Inter-Commission Committee on Theory (ICCT)

http://icct.kma.zcu.cz

President: Nico Sneeuw (Germany)
Vice President: Pavel Novák (Czech Republic)

Structure

IC-SG1: Theory, Implementation and Quality Assessment of Geodetic Reference Frames
IC-SG2: Quality of Geodetic Multi-Sensor Systems and Networks
IC-SG3: Configuration Analysis of Earth Oriented Space Techniques
IC-SG4: Inverse Theory and Global Optimization
IC-SG5: Satellite Gravity Theory
IC-SG6: InSAR for Tectonophysics
IC-SG7: Temporal Variations of Deformation and Gravity
IC-SG8: Towards cm-accurate Geoid – Theories, Computational Methods and Validation
IC-SG9: Application of Time Series Analysis in Geodesy

Overview

The Inter-Commission Committee on Theory (ICCT) was formally approved and established after the IUGG XXI Assembly in Sapporo, 2003, to succeed the former IAG Section IV on General Theory and Methodology and, more importantly, to interact actively and directly with other IAG entities.

The main objectives of the ICCT are:

- to be the international focal point of theoretical geodesy,
- to encourage and initiate activities to further geodetic theory,
- to monitor research developments in geodetic modelling.

The structure of the ICCT is specified in the IAG by-laws. The ICCT Steering Committee consists of the President, the Vice-President and representatives from all IAG Commissions:

President: Nico Sneeuw (Germany)
Vice-President: Pavel Novák (Czech Republic)
Representatives:
Commission 1: Zuheir Altamimi (France)
Commission 2: Pieter Visser (The Netherlands)
Commission 3: Richard Gross (USA)
Commission 4: Sandra Verhagen (The Netherlands)

After the IUGG General Assembly in Perugia (held in July 2007), a structure of nine ICCT Study Groups was created. They are denoted as IC-SG1 to IC-SG9, see the list above. The new structure, terms of reference, objectives and program of activities for the 2007-2011 period were presented in the Geodesist's Handbook 2008 published in the *Journal of Geodesy* (J Geod 82: 783-792, November 2008). During the fall of 2007, the new ICCT Website was also established at: http://icct.kma.zcu.cz. The website is located at the web server of the Department of Mathematics, University of West Bohemia in Pilsen, and is powered by the

MediaWiki Engine (similar to that used for the Wikipedia, a free, web-based multilingual encyclopaedia project). Due to this setup, the content of the ICCT Website can easily be edited by any authorized personnel (members of the ICCT Steering Committee and Chairmen of the Study Groups). Thus, the website can be used by for fast and easy communication of ideas among the members of the Study Groups. During 2008 the latest Study Group was established (IC-SG9), i.e., there are currently nine active Study Groups within the ICCT.

During the 2007-2009 period, the ICCT Steering Committee organized two meetings. The ICCT Splinter Meeting was held during the IAG International Symposium on *Gravity, Geoid and Earth Observation* in Chania (June 2008). The agenda of the meeting included these issues: the information of the ICCT President on the structure of the ICCT, organization of the Hotine-Marussi Symposium in 2009, the new website of the ICCT and short reports of the present chairmen of the ICCT Study Groups. The second meeting of the ICCT Steering Committee was organized during the VII Hotine-Marussi Symposium in Rome (July 2009). The committee was almost complete with the ICCT President, Vice-President, three of four commission representatives and six of nine Study Group Chairmen attending the meeting. The business meeting took place at the Academia Nazionale dei Lincei in Rome on July 8, just in the middle of the VII Hotine-Marussi Symposium. The program of the meeting included the evaluation of the first part of the Hotine-Marussi Symposium and the mid-term report of the ICCT to the IAG. The SG Chairmen attending the business meeting presented shortly reports of their Study Groups for the 2007-2009 period and outlined plans for the next two-year period (until 2011).

The highlight of the ICCT activities in 2009 was the organization of the VII Hotine-Marussi Symposium in Rome, 6-10 July 2009. The conference was organized by the ICCT with the strong support from the local organizing committee under the leadership of Mattia Crespi, University La Sapienza in Rome. The five-day program of the Symposium consisted of eight sessions covering research areas of all nine ICCT Study Groups, namely:

- Geodetic sensor systems and sensor networks (Verhagen)
- Estimation and filtering theory, inverse problems (Kutterer, Kusche)
- Time series analysis and prediction of multi-dimensional signals (Kosek, Schmidt)
- Geodetic boundary-value problems and cm-geoid computational methods (Wang, Novák)
- Satellite gravity theory (Mayer-Gürr, Sneeuw)
- Earth-oriented space techniques and their benefit for Earth system studies (Seitz, Gross)
- Theory, implementation and quality assessment of geodetic reference frames (Dermanis, Altamimi)
- Temporal variations of deformation and gravity (Spada, Crespi, Wolf)

Additionally, a special session was organized at the Academia Nazionale in commemoration of Antonio Marussi (Sansò). The program of the conference consisted of 52 oral presentations (12 of them invited) and approximately of 50 posters. In total, 112 participants from 20 countries attended the VII Hotine-Marussi Symposium.

The Hotine-Marussi Symposium was not the only scientific meeting with the visible presence of the ICCT. At the last two EGU General Assemblies in Vienna (2008, 2009), sessions on recent developments in geodetic theory were co-organized and co-convened by the ICCT President. The ICCT Vice-President is a member of the Scientific Committee of the next IAG Scientific Meeting held in Buenos Aires, September 2009. The ICCT was also present

through its Working Groups at other meetings, see their respective reports below. The Study Group 1 will organize the IAG School on Reference Systems that will be held for the period May 31 - June 6, 2010 at the facilities of the Aegean University at Mytilene, Island of Lesvos, Greece.

The activities of the ICCT are related namely to the research carried out by members of its Study Groups. Their mid-term reports specify the areas investigated by the members of the Study Groups, achieved results (publications and presentations) and plans for the future work. All the SG Chairmen (but one) submitted their reports that can be found at the following pages. Based on the content of the reports, it can be concluded that the Study Groups are active, although the level of mutual co-operation and/or interaction between its members is not necessarily the same for all the Study Groups.

IC-SG1: Theory, Implementation and Quality Assessment of Geodetic Reference Frames

Chair: A. Dermanis (Greece)

Introduction

This document presents a status report of the work undertaken by the ICCT Study Group IC-SG1 on "Theory, implementation and quality assessment of geodetic reference frames" since its creation in 2007 after the IUGG General Assembly in Perugia. It is a joint Study Group of the ICCT, the IAG Commission 1 (Reference Frames) and the IERS (International Earth Rotation and Reference Systems Service).

Primary Objectives of the Study Group

The primary objectives of this SG are:

- Study of models for time-continuous definitions of reference systems for discrete networks with a non-permanent set of points and their realization through discrete time series of station coordinate functions and related earth rotation parameters.
- Understanding the relation between such systems and reference systems implicitly introduced in theories of earth rotation and deformation.
- Extension of ITRF establishment procedures beyond the current linear (constant velocity) model, treatment of periodic and discontinuous station coordinate time series, understanding of their geophysical origins and related models.
- Understanding the models used for data treatment within each particular technique, identification of possible biases and systematic effects and study of their influence on the combined ITRF solution. Study and improvement of current procedures for the merging of data from various space techniques.
- Statistical aspects of reference frames, introduction and assessment of appropriate quality measures.

Current Membership Structure

Full members:

A. Dermanis (Chair, Greece)
Z. Altamimi (France)
G. Blewitt (USA)
C. Boucher (France)
X. Collilieux (France)
H. Drewes (Germany)
F. Lemoine (USA)
A. Nothnagel (Germany)
E. Pavlis (USA)
G. Petit (France)
J. Ray (USA)
F. Sansò (Italy)

Activities of the Study Group

The main activity of the Study Group has been the research carried out by its members which is documented in the list of publications below. No meetings of the Study Group took place, due to lack of sufficient overlapping of member presence at the various meetings. The Study Group Web page has been established at: http://der.topo.auth.gr/sgrf/. A conference session on the Study Group topic will take place at the VII Hotine-Marussi Symposium, Rome 6-10 July 2009 (Session 7: Theory, implementation and quality assessment of geodetic reference frames, Conveners: A. Dermanis, Z. Altamimi).

Future Activities

As an initiative of the Study Group an IAG School on Reference Systems will be held for the period May 31 - June 6, 2010, at the facilities of the Aegean University at Mytilene, Island of Lesvos, Greece. The School will cover theoretical aspects, data assessment and analysis for each particular technique (VLBI, SLR, GPS, Doris), their implementation in the derivation of the International Terrestrial Reference Frame (including computational aspects and training in the use of relevant software) as well as the geophysical interpretation and use of the ITRF results. We have asked the IAG to sponsor the School and official approval will be (hopefully) given at the next meeting of the IAG Executive Board.

Publications

Abbondanza C, Altamimi Z, Sarti P, Negusini M, Vittuari L (2009) Local effects of redundant terrestrial and GPS-based tie vectors in ITRF-like combinations. *Journal of Geodesy* (online).

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Böckmann S, Artz T, Nothnagel A, Tesmer V (2007) Comparison and combination of consistent VLBI solutions. Geowissenschaftliche Mitteilungen, Schriftenreihe Vermessung und Geoinformation der TU Wien, Heft 79: 82-87

Collilieux X, Altamimi Z, Coulot D, Ray J, Sillard P (2007) Comparison of very long baseline interferometry, GPS, and satellite laser ranging height residuals from ITRF2005 using spectral and correlation methods. *Journal of Geophysical Research* 112: B12403, doi:10.1029/2007JB004933

Collilieux X, Altamimi Z, Ray J, van Dam T, Wu X (2009) Effect of the satellite laser ranging network distribution on geocenter motion estimation. *Journal of Geophysical Research* 114, B04402, doi:10.1029/2008JB005727.

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Dermanis A (2008) The ITRF Beyond the "Linear" Model. Choices and Challenges. In: Xu P, Liu J, Dermanis A (eds.), VI Hotine-Marussi Symposium on Theoretical and Computational Geodesy, IAG Symposia 132: 111-118, Springer Berlin.

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Nothnagel A (2008) Conventions on thermal expansion modelling of radio telescopes for geodetic and astrometric VLBI. *Journal of Geodesy* 10.1007/s00190-008-0284-z.

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Ray J, Crump D, Chin M (2007) New Global Positioning System reference station in Brazil. *GPS Solutions* 11: 1-10, DOI 10.1007/s10291-006-0032-x.

Ray J, Altamimi Z, van Dam T, Herring T (2007) Principles for conventional contributions to modeled station displacements, position paper for IERS workshop on Conventions, September 2007. http://www.bipm.org/utils/en/events/iers/Conv_PP1.txt

Ray J, Z. Altamimi, Collilieux X, van Dam T (2008) Anomalous harmonics in the spectra of GPS position estimates. *GPS Solutions* 12: 55-64, DOI 10.1007/s10291-007-0067-7.

Rothacher M, Drewes H, Nothnagel A, Richter B (2007) Integration of Space Geodetic Techniques as the Basis for a Global Geodetic-Geophysical Observing System (GGOS-D): An Overview. Geotechnologien Science Report 11: *Observations of the System Earth from Space*, ISSN 1619-7399, 75-79

Vennebusch M, Böckmann S, Nothnagel A (2007) The contribution of Very Long Baseline Interferometry to ITRF2005. *Journal of Geodesy* 81: 553 – 564

IC-SG2: Quality of Geodetic Multi-Sensor Systems and Networks

Chair: H. Kutterer (Germany)

Introduction and Primary Objectives of the Study Group

Modern geodetic observations are usually embedded in an integrated approach based on multi-sensor systems and networks. The fields of application are as manifold as the sensors in use. For example, total stations, GPS receivers and terrestrial laser scanners are applied in engineering geodesy for structural monitoring purposes together with permanently installed equipment. Geometric and physical space-geodetic sensors may serve as a second example since they are used for the determination of global reference frames. This report comprises relevant research in theory (uncertainty modeling and propagation, recursive state-space filtering) and applications (design, implementation and validation of multi-sensor systems) which has been carried out during the last two years.

Activities of the Study Group

The field of uncertainty modeling and propagation is of interest in many disciplines. It also concerns international standardization activities in the field of metrology. Here, an approach is broadly used which is based on stochastics – more or less on Bayesian theory in a very technical way (ISO, 1995; ISO, 2007). As this approach relies on a special interpretation of uncertainty – and is more or less restricted to uncertainty measures for scalar measurement results – alternative approaches are of increased interest. Neumann et al. (2008) and Alkhatib et al. (2009a, b) consider the joint modeling and propagation of two major types of data uncertainty – random variability and imprecision – of vector quantities. For the modeling of random variability a Bayesian approach in combination with Monte-Carlo simulations is used. Imprecision is modeled using fuzzy theory which allows a more flexible concept of uncertainty propagation. Presently, a linear propagation is considered which is more meaningful in case of the uncertainty about systematic errors. However, depending on the particular definition of a fuzzy vector other types of propagation are possible such as, e. g., a quadratic propagation. Note that Koch (2008a, b) studied the same topic in a Bayesian framework. The analysis of fuzzy data is described, e.g., in Viertl (1996); see Neumann (2009) for some recent developments in Geodesy.

For state-space filtering recursive algorithms are of major interest as they provide the basis for real-time applications. The classical Kalman filter is the most prominent example. In order to take deviations from the normality and linearity assumptions into account, several extensions have been studied. Alkhatib et al. (2008) compare the so-called extended Kalman filter (use of functional 2^{nd} order terms), the unscented Kalman filter (use of so-called sigma points to approximate a non-normal distribution) and the particle filter (Monte-Carlo solution of a Bayesian state-space filter). Meanwhile, this work has been extended with respect to both efficiency and the use of adaptive parameters in the system equations; a dedicated publication is in preparation. Vennegeerts and Kutterer (2009) consider efficiency issues of the algorithmic variance-covariance propagation of geometric mass data (3D point clouds) which are observed using a kinematic multi-sensor system (GPS, INS, terrestrial laser scanner).

Neumann and Kutterer (2007) and Kutterer and Neumann (2009) develop a Kalman filter extension with respect to data imprecision. Here, the set-theoretical overestimation is the main problem as in recursive formulations some information on data dependencies gets lost. In case of fuzzy data – defining fuzzy vectors by the so-called minimum principle – this yields true supersets of the correct fuzzy state-space vectors. Hence, the obtained uncertainty measures

are only rough estimates (upper bounds) of the true ones. In linear estimation problems this problem is easily overcome if the observation data uncertainty is strictly referred to originally independent uncertain influence quantities. Hence, the same idea has been applied to state-space recursion which has consequently been resolved for the uncertainty propagation. In this case it is also possible to introduce adaptive system parameters

The theoretical developments on uncertainty modeling and state-space filtering have been supported by R&D work on kinematic multi-sensor systems using a terrestrial laser scanner as the main sensing device.

Future Activities

In the second phase of the SG, the work on uncertainty modeling and propagation will be continued with more emphasis on uncertainty-based quality measures such as sensitivity and integrity. It is still necessary to look into the total uncertainty budget in detail regarding meaningful original and independent influence quantities to better describe dependencies and to suggest adequate uncertainty propagation techniques. Data pre-processing methods such as differencing and averaging are of further interest. The extensions of recursive state-space filters, mainly the particle filter, will be studied regarding efficiency and the interpretation of the results. Although there are already some meaningful results the fuzzy extension of the Kalman filter has not yet been completely understood; this needs to be improved. In addition, issues of terminology will be addressed. For these purposes the performance of the SG has to be improved. A number of colleagues working in related fields will be invited to join the SG.

Publications

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Alkhatib H, Neumann I, Kutterer H (2009b) Evaluating uncertainties of laserscanner measurements in a joint Monte Carlo und fuzzy approach. In: CD-ROM Proc. XIX IMEKO World Congress – Fundamental and Applied Metrology, September 6-11, 2009, Lisbon.

Alkhatib H, Neumann I, Neuner H, Kutterer H (2008) Comparison of Sequential Monte Carlo Filtering with Kalman Filtering for Nonlinear State Estimation, In: Ingensand H, Stempfhuber W (eds.): Proc. 1st International Conf Machine Control & Guidance, June 2008, Zurich, 132-142

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ISO (2007) Evaluation of measurement data – Supplement 1 to the "Guide to the expression of uncertainty in measurement" – Propagation of distributions using a Monte-Carlo method. Joint Committee for Guides in Metrology, Bureau Internationale des Poids et Mesures, Geneva.

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Koch K-R (2008a) Determining uncertainties of correlated measurements by Monte Carlo simulations applied to laserscanning. *J Applied Geodesy* 2 (3), 139-147

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Neumann I (2009) Zur Modellierung eines erweiterten Unsicherheitshaushalts in Parameterschätzung und Hypothesentests. DGK, C 634, Munich (in preparation).

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Vennegeerts H, Kutterer H (2009): Variants to compute variance information for mass data. In: Proc. ISPRS Workshop Laserscanning 2009, Paris, September 1-2, 2009.

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IC-SG3: Configuration Analysis of Earth Oriented Space Techniques

Chair: F. Seitz (Germany)

Introduction and Primary Objectives of the Study Group

This document presents a status report of the work undertaken in the framework of the ICCT Study Group SG3 since its creation in 2007. Activities of the study group are focussed on modern methods of Earth observation from space. Today, a multitude of simultaneously operating satellite systems with different objectives is available. They offer a broad spectrum of information on global and regional-scale processes within and/or between individual components of the Earth system in different temporal resolutions.

The primary objective of this study group is the development of strategies for multi-mission approaches for Earth sciences which combine complementary and redundant information from heterogeneous space-based, air-borne and terrestrial sensors. The study group provides a forum for researchers from various fields of space geodesy and geophysics in order to discuss theoretical and computationan aspects of sensor combination. Special attention of the research is turned to methodology and data analyses with view to physical processes in the Earth system.

Since many observation techniques are restricted to the measurement of integral effects, i.e. a combined signal of a multitude of underlying geophysical processes, it shall be investigated in which way the combination of heterogeneous data sets allows for the separation of processes and the identification of individual contributors. This way the study group aims on fostering and improving the understanding of the Earth system by creating more reliable information on processes and interactions in the subsystems of the Earth. This is especially necessary in view of studies related to global change.

Among the most important tasks are the compilation and assessment of background information for individual systems and sensors (mode of operation, sensitivity, accuracy, deficiencies) as well as theoretical studies, which (new) information on the Earth system can be gained from a combination of different observation methods. Furthermore the work comprises theoretical studies on combination strategies and parameter estimation.

Current Membership Structure

Full members:

F. Seitz (Chair, Germany)
J. Dickey (USA)
F. Meyer (USA)
M. Motagh (Germany)
M. Schmidt (Germany)
M. Seitz (Germany)
X. Wang (Germany)

Activities of the Study Group

Conference Contributions of SG Members

Anderssohn J, Motagh M, Walter T (2008) Magma source modeling derived from ScanSAR and InSAR time series analysis. *IAVCEI General Assembly*, Reykjavik, 2008.

Albertella A, Wang X, Rummel R (2007) Filtering of Altimetric Sea Surface Heights with local and global approaches. *Joint International GSTM and DFG SPP Symposium*, Potsdam, 2007.

Dickey J, Marcus S, Seitz F (2006) Freshening of the Arctic Ocean and melting effects in Siberia and Northern Canada: Motivation and Initial GRACE Results. *AGU Fall Meeting*, San Francisco, 2006.

Dickey J et al. (2007) Constraints of Global Time Variable Gravity Measurements on Global Continental Hydrology Models. *NASA Modeling, Analysis and Prediction Meeting*, College Park, USA, 2007.

Dickey J, de Viron O, Marcus S (2007) Global and Regional Modes of Mass Variability in the GRACE Data. *GRACE Science Team Meeting*, Potsdam, Germany, 2007.

Dickey J, Marcus S, Chin T (2007) Thermal Wind Forcing, Atmospheric Angular Momentum & Earth Rotation: Origin of the Earth's Delayed Response to ENSO, *AGU Fall Meeting*, San Francisco, USA 2007.

Dickey J, Marcus S, Willis J (2008) Ocean Cooling: Constraints from Time-Varying Gravity and Altimetry. *GRACE Science Team Meeting*, San Francisco, USA, 2008.

Dickey J, Marcus S (2008) The Changing Cryosphere in Alaska: Results and Implications. *Western Pacific Geophysical Meeting,* 2008.

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Marcus S, Dickey J, Willis J (2008) Earth Oblateness (J_2) Variations on Interannual-Decadal Time Scales: Constraints on Anelastic Effect. *AGU Fall Meeting,* San Francisco, USA, 2008.

Marcus S, Dickey J, Willis J (2007) Non-steric sea level rise: Insights from interannual changes in Earth's dynamic oblateness. *EGU General Assembly*, Vienna, Austria, 2007.

Meyer F, Bamler R, Leinweber R, Fischer J (2008) A Comparative Analysis of Tropospheric Water Vapor Measurements from MERIS and SAR. In: Proc. Int. Geosci. Remote Sensing Symp., IGARSS, Boston, 2008.

Motagh M, Hooper A, Walter T (2009) The value of InSAR time-series analysis to investigate natural and anthropogenic processes. *AGU Spring Meeting*, Toronto, 2009.

Motagh M, Anderssohn J, Krüger F, Schurr B, Walter T (2008) Coseismic and early postseismic deformation of the 14 Mw=7.7 Tocopilla earthquake: Results from space-geodetic and seismological data. *AGU Fall Meeting*, San Francisco, 2008.

Motagh, M, Sharifi M, Aipour S, Akbari V, Walter T, Rajabi M, Samadzadegan F, Djamour Y, Sedighi M (2008) InSAR time-series analysis of land subsidence due to groundwater overexploitation in groundwater basins of central and northeast Iran. *AGU Fall Meeting,* San Francisco, 2008.

Motagh M, Walter T (2008) InSAR time series analysis of surface deformation at Uturuncu volcano in Bolivia. *IAVCEI General Assembly*, Reykjavik, Iceland, 2008.

Schmeer M, Bosch W, Drewes H, Schmidt M (2007) Analysis of Atmospheric Density Variations - MaSiS: Separation of Mass Signals by Common Inversion of Gravimetric and Geometric Observations, *Joint International GSTM and DFG SPP Symposium*, Potsdam, 2007.

Schmeer M, Bosch W, Schmidt M (2008) Separation and estimation of oceanic and hydrological model parameters from simulated gravity observations. *EGU General Assembly*, Vienna, 2008.

Schmeer M, Bosch W, Schmidt M (2009) Separation of GRACE observations into individual mass variations of atmosphere, oceans, and continental hydrosphere. *EGU General Assembly*, Vienna, 2009.

Schmidt M (2008) Spatio-temporal multi-resolution representation of the gravity field from satellite data. Goddard Space Flight Center, Seminar, Greenbelt, 2008.

Seitz F, Dickey J, Marcus S (2006) Loading effects in Siberia and Northern Canada determined from a combination of hydrological model data and GRACE gravity field observations, *AGU 2006 Fall Meeting*, San Francisco, 2006.

Seitz F, Schmidt M, Shum CK, Chen Y (2007) Hydrological mass variations due to extreme weather conditions in Central Europe from regional GRACE 4-D expansions, *ESA Hydrology Workshop* Surface Water Storage and Runoff: Modeling, In-Situ Data and Remote Sensing, Geneva, 2007.

Seitz F, Güntner A, Schmidt M, Bosch W (2008) Mass variations in continental water storages from a combination of heterogeneous space and in-situ observations. 2nd Colloquium of the DFG-Priority Programme SPP1257 'Mass transport in the Earth System', Munich, 2008.

Sharifi M, Motagh M, Mirboroon S, Esmaeili M, Akbari V (2009) The use of GPS Radio Occultation technique for atmospheric corrections in InSAR data. *AGU Spring Meeting*, Toronto, 2009.

Wang X, Peters T (2008) Determination of mass transport in the Earth system from satellite constellation flights. *IAG International Symposium on Gravity, Geoid and Earth Observation 2008*, Chania, 2008.

Conference Sessions:

German Geodetic Week, Bremen, 2 October 2008:

Session 5: GGOS – Global Geodetic Observing System (Convenor: F. Seitz): 5 oral presentations.

VII Hotine-Marussi Symposium, Rome 6-10 July 2009:

Session 6: Earth oriented space techniques and their benefit for Earth system studies (Convenors: F. Seitz, R. Gross): 6 oral & 6 poster presentations.

German Geodetic Week, Karlsruhe, 24 September 2009:

Session 5: GGOS – Global Geodetic Observing System (Convenor: F. Seitz)

Publications

Anderssohn J, Motagh M, Walter T, Rosenau M, Kaufmann H, Oncken O (2009) Surface deformation time-series and source modeling for a volcanic complex system based on satellite wide swath and image mode interferometry: The Lazufre system, Central Andes. *Remote Sensing of Environment*. In press.

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Marcus S, Dickey J, Willis J, Seitz F (2009) Constraints on land ice ablation and sea level rise from the Earth's changing oblateness. Under review in *Geophys. Res. Lett.*

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Schmidt M, Seitz F, Shum CK (2008) Regional four-dimensional hydrological mass variations from GRACE, atmospheric flux convergence and river gauge data. *J. Geophys. Res*. 113, B10402, doi: 10.1029/2008JB005575.

Seitz M (2009) *Kombination geodätischer Raumbeobachtungsverfahren zur Realisierung eines terrestrischen Referenzsystems* (in German). German Geodetic Commission, DGK C 630, Munich.

Seitz F, Krügel M (2009) Inverse model approach for vertical load deformations in consideration of crustal inhomogeneities. In: Drewes H (ed.) *Geodetic Reference Frames*, IAG Symposia 134: 23-29, Springer, doi: 10.1007/978-3-642-00860-3_4.

Seitz F, Schmidt M (2007) Hydrological mass variations due to extreme weather situations in Central Europe from global and regional GRACE expansions. In: Benveniste J, Berry P, Calmant S, Grabs W, Kosuth P (eds.): *Proceedings of the 2nd Space for Hydrology Workshop "Surface Water Storage and Runoff: Modeling, In-Situ Data and Remote Sensing.* ESA Publication WPP-280, Noordwijk.

Seitz F, Schmidt M, Shum CK (2008) Signals of extreme weather conditions in Central Europe from GRACE 4-D hydrological mass variations. *Earth and Planetary Science Letters,* 268/1-2, 165-170, doi:10.1016/j.epsl. 2008.01.001.

IC-SG4: Inverse Theory and Global Optimization

Chair: C. Kotsakis (Greece)

There is no report available for this study group.

IC-SG5: Satellite Gravity Theory

Chair: T. Mayer-Gürr (Germany)

Introduction

At the present there is the unique situation in satellite geodesy. The satellite mission GOCE was successfully launched from Plesetzk on March, 17, 2009 exactly seven years after the launch of GRACE. Together with CHAMP this means three dedicated gravity field satellite missions being in orbit at the same time. Besides the data processing and interpretation of the results, the theoretical background of satellite gravity requires special attention. This study group focuses on the following research activities:

Primary objectives and Activities of the Study Group

Members of the study group are involved in the development and implementation of different methods for the estimation of gravity field models from satellite data. The different strategies include the analysis of short arcs of the satellites orbit, the acceleration approach, the energy balance approach, and the use of invariants in satellite gradiometry. Furthermore, algorithms have been developed to deal with the large amount of data occurring especially in case of the GOCE mission.

Noise and error treatment, aliasing problem

Especially when dealing with GRACE data it has been identified that one of the key problems in gravity field processing is the understanding of the behaviour of the gravity field in space and time and the resulting aliasing problem due to insufficient data coverage. Special effort has been carried out by members of the study group to deal with the aliasing effect caused by ocean tides on the GRACE and GOCE processing. Another approach to deal with the aliasing problem is the adaption of the temporal and spatial gravity field parametrization, see next section.

Gravity field modelling

Concerning different gravity field modelling techniques there is currently a large variety of research activities taking place with a strong participation of member of the study group. One major focus in this context is the use of regional parametrizations, such as Wavelets, radial basis functions, or Slepian functions. In the time domain, some approaches have been developed to model the gravity field variations by temporal splines or by use of a Kalman filter.

Post processing, filtering

Due to the noise level present in the GRACE solutions, these gravity field solutions have to be post-processed by filtering techniques. In the recent years there have been several publications by members of the study group dealing with the development of sophisticated filters tailored to the non-isotropic error structure of the GRACE gravity field solutions.

Future satellite missions

Currently there are several simulation studies for future gravity field mission concepts have been performed, investigating different observation types, formation flights, etc. The underlying challenges are the improvement of spatial and temporal resolution, reduction of temporal aliasing, as well as minimizing the effect of specific covariance characteristics of different observations types. There exists a strong connection to IAG Sub-Commission 2.3 (Dedicated Satellite Gravity Mapping Missions).

Current Membership Structure

Full members:

T. Mayer-Gürr (Chair, Germany)
O. Baur (Germany)
W. Bosch (Germany)
P. Ditmar (Netherlands)
T. Gruber (Germany)
S.-C. Han (USA)
J. Kusche (Germany)
P. Moore (Great Britain)
M. Schmidt (Germany)

Corresponding members:

R. Pail (Austria)
M. Kern (Netherlands)
F. Wild-Pfeiffer (Germany)

Selected References

Baur O (2008) Tailored least-squares solvers implementation for high-performance gravity field research. *Computers and Geosciences*, doi:10.1016/j.cageo.2008.09.004.

Baur O, Austen G, Kusche J (2008) Efficient GOCE satellite gravity field recovery based on LSQR. *Journal of Geodesy*, doi:10.1007/s00190-007-0171-z.

Baur O, Sneeuw N, Grafarend EW (2008) Methodology and use of tensor invariants for satellite gravity recovery. *Journal of Geodesy*, doi:10.1007/s00190-007-0178-5.

Ditmar P, Klees R, Liu X (2007) Frequency-dependent data weighting in global gravity field modeling from satellite data contaminated by non-stationary noise. *Journal of Geodesy*, 81:81–96, doi:10.1007/s00190-006-0074-4.

Eicker A, Mayer-Gürr T, Ilk KH (2009) Improved resolution of a GRACE gravity field model by regional refinements. In: Proceedings IUGG General Assembly, Perugia.

Han S-C, Ditmar P (2007) Localized spectral analysis of global satellite gravity fields for recovering time-variable mass redistributions. *Journal of Geodesy*.

Han S-C, Rowlands DD, Luthcke SB, Lemoine FG (2008) Localized analysis of satellite tracking data for studying time-variable Earth's gravity fields. *Journal of Geophysical Research-Solid Earth* 113: B06401.

Han S-C, Simons FJ (2008) Spatiospectral localization of global geopotential fields from the Gravity Recovery and Climate Experiment (GRACE) reveals the coseismic gravity change owing to the 2004 Sumatra-Andaman earthquake. *Journal of Geophysical Research-Solid Earth* 113: B01405

Klees R, Revtova EA, Gunter BC, Ditmar P, Oudman E, Winsemius HC, Savenije HHG (2008) The design of an optimal filter for monthly GRACE gravity models. *Geophysical Journal International*, 175:417–432, doi:10.1111/j.1365-246X.2

King M, Moore P, Clarke P, Lavallée D (2006) Choice of optimal averaging radii for temporal GRACE gravity solutions, a comparison with GPS and satellite altimetry. *Geophysical Journal International* 166: 1–11, doi:10.1111/j.1365-246X.2006.03017.x.

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Kusche J, Schmidt R, Petrovic S, Rietbroek R (2009) De-correlated GRACE time-variable gravity solutions by GFZ, and their validation using a hydrological model. *Journal of Geodesy*, doi:10.1007/s00190-009-0308-3.

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Schmidt M, Han S-C, Kusche J, Sanchez L Shum CK (2006) Regional high-resolution spatiotemporal gravity modeling from GRACE data using spherical wavelets. *Geophysical Research Letters* 33: 8404, doi:10.1029/2005GL025509.

Schmidt M, Fengler M, Mayer-Gürr T, Eicker A, Kusche J, Sánchez L, Han S-C (2007) Regional gravity modeling in terms of spherical base functions. *Journal of Geodesy* 81:17–38, doi:10.1007/s00190-006-0101-5.

IC-SG6: InSAR for Tectonophysics

Chair: M. Furuya (Japan)

Introduction

This document is a status report of the work undertaken by the ICCT Study Group "InSAR for Tectonophysics" since its creation in 2007. Against a backdrop of a series of SAR satellite missions, ERS1/2, JERS, Envisat/ASAR, ALOS/PALSAR, Radarsat-1/2, TerraSAR/X, and planned future missions (e.g. Centinel-1 and DESDyni), many interesting and exciting results have been presented from this SSG as illustrated in the publication list. Those results include the following research areas, related to geodetic measurement and analysis of SAR/InSAR data and their application to tectonophysical problems: (1) SAR/InSAR data analysis for tectonophysics, (2) retrieval and separation of atmospheric and crustal deformation signal, (3) modeling and interpretation of SAR/InSAR data, (4) combination of InSAR data with other measurement sources.

Primary Objectives of the Study Group

The primary objective of this SG has been to be a focus of activities related to geodetic measurement and analysis of SAR/InSAR data and their application to tectonophysical problems.

Current Membership Structure

M. Furuya (Chair, Japan)
F. Amelung (USA)
A. Donnellan (USA)
Y. Fukushima (Japan)
R. Hanssen (Netherlands)
B. Heck (Germany)
S. Jónsson (Switzerland)
Z. Li (UK)
D. Sandwell (USA)
T. Wright (UK)

Activities of the Study Group

Conference Contributions of SG Members

Each of the SC members have presented their papers at a number of international meetings, which include American Geophysical Union, European Geoscience Union, Asia Oceania Geosciences Society, IEEE International Geoscience and Remote Sensing, the ESA's FRINGE2007 workshop, ALOS-PI meeting and the IAG's 2008 GGEO meeting.

Conference Sessions

We are planning to organize a relevant session at any international meetings during the up-coming two years.

Future Activities

Each of the group members will conduct her/his own research around the research areas mentioned above. During the next two years, we plan to organize a conference session to present the cutting-edge status on "InSAR for Tectonphysics".

Publications

Furuya M, Mueller K, Wahr J (2007) Active Salt Tectonics in the Needles District, Canyonlands (Utah) as Detected by Interferometric SAR and Point Target Analysis: 1992-2002. *J. Geophys. Res*. 112(B6), B06418, doi:10.1029/2006JB004302.

Rowland JV, Baker E, Ebinger CJ, Keir D, Kidane T, Biggs J, Hayward N, Wright TJ (2007) Fault growth at a nascent slow-spreading ridge: 2005 Dabbahu rifting episode. *Geophys J Int* 171(3): 1226-1246, doi:10.1111/j.1365-246X.2007.03584.x.

Funning GJ, Parsons B, Wright TJ (2007) Fault slip in the 1997 Manyi, Tibet earthquake from linear elastic modelling of InSAR displacements. *Geophys J Int* 169(3): 988-1008, doi:10.1111/j.1365-246X.2006.03318.x.

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Taymaz T, Wright TJ, Yolsal S, Tan O, Fielding E, Seyitoglu G (2007) Source characteristics of the 6 June 2000 Ortaakankiri (central Turkey) earthquake: a synthesis of seismological, geological and geodetic (InSAR) observations, and internal deformation of the Anatolian plate. Special Publication Geological Society of London 291: 259-290, doi:10.1144/SP291.12

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Shimada M, Ozawa T, Fukushima Y, Furuya M, Rosenqvist A (2008) Japanese L-band Radar Improves Surface Deformation Monitoring. *EOS* Trans. AGU 89(31): 277-278

Li Z, Feng W, Xu Z, Cross P, Zhang J (2008) The 1998 Mw 5.7 Zhangbei-Shangyi earthquake revisited: a buried thrust fault revealed with interferometric synthetic aperture radar. *Geochemistry, Geophysics, Geosystems* 9, doi:04010.01029/02007GC001910.

Konca AO, Avouac J-P, Sladen A, Meltzner AJ, Sieh K, Fang P, Li Z, Galetzka J, Genrich J, Chlieh M, Natawidjaja DH, Bock Y, Fielding EJ, Ji C, Helmberger DV (2008) Partial rupture of a locked patch of the Sumatra megathrust during the 2007 earthquake sequence. *Nature* 456: 631-635

Fukahata Y, Wright TJ (2008) A non-linear geodetic data inversion using ABIC for slip distribution on a fault with an unknown dip angle. *Geoph J Int* 173(2): 353-364, doi:10.1111/j.1365-246X.2007.03713.x.

Ebinger CJ, Keir D, Ayele A, Calais E, Wright TJ, Belachew M, Hammond JOS, Campbell E, Buck WR (2008) Capturing magma intrusion and faulting processes during continental rupture: seismicity of the Dabbahu (Afar) rift. *Geoph J Int*, 174(3): 1138-1152, doi:10.1111/j.1365-246X.2008.03877.x.

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Fukushima Y, Ozawa T, Hashimoto M (2008) Fault model of the 2007 Noto Hanto earthquake estimated from PALSAR radar interferometry and GPS data. *Earth, Planets and Space* 60: 99–104

Takada Y, Kobayashi T, Furuya M, Murakami M (2009) Coseismic displacement due to the 2008 Iwate-Miyagi Nairiku earthquake detected by ALOS/PALSAR: preliminary results. *Earth Planets Space* 61: e9-e12

Kobayashi T, Takada Y, Furuya M, Murakami M (2009) Location and types of ruptures involved in the 2008 Sichuan Earthquake inferred from SAR image matching. *Geophys. Res. Lett.*, doi:10.1029/2008GL036907.

Furuya M, Takada Y, Aoki Y (2009) PALSAR InSAR observation and Modeling of Crustal Deformation due to the 2007 Chuetsu-Oki Earthquake in Niigata, Japan. Proc. IAG Symposia, *Gravity, Geoid, and Earth Observation* 2008, in press.

Li Z, Liu Y, Zhou X, Cross P, Feng W (2009) Using small baseline Interferometric SAR to map nonlinear ground motion: A case study in northern Tibet. *Journal of Applied Geodesy*, in press.

Li Z, Fielding EJ, Cross P, Preusker R (2009) Advanced InSAR atmospheric correction: MERIS/MODIS combination and stacked water vapour models. *International Journal of Remote Sensing*, in press.

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Feng W, Xu L, Xu Z, Li Z, Li C, Zhao H (2009), Source parameters of the 2008 Gaize Mw 6.4 and Mw 5.9 earthquakes from InSAR measurements. *Chinese Journal of Geophysics* 52: 983-993

Keir D, Hamling IJ, Ayele A, Calais E, Ebinger C, Wright TJ, Jacques E, Mohamed K, Hammond JOS, Belachew M, Baker E, Rowland JV, Lewi E, Bennati L (2009) Evidence for focused magmatic accretion at segment centers from lateral dike injections captured beneath the Red Sea rift in Afar. *Geology* 37(1): 59-62. doi:10.1130/G25147A.1.

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Fukushima Y, Mori J, Hashimoto M, Kano Y (2009), Subsidence associated with the LUSI mud eruption, East Java, investigated by SAR interferometry. *Marine and Petroleum Geology*, doi:10.1016/j.marpetgeo.2009.02.001.

IC-SG7: Temporal Variations of Deformation and Gravity

Chair: D. Wolf (Germany)

Introduction

This document presents a status report of the work undertaken by the ICCT Study Group 7 since its foundation in 2007.

Primary Objectives of the Study Group

The topic of the study group is based on recent advances in ground-, satellite- and space-geodetic techniques, which monitor temporal variations of deformation and gravity with unprecedented accuracy over a wide period range. These variations are related to a variety of surficial and internal earth processes. The new types of observational data require the development of 2-D/3-D earth models and novel interpretational techniques. The primary objectives are: (i) Development of 2-D/3-D elastic/viscoelastic earth models for simulating the individual processes responsible for deformation and gravity variations. (ii) Forward modelling of deformation and gravity variations caused by atmospheric, cryospheric, hydrospheric or internal forcing functions. (iii) Inverse modelling of observed deformation and gravity variations in terms of forcing functions or in terms of elastic/viscoelasic earth parameters.

Current Membership Structure

Full members:

D. Wolf (Chair, Germany)
H. Abd-Elmotaal (Egypt)
M. Bevis (USA)
A. Braun (Canada)
L. Brimich (Slovak Republic)
D. Carbone (Italy)
B. Chao (Taiwan)
J. Fernández (Spain)
L. Fleitout (France)
P. Gonzáles (Spain)
E. Ivins (USA)
V. Klemann (Germany)
Z. Martinec (Ireland)
G.A. Milne (Canada)
J. Müller (Germany)
Y. Rogister (France)
H.-G. Scherneck (Sweden)
G. Spada (Italy)
W. Sun (Japan)
Y. Tanaka (Japan)
P. Vajda (Slovak Republic)
P. Varga (Hungary)
L.L.A. Vermeersen (Netherlands)
P. Wu (Canada)

Corresponding members:

J. Davis (USA)
E.W. Grafarend (Germany)
J. Hinderer (France)
L.E. Sjöberg (Sweden)

Activities of the Study Group

The major activity of the study group has been the organization of the 3rd Workshop on 'Deformation and Gravity Change: Indicators of Isostasy, Tectonics, Volcanism and Climate Change'. The Workshop took place on Lanzarote, Spain, during February 23-26, 2009. Responsible for the scientific organization were D. Wolf (Germany), J. Fernández (Spain) and P. Gonzáles (Spain). The workshop was attended by 14 participants presenting 16 talks or posters. Details of the workshop are documented in a 'Program and Abstracts' booklet.

Publications

The main publication activity of the study group has been the preparation of a Pageoph topical volume entitled 'Deformation and Gravity Change: Indicators of Isostasy, Tectonics and Climate Change, Volume 2' edited by D. Wolf, J. Fernández and P. Gonzáles. The volume (in print) has approximately 400 pages with 16 contributions. Many of the publications in it were presented at the 2nd Workshop on 'Deformation and Gravity Change: Indicators of Isostasy, Tectonics, Volcanism and Climate Change' that took place on Lanzarote, Spain, during March 27-30, 2007. Volume 1 was published in 2007 and documents the 1st Workshop held in 2005. Together, the two volumes reflect the activities of the ICCT Working Group 2 on 'Dynamic Theories of Deformation and Gravity Fields' that existed during 2003-2007.

Future Activities

It is intended to document the 3rd Workshop in a further topical volume. The details are presently discussed by the organizers of the workshop.

IC-SG8: Towards cm-accurate Geoid – Theories, Computational Methods and Validation

Chair: Y. M. Wang (USA)

Primary Objectives of the Study Group

The Inter-Commission Study Group (SG 8) focuses on the theories and computation methods for cm-accurate geoid. Geoid computation is a sophisticated process. Its accuracy depends on a precise theory and quality data. Computation methods are important as well. Decimeter differences have been reported purely due to the use of different computation methods. The cm-geoid is a challenge not only to theoreticians, but also to practitioners.

Since the creation of the SG, the focus has been placed on the following topics:

- Optimal combination of global gravity models with local gravity data.
- Rigorous calculation of the topographic effect, refinement of the topographic and gravity reductions.
- Studies on harmonic downward continuations.
- Non-linear effect of the geodetic boundary value problems on geoid determinations.
- The effect of topographic density variations on the Earth's gravity field, especially the geoid.

The geoid has applications in other disciplines, such as in oceanography. Joint efforts between different disciplines have produced useful results.

Current Membership Structure

Y.M. Wang (USA, Chair)
W. Featherstone (Australia)
N. Kühtreiber (Austria)
H. Moritz (Austria)
M.G. Sideris (Canada)
M. Véronneau (Canada)
J. Huang (Canada)
M. Santos (Canada)
J.C. Li, (China)
D.B. Cao (China)
W.B. Shen (China)
Z. Martinec (Czech Republic)
R. Forsberg (Denmark)
O. Anderson (Denmark)
H. Abd-Elmotaal (Egypt)
H. Denker (Germany)
B. Heck (Germany)
W. Freeden (Germany)
E. Grafarend (Germany)
J. H. Kwon (South Korea)

L. Sjöberg (Sweden)
D. Roman (USA)
J. Saleh (USA)
D. Smith (USA)

Main Activities of the Study Group

This document presents the status report of IC-SG 8 since its creation in 2007. During the period 2007-09 the SG established its terms of references, organized its membership structure, adopted an Internet site, and proposed focus items. We also proposed to have a group meeting at IAG 2009 Science Meeting. This report can only cover the main activities of SG members and that there are more activities within as well as outside the SG. The material presented here has been compiled from information and feedback obtained from individual SG members. Important developments by research outside the SG are also included.

Sjöberg (2008, 2009) continues research in the topographic bias. Since the downward continuation is always associated with instability and may be divergent, his simple formula for the bias has been under stringent scrutiny. The relationship between the height anomaly and geoid height in Heiskanen and Moritz (1967) is an approximation. Flury and Rummel (2009) find the separation between the two surfaces is much smaller. In the Alps, it is only 30 cm at the highest summit—while results based on approximations are often larger by several decimeters. Huang and Novák (2008) revisited their one step geoid computation that combines the Stokes integral and the harmonic downward continuation, aimed to avoid the step function caused by computation blocks. Huang et al (2009) also computed a gravimetric geoid in combination with mean see surface height to determine the Labrador Current. Abd-Elmotaal and Kühtreiber (2007a, b) compared the method of Stokes kernel modification and the Window Technique used in geoid computation. They (2008) also attempted on the optimal combination surface gravity data with a global coefficient model. The method of optimal combination of the deflections of the vertical and the surface gravity anomaly is also proposed by Kühtreiber and Abd-Elmotaal H (2007). Ellmann (2009) showed a large difference (9 cm standard deviation) between the geoids computed by using different kernel modifications. The difference is one order larger than the cm-geoid requirement. Similar results are obtained by other researchers. This draws attention to how to use the kernel modification method properly. Traditionally, the gravimetric geoid is fitted to GPS/levelling data. Featherstone and Lichit (2009) fitted the deflections of the vertical to a geoid model. Wang et al (2008) computed the direct and indirect effects on a global scale in 30" resolution. Different ways of downward continuation are proposed and tested in a rugged high mountain region.

Future Activities

During the upcoming two-year period 2009-11 the SG aims to work on the special subjects listed above. Because the differences between the geoid computed from different methods are almost one order larger than cm–geoid requirement, the SG intents to set up a special sub-study group investigate this issue. Strategy of the investigation and structure of the sub-group will be discussed at SG group meeting at IAG 2009. Since the geoid computation is the prime task of the physical geodesy, cooperation between study groups is proposed.

Publications and Conference Presentations

Publications

Abd-Elmotaal H (2007a) Reference Geopotential Models Tailored to the Egyptian Gravity Field. *Bollettino di Geodesia e Scienze Affini* 66(3): 129–144

Abd-Elmotaal H (2007b) High-Degree Geopotential Model Tailored to Egypt. Proc. 1st Int. Symp. of the IGFS, Harita Dergisi, Özel Sayı 18: 187–192

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IC-SG9: Application of Time-Series Analysis in Geodesy

Chair: W. Kosek (Poland)

Introduction

The IC-SG9 "Application of time-series in geodesy" was created in July 2008.

Observations of the new space geodetic techniques (geometric and gravimetric) deliver a global picture of dynamics of the Earth usually represented in the form of time series which describe 1) changes of the surface geometry of the Earth due to horizontal and vertical deformations of the land surface, variations of the ocean surface and ice covers, 2) the fluctuations in the orientation of the Earth divided into precession, nutation, polar motion and spin rate, and, 3) the variations of the Earth's gravitational field as well as the variations of the centre of mass of the Earth. Geometry, Earth rotation and the gravity field are the three components of the Global Geodetic Observing System (GGOS). The vision of GGOS is to integrate all observations and elements of the Earth's system into one unique physical and mathematical model. However, the temporal variations of Earth rotation and gravity/geoid represent the total, integral effect of all mass exchange between all elements of Earth's system including atmosphere, ocean and hydrology.

Different time series analysis methods are applied to analyze all these geodetic time series for better understanding of the relation between all elements of the Earth's system as well as their geophysical causes. The interactions between different components of the Earth's system are very complex so the nature of considered signals in the geodetic time series is mostly wide-band, irregular and non-stationary. Thus, it is necessary to apply time frequency analysis methods in order to analyze these time series in different frequency bands as well as to explain their relations to geophysical processes e.g. by computing time frequency coherence between Earth's rotation or the gravity field data and data representing the mass exchange between the atmosphere, ocean and hydrology. The techniques of time frequency spectrum and coherence may be developed further to display reliably the features of the temporal or spatial variability of signals existing in various geodetic data, as well as in other data sources.

Geodetic time series may include for example variations of site positions, tropospheric delay, ionospheric total electron content, temporal variations of estimated orbit parameters. Time series analysis methods can be also applied to analyze data on the surface including maps of the gravity field, sea level and ionosphere as well as temporal variations of such surface data. The main problems to deal with concern the estimation of deterministic (including trend and periodic variations) and stochastic (non-periodic variations and random changes) components of the geodetic time series as well as the application of digital filters for extracting specific components with a chosen frequency bandwidth.

The multiple methods of time series analysis may be encouraged to be applied to the preprocessing of raw data from various geodetic measurements in order to promote the quality level of enhancement of signals existing in the raw data. The topic on the improvement of the edge effects in time series analysis may also be considered, since they may affect the reliability of long-range tendency (trends) estimated from data series as well as the real-time data processing and prediction.

For coping with small geodetic samples one can apply simulation-based methods and if the data are sparse, Monte-Carlo simulation or bootstrap technique may be useful.

Understanding the nature of geodetic time series is very important from the point of view of appropriate spectral analysis as well as application of filtering and prediction methods.

Primary Objectives of the Study Group

- Study of the nature of geodetic time series to choose optimum time series analysis methods for filtering, spectral analysis, time frequency analysis and prediction.
- Study of Earth rotation and gravity field variations and their geophysical causes in different frequency bands.
- Evaluation of appropriate covariance matrices for the time series by applying the law of error propagation to the original measurements, including weighting schemes, regularization, etc.
- Determination of the statistical significance levels of the results obtained by different time series analysis methods and algorithms applied to geodetic time series.
- Comparison of different time series analysis methods in order to point out their advantages and disadvantages.
- Recommendations of different time series analysis methods for solving problems concerning specific geodetic time series.

Current Membership Structure

Full members:

W. Kosek (Chair, Poland)
M. Schmidt (Germany)
J. Vondrák (Czech Republic)
W. Popinski (Poland)
T. Niedzielski (Poland)
J. Boehm (Austria)
D. Zheng (China)
Y. Zhou (China)
M.O. Karslioglu (Turkey)
O. Akyilmaz (Turkey)
L. Fernandez (Argentina)
R. Gross (USA)
O. de Viron (France)
S. Petrov (Russia)
M. van Camp (Belgium)
H. Neuner (Germany).

Corresponding members:

M. Schmidt (Germany)

Activities of the Study Group

Conference Contributions of SG Members

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Study Group Webpage

The webpage of the group is http://www.cbk.waw.pl/~kosek/ICSG9/.

Conference Sessions

- Michael Schmidt - EGU General Assembly 2008, Vienna, Austria
- Michael Schmidt - EGU General Assembly 2009, Vienna, Austria

Future Activities of the Group

The IERS Workshop on EOP Combination and Prediction will be held in Warsaw on October 19-21 2009. The Session 3 of this Workshop "EOP prediction techniques and algorithms" will be convened by W. Kosek and W.H. Wooden. This session present different EOP prediction techniques as well as results of EOP predictions provided by them and will cover three of the aspects given in primary objectives of the Study Group (1, 4, 5 and 6). Among all the topics concerning time sere analysis methods (e.g., filtration, spectral analysis and prediction), prediction is the most difficult because good approximation does not guarantee good forecast due to irregular variations of the EOP.

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