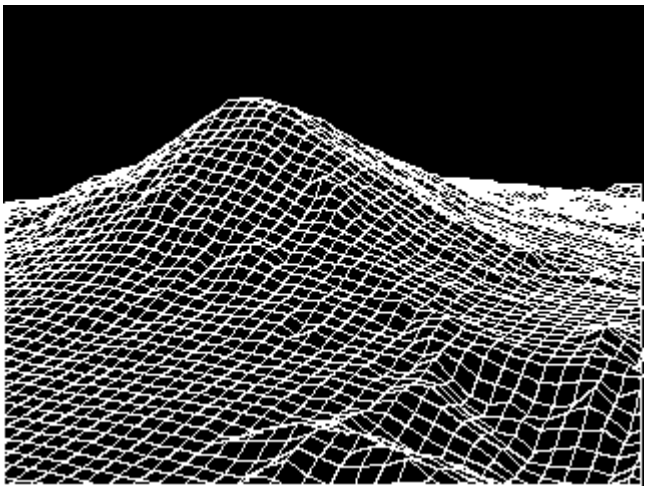
USGS DEM Geometry Import Converter

The **USGS DEM** geometry import converter imports, manipulates and converts digital elevation model (DEM) data. This DEM data is provided as a service of the United States Geological Survey (USGS). Each data set describes the elevation of semi-square regions of land for various locations across the U.S.A., Alaska, Hawaii and some surrounding areas of Mexico and Canada. The most accurate DEM data sets are sampled every 30 metres (7.5 minute DEMs) while the least accurate are sampled every 3 arc seconds (for 1:250,000 scale DEMs). See below for a description of the various DEM dataset types.

Since these datasets are abundant and available freely via the Internet, this converter can be put to good use for creating realistic (and accurate) 3d landscape geometry. The following is a hidden line rendering of the Mount St. Helens dataset.



and this is a shaded rendering of the same dataset (being visited by Al the gangster):

PLEASE NOTE: the **Create only one object'** checkbox should be enabled (check-marked) if the DEM data is destined for **3D Studio** (see explanation in the dialog box descriptions section below).

The following Internet sites provide more information about USGS DEM data:

http://nsdi.usgs.gov/nsdi/products/dem.html
http://nsdi.usgs.gov/nsdi/maps/dem1deg.HTML

And the following Internet sites contain vast amounts of USGS DEM data:

ftp://spectrum.xerox.com/ds9/map/dem
A multiple of DEM Files from XEROX (Mt. St. Helens)
ftp://edcftp.cr.usgs.gov/pub/data/DEM/250
http://nsdi.usgs.gov/nsdi/wais/maps/dem1deg.HTML
http://sun1.cr.usgs.gov/doc/edchome/ndcdb/ndcdb.html

Please Note: If you download DEM data from the USGS ftp site then there is no need to de-block the data or use the chop.exe program as suggested by the USGS Department since this converter can handle any variety of input formats.

The DEM file format document is available from the following ftp site:

ftp://nmdpow9.er.usgs.gov/public/demstnds/stdempt1.ps
ftp://nmdpow9.er.usgs.gov/public/demstnds/stdempt2.ps
ftp://nmdpow9.er.usgs.gov/public/demstnds/stdempt3.ps

Problems with USGS DEM Data

While one might be lead to believe that elevation data sampled from satellites is perfect and 100% accurate, it is not, nor even close to being accurate. Several problems exist with USGS DEM data that one must be aware of:

1. First, the projection mapping techniques used to transform the spherically sampled data to UTM or longitude/latitude coordinates introduces distortion into the dataset. This is similar to flattening out a spherical map of the world into a flat macerator map.

2. Second, undefined regions (areas with no valid elevation data) are often found at the corners and sides of the DEM datasets. This causes a problem if two or more DEM datasets are imported and "stitched" together - holes will most likely appear between the datasets.

Features of this converter

1. DEM datasets typically contain 60000 or more quadrilateral polygons, or 1200000 triangles (for a 258x258 resolution sample; the maximum DEM dataset size if 2050x2050 which would result in 4.2 million quadrilaterals or 8.4 million triangles). This is an enormous number of polygons for most 3d rendering programs so this DEM converter incorporates two unique options to overcome this problem:.

A. The converter can skip over samples in the dataset so that only every n-th sample is used. Rather than importing 258x258 samples, the converter imports 51x51 samples (for a skip factor of 5) which results in only 2601 quadrilateral polygons.

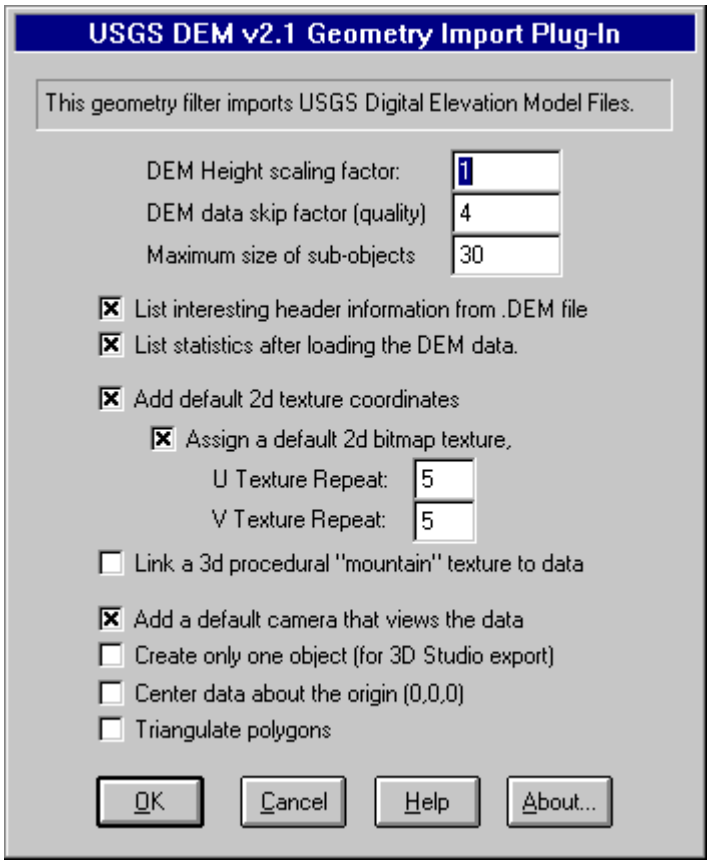
B. Rather than store the entire DEM dataset in single object, the DEM converter breaks up the data into multiple smaller objects with a common parent. This has shown to be an effective method to speeding up the wireframe redraws of the DEM data (by a factor of 2 or 3), and makes interactive user movement of a 3d camera much faster since each sub-object is only a few hundred polygons. In addition, certain rendering programs (such as Okino's NuGraf renderer) use much less memory when many smaller objects are used rather than one large object with many polygons. By default each sub-object stores a maximum of 900 polygons; contrast this with other converters which lump all 120,000 polygons into a single object - few renderers will be able to render such a large object.

1. A default 3d camera is added to the scene which views the DEM data from a pleasing angle.

2. u/v texture coordinates are added to the imported data so that a bitmap image can be easily draped over the DEM data.

3. The converter creates smoothed vertex normals so that the DEM data appears to be smooth when rendered.

Dialog Box Options



DEM Height scaling factor

This option scales the height of the DEM data. It default to 1.0. Values greater than 1.0 will make the DEM data higher while values between 0.0 and 1.0 will make the DEM data shorter.

DEM Data skip factor (mesh quality)

This option determines the quality of the imported DEM data (it directly controls how many polygons will be used to approximate the input DEM data). **THIS IS AN IMPORTANT CONTROL PARAMETER**!! A value of 1 results in the highest quality mesh while higher values (2, 3, 4, etc) result in lower quality, but at the benefit of reducing the number of polygons in the input data. This number will cause the converter to 'skip' over every n-th input sample. For example, if the input dataset size is 258x258 samples, and the skip factor is set to 4, then the converter will actually read in the data as if it were of size 65x65 (258/4 = 65). This will produce 4225 polygons (65x65) instead of 66565 polygons. A **value of 2 or 3** (16641 polygons to 7396 polygons) will produce good results for a final rendering, while **values of 5 to 8** will produce small datasets ideal for fast previews (2704 polygons to 1024 polygons).

Maximum size of sub-objects

By default the DEM data will be cut up into several smaller sub-objects rather than having all of the DEM data clumped together into one huge object. This option controls how many polygons will be put into each sub-object. The default is 30 which will cause 900 polygons (30x30) to be stored in each sub-object. The value range for this parameter is 5 to 100.

List interesting header information from the DEM file

If the checkbox is enabled (check-marked) then the converter will print out information about the imported DEM data including the following information:

1. The DEM data description from the file,
2. The number of profiles which is the number of lines of sample data in the X direction,
3. The projection mapping type (geographic, UTM or state plane),
4. The actual geographic coordinates of the DEM dataset's four corners,
5. The minimum and maximum elevations.

List statistics after loading the DEM data

If the checkbox is enabled (check-marked) then the converter will print out the number of objects and polygons created.

Add default 2d texture coordinates

If the checkbox is enabled (check-marked) then u/v texture coordinates will be added to the imported dataset. These texture coordinates will allow a 2d bitmap image to be easily mapped to the surface of the data. Please note that the

texture coordinates are aligned with the mathematical bounding quadrilateral of the dataset, not the actual physical edges of the data (this is because the physical edges of the data are not square or precise).

Assign a default 2d bitmap texture

This option is only valid if the converter is running within the **NuGraf Rendering System** software. If this checbox is enabled (check-marked) then a default 2d bitmap texture file (default.tif) will be linked to the DEM data. This option is useful if you intend to apply a 2d bitmap image to the DEM data. The **Add default 2d texture coordinates** option must also be enabled.

Once the DEM data has been imported, you can change the default bitmap image assigned to the data by pressing the **Textures** tab on the **Selector Window** (within the **NuGraf Rendering System** software) then clicking and holding the left mouse down over the **default dem texture** entry. A small pop-up menu will appear - choose the **Edit Texture** menu item. The **2D Image Texture Parameters** dialog box will appear; press the **Select** button to choose the new texture bitmap. When done, press the **Update and Exit** button on the dialog box.

U/V Texture Repeat

These two values determine how many times the 2d bitmap texture is to repeat across the DEM data surface (see the **Assign a default 2d bitmap texture** option above). The default values are 5 which will make the texture repeat 5 times in the horizontal and vertical directions.

Once the DEM data has been imported you can change the u/v repeat values by pressing the **Surfaces** tab on the **Selector Window** (within the **NuGraf Rendering System** software) then clicking and holding the left mouse down over the **default dem surface** entry. A small pop-up menu will appear - choose the **Edit Surface** menu item. The **Surface Attribute Editor** dialog box will appear; press the **Texture Layers** button so that the Texture Layer Editor dialog box appears. Now modify the values shown beside **U/V Repeat**.

Link a 3d procedural mountain texture to data

This option is only valid if the converter is running within the **NuGraf Rendering System** software. If the checkbox is enabled (check-marked) then a NuGraf "**mountain**" 3d procedural texture definition will be added to the scene and assigned to the current shader (useful for rendering the DEM data with the NuGraf renderer). This texture varies the color of the DEM data according to the elevation and slope of a polygon (the color varies from greens, to browns to whites at the highest altitudes). Please note that this texture tends to be slow to compute due to the turbulence math functions; a better alternative would be to assign a 2d bitmap texture.

Add a default camera that views the data

If the checkbox is enabled (check-marked) then the converter will add a default camera to the scene which views the DEM data at a pleasing angle.

Create only one object (for 3D Studio)

If the checkbox is enabled (check-marked) then one single object is created for

all of the imported data rather than having the data broken up into multiple smaller sub-objects (the default). **THIS OPTION SHOULD BE USED FOR DATA DESTINED FOR 3D STUDIO** because 3D Studio requires all polygons to be inside a single object so that its smoothing algorithm will work properly; if multiple objects are used then the vertex normals will not be the same where the sub-objects meet and hence "cracks" may appear at the junctions.

Center data about the origin (0,0,0)

If the checkbox is enabled (check-marked) then the DEM data will be centered about the origin (0,0,0). Please note that if the input DEM dataset uses the "**Geographic**" or "**State Plane**" grid types then the DEM data will always be centered about the origin; this may cause a problem if you want to import two DEM datasets and have them sit side-by-side; in this case you will have to physically move the two datasets so that they are side-by-side.

Triangulate Polygons

If the checkbox is enabled (check-marked) then the DEM data will be imported as triangles instead of 4 sided polygons. This is sometimes useful to enable since 4-sided DEM data polygons are not planar.

Overview of the DEM Dataset Types

DEM elevation data spacing varies from 30 meters for 7.5-minute DEMs to 3 arc seconds for 1:250,000 scale maps. All DEM data are similar in logical data structure and are ordered from south to north in profiles that are ordered from west to east.

1. **7.5-minute** DEM data are produced in 7.5-minute units which correspond to USGS 7.5-minute topographic quadrangle map series. 7.5-minute DEM data consist of a regular array of elevations referenced horizontally on the Universal Transverse Mercator (UTM) coordinate system of the North American Datum of 1927 (NAD 27). These data are stored as profiles with 30-meter spacing along and between each profile.

2. **15-minute** DEM data correspond to USGS 15-minute topographic quadrangle map series in Alaska. The unit sizes in Alaska vary depending on the latitudinal location of the unit. 15-minute DEM data consist of a regular array of elevation referenced horizontally to the geographic (latitude/longitude) coordinate system of North American Datum 1927 (NAD 27). The spacing between elevations along profiles is 2 arc seconds of latitude by 3 arc seconds of longitude.

3. **30-minute** DEM data cover 30-minute by 30-minute areas which correspond to the east half or west half of the USGS 30- by 60-minute topographic quadrangle map series for the conterminous United States and Hawaii. Each 30-minute unit is produced and distributed as four 15- by 15-minute cells. 30-minute DEM data have the same characteristics as the 15-minute DEM data except that the spacing of elevations along and between each profile is 2 arc seconds.

4. **1-degree** DEM data are produced by the Defense Mapping Agency in 1-degree by 1-degree units which correspond to the east half or west half of USGS 1- by 2-

degree topographic quadrangle maps series, for all the United States and its territories. 1-degree DEM data consist of a regular array of elevations referenced horizontally using the geographic (latitude/longitude) coordinate system of the World Geodetic System 1972 Datum. A few units are also available using the World Geodetic System 1984 Datum. Spacing of the elevations along and between each profile is 3 arc seconds with 1,201 elevations per profile. The only exception is DEM data in Alaska, where the spacing and number of elevations per profile varies depending on the latitudinal location of the DEM.

Limitations of the Converter

1. This converter will only handle DEM datasets which use UTM or longitude/latitude coordinate systems. These are the common coordinate systems used for most DEM data.

2. If exporting to 3D Studio then all of the DEM data must be exported as one object so that proper smoothing occurs between the sub-chunks. 3D Studio has a limit of 64k vertices and 64k polygons, therefore the chunk size must be set appropriately to limit the number of polygons and vertices output (the number of polygons created can be verified by enabling the '**List statistics after loading**' and checking that the number of polygons created is less than 65536).

3. As explained above, most DEM data files have regions of invalid elevation data (typically at the corners and at the sides). This will cause problems if two or more datasets are imported and "stitched" together: holes will most likely appear between the data. This converter cannot fix this problem which is an anomaly of the input data.