ON THE CURRENT STATUS OF THE COOPERATIVE RESEARCH PROJECT REAL DATA ANALYSIS GOCE (REAL GOCE)

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ABSTRACT

The goal of the current REAL GOCE project, which is funded throughout the years 2009 - 2012 by the Federal Ministry of Education and Research (BMBF) of Germany through the Geotechnologien Programme, is the complete implementation of a GOCE data processing chain and its application to the GOCE real data within the framework of a cooperative scientific analysis. In this paper we present an overview of the crucial scientific goals of REAL GOCE and the organizational structure of this project.

Key words: Gravity and Steady-State Ocean Circulation Explorer (GOCE), Living Planet Programme, Geotechnologien, Gravity field.

1. INTRODUCTION

The determination of the detailed structure of the Earth’s gravity field is of vital importance e.g. for the exploration of dynamic processes in the Earth system and for the precise orbit prediction of satellites. The high demand for globally spread and highly accurate gravity data in research fields such as oceanography, geophysics, glaciology, and geodesy led the European Space Agency (ESA) to implement the satellite mission GOCE (Gravity and Steady-State Ocean Circulation Explorer) as the first core mission of the Living Planet Programme (cf. ESA 1999).

The purpose of GOCE, which was launched on March 17, 2009, is to deliver data that allows for a representation of the stationary component of the Earth’s global gravity field with unprecedented accuracy. The mission goal concerning the geoid, for instance, is to achieve an accuracy of 1-2 cm at a resolution of at least 100 km. This goal can be reached by a combination of orbit determination by means of GPS satellites (the measurement principle is called Satellite-to-Satellite Tracking or SST in high-low mode) and with direct measurements of the second derivatives of the gravity potential (the technique is Satellite Gravity Gradiometry or SGG) at a very low altitude of approximately 250 km (i.e. GOCE is a low earth orbiter or LEO).

The key elements of a tailored GOCE data processing chain were already studied and implemented from 2001-2008 in the course of the national cooperative research projects GOCE GRAND (GOCE Gravitationsfeldanalyse Deutschland), which were jointly funded by the Federal Ministry of Education and Research of Germany (Bundesministerium für Bildung und Forschung, BMBF) and the German Research Foundation (Deutsche Forschungsgemeinschaft, DFG). In the main focus of GOCE GRAND I (2001-2004) was the implementation of standard procedures for the analysis, processing, calibration, and validation of GOCE data and their combination with GRACE data (cf. the contributions in Flury, Rummel, Rothacher, Boedecker and Reigber, 2006). During GOCE GRAND II (2005-2008) research was mainly concerned with adaptations of the methods, algorithms, and software modules to the final configuration of the GOCE satellite and its instruments (cf. the contributions in Flechtner, Gruber, Günther, Mandea, Rothacher, Schöne and Wickert, 2010).

The goal of the current BMBF-funded REAL GOCE project (granting period 1.6.2009 - 31.5.2012), which is currently coordinated at the Department of Theoretical Geodesy of the Institute of Geodesy and Geoinformation (IGG-TG) of the University of Bonn (Germany), is now the complete implementation of the GOCE data processing chain and its application to the GOCE real data within the framework of a cooperative scientific analysis. In this paper we present an overview of the crucial scientific goals of REAL GOCE and the organizational structure of this project.

References of this section:


2. GENERAL GOALS AND STRUCTURE OF REAL GOCE

To realize the scientific goals of REAL GOCE in a joint venture, the project partners have defined their individual work packages according to a matrix as shown in Fig. 1. This matrix structures the thematic interconnections of these individual contributions.

The different rows within the matrix structure reflect the three main thematic focuses.

1. **GOCE gradient analysis and gravity field computation (first row):**
   GOCE gradient analysis aims at a continuous evaluation of the information content of the GOCE data, which is necessary for an ensuing optimal computation of the desired Earth gravity field models on the basis of calibrated GOCE measurements. In this context, five work packages (WP110 - WP150) were designed with the following particular goals:

   - Analysis of the characteristics and quality of the measured GOCE gravity gradients in the orbit system
   - Derivation of a GOCE gravity field model based on rotational invariants of the gravitational tensor (i.e., independent of observed GOCE orientation data)
   - Data-adaptive determination of the stochastic model of GOCE measurements
   - Determination of global GOCE–only gravity field solutions from in-situ measurements
   - Derivation of regionally refined gravity field models and their fusion to a global model
   - Study on the consideration of topographic and isostatic prior information as part of GOCE gravity field modeling

2. **GOCE validation (second row):**
   Besides the evaluation of the GOCE data, the independent validation of the calibrated measurements and of the various gravity field products will be of crucial importance in order to guarantee their reliability and accuracy. Two work packages (WP210 and WP210) deal with this topic in particular and have the following specific goals:

   - Detailed understanding of sensor-related systematic effects via application of independent validation procedures
   - External validation via computation of reference gravity gradients at the satellite’s altitude from European terrestrial gravity data and evaluation of occurring differences
   - Internal validation via comparison of measured GOCE gravity gradients in satellite orbit cross-over points

3. **GOCE combination (third row):**
   Combinations of GOCE data with available terrestrial gravity field data, altimetric data or GRACE data provide numerous opportunities for both improvements and further consistency assessments of the GOCE-only products. The final two work packages (WP310 and WP320) were designed to carry out the following tasks in particular:

   - Merging of the GOCE geoid with a numerical ocean circulation model for quantitative evaluation of the model accuracy

The columns represent the distinct spatial characteristics of the different approaches to GOCE data analysis, which are considered as cross-sectional research topics.

1. **Focus on orbital gradients (first column):**
   The analysis of the gravity gradient components in the orbit system aims at the full utilization especially of the high-frequency part of the information content of the GOCE data. Cross-over analyses, computation of reference gradients from terrestrial data (topography and geoid), and trace-wise comparisons of GOCE data with regional geoid models are also within this focus.

2. **Focus on regional gravity models (second column):**
   The focus is mainly on Europe, the Atlantic and Pacific ocean, as well as the transition zones from the rugged continental to smooth sea topography.

3. **Focus on global gravity models (third column):**
   Through the combination of GOCE–only global gravity field models with ocean circulation models, GRACE models, and terrestrial data, it is intended to assess the consistency of the information content.
Figure 1. REAL GOCE comprises 9 work packages (WPs) with different spatial (orbital, regional, global) and thematic (gradient analysis and gravity field computation, validation, combination) focuses.

The participating national research institutions are:

1. Institute of Geodesy and Geoinformation, Department of Theoretical Geodesy (IGG-TG), University of Bonn
2. Institute of Geodesy and Geoinformation, Department of Astronomical, Physical and Mathematical Geodesy (IGG-APMG), University of Bonn
3. Federal Agency for Cartography and Geodesy (BKG), Frankfurt
4. Institute of Oceanography (IFM), University of Hamburg
5. Institute of Geodesy (IFE), Leibniz University Hannover
6. German Geodetic Research Institute (DGFI), Munich
7. Institute of Astronomical and Physical Geodesy (IAPG), Technical University Munich
8. Geodetic Institute (GIK), Karlsruhe Institute of Technology
9. Institute of Geodesy (GIS), University of Stuttgart
10. GFZ German Research Centre for Geosciences (GFZ), Helmholtz Centre Potsdam
3. CURRENT STATUS

In the following, we provide a list of contributions, which reflect the research activities of the REAL GOCE project partners (with currently 37 contributing scientists), in terms of written publications, oral and poster presentations throughout the period 1. June 2009 – 31. December 2010. These presentations were given at a wide range of meetings and conferences. Aside from national and international conferences with dedicated GOCE sessions, a number of project meetings directly devoted to REAL-GOCE were held so far:

- 1. REAL-GOCE project meeting: 22. September 2009 in Karlsruhe/Germany (30 participants)
- 2. REAL-GOCE project meeting: 15.-16. March 2010 in Munich/Germany (28 participants)
- 3. REAL-GOCE project meeting: 23.-24. September 2010 in Stuttgart/Germany (22 participants)
- Geotechnologien Status Seminar: 4. October 2010 in Bonn/Germany (51 participants)
- 4. REAL-GOCE project meeting: 30. March 2011 in Munich/Germany (25 participants)

3.1. Publications


3.2. Talks and Posters


15. Brieden P (talk) Qualitätsbeurteilung von Gravitationsgradienten, der Messgröße der Schwerefeldsatellitenmission GOCE. Seminar for doctoral students in the geodesy and geoinformatics program of the Leibniz University Hannover, 9.11.2010
16. Brockmann JM, Schuh W-D, Krasbutter I (talk) WP6000: Gravity field determination with the time-wise approach (Tuning-Machine). 18. GOCE-HPF project meeting, Munich/Germany, 17.3.2010
22. Cai J, Baur O, Sneeuw N (talk) WP120: GOCE Realdatenauswertung unter Anwendung der Invariantendarstellung. 2. REAL-GOCE project meeting, Munich/Germany, 15.3.2010
23. Cai J, Baur O, Sneeuw N (talk) WP120: GOCE Realdatenauswertung unter Anwendung der Invariantendarstellung. 3. REAL-GOCE project meeting, Stuttgart/Germany, 23.9.2010
25. Denker H, Voigt C (talk) WP310: GOCE Cal/Val, Quasigeoid und Höhensysteme in Deutschland (Teil 1). 2. REAL-GOCE project meeting, Munich/Germany, 16.3.2010
26. Denker H, Voigt C (talk) WP310: GOCE Cal/Val, Quasigeoid und Höhensysteme in Deutschland (Teil 2). 3. REAL-GOCE project meeting, Stuttgart/Germany, 24.9.2010
30. Fuchs M, Bouman J (talk) WP110: GOCE-Gradientendarstellung in einem lokalen Bezugssystem. 3. REAL-GOCE project meeting, Stuttgart/Germany, 23.9.2010


60. Rülke A, Ihde J, Liebsch G, Schirmer U, Schäfer U (talk) WP310: GOCE Cal/Val, Quasigeoid und Höhensysteme in Deutschland (Part 2). REAL-GOCE project meeting, Munich/Germany, 15.3.2010


62. Schall J (talk) WP140: Gravitationsfeldbestimmung aus GOCE Gradiometerbeobachtungen in GROOPS. REAL-GOCE project meeting, Munich/Germany, 16.3.2010

63. Schall J, Kusche J, Eicker A, Mayer-Gürr T (poster) Optimized regional gravity field solutions from GOCE. General Assembly of the European Geosciences Union, Vienna/Austria, 2.-7.5.2010

64. Schall J (talk) WP140: (Regionale) Gravitationsfeldbestimmung aus GOCE Echtdaten. REAL-GOCE project meeting, Stuttgart/Germany, 23.9.2010


68. Schuh W-D (talk) Filtering of correlated data - stochastical considerations within GOCE data processing. GOCE Summer School, Munich/Germany, 31.5.-4.6.2010

69. Schuh W-D, Brockmann JM, Kargoll B, Krasbutter I, Pail R (talk) Refinement of the stochastic model of GOCE scientific data and its effect on the in-situ gravity field solution. ESA Living Planet Symposium, Bergen/Norway, 29.6.2010


72. Sebera J, Bouman J, Bosch W (talk) WP110: Satellite attitude for GOCE validation. 2. REAL-GOCE projekt meeting, Munich/Germany, 15.3.2010

73. Shabanloui A, Ilk KH (talk) A new approach for pure Kinematical and reduced Kinematical determination of LEO orbit based on GNSS observations. IAG Symposium ”Geodesy for Planet Earth”, Buenos Aires/Argentina, 31.8.-4.9.2009


75. Shabanloui A, Ilk KH (poster) Pure geometrical precise orbit determination of a LEO satellite based on carrier phase observations. IAG Symposium ”Geodesy for Planet Earth”, Buenos Aires/Argentina, 31.8.-4.9.2009

76. Shabanloui A (talk) WP140: Precise orbit determination. 2. REAL-GOCE project meeting, Munich/Germany, 15.3.2010

77. Shabanloui A, Kusche J (poster) How important is the dynamical information in determination of LEO orbits? ESA Living Planet Symposium, Bergen/Norway, 28.6.-2.7.2010

78. Shabanloui A (talk) WP140: Geometrical precise orbit determination (GPoD). 3. REAL-GOCE project meeting, Stuttgart/Germany, 23.9.2010

80. Shabanloui A, Kusche J (talk) Geometrical and kinematical precise orbit determination of GOCE. Geodetic Week 2010, Cologne/Germany, 5.-7.10.2010

81. Shako R, Förste C (talk) WP320: Hochauflösende globale GOCE-Kombinationsmodelle. 2. REAL-GOCE project meeting, Munich/Germany, 16.3.2010

82. Shako R, Förste C (talk) WP320: Hochauflösende globale GOCE-Kombinationsmodelle. 3. REAL-GOCE project meeting, Stuttgart/Germany, 24.9.2010


84. Stammer D, Siegismund F (talk) WP220: Der zeitliche Mittelwert der Ozeanzirkulation und das ozeanische Geoid. 2. REAL-GOCE project meeting, Munich/Germany, 16.3.2010

85. Stammer D, Siegismund F (talk) WP220: Der zeitliche Mittelwert der Ozeanzirkulation und das ozeanische Geoid. 3. REAL-GOCE project meeting, Stuttgart/Germany, 23.9.2010

86. Stammer D (talk) Sea level Change, oceanographic aspects. (Altimetry, GRACE, and Argo). Workshop on "Gravity from Space" for OCEANS, LAND ICE, and SEA LEVEL RISE, Hamburg/Germany, 29.-30.9.2010


88. Stummer C, Murböck M (talk) WP110: GOCE gravity gradients: a new satellite observable. 2. REAL-GOCE project meeting, Munich/Germany, 15.3.2010


92. Voigt C, Denker H (poster) Validation of GOCE products by terrestrial data sets in Germany. Geotechnologie Status Seminar, Bonn/Germany, 4.10.2010