The new combined satellite only model GOCO03s

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Institute of Theoretical Geodesy and
Satellite Geodesy
Graz University of Technology

**International Symposium on Gravity,
Geoid and Height Systems 2012
Venice, Italy**

Gravity Observation Combination (www.goco.eu)

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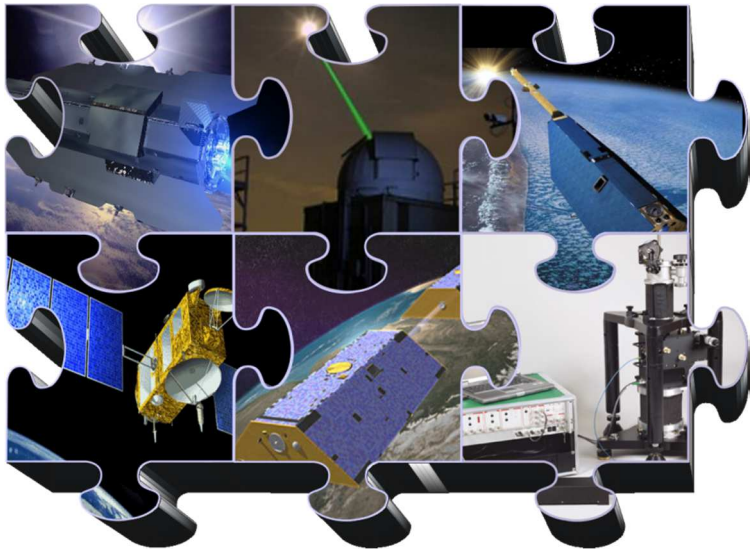


The GOCO initiative computes high-accuracy and high-resolution global gravity field models from complementary gravity data sources:

- satellite gravity missions GOCE, GRACE and CHAMP, and SLR data

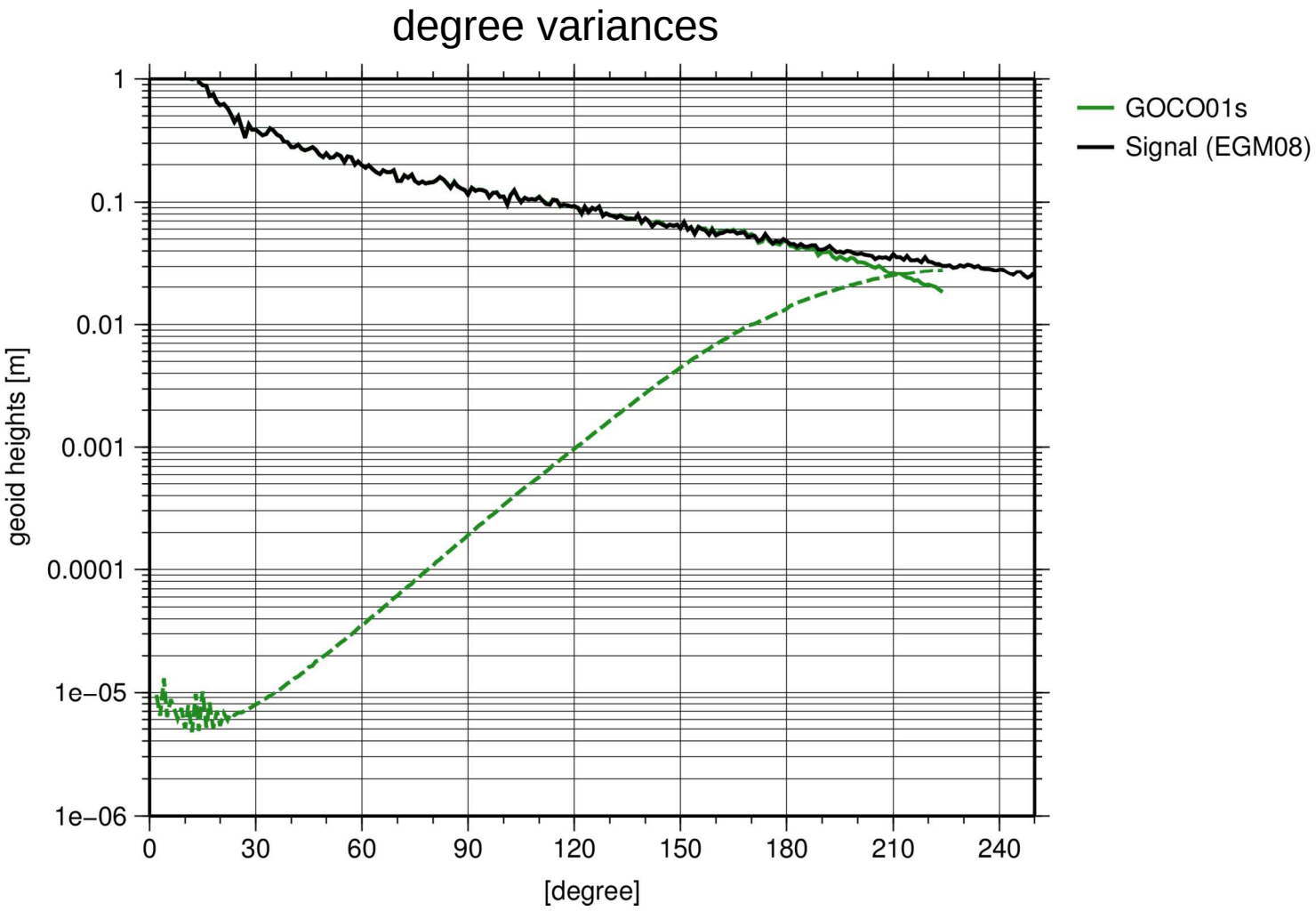
- plus terrestrial gravity field and satellite altimetry data

=> 3 solutions of satellite-only models are currently released: GOCO01s, GOCO02s, GOCO03s

The satellite only model GOCO01s

Data:

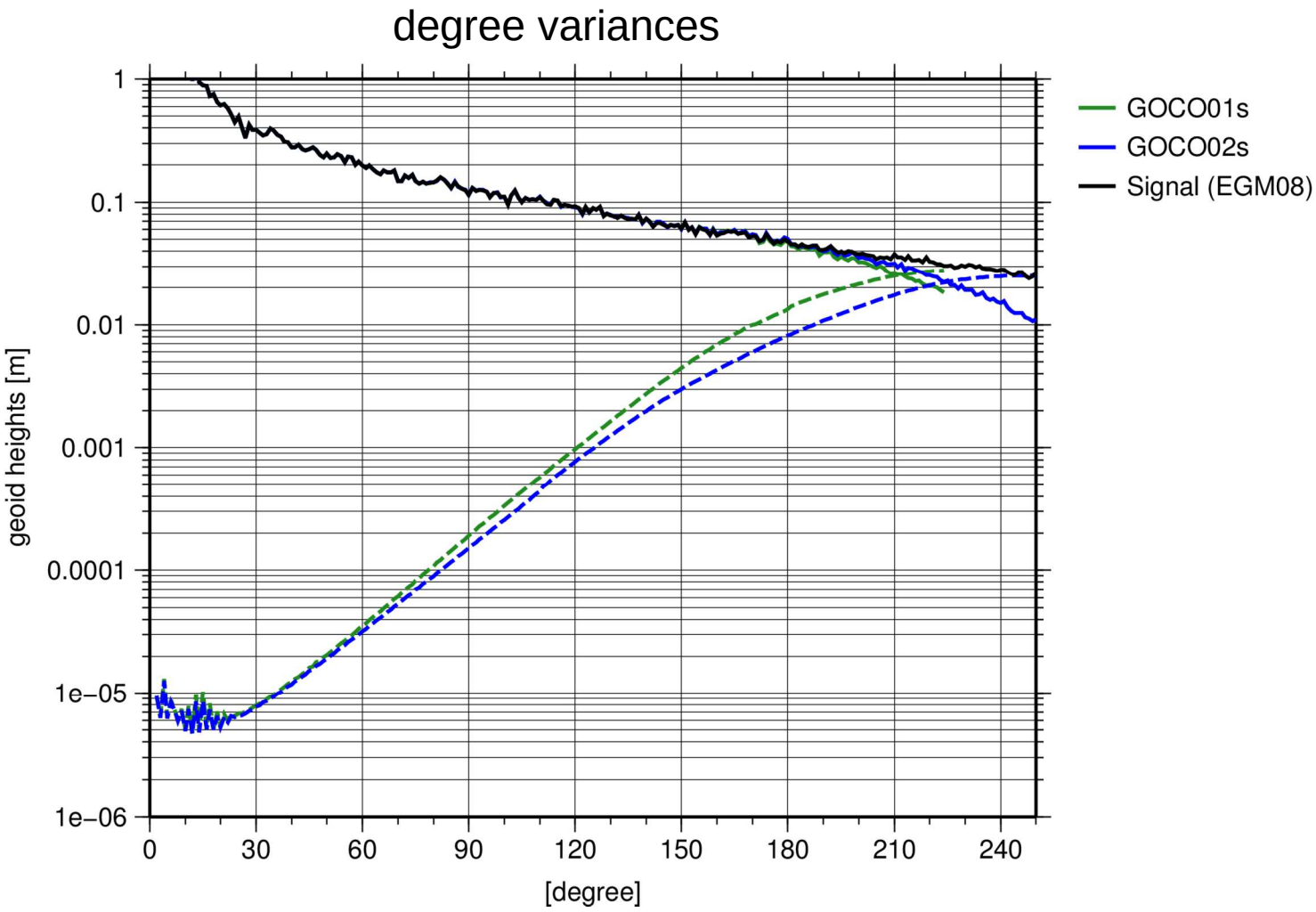
- GRACE:
  (7.5 years)
- GOCE:
  (2 months)
- Constrains:
  Kaula, deg>170



The satellite only model GOCO02s

Data:

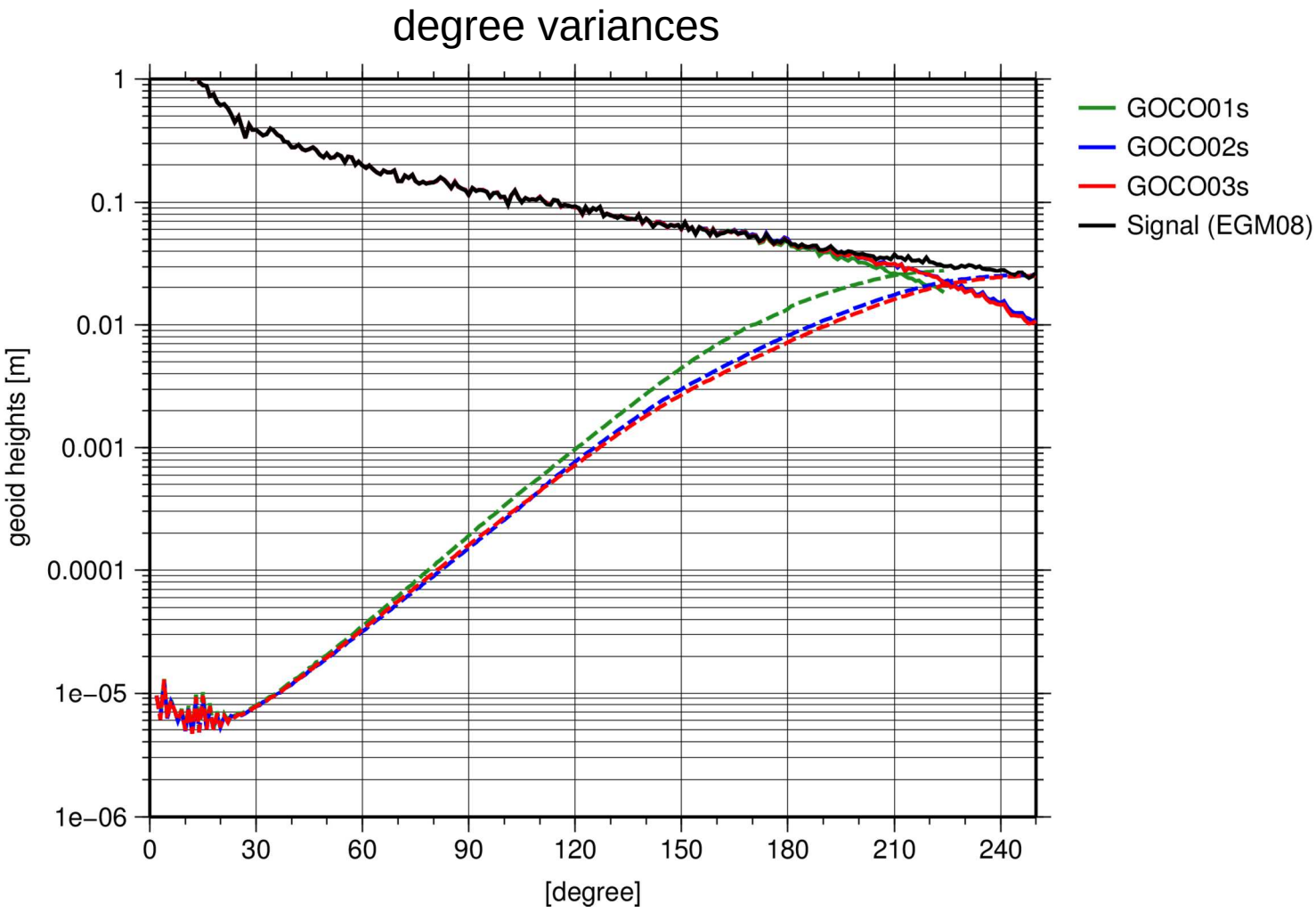
- GRACE:
  (7.5 years)
- GOCE:
  (8 months)
- SLR:
  (5 years, 5 sat)
- CHAMP:
  (8 years)
- Constrains:
  Kaula, deg>180



The satellite only model GOCO03s

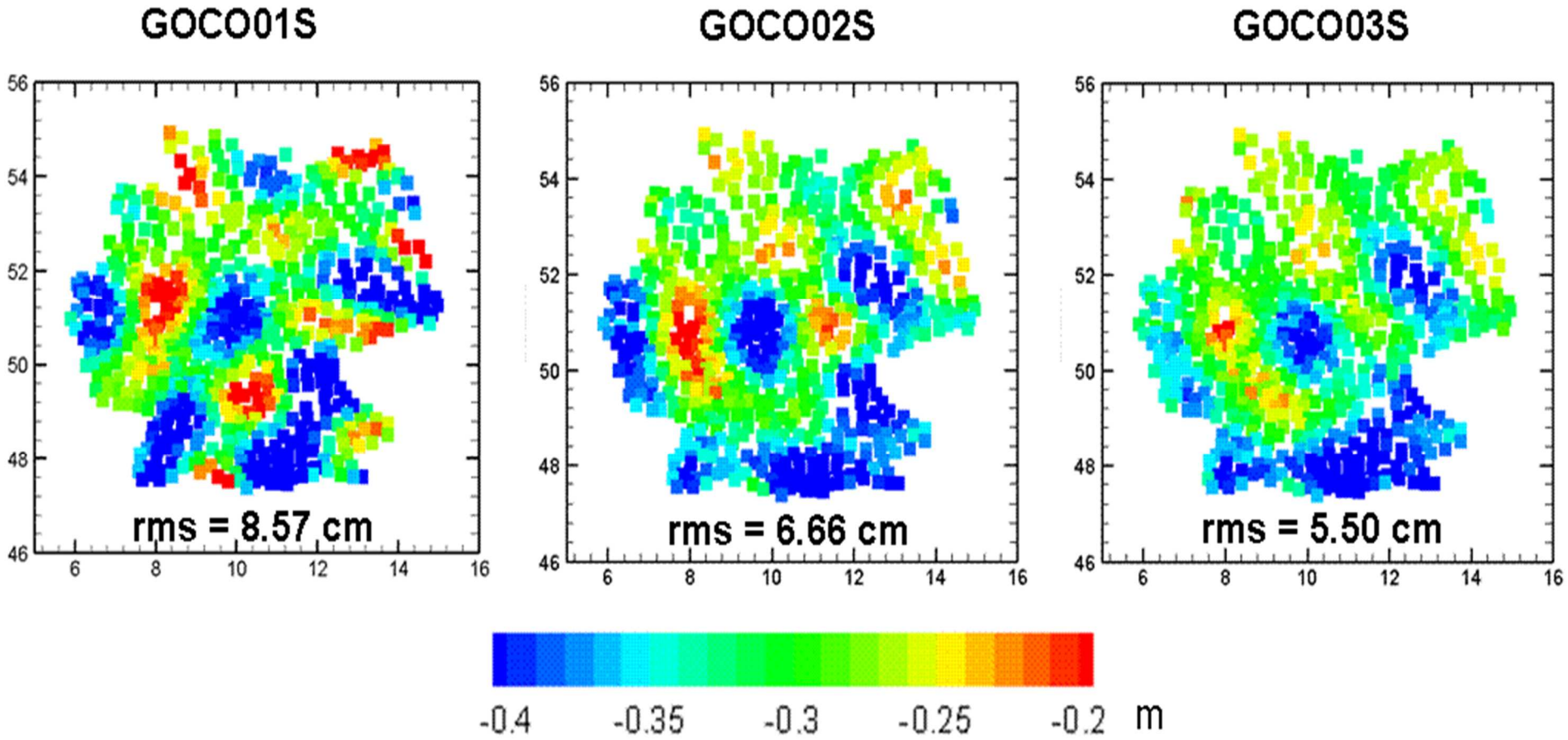
Data:

- GRACE:
  (7.5 years)
- GOCE:
  (18 months)
- SLR:
  (5 years, 5 sat)
- CHAMP:
  (8 years)
- Constrains:
  Kaula, deg>180



Validation of the GOCO-s series

Geoid differences at 675 GPS/levelling data points in Germany (courtesy: BKG), complete to degree 190



The formal errors of the GOCO-s series

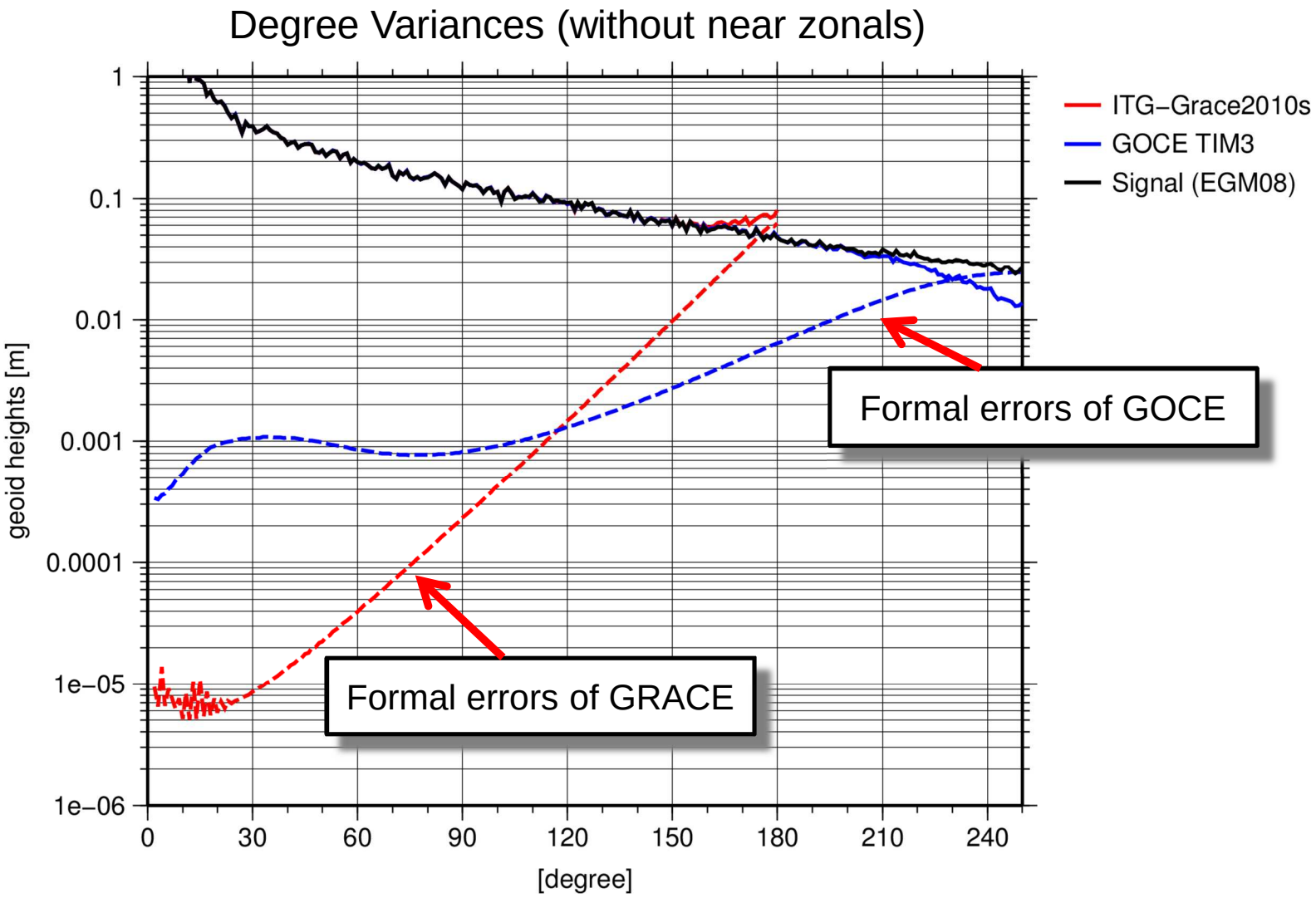
The goal of GOCO is not only to compute accurate gravity field solutions but also to provide realistic accuracy information:

- Realistic accuracy description on observation level (taken into account the non-white noise behavior)

- Variance Component Estimation (VCE) for a optimal weighting strategy in the combination of the normal equations

- Avoidance of manipulation of the formal errors in the postprocessing (no calibration factors are applied)

Intercomparision of GRACE and GOCE input data



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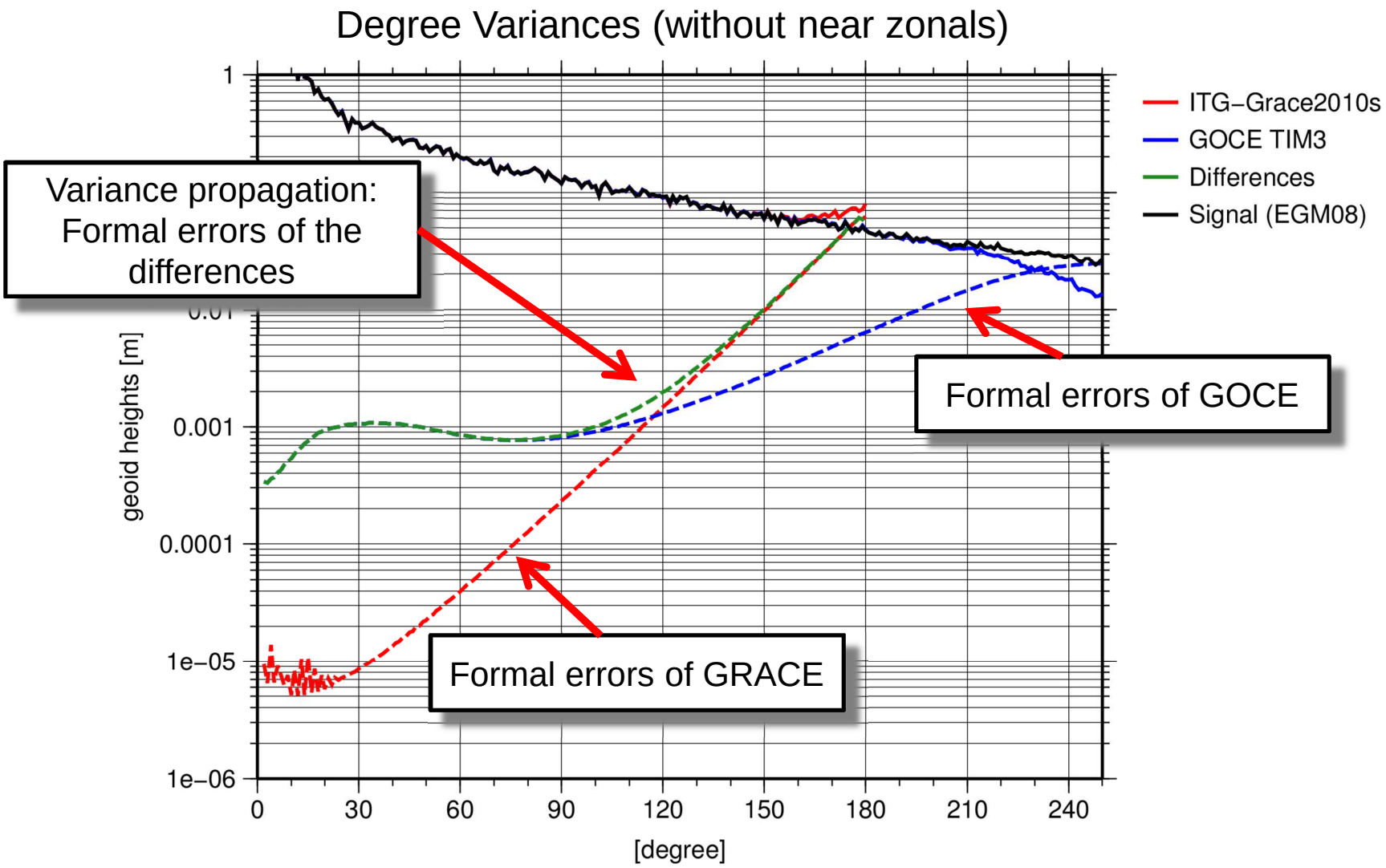

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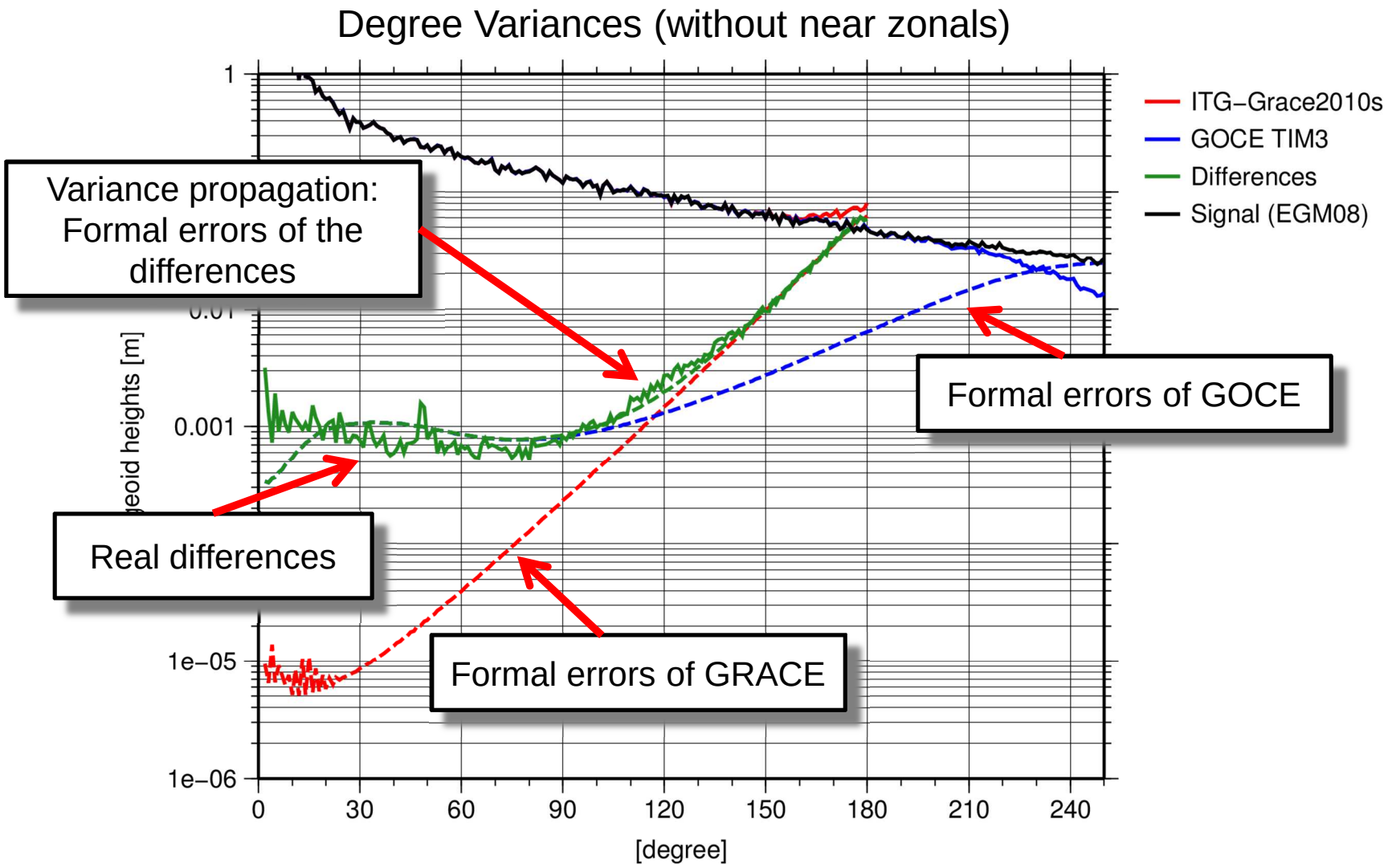

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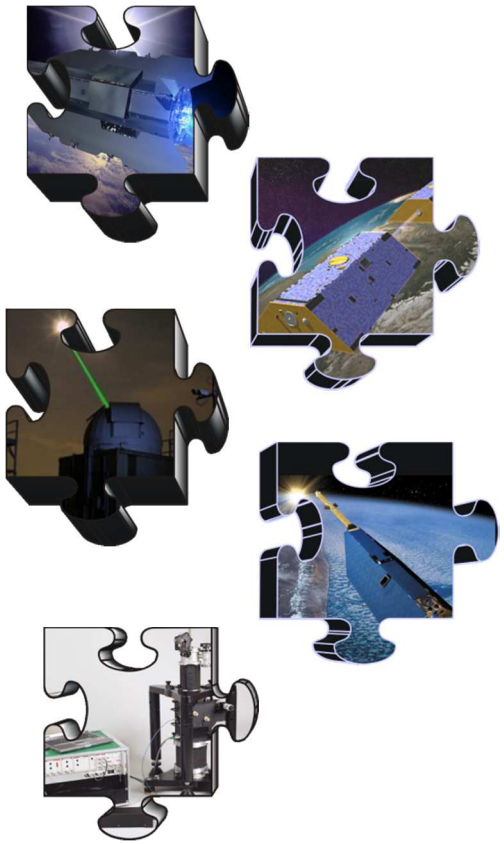
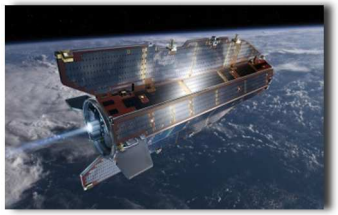


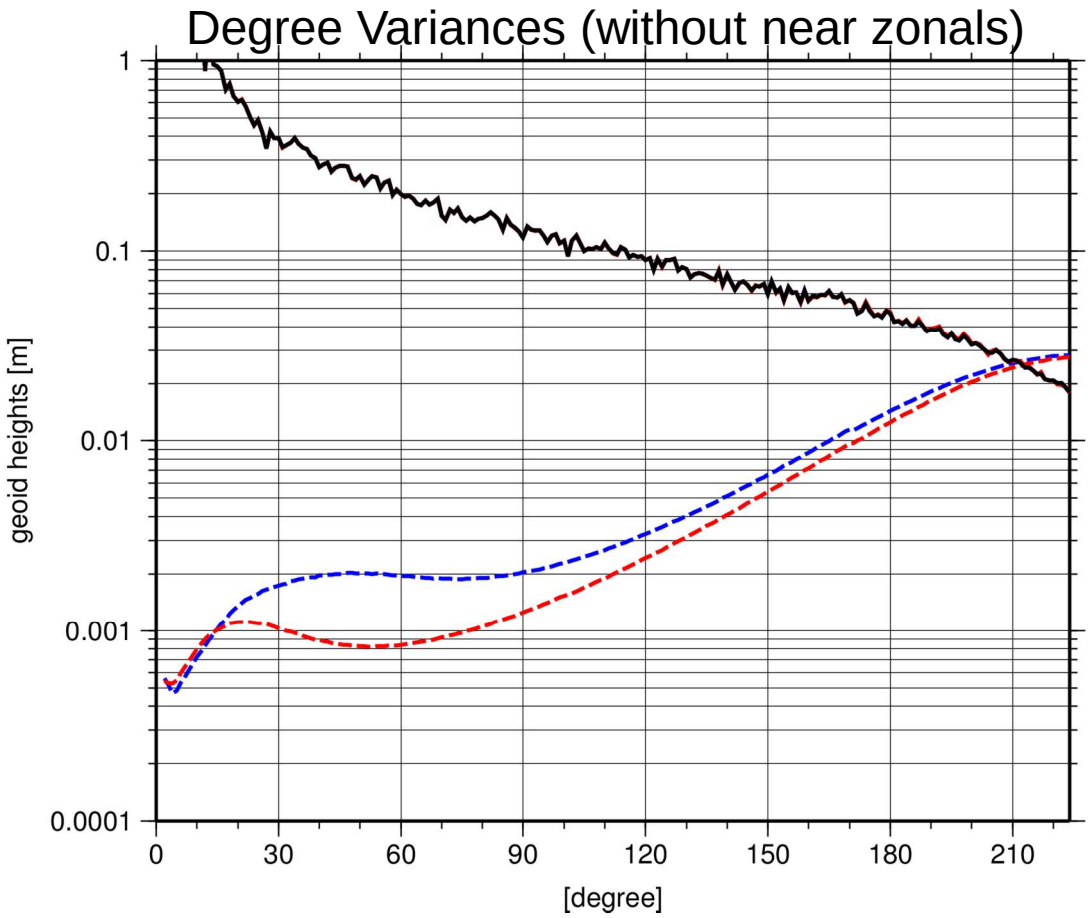
Current investigations and further steps:

- GOCE
- GRACE
- SLR
- GNSS constellation and kinematic orbits
- Terrestrial data and altimetry



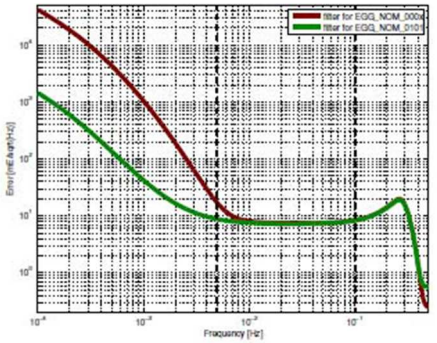
GOCE

- Level1b are currently reprocessed
- First gravity field tests with 2 month of data

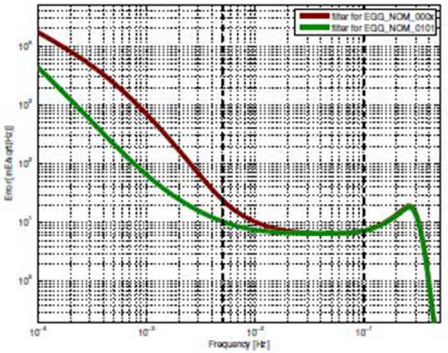


Power spectra of Gradiometer residuals

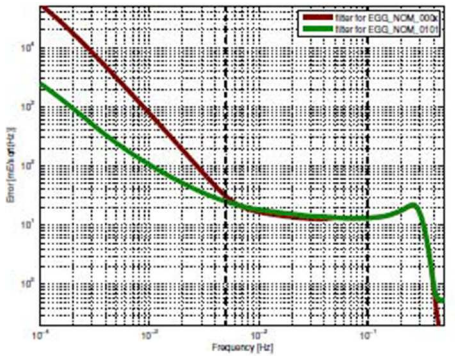
Vxx

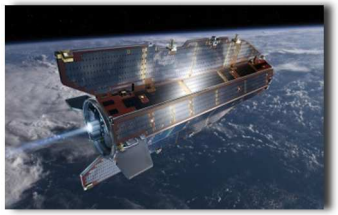


Vyy



Vzz





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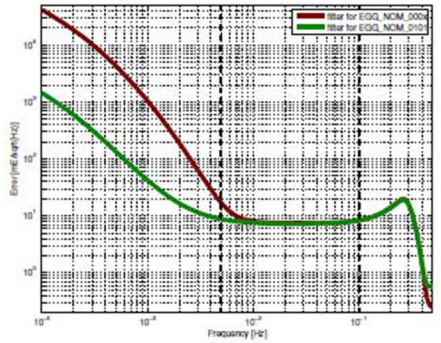

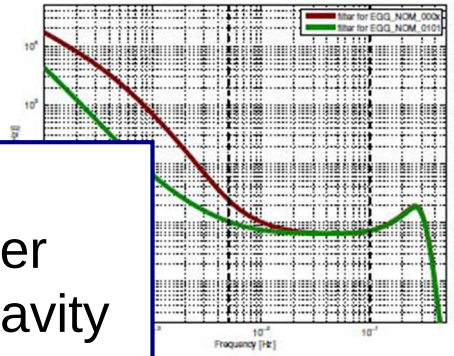

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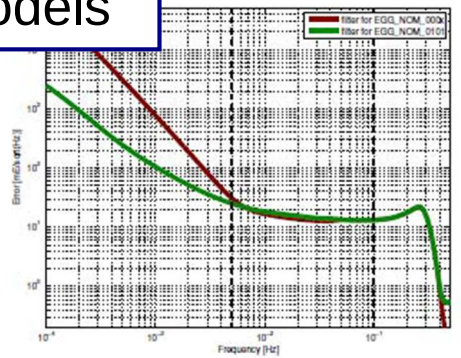
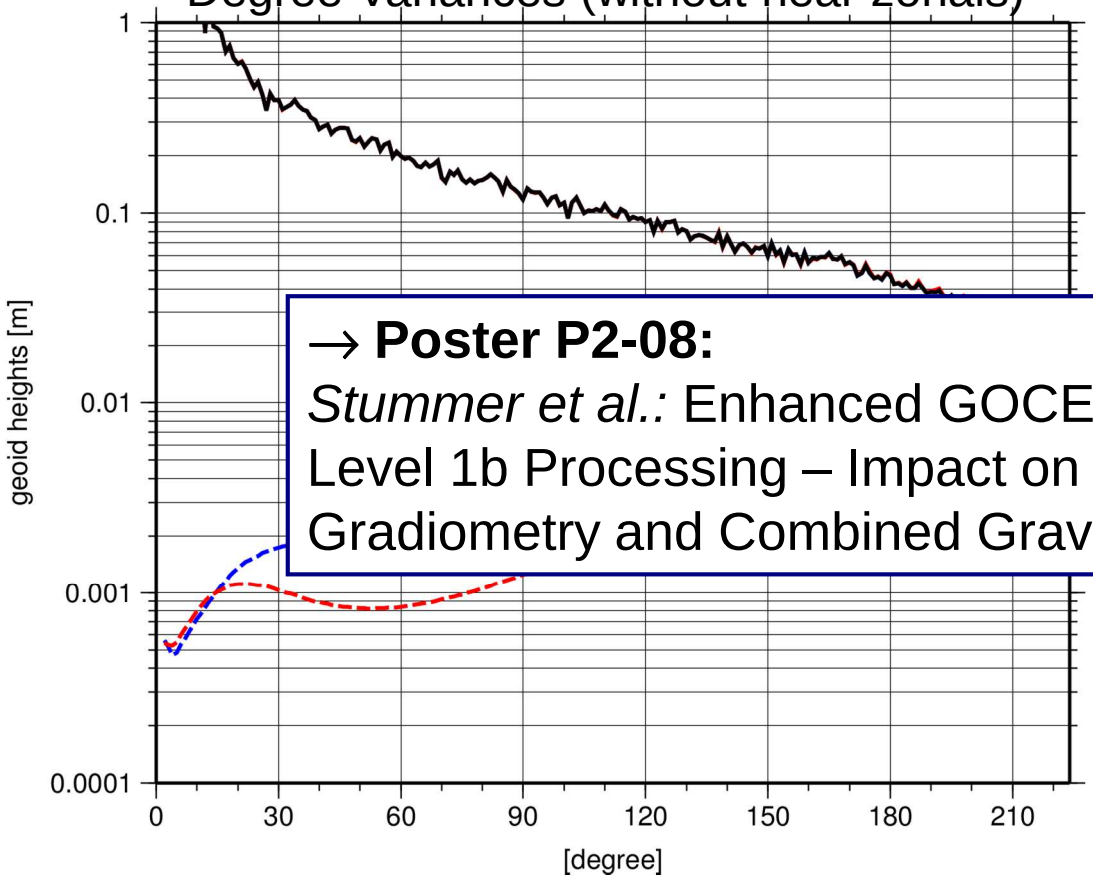
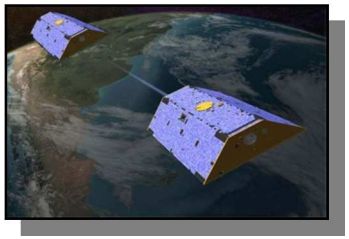


Degree Variances (without near zonals)

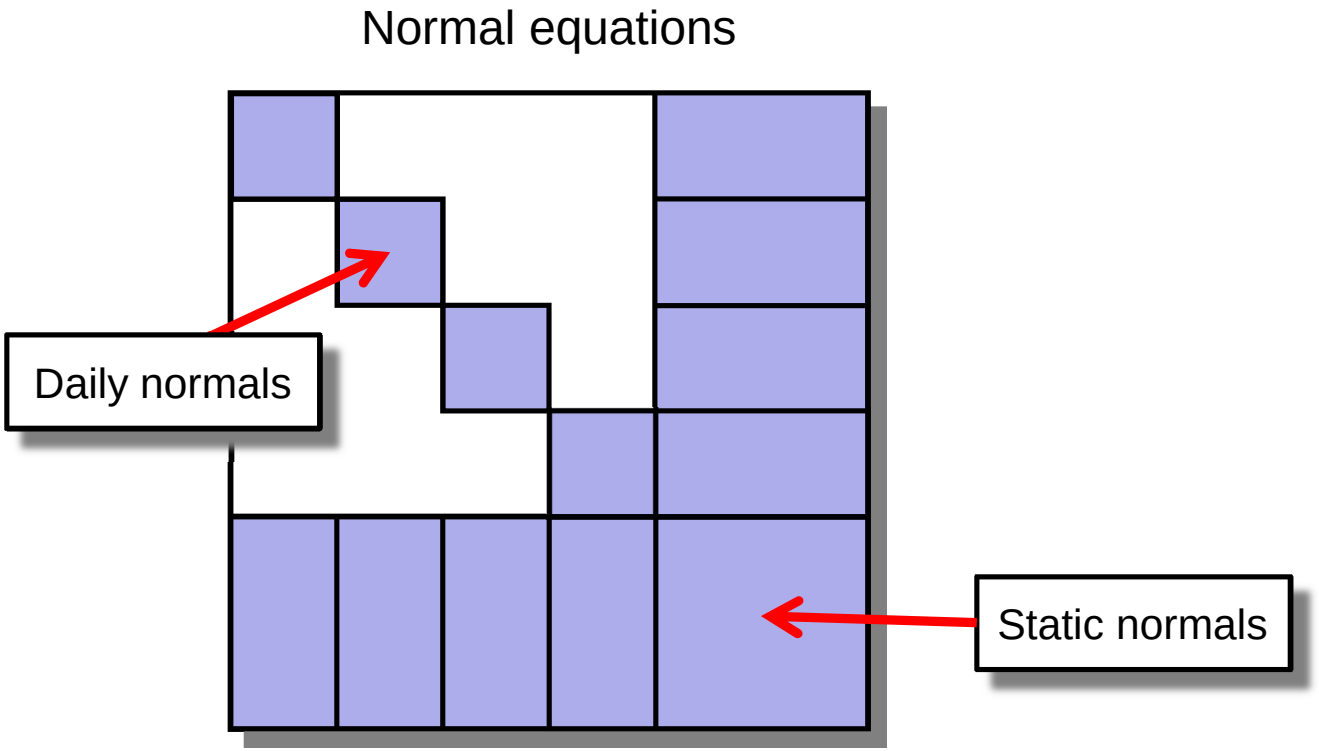


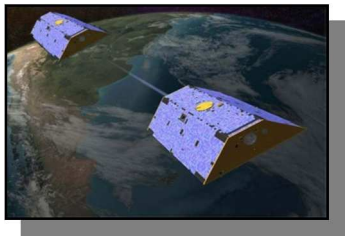
→ **Poster P2-08:**
Stummer et al.: Enhanced GOCE Gradiometer Level 1b Processing – Impact on Satellite Gravity Gradiometry and Combined Gravity Field Models



ITSG-GRACE2013s

- Reprocessed Level 1b data are available
- Taken into account the errors in dealiasing product by a combined estimation of static field and daily constrained variations

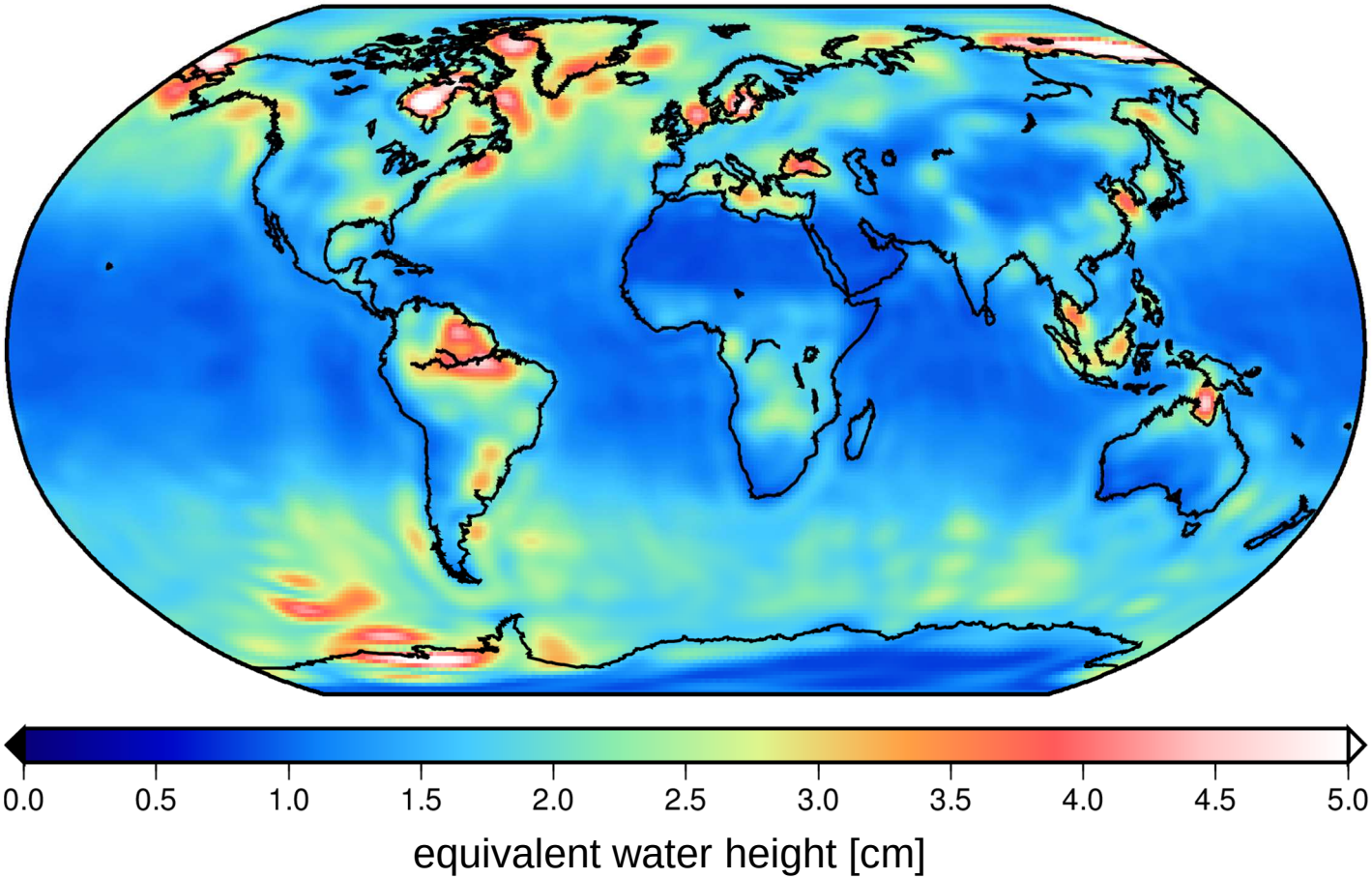




ITSG-GRACE2013s

- Reprocessed Level 1b data are available
- Taken into account the errors in dealiasing product by a combined estimation of static field and daily constrained variations

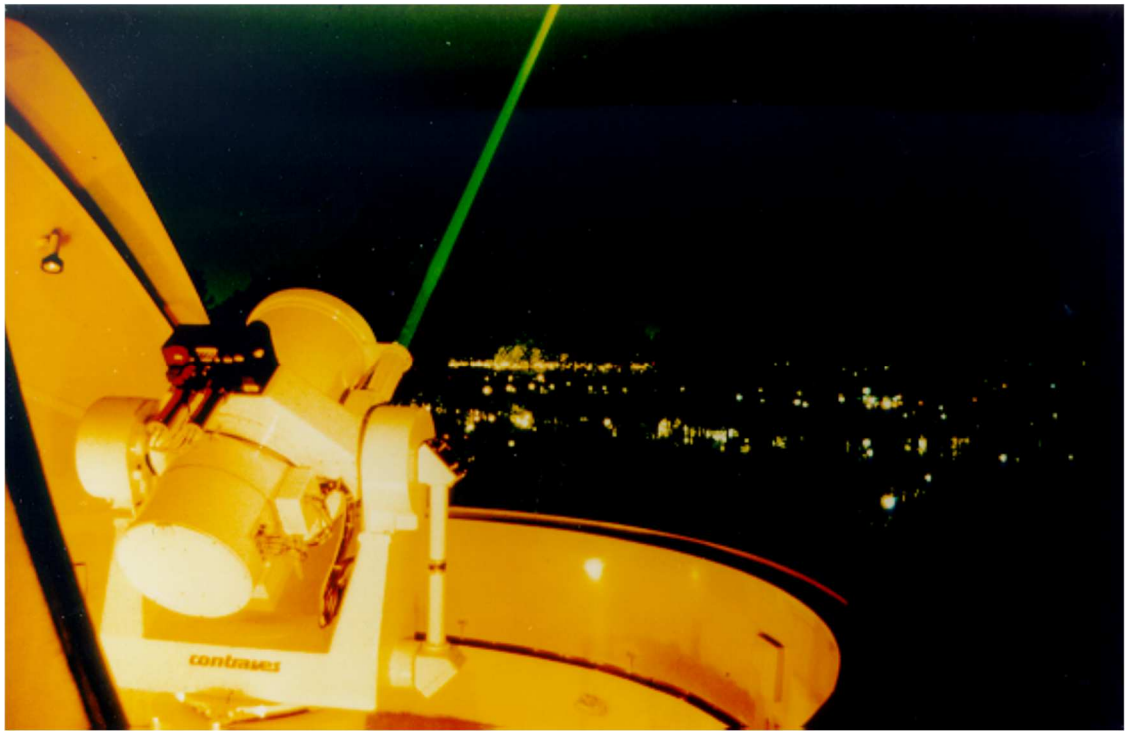
Variability (RMS) of 28 daily solutions (2008-02) without
- monthly mean
- trend
- annual
- semiannual



Satellite Laser Ranging (SLR)

Processing of SLR data is ongoing

- 5 satellites (LAGEOS 1, 2, Ajisai, Stella, Starlette)
- Extension to about 15 years of data
- monthly and weekly solutions



Kinematic orbits: Consistent GNNS+SLR Modeling

The high-low SST data of CHAMP, GRACE, GOCE depend on accurate and consistent GNSS products (orbits and clocks):

- Consistent processing of GPS and GLONASS with GNNS station network and SLR measurements

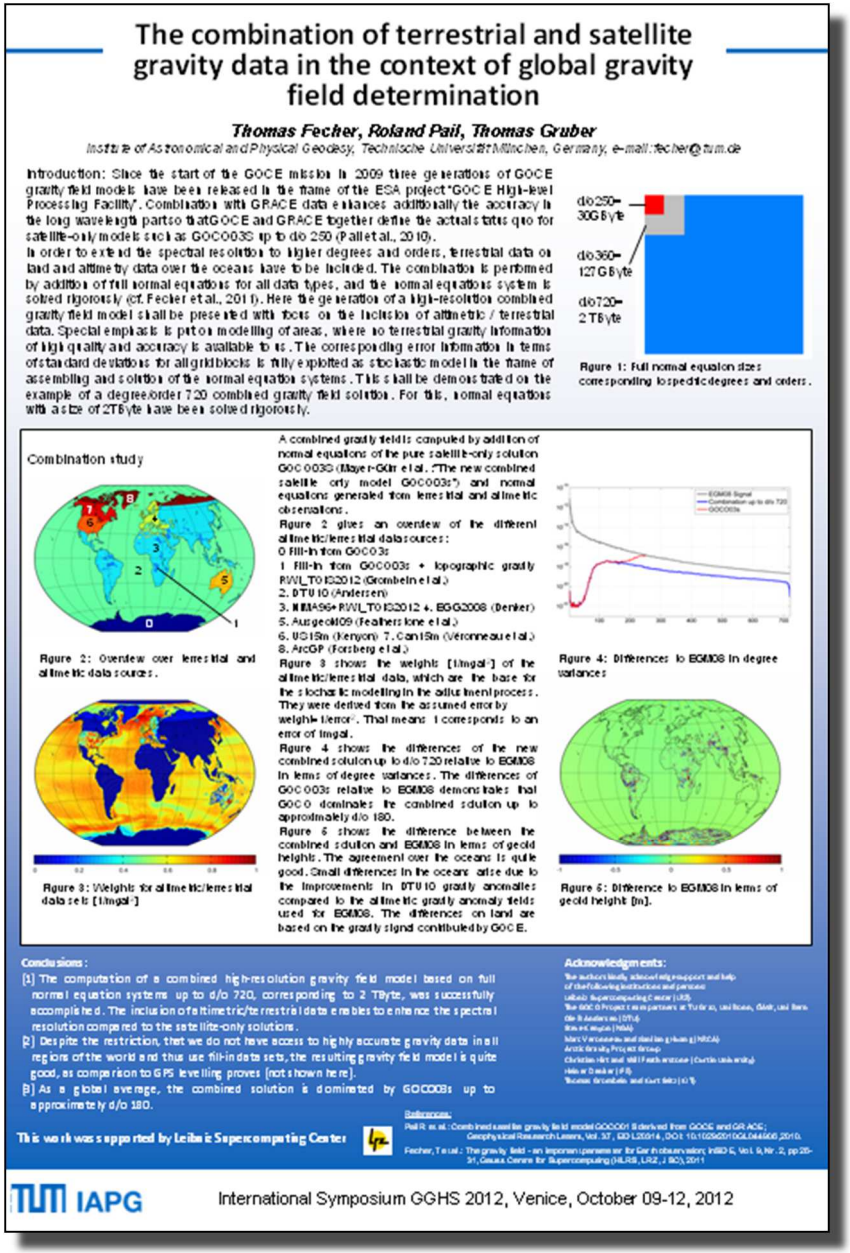
- New approach for kinematic orbit determination using all observations directly (without linear combination) and integer resolution

→ **Presentation, Wednesday 15:30:**
Zehentner, N., Mayer-Guerr, T.: New approach to estimate time variable gravity fields from high-low satellite tracking data

Terrestrial data & Altimetry

- Collection and homogenization of terrestrial data and satellite altimetry
- based on full normal equations complete to degree 720

→ **Poster P2-07:**
Fecher T., Pail R., Gruber T.: The combination of terrestrial and satellite gravity data in the context of global gravity field determination



The combination of terrestrial and satellite gravity data in the context of global gravity field determination

Thomas Fecher, Roland Pail, Thomas Gruber

Institute of Astronomical and Physical Geodesy, Technische Universität München, Germany, e-mail: fecher@tum.de

Introduction: Since the start of the GOCE mission in 2009 three generations of GOCE gravity field models have been released in the frame of the ESA project "GOCE High-level Processing Facility". Combination with GRACE data enhances additionally the accuracy in the long wavelength parts so that GOCE and GRACE together define the actual status quo for satellite-only models such as GOCO03S up to d/o 250 (Pail et al., 2010).
In order to extend the spectral resolution to higher degrees and orders, terrestrial data on land and altimetry data over the oceans have to be included. The combination is performed by addition of full normal equations for all data types, and the normal equations system is solved rigorously (cf. Fecher et al., 2011). Here the generation of a high-resolution combined gravity field model shall be presented with focus on the inclusion of altimetric / terrestrial data. Special emphasis is put on modelling of areas, where no terrestrial gravity information of high quality and accuracy is available to us. The corresponding error information in terms of standard deviations for all grid blocks is fully exploited as stochastic model in the frame of assembling and solution of the normal equation systems. This shall be demonstrated on the example of a degree/order 720 combined gravity field solution. For this, normal equations with a size of 2TByte have been solved rigorously.

d/o 250– 30GByte
d/o 360– 127GByte
d/o 720– 2TByte

Figure 1: Full normal equation sizes corresponding to specific degrees and orders.

Combination study

A combined gravity field is computed by addition of normal equations of the pure satellite-only solution GOC003S (Mayer-Gürr et al. "The new combined satellite only model GOCO03s") and normal equations generated from terrestrial and altimetric observations.
Figure 2 gives an overview of the different altimetric/terrestrial data sources:
0 Fill-in from GOCO3s
1 Fill-in from GOCO03s + topographic gravity RWI_TOI32012 (Grombein et al.)
2. DTU10 (Andersen)
3. KMA96+RWI_TOI32012 4. EGG2008 (Denker)
5. Augeoid09 (Featherstone et al.)
6. UC15m (Kenyon) 7. Can15m (Véronneau et al.)
8. ArcGP (Forsberg et al.)

Figure 2: Overview over terrestrial and altimetric data sources.

Figure 3 shows the weights [1/mgal²] of the altimetric/terrestrial data, which are the base for the stochastic modelling in the adjustment process. They were derived from the assumed error by weight=1/error². That means 1 corresponds to an error of 1mgal.
Figure 4 shows the differences of the new combined solution up to d/o 720 relative to EGM08 in terms of degree variances. The differences of GOC003s relative to EGM08 demonstrates that GOCO dominates the combined solution up to approximately d/o 180.
Figure 5 shows the difference between the combined solution and EGM08 in terms of geoid heights. The agreement over the oceans is quite good. Small differences in the oceans arise due to the improvements in DTU10 gravity anomalies compared to the altimetric gravity anomaly fields used for EGM08. The differences on land are based on the gravity signal contributed by GOCE.

Figure 3: Weights for altimetric/terrestrial data sets [1/mgal²]

Figure 4: Differences to EGM08 in degree variances

Figure 5: Difference to EGM08 in terms of geoid height [m].

Conclusions:
(1) The computation of a combined high-resolution gravity field model based on full normal equation systems up to d/o 720, corresponding to 2 TByte, was successfully accomplished. The inclusion of altimetric/terrestrial data enables to enhance the spectral resolution compared to the satellite-only solutions.
(2) Despite the restriction, that we do not have access to highly accurate gravity data in all regions of the world and thus use fill-in data sets, the resulting gravity field model is quite good, as comparison to GPS levelling proves (not shown here).
(3) As a global average, the combined solution is dominated by GOCO03s up to approximately d/o 180.

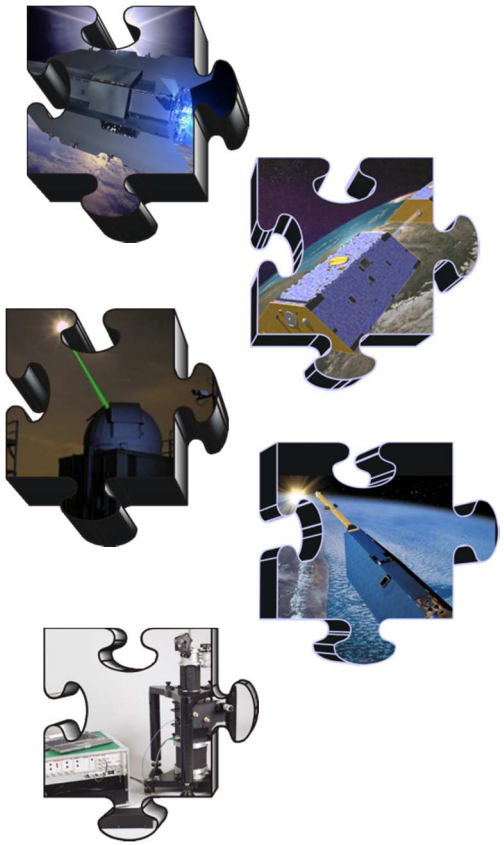
Acknowledgements:

This work was supported by Leibniz Supercomputing Center

References:

IAPG International Symposium GGHS 2012, Venice, October 09-12, 2012

Summary



- The new combined satellite only model GOCO03s is released
  (available at ICGEM and goco.eu)
- Consistent combination with realistic accuracy information
- Ongoing activities to improve all components

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