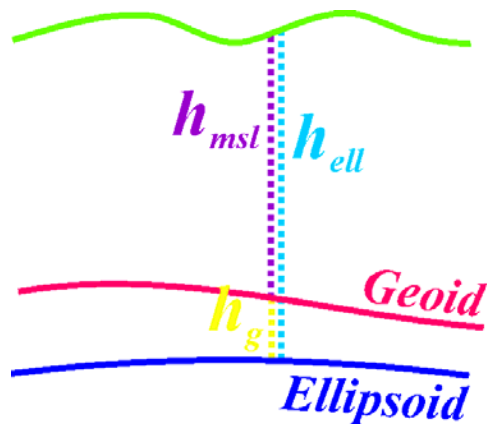


GEOIDS FAQ

1. What is a geoid?

A geoid is a representation of the equipotential surface of the Earth's gravity field. It can be thought of as a surface coinciding with the undisturbed mean sea level extended through the continents. By definition, the gravity vector at any given point is perpendicular to the geoid. Geoids are used by Waypoint's software to provide mean sea level (MSL), or orthometric, heights.



$$h_{ell} = h_{msl} + h_g$$

2. Where does Waypoint get the geoids from?

It is important to keep in mind that Waypoint Products Group does not derive any of the geoid values provided with the software. Rather, the data has been acquired from various international or government agencies and been converted into a format (WPG) readable by Waypoint's software.

In the United States, for example, the *Geoid96/Geoid99/Geoid03* files provided with the software are converted from data files provided by the National Geodetic Survey (NGS). The data contained by the *EGM96* file, which covers the entire Earth, was provided by the joint effort of the National Aeronautics and Space Administration (NASA) and the National Imagery and Mapping Agency (NIMA).

3. **How accurate are the geoids?**

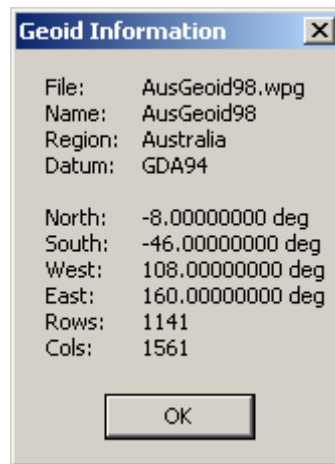
The accuracy of each geoid will depend on the methods used to derive it. Each geoid will have been formulated using different computations and data measurements. For these reasons, the agencies producing the geoid values should be consulted for any inquiries regarding accuracies.

4. **How do geoids relate to datums?**

Undulation values represent the distance along the ellipsoidal normal from the ellipsoid to the geoid. As such, each geoid is referenced to a specific ellipsoid and datum. For example, the *Geoid96/Geoid99/Geoid03* undulations are all relative to NAD83, while *EGM96* is relative to WGS84. It is important that the correct datum be selected when using a geoid for MSL height input or output since the horizontal position will determine the undulation value applied. Where the difference between datums is small, such as WGS84 and ITRF, the error will be negligible given the grid spacing of the geoid, but for other datums, such as NAD27 and NAD83, the differences are too large to ignore.

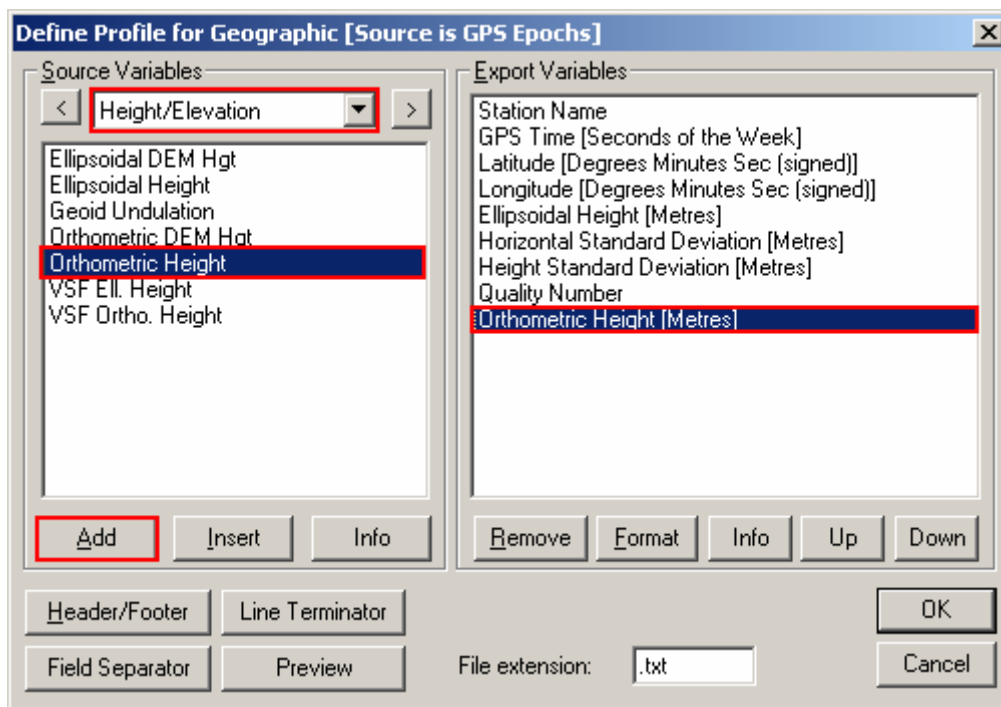
5. **How can I check if a WPG file covers my region?**

Under the *Tools | Geoid* menu of Waypoint's software, you can access a feature called *Geoid Information*. This feature will provide the latitude and longitude boundaries of any selected WPG file, as well as the associated datum.

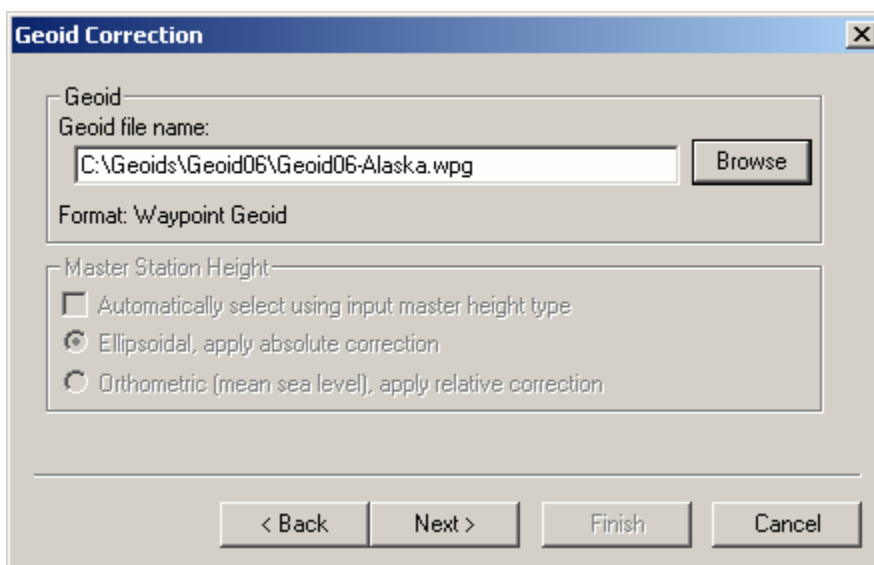


6. How do I output orthometric heights after processing?

After processing with Waypoint's software, the *Export Wizard* can provide orthometric heights for your trajectory points or features. Ensure that the output profile selected contains the **Orthometric Height** field by creating a new profile or by selecting an existing profile and clicking the **Modify** button. To add the field to a profile, select **Height/Elevation** from the *Source Variables* drop-down menu. Select the **Orthometric Height** variable and click on the **Add** button.

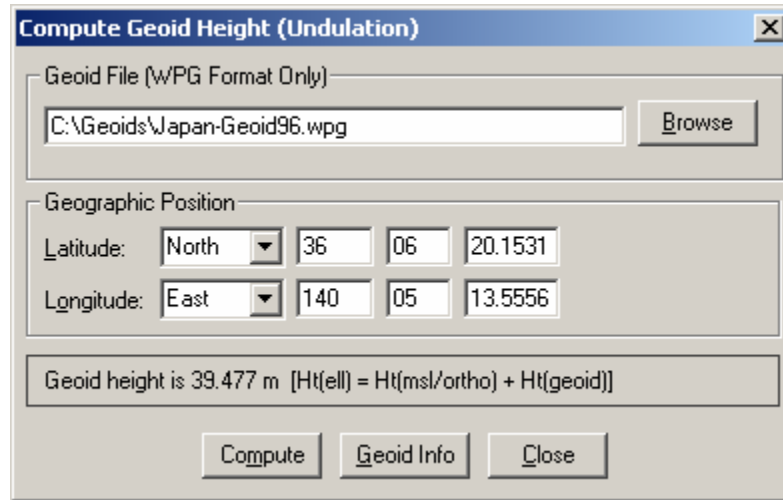


Once the field has been added, the *Export Wizard* will automatically prompt you to specify a WPG file for use during the orthometric height output.



7. Can I compute the geoid height of a specific point without processing?

Yes, by using the *Compute Geoid Height* feature found under *Tools | Geoid*. Simply select the appropriate geoid, enter your horizontal position, and the tool will output the undulation at that point. If MSL height is required, simply subtract the undulation value from your ellipsoidal height.



Alternatively, if you have several points for which an orthometric height is required, you can use the batch coordinate conversion utility available under *Tools | Convert Coordinate File*. In such a case, you should provide the utility with the following space-delimited fields:

<i>PointID</i>	<i>Latitude</i>	<i>Longitude</i>	<i>Height</i>
1	36 06 20.1531	140 05 13.5556	20.169
2	35 17 26.5326	135 01 03.1522	10.194

Note that the *Latitude* and *Longitude* fields can be substituted with corresponding horizontal grid coordinates. The *Height* field should represent the ellipsoidal heights, if known. The utility will then convert these values into orthometric heights using whichever WPG file is specified.

8. What if I have a geoid, but it is not in WPG format?

Waypoint's software includes command-line utilities to help create WPG files. These programs can only be used with ASCII files which have been properly formatted. Binary utilities exist but are only compatible with the source files of specific geoids, all of which are now obsolete (i.e. *GSD95*, *Geoid96*, *AUSGeoid93*).

The utilities provided with the software are *read_ascii_geoid.exe* and *makegeoid.exe*. The latter program is needed to produce the final WPG file. In addition, the program will also produce a bitmap file (BMP), giving a visual representation of the geoid. The input ASCII file must be in the following space-delimited format:

<i>Latitude</i>	<i>Longitude</i>	<i>Undulation</i>
60.0000000000000	-188.000000000000	-3.40570000000
60.0000000000000	-187.983333333320	-3.44000000000
60.0000000000000	-187.966666666640	-3.47290000000
60.0000000000000	-187.949999999960	-3.50420000000

Note that the *Latitude* and *Longitude* values must be in decimal degrees and should be specified to at least 12 decimal places. Furthermore, Southern latitudes and Western longitudes should be designated as such via the use of a negative sign. The *Undulations* values must be in meters.

If the source file is not provided in the aforementioned format, the *read_ascii_geoid.exe* utility can be used to re-organize it. This utility will read in an ASCII file containing undulation values, assuming they have been sorted in a specific way. The header of this file must provide the following space-delimited fields:

<i>S_border</i>	<i>W_border</i>	ΔLat	$\Delta Long$	<i>nrows</i>	<i>ncols</i>
49.0000000	202.0000000	1.6666666667e-02	1.6666666667e-02	721	1921

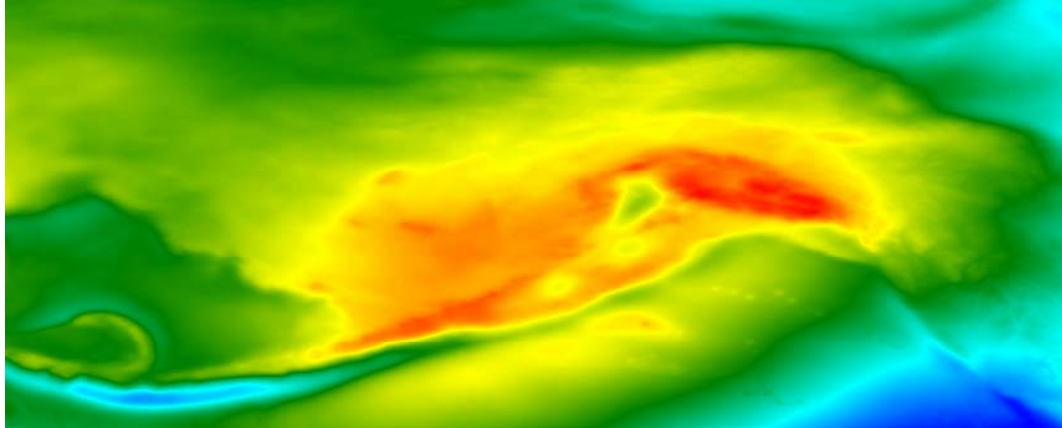
Note that *S_border* and *W_border* represent the southern and western boundaries, respectively, of the region covered by the geoid. These values must be in decimal degrees, and negative signs should be used to indicate a Southern latitude or a Western longitude. The ΔLat and $\Delta Long$ fields represent the grid spacing, in decimal degrees, of the source file. Finally, the *nrows* and *ncols* values represent the number of rows and columns covered by the source grid.

The remainder of the file must provide space-delimited undulations. The first undulation value should be at the south-west corner of the grid. The subsequent space-delimited undulations should remain along the same latitude but moving eastward by $\Delta Long$. Once the eastern boundary is reached, the latitude should increment by ΔLat and the undulations should begin from the western boundary again and move eastwards. It follows, then, that the last undulation value in the file should be that of the north-east corner of the grid.

The output file created from the *read_ascii_geoid.exe* utility can then be run as input for the *makegeoid.exe* utility.

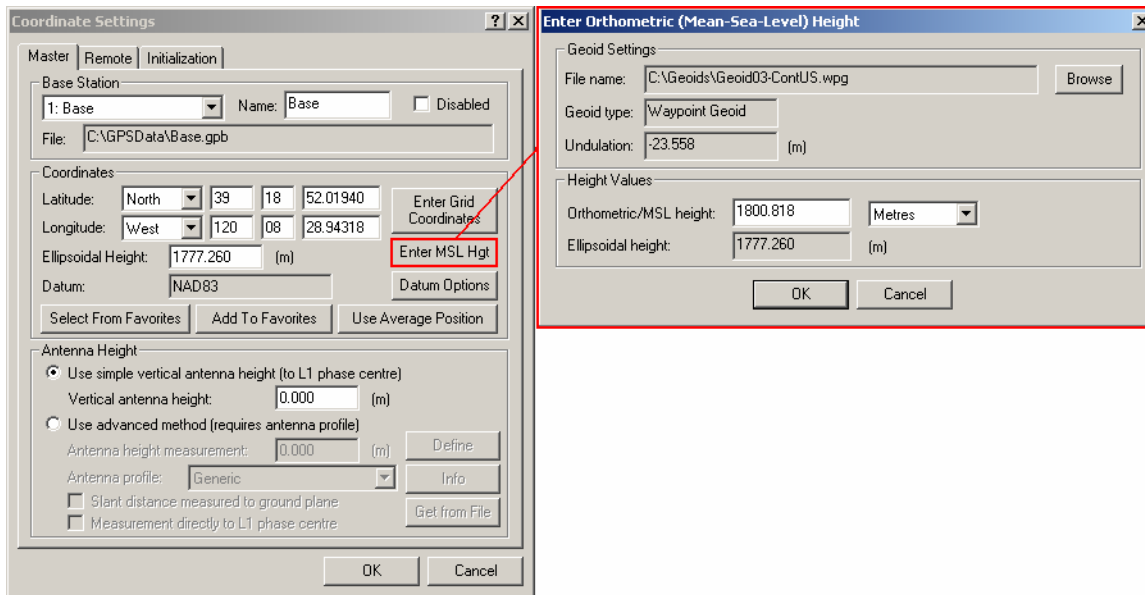
```
makegeoid g2006.txt -o Geoid06 -d NAD83 -g "Geoid06" -r "Alaska"
```

In addition to creating a WPG file, this utility also produces a BMP image of the geoid undulation.



9. What if I only have a published MSL height for my base station?

If the WPG file corresponding to the MSL height is available, then the software can perform the conversion to ellipsoidal height for you. In the *Coordinate Settings* window within GrafNav, click the **Enter MSL Height** button. This will open a window in which you can enter the MSL height value and specify the appropriate WPG file. GrafNav will use this information to convert the height into an ellipsoidal value.



Note that the same capability is available to GrafNet users when entering check point and control point coordinates. Using the proper WPG file will help avoid relative geoid errors from being applied.

However, if the corresponding WPG file is not available, then you are left with two options. The first option is to enter the MSL height value and specify the *EGM96* model as your geoid. The second option is to enter the MSL height as though it were the ellipsoidal height. In this case, you would not specify any WPG file, and you would interpret the ellipsoidal height output as being the MSL output. Note that both options will result in sub-optimal results as the local variations that are present in most localized geoids will be missed.

10. What algorithm is used for interpolating between points?

In order to derive the undulation at a user-defined point, Waypoint's software uses the following polynomial equation:

$$h_u = a_0 + a_1x + a_2y + a_3x^2 + a_4y^2 + a_5xy + a_6x^2y + a_7xy^2 + a_8x^2y^2$$

Where,

h_u	undulation of user-defined point
x,y	grid coordinates of user-defined point
$a_0...a_8$	polynomial constants

To solve for the undulation (h_u) at the user-defined point (x, y), the nine polynomial terms must first be solved for. This is accomplished by solving the system of equations (i.e. nine equations for nine unknowns) that results from the evaluation of the polynomial at all nine grid points, where the undulation values are known. Once the polynomial constants are solved for, the equation is evaluated at the user-defined point.

