Institute of Navigation and Satellite Geodesy, Graz University of Technology[(1)]
Space Research Institute, Dpt. Of Satellite Geodesy, Austrian Academy of Sciences[(2)]
Institute Of Astronomical and Physical Geodesy, Technical University of Munich[(3)]
Astronomical Institute, University of Bern[(4)]
Institute of Geodesy and Geoinformation, University of Bonn[(5)]

COMBINED GLOBAL GRAVITY FIELD MODEL FROM SPACE-BASED (AND GROUND-BASED) DATA: GOCO01S

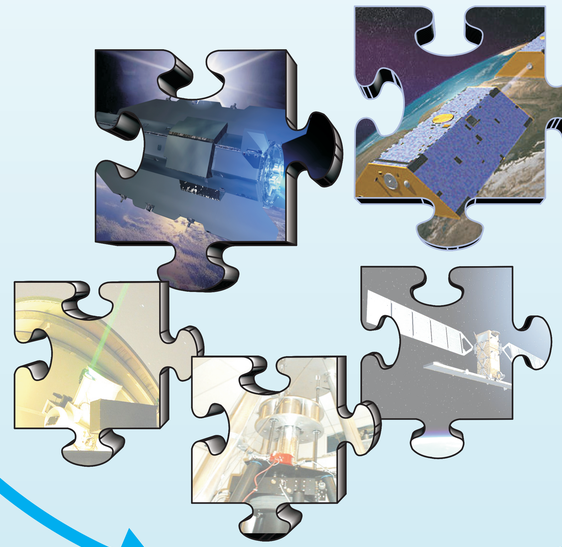
H. Goiginger[(1)], D. Rieser[(1)], T. Mayer-Guerr[(1)], W. Hausleitner[(2)], E. Höck[(2)], S. Krauss[(2)], A. Maier[(2)], O. Baur[(2)], R. Pail[(3)], T. Gruber[(3)], T. Fecher[(3)], A. Albertella[(3)], A. Jäggi[(4)], U. Meyer[(4)], W.-D. Schuh[(5)], J.M. Brockmann[(5)], J. Kusche[(5)], A. Eicker[(5)]

Abstract

The main objective of the GOCO (GOCE Combination) consortium is to combine space-based and ground-based data to compute global gravity field models with high accuracy and high spatial resolution. Benefit can be taken from their individual strengths and favourable features, and in parallel specific deficiencies can be reduced.
The new series of global gravity models started with the release of the satellite-only model GOCO01S. The model is composed by GOCE gravity gradient data and GRACE GPS and K-band range rate data and has a resolution of degree and order 224.

A) Why is data combination essential?

As an example, due to the orbit design GRACE observations cover the whole globe whereas GOCE is not able to deliver measurements near the poles. Focusing the spectral characteristics GOCE provides measurements to resolve especially the medium wavelengths of the Earth's gravity signal with unprecedented accuracy. To conclude, a data combination benefits from the specific strength of each data type.



B) Which data types are used?

GOCE: The GOCE-only model comprises two months (Nov + Dec 2009) of satellite gravity gradients (SGG). The system is parametrized up to degree and order (d/o) 224.
GRACE: For the combination the well established ITG-Grace2010s model up to d/o 180 is used which is based on GRACE data covering the time span from August 2002 to August 2009.

For both models a realistic stochastic model is incorporated.

C) How is the data combined?

The Earth's gravity field is parametrized in terms of spherical harmonic coefficients. First, the normal equation systems are assembled for each observation type. Second, a weighted addition of the equation systems is performed. Due to the adequate stochastic modeling of the GOCE and GRACE components, they entered the present GOCO01S solution ([2]) with unit weight.

D) What is the result?

Figure 1 illustrates the median of the estimated standard deviations per degree. The combined solution clearly demonstrates that the low to medium degrees are determined by GRACE. The contribution of GOCE SGG can already be observed at degree 100. Beyond degree 150, GOCE is the dominant contributor.
Figure 2 displays the geoid height differences [m] of GOCO01S (top) and the ITG-Grace2010s (bottom) w.r.t. EGM2008 up to d/o 180. Both plots demonstrate that satellite data deliver additional information especially in mountainous regions (i.e. Himalayas, Andes) and in regions where only a few and less accurate terrestrial measurements are available (i.e. Africa, Antarctica). This added-value is most underlined by the GOCO01S model. Furthermore typical GRACE errors disappear when using GOCE SGG data.
Figure 3 shows the propagated geoid height errors of GOCO01S (top) and ITG-Grace2010s (bottom) up to d/o 180 based on the particular full covariance matrix. Again, the added-value of the combination of GOCE and GRACE is obvious.

E) Where is the GOCO01S model accessible?

The GOCO01S model and the documentation is available either over the project website http://inas.tugraz.at/GOCO or over the website of the "International Center for Global Gravity Field Models" (http://icgem.gfz-potsdam.de/ICGEM). Soon there will also be the full variance-covariance matrix available.

F) For what can the GOCO01S model be used?

To answer this question one application is addressed here. The objective of the project GEO-TOP ([1]) is the determination of the absolute (but temporally changing) ocean flow field in the Atlantic section of the Antartic Circumpolar Current from the assimilation of geodetic Dynamic Ocean Topography (DOT) into a state-ot-the-art ocean circulation model. The DOT is computed on a 0.5°x0.5° grid using mean sea surface multi-years (17.5 years of data) and multi-mission (ERS-1 geodetic missions, ERS-2, ENVISAT, TOPEX/Poseidon, Jason-1, Jason-2) data. Figure 4 shows the DOT derived from GOCO01S (bottom)/ITG-Grace2010s (top) and a mean sea surface. The benefit of GOCO01S is evident: the GRACE specific stripes could significantly be reduced.

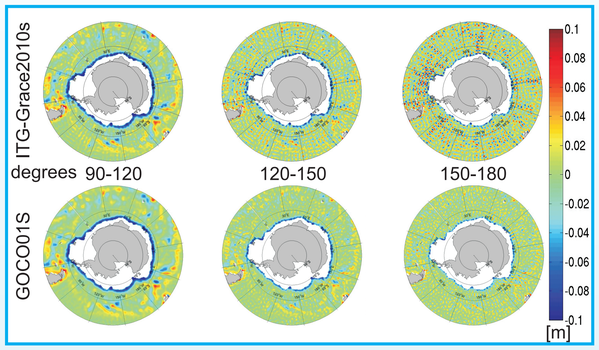


Fig. 4. DOT derived from GOCO01S/ITG-Grace2010s and mean sea surface.

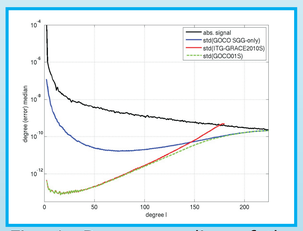


Fig. 1. Degree median of the estimated errors.

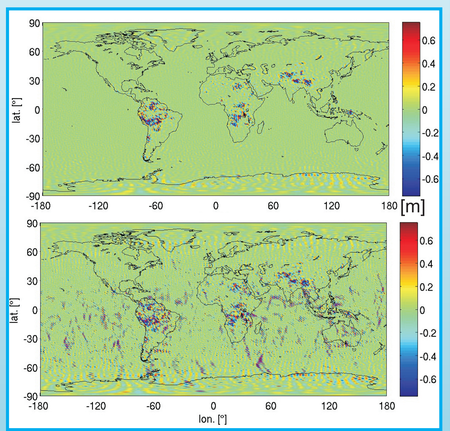


Fig. 2. Geoid height differences [m] of GOCO01S (top) and ITG-Grace2010s (bottom) w.r.t. EGM2008.

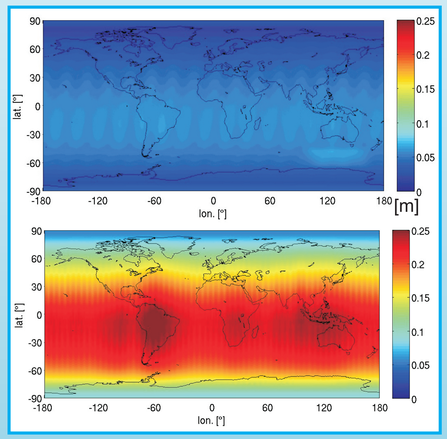


Fig. 3. Propagated geoid height errors [m] based on GOCO01S (top) and ITG-Grace2010s (bottom).

Summary and Outlook

The presented GOCO01S model clearly demonstrates the benefits of a GOCE and GRACE combination. In spite of the fact that only two months of GOCE data have been used, significant contributions can already be observed from degree 100 upwards. With the availability of more and more GOCE and GRACE data further improvements of global gravity field models will be achieved. Additionally, also normal equation systems based on SLR observations, altimetry, and terrestrial gravity data will be set up and included into the combination procedure of the GOCO model.

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[1] Albertella, A., Wang, X. and Rummel, R.: (2010), "Filtering of altimetric sea surface heights with a global approach". In: Mertikas, S. P. (eds.) Gravity, Geoid and Earth Observation, IAG Symposia, Vol. 135, pp 247-252, Springer.
[2] Pail, R., et al. (2010), Combined satellite gravity field model GOCO01S derived from GOCE and GRACE, Geophys. Res. Lett., 37, L20314, doi:10.1029/2010GL044906.