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Outstanding Student Poster Contest

Evaluation of GOCE-based Global Geoid Models in Finnish Territory

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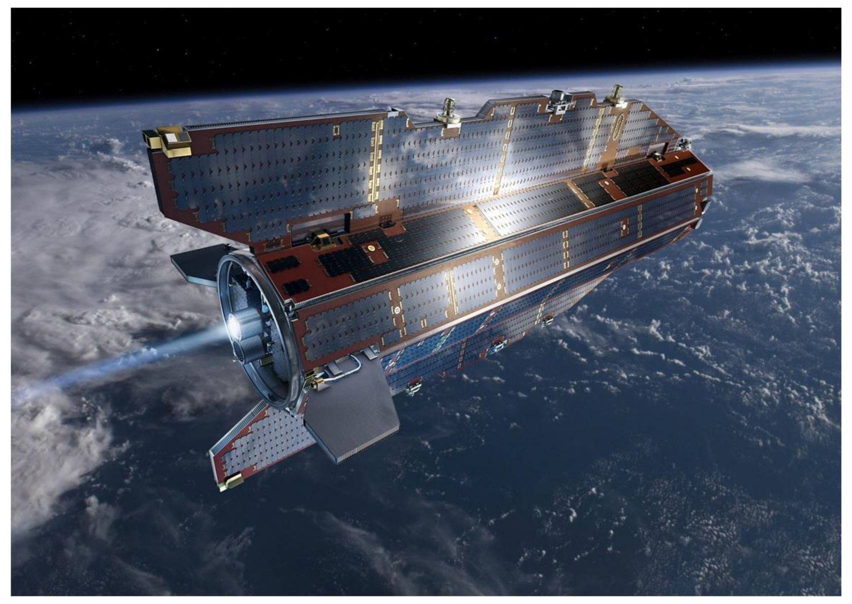

Figure 1. (GOCE) (image credit: European Space Agency).

Introduction

The start of the millennium has been an era of the global gravity satellite missions. It started with the Challenging Minisatellite Payload (CHAMP), followed by the Gravity Recovery And Climate Experiment (GRACE) and most recently the Gravity field and steady-state Ocean Circulation Explorer (GOCE). GOCE made its final observations in the fall of 2013, by then it had exceeded its expected lifespan of 20 months with 35 additional months due to milder solar winds. The last six months of its mission GOCE flew in much lower orbits than originally planned. Thus, the mission was a huge success, since GOCE not only collected more data but also denser data from the Earth's gravitational field than ever imagined.

In this study the global geoid models produced by the GOCE mission are studied. Altogether 16 GOCE models and 6 combined GOCE+GRACE models are evaluated using Finnish terrestrial data to see how well the models perform relative to each other, but also to see their absolute agreement with terrestrial data. The latest satellite-only models are also compared against pre-GOCE high resolution global geoid models EGM96 and EGM2008 to see the effect of the GOCE mission in the lower degrees and orders.

GOCE-only + combined GOCE+GRACE models

Models of the GOCE High-level Processing Facility (HPF) by ESA

- **Direct (DIR) approach (maximum degree and order 300)**
  - 5 data levels – Released data 01/11/2009 – 20/10/2013
  - A priori data (EIGEN-5C (DIR1), ITG-Grace2010s (DIR2))
  - Complementary data from LAGEOS + GRACE for lower degrees and orders
- **Time-wise (TIM) approach (maximum degree and order 280)**
  - 5 data levels – Released data 01/11/2009 – 20/10/2013
  - GOCE-only models
- **Space-wise (SPW) approach (maximum degree and order 280)**
  - 3 data levels – Released data 11/2009 – 31/7/2012
  - GOCE-only models
  - A priori high resolution models (e.g. EGM2008) used for variance and covariance modelling

Other GOCE-only models

- **ITG-Goce02 (maximum degree and order 240)**
  - Released data 01/11/2009 – 31/6/2010
- **JYY_GOCE02S (maximum degree and order 230)**
  - Released data 01/11/2009 – 31/08/2012
- **JYY_GOCE04S (maximum degree and order 230)**
  - Released data 01/11/2009 – 19/10/2013

Combined GOCE+GRACE models

- **EIGEN-6S2 (maximum degree and order 260)**
  - Released data GOCE 01/11/2009–24/5/2013, GRACE 2/2003–9/2012, LAGEOS 1985–2010
- **GOCO01S, GOCO02S and GOCO03S (maximum degree and order 250)**
  - Released data GOCE 01/11/2009–17/4/2011, GRACE 7.5 y, CHAMP 8 y
- **GOGRA02S and GOGRA04S (maximum degree and order 230)**
  - Released data GOCE 01/11/2009–19/10/2013, GRACE 8/2002–8/2009

International Center for Global Gravity Field Models (ICGEM)

For more information see the website (http://icgem.gfz-potsdam.de/ICGEM/modelstab.html)

Datasets of the ground truth in Finland

The gravity database of the Finnish Geospatial Research Institute (FGI, former Finnish Geodetic Institute) and two GPS-levelling datasets were used as a ground truth. Both the gravity data and the GPS data were corrected for the land uplift (vertical velocities from the NKG2005LU land uplift model) and converted to the epoch 2000.0. The datasets:

- The FGI's gravity database containing observations from 1938 to present.
- The EUVN-DA dataset containing 50 GPS–levelling points (class 1) in Finland. The points have EUREF-FIN GPS coordinates as well as levelled heights in the Finnish height system N2000.
- The NLS GPS-levelling dataset by the National Land Survey of Finland containing 526 GPS–levelling points (classes 1 to 3). The accuracy and distribution of the points is not homogenous and the dataset partly overlaps with the EUVN-DA dataset.

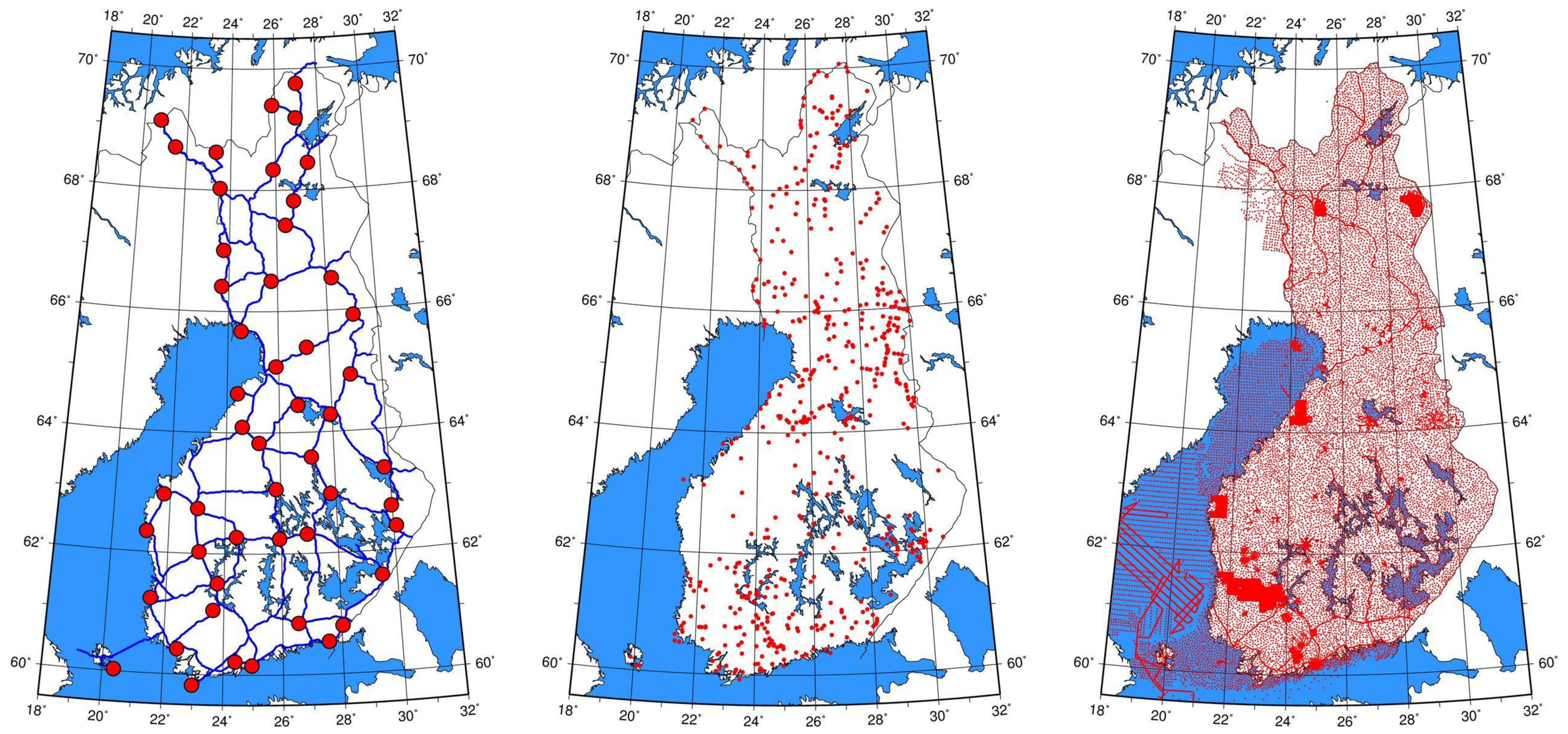

Figure 2. The coverage of the GPS-levelling and gravity datasets over Finland: EUVN-DA with 1st order precise levelling network (left), NLS (middle) and gravity database of the FGI (right).

Results

The results of the evaluations are illustrated into four graphs, where the models were evaluated up to three different degrees and orders: 200, 240 and maximum.

- At degree and order 200 (**Figure 3, left**) no significant improvements can be seen between the later models comparing to earlier models.
- At degree and order 240 (**Figure 3, right**) it is clearly seen how the later models perform better → more data is included → better determination of the higher degrees and orders above 200.
- The GOCE-based models perform better than EGM96 and quite equally with EGM2008 when developed up to degree and order 200 (**Figure 4, left**). At 240 the best satellite-only models are at the same level as the pre-GOCE high resolutions models in Finland (**Figure 4, right**).
- At degree and order 240 and maximum (**Figure 5**) the latest GOCE and GOCE+GRACE models give standard deviations of the height anomaly differences of around 15 cm and of gravity anomaly differences of around 10 mgal over Finland.
- The best results with maximum coefficients are achieved with the latest DIR and TIM models (**Figure 6**), however, the best performance of the satellite-only models is not usually achieved with the maximum coefficients, since the highest coefficients (above 240) are less accurately determined (**Figure 5**).
- The high resolution EGM96 and EGM2008 models perform very well over Finland. The excellent performance is due to the good high resolution terrestrial gravity data that was already available in the area of Finland for the EGM96 and EGM2008.

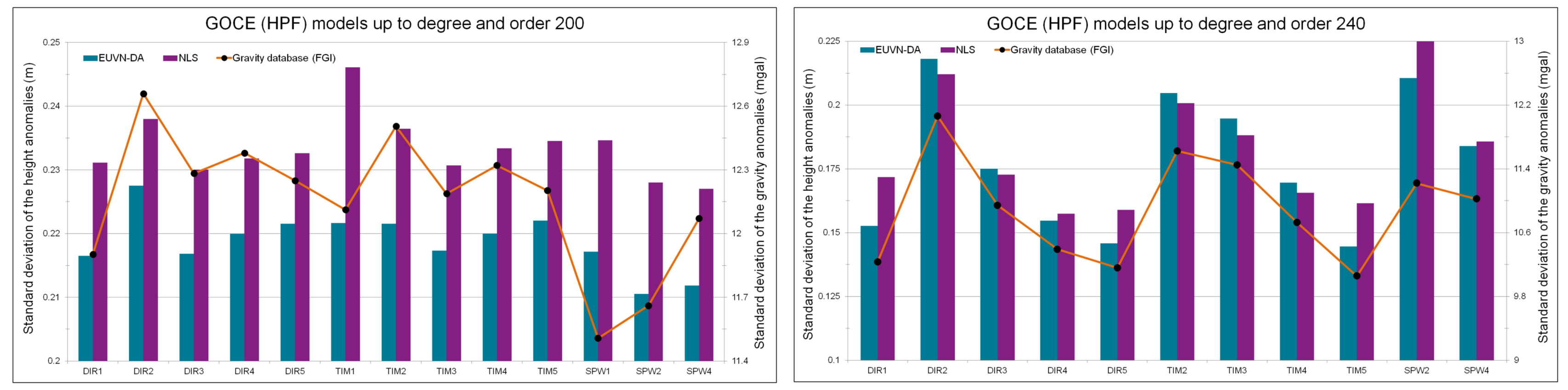

Figure 3. Comparison of the height and gravity anomalies from the GOCE (HPF) models using coefficients up to 200 (left) and 240 (right) against GPS-levelling and gravity data: standard deviations of the differences (m) and (mgal).

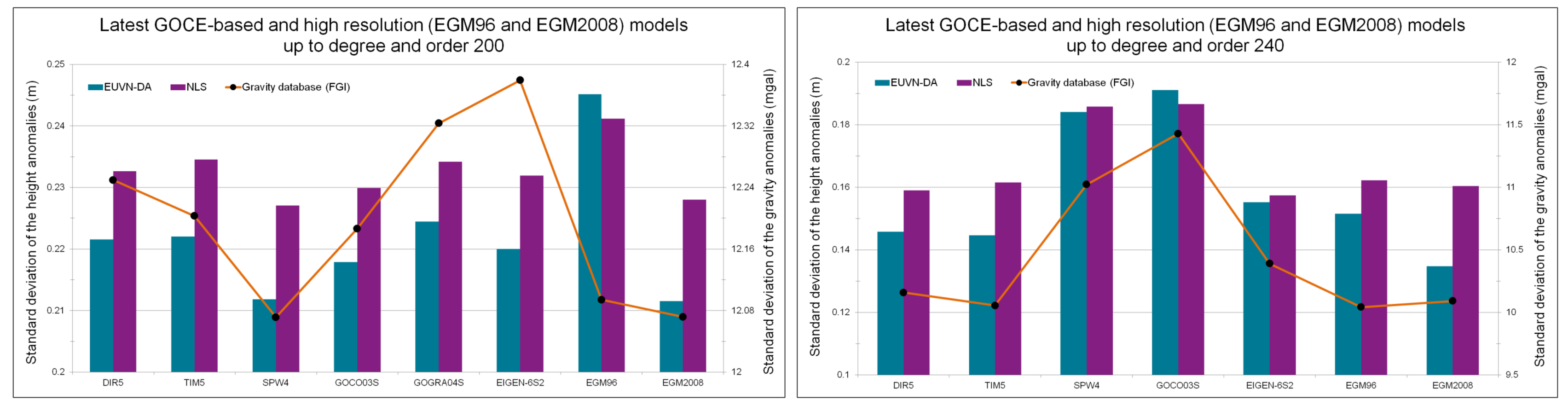

Figure 4. Comparison of the height and gravity anomalies from the latest GOCE-based satellite-only models (GOCE and GOCE+GRACE) and high resolution (EGM96 and EGM2008) models using coefficients up to 200 (left) and 240 (right) against GPS-levelling and gravity data: standard deviations of the differences (m) and (mgal).

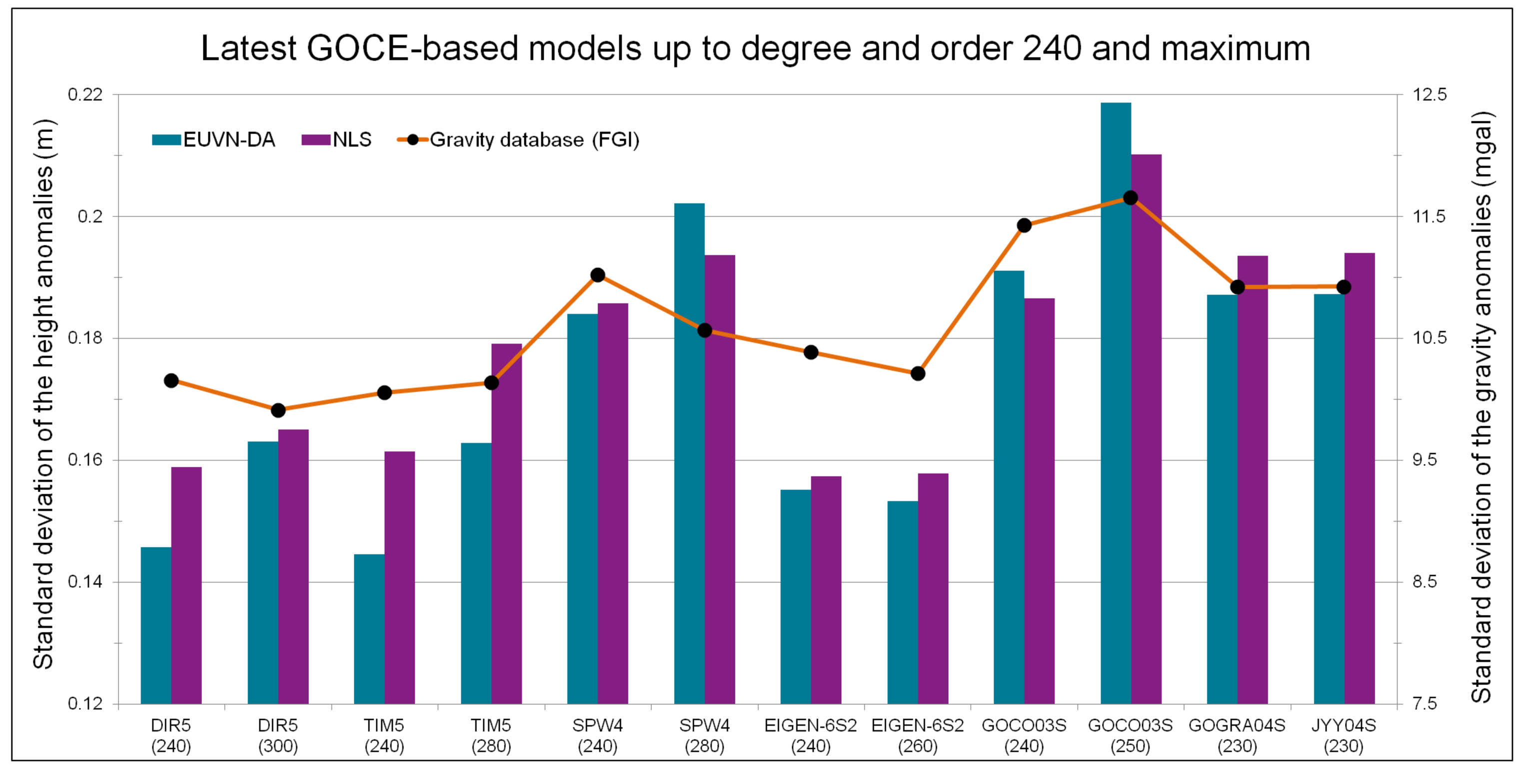

Figure 5. Comparison of the height and gravity anomalies from the latest GOCE-based satellite-only models (GOCE and GOCE+GRACE) using coefficients up to 240/maximum against GPS-levelling and gravity data: standard deviations of the differences (m) and (mgal).

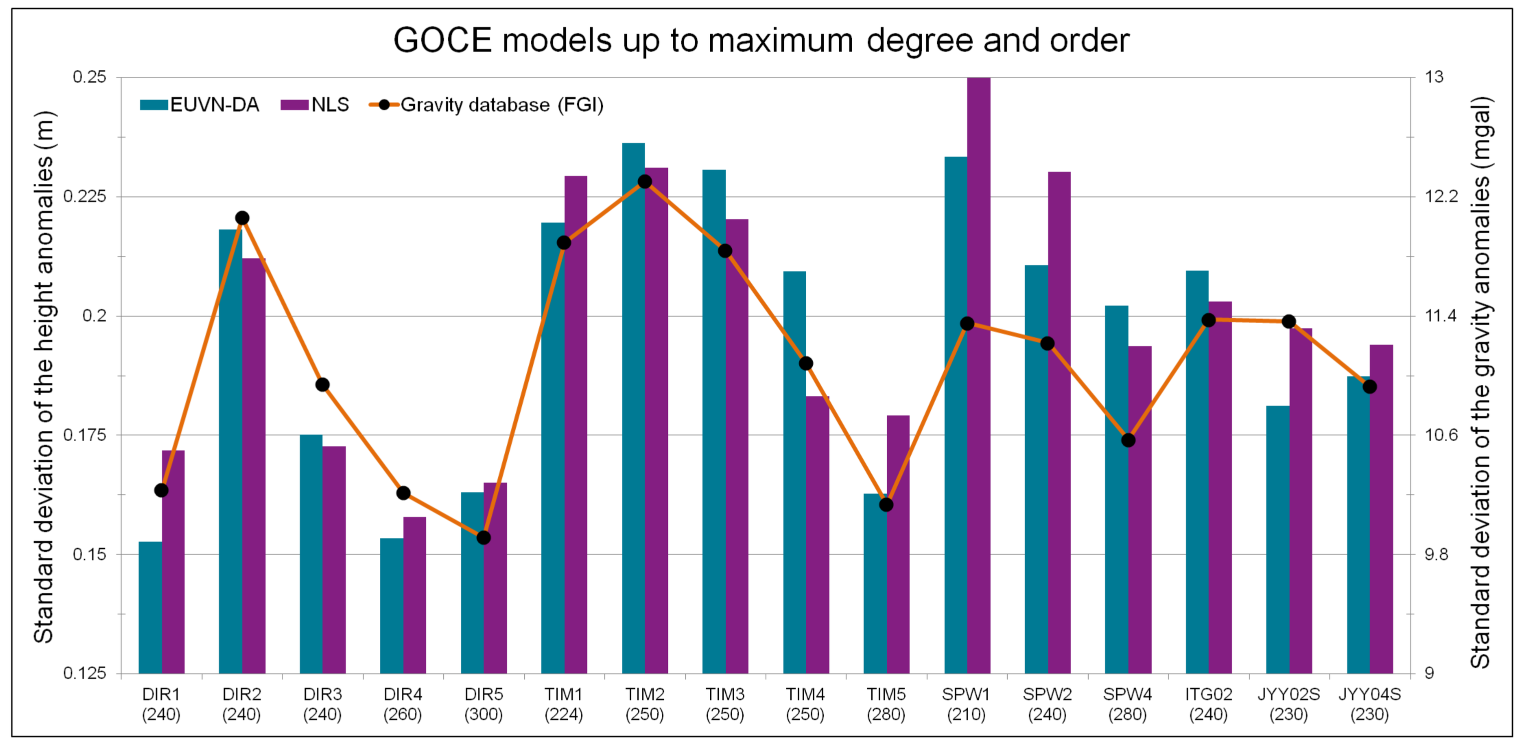

Figure 6. Comparison of the height and gravity anomalies from the GOCE models using all available coefficients against GPS-levelling and gravity data: standard deviations of the differences (m) and (mgal).

Acknowledgements

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