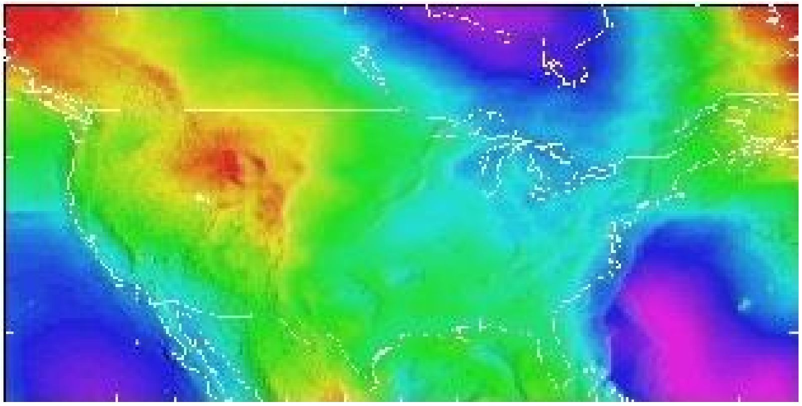
G99SSS



G99SSS is a gravimetric geoid that served as the basis for **GEOID99** within the conterminous United States only.

G99SSS was determined from more than 3 million gravity points and several high resolution elevation models.

Its heights range from a low of -52.56 meters (magenta) in the Atlantic Ocean to a high of 3.08 meters (red) in the Labrador Strait.

Technical Information Page for G99SSS, GEOID99 and DEFLEC99

G99SSS

The **G99SSS**
geoid model is a purely gravimetric, geocentric geoid model covering the Conterminous United States. Input data for G99SSS consisted of:

- 2.6 million terrestrial, ship, and altimetric gravity measurements
- 30 arc second Digital Elevation Data
- A 1 arcsecond DEM for the Northwest USA **(NGSDEM99)**
- The **EGM96**
  global geopotential model

Using EGM96 as an underlying long wavelength model, G99SSS was computed using a 1-D FFT remove/compute/restore application of the spherical Stokes integral, where Faye anomalies approximated Helmert anomalies. In computing G99SSS, the geopotential value of the geoid was chosen as W_0 = 62636856.88 m^2 / s^2. The G99SSS geoid undulations refer to a geocentric GRS-80 ellipsoid (**click here for details** about the difficulty in defining the origin of the reference ellipsoid). G99SSS was computed on a 1 x 1 arc minute grid, covering the Conterminous United States in the region 24-58 N latitude and 230-300 E longitude.

For most regions, thirty arcsecond resolution DEMs were employed for the terrain correction calculations. In the Northwest USA (39-49N, 234-256E), however, three arcsecond DEMs (decimated from the NGSDEM99 data) were used. Because the highest frequency information in the geoid comes mostly from local terrain, and the accuracy of NGSDEM99 surpassed previous models, it was theorized that geoid signal missing at the two arcminute spacing (such as for G96SSS) could be accurately modeled if the geoid were computed at one arcminute. Details on the successful validation of this theory appear in a forthcoming paper on G99SSS and GEOID99. Additionally, a one-arcminute grid retains more information in regions of higher density gravity observations. An ellipsoid correction to reduce the spherical assumption implicit in the Stokes equation was then applied to the intermediate model to create the G99SSS model (See Fei and Sideris, 1999).

GEOID99

The **GEOID99** geoid model is (in the Conterminous United States) a hybrid geoid model, combining the gravimetric geoid G99SSS with datum transformations and NAD 83 GPS ellipsoid heights on NAVD 88 leveled bench marks. Unfortunately, the areas of Alaska, Hawaii and Puerto Rico and the U.S. Virgin Islands do not currently have GPS on Bench Mark data sufficient to create a hybrid model, and in those three areas, the GEOID99 model is a purely gravimetric, geocentric geoid model.

In addition to the gravimetric geoid model G99SSS, the GEOID99 model consisted of the following input:

- 6169 NAD 83 GPS heights on NAVD 88 leveled bench marks

The G99SSS geoid undulations were compared nationally these GPS/Bench Marks. After removing a 52 cm bias and a trend (0.15 ppm, 327 degrees azimuth), an 18.2 cm RMS difference remained. These remaining differences were highly correlated, locally, due to both correlated geoid error and the state-by-state nature of each GPS adjustment (i.e. HARNs). A Gaussian covariance model (variance: 18.2^2 cm^2, correlation length: 400 km) which approximated the empirical covariance function of the residuals was used in a least squares collocation adjustment to model the long wavelength features of these differences on a grid. This grid, along with the bias, trend and ITRF96(1997.0)/NAD 83 transformation were used to compute a conversion surface which when removed from G99SSS yields GEOID99. GEOID99 undulations have a 4.6 cm RMS difference when compared to the GPS on Bench Mark data, which represents 16% improvement over the GEOID96 model.

G99BM

The **G99BM** model incorporates improved intermediate wavelength control derived from the 6169 GPSBM's but refers to a GRS-80 ellipsoid centered at the ITRF96(1997.0) reference center. Like GEOID99, it is only applicable inside the Conterminous United States with limited utility in near border regions (it has been reported useful up to half a degree into Canada). Essentially the same information was used in generating a conversion surface except the ITRF96(1997.0)/NAD 83 transformation. Be cause we excluded the transformation grid from this conversion surface, G99BM refers to the same ellipsoid surface as G99SSS. The ITRF96(1997.0) is within a few centimeters of the locations of several other commonly used ellipsoid models, such as WGS-84 (G873), and thereby provides ready comparison to many scientific data sets.

DEFLEC99

The **DEFLEC99** deflection of the vertical model is based upon GEOID99. A two-step procedure was used to compute DEFLEC99:

- Compute slopes of GEOID99 using bicubic splines to yield deflections of the vertical at the surface of the geoid.
- Use simple Bouguer anomalies to compute a plumb-line curvature correction to change the geoid-surface deflections into deflections of the vertical at the Earth's surface.

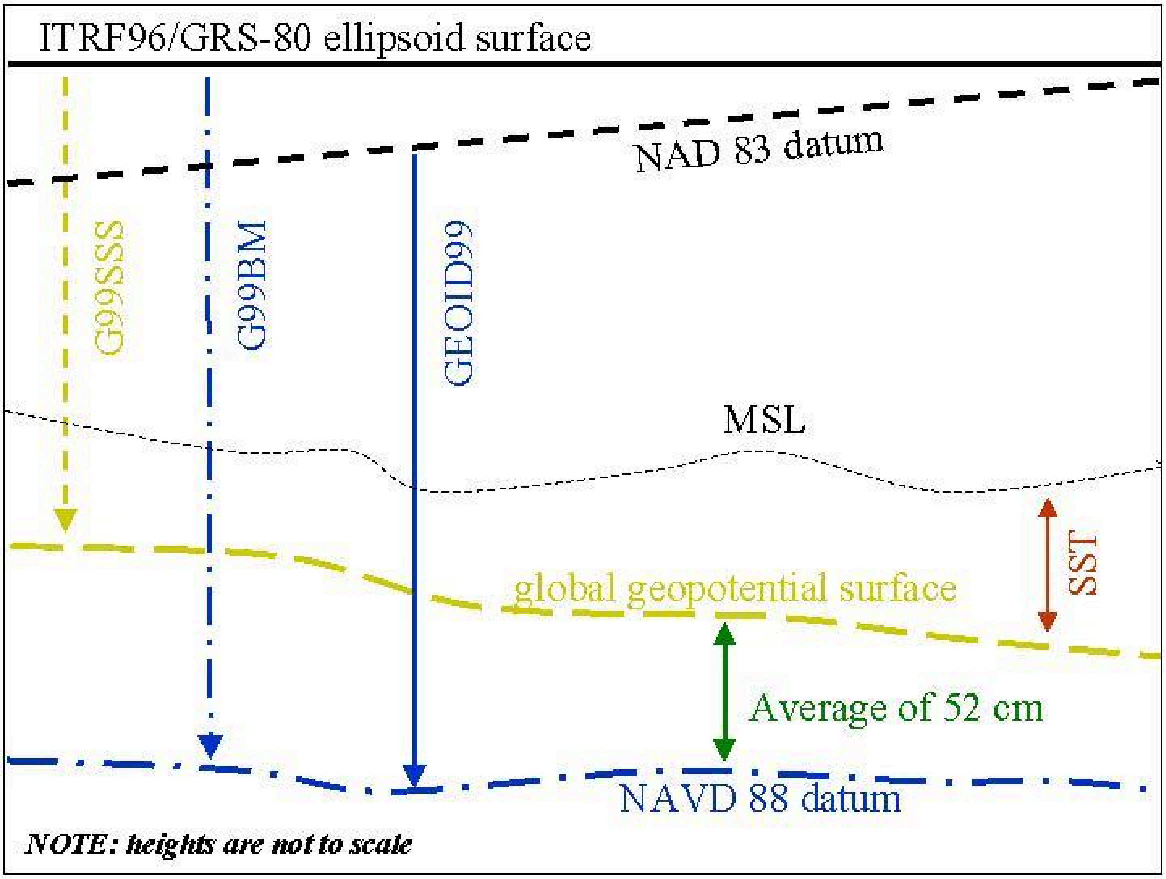
Because DEFLEC99 is based on GEOID99, it will include both gravimetric information and (in the Conterminous United States) GPS on leveled bench mark information.

REFERENCES

Fei, Z. and M. Sideris, 1999: A new method for computing the ellipsoidal correction for Stokes's formula, accepted for publication in *Journal of Geodesy*.

RELATIONSHIP OF HEIGHTS TO EACH OTHER AND MSL

The below image should help to help clarify the relationship between the various geoid models and the datums that they can be used to convert between. In the below figure, I refer to a "global geopotential surface" rather than a geoid, because G99SSS does not necessarily model the true geoid. G99SSS uses the EGM96 model and incorporates further gravimetric and terrain information at higher spatial resolution. However, it depends on EGM96 to establish the bias and long wavelength tilt of the geoid, because of the gravity and terrain models are not global in coverage. To the level that EGM96 has modeled these components, G99SSS can be used to generate an approximation of the true geoid.



Frequently Asked Questions for GEOID99/G99SSS/DEFLEC99

(You may also wish to look at the **GEOID96 FAQ** for additional information).

Why don't the filesizes for the INTG.EXE, INTG, INTD.EXE, and INTD executable files match those given in the README files on the CD-ROM?

The executable files were recompiled after revisions had been made to them. The filesizes for the source code were changed in the README files, but the filesizes for the executables were not updated before the CD-ROM's were pressed. The correct file sizes are given below and are now reflected in the online versions of the README files.

The following is a list of file sizes that are wrong and need fixing in the README file:

```
Name                 Wrong value in README           Correct value
```

INTG.EXE	161,280	169,472
INTG	107,320	122,388
INTD.EXE	183,296	194,048
INTD	127,112	148,012

In simplest terms, what files do I need and how must they be set up to run GEOID99?

To “run” GEOID99, you need the following things:

- A working version of the INTG program on your computer
  (“INTG.EXE” on PC/INTEL or “INTG” on SUN).
- At least one “g1999***.bin” file on your computer, or have the GEOID99 CD in your CD-ROM drive.

That’s it. The “*.bin” data files may be stored anywhere on your computer, or you may use the files as stored on the GEOID99 CD-ROM. If you are not working with an INTEL or SUN computer, then instructions for setting up a working version of GEOID99 on other computers can be found in the GEOID99 readme file (g1999rme.txt). This answer is applicable to G99SSS (needs one “s1999***.bin” file) and DEFLEC99 (needs one pair of “x1999***.bin” and “e1999***.bin” files).

Are there formal accuracy estimates for GEOID99?

There are no formal accuracy estimates for GEOID99. The computation of the gravimetric residual co-geoid undulations from residual Faye gravity anomalies was done through a 1-D FFT representation of the spherical Stokes integral, which inherently contains no formal accuracy estimation.

However, in the United States we have a fairly homogenous distribution of GPS-derived ellipsoid heights (in the NAD 83 datum) co-located with leveled Helmert orthometric heights (in the NAVD 88 datum) and these data are used to control long wavelength errors in the geoid model as well as providing an accuracy check. It is found, nationwide, that we are able to reproduce GPS/level derived geoid undulations with our GEOID99 model to the +/- 4.6 cm level. The source of this disagreement is both the error in GPS heights as well as geoid and leveling errors. Separation of the errors is difficult, but preliminary analysis indicates that +/- 2.5 cm of that is geoid error.

Dr. Dennis Milbert performed some preliminary Monte Carlo estimates of the geoid error back in 1993 and found that the propogation of anomaly error into geoid error was bowl-shaped, leaving small (sub cm) errors in the center of the country and large (10+ cm) errors in the oceans. This situation has changed somewhat with the inclusion of satellite altimetry, and numerous data and computational improvements since 1993, however.

What's the difference between GEOID96 and GEOID99 (in plain English, please)?

Put simply, GEOID99 is an improved version of GEOID96. There was better data in GEOID99 and better computational methods in GEOID99. That meant, overall, a better geoid model. This is most obviously seen in the comparison of each geoid model to GPS on leveled benchmarks. GEOID96 had an absolute agreement of +/- 5.5 cm (1 sigma) relative to 2951 GPS-BMs. GEOID99 has an absolute agreement of +/- 4.6 cm (1 sigma) relative to 6169 GPS-BMs.

For those who care about technical details, here's a running list of differences between GEOID96 and GEOID99:

Category	**GEOID96**	**GEOID99**
Year	1996	1999
Gravimetric Base Model	G96SSS	G99SSS
Gravity Measurements	1.6 Million*	2.0 Million*
Altimetry	Sandwell/Smith Version 6.2	KMS98
DEM	TOPO30 (30 arcsecond)	Corrected TOPO30 (30 arcsecond) and NGSDEM99 (1 arcsecond)
Terrain Corrections (Resolution)	30 arc-second	30 and 3 arc-second
Terrain Corrections (Method)	2-D FFT single run	2-D FFT multi-band runs
Global Geopotential Model	EGM96	EGM96
Geocentric Reference Frame	ITRF94	ITRF97
Horizontal Resolution	2 arc-minutes	1 arc-minute
North Edge of CONUS computation	54 degrees	58 degrees
NAVD 88 bias estimate	-31 cm	-52 cm
GPS on Benchmarks	2951	6169
Accuracy (1 sigma) wrt GPS/Benchmarks	5.5 cm	4.6 cm

* – There were not 400,000 new gravity measurements taken between 1996 and 1999. The reason for this increase is mostly due to expanding the computational area of the CONUS grid.

Are you telling me that *POSITIVE WEST LONGITUDES* don't work in INTG?

The initial version (1.0) of INTG and INTD was loaded on September 30, 1999. That version only allowed positive East longitudes. Later versions (1.1 and higher) of INTG and INTD do allow positive WEST longitudes.

My copy of INTG (or INTD) doesn't work right. What's up?

The initial version of INTG (and INTD) was version 1.0, loaded on September 30, 1999. There were some bugs and oversights still in that code, particularly with respect to Blue Book formats. Newer versions of INTG (and INTD), have been loaded since then. Try downloading the latest version and see if that helps.

What do the filenames indicate about the type of data they contain?

A typical filename, **"tyyyyrnn.fff"**, would indicate:

- **t: The type of data contained in the file**
  - t = g means hybrid geoid model undulations (i.e. GEOID96, GEOID99)
  - t = s means gravimetric geoid model undulations (i.e. G99SSS, G96SSS)
  - t = x means Deflections of the vertical in the North/South direction (Xi)
  - t = e means Deflections of the vertical in the East/West direction (Eta)
- **yyyy: The year the data was created**
- **r: The main region where the data are located**
  - r = u means "Conterminous USA"
  - r = a means "Alaska"
  - r = h means "Hawaii"
  - r = p means "Puerto Rico and the American Virgin Islands"
- **nn: The sub-region number of this file**
  - CONUS, has 8 overlapping sub-regions (nn=01 to 08)
  - Alaska, has 4 overlapping sub-regions (nn=01 to 04)
  - Hawaii has1 sub-region (nn=01)
  - Puerto Rico and the American Virgin Islands has 1 sub-region (nn=01)
- **fff: The format of the data file**
  - fff = bin means FORTRAN 77 direct access binary file
  - fff = asc means ASCII file

So, for example, "g1999u01.bin" means "GEOID99 in CONUS, sub-grid #1, in binary"

What is the new format for the data files?

The new file format for any sub-grid file (GEOID99, G99SSS or DEFLEC99 files) is identical: A 44 byte header followed by “nla” rows of data, each row being “nlo” elements long, each element being a 4 byte floating point number. The format chosen is known in FORTRAN lingo as “direct access binary”. The exact ordering of the bytes is mapped below:

```
Bytes    Data    Variab      Variable
         Type    Name        Description
 1- 8    real*8  glamn       Southermost Latitude of grid (decimal degrees)
 9-16    real*8  glomn       Westernmost Longitude of grid (decimal degrees)
17-24    real*8  dla         Latitude spacing of grid (decimal degrees)
25-32    real*8  dlo         Longitude spacing of grid (decimal degrees)
33-36    int*4   nla         Number of rows of grid
37-40    int*4   nlo         Number of columns of grid
41-44    int*4   ikind       Set to "1", meaning the gridded data is "real*4"

45-48    real*4  data(1,1)   Gridded value at element 1,1 (Southwest corner)
. . .
The rest of the file continues as 4 byte real values, filling in first the
south row (data(1,nlo) being the last variable in the south row), and then
proceeding northward.

The total number of bytes in a "*.bin" file is:
44 + 4*nla*nlo
```

The actual numbers of rows (nla) and columns (nlo) for each sub-grid is the same within each region but varies between regions:

REGION	**ROWS (nla)**	**COLUMNS (nlo)**
Conterminous United States	**1081**	**1141**
Alaska	**721**	**1921**
Hawaii	**361**	**421**
Puerto Rico and the Virgin Islands	**361**	**301**

Isn’t this different than what you announced in May?

Yes, slightly. In May we anticipated using **FORTRAN unformatted binary** files. We ended up using **FORTRAN direct-access binary** files. Because each FORTRAN compiler (we tried 4 of the many available) stores “buffer” bytes differently in a FORTRAN unformatted binary file, that prevented us from creating unformatted binary files with one compiler and letting users use another compiler to read them. All compilers use the same way of storing direct access binary files, so this was clearly the solution. The ordering of the data remains as we announced in May, there just aren’t any of the “buffer” bytes that come with a FORTRAN unformatted binary file now.

Why was the file format changed from the old “*.GEO” (and “*.XII” and “*.ETA”) format in the first place?
For GEOID96, the header information was ASCII data while the gridded data were in binary. This caused failures for some browsers attempting to download those data. Due to these difficulties, a purely binary format was desired.

Will you be releasing GEOID99 in the “*.GEO” format at all?
No. The “*.GEO” format is effectively retired.
On which platforms can I run GEOID99 (G99SSS, DEFLEC96) software?
We have provided working versions of all software for GEOID99, G99SSS and DEFLEC96 for the PC(Intel) platform and the Sun platforms. In addition we provide a third set of data and software, which we call “ASCII”, which is not ready-to-run as is, but does allow you to set up your own working version on whatever non-PC non-Sun platform you use. If you wish to run the software on any machine besides a PC or Sun, you should download the ASCII version of the data (and un-gzip it), and compile the XNTG.FOR (or XNTD.FOR) program with your own local FORTRAN compiler. Then you may use the XNTG (or XNTD) executable to convert the “*.asc” data files into “*.bin” files on your machine. After that, you need only compile the INTG.FOR (or INTD.FOR) program and you should have a working version of data and software on your own platform!

Will the new software work with the old (i.e. GEOID96) data files?
Not yet. The new software does not work with .GEO, .XII nor .ETA files. A re-release of GEOID96 with the new .bin format may occur later in 1999. For now, the GEOID96 files still work with the old GEOID.FOR and GEOGRD.FOR programs.

I see you have two different models for the U.S., GEOID99 and G99SSS. Which should I use?
In general, most users should work with GEOID99. It is constructed to relate GPS ellipsoid heights in NAD 83 and orthometric heights in the NAVD 88 datum. These are the datums used in many maps and charts, and it is likely that your application requires that consistency.

```
                        THE G99SSS README FILE
                         ----------------------

Version: January 12, 2000   das/drr

The G99SSS GEOID MODEL
----------------------
You have received these models on CD-ROM, or downloaded them from the National
Geodetic Survey (NGS) web site or the NGS FTP site.

Files you may have received include:

 INTG.EXE (PC) or   The geoid interpolation program (source code is
 INTG     (Sun)     INTG.FOR (PC) or INTG.F (Sun))

 XNTG.EXE (PC) or   Program for extracting, translating (ascii/binary)
 XNTG     (Sun)     and yielding statistics of geoid files (source code
                    is XNTG.FOR (PC) or INTG.F (Sun))

 DOSXMSF.EXE (PC)   32-bit DOS extender (needed for running INTG.EXE on a 386 PC)

The following file names are valid for PC or Sun (if, however, you downloaded the
```

```
ASCII versions of these files, the suffix will be ".asc" rather than ".bin"):
 s1999u01.bin       G99SSS grid #1 for CONUS (40-58N, 230-249E)
 s1999u02.bin       G99SSS grid #2 for CONUS (40-58N, 247-266E)
 s1999u03.bin       G99SSS grid #3 for CONUS (40-58N, 264-283E)
 s1999u04.bin       G99SSS grid #4 for CONUS (40-58N, 281-300E)
 s1999u05.bin       G99SSS grid #5 for CONUS (24-42N, 230-249E)
 s1999u06.bin       G99SSS grid #6 for CONUS (24-42N, 247-266E)
 s1999u07.bin       G99SSS grid #7 for CONUS (24-42N, 264-283E)
 s1999u08.bin       G99SSS grid #8 for CONUS (24-42N, 281-300E)
 (note: the G99SSS model only exists for the conterminous United States)

To Install:
   1) Make a subdirectory on your hard disk.
   2) Copy the various geoid files into that subdirectory.  You need not
      put the geoid files in the same directory as the programs.
      (If you have also received GEOID99 model files, you may safely place
      them in the same directory as G99SSS, if you like.)
   3) If you are using a PC, check your AUTOEXEC.BAT and CONFIG.SYS files
      to insure compliance with the following notes:

   Note 1:  If you are running a 16-bit PC (such as a 386), then DOSXMSF.EXE
            must either be present in the same directory as
            INTG.EXE, or, it must be in a directory in your DOS PATH
            environment variable (such as:  c:\dos).   DOSXMSF.EXE
            may be freely reproduced and distributed, without royalty.

   Note 2:  You must have a statement FILES=25 (or a number greater than 25)
            in your CONFIG.SYS file.

To Execute
   (PC or Sun) Type INTG            , and follow the prompts.

To Terminate
   You can stop the program at any time by the Control C key combination.

BUT, PLEASE DON'T START YET.  PLEASE KEEP READING THIS DOCUMENT.

Check The Byte Counts of all Downloaded Files
---------------------------------------------
    Before beginning, it will be useful to ensure that all files
you have received are the correct size.  (Download problems are
often manifested by incorrect byte counts in the files).  Check
with the list below to make sure your files match these numbers
exactly.  These values are good for the PC and Sun versions of
the data.

PC or Sun Data:
     s1999u**.bin    4,933,728 bytes
ASCII Data:
     s1999u**.asc   12,488,896 bytes (uncompressed)
PC executables:
     INTG.EXE          169,472 bytes
     XNTG.EXE          165,888 bytes
     DOSXMSF.EXE       393,942 bytes
Sun executables:
```

INTG 122,388 bytes
XNTG 67,840 bytes

How Program INTG Works

The various geoid height grids are stored in the ".bin" files. Program INTG will prompt you for the name of the directory where you have chosen to store the .bin files, as well as prompting you for which geoid model you wish to use. You can operate with as few as one .bin file, or as many as 14. When the program interpolates a given point, it checks an internal list of .bin boundaries, and uses the earliest list entry whose boundaries contain that point. The order in which the .bin file names appear on the opening screen indicates the order in which the .bin files are searched.

When running program INTG.EXE (PC) or INTG (Sun), the latitude and longitude of each point must be input. The GEOID99 models are heights above the NAD 83 ellipsoid. However, latitudes and longitudes in the ITRF97/GRS-80 and WGS84(G873) systems are very close to those of the NAD 83 system (with only 1-2 meters of horizontal shift.) So any of these types of latitude and longitude (NAD 83, ITRF97, WGS84) may be input, without affecting the interpolated geoid value. This does *not* imply that the geoid heights are heights above a different ellipsoid. Using NAD 83 latitudes and longitudes interchangeably with ITRF97/GRS-80 or WGS84 latitudes and longitudes is merely an acceptable horizontal approximation. GEOID99 geoid heights, will always be above the NAD83 ellipsoid.

Do *NOT* use NAD 27 latitudes and longitudes. The horizontal shifts between NAD 83 and NAD 27 can exceed 100 meters, causing a noticeable difference in the interpolated geoid value. To convert from NAD 27 to NAD 83 latitudes and longitudes you may use programs NADCON or CORPSCON, available from NGS.

Data Input

You can key data by hand, point by point, or you can create an input file using a text editor. Several file formats are provided, including the NGS "Blue Book" format. These formats are detailed in a "Help" menu option which appears if you specify that you wish to use an input file.

Data Output

Results may be collected into an output file. There is no default output file name. The format of the output file is linked to the format of the input file to maintain consistency. If, however, you input your data by keyboard, and ask for an output file, the format of that output file will be in the format known as "Free Format, Type 1".

The G99SSS Model

The G99SSS model is known as a gravimetric geoid model, as it makes use purely of gravimtric information, and does not rely on GPS ellipsoid heights on leveled bench marks. The G99SSS model refers to a GRS-80 shaped ellipsoid, centered at the ITRF97 origin. It does not support direct conversion between NAD 83 GPS ellipsoidal heights and NAVD 88 orthometric heights.

When comparing the G99SSS model with GPS ellipsoidal heights in the ITRF97 reference frame and leveling in the NAVD 88 datum, one can discern a systematic offset at a 50 cm level. It is likely that this offset is inherent in the definition of the NAVD 88 datum; where the NAVD 88 zero reference is below the current estimate of global mean sea level. In addition, long-wavelength systematic errors are evident in the comparisons. These errors are a composite of error in the NAVD 88 elevations, error in the GPS ellipsoidal heights, and error in the G99SSS model itself. Since the errors are long-wavelength, they can be modeled locally as a plane; usually at a 1 to 2 part-per-million level.

Alaska, Hawaii, Puerto Rico and the Virgin Islands

The difference between G99SSS and GEOID99 is primarily a difference of reference frames. G99SSS is a gravimetric geoid relative to a geocentric GRS80 ellipsoid. GEOID99, in the conterminous United States, is computed through a conversion using knowledge of reference frame differences and GPS ellipsoidal heights on leveled bench marks. In Alaska, Hawaii, Puerto Rico and the Virgin Islands, only the gravimetric, geocentric, geoid models are available. These models are designated as GEOID99 to facilitate ordering by our users, though they have no GPS/Bench Mark data in their production.

Deriving Orthometric Heights From GPS

One key problem is deciding which orthometric height datum to use. NGVD 29 is not a sea-level datum, and the heights are not true orthometric heights. The datum of NAVD 88 is selected to maintain reasonable conformance with existing height datums, and its Helmert heights are good approximations of true orthometric heights. And, while differential ellipsoidal heights obtained from GPS are precise, they are often expressed in the NAD 83 datum, which is not exactly geocentric. In addition, G99SSS rests upon an underlying EGM96 global geopotential model, and EGM96 does possess some error of commission.

This leads to a warning:
Do not expect the difference of a GPS ellipsoidal height at a point and the associated G99SSS height to exactly match the vertical datum you need. However, one can combine the precision of differential carrier phase GPS with the precision of G99SSS height differences, to approach that of leveling.

Include at least one existing bench mark in your GPS survey (preferably many bench marks). The difference between the published elevation(s) and the height obtained from differencing your adopted GPS ellipsoidal height and the G99SSS model, could be considered a "local orthometric height datum correction". If you are surveying an extensive area (100+ km), and you occupy a lot of bench marks, then you might detect a trend in the corrections up to a one part-per-million level. This may be error in the G99SSS model.

We do not currently consider geoid-corrected GPS orthometric heights as a substitute for geodetic leveling in meeting the Federal Geodetic Control Subcommittee(FGCS) standards for vertical control networks. Studies are underway, and many less stringent requirements can be satisfied by geoid modeling. Widespread success has been achieved with the preceeding models, GEOID96, GEOID93 and GEOID90.

The XNTG Utility Program

The XNTG program can perform various functions, none of which are required to use the INTG program. The functions of XNTG are the extraction of sub-grids from the provided geoid grids, the translation between ASCII and binary grids, and the reporting of basic statistics for geoid grids.

Future Plans

Due to the quickly expanding availability of GPS data on leveled bench marks in the NGS database, there is some incentive to providing annual (hybrid) geoid models which reflect the latest GPS/BM data. In addition, from the gravimetric geoid side, there is always ongoing research to improve the theory of geoid determination. This research moves at a slower pace than GPS/BM data acuqisition, so while annual *hybrid* geoid models (like GEOID99) may be provided, there may be bi- or tri-annual *gravimetric* geoid models (like G99SSS).