EGU05-A-04561

GFZ POTSDAM

A NEW HIGH RESOLUTION GLOBAL GRAVITY FIELD MODEL DERIVED FROM COMBINATION OF GRACE AND CHAMP MISSION AND ALTIMETRY/GRAVIMETRY SURFACE GRAVITY DATA

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1) Introduction

With the GRACE und CHAMP satellite missions, a new generation of global gravity field models from space came up. Here the latest result of the gravity processing at GFZ Potsdam is presented: The newly obtained global mean gravity field model EIGEN-CG03C is a combination of the GRACE mission (376 days out of February to May/July to December 2003 and February to July 2004) and the CHAMP mission (860 days out of October 2000 to June 2003) data plus altimetric and gravimetric surface data. This model is an upgrade of EIGEN-CG01C (Reigber et al., 2004), which was based on the same CHAMP and surface data.

EIGEN-CG03C is complete to degree/order 360 in terms of spherical harmonic coefficients and resolves wavelengths of 110 km in the geoid and gravity anomaly fields. A special band-limited combination method has been applied in order to preserve the high accuracy from the satellite data in the lower frequency band of the geopotential and to form a smooth transition to the high-frequency information coming from the surface data. Compared to pre-CHAMP/GRACE global high-resolution gravity field models, the accuracy could be improved by one order of magnitude to 3 cm and 0.4 mgal in terms of geoid heights and gravity anomalies, respectively, at a spatial resolution of 400 km wavelength. The overall accuracy of the full model is estimated to be 30 cm and 8 mgal, respectively, and benefits also from recently issued new gravity anomaly compilations over polar regions.

2) CHAMP and GRACE satellite data

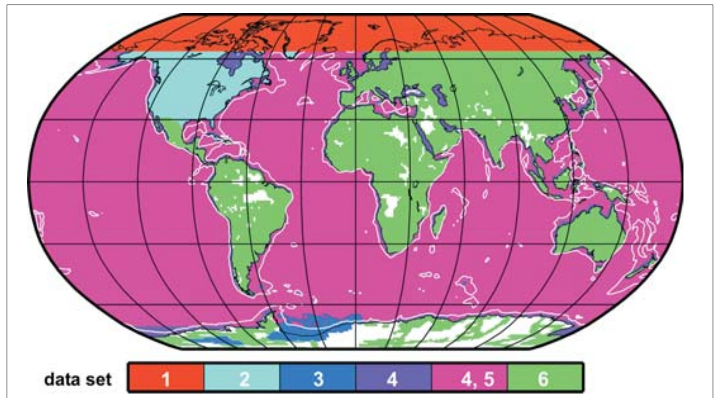
CHAMP:
860 days between October 2000 and June 2003, arcs of 1.5 days length
- GPS high-low code and phase measurements (30s)
- STAR linear accelerations (10s)
- star camera attitude data (10s)
- attitude thruster data

GRACE:
376 days out of February to May/July to December 2003 and February to July 2004, arcs of 1.5 days length
- GPS high-low code and phase measurements (30s)
- inter-satellite K-band low-low range-rate tracking data (5s)
- SuperSTAR linear accelerations (5s)
- star camera attitude data (5s)

3) Surface data used for the combination with the CHAMP and GRACE satellites' normal equations

(1) Arctic Gravity Project (ArcGP) gravity anomalies (Forsberg, Kenyon 2004), for regions of latitude > 64°,
(2) NRCan gravity anomalies (Véronneau 2003, personal communication), covering North America,
(3) AWI (Studinger 1988) and LDO (Bell et al., 1999) gravity anomalies, over two small areas of Antarctica and adjacent sea ice (AWI),
(4) NIMA altimetric gravity anomalies over the ocean including standard deviations,
(5) Geoid undulations over the oceans derived from CLS01 altimetric Sea Surface Heights (Hernandez et al., 2001) and ECCO simulated sea surface topography (Stammer et al., 2002),
(6) NIMA terrestrial gravity anomalies (if not covered by data sets 1 to 3) including standard deviations, with almost worldwide continental coverage, except for Antarctica and some smaller data gaps, and
(7) NIMA ship-borne gravity anomalies over water depths less than 2000 m.

All data sets are available or averaged to equi-angular 30' x 30' block mean values, except data sets 5 and 7 that are provided with a 1° x 1° resolution. The NIMA data sets (Kenyon, Pavlis 1997) are those already incorporated in the EGM96 solution.



Coverage of surface data sets 1 through 6; white lines mark used ship gravimetry data (data set 7) over water depths less than 2000 m; white areas are not covered with surface data.

4) Algorithms and steps for the adjustment of the combined solution EIGEN-CG03C:

1) Satellite orbit determination and computation of obervation equations from the so-called two-step approach as used for the previously published EIGEN-models (Reigber et al., 2003, Reigber et al., 2005):
   - Adjustment of the high GPS constellation orbits and clock parameters from ground based tracking data,
   - CHAMP and GRACE orbit determination and computation of observation equations with fixed GPS spacecraft positions and clocks from step one.

2) Computation of normal equations for the spherical harmonic expansion of the geopotential for: CHAMP: complete to degree/order 120 and within CHAMP-resonant orders up to degree 140 GRACE: complete to degree and order 150.

3) Generation and combination of rigorous normal equation systems complete up to degree/order 140 with individual data weighting for the surface data sets, the surface data were spectral filtered to suppress the contribution from spectral gravitational constituents higher than degree 120.

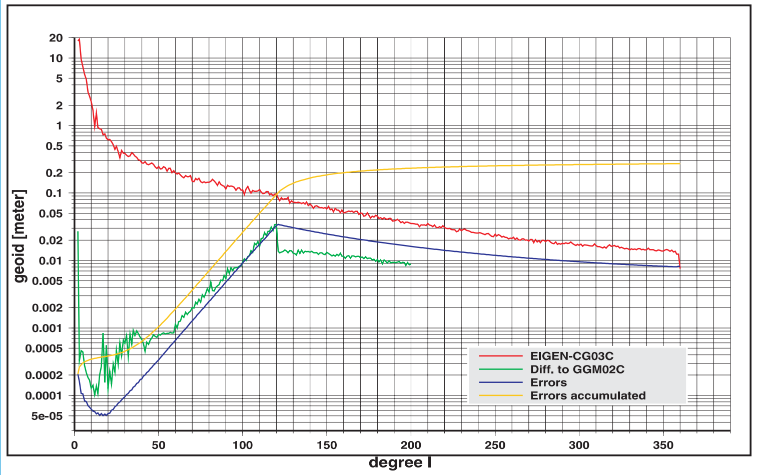
4) Combination of the satellite and ground based normal equation equation systems and solution to get a gravity model complete up to degree/order 140 taking into account the following conditions:
   - overlapping of the GRACE/CHAMP and terrestrial contributions between degree 71 and 120,
   - the long-wavelength part up to degree 70 is based on GRACE/CHAMP satellite data only,
   - the GRACE/CHAMP contribution between degree 121 and 150 was stabilized and kept separate.

5) Creation and independent solution of a block diagonal normal equation system from 30' x 30' gridded terrestrial data (gravity anomalies only) for the spherical harmonic coefficients from degree 121 to 359.

6) Computation of the sperical harmonic coefficients of degree 360 by numerical integration of the 30' x 30' gridded data.

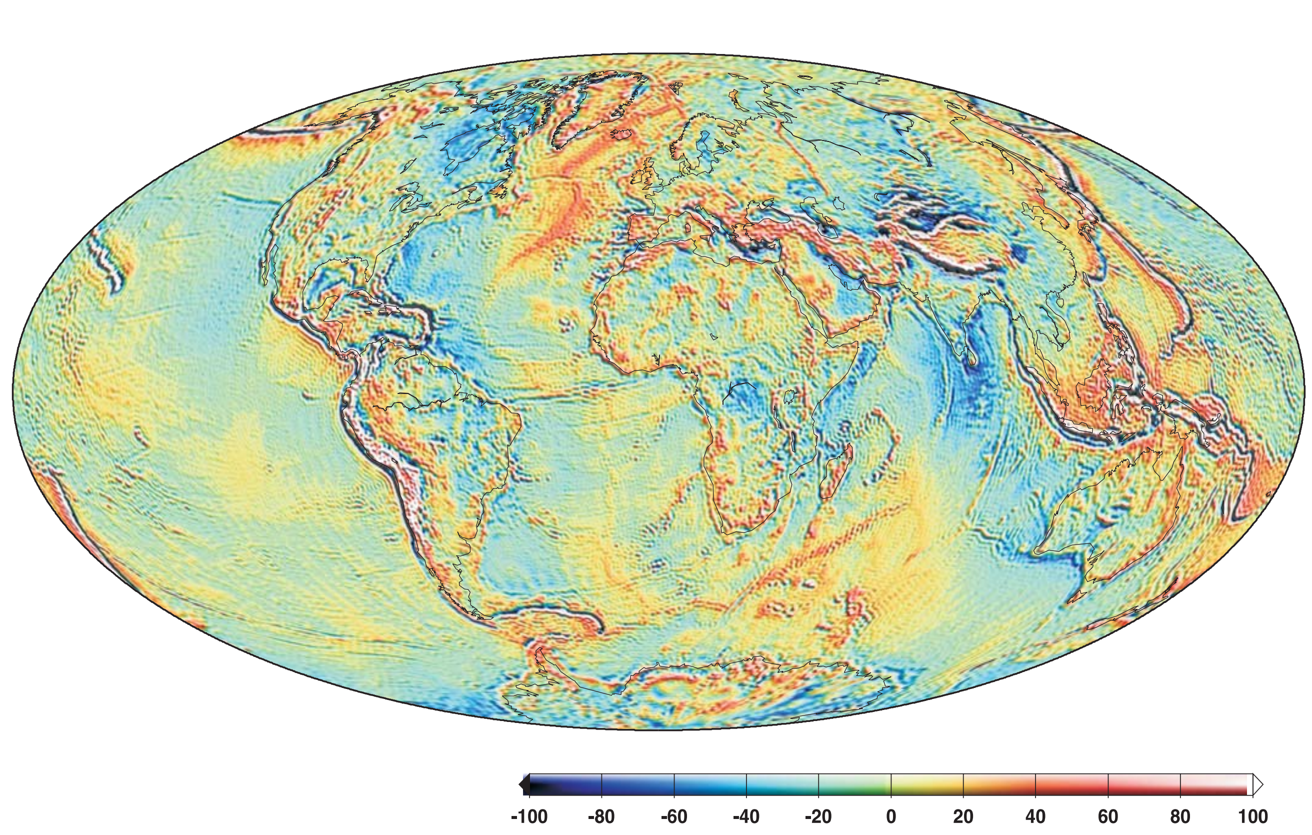
7) Extension of the coefficient series up to degree 120 obtained from the full normal system by the coefficients of the two other solutions.

5) EIGEN-CG03C Geoid Degree Amplitudes



Amplitudes per degree of EIGEN-CG03C (red), of the difference between EIGEN-CG03C and GGM02C (green) and of the calibrated errors of EIGEN-CG03C (blue); Amplitudes degree-wise accumulated of the errors of EIGEN-CG03C (yellow); All curves in terms of geoid heights

EIGEN-CG03C Gravity Anomalies (mgal)



6) Comparison with GPS levelling

An independent comparison with external data can be made using geoid heights determined point-wise by GPS positioning and levelling (GPS levelling). The table below shows the results for the present model EIGEN-CG03C in comparison with the previous models EIGEN-CG01C and EGM96 using GPS-Levelling points from the USA (Milbert, 1998), Canada (Véronneau, personal communication 2003, Natural Resources Canada, GPS on BMs file, update February 2003) and Europe/Germany (Ihde et al., 2002).

Gravity Model	GPS levelling Geoid Heights			
	USA (6169)	Canada (1930)	Europe (186)	Germany (675)
EIGEN-CG03C	43 cm	35 cm	38 cm	20 cm
EIGEN-CG01C	44 cm	32 cm	40 cm	22 cm
EGM96	47 cm	38 cm	45 cm	28 cm

Weighted (cosine of latitude) root mean square (wrms) about mean of GPS-Levelling minus model-derived geoid heights (number of points in brackets).

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