John BROZENA) reported on airborne gravimetry work in the Gulf Coast region: the coastal regions of the Florida panhandle, Alabama, Mississippi, and some of Louisiana. Profiles were at above 10 km elevation and spaced 10 km part, which should mitigate aliasing. There were 41 north-south trending tracks, each about 500 km long. The total spatial coverage is then 400 km x 500 km.

The expectation is that these data will be used to

1. test various EGM’s based on GRACE data to find the most optimal (400-500 km correlates to degree 90-100, where GRACE is thought to be valid) and
  2. locate and possibly fix any systematic errors in terrestrial and shipborne data.
- Publication lists were furthermore contributed by Hussein Abd-Elmotaal, Will Featherstone, Petr Holota, J. Kusche, Ernst Schrama, C.K. Shum, Dimitris Tsoulis and Petr Vaníček.

## 5 Publications

Below we list some publications by members of the Subcommission (and others) that are relevant to the field of the Subcommission according to the Terms of Reference. The list includes the presentations at the Porto Symposium in Session 8: “Temporal gravity variations: modeling and measurements”.

A more extensive reference list over the several past years is found, in richly cross-referenced form, on the Subcommission’s web site, at <http://users.tkk.fi/~mvermeer/bib2html/index.html>.

## References

- [AE05a] H Abd-Elmotaal. Global isotropic isostatic response function in terms of zonal spherical harmonics. In F. Sansó, editor, *A Window on the Future of Geodesy, International Association of Geodesy Symposia*, volume 128, pages 471–476, Sapporo, Japan, June 30 - July 11 2005. Refereed paper.
- [AE05b] H. Abd-Elmotaal. Modelling the long-period temporal variation of the gravity field. *Bollettino di Geodesia e Scienze Affini*, 64(2):77–91, 2005.

- [AE05c] H. Abd-Elmotaal. Response of earth's crust due to topographic loads derived by inverse and direct isostasy. In *IAG Scientific Assembly, Dynamic Planet 2005*, Cairns, Australia, August 22-26 2005. Presented.
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- [AFB05] MJ Amos, WE Featherstone, and J Brett. Crossover adjustment of New Zealand marine gravity data, and comparisons with satellite altimetry and global geopotential models. In C Jekeli, L Bastos, and J Fernandes, editors, *Gravity, Geoid and Space Missions*, pages 266–271. Springer, Berlin, 2005.
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- [BHL<sup>+</sup>06] V Baramidze, S Han, M Lai, C Shum, P Wenston, and J Xie. Spherical Splines for Reconstructing Geopotential. *SIAM J. Scientific Computing*, 2006. in review.
- [BKC<sup>+</sup>05] I Baran, M Kuhn, SJ Claessens, WE Featherstone, SA Holmes, and P Vaníček. A synthetic Earth's gravity model designed specifically for testing regional gravimetric geoid determination algorithms. *Journal of Geodesy*, 2005. Submitted in February, 2005.
- [BLS05] V Baramidze, MJ Lai, and CK Shum. Spherical splines for data interpolation and fitting. *SIAM J. Scientific Computing*, 2005. in press.
- [CF05] SJ Claessens and WE Featherstone. Computation of geopotential coefficients from gravity anomalies on the ellipsoid. In F Sansó, editor, *A Window on the Future of Geodesy*, pages 459–464. Springer, Berlin, 2005.
- [DBB<sup>+</sup>05] H Denker, J-P Barriot, R Barzaghi, R Forsberg, J Ihde, A Kenyeres, U Marti, and IN Tziavos. Status of the European Gravity and Geoid Project EGGP. In C Jekeli, L Bastos, and J Fernandes, editors, *IAG Internat. Symp. "Gravity, Geoid and Space Missions - GGSM2004"*, volume 129, pages 125–130, Porto, Aug. 30 - Sept. 3, 2004 2005. Springer Verlag, Berlin, Heidelberg, New York.
- [Den05a] H Denker. Evaluation of srtm3 and gtopo30 terrain data in germany. In C Jekeli, L Bastos, and J Fernandes, editors, *IAG Internat. Symp. "Gravity, Geoid and Space Missions - GGSM2004"*, volume 129, pages 218–223, Porto, Aug. 30 - Sept. 3, 2004 2005. Springer Verlag, Berlin, Heidelberg, New York.
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## Appendix 3

### Sub-Commission 2.3 – Dedicated Satellite Gravity Mapping Missions Commission 2 (Gravity Field) International Association of Geodesy (IAG)

Report 2005

<http://www.deos.tudelft.nl/~pieter/IAG/sc23.htm>

*Pieter Visser (chair)*

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#### Activities:

- The sub-commission members have all been actively involved in the analysis of more CHAMP and GRACE data. Highlights include strongly improved GRACE-based temporal gravity solutions, both on a regional and global scale (reflected by the selected publications included below). Continuous efforts have led (and are still leading) to improved GRACE observation modelling and corrections schemes, and improved local and global gravity field estimation methods and parameterizations.
- The members are all involved in the dissemination of achieved and expected results from satellite gravity missions to the wide field of user applications in geosciences. Many results/achievements were presented at the *Dynamic Planet 2005* conference in Cairns, Australia.
- In addition, sub-commission members played an active role in the preparations for the GOCE mission, with the launch rapidly approaching (currently foreseen to take place in 2007). Preparations include the implementation of operational GOCE data reduction schemes for deriving gravity field products.
- Moreover, sub-commission members are actively involved in the definition of future GRACE and GOCE follow-on missions and concepts. Opportunities are being explored at both national and international level (ESA, NASA, ESA+NASA) for seeking support for such follow-on missions.
- Finally, Srinivas Bettadpur has been elected chair of the Space Mission Working Group within IAG's Global Geodetic Observing System (GGOS, <http://www.ggos.org>), establishing a forum to discuss and coordinate the role of diverse space missions to the GGOS. Cheinway Hwang and his co-workers are preparing for the COSMIC mission, aiming at computing cm-precision

orbits and retrieving the maximum possible gravity field information content from its future observations.

Future plans and activities:

- It is planned to monitor relevant activities and stimulate participation in workshops and conferences, and support/propose dedicated sessions.
- Sub-commission members will continue their efforts to promote ongoing, near-future and far-future gravity field missions.

Selected publications:

Bouman, J., R. Koop, R. Haagmans, J. Müller, N. Sneeuw, C. Tscherning, and P. Visser (2005), Calibration and validation of GOCE gravity gradients, in *A Window on the Future of Geodesy*, vol. 128 of *International Association of Geodesy Symposia*, edited by F. Sansö, 265-270, Springer-Verlag, Berlin Heidelberg

Bouman, J., M. Kern, R. Koop, R. Pail, R. Haagmans and T. Preimesberger (2005), Comparison of outlier detection algorithms for GOCE gravity gradients, Vol. 129 of *International Association of Geodesy Symposia*, edited by C. Jekeli, L. Bastos and J. Fernandes, 83-88, Springer-Verlag, Berlin Heidelberg

Hwang, C., and E.-C. Kao (2005), Spherical harmonic analysis and synthesis: application to temporal gravity variation, in press, *Computers and Geosciences*

IJssel, J. van den, and P.N.A.M. Visser (2005), Determination of non-gravitational accelerations from GPS satellite-to-satellite tracking of CHAMP, *Adv. Space Res.*, 36(3), 418-423

Kroes, R., O. Montenbruck, W. Bertiger, and P. Visser (2005), Precise GRACE baseline determination using GPS, *GPS Solutions*, 9, 21-31

Sneeuw, N., J. Flury J and R. Rummel (2005), Science requirements on future missions and simulated mission scenarios. *Earth, Moon and Planets* 94, 113-142, DOI 10.1007/s11038-005-7605-7.

Sneeuw, N., Gerlach Ch., Földvary L., Gruber Th., Peters Th., Rummel R., Svehla D. (2005), One Year of time-variable CHAMP-only Gravity Field Models using kinematic Orbits; *IAG Symposia Proceedings*, Vol. 128, Ed. F. Sanso, 288-293, Springer Verlag

Tapley, B., J. Ries, S. Bettadpur, D. Chambers, M. Cheng, F. Condi, B. Gunter, Z. Kang, P. Nagel, R. Pastor, T. Pekker, S. Poole and F. Wang (2005), GGM02 – An improved Earth gravity field model from GRACE, *J. Geod.*, 79(8), 467-478, 2005

Visser, P.N.A.M. (2005), Impact of Space-borne gravity gradiometer instrument filter on observation error and gravity field recovery performance of GOCE, in *A Window on the Future of Geodesy*, vol. 128 of *International Association of Geodesy Symposia*, edited by F. Sansö, 271-276, Springer-Verlag, Berlin Heidelberg.

Visser, P.N.A.M. (2005), ERS-2 Orbit Computations with CHAMP- and GRACE-based Gravity Field Models, *Adv. Space Res.*, 36/(3), 454-459

Visser, P.N.A.M. (2005), Low-low satellite-to-satellite tracking: applicability of analytical linear orbit perturbation theory, *J. Geod.*, 79/(1-3), 160-166

Visser, P.N.A.M., and E.J.O. Schrama (2005), Space-borne gravimetry: how to decouple the different gravity field constituents?, in *Gravity, Geoid and Space Missions*, vol. 129 of *International Association of Geodesy Symposia*, edited by C. Jekeli, L. Bastos and J. Fernandes, 6-11, Springer-Verlag, Berlin Heidelberg

# Activity Report of Sub-Commission 2.4 "Regional Geoid Determination" for the period: January 2005 - January 2006

## General organization, overview

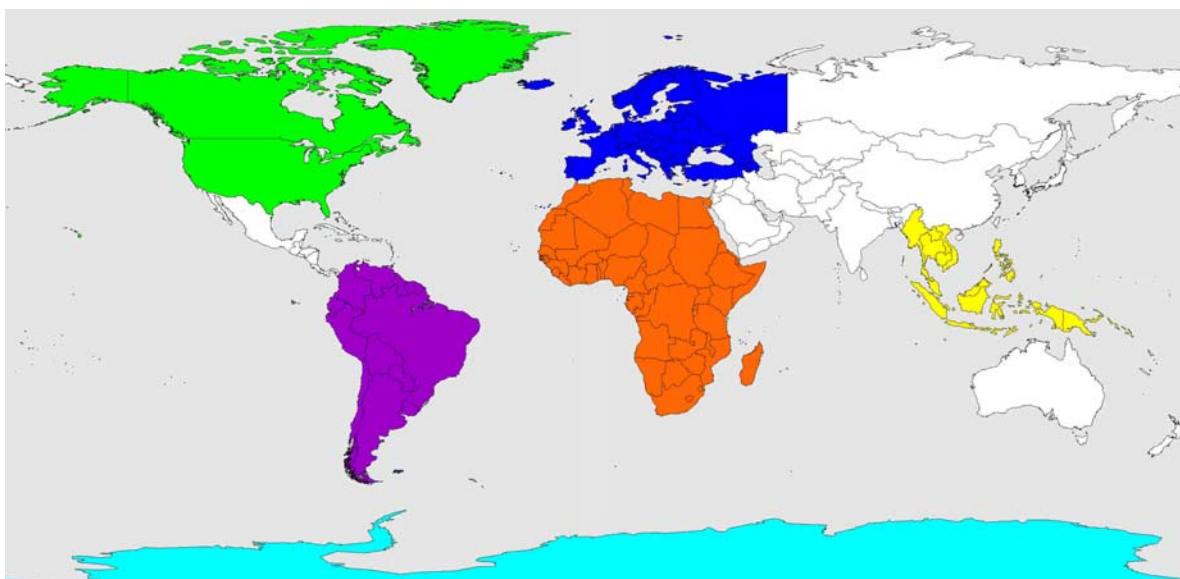
Sub-Commission 2.4 was initiated after the IUGG General Assembly in Sapporo (2003) and covers the following principal objectives:

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

The steering committee of SC 2.4 is formed by the chair and the leaders of the Sub-Commission projects:

|                  |   |
|------------------|---|
| Urs Marti        | chair   |
| Heiner Denker    | CP 2.1: European Gravity and Geoid Project (EGGP)         |
| Marc Véronneau   | CP 2.2: North American Geoid Project                      |
| Charles Merry    | CP 2.3: African Geoid Project                             |
| Mirko Scheinert  | CP 2.4: Antarctic Geoid Project (AntGP)                   |
| Denizar Blitzkov | CP 2.5: Gravity in South America and South American Geoid |
| Bill Kearsley    | CP 2.6: Southeast Asian Geoid                             |

There has been no official meeting of the steering committee until now but there have been many informal contacts especially during the IAG Symposium " Gravity, Geoid and Space Missions" (GGSM2004) in Porto (August 30 - September 3 2004) and the IAG Scientific Assembly in Cairns (August 22 - 26 2005). The web-site of SC2.4 can be found at <http://www2.swisstopo.ch/um/sc24.htm>, where the reports of the projects and several other information can be found.



Areas covered by the Commission 2 Projects

## Meetings, Workshops

The principal meeting of SC2.4 during the reporting period (2005) was the IAG Scientific Assembly in Cairns (<http://www.dynamicplanet2005.com>) where sessions G2 "Gravity field determination from a synthesis of terrestrial, satellite, airborne and altimetry measurements" and GP3 "Oceanography and geodesy in polar regions" covered many parts of the SC2.4 objectives.

Some special meetings of the Commission projects are the following:

- CP2.1: no meeting in 2005
- CP2.2: no meeting in 2005
- CP2.3: April 2005, Vienna  
April 2005, Minia (Egypt)  
August 2005, Cairns
- CP2.4: April 2005, Vienna  
May 2005, Bremerhaven  
August 2005, Cairns  
September 2005, Jena  
December 2005, San Francisco
- CP2.5: October 2005, Rio de Janeiro
- CP2.6: no meeting in 2005

## Measuring Campaigns, computational efforts

The project CP2.1 (**European Gravity and Geoid**) is in the status of contacting national representatives and of updating the gravity and terrain data sets. All older gravity data has been re-processed and transformed to a common horizontal and vertical datum. For control purposes also GPS/leveling data is collected. Preliminary geoid computations showed the big improvements caused by applying the recent GRACE global gravity field models.

For the CP2.2 (**North American Geoid**) each partner (Canada and USA) continue their work on the National geoid model and height systems. A combination and common solution is planned for a later stage of the project. In 2005 further data between the partners was exchanged but not yet analyzed.

Project CP2.3 (**African Geoid**) is advancing very slowly due to difficulties in finding funds and in collecting new gravity data. The main focus is on analyzing the existing data sets and on testing the global GRACE models and the SRTM topography data set.

The members of the interdisciplinary project CP2.4 (**Antarctic Geoid**) are very active in several domains (absolute and relative gravity data collection, modeling of ice masses and crustal structures). The project is advancing well.

For the project CP2.5 (**Gravity and Geoid in South America**) a new gravity network in Ecuador has been established and a new geoid model for Argentina was determined. A course on 'STOKES-HELMERT'S SOLUTION TO GEODETIC BOUNDARY VALUE PROBLEM' was organized in Rio de Janeiro.

The project CP2.6 (**geoid in SEAsia**) has many problems in. Data exchange is not granted between most countries. Contacts to the UN 'Permanent Commission for Geographic Information Infrastructure for the Asia-Pacific Region' have been established.

## Future plans

The **European** Geoid project advances well. Until 2007 the gravity data update will be finalized and the final geoid/quasigeoid computations will be carried out. The project should finish until the next IUGG General Assembly in Perugia.

In **North America**, the main goal is to converge the national geoid solutions of the USA and of Canada to one single North American geoid model and to define the North American Height system. A meeting is for seen during the AGU spring meeting in Baltimore. New GPS/leveling measurements are planned for some regions in the Northwest of the continent.

In **Africa**, a new geoid calculation is under way and new GPS/leveling data will be collected. The aim of calculating a 5' African geoid model may be superseded by the determination of the global EGM06 model and the working group may put more emphasis on the calculation of regional or national models.

The **Antarctic** Geoid Project is advancing well. One main goal for 2006 is to carry out further gravity surveys and to build up a gravity data base for Antarctica. Very important will be the 'International Polar Year' (2007/2008)

In **South America**, the introduction of new gravity data from Columbia and Ecuador allows now the calculation of an improved geoid model. New gravity surveys will be carried out in Southern Chile. The National Observatory of Brazil will observe some existing or new absolute gravity stations in Brazil and other countries.

The **Southeast Asian** Geoid project is advancing very slowly. A very important meeting will be the workshop of May/June (Height Systems, Geoid and Gravity of the Asia-Pacific) in Mongolia.

## Proposals to SC2.4

It would be useful if Sub-Commission 2.4 could establish guidelines for GPS measurements for the determination of GPS/Leveling data. (*Ch. Merry*)

A further aim may be to encourage international agencies to support the acquisition of gravity data in regions that are currently without such data. (*Ch. Merry*)

## Some publications (see also proceedings of the 'Dynamic Planet 2005')

Abd-Elmotaal, H (2005). Modelling the Long-Period Temporal Variation of the Gravity Field. *Bollettino di Geodesia e Scienze Affini*, 64(2):77–91.

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# **Appendix 5**

## **Midterm Report**

### **IAG Special Group 2.3: Satellite altimetry: data quality improvement and coastal applications**

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#### **1. Status**

Most of the members are active in the researches they proposed as members. Current activities of the members include:

- 1) Retracking altimeter waveforms
- 2) Optimal combination of altimeter and airborne data
- 3) Inclusion of Iceasat altimeter data for coastal gravity modeling
- 4) Evaluation of gravity field models by means of long-term averaged single satellite altimetry crossovers (SSC), derived from altimetry of ERS 1, 2 and Geosat
- 5) Examination of global ocean laser altimetry in support of cal/val efforts for ICESat (40 Hz, 70 m footprint, 170 m separation). Some specific coastal, river, wetland and lake areas have been examined.

#### **3. Current achievements of members**

- 1) Retracked Geosat, ERS-1, ERS-2, TOPEX waveforms and improved gravity determination from such data
- 2) Improved procedure of gravity anomaly computations over shallow waters
- 3) Calibration factors of the covariance matrices of recent gravity field models checked or corrections.
- 4) Improved shallow-water tides for geophysical corrections.
- 5) Combination with coastal altimeter data with airborne gravity data

#### **4. International workshop on coast and land applications of satellite altimetry, Beijing, China, July 21-22, 2006**

This workshop is dedicated to the problems and solutions of coast and land applications of satellite altimetry in such areas as coastal gravity field modeling, coastal circulations, river level and lake level monitoring and desert study using satellite altimetry. This workshop is part of the activities of Special Group 2.3, International Association of Geodesy. The scientific committee and local organizing committee welcome world scientists interested in the these topics to participate in this

workshop. The participants of this workshop are also encouraged to attend the Western Pacific Geophysical Meeting, July 24-27, 2006, Beijing. The problems and proposed solutions to be discussed in this workshop are listed in Tables 1 and 2.

**Table 1:** Problems and proposed solutions for satellite altimetry at coastal zones and land-sea boundaries

| Problem   | Proposed solution   |
|---|---|
| Bad tide model  | <ul style="list-style-type: none"> <li>- use local tide models</li> <li>- stack repeat cycles data to average out tide model error</li> <li>- use “pseudo” altimeter observations to minimize tide error effect</li> <li>- remove serious tide-affected data</li> </ul> |
| Bad waveform (bad altimeter ranging)                                  | <ul style="list-style-type: none"> <li>- retrack waveform; remove data if retracking fails</li> <li>- use laser altimeter data (icesat)</li> </ul>  |
| Bad wet tropospheric correction (contaminated radiometer measurement) | <ul style="list-style-type: none"> <li>- replace radiometer measurement by model value</li> <li>- correct radiometer measurement</li> <li>- use ground-based radiometer measurement</li> <li>- do not apply it if it is too bad (for the entire track)</li> </ul>       |
| Large sea surface height variability                                  | <ul style="list-style-type: none"> <li>- stack repeat cycles data</li> <li>- filter data (will lose spatial resolution)</li> <li>- remove data contaminated by large SSH variability</li> </ul>   |
| Dynamic height (for gravity field modeling)                           | <ul style="list-style-type: none"> <li>- remove model value</li> <li>- use “pseudo” observation of altimetry to minimize such an effect</li> </ul>  |
| Void zone at coasts (for gravity field modeling)                      | <ul style="list-style-type: none"> <li>- use land data</li> <li>- use ship data</li> <li>- use a good, short wavelength global gravity model</li> </ul>   |
| Poor determination of coastal circulation from altimetry              | <ul style="list-style-type: none"> <li>- improve altimeter data quality</li> <li>- improve modeling of coastal</li> </ul>   |

|                             |                               |
|-----------------------------|-------------------------------|
|                             | circulation                   |
| Uncertain in sea state bias | - develop improved algorithms |

**Table 2:** Problems and proposed solutions for altimetry applications on land

|  |   |
|--|---|
| Bad waveform                               | <ul style="list-style-type: none"> <li>- retrack waveform</li> <li>- use icesat altimeter data</li> </ul>   |
| No wet and dry tropospheric correction     | - use model value   |
| No ionospheric correction                  | - use model value   |
| Lack of lake/river horizontal gradients    | - use gradient from a global high-degree model  |
| No ground-based measurement for validation | <ul style="list-style-type: none"> <li>- use ‘indirect’ methods for validation</li> <li>- deploy validation sensors<br/>(cooperation with people in hydrology)</li> </ul> |
| Backscatter for desert study               | Develop algorithms to extract backscatter   |

## **European Gravity and Geoid Project (EGGP) Status Report, February 2006**

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At the GGSM2004 symposium in Porto, a meeting of the project members was held and about 30 people participated. Information was given on the project organization and status. The main discussion concentrated on possible improvements of the relevant data sets. Several problem areas were identified and discussed (e.g., the Mediterranean Sea), and several project members offered their support. Furthermore, a complete project status report was presented by H. Denker at the GGSM2004 symposium (oral and poster); the report is also published in the proceedings and in Newton's bulletin (Denker et al., 2004 and 2005).

During the last year, the update of the gravity and terrain database was continued. New gravity data were released to the project for Austria, Germany and the area of former Yugoslavia. Moreover, positive responses were received from Russia, Poland and all Scandinavian countries, indicating a data transfer in the near future. In addition, the existing older gravity data sets were completely reprocessed, including a transformation of the horizontal and vertical coordinates to common European reference systems (ETRS, EVRS, e.g., see Ihde et al. 2000). Significant progress was also made in the collection of digital terrain models (dtms). For Germany, Austria and Switzerland models with a resolution of 1"×1" are available now. For the remaining parts of Europe, dtms with a resolution of 3"×3" were generated. The starting point for the 3"×3" dtms were the SRTM results (JPL 2004) that were then replaced by the available national terrain models. As the SRTM data extends only up to about 60°N, the GTOPO30 (LP DAAC 2004) and GLOBE data (both 30"×30") had to be used for the areas north of 60°N. As in previous investigations, it turned out that the geographic longitudes for the 30" elevations had to be increased by 30" (1 block) up to 70°E. The dtm generation has reached an almost final state, i.e., there is only an update for the Scandinavian countries pending. It is clear that the new dtms are a significant improvement compared to the models used for the EGG97 computations, having resolutions ranging from 7.5"×7.5" up to 5'×5'. In addition to the gravity and terrain data, new GPS/levelling data sets were acquired for Austria, Germany, Russia, etc. These data sets will primarily serve for control purposes.

During the last year, preliminary (quasi)geoid computations were also carried out based on the most recent GRACE global gravity field models (e.g., Denker 2005c and 2005d). The computations were done by the spectral combination method. The comparisons of the new geoid models with independent data from satellite altimetry and GPS/levelling showed improvements in the RMS differences of 15% to 65%, as compared to the EGG97 solution. Especially the previously existing long wavelength errors could be reduced substantially.

In summary, significant progress was made within the framework of the European Gravity and Geoid Project EGGP regarding the collection and homogenization of high-resolution and accurate gravity, terrain and GPS/levelling data. Especially the new geopotential models from the CHAMP and GRACE missions improved the geoid/quasigeoid modelling very much.

In my opinion, the project is running well. Until 2007 the gravity data update will be finalized and the final geoid/quasigeoid computations will be carried out.

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## **North American Geoid Status Report, February 2006**

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Actually, we did not have the opportunity to meet or share activities together in 2005 due to higher priorities within our respective agency.

For Canada, the focus has been on the Height Modernization project, i.e., the implementation of a geoid model as a new vertical datum for Canada. This new datum would represent a significant change in absolute heights because the current datum has distortion reaching about 1.5 m and in the technique to access it. A main phase of this project is a consultation with the Canadian geomatics industry (direct and indirect clients) regarding possible impact of adopting this new vertical datum by 2009 and abandoning maintenance of most benchmarks across the country. The results from this public consultation should be available by May 2006. The consultation is made in cooperation with the provincial agencies.

However, there will meet a North American Geoid session at the AGU spring meeting (May 2006) in Baltimore. The session will be co-chaired by my colleagues Dr. Roman (US NGS) and Dr. Huang (GSD). During the AGU meeting, I hope that GSD and NGS could meet to discuss our respective long-term plan about height systems and how to arrive to a common datum between Canada, USA and Mexico. In addition, I would like to address the merit for Alaska of using the future vertical datum for Canada. It might also include discussion of certain projects related to water management along the US/Canada border. Finally, GSD intends to conduct some GPS and Levelling surveys during the 2006 summer for validating the geoid model. The surveys will cover regions in British Columbia, Yukon and Alaska.

Data have been exchanged between the two countries over the last two years, but GSD did not have the time to process the new information



**REPORT OF COMMISSION PROJECT 2.3: AFRICAN GEOID PROJECT**  
**(part of Sub-Commission 2.4: Regional Geoid Determination)**

**For the period: January 2005 - December 2005**

**General:**

The progress of this group has been slow, and there is little to show for the past year. Members have found it difficult to find funding, and little new gravity data have been acquired. Large gaps in the available gravity coverage over Africa continue to exist. During the year under review members have focussed on analysing existing gravity data sets and on assessing the SRTM and GRACE models in the context of a geoid model for Africa. Although the SRTM DEM shows good agreement with a photogrammetrically-based DEM in selected degree squares in South Africa, the results are less clear in Tanzania, where in some instances the GLOBE model performs better. Some progress has been made in acquiring GPS/levelling data in Algeria, South Africa and Tanzania, but much more needs to be done.

Members of the group attended the EGU General Assembly in Vienna; the 3rd Minia International Conference on Advanced Trends in Engineering, in Minia, Egypt (both in April 2005); and the Scientific Assembly of the International Association of Geodesy in Cairns, Australia, in August 2005.

**Future Plans:**

A fresh computation of the African geoid on a 5' grid is under way. This will make use of the SRTM 3" DEM for anomaly interpolation and for terrain correction, and the Eigen CG03C geopotential model for long and medium wavelength features of the geoid. Further GPS/levelling data will be collected in order to validate this model.

The proposed EGM06 geopotential model from the US National Geo-spatial Intelligence Agency (NGIA) will provide a global geoid model with a resolution equivalent to a 5' grid. NGIA have essentially the same gravity data for Africa as does this working group, and the opportunity exists for a cross-validation of techniques and for the group to use its GPS/levelling data to validate EGM06.

In the longer term, the working group may have to re-consider its terms of reference and goals. One of its primary goals was to determine a 5' geoid model for Africa - the NGIA EGM06 may supersede this. The group may well wish to consider putting greater emphasis on generating regional and national solutions (where sufficiently dense data exist), and on acquiring more GPS/levelling data for validation/transformation purposes. In this regard, it would be useful if Sub-Commission 2.4 could establish guidelines for GPS measurements for this purpose. A further aim may be to encourage international agencies to support the acquisition of gravity data in regions that are currently without such data.

A member of the group will attend the EGU General Assembly in Vienna in April 2006 and will also attend the First Symposium of the International Gravity Field Service in Istanbul in September 2006.

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## **Report of Commission Project 2.4 “Antarctic Geoid” (AntGP)**

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February 28, 2006

### **Short Review**

Adopted in 2003, it is the first time that within IAG a special group is dedicated to the determination of the gravity field in Antarctica. This should be done utilizing terrestrial and airborne methods to complement and densify satellite data. Because of the region and its special conditions collaboration extends beyond the field of geodesy – an interdisciplinary cooperation is anticipated, especially incorporating geophysics and glaciology. This is also reflected in the group membership (cf. below).

For AntGP, the year 2005 can primarily be seen against the background of the upcoming International Polar Year 2007/2008 (IPY; actual period: March 2007 to February 2009). Many members of AntGP have been involved in preparatory work of internationally coordinated projects, which eventually may have got an official endorsement of the IPY Joint Committee. In terms of planned aerogeophysics, which provide the most promising method to further close gaps in the gravity data coverage in Antarctica, two projects should be emphasized: IPY Full Proposal 67 “Origin, evolution and setting of the Gamburtsev subglacial highlands: Exploring an unknown Antarctic territory” and IPY Full Proposal 97 “Investigating the Cryospheric Evolution of the Central Antarctic Plate (ICECAP): Internationally coordinated long-range aerogeophysics over Dome A, Dome C and the Aurora Subglacial Basin of East Antarctica” (see also [www.ipy.org](http://www.ipy.org)). Taking these projects and further IPY activities into account, a very promising perspective has been opened to pursue the goals of AntGP on a time scale of the next three, four years (acknowledging the duration of the IPY until 2009).

Within this context, AntGP fulfills an important role to maintain the linkage to the Antarctic community and its respective representative, the Scientific Committee on Antarctic Research (SCAR), namely the SCAR Standing Scientific Group on Geosciences, Expert Group on Geospatial Information and Geodesy and its work plan for Geodetic Infrastructure in Antarctica (GIANT). Project 3 of GIANT “Physical Geodesy” is chaired by A. Capra and co-chaired by M. Scheinert.

Specific activities of AntGP members during the Antarctic seasons 2004/2005 and 2005/2006 are addressed below.

Communication is maintained meeting at conferences, by circular letters and by e-mail. The comprehensive report on the status of AntGP, given by M. Scheinert at the IAG Symposium GGSM 2004 in Porto, was published in the reviewed proceedings (Scheinert 2005c). At the IAG General Assembly in Cairns, August 2005, an updated overview could be given by an invited talk (Scheinert 2005b). To present AntGP to the community, a website is being maintained under [www.tu-dresden.de/ipg/antgp](http://www.tu-dresden.de/ipg/antgp)

### **Future plans and activities**

Future activities are well defined following the “Terms of Reference”. Since any Antarctic activities call for a long-term preparation the main points to be focussed on does not change:

- (a) Promotion and realization of new gravity surveys in Antarctica

As described above, the upcoming IPY plays an important role for the international coordination and preparation of such surveys. Due to the huge logistic efforts of Antarctic survey campaigns, coordination is organized well in advance and on a broad international basis.

## (b) Built-up of databases

An overview of already existing data has been published in (Scheinert 2005c). Within AntGP, a discussion on methods and rules of data exchange is in progress and has to be followed on. Compilations of metadata and databases have to cover certain aspects of gravity surveys in Antarctica (large-scale airborne surveys, ground-based relative gravimetry, absolute gravimetry at coastal stations).

Upcoming conferences play an important role to coordinate work between AntGP members and the diverse communities. The following conferences should be emphasized in this respect: EGU General Assembly (Vienna, April 02–07, 2006), XXIX SCAR Meeting and Open Science Conference (Hobart, July 09–19, 2006) and the 1st International Symposium of the International Gravity Field Service “Gravity Field of the Earth” (Istanbul, Aug 28–Sept 01, 2006). Dedicated to the IPY project (full proposal 185) “Polar Earth Observing Network” (POLENET), a workshop will be held in Dresden, October 4–6, 2006, which offers also the possibility to discuss certain aspects of AntGP (especially with regard to observatories on absolute gravity and gravity time series).

## **Membership** (as of January 2006)

### *Active members*

|                         |   |
|-------------------------|---|
| Mirko Scheinert (chair) | TU Dresden, Germany                         |
| Martine Amalvict        | Université Strasbourg, France               |
| Alessandro Capra        | Universita di Modena a Reggio Emilia, Italy |
| Detlef Damaske          | BGR Hannover, Germany                       |
| Reinhard Dietrich       | TU Dresden, Germany                         |
| René Forsberg           | Danish National Space Center, Denmark       |
| Larry Hothem            | USGS, USA                                   |
| Wilfried Jokat          | AWI Bremerhaven, Germany                    |
| Gary Johnston           | Geoscience Australia                        |
| Fausto Ferracioli       | British Antarctic Survey, United Kingdom    |
| A.H. William Kearsley   | University of New South Wales, Australia    |
| Steve Kenyon            | NIMA, USA                                   |
| Christopher Kotsakis    | University of Calgary, Canada               |
| German L. Leitchenkov   | VNIIOkeangeologia, Russia                   |
| Jaakko Mäkinen          | FGI, Finland                                |
| Kazuo Shibuya           | NIPR, Japan                                 |
| C.K. Shum               | OSU Columbus, USA                           |
| Dag Solheim             | Statens Kartverk, Norway                    |
| Michael Studinger       | Lamont-Doherty Earth Observatory, USA       |

### *Corresponding members*

|                |  |
|----------------|--|
| Robin Bell     | Lamont-Doherty Earth Observatory, USA    |
| Graeme Blick   | LINZ, New Zealand                        |
| John Brozena   | Naval Research Lab, USA                  |
| Cheinway Hwang | National Chiao Tung University, Taiwan   |
| John Manning   | University of New South Wales, Australia |
| Dave McAdoo    | NOAA, USA                                |

## **Selected conferences and workshops with participation of AntGP members**

2nd EGU General Assembly, Vienna, Austria, April, 24–29 April, 2005.

Seminar on Airborne Operations in Polar Regions: Status and Future Prospects, Bremerhaven, May 09–11, 2005.

IAG General Assembly “Monitoring a dynamic planet with geodetic tools”, Cairns, Australia, August 22–26, 2005.

22nd International Polar Meeting of the German Society of Polar Research, Jena, Germany, September 19–24, 2005.

AGU Fall Meeting, San Francisco, USA, December 05–09, 2005.

## **Selected activities in Antarctic observation campaigns**

Joint project of TU Dresden and AWI Bremerhaven (Germany) “Validation, Densification and Interpretation of Satellite Data for the Determination of the Magnetic Field, Gravity Field, Ice Mass Balance and Crustal Structure in Antarctica by Means of Airborne and Terrestrial Measurements” (PIs: R. Dietrich and W. Jokat): Antarctic campaign in Western Dronning Maud Land in the season 2004/05 (incorporating airborne and ground gravity observations).

Projects of VNIIOkeangeologia (Russia) in Antarctica (G. Leitchenkov)

Observatory programme (superconducting gravimeter and others) at Japanese Syowa station, and field programmes, East Antarctica (K. Shibuya)

Absolute gravity observations at Antarctic stations Aboa, SANAE IV and Novolazarevskaya, Dronning Maud Land, 2005/06 (J. Mäkinen)

## **Selected publications and presentations of members**

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Damaske, D. (2005). BGR Polar Aerogeophysics. Oral Presentation at Seminar on Airborne Operations in Polar Regions: Status and Future Prospects. Bremerhaven, May 09-11, 2005.

Ferracioli, F., P. Jones, M. Hugh Corr, and A. Curtis (2005). Recent Airborne Geophysics Exploration Projects at BAS. Oral presentation at Seminar on Airborne Operations in Polar Regions: Status and Future Prospects. Bremerhaven, May 09-11, 2005.

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# IAG – Gravity and Geoid Project in South America

Prepared by: Denizar Blitzkow and Maria Cristina Pacino

## REPORT

February 2006

### ACTIVITIES

**Fundamental Gravity Network of Ecuador.** A total of 33 gravity stations have been established in a cooperation between EPUSP, IBGE (Brazil), IGM and INOCAR (Ecuador). The network has been adjusted recently and the results are presented in the master dissertation of Carlos Alberto Correa e Castro Jr. A problem that still exist in Ecuador is the inexistence of absolute gravity stations.

**PMRG (Project for the Geodetic Reference System) in Brazil.** SIRGAS2000.4 has been adopted in Brazil since February 2005. A new geoid model for Brazil has been computed and delivered in a grid as part of the new reference system. A software was also provided for interpolation in a point from the grid: MAPGEO2004.for. The results are presented in the doctor thesis of Maria Cristina B. Lobianco.

**Course.** STOKES-HELMERT'S SOLUTION TO GEODETIC BOUNDARY VALUE PROBLEM. It was taught by Prof. Dr. Petr Vaníček, in Rio de Janeiro, October 2005. It was supported by IBGE, University of New Brunswick and CIDA (Canadian International Development Agency).

Geoid in Argentina. A new geoid model for Argentina was computed and the result is part of the doctor thesis of Claudia Tocho.

**Future efforts.** A new set of gravity data is now available in Colombia and Ecuador due to an effort of Laura Sanchez and Alfonso Tierra to validate the data in the two countries. The next version of the geoid model will benefit of this effort.

A new gravity survey is expected to be accomplished in south of Chile, along Carretera Austral. The survey will be carried out in a joint cooperation between EPUSP, IBGE and IGM.

As a result of the fact that National Observatory of Brazil has two absolute gravimeters it is planned to re-observe existing absolute gravity stations in Brazil and in South America in the new future as well as the establishment of new stations.

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**South-East Asian Geoid  
Status Report, February 2006**

*Bill Kearsley (w.kearsley@unsw.edu.au)*

Not much to report from the SEAsian Geoid Commission, as it is having some trouble getting off the ground. However, I hope that we will have at least some representation at Rene Forsberg's IGFS meeting in Mongolia in May/June 2006.

In August 2005, I attended the workshop organised by the PCGIAP, the weekend leading into the IAG Dynamic Planet, and there is now a strong link established between the UN Permanent Commission for Geographic Information Infrastructure for the Asia-Pacific region, and the SEAsian Subcommittee of IAG. There is a good deal of overlap between the two groups, (both geographically and in topics of interest) that it seems the most logical and effective way to go, especially as it is hard to get the countries involved together at normal IAG meetings. There seems to be general acceptance of the concept of the SEAsia S/committee for the Geoid by delegates, although I understand some (notably Indonesia) are cautious about sharing data - esp. via Geotech as they believe this group have been on-selling their data, against the terms of agreement under which they (Geotech) obtained it. We are encouraging member groups to go to Rene's Airborne Gravity Meeting in Mongolia in May/June too, as this affords an excellent forum to discuss matters of mutual interest.

**Inter-Commission Working Group 2.1  
International Association of Geodesy (IAG)**

***Satellite Gravity Theory***

**Commission 2 (Gravity Field)  
&  
InterCommission Committee on Theory**

Annual Report 2005

*Nico Sneeuw (chair)*

**Main activities**

The WG members' ongoing research activities in the area of Satellite Gravity Theory are documented in the list of selected literature below. Beyond these activities we need to report on the following main activities:

- Special Issue, Journal of Geodesy
- IAG meeting Cairns, 2005
- Organization in/of upcoming meetings

**Progress Special Issue, Journal of Geodesy**

During the IAG GGSM2004 meeting, August/September 2004, Porto, Portugal, a joint meeting had been organized between the Intercommission Working Group 2.1 and the Intercommission Committee on Theory Working Group on Inverse Problems (chair: J Kusche). It was proposed and agreed then that the two WG chairs will organize a special issue of the Journal of Geodesy, dedicated to the combined areas of the two working groups.

This Special Issue is meanwhile taking shape. Close to 10 papers were submitted, a few of which have already been approved for publication. They will be available in the on-line journal version immediately. The print version will appear when the review procedure of all contributions has been concluded. This is expected for Fall 2006.

**Further activities / IAG Meetings**

***Cairns 2005***

The 2005 IAG/IAPSO/IABO Joint Assembly *Dynamic Planet 2005* in Cairns, Australia, featured many sessions related to Satellite Gravity Theory, most prominently:

- GP1 Ocean circulation and contributions from new gravity field missions (Conveners: D. Chambers, V. Zlotnicki)
- GP3 Oceanography and geodesy in polar regions (Conveners: M. Drinkwater, S. Rintoul)
- G1 Frontiers in the analysis of space geodetic measurements (Conveners: M. Rothacher, M. King, J. Kusche)
- G2 Gravity field determination from a synthesis of terrestrial, satellite, airborne and altimetry measurements (Conveners: C. Jekeli, M. Kuhn)

Many WG members actively participated in these sessions.

### **Wuhan 2006**

The VI Hotine-Marussi Symposium that will take place May 29 - June 2, 2006, in Wuhan, China is dedicated to Theoretical Geodesy. Session 2, in particular, is dedicated to the scope of our WG. The session name is *Theoretical Developments in Spaceborne Gravimetry*; it is convened by Nico Sneeuw and Cheinway Hwang.

### **Istanbul 2006**

From August 28 to September 1, 2006, the 1<sup>st</sup> International Symposium of The International Gravity Field Service (IGFS) will take place in Istanbul, Turkey. There will be a session called *Satellite Gravity Missions*, convened by Nico Sneeuw and Mahmut Kararlioglu, in which both results and theoretical developments can and will be displayed. A strong participation of the WG members is expected.

### **Members**

|                       |                         |                |                                 |
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Since the previous reporting period, the following affiliation changes took place:

- Nico Sneeuw from University of Calgary to Stuttgart University, Germany
- Michael Kern from TU Graz to ESA, ESTEC, Noordwijk, The Netherlands

### **List of Selected Literature**

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# Report of IAG ICCT Joint Working Group with Commission on Gravity:

## JWG 5: Multiscale Modelling of the Gravity Field

### Introduction

During the last decades technological progress has changed completely the observational methods in all fields of geosciences with a trend to achieve immediate results, thus reducing time and costs. A reconstruction of the gravity field from data material coming from satellite as well as airborne and terrestrial measurements requires a careful multiscale analysis of the gravity potential, fast solution techniques, and a proper stabilization of the solution by regularization. While global long-wavelength modelling can be adequately done by use of spherical harmonic expansions, harmonic splines and/or wavelets are most likely candidates for medium and short-wavelength approximation. The working group intends to bring together scientists concerned with the diverse areas of geodetically relevant wavelet theory in general and its applications. An essential field of research is the specific character of geodetic multiresolution methods used in addition or in contrary to standard spectral techniques based on spherical harmonic framework.

### Objectives

- Theoretical research in the field of spherical and ellipsoidal wavelets as well as wavelet introduction and modelling on geodetically relevant surfaces (like spheroid, geoid, (actual) Earth's surface).
- Studies of harmonic wavelets in geodetic boundary-value problems (e.g., Runge-Walsh wavelets, layer potential wavelets, etc).
- Studies on spline/wavelet kernel modelling, multiscale pyramid algorithms via kernel functions known from (least squares) collocation and spline approaches, noise cancellation, least-squares adjustment and spline smoothing vs. multiscale thresholding, etc.
- Development of specific numerical methods: fast wavelet transform, tree algorithms, data compression, domain decomposition techniques, fast multipole methods, panel clustering, data transmission, etc.
- Comparison of spherical harmonic and/or wavelet modelling: Combined spectral and multiscale expansion of the gravitational potential, degree variances vs. local wavelet variances, spectral and/or multiscale signal to noise thresholding, etc.
- Investigation of different wavelet types in geodetic pseudodifferential equations (using numerical methods such as collocation, Galerkin method, least-squares approximation, etc).
- Regularization of inverse problems by multiresolution, locally reflected multiscale vs. globally reflected spectral regularization, multiscale parameter choice strategies, multiscale modelling in SST, SGG.
- Time dependent multiscale modelling in boundary value and inverse problems, numerical implementation and application to GRACE-, GOCE-data.

### Members and Correspondent Members

W. Freeden, Germany (chair)

M. J. Fengler (Germany), T. Gervens (Germany), E. W. Grafarend (Germany), M. Gutting (Germany), K. Hesse (Australia), C. Jekeli (USA), P. Kammann (Germany), W. Keller (Germany),

A. Kohlhaas (Germany), J. Kusche (Netherlands), D. Michel (Germany), V. Michel (Germany), J. Otero (Spain), S. Pereverzev (Austria), F. Sacerdote (Italy), F. Sanso (Italy), M. Schreiner (Switzerland), J. Schröter (Germany), W.-D. Schuh (Germany), I. H. Sloan (Australia), N. Sneeuw (Canada), L. Svensson (Sweden), C. C. Tscherning (Denmark)

### Past Activities

- Presentations at several conferences:
  - General Assembly of the European Geoscience Union (EGU) in Vienna, April 2005.
  - SIAM Conference on Mathematical and Computational Issues in the Geosciences, Avignon, June 2005.
  - ÖMG-DMV-SIAM-Conference "Mathematics 2005", Klagenfurt, September 2005.
  - Geodetic Week, Düsseldorf, October 2005.
  - Fall Meeting of the American Geophysical Union (AGU) in San Francisco, December 2005.
- Cooperation between the groups in Kaiserslautern (W. Freeden) and Munich (R. Rummel) about multiscale modelling of temporal changes of the gravitational field measured by GRACE (see: M.J. Fengler, W. Freeden, A. Kohlhaas, V. Michel, T. Peters, "Wavelet Modelling of Regional and Temporal Variations of the Earth's Gravitational Potential Observed by GRACE", submitted to Journal of Geodesy, 2005).
- Cooperation between the groups in Kaiserslautern (W. Freeden) and Stuttgart (E. W. Grafarend) in form of a joint DFG-project: Inverse Multiscale Geoid Computation (IMGC).
- Cooperation between the groups in Delft (J. Kusche) and Kaiserslautern (W. Freeden) about Wavelet Modelling of satellite data and its combination with regional terrestrial data. (see: M. J. Fengler, W. Freeden, V. Michel: "The Kaiserslautern Multiscale Geopotential Model SWITCH-03 from Orbit Perturbations of the Satellite CHAMP and Its Comparison to the Models EGM96, UCPH2002.02.0.5, EIGEN-1s, and EIGEN-2." Geophysical Journal International, Vol. 157, pp. 499-514, 2004; and: M. J. Fengler, W. Freeden, J. Kusche: "Multiscale Geopotential Solutions from CHAMP Orbits and Accelerometry." C. Reigber, H. Lühr, P. Schwintzer, J. Wickert (Eds.), Proceedings of the 2nd CHAMP Science Meeting, Springer Berlin, Heidelberg, New York, pp. 139-144, 2004.).
- Cooperation between the groups in Frankfurt (H. Schmeling) and Kaiserslautern (W. Freeden) about plume detection from gravity and topology.
- Organization of the international workshop "Inverse Problems" (see below for further details).

### International Workshop "Inverse Problems" at the University of Kaiserslautern

From 24th to 25th November an international workshop on "Inverse Problems" took place at the hotel "Zum Schwan" in Trippstadt (organisers: Prof. Dr. W. Freeden, HDoz. Dr. V. Michel, University of Kaiserslautern, and Dr. J. Flury, GOCE Project Office Germany, Technische Universität München). This workshop was hosted by the Geomathematics Group of the University of Kaiserslautern, by the Johann Radon Institute for Computational and Applied Mathematics in Linz (represented by Prof. Dr. S. V. Pereverzev) and by the GOCE Project Office Germany (directed by Prof. Dr. mult. R. Rummel, TU München).

The workshop was financially supported by the DFG Graduate Research Training Programme "Mathematics and Practice" and the DFG Priority Programme of the same name at the University of Kaiserslautern. Participants were among others Prof. Dr. mult. E. W. Grafarend (Institute of Geodesy, Universität Stuttgart), Prof. Dr. P. Maaß (Director of the Center of Industrial Mathematics, Bremen University), Prof. Peiliang Xu (Disaster Prevention Research Institute, Kyoto

University), Prof. Dr. W. Rundell (Director of the Division of Mathematical Sciences, National Science Foundation, USA) and Prof. Dr. mult. E. Groten (Institute for Physical Geodesy, TU Darmstadt).

Inverse problems play an important role, e.g., in modern medicine, materials science, geophysics or geodesy. An inverse problem is given if we want to determine an inaccessible cause from its observable effect. The challenge for the scientists is that inverse problems are mostly ill-posed and cannot be solved by numerical standard methods. “Ill-posed” means that small errors in the given data cause large errors in the solution. The problem can often be stabilised by a so-called regularisation, i.e., by replacing the problem by a closely related well-posed problem which can be stabilised.

Mathematicians, engineers as well as geoscientists met at the interdisciplinary workshop. 27 speakers, e.g., from the USA, Japan, Austria, Switzerland, Great Britain, the Netherlands and Germany reported on their research and presented the difficulties of inverse problems, especially in geosciences but also in image processing. Prof. Dr. Z. Nashed (University of Central Florida, Orlando), a worldwide respectable scientist, gave the introductory talk. He spoke about the importance of inverse problems and placed emphasis on the reconstruction of signals from disturbed partial information. Prof. Dr. mult. R. Rummel (head of the Institute for Astronomical and Physical Geodesy (IAPG) of the TU München) explained the challenges in modern satellite technology when determining a geopotential or a high-precision geoid. He expected new approaches for research and increased cooperation of geoscientists, geophysicists and mathematicians from the workshop. For instance, the downward continuation problem arises in satellite geodesy: A geopotential was measured by a satellite and is to be continued to the Earth’s surface. The measured data are given in discrete points on the satellite’s orbit and are disturbed. In this context, Prof. Dr. S. V. Pereverzyev presented recent regularisation methods for geoscientific applications occurring in the ESA satellite mission GOCE. Prof. Dr. J. Prestin pointed out the importance of radial basis functions. Prof. Dr. P. Maaß talked about an inverse approach to image processing. The Geomathematics Group presented new wavelet (multiresolution) methods to regularise the downward continuation problem for the determination of the gravity or magnetic field of the Earth.

More than 40 scientists attending the workshop were extremely interested in the talks and the corresponding discussions. Furthermore, recent results of students and doctorands of the Geomathematics Group were presented in a poster session. The positive acknowledgment showed that the workshop achieved its aim, i.e., the connection of mathematical theory and modelling on the one hand and the geotechnical and industrial application on the other hand in the domain of inverse problems.

### **Planned Activities**

- Further Email discussion and electronic exchange.
- Launch of an extended web-page for dissemination of information, expressing aims, objectives, and providing a bibliography.
- Further monitoring and presentation of activities, either of working group members or interested external individuals.
- Organisation of a further workshop about multiscale modelling in geosciences.



# **Evaluation of Global Earth Gravity Models**

## **Newsletter #1**

Chair: Dr. Jianliang Huang (Geodetic Survey Division, CCRS, NRCan, Canada)

Vice-chair: Dr. Christopher Kotsakis (Aristotle University of Thessaloniki, Greece)

### **1. TERMS OF REFERENCE**

The CHAMP and GRACE satellite gravity missions, along with the upcoming GOCE mission, are and will be mapping the Earth's gravity field with significantly increasing accuracy and spatial resolution. The data obtained from these missions are being and will be used to develop a series of new static satellite-only gravity models down to 150 – 200 km wavelength, as well as combined Earth Gravity Models (EGMs) down to about 20 km wavelength. The evaluation of such global EGMs is commonly based on comparisons with other “external” data sets that depend on the same gravity field. The various centers responsible for the development of these models routinely perform such comparisons using a variety of validation data sets such as geoid heights from GPS and leveling heights, airborne and surface gravity measurements, marine geoid heights from mean oceanographic sea surface topography models and altimetry observations, orbits from other geodetic and altimetry satellites etc.

In response to the call of having an independent and coordinated initiative for the evaluation of the new EGMs, a new Joint Working Group (JWG) has been established between IGFS and the IAG Commission 2. The main objective of the JWG is to develop standard validation/calibration procedures, and to perform the quality assessment of GRACE-, CHAMP- and GOCE-based satellite-only and combined solutions for the static Earth's gravity field. The external data sets that will be used for such purposes include mainly GPS-leveling data, airborne and surface gravity data, mean oceanographic sea surface topography models and altimetry data, orbit data from other geodetic and altimetry satellites and astro-geodetic deflection data etc.

Another equally important evaluation is with respect to temporal variation of the Earth's gravity field derived from the GRACE monthly gravity solutions. The repeated absolute/relative gravity measurements and super-conducting gravity observations provide the most accurate temporal variation on the ground. As part of the initiative, validation/calibration methods for temporal gravity variation will be explored.

### **2. PROGRAM OF ACTIVITIES**

- The JWG creates opportunities through communication and workshops/conferences for international cooperation to develop and propose standard methods for evaluating global EGMs using external geodetic and oceanographic data. A specific research area of interest will be the issue of how

to handle the different spectral content of satellite-based global gravity field models and terrestrial gravity data.

- The JWG defines a set of synthetic data to test the feasibility and the performance of various evaluation methods for EGMs.
- The JWG conducts evaluation of new global EGMs.
- The JWG explores evaluation methods for temporal gravity variation.
- The JWG encourages active participation and contribution from its members through email contact, conferences/meetings, scientific presentations and publications.
- A WWW site will be created to facilitate communication, information and data exchanges.

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

### **3. Membership:**

Dr. Hussein Abd-Elmotaal, Minia University, Egypt  
Dr. Min Kang Cheng, CSR, University of Texas & Austin, USA  
Dr. Gleb Demianov, Agency of Geodesy and Cartography, Ministry of Transport, Russia  
Dr. Heiner Denker, University of Hannover, Germany  
Prof. Will Featherstone, Curtin University of Technology, Australia  
Dr. Rene Forsberg, National Space Centre, Denmark  
Dr. Thomas Gruber, IAPG, TUM, Germany  
Dr. Jianliang Huang, Geodetic Survey Division, CCRS, NRcan, Canada  
Dr. Jaroslav Klokočnic, Astronomical Institute of the Acad. of Sciences, Czech Republic  
Dr. Christopher Kotsakis, Aristotle University of Thessaloniki, Greece  
Prof. Jiancheng Li, Wuhan University, P. R. China  
Prof. Charles Merry, University of Cape Town, South Africa  
Prof. Phil Moore, Newcastle University, UK  
Dr. Pavel Novák, Research Institute of Geodesy, Czech Republic  
Dr. Niko K Pavlis, Raytheon ITSS Corporation, USA  
Dr. Dan Roman, National Geodetic Survey, USA

### **4. Correspondence:**

Dr. S. Bettadpur, CSR, University of Texas & Austin, USA  
Prof. C. Jekeli, The Ohio State University, USA  
Mr. S. C. Kenyon, National Geospatial-Intelligence Agency, USA  
Prof. Ch. Reigber, GeoForschungsZentrum, Potsdam, Germany  
Dr. J. Ries, CSR, University of Texas & Austin, USA  
Prof. R. Rummel, IAPG, TUM, Germany  
Prof. M.G. Sideris, University of Calgary, Canada  
Dr. N. Sneeuw, Universität Stuttgart, Germany  
Prof. B.D. Tapley, CSR, University of Texas & Austin, USA  
Dr. C. C. Tscherning, University of Copenhagen, Denmark  
Prof. I.N. Tziavos, Aristotle University of Thessaloniki, Greece

Mr. M. Véronneau, Geodetic Survey Division, CCRS, NRCan, Canada  
Dr. P. Visser, Delft University of Technology, The Netherlands  
Dr. Y. M. Wang, National Geodetic Survey, USA

## 5. Activities for 2006

- The first group meeting is scheduled in the first IGFS Assembly, Istanbul, Turkey, August 28th – September 1<sup>st</sup>, 2006 (see <http://www.igfs.net>).
- Development of the standard spatial and spectral methods for evaluating the global gravity models.
- Selection/Creation of synthetic gravity data for verifying the methods. Information for the latest synthetic gravity field can be found at the IAG SGG3.177 web pages ( <http://www.cage.curtin.edu.au/~will/iagssg3177.html> ).
- Evaluation of the latest global Earth gravity models using CHAMP/GRACE data (GGM02C from CSR, CG03C from GFZ, EGM06 from NGA). EGM06 will be made available to the group before public release (tentative public release time: 30 June 2006).
- WWW site for the JWG

## 6. The latest publication of GRACE's gravity models

- B. Tapley, J. Ries, S. Bettadpur, D. Chambers, M. Cheng, F. Condi, B. Gunter, Z. Kang, P. Nagel, R. Pastor, T. Pekker, S. Poole, F. Wang (2005) GGM02 – An improved Earth gravity field model from GRACE, *Journal of Geodesy*, 79:467-478
- Ch. Reigber, R. Schmidt, F. Flechtner, R. König, U. Meyer, K.-H. Neumayer, P. Schwintzer, S. Y. Zhu (2005) An Earth gravity field model complete to degree and order 150 from GRACE: EIGEN-GRACE02S, *Journal of Geodynamics*, 39, 1-10

## 7. The latest publication and presentations on the validation of CHAMP/GRACE's gravity models from members

- S. Kenyon, J. Factor, P. Nikolaos, S. Jahir, S. Holmes (2005) Towards the next Earth gravitational model to degree 2160: status and progress, IAG/IAPSO/IABO Joint Assembly, Cairns, Australia, 25 August 2005
- T. Gruber (2005) Validating gravity fields from new satellite missions: methods and limitations, [http://tau.fesg.tu-muenchen.de/~gruber/web/pr\\_2005e.pdf](http://tau.fesg.tu-muenchen.de/~gruber/web/pr_2005e.pdf), IAG/IAPSO/IABO Joint Assembly, Cairns, Australia, 25 August 2005
- J. Klokočník, J. Kostelecký, C. A. Wagner, P. Schwintzer, C. Förste, R. Scharroo (2004) Evaluation of the accuracy of the EIGEN-1S and –2 CHAMP-derived gravity field models by satellite crossover altimetry, *Journal of Geodesy*, 78, 405-417
- Y. M. Wang and D. Roman Validation of gravity models from CHAMP/GRACE gravity missions using the GPS/leveling data from the continental US, [http://www.ngs.noaa.gov/GEOID/PRESENTATIONS/2004\\_July\\_FGZ/GFZ\\_Julu0](http://www.ngs.noaa.gov/GEOID/PRESENTATIONS/2004_July_FGZ/GFZ_Julu0)

- [4 talk files/frame.htm](#), Joint CHAMP/GRACE Science Meeting, Potsdam, 6-8 July 2004
- R. Forsberg and A. V. Olesen (2004) Validation of static GRACE models by airborne gravimetry and GPS-leveling, Joint CHAMP/GRACE Science Meeting, Potsdam, 6-8 July 2004
  - J. Huang and M. Véronneau (2004) GPS-leveling and CHAMP&GRACE geoid models, <ftp://ftp.geod.nrcan.gc.ca/pub/GSD/jianhuan/JWGpublications/jcgPotsdam04.pdf>, Joint CHAMP/GRACE Science Meeting, Potsdam, 6-8 July 2004
  - P. Moore, J. F. Turner, Z. Qiang (2003) Error analyses of CHAMP data for recovery of the Earth's gravity field, *Journal of Geodesy*, 77, 369 – 380
  - M. Amos and W. E. Featherstone (2003) Comparisons of recent global geopotential models with terrestrial gravity field data over New Zealand and Australia, *Gomatics Research Australia*, 79: 1-20
  - M. K. Cheng, B. D. Tapley (2002) Temporal variation in the Earth's gravity field from SLR and CHAMP GPS data, In: Tziavos IN (ed) *Gravity and Geoid 2002*, Proceedings of the International Gravity and Geoid Commission, Thessaloniki, Greece, 424-431

## 8. Upcoming meetings

- Joint Assembly, 23-26 May 2006, in Baltimore, MD, G02: Toward a Continental Geoid Model and a Dynamic Vertical Datum, <http://www.agu.org/meetings/ja06>
- The first IGFS Assembly, Istanbul, Turkey, August 28th – September 1<sup>st</sup>, 2006 (see <http://www.igfs.net>)

## **Short status report – International Gravity Field Service**

The IGFS has set up its web page – [www.igfs.net](http://www.igfs.net). Major current activities include the preparation of the “1<sup>st</sup> International Gravity Field Service Symposium, Istanbul”, Aug 2006, and the regional workshop on “Height Systems, Geoid and Gravity of the Asia-Pacific”, June 2006.

The IGFS is an umbrella organization over the International Gravity Bureau (BGI), International Center for Earth Tides (ICET), International Geoid Service (IGeS), International Center for Global Earth Models (ICGEM), and the International DEM Service (IDEMS). The latter not yet started operations. The services under the IGFS umbrella have a varying degree of success in operations. Currently the BGI and the ICET needs new directors for 2007. It could be an option that an international call for new international hosts for BGI and ICET should be made, but so far no feedback from the current institutions on possible new directors.

The IGFS has a working group on Evaluation of Global Gravity Field Models (Jianliang Huang, Canada), and a new group is currently formed for Coordination of Absolute Gravimetry (O. Francis, Luxembourg). The IGFS participates in the preparations of the GGOS project on behalf of the gravity-related services.

Rene Forsberg  
March 2, 2006