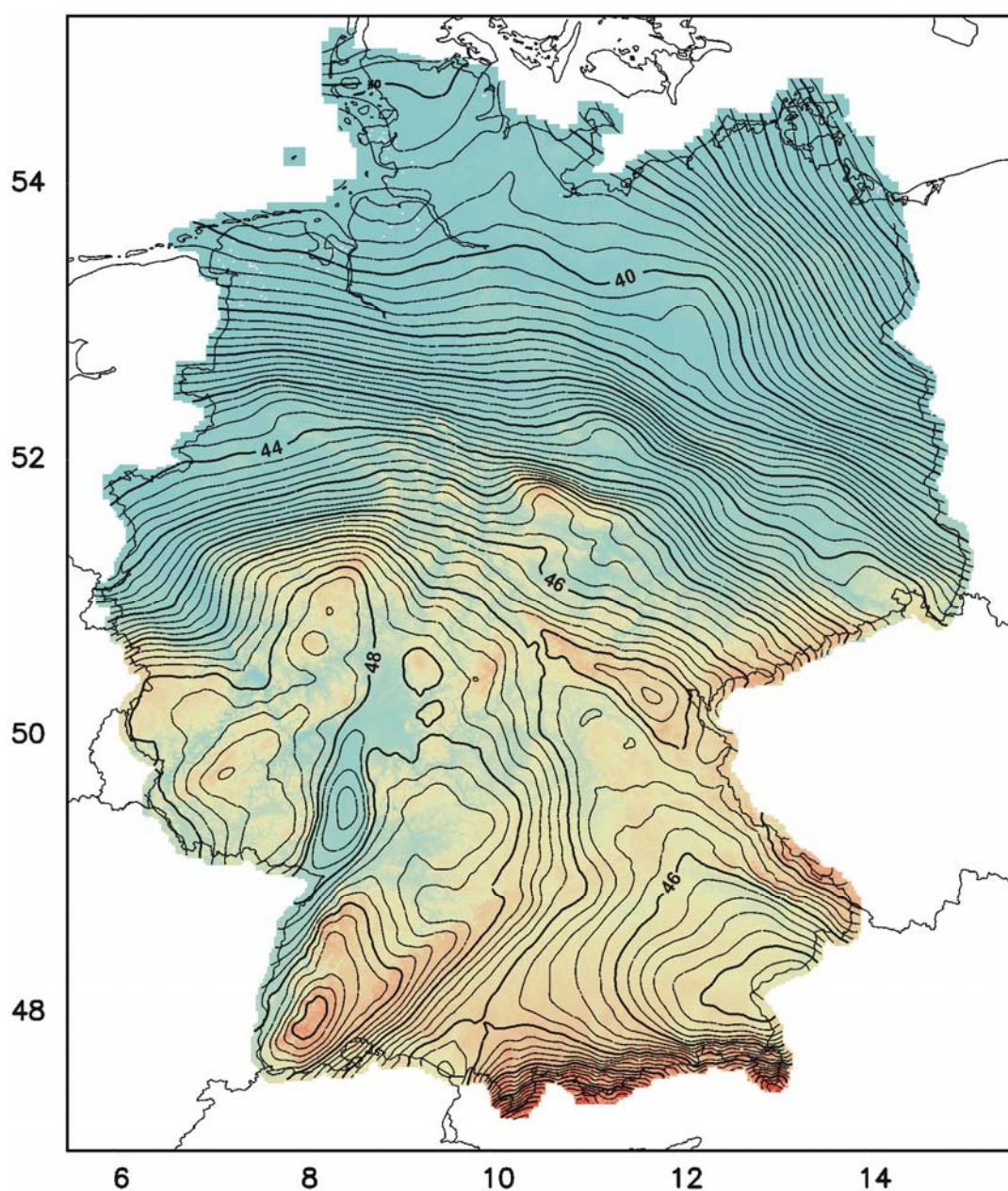


## Quasigeoid of the Federal Republic of Germany

The height reference surface of the Working Committee of the Surveying Authorities of the States of the Federal Republic of Germany

### **GCG05**

(German Combined QuasiGeoid 2005)



Status of documentation: 30.01.2009

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## 1 Dataset overview

<b>Product</b>	: GCG05
<b>Contents</b>	: The data set contains the quasigeoid model for the area of the Federal Republic of Germany called GCG05. It was derived due to the combination of ellipsoidal heights obtained by GPS measurements, normal heights in the German national height system and gravimetric observations. It is a combination of two independent solutions of the BKG and the Institute of Geodesy of the University of Hannover (IfE). The model can be used to transform ellipsoidal heights in the ETRS89 into heights of the German national height system DHHN92 (NHN) and vice versa with an accuracy of 2 cm.
<b>Area</b>	: Territory of the Federal Republic of Germany (cf. detailed information under 2.)
<b>Spatial classification</b>	: Grid file 1' x 1,5'
<b>Georeferencing</b>	: ETRS89 in relation to the reference ellipsoid GRS80 and levelling heights in the German national height system DHHN92
<b>Source</b>	: – Quasigeoid heights (height anomalies), derived from ellipsoidal heights in the ETRS89 and normal heights in the DHHN92 – Mean gravity anomalies (corresponding to the German national gravity system DHSN96) – Digital terrain model 1'x1,5' (Base DGM25 within Germany and DTED level1 outside) – Global geopotential model CG01C of GFZ Potsdam
<b>Production method</b>	: The product is created by averaging two independent solutions a) BKG: point mass adjustment, basing on a remove-restore technique b) IfE: integration and collocation method, basing on a remove-restore technique, too.
<b>Resolution</b>	: Horizontal position: geogr. latitude 1', geogr. longitude 1,5' (ca. 1,8 km x 1,7 km) vertical: 0.5 mm
<b>Accuracy</b>	: Elevation: 1 - 2 cm (German Alps, Baltic Sea 3 – 4 cm)
<b>Data formats</b>	: – ASCII (L, L, E) – Binary incl. access program (interpolation program) – Trimble format (.GGF)
<b>Data carrier</b>	: CD-ROM

## 2 Description of data contents

The determination of the quasigeoid started in 1993 is performed as a joint project in cooperation with the Vermessungsverwaltungen der Länder (State Survey Offices).

By means of the quasigeoid of the Federal Republic of Germany the conditions are created for the transition between ellipsoidal heights in the ETRS89 and normal heights in the German national height system DHHN92 with an accuracy of 1 ... 2 cm.

Conversion is possible throughout Germany without any local corrections. By means of satellite positioning service SAPOS normal heights can thus be derived in the DHHN92:

$$H^{DHHN} = h^{ETRS} - \zeta_{DHHN}^{ETRS}$$

For the determination of the quasigeoid the following data have been used:

- app. 900 quasigeoid heights ( $\zeta_{SN}$ ) derived from GPS measurements (observation time 2 x 24 h, partly 2 x 8 h) in the ETRS89 and normal heights in the German national height system DHHN92
- Mean gravity anomalies ( $\Delta g_F$ ) derived from 400 000 point gravity values of the state survey offices, the IfE Hannover, the DGFI München, the Federal Maritime and Hydrographic Agency (BSH) in Hamburg, the Employers' Association of Oil and Gas Production and the neighbouring countries of Germany.
- Digital terrain model, basic resolution 50 m x 50 m (DGM25) within Germany resp. 90 m x 90 m (DTED level1) outside.
- Global geopotential model CG01C.

The method of computation of the BKG is based on the adjustment of point masses in connection with a remove-restore technique.

At first the observations (GPS- and levelling heights, mean free air anomalies) are reduced by the influence of the topography and the part of a global geopotential model. After the adjustment these parts are added back to the computed quasigeoid heights.

3 levels of grids of point mass points are introduced as unknowns:

Level		Grid width
1	5 km	2' x 3'
2	30 km	0,2° x 0,3°
3	200 km	1° x 1,5°

The method of computation of the IfE is based on a remove-restore technique too. First in a two-step solution method free air anomalies and topographical data together with a global geopotential model are combined by an integration approach to a gravimetrical solution of the quasigeoid. In a second step the GPS- and levelling heights are included by a collocation approach.

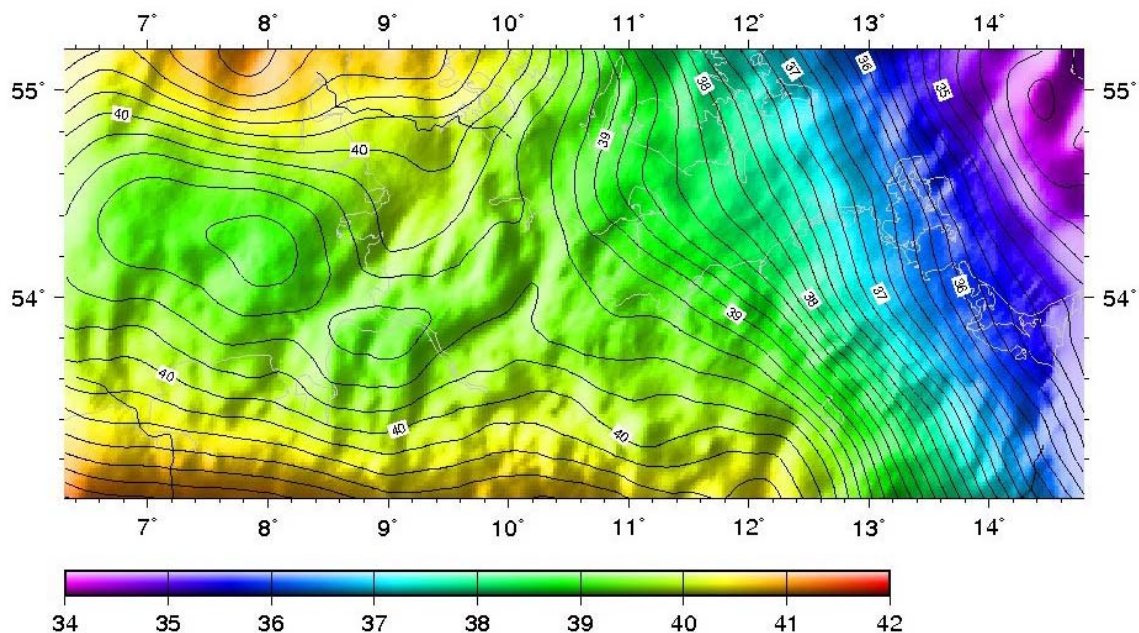
Finally, the computed quasigeoid heights of both model have a mean agreement of better than 0.1 mm (Baltic Sea 2mm), the standard deviation is 3 mm (Baltic Sea 13mm). The final quasigeoid is obtained by averaging the quasigeoid heights of both models.

Modelling is performed for the whole area of Germany, alternatively for 4 partial regions:

Northeast:	Berlin, Brandenburg, Mecklenburg-Vorpommern, Sachsen, Sachsen-Anhalt, Thüringen
South:	Baden-Württemberg, Bayern
West:	Hessen, Nordrhein-Westfalen, Rheinland-Pfalz, Saarland
Northwest:	Bremen, Hamburg, Niedersachsen, Schleswig-Holstein
Coast:	Extended model of the coastal region of Germany up to 55.2°

The grid width in each model is 1'x 1,5' in geographical coordinates.

Extension of the coastal model:



### 3 Data volume

The data volume of the whole dataset reaches for the different data formats:

Specification	Data volume	
	BRD total	Partial regions ca.
ASCII	4850 KB	1600 KB
Binary	690 KB	230 KB
GGF	690 KB	230 KB

### 4 Information on the data supply

In all formats and for all regions the quasigeoid heights are contained only at raster points situated within the territory of the FR of Germany. Raster points situated outside the boundaries of the FRG contain a pseudo-value as quasigeoid height. Within the grid the quasigeoid heights are available in sorted form: 1<sup>st</sup> sorting according to descending geographical latitude, 2<sup>nd</sup> sorting according to ascending geographical longitude.

### 5 Description of data formats

#### 5.1 ASCII format

The ASCII file contains per raster point one dataset consisting of the horizontal position of the respective point (in degrees) and the pertaining quasigeoid height (in m). The columns are separated by a blank space. As file extension „.txt“ is used as standard.

As pseudovalues applying outside the FRG the value "999999." has been entered.

Example:

53.641667 13.8625 36.483

53.641667 13.8875 36.438

...

## 5.2 Binary format

The binary file of the quasigeoid heights consists analogously to the EGG97 geoid (Denker et al.) of 4 byte values that have been stored continuously in series. The first 18 data fields forming a header serving the description of the raster, which consists of 3 integer values each (degree, minutes, seconds\*1000000) for min. geod. latitude, max. geod. latitude, min. geod. longitude, max. geod. longitude, grid distance in latitude, grid distance in longitude. The quasigeoid heights in 1/10 mm (or as binary 99999999 for pseudovalues applying outside the FRG) follow for the respective raster as real values.

In addition, an interpolation program serving the interpolation of quasigeoid heights at any points (within Germany) is supplied for this version (bicubic spline interpolation):

gintbs.exe    Input:    - File of the respective quasigeoid model  
                          - File of the coordinates of the points at which the quasigeoid height is to be interpolated (lat, lon, ellipsoidal resp. normal height or lat, lon, only; arbitrarily divided into decimals and separated by blank spaces)  
                          - The file names are queried by the program via dialogue  
          Output:    - File with lat, lon and interpolated quasigeoid heights. Depending on the choice the normal height or ellipsoidal height follows.  
                          - The File name is queried by the program via dialogue.

Example of a coordinate file:

49.027 11.287654987

51.2000001 13.9

48.55 9.0124

etc.

This format is also used for the integration into the GART-2000-Software of TOPCON devices.

Similarly this format is used for the integration into the SKI Pro-Software of LEICA. In this case the file of the used quasigeoid model is to be renamed to "GCG05\_da" and the program "gintleic.exe" must be used for interpolation.

The file of the quasigeoid model and the interpolation program must be located in the same directory. Input/output of the coordinates/quasigeoid heights is controlled by SKI Pro.

For the application under WINDOWS there is a graphical interface "geoid.exe" available, which allows transformations between different coordinate systems in addition to the computation of quasigeoid heights too.

Content and handling is described in the file "geoid.readme".

## 5.3 TRIMBLE format

Special data format serving the linkage of the module „GridFactory“ of the Trimble Geomatics Office Software. As file extension ".GGF" is used as standard.



## 6 Other

As a standard, supply is ensured for the WINDOWS (95/98/NT/2000XP) operating system and for LINUX. Delivery covers in each case all formats including interpolation program and documentation. The README-file contains information about the contents of the CD, advices for the installation and handling of the interpolation program. Additionally, on the Internet page of BKG single point interpolation will be offered as a free online service.

## 7 Ordering and other services

Orders can be performed through our **online ordering system** under [www.geodatenzentrum.de](http://www.geodatenzentrum.de) → *ordering*.

Orders may also be sent to the following address:

Bundesamt für Kartographie und Geodäsie  
Referat GI1  
Richard-Strauss-Allee 11  
D-60598 Frankfurt am Main

Tel.: (069) 63 33 - 349 oder 400  
Fax: (069) 63 33 - 441  
E-Mail: [geodateninfo@bkg.bund.de](mailto:geodateninfo@bkg.bund.de)

Further information and services can be found under [www.geodatenzentrum.de](http://www.geodatenzentrum.de).