International Centre for Global Earth Models (ICGEM)

http://icgem.gfz-potsdam.de/ICGEM/

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Overview

The International Centre for Global Earth Models is mainly a web based service and comprehends:

- collecting and long-term archiving of existing global gravity field models
- making them available on the web in a standardised format (self-explanatory)
- interactive visualisation of the models (geoid undulations and gravity anomalies)
- solutions from dedicated time periods (e.g. monthly GRACE models) are included
- animated visualization of monthly GRACE models
- web-interface to calculate gravity functionals from the spherical harmonic models on freely selectable grids (filtering included)
- theory and formulas of the calculation service in STR09/02 (downloadable)
- managing the ICGEM web-based discussion forum (answering questions)
- evaluation of the models
- visualisation of surface spherical harmonics as tutorial

Services

The Models

Currently, 119 models are listed with their references and 105 of them are available in form of spherical harmonic coefficients. If available, the link to the original model web site has been added. Models from dedicated time periods (e.g. monthly solutions from GRACE) of CSR, JPL, CNES/GRGS and GFZ are also available.

The Format

The spherical harmonic coefficients are available in a standardised self-explanatory format which has been accepted by ESA as the official format for the GOCE project.

The Visualisation

An online interactive visualisation of the models (height anomalies and gravity anomalies) as illuminated projection on a freely rotatable sphere is available. Monthly solutions from GRACE are included. Differences of two models, arbitrary degree windows, zooming in and out, are possible. The visualisation of single spherical harmonics is possible for tutorial purposes.

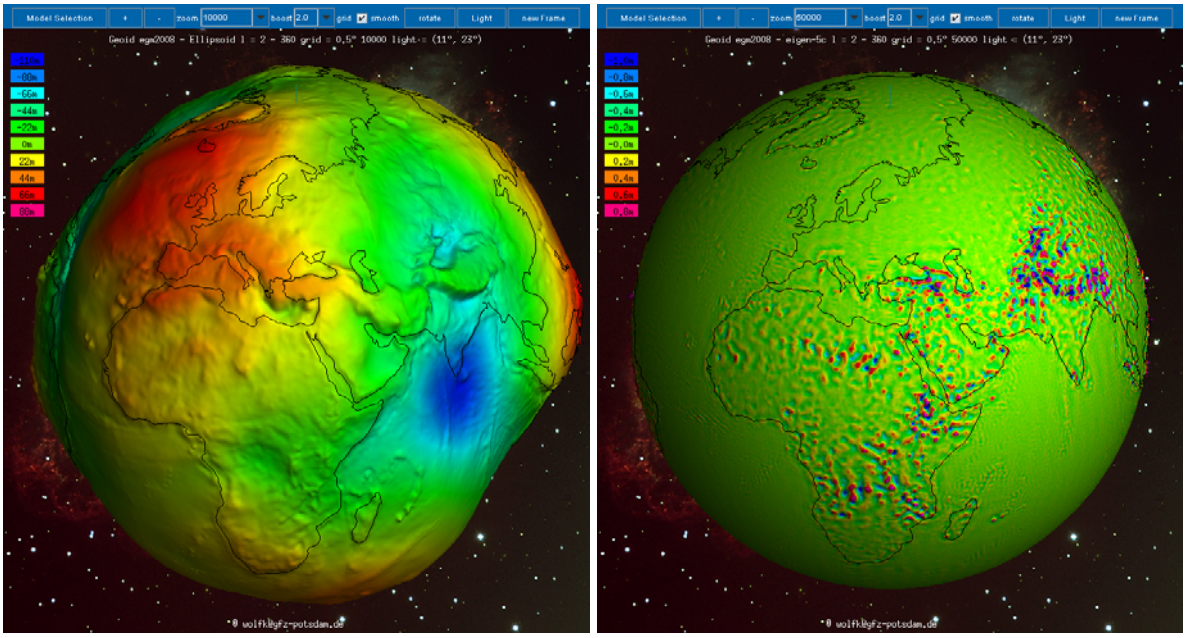

Fig. 1: Visualisation (geoid) of a global gravity field model and of differences of two models

The Calculation Service

A web-interface to calculate gravity functionals from the spherical harmonic models on freely selectable grids, with respect to a reference system of the user's choice, is provided. The following functionals are available:

- pseudo height anomaly on the ellipsoid (or at arbitrary height over the ellipsoid)
- height anomaly (on the Earth's surface as defined)
- geoid height (height anomaly plus spherical shell approximation of the topography)
- gravity disturbance
- gravity disturbance in spherical approximation (at arbitrary height over the ellipsoid)
- gravity anomaly (classical and modern definition)
- gravity anomaly (in spherical approximation, at arbitrary height over the ellipsoid)
- simple Bouguer gravity anomaly
- gravity on the Earth's surface (including the centrifugal acceleration)
- gravity on the ellipsoid (or at arbitrary height over the ellipsoid, including the centrifugal acceleration)
- gravitation on the ellipsoid (or at arbitrary height over the ellipsoid, without centrifugal acceleration)
- second derivative in spherical radius direction (at arbitrary height over the ellipsoid)
- equivalent water height (water column)

Filtering is possible by selecting the maximum degree of the used coefficients or the filter length of a Gaussian averaging filter. The models from dedicated time periods (e.g. coefficients of monthly solutions from GRACE) are also available after non-isotropic smoothing (decorrelation). The calculated grids (self-explanatory format) and corresponding plots (postscript) are available for download after a few seconds or a few minutes depending on the functional, the maximum degree and the number of grid points.

Figure 2 shows the input mask of the calculation service and figures 3 to 5 show examples of plots (of grids) generated by the calculation service.

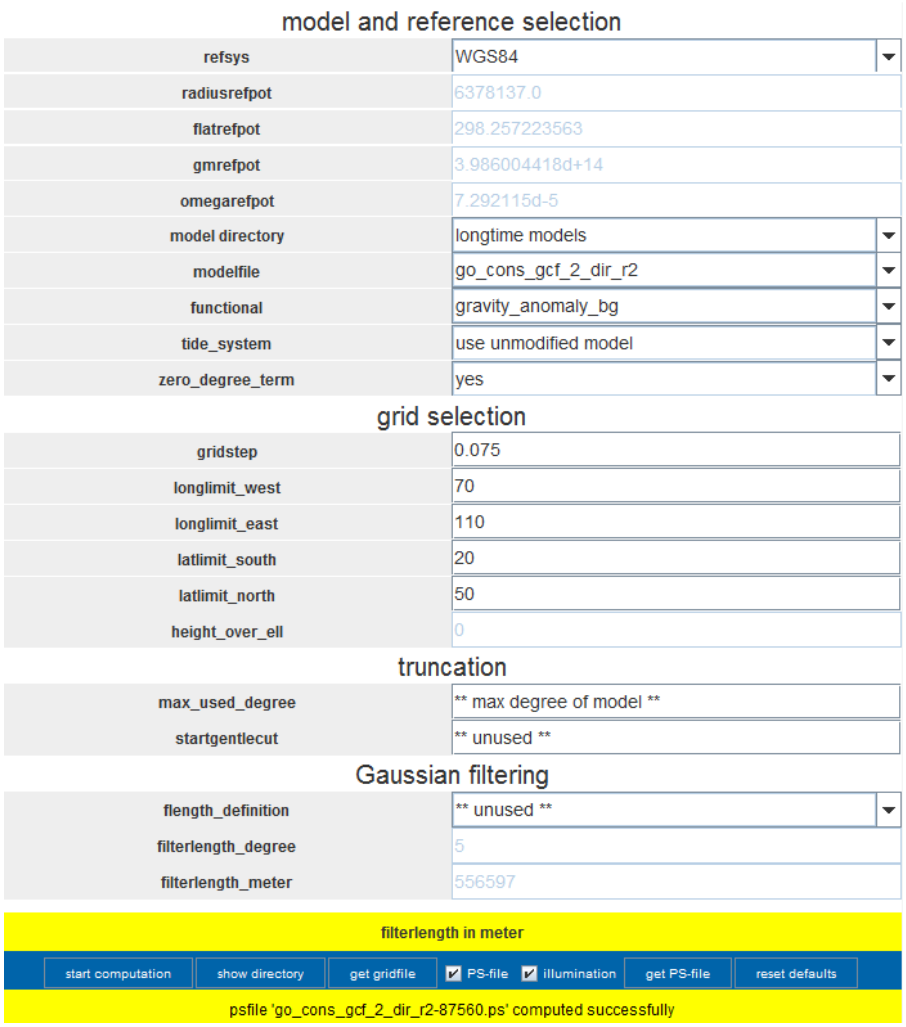

Fig. 2: Input mask of the calculation service

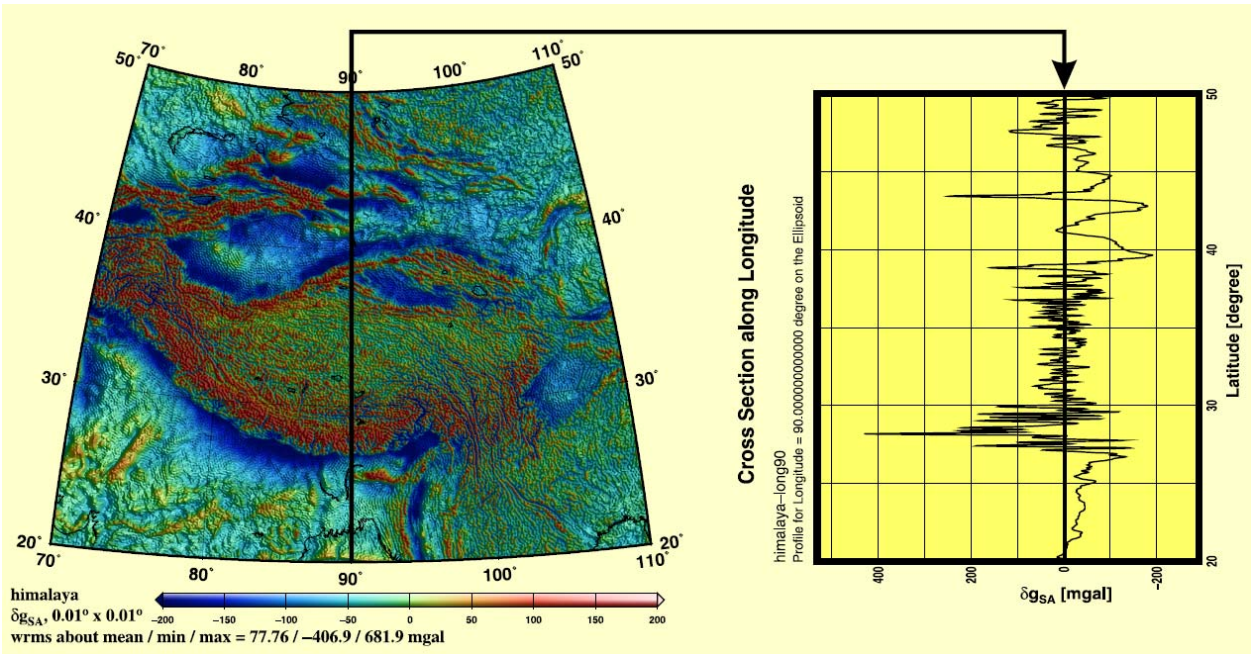

Fig. 3: Example of grid and plot generation by the calculation service: gravity disturbances of the Himalayan region and cross section along a defined longitude from the model EGM2008

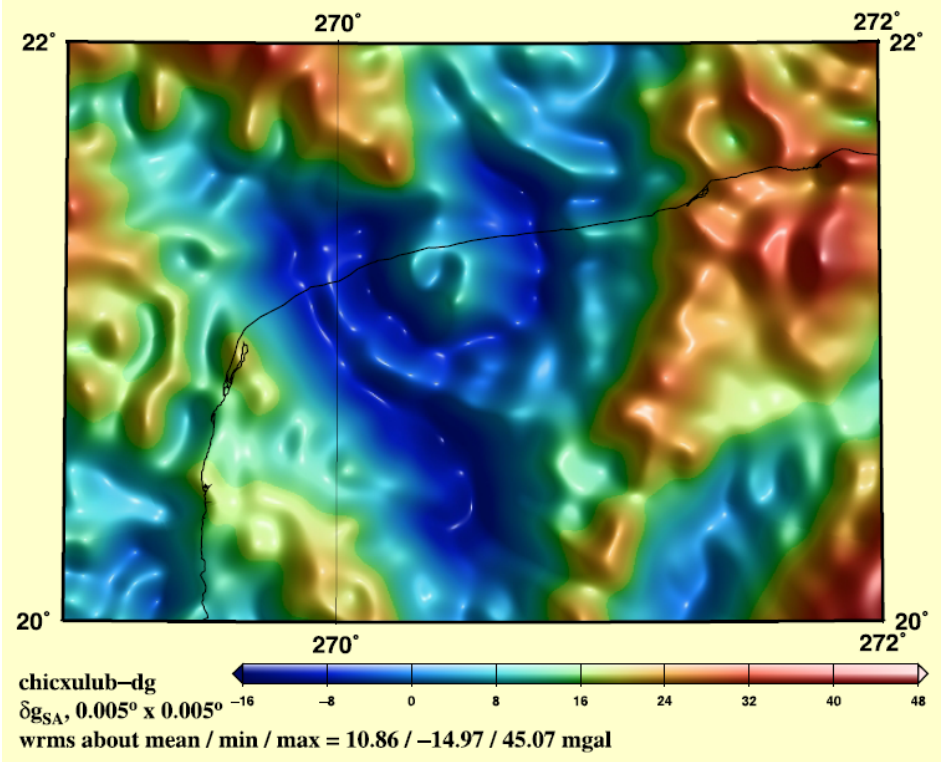

Fig. 4: Example of grid and plot generation by the calculation service: gravity disturbances of the Chicxulub crater region from the model EGM2008

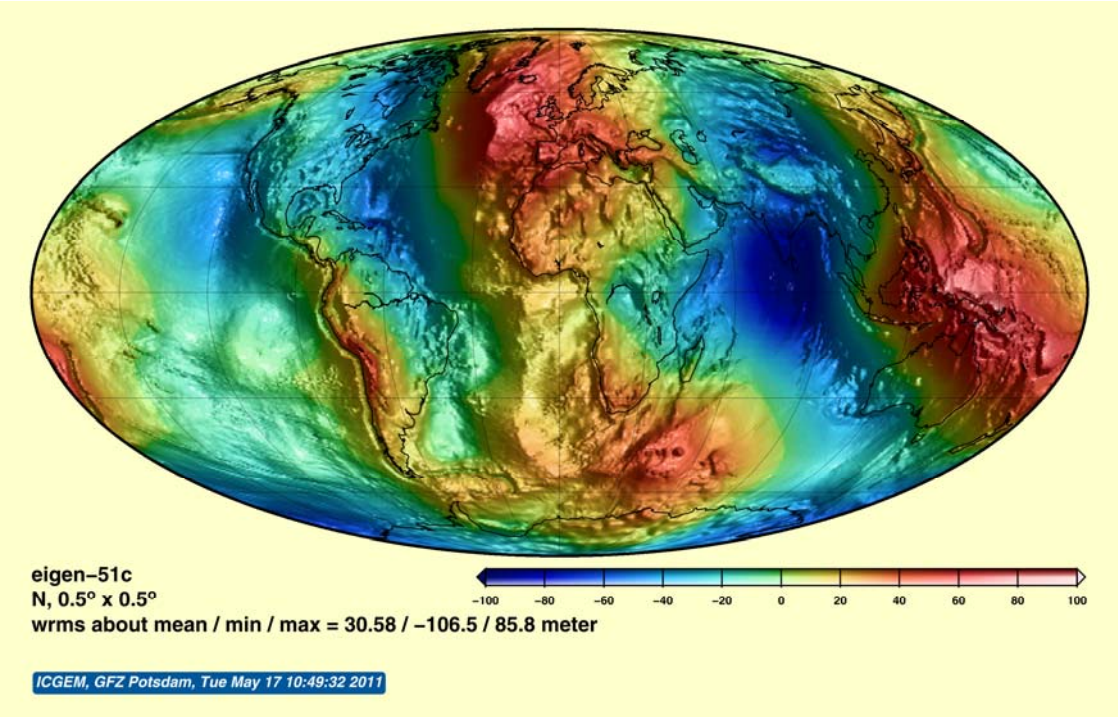

Fig. 5: Example of grid and plot generation by the calculation service: global geoid from the model EIGEN-51C

Evaluation

For a concise evaluation of the models, comparisons with GPS-levelling data and with the most recent combination model in the spectral domain are provided (see figures 6 and 7).

Model	Nmax	USA 6169 points	Canada 1930 points	Europe 1235 points	Australia 201 points
GOCO02S	250	0.435 m	0.352 m	0.434 m	0.372 m
AIUB-GRACE03S	160	0.650 m	0.514 m	0.713 m	0.486 m
GO_CONS_GCF_2_DIR_R2	240	0.443 m	0.374 m	0.449 m	0.391 m
GO_CONS_GCF_2_TIM_R2	250	0.436 m	0.355 m	0.434 m	0.376 m
GO_CONS_GCF_2_DIR_R1	240	0.407 m	0.319 m	0.402 m	0.319 m
GO_CONS_GCF_2_TIM_R1	224	0.455 m	0.378 m	0.474 m	0.371 m
GO_CONS_GCF_2_SPW_R1	210	0.471 m	0.399 m	0.498 m	0.384 m
GOCO01S	224	0.451 m	0.374 m	0.473 m	0.370 m
EIGEN-51C	359	0.335 m	0.245 m	0.289 m	0.234 m
EIGEN-5C	360	0.341 m	0.251 m	0.303 m	0.244 m
AIUB-CHAMP03S	100	0.755 m	0.743 m	1.148 m	1.148 m
EIGEN-CHAMP05S	150	0.784 m	0.763 m	1.216 m	0.661 m
ITG-GRACE2010S	180	0.548 m	0.459 m	0.595 m	0.523 m
AIUB-GRACE02S	150	0.630 m	0.571 m	0.701 m	0.495 m
GGM03C	360	0.346 m	0.279 m	0.334 m	0.259 m
GGM03S-UPTO150	150	0.641 m	0.521 m	0.710 m	0.494 m
AIUB-GRACE01S	120	0.724 m	0.628 m	0.930 m	0.563 m
EGM2008	2190	0.248 m	0.126 m	0.208 m	0.217 m
EIGEN-5S	150	0.630 m	0.547 m	0.737 m	0.475 m

Fig. 6: Table (truncated) of comparison of the models with GPS-levelling: Root mean square (rms) about mean of GPS / levelling minus gravity field model derived geoid heights [m]

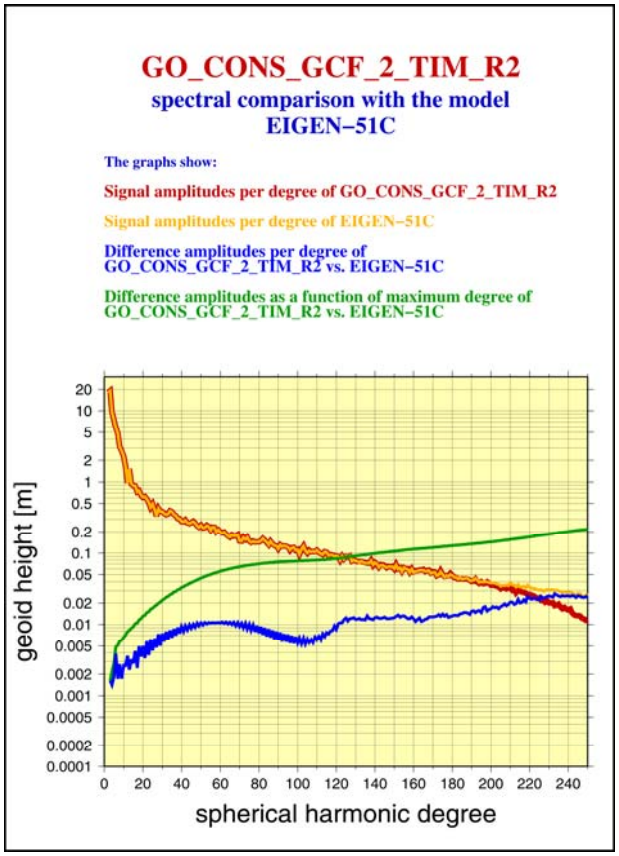

Fig. 7: Comparison of the models in the spectral domain (e.g.: GO_CONS_GCF_2_TIM_R2) with one of the most recent combination models (e.g. EIGEN-51C)

Main changes since 2006

For the calculation service the new software shm2func has been developed and installed in April 2007. Now it is possible to use the information of a digital terrain model. The topography model is used for two different purposes: (a) to calculate the exact coordinates on the Earth's surface for the height anomalies on the Earth's surface, the gravity disturbances and the modern gravity anomalies, and (b) to calculate the geoid undulations from pseudo height anomalies on the ellipsoid considering the topographical effect. For (a) bi-linear interpolation of the original ETOPO2-grid is used to calculate the positions as accurately as possible. For (b) the spherical harmonic expansion of the DTM2006 model is used which comes with EGM2008. The software was ready to calculate the Legendre functions up to degree and order higher than 2190, hence with the availability of EGM2008 (April 2008) the full service was offered for this model.

The report STR09/02 has been published where the theory and formulas of the calculation service are described.

The visualisation is now possible not only for geoid undulations but also for gravity anomalies. A new tool for the animated visualisation of monthly models has been installed.

The GPS/Levelling data (Button "Evaluation of the Models") are now compared with geoid heights instead of height anomalies.

The release-04 monthly solutions and the GRGS-10-day solutions are now also available after non-isotropic smoothing (decorrelation). For this purpose the mean model EIGEN-5C has been subtracted and to the difference the 3 different filters DDK1, DDK2, and DDK3 after Kusche et al (2009) have been applied. After filtering the mean model has been added back to ensure that they can be used in our calculation service to calculate the defined functionals.

All changes since October 2006 are recorded on the web site under the button "latest changes".

Main changes since 2009

In the calculation service the calculation of the simple Bouguer gravity anomaly has been realised.

The new models based on data of the GOCE mission have been included into ICGEM as soon as they were available.

Some ICGEM-related documents are now available for downloading, e.g. a figure which demonstrates the improvement of the global models during the past decades (see fig. 8).

Although it is not the main purpose of ICGEM, we also offer the calculation and visualisation service for some gravity field models of the celestial bodies Moon, Mars and Venus (see fig. 9).

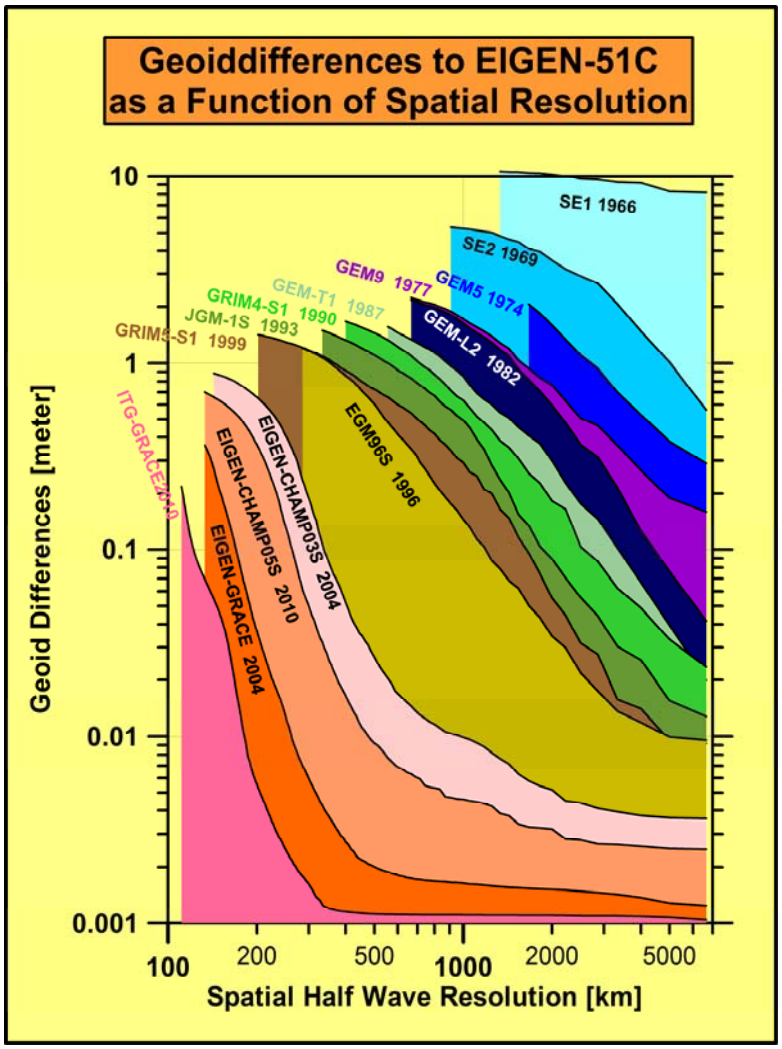

Fig. 8: Visualisation of the improvement of satellite-only models over the past decades: Geoiddifferences to the model EIGEN-51C as a function of spatial resolution.

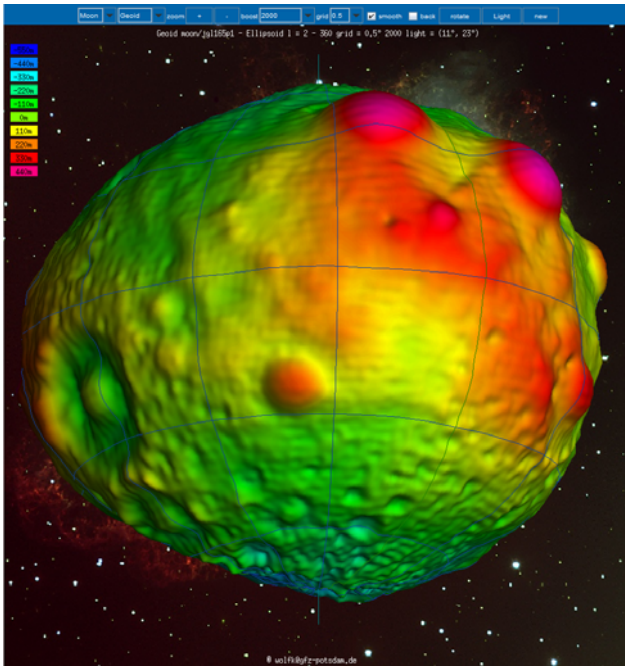

Fig. 9: Visualisation of the "Geoid" of the Moon

Publications

Kusche, J.; Schmidt, R.; Petrovic, S.; Rietbroek, R. (2009): Decorrelated GRACE time-variable gravity solutions by GFZ, and their validation using a hydrological model, Journal of Geodesy, DOI 10.1007/s00190-009-0308-3

Barthelmes, F.; Köhler (2010): ICGEM - The International Centre for Global Earth Models, Second International Symposium of the International Gravity Field Service (Fairbanks, USA 2010).

Barthelmes, F.; Köhler (2010): ICGEM – A Web Based Service for Using Global Earth Gravity Field Models, Arbeitskreis Geodäsie/Geophysik, Herbsttagung (Smolenice, Slovakia 2010)

Barthelmes, F. (2009): Definition of Functionals of the Geopotential and Their Calculation from Spherical Harmonic Models: Theory and formulas used by the calculation service of the International Centre for Global Earth Models (ICGEM), http://icgem.gfz-potsdam.de, Scientific Technical Report ; 09/02, Deutsches GeoForschungsZentrum GFZ.

Barthelmes, F.; Köhler, W.; Kusche, J. (2008): ICGEM The International Centre for Global Earth Models, Observing and Forecasting the Ocean GODAE Final Symposium (Nice, France 2008).

Barthelmes, F.; Köhler, W.; Kusche, J. (2007): ICGEM - The International Centre for Global Earth Models, General Assembly European Geosciences Union (EGU) (Vienna, Austria 2007).

Barthelmes, F.; Köhler (2006): ICGEM - The International Centre for Global Earth Models, General Assembly European Geosciences Union (EGU) (Vienna, Austria 2006).