International Centre for Global Earth Models (ICGEM)

http://icgem.gfz-potsdam.de

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Overview

The International Centre for Global Earth Models was established in 2003.

It is mainly a web based service and comprehends:

- collecting and long-term archiving of existing global gravity field models; solutions from dedicated time periods (e.g. monthly GRACE models) are included
- making them available on the web in a standardised format (self-explanatory)
- interactive visualisation of the models (geoid undulations and gravity anomalies)
- animated visualization of monthly GRACE models
- web-interface to calculate gravity functionals from the spherical harmonic models on freely selectable grids (filtering included)
- web-interface to calculate and plot the time variation of the gravity field at freely selectable positions or over defined basins → the G^3-Browser (GFZ Grace Gravity Browser)
- theory and formulas of the calculation service in STR09/02 (downloadable)
- the ICGEM web-based discussion forum (answering questions)
- evaluation of the models
- visualisation of surface spherical harmonics as tutorial

Thanks to the availability of the monthly model series from GRACE, the static models from the recent GOCE mission, and their combined models of high spatial resolution, the importance of gravity field functionals for nearly all geosciences is rising permanently. In addition to its use for educational purposes, ICGEM helps researchers from different geoscientific fields to overcome the first obstacles in using these models and to get acquainted with the mathematical representation of gravity field in terms of spherical harmonic series. In this way ICGEM enables and stimulates the research based on these products, which are primarily the result of rapid and fruitful development of the satellite based geodetic gravity field determination methods in the past decades.

To avoid the latest restrictions concerning Java Applets, since 2015 all web-interactions are implemented in Java Script and should run on all operating systems and browsers including tablet computers and smartphones.

Services

The Models

Currently, 149 models are listed with their references and 135 of them are available in form of spherical harmonic coefficients. If available, the link to the original model web site or to a freely available publication has been added. Models from dedicated time periods (e.g. monthly solutions from GRACE) of different analysing centres 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 (fig. 1). Differences of two models, arbitrary degree windows, zooming in and out, are possible. To get an impression of the time variations there is an animation of the monthly solutions (fig. 2). The visualisation of single spherical harmonics is possible for tutorial purposes.

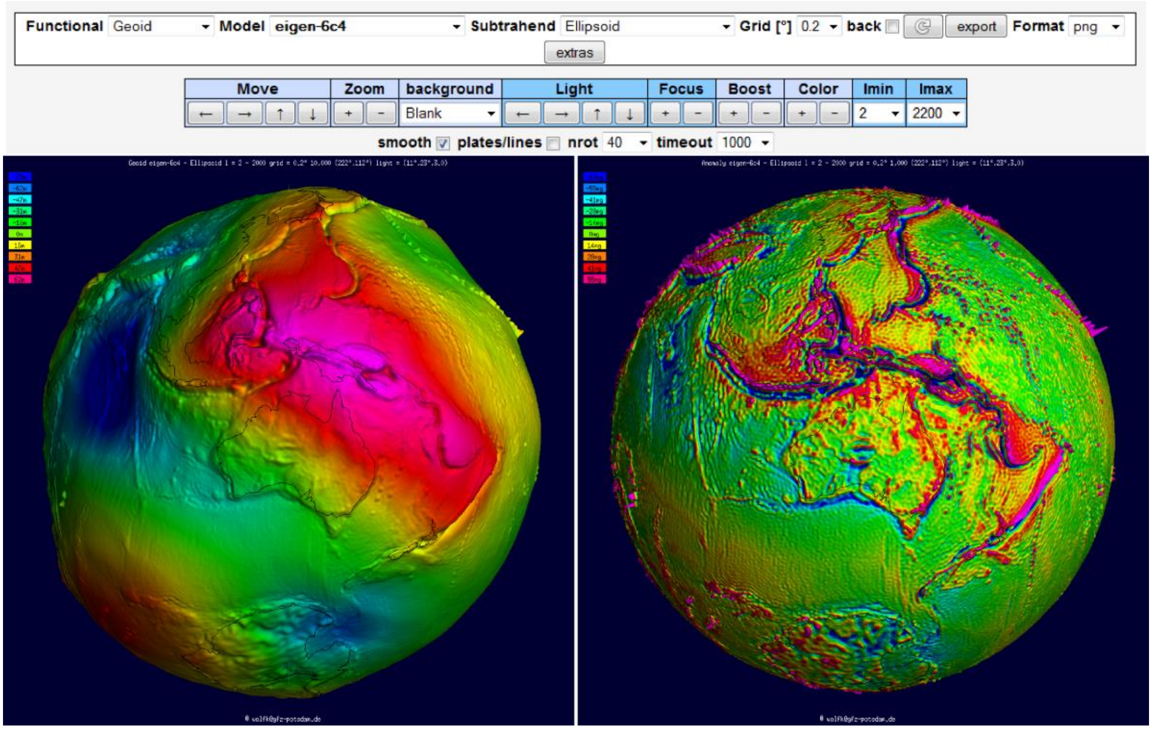

Fig. 1: Visualisation of a global gravity field model, geoid undulations (left) and gravity anomalies (right)

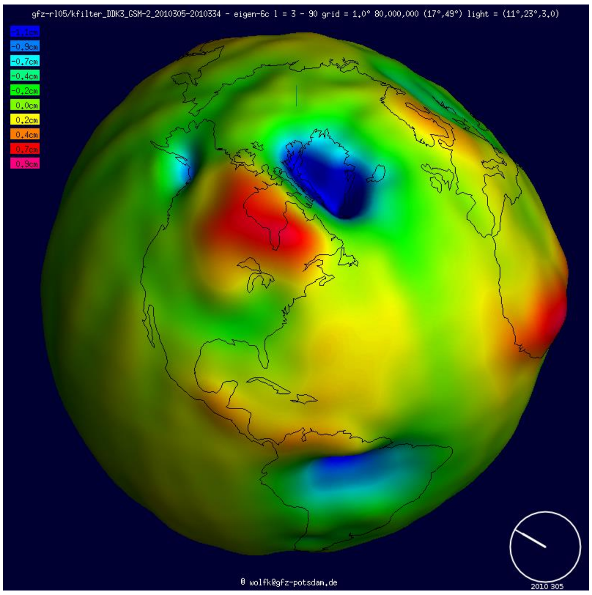

Fig. 2: Snapshot from the animation of the monthly models: geoid differences of the model for November 2010 to the mean model EIGEN-6C. Visible are the effect of mass loss (blue) due to deglaciation during the last years in Greenland and Alaska (eyes ☺), as well as the snapshot of the annual hydrological mass variations in the basin of the Amazon (mouth ☺), and the effect of increasing mass (red) due to postglacial uplift in North America (nose ☺).

The G³-Browser (GFZ Grace Gravity Browser)

To calculate and visualise the time variation of the gravity field at any desired point on the Earth or as mean over predefined basins, a specific web-interface has been developed. The results can be downloaded as plots or ASCII data. Figures 3 and 4 show to examples.

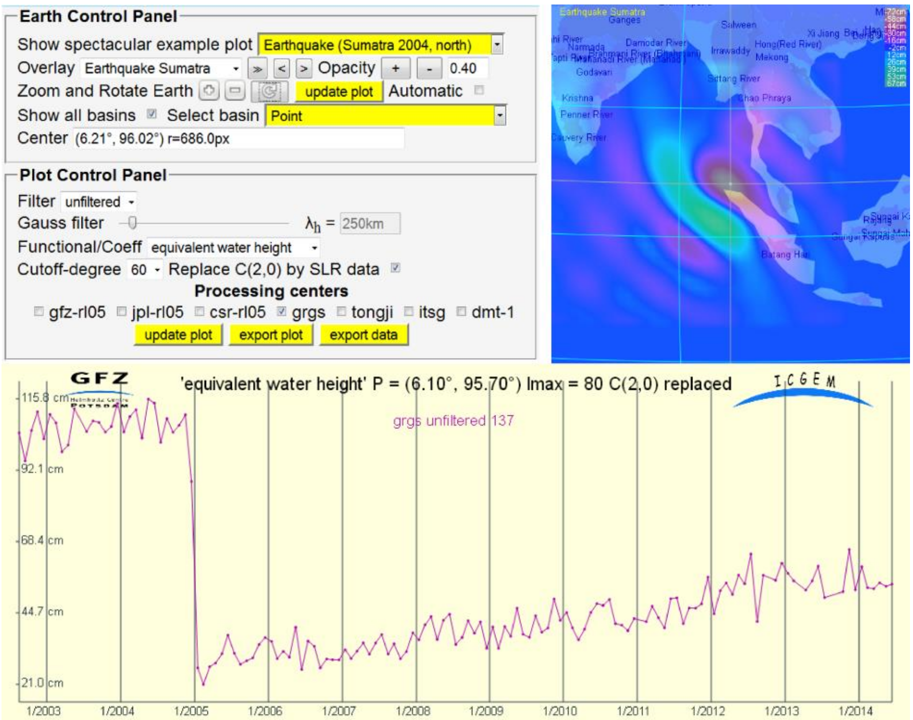

Fig. 3: Snapshot of the G³-Browser; selected is a point affected by the Sumatra earthquake of 2004; the time series is computed from the GRGS monthly solutions

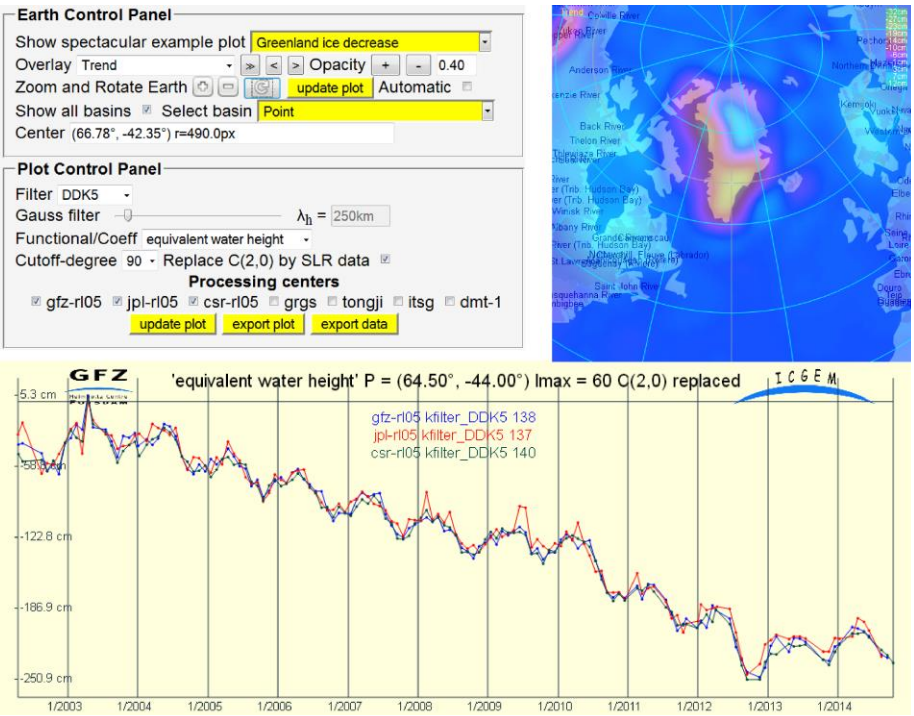

Fig. 4: Snapshot of the G³-Browser; the plot shows the time series of the anisotropically filtered (DDK5) monthly solutions from GFZ, JPL and CSR at a point affected by the ice loss in Greenland

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)
- potential on the ellipsoid (or at arbitrary height over the ellipsoid, without centrifugal potential)
- second derivative in spherical radius direction of the potential (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 or png-format) 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

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Figure 5 shows the input mask of the calculation service and figures 6 to 8 show examples of plots (based on the grids) generated by the calculation service.

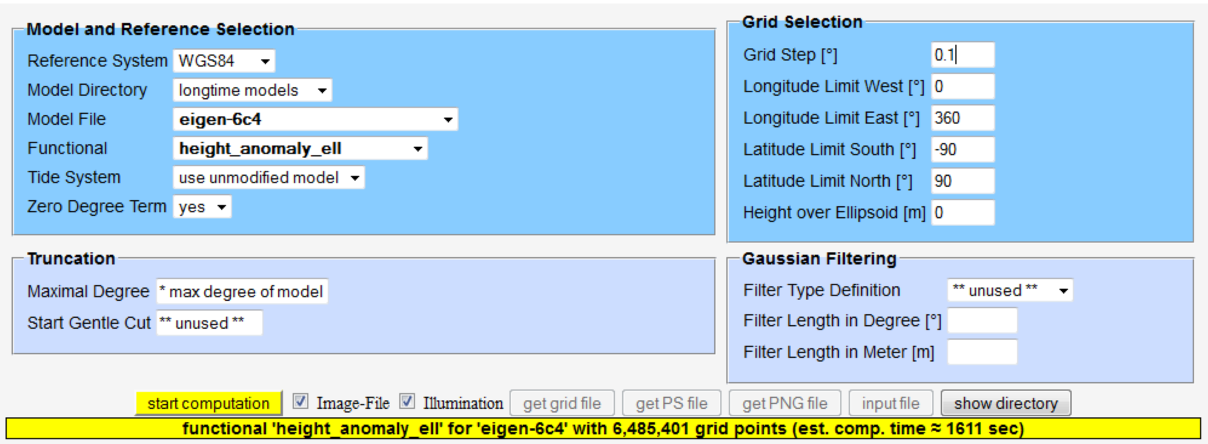

Fig. 5: Input mask of the calculation service

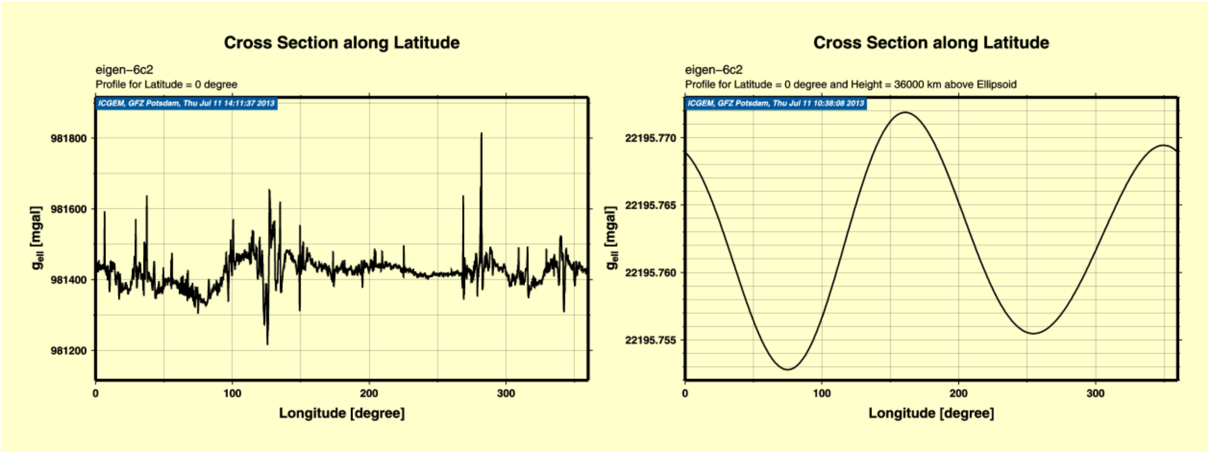

Fig. 6: Example of grid and plot generation by the calculation service: gravitation along the equatorial cross section on the ellipsoid (left), and 36000 km above the ellipsoid (right) from the model EIGEN-6C2

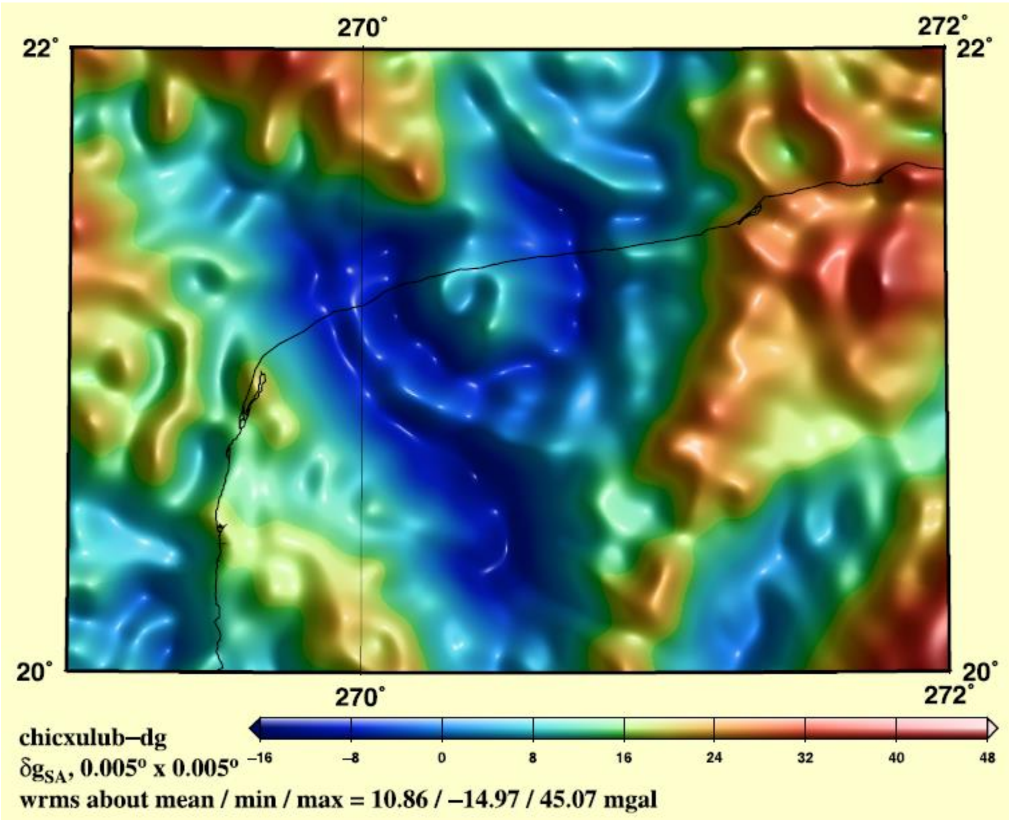

Fig. 7: Example of grid and plot generation by the calculation service: gravity disturbances of the Chicxulub crater region from the model EGM2008

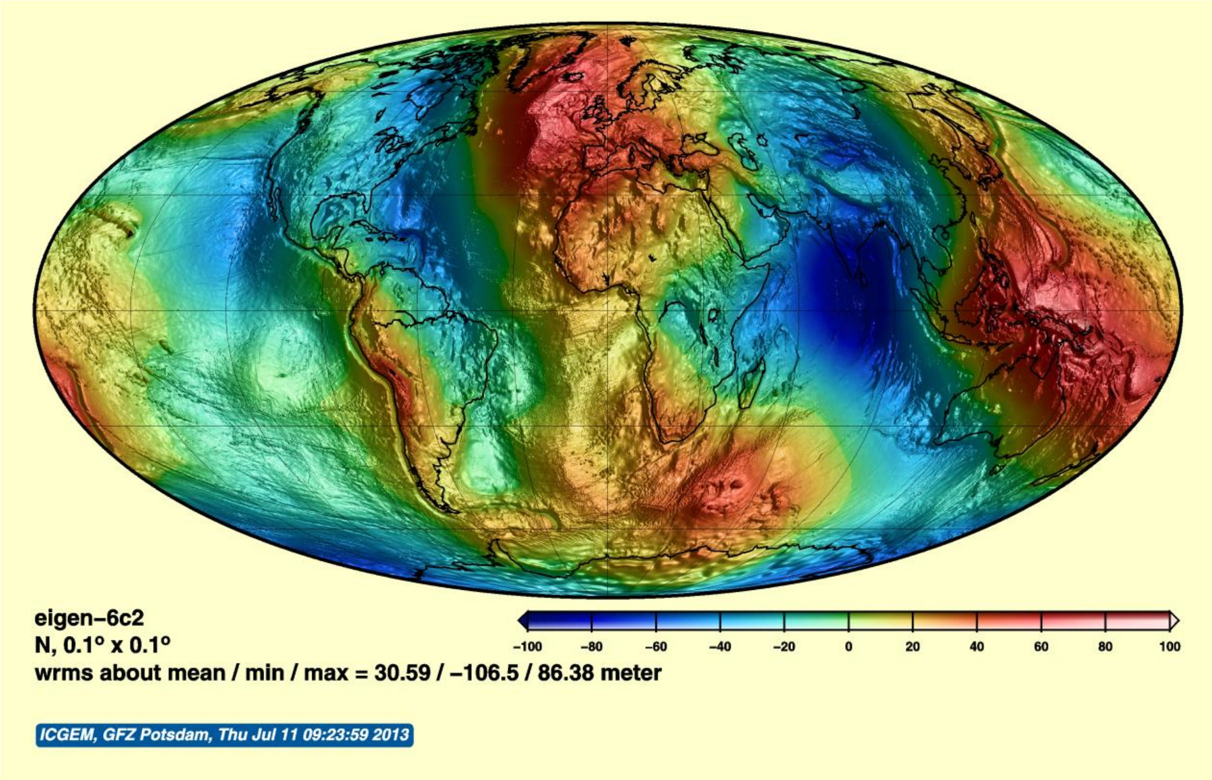

Fig. 8: Example of grid and plot generation by the calculation service: global geoid undulations from the model EIGEN-6C2 (with respect to WGS84)

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 9 and 10). A visualisation of the improvement of the satellite-only models over the past decades is also provided (fig. 11).

The table is interactively re-sortable for all columns by clicking in the header cells.

Nr	Model ⇅	Nmax ⇅	USA ⇅ 6169 points	Canada ⇅ 2691 points	Europe ⇅ 1235 points	Australia ⇅ 201 points	Japan ⇅ 816 points	Brazil ⇅ 1112 points	All ▲ 12224 points
134	EIGEN-6C4	2190	0.247 m	0.126 m	0.210 m	0.212 m	0.079 m	0.446 m	0.2408 m
125	EIGEN-6C3STAT	1949	0.247 m	0.129 m	0.212 m	0.213 m	0.078 m	0.447 m	0.2415 m
117	EIGEN-6C2	1949	0.249 m	0.129 m	0.212 m	0.214 m	0.080 m	0.445 m	0.2423 m
112	EIGEN-6C	1420	0.247 m	0.136 m	0.214 m	0.219 m	0.082 m	0.448 m	0.2429 m
91	EGM2008	2190	0.248 m	0.128 m	0.208 m	0.217 m	0.083 m	0.460 m	0.2439 m
111	GIF48	360	0.319 m	0.209 m	0.275 m	0.236 m	0.275 m	0.474 m	0.3082 m
100	EIGEN-51C	359	0.335 m	0.234 m	0.289 m	0.234 m	0.312 m	0.476 m	0.3242 m
99	EIGEN-5C	360	0.341 m	0.278 m	0.303 m	0.244 m	0.339 m	0.524 m	0.3444 m
86	EIGEN-GL04C	360	0.339 m	0.282 m	0.336 m	0.244 m	0.321 m	0.541 m	0.3484 m
94	GGM03C	360	0.347 m	0.337 m	0.334 m	0.259 m	0.316 m	0.513 m	0.3588 m
81	EIGEN-CG01C	360	0.351 m	0.335 m	0.370 m	0.263 m	0.351 m	0.543 m	0.3700 m
84	EIGEN-CG03C	360	0.346 m	0.373 m	0.355 m	0.260 m	0.326 m	0.534 m	0.3714 m
131	GO_CONS_GCF_2_TIM_R5	280	0.398 m	0.310 m	0.371 m	0.336 m	0.450 m	0.505 m	0.3919 m
130	GO_CONS_GCF_2_DIR_R5	300	0.405 m	0.299 m	0.373 m	0.327 m	0.447 m	0.507 m	0.3937 m
118	GO_CONS_GCF_2_DIR_R4	260	0.404 m	0.322 m	0.393 m	0.337 m	0.476 m	0.512 m	0.4020 m
127	EIGEN-6S2	260	0.405 m	0.322 m	0.393 m	0.337 m	0.476 m	0.512 m	0.4025 m

Fig. 9: 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]

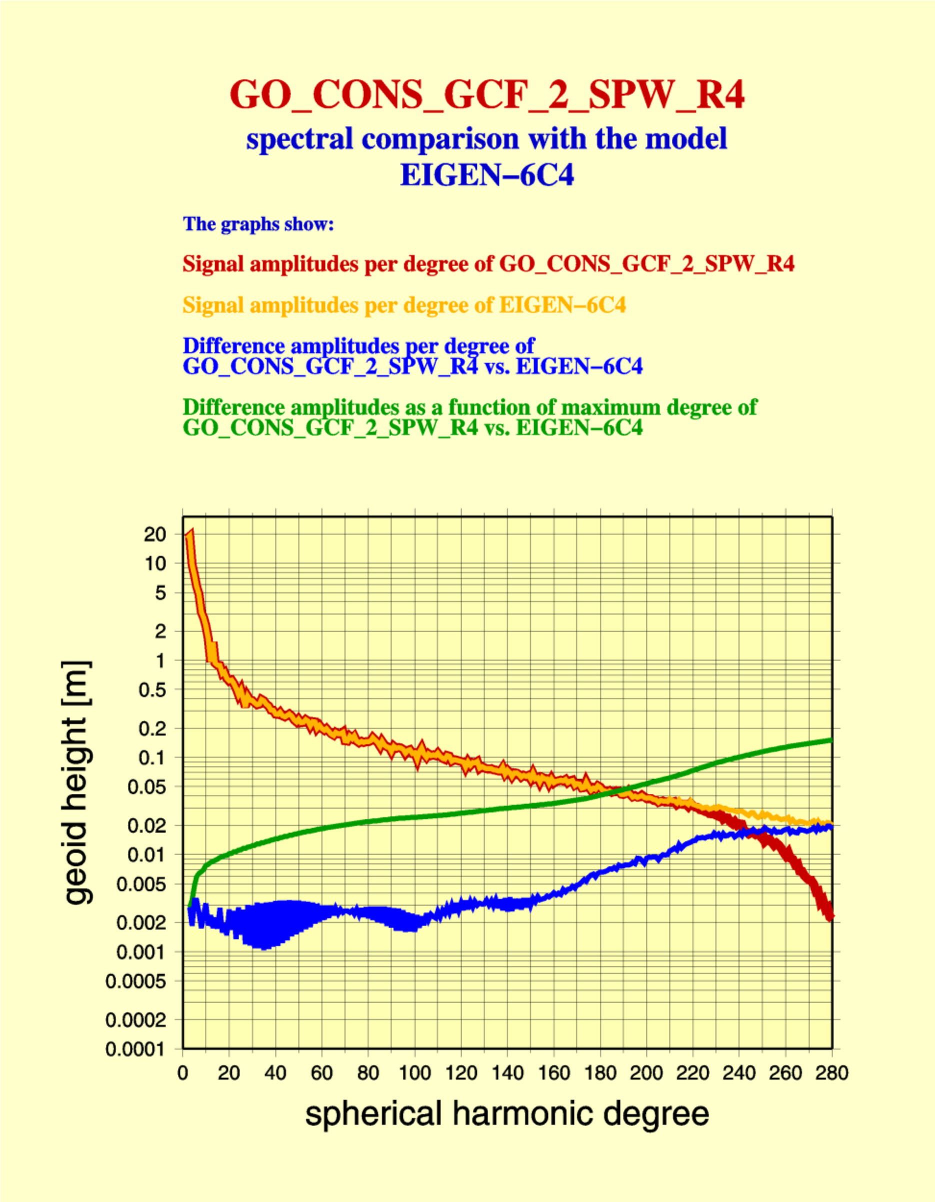

Fig. 10: Comparison of the models in the spectral domain (e.g.: GO_CONS_GCF_2_SPW_R4) with one of the most recent combination models (e.g. EIGEN-6C4)

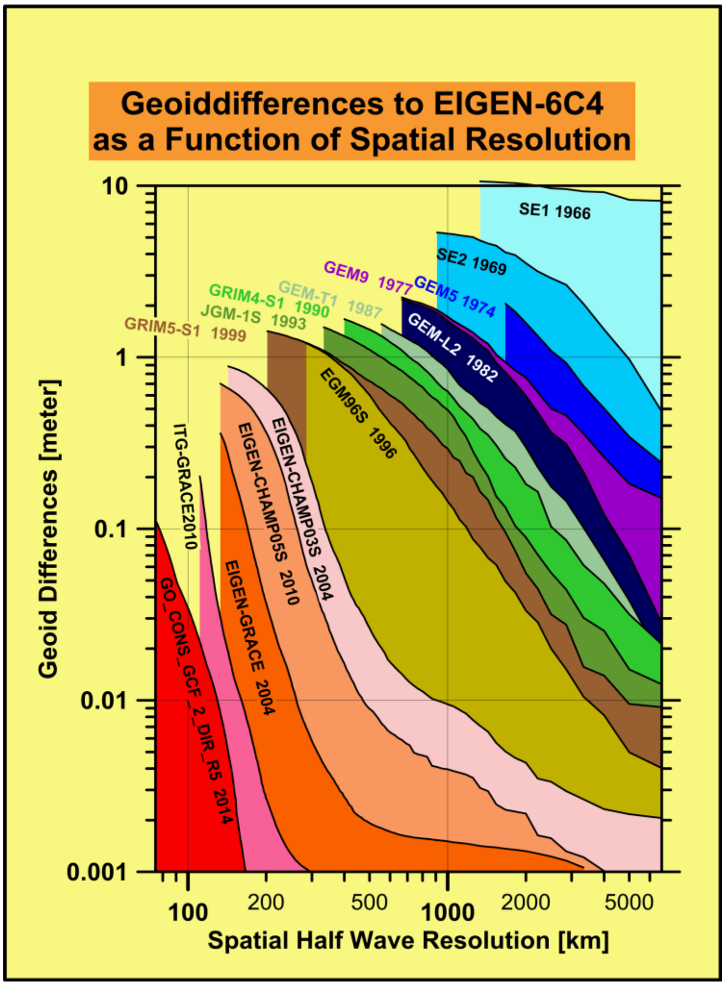

Fig. 11: Visualisation of the improvement of satellite-only models over the past decades: Geoiddifferences to the model EIGEN-6C4 as a function of spatial resolution.

Publications

Barthelmes, F.; Köhler, W., 2012: International Centre for Global Earth Models (ICGEM), Journal of Geodesy, The Geodesists Handbook 2012, 86(10), 932-934.

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

Barthelmes, F.; Köhler, W. (2010): ICGEM - a Web Based Service for Using Global Earth Gravity Field Models. IAG Symposium on Terrestrial Gravimetry: Static and Mobile Measurements (TG-SMM2010) (Saint Petersburg, Russia 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, Revised Edition, January 2013, Deutsches GeoForschungsZentrum GFZ, DOI 10.2312/GFZ.b103-0902-26

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).