Geodetic Networks, Gravity and the Geoid

by

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Abstract: Ellipsoidal or Cartesian coordinates of points at the surface of the Earth are today determined using a combination of space techniques and traditional observations. The calculated associated ellipsoidal heights may be converted to heights above mean sea-level (orthometric or normal heights) using the knowledge of the geoid.

The height of the geoid may be calculated from available spherical harmonic series, regular grids of pre-calculated geoid heights or by using the heights of the points in a levelling network with known ellipsoidal heights.

Gravity values may be obtained by interpolation in the points of a gravity network or observed with a gravimeter. These gravity values may be used locally to determine geoid height differences or improve values calculated from a spherical harmonic expansion. This is due to the very strong (70 % - 90 %) correlation between residual gravity anomalies and residual geoid heights obtained by subtracting the contribution from a spherical harmonic expansion and the residual topography from the original gravity and geoid height values.

Using a few simple examples it is shown how gravity information may be used to support the calculation of geoid height differences and thereby the transfer of physical heights between points in a geodetic network.

It is finally pointed out, that geoid and gravity data may be used to calculate the deflections of the vertical which are needed in order to rigorously combine points in a network determined with space techniques and "ex-centric" points determined by traditional types of geodetic measurements. Differences between deflections of the vertical determined by gravity data will generally be superior to values obtained by astronomical methods.

Presented at "WHERE ARE WE GOING ?", A symposium to mark the retirement of Professor Vidal Ashkenazi, Nottingham, UK, October 1998.

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http://www.gfy.ku.dk/~cct/

http://www.gfy.ku.dk/~iag/

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NETWORKS TODAY ESTABLISHED USING :

SPACE TECHNIQUES (GPS)

TRADITIONAL ANGLES & DISTANCES

Ellipsoidal height (h) determined - **not** some type of height above mean sea level.

In practice needed

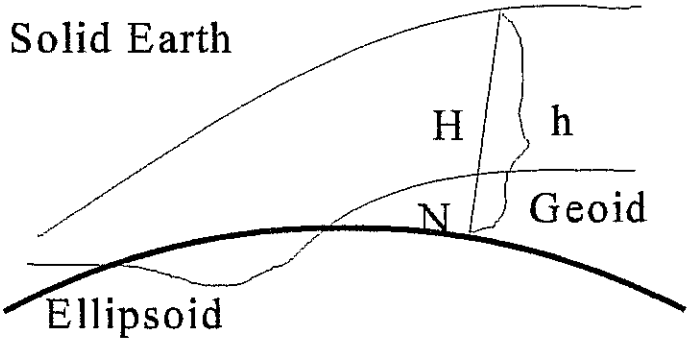
Normal heights H^*

Orthometric heights H.

In the following we will generally make no distinction.

Conversion possible if geoid height, N, known:

$H = h - N.$



When connecting local points with points in a "GPS-network" using any kind of angular information (directions/height angles)

Deflections of the vertical in WGS84 are needed if highest precision is needed.

Very typical deflections: 5"

Corresponds to 2.5 cm/km in altitude.

If geoid is available with precision 1 cm/km then we can make reasonable corrections !

Available Geoid Information

Spherical Harmonic Series:

Name	Max. Degree	Resolution
OSU91A	360	55 km
EGM96	360	55 km
GPM98	1800	11 km

Very easy to use.

Estimates of geoid

as well as of

Gravity and deflections of the vertical

Easily computable in arbitrary points.

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Errors due to

missing gravity data

missing density information in topographic reductions

low-degrees calculated from satellite orbit pertubations, with non-uniform distribution of orbit inclinations.

Error often has character of a bias, which may be determined from point with known height above mean-sea level and ellipsoidal height (GPS levelling).

If more points available then error may be represented as bi-linear surface in (N, E) or (latitude, longitude). May be determined "in the field" by a surveyor.

May also be used to correct deflections of the vertical.

Grids of geoid heights.

Values computed from gravity, topography and spherical harmonic expansion (SHE).

Values in arbitrary points obtained by interpolation in grid.

Deflections computable from grid values. Difficult to get gravity ("inverse Stokes").

Errors same as for SHE, but resolution locally much better, if local data has been used. On sea erroneous, if gravity from satellite radar altimetry has been used.

Example: EGG97.

GPS-Levelling:

observed geoid heights in local system (no bias).

Problem: Systematic and gross errors in levelling, especially at higher altitudes.
1 % probability for gross-error !

Values given in irregular grid

No values at sea, so interpolation difficult close to coast.

Levelling points often difficult to access (covered by earth, vegetation).

Information not always readily accessible. Data-base needed. (Goal of International Geoid Service).

Compute your own geoid !

Many methods available:

Stokes (integration, FFT) - only gravity data

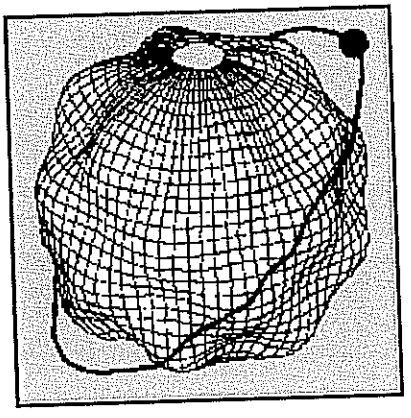
Least-squares collocation - all data types can be used, but use of method requires special expertise.

International Geoid Service (IGeS) organizes schools. **Lecture notes** available from Milano.

Software available from different sources (IGeS, GRAVSOFT, ..)

Gravity Data from Bureau Gravimetrique International. **Topography** from World data Centres. SHE-**coefficients** from IGeS.

WELCOME TO IGeS



International Geoid Service

IGeS Geoid Repository

Bulletins

School, Seminar, etc.

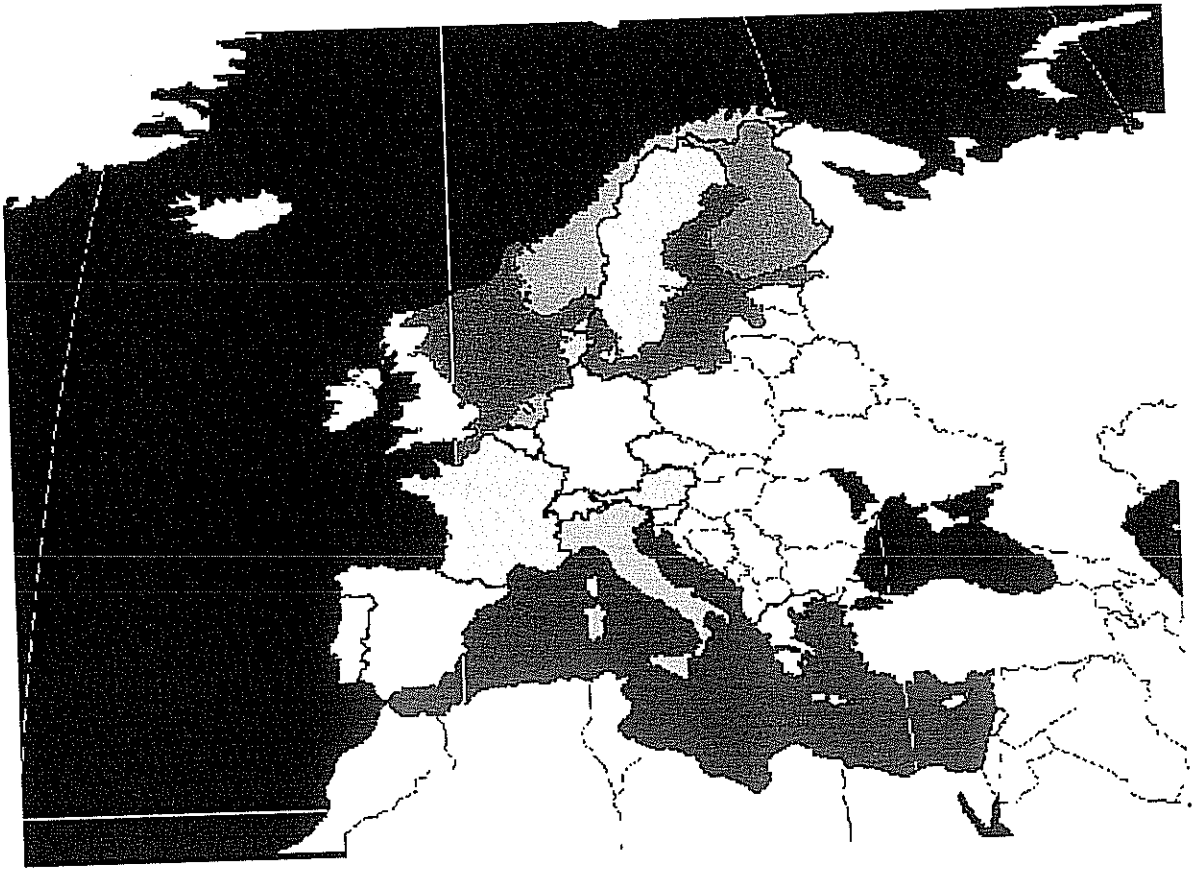
SAGE project

Links

For any information: e-mail: iges@ipmtf4.topo.polimi.it

Europe Map

Click on the map to select a geoid



IGeS Files Repository - Baltic

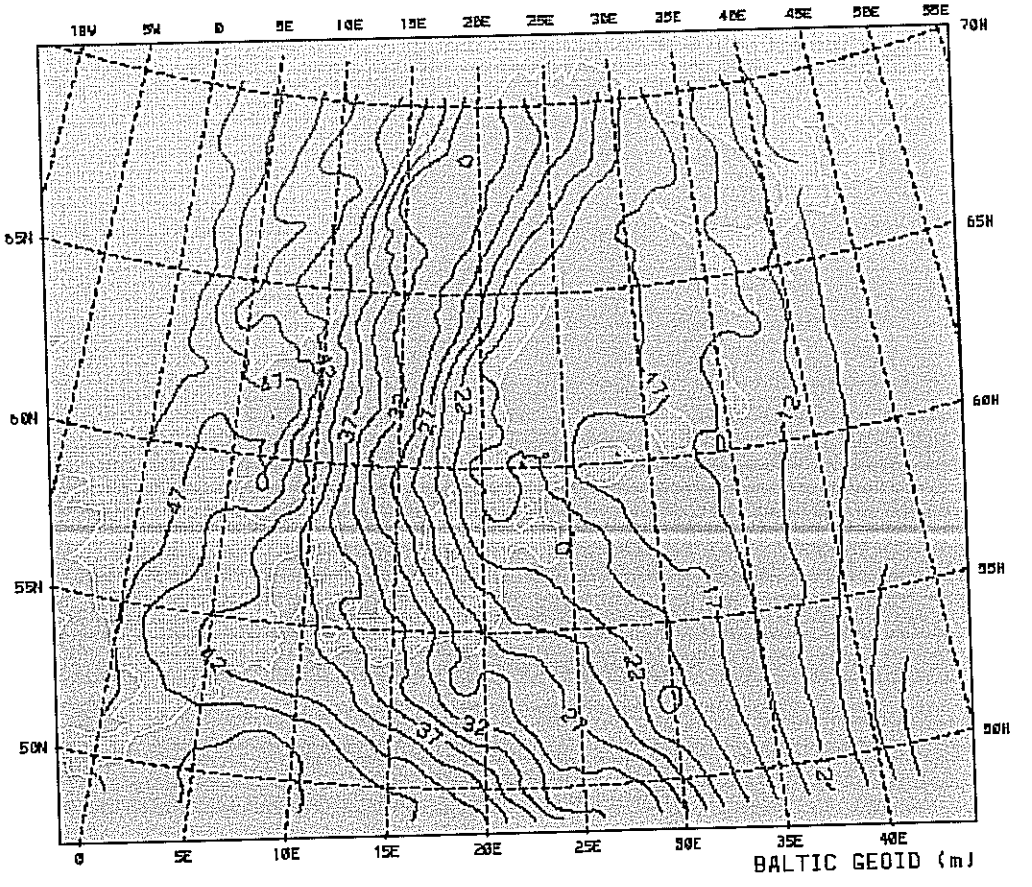
Author: Martin Veermer | Created: 1995 | RSP: Martin Veermer

Format:GRD | Size: 674.638 bytes | Status: PUBLIC

Description:

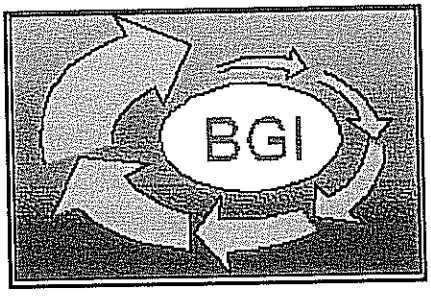
- a header (unit degree)
southern latitude northern latitude
western longitude eastern longitude
latitude increement longitude increeement
- the geoid undulation (in meters) from north to south
and from west to east

Retrieve file: bsl95a.gra.gz | Send email: mv@fgi.fi

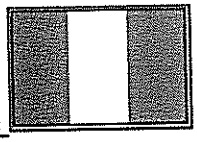


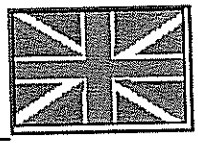
BUREAU GRAVIMETRIQUE INTERNATIONAL

Bienvenue au



Welcome to

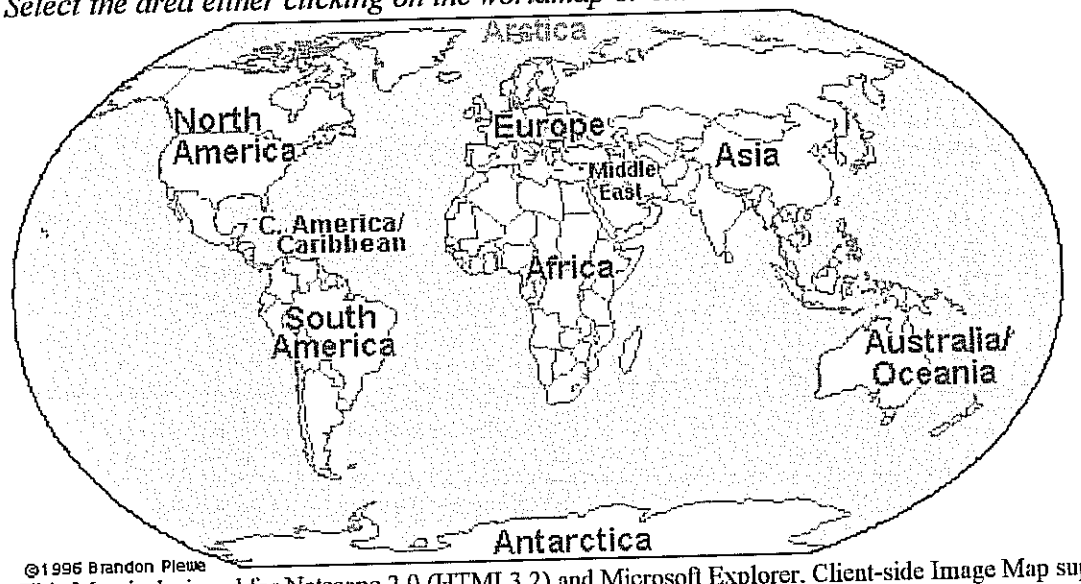
Version française 

English version 

Pour plus de renseignement / For more information

LAND GRAVITY DATA EXTRACTION

Select the area either clicking on the worldmap or enter its coordinates using the formular:



This Map is designed for Netscape 2.0 (HTML3.2) and Microsoft Explorer, Client-side Image Map supported browser only.
The portrayal of boundaries and the states' names must not be taken as implying approval by BGI of the political status

Max latitude
60

Min longitude 20 30 Max longitude

55
Min latitude

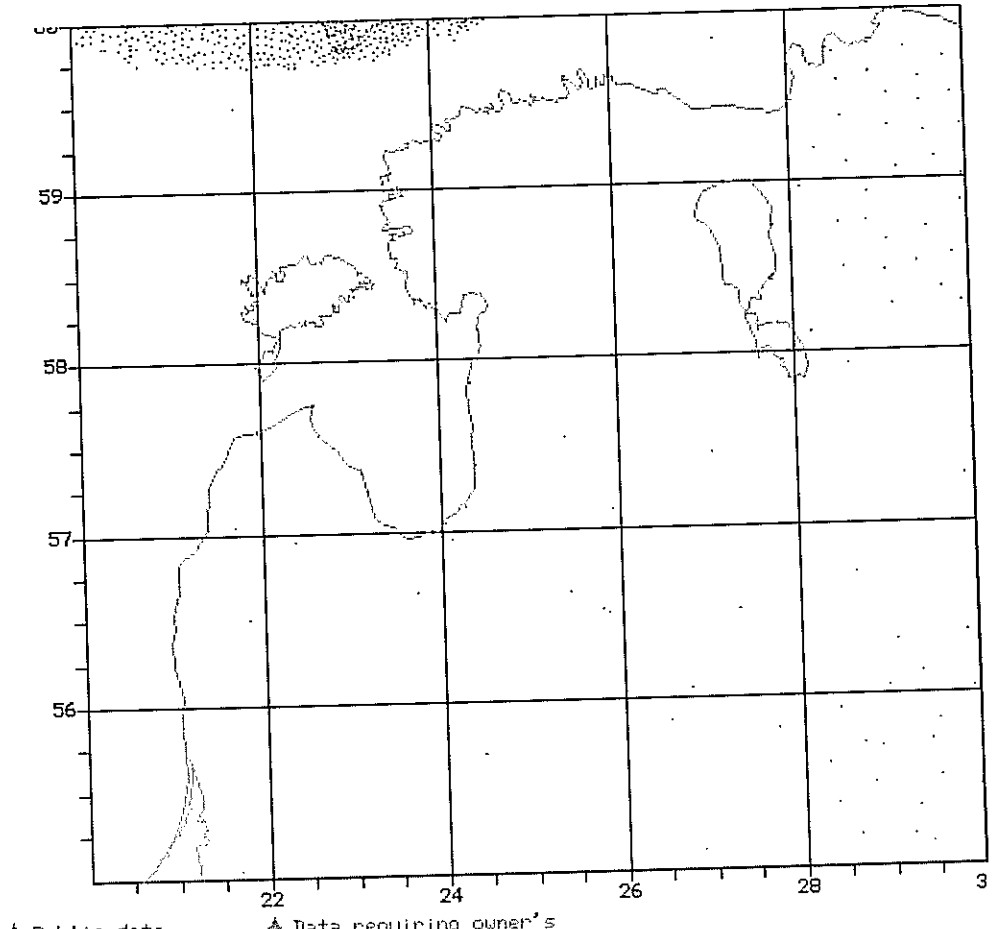
*By default, the coverage map is a GIF file with a maximum size of 500*500 pixels, you can modify this value (maximum size 1000):* ___

send request | cancel request

For more information

BGI DATABASE EXTRACTION

Land gravity data :



The portrayal of boundaries and the states' names must not be taken as implying approval by BGI of the political status

If you want the surveys description, click on the button :

surveys description

vers. 15 jan. 1996

GRAVSOFT

A SYSTEM FOR GEODETIC GRAVITY FIELD MODELLING

4th ed. Jan 1994

More info:

International Association of Geodesy

IAG General News IUGG Meeting Calendar Meeting Announcements Miscellaneous Bibliographic services Links	*International Association of Geodesy, Central Bureau,* c/o Department of Geophysics Juliane Maries Vej 30, DK-2100 Copenhagen Ø, Denmark. Phone: +45 35320600 , Fax: +45 35365357 E-mail: iag@gfy.ku.dk The International Association of Geodesy (IAG) is one of seven associations within the International Union of Geodesy and Geophysics (IUGG) (e-mail: *balmino@pontos.cst.cnes.fr*).

IAG General

Geodesists Handbook 1996 - Manuel du geodesien Internet version.
IAG Structure & Officers elected at the XXI General Assembly, Boulder, Colorado, July 1995. Includes updated information on IAG Special Commisions - Special Study Groups, 1995-1999.
IAG Information Service provided by the Central Bureau. NOT UPDATED !
Adresses of officers, fellows and (a part of) the associates of IAG.
E-mail adresses of officers, fellows and (a part of) the associates of IAG.
IAG is also a member of International Union of Surveying and Mapping .

News and IAG announcements

IAG Best Paper Award for young scientists.

IUGG

IUGG International Union of Geodesy and Geophysics. IUGG Structure 91-95.
IUGG Officers 1995-99.

Calendar

List of Future Meeting & Symposias relevant to geodesists.

Meeting Announcements:

The Ninth International Symposium on Recent Crustal Movements, CRCM '98 Egypt, 14-19 Nov, 1998. (Location moved)
Second Circular available from salahmm@frcun.eg Dr. Salah Mahmoud, NRIAG, Cairo.
IUGG General Assembly Birmingham, July, 1999. NEW Second Circular NEW IAG Program
NEW Geodesy and Surveying in the Future, The Importance of Heights , Gavle, Sweden, 15-17 March, 1999
IAU Coll 178 - polar motion history and scientific problems Sardinia, Italy,27-30 September 1999, first circular GPS 99 in Tsukuba Int. Symp. on GPS - App. to Earth Sciences and Interaction ....., Oct. 18-22, 1999, Tsukuba, Japan.
14th International Symposium on Earth Tides August 28th - Septmeber 1st 2000 (subject to slight change !).
XIXth ISPRS congress "Geoinformation for all" , Amstercam, The Netherlands, 16-23 july, 2000
Int. Symposium on. Gravity, Geoid and Geodynamics 2000 , Banff, Alberta, Canada, July 31 - aug 4 , 2000

Miscellaneous

International Call for Participation (GLONASS IGEX-98 campaign)
European Gravimetric Geoid 1997 available on CD rom
Vacant positions within geodesy
Journal of Geodesy the journal of IAG

IAG Newsletter in Journal of Geodesy NEW IAG Fast bibliographic entries 1996 - 1998
Call for Proposal Int. Gravity Bureau.
Minutes of IAG exececutive committee meetings: Copenhagen, Nov. 95., Potsdam, April. 1997
Proceedings of IAG Symposia published by Springer Verlag
History of Com. on Int. Coordination of Space Techniques for Geodesy and Geodynamics (By I. I. Mueller)
CDDIS Bulletin Crustal Dynamics Data Information System Bulletin, Published by NASA GSFC.
SCAR WG Geodesy & Geographic Information
IAG Travel Award Application Form
DOD WGS84 Definition and relationships to local geodetic systems, NIMA TR 8350.2, 1997.

Bibliographic services

NEW IAG Fast bibliographic entries 1996 - 1998
IAG Bibliographic Service via IFAG.
Tables of Content in Geodesy provided by M&M Craymer
American Congress on Surveying and Mapping (ACSM) Bibliographic service

Geoscience WWW links

Geoscience WWW server-list from IAG handbook
Geoscience WWW servers via IFAG-Potsdam, Germany (comprehensive list)
IASPEI home-page.
EU Center of Earth Observation at JRC, Ispra, Italy.
ISPRS International Soceitey for Photogrammetry and Remote Sensing
International Center for Earth Tides Home Page
Earth Tide Commission Home-page .
Int. Earth Rotation Service IERS home page
Geodesy at Ohio State

More information e-mail: iag@gfy.ku.dk

Last update 1998-10-27 by cct (iag@gfy.ku.dk).

Combining GPS/Levelling & gravity:

AIDS LOCAL GEOID INTERPOLATION

Subtract first SHE and topography. Remaining signal of both geoid and gravity very smooth.

Example: New Mexico White Sands test area (used in Geoid School Notes).
OSU91A/EGM96 and topography subtracted:

From local covariance function:

SHE degr.	Stdv. Geoid m	50% Correl dist(^{0})	Stdv. Grav. mgal	50 % Correl dist(^{0})	Geoid Grav. Correl
180*	0.42	0.37	17.1	0.28	87 %
360**	0.26	0.40	11.9	0.16	73 %

* = OSU91A, ** = EGM98.

CONCLUSION (II).

Title of Symposium:

Where are we going ?

We are **going** to need a spaceborne gravity mission like GOCE & GRACE.

This will reduce long-wavelength errors and errors caused by erroneous or missing ground gravity data.

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