CONCEPT OF OPERATION

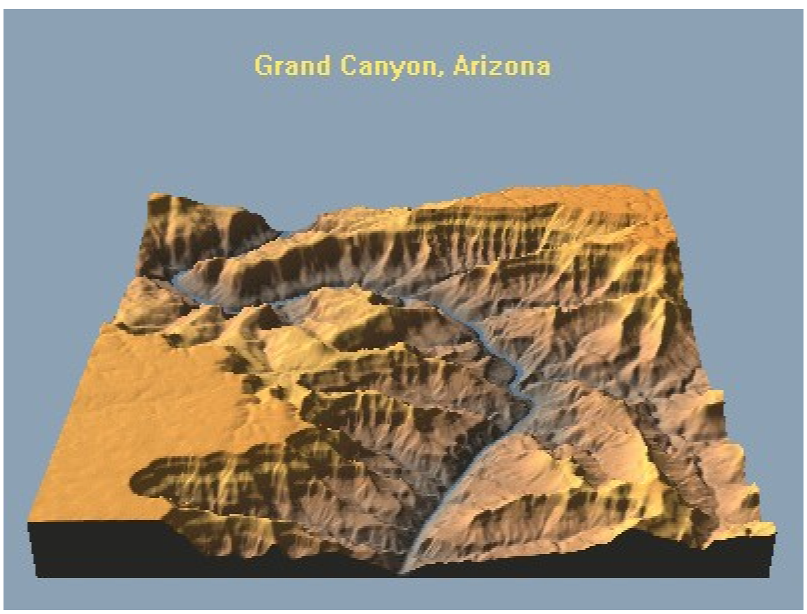
3DEM can render 3D terrain scenes and MPEG flyby animations from the following data sources:

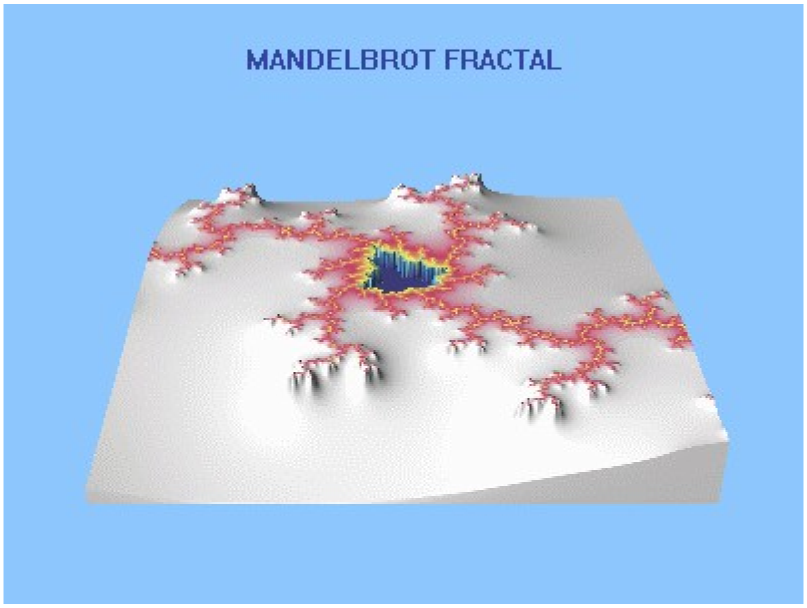
USGS Digital Elevation Model (DEM) files,
USGS Spatial Data Transfer Standard (SDTS DEM) files,
USGS Global 30 Arc Second Elevation Data Set (GTOPO30 DEM) files
NOAA Global Land One-km Base Elevation (GLOBE) files
NASA Mars Digital Topographic Map (DTM) files
Any topographic data file organized by rows and columns of elevation data
Internally generated Mandelbrot fractals

3DEM uses the SGI/Microsoft OpenGL libraries for high speed 3D rendering. 3DEM will render 16 or 24 bit color three-dimensional projections, red-blue projections requiring red-blue 3D glasses for viewing, or color 3D projections requiring Liquid Crystal Shutter (LCS) electronic shutter glasses for viewing. 3DEM scenes can be saved in the following formats.

JPEG (*.jpg)
Windows bitmap (*.bmp)
Flyby animation MPEG (*.mpg)
LCS Flyby Animation (*.fly)
VRML world (*.wrl)
Binary terrain matrix (*.bin)
Terragen terrain (*.ter)

Program updates are periodically available from the 3DM web page located at http://www.monumental.com/rshorne/3dem.html.




MANDELBROT FRACTAL

EQUIPMENT AND SOFTWARE REQUIRED

3DEM is designed to run under Win95/98 or WinNT 4.0 with 24 bit color graphics. A 200 MHz Pentium or better microprocessor and fast graphics card are recommended.

A minimum of 32 MBytes of memory is also required. However, less than 64 MBytes of memory will limit the usefulness of the high resolution modes of OpenGL rendering.

For Win95 you will need the Microsoft OpenGL dynamic link libraries (opengl32.dll and glu32.dll) These file can also be downloaded from the 3DEM home page at http://www.monumental.com/rshorne/3dem.html.

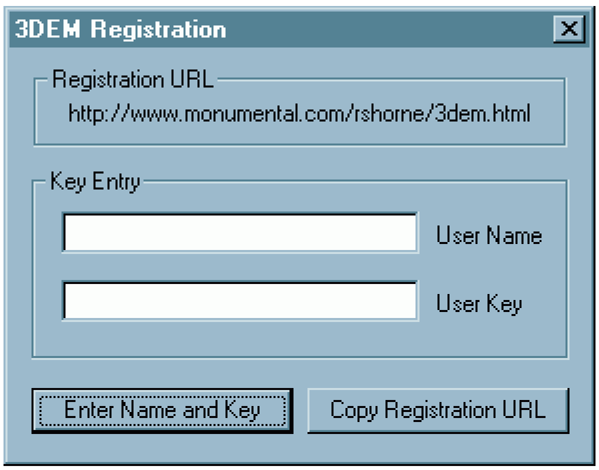
To install 3DEM just copy 3dem.exe, 3dem.hlp, and 3dem.cnt to a convenient directory on your hard drive. You can run 3dem.exe directly from this location or create a shortcut to 3dem.exe for your desktop. Opengl32.dll and glu32.dll should reside in your Windows/System directory.

3DEM will display GPS waypoints, routes, and tracks on both the 2D overhead view and the 3D projection generated from a Digital Elevation Model. This will allow you to view the track of any journey across a high resolution 3D image of the terrain. GPS data can be read directly from Garmin and Magellan handheld GPS receivers via a serial data connection to your computer. Waypoint text files can also be read and displayed.

SHAREWARE REGISTRATION

3DEM is distributed as shareware. The unregistered version of 3DEM allows you to load and view OpenGL 3D projections and flybys of Digital Elevation Model (DEM) terrain. Registration will unlock the program's image save and file save capabilities, allowing terrain, 3D images, and flyby animations to be saved as files and used in other applications. Registration will also remove the text, "3DEM Demonstration," which is inserted over all images by the unregistered version.

Registration is accomplished by entering a User Name and User Key in the registration dialog box that appears when the program is started. Once registered, a user may download frequent program updates at no charge and is entitled to email technical support.



A User Key, matched to User Name, can be obtained online from the 3DEM web page at http://www.monumental.com/rshorne/3dem.html. Choose "Copy Registration URL" to copy this web address to the clipboard. Then paste this URL into your web browser address entry box to take you directly to the 3DEM web page.

CONTACTING THE AUTHOR

Programs are only improved by the incorporation of new ideas. Your ideas are welcome. Please report any bugs or send any questions, comments, or ideas to rshorne@mnsinc.com, or visit the 3DEM web page at http://www.monumental.com/rshorne/3dem.html for the latest program update.

CHANGES IN VERSIONS 7 AND 8

For users of 3DEM version 7, a summary of the major changes in Version 8 is provided below

§ 3DEM will now merge multiple DEMs to provide high-resolution maps and 3D projections of large surface areas, limited only by the computer's memory.
§ 3DEM now shows geographic coordinates (latitude and longitude) on all overhead view displays. Both Lat-Lon and UTM coordinates are supported, allowing display and measurement of position to high accuracy.
§ 3DEM will now load and display Global Positioning System (GPS) waypoints, routes, and tracks on both the overhead view display and all 3D projections and flyby animations. Position data can be read directly from Garmin and Magellan GPS receivers via a serial data connection.
§ 3DEM now provides full support for global topographic data sets including USGS GTOPO30 and NOAA GLOBE including the ability to merge multiple data tiles, save selected areas, enter and view GPS data, produce 2D and 3D terrain projections and flyby animations.
§ 3DEM now provides both interlace and side-by-side display modes for use with Liquid Crystal Shutter (LCS) 3D glasses.
§ 3DEM now exports Terragen terrain of sizes up to 4097 by 4097 in support of Terragen ver 0.8 and higher.

The major changes in Version 7 are described below

- 3DEM now provides for easy visual translation and rotation of the terrain scene without the need to re-enter numerical projection parameters.
- 3DEM will now translate and read USGS SDTS DEMs directly.
- 3DEM can now save and read both ASCII and binary matrix files of terrain data.
- 3DEM can now read CDF matrix data files directly.
- 3DEM can now produce 3D scenes from internally generated Mandelbrot Set fractals.
- The dimensions of the 3D scene are now continuously adjustable by dragging the corner of the scene outline rectangle on the overhead view. There is no limitation to fixed sizes of 1, 4, and 16 enlargement.
- The field of view of the 3D scene is now adjustable, and viewpoint height adjustment is improved.
- Texture ovelay has been vastly simplified. JPEG or Windows bitmap overlays of any size can now be used. To use map overlays only requires that you know the coordinates of the map relative to the underlying DEM.
- Color assignment to scene altitude can now be saved and recalled for later use.
- 3DEM can now print color images of the rendered 3D scenes.
- 3DEM can now save images in both JPEG and Window bitmap format.
- 3DEM can now save VRML world files for viewing and exploration via the Internet.
- There is now no limit to the number of frames which can be recorded in a flyby animation.
- LCS flyby animations are now saved as a series of JPEG frames rather than 8 bit color frames, resulting in superior LCS animations.

3D TERRAIN RENDERING

To produce a three dimensional scene you must perform four operations in sequence with the 3DEM software as follows:

STEP 1 - Load a new DEM, SDTS DEM, GLOBE DEM, GTOPO30 DEM, NASA Mars DTM, or Terrain Matrix file and draw an overhead view of scaled altitude data. Choose "File - Load Terrain - Digital Model" from the overhead view menu to bring up the DEM File Type dialog box for selection of the desired file type. Select the file type, and then locate and open the desired DEM file. 3DEM will then load the selected terrain model and draw an overhead view of the entire geographical area with color scaled to the altitude at each point on the map.

STEP 2 - Define an area within the overhead view for conversion into a three dimensional scene. Click the left mouse button at a location on the overhead view which interests you. The area to be viewed will be outlined by a black rectangle. The observer's location and direction of view are indicated by a notch in one side of the outline rectangle. Increase or decrease the size of the outline rectangle by clicking and holding down the left mouse button at any corner of the rectangle. Then move the mouse forward or back to change the size of the area. Reposition the outline rectangle while holding down the left mouse button. Rotate the outline rectangle while holding down the right mouse button and moving the mouse left or right at the bottom of the display window. You can also make fine adjustments to the rotation of the outline rectangle using the left and right arrow keys.

STEP 3 - Once you are satisfied with the selected area, compute and display a three-dimensional landscape scene. Choose "Operation - View Scene" and 3DEM will give you a choice of terrain projection parameters as explained in the following paragraphs. Initially, you can just accept the default values and 3DEM will proceed to render the selected projection using OpenGL. The 3D image will be displayed in a separate window as the “OpenGL View.” Once the scene is complete, you can save the image as a Windows bitmap or JPEG file by choosing "File – Save Scene Image" from the OpenGL View menu.

STEP 4 - To tilt, rotate, or shift the position of the landscape relative to the observer, choose "Operation - Modify Position" from the OpenGL View menu (or function key “F5”) to bring up the Terrain Position Dialog Box. These controls allow you to tilt, rotate, or move the scene to obtain the best view of the terrain.

3D FLYBY ANIMATION

A flyby animation is a stored series of 3D scenes (or frames) which are played back rapidly in sequence to produce the appearance of a flyby. 3DEM compresses these frames into an mpeg file which can be played back with most any commercial or freeware mpeg animation player. To produce a flyby animation you must perform four operations in sequence with the 3DEM software as follows:

STEP 1 - Load a new DEM, SDTS DEM, GLOBE DEM, GTOPO30 DEM, NASA Mars DTM, or Terrain Matrix file and draw an overhead view of scaled altitude data. Choose "File - Load Terrain - Digital Model" from the overhead view menu to bring up the DEM File Type dialog box for selection of the desired file type. Select the file type, and then locate and open the desired DEM file. 3DEM will then load the selected terrain model and draw an overhead view of the entire geographical area with color scaled to the altitude at each point on the map.

STEP 2 - Define an area within the overhead view for conversion into a three dimensional scene. Click the left mouse button at a location on the overhead view which interests you. The area to be viewed will be outlined by a black rectangle. The observer's location and direction of view are indicated by a notch in one side of the outline rectangle. Increase or decrease the size of the outline rectangle by clicking and holding down the left mouse button at any corner of the rectangle. Then move the mouse forward or back to change the size of the area. Reposition the outline rectangle while holding down the left mouse button. Rotate the outline rectangle while holding down the right mouse button and moving the mouse left or right at the bottom of the display window. You can also make fine adjustments to the rotation of the outline rectangle using the left and right arrow keys.

STEP 3 - Select "Operation - View Flyby" and 3DEM will give you a choice of flyby projection parameters as explained in the following paragraphs. Initially you can just accept the default values, and 3DEM will render a real-time animated view of a flyby of the DEM landscape. The speed of this animation will depend on the speed of your computer and graphics card, and memory available. A fast machine will allow a frame rate of up to 10 frames per second. If you are fortunate to have OpenGL hardware acceleration, faster frame rates are possible. The primary purpose of this operation is to record a flight path through space over the DEM surface for subsequent conversion into a full resolution mpeg animation. Use the keyboard arrow keys to turn, climb, and dive. A cross mark cursor at the center of the view indicates your current flyby attitude, whether turning left or right, climbing, or diving.

STEP 4 - Once you are satisfied with the flight path through space, you can record a high resolution flyby animation using 16 or 24 bit color, red-blue color for viewing with red-blue lens 3D glasses, or interlaced color for viewing with Liquid Crystal Shutter (LCS) electronic shutter glasses.

Color and red-blue animations are saved as mpeg-1 files which may be played back with freeware mpeg players such as VMPEG or Hyper MPEG Player. Choose “Operation - Animate Flyby - Color MPEG” or “Operation - Animate Flyby - Red/Blue MPEG” to create a color or red-blue mpeg-1 animation.

Side-by-side LCS animations are saved as mpeg-1 files which can be played back with freeware mpeg players uch as VMPEG or Hyper MPEG Player. Choose “Operation - Animate Flyby - Side by Side MPEG.” In this format, the left-eye view and right-eye view are displayed side by side.

Interlaced LCS animations are saved as a sequence of jpeg frames which can be played back from within 3DEM. This jpeg animation is saved as a *.fly file. Choose “Operation - Animate Flyby - Interlace JPEG” to create an interlaced animation for LCS electronic shutter glasses. To play back this animation, choose “File - Load LCS Flyby.”

It is also possible to save the flyby animation as a series of individual JPEG frame files for assembly into an animation by other graphics programs. Choose “Operation - Animate flyby - JPEG Frames.” You will be prompted for a file name, and then individual 800x600 JPEG images will be saved for each animation frame. A frame sequence number will be appended to the file name for each frame.

FLYBY ANIMATION PLAYBACK

Color, red-blue and side-by-side animations are saved as mpeg-1 files which may be played back with freeware mpeg players such as VMPEG or Hyper MPEG Player. These players are available for download from the 3DEM home page at http://www.monumental.com/rshorne/3dem.html and at many other sites on the Internet.

Interlaced animations for Liquid Crystal Shutter (LCS) electronic shutter glasses are saved as *.fly files which may be played back from within 3DEM. Choose “File - Load LCS Flyby” to load and playback and LCS animation. 3DEM will loop through the recorded animation continuously until you choose “Operation - Stop Operation” from the 3DEM menu.

TEXTURE APPLICATION

3DEM allows you to apply textures to the terrain, ocean, and sky. This allows more realistic land and ocean surfaces, and allows the sky to be rendered with clouds or other atmospheric effects. Textures are added using the Scene Textures dialog box. To add a texture to your scene, take the following steps in sequence.

STEP 1 - Create or locate a suitable texture for the terrain, ocean, or sky. Thousands of textures are available for free download via the Internet. Browse for a collection of textures that fit the scenery which you are rendering. Textures used by 3DEM can be either Windows bitmaps or JPEG files of any dimension.

STEP 2 - After creating a 3D image as described above under “3D Terrain Rendering,” choose “Operation - Modify Textures” from the OpenGL View menu (or function key “F3”) to bring up the Scene Textures dialog box. Press the “Load” button under Terrain, Ocean, or Sky texture as appropriate to select and load the texture file.

STEP 3 - Choose the method of texture application to your scene. Textures can either “Blend” with the underlying terrain color, or “Replace” the terrain color entirely. Texture patterns can also either “Repeat” many times across the chosen surface or “Stretch” so that the texture image is only repeated once across the entire width and height of the chosen surface. Choose “Blend” and “Repeat” where you wish to apply a very fine pattern across an entire surface. Choose “Replace” and “Stretch” where you have a large texture image that you wish to apply as a fixed background (such as clouds for the sky). Note that if you plan to use textures in generating a flyby animation that you must use the “Stretch” option to fix the texture to the underlying terrain surface. Otherwise, the texture image will move and flicker from frame to frame during the animation.

STEP 4 - Once your textures are chosen, exit the Scene Textures dialog box and 3DEM will automatically render a new scene using the textures you have selected You should plan on experimenting with a number of different textures to get the best results.

MAP OVERLAY APPLICATION

3DEM allows you to overlay surface maps showing roads, cities, lakes and rivers, and other features over the 3D terrain image. Overlay maps are textures that are fixed to the geographical coordinates of the underlying DEM. To apply a map overlay using the Scene Textures dialog box, take the following steps in sequence.

STEP 1 - Locate a source of DEMs and corresponding surface maps, which cover the same geographical area at about the same scale. For the United States, good matches are the 7.5 Minute SDTS DEMs provided by the US Geological Survey at

http://edcwww.cr.usgs.gov/doc/edchome/ndcdb/ndcdb.html

and the Digital Raster Graphics available from the DRG Exchange at

http://216.36.33.21/~mgreger/GIS/exchange.html

The following instructions will illustrate overlay of Digital Raster Graphics on a Digital Elevation Model using the matching Snowshoe Peak, Montana, DEM and DRG available here.

STEP 2 - Download the Showshoe Peak SDTS DEM from http://edcwww.cr.usgs.gov/doc/edchome/ndcdb/7_min_dem/states/MT.html (tar.gz file) and the SnowShoe Peak DRG from http://nris.state.mt.us/nsdi/drg/d48115/index.html (tgz file).

STEP 3 - Decompress the SDTS DEM tar.gz file into its components and convert them into a standard DEM following the instructions given under USGS SDTS Files.

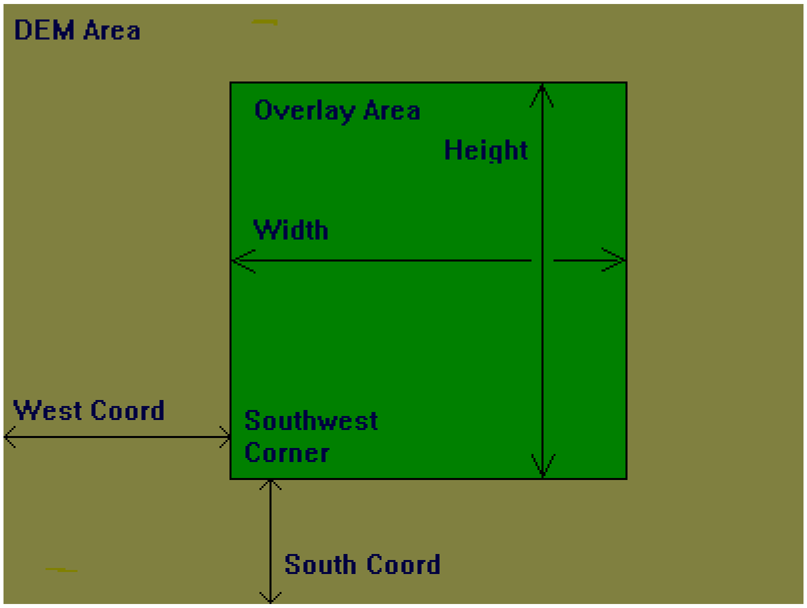
STEP 4 - Decompress and extract the TIFF graphics file from the DRG tgz file. Winzip can be used for this operation.

STEP 5 - Convert the DRG TIFF graphics file into a Windows bitmap for use with 3DEM. This can be done with an external graphics utility such as the excellent freeware “IrfanView” available from http://stud1.tuwien.ac.at/~e9227474/english.htm. First, load the DRG TIFF into IrfanView. Now you will see a large image of the DRG including the map “collar” containing a legend, geographic coordinates, and other information. To simplify using the map with 3DEM, this collar should be removed. Using the left mouse button, click and drag an outline rectangle around the entire DRG to include all four corners of the terrain (colored area) of the map and exclude the collar. Note that the map is not rectangular due to the UTM projection being used. So it is important that the outline rectangle include all four corners of the terrain, even if narrow sections of the map collar are also included. Once the outline rectangle is correctly drawn, choose “Edit - Crop” from the IrfanView menu to cut and discard the DRG collar. Next, choose “Image - Resample” from the IrfanView menu, set width to 1024 (height will be automatically calculated) and click “OK.” IrfanView will then resample and resize the image to a minimum width dimension of 1024 points which is an optimum size for use with 3DEM. Finally, choose “File - Save As” from the IrfanView menu, and select “Save As Type - Windows Bitmap” to save this image for use as an overlay by 3DEM. This conversion can be a very lengthy operation depending on your computer’s speed and memory, so be patient.

STEP 6 - The map overlay will be matched to the underlying DEM at a common southwest corner using relative coordinates. After creating a 3D image as described above under 3D Terrain Rendering, choose “Operation - Modify Textures” from the OpenGL View menu to bring up the Scene Textures dialog box. Then load the DRG bitmap as a terrain texture. Then choose “Stretch” in order to fit the map overlay to the underlying DEM. Now you must enter the relative coordinates of the southwest corner and the relative width and height of the map overlay. The values to be entered here are defined as follows:

West Coord = (Distance, west edge of DEM to west edge of map overlay)/(Total DEM Width)
South Coord = (Distance, south edge of DEM to south edge of map overlay)/(Total DEM Height)

Width = (Width of map overlay)/(Total DEM Width)
Height = (Height of map overlay)/(Total DEM Height)



These dimensions can be calculated using pixel dimension, inches, degrees of latitude and longitude, or any other unit of measure that is common to both the DEM and the map overlay. Since the DEM and DRG we are using here are exactly matched in geographic coordinates, the calculation is simple. Note that removal of the DRG map collar in Step 5 was necessary to allow this exact match. Choosing the "Match" button will automatically enter the proper values for map overlay coordinates and dimensions for the special case that the map overlay exactly matches the geographic dimensions of the underlying DEM.

West Coord = 0.0	South Coord = 0.0
Width = 1.0	Height = 1.0

Now click OK, and 3DEM will complete the 3D scene, making use of the DRG as an overlay to the DEM.

STEP 6 - Examine the resulting image to see that there is a good match between the map overlay and the underlying DEM features. It may be necessary to adjust the map overlay coordinates or dimensions slightly to obtain a perfect match.

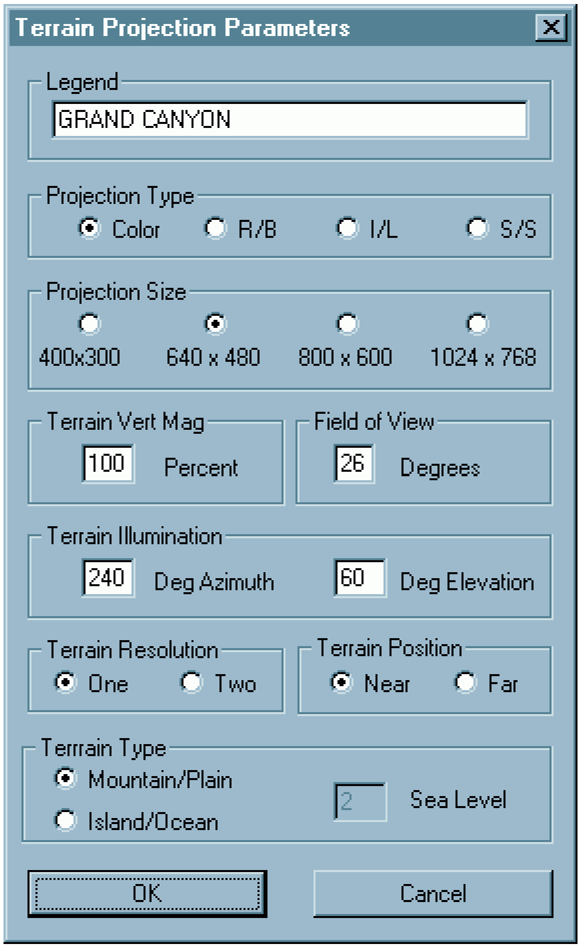
Note that for one degree DEMs only, it is also possible to match the map overlay to the DEM using geographic coordinates. Choose "Geo Coord" and the values to be entered can be expressed in degrees of latitude and longitude as follows:

West Coord = Longitude (decimal degrees) of the west edge of the map overlay
(Remember that longitude is negative in the Western Hemisphere)
South Coord = Latitude (decimal degrees) of the south edge of the map overlay
Width = Width (decimal degrees) of the map overlay
Height = Height (decimal degrees) of the map overlay

Currently, 3DEM provides this capability only for one degree USGS DEMs.

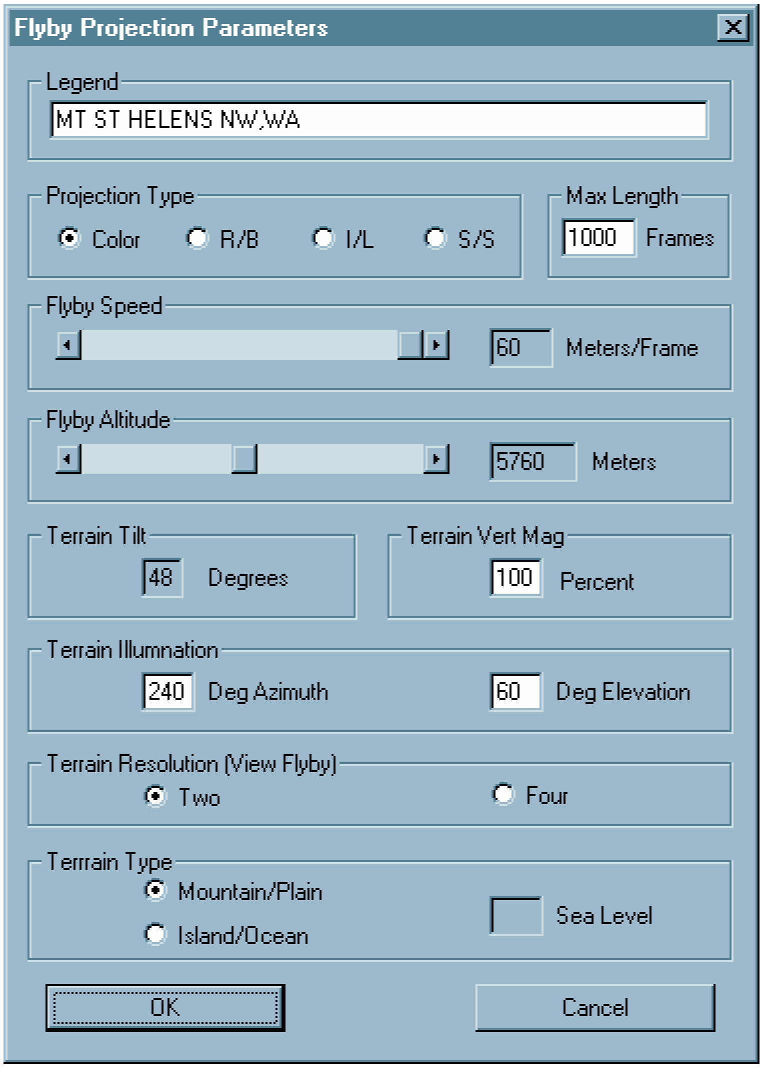
TERRAIN PROJECTION PARAMETERS

Terrain projection parameters are selected using this dialog box. Click on any control to see a description of its use in rendering a three dimensional scene.



FLYBY PROJECTION PARAMETERS

Flyby projection parameters are selected using this dialog box. Click on any control to see a description of its use in rendering a flyby animation.



SCENE LEGEND & PROJECTION SIZE

These controls are available from the dialog boxes for Terrain Projection Parameters and Flyby Projection Parameters and are used to adjust the appearance of the final 3D rendering.

LEGEND

The Legend is text which will appear at the top of your finished three dimensional scene. Initially, this legend is read from the DEM file header. Legends in Flyby are printed at the bottom of the screen and are only displayed for the first 50 frames of the animation. Adjust the legend words to your own preference.

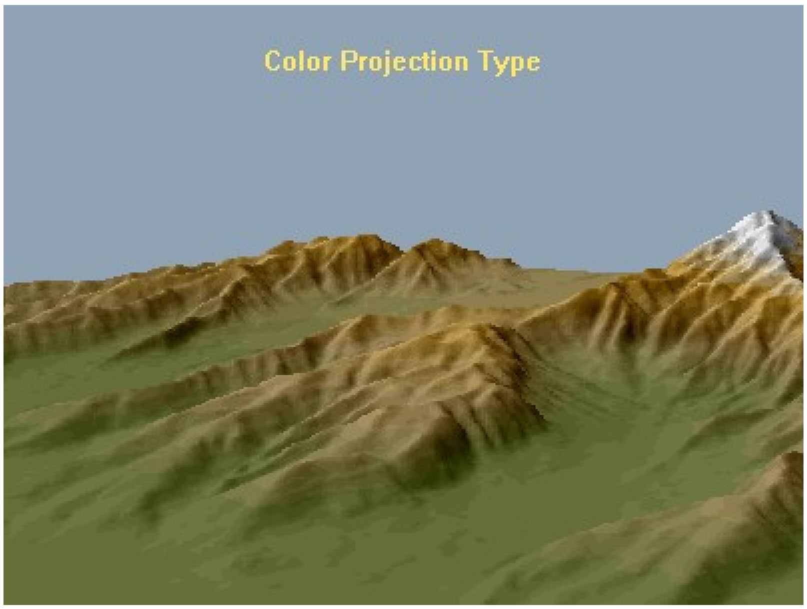
PROJECTION SIZE

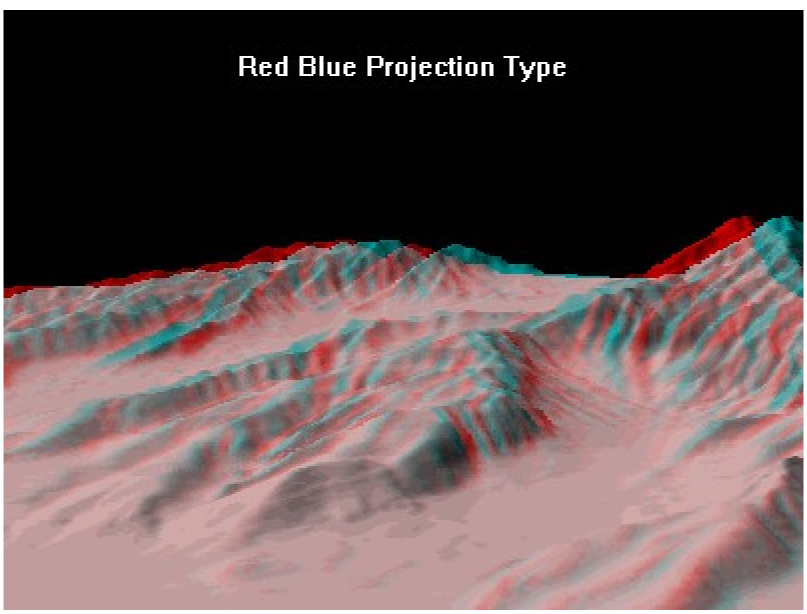
For 3D terrain rendering, you have a choice of projection sizes of 640 by 480, 800 by 600, and 1024 by 768 pixels. 3D flyby animation will always be rendered in a 400 by 300 pixel window.

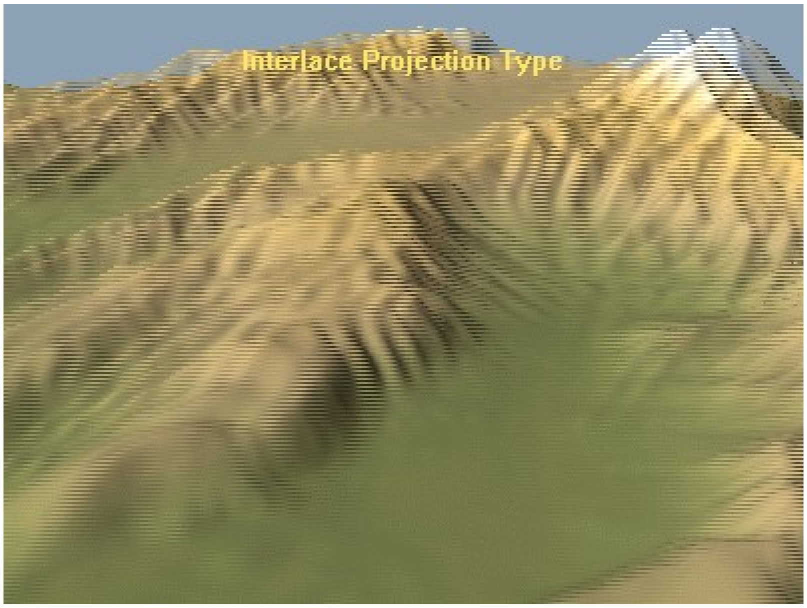
PROJECTION TYPE

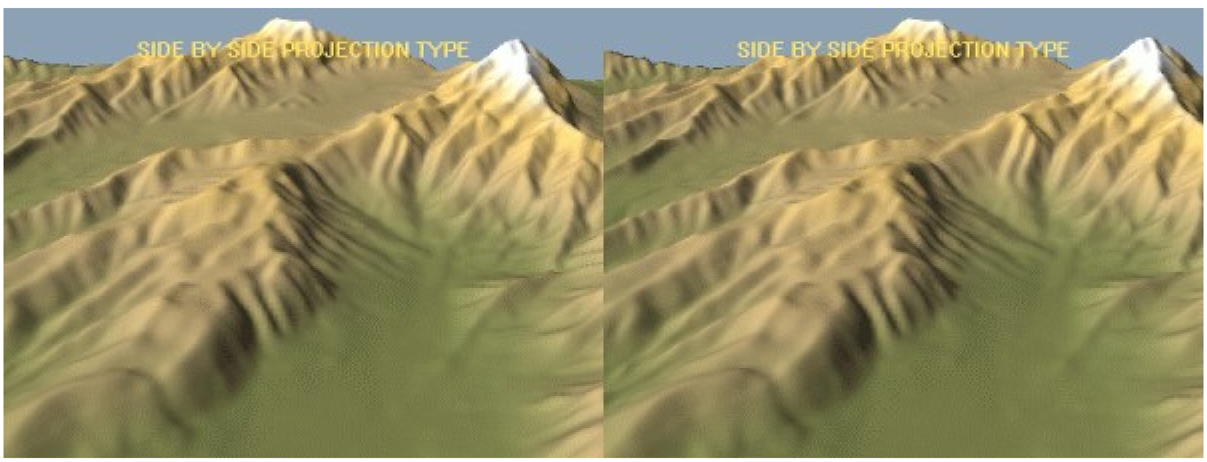
This control is available from the dialog boxes for Terrain Projection Parameters and Flyby Projection Parameters and is used to adjust the appearance of the final 3D rendering.

The type of 3D projection for either single scenes or for flyby projections is determined here. The "Color" selection provides a color 3D projection with surface colors determined by terrain height and the direction of illumination. The “R/B” or “Red Blue” selection provides a 3D projection for viewing with red-blue lens 3D glasses. The “I/L” selection provides an interlaced color 3D projection for viewing with Liquid Crystal Shutter (LCS) electronic glasses. The “S/S” selection provides a side-by-side color 3D projection of the left eye and right eye views. See the illustrations of projection type below.






Interlace Projection Type


SIDE BY SIDE PROJECTION TYPE
SIDE BY SIDE PROJECTION TYPE

FLYBY MAX LENGTH, FLYBY SPEED & ALTITUDE

These controls are available from the Flyby Projection Parameters dialog box and are used to adjust the appearance of the final 3D rendering.

MAX LENGTH

Select here the maximum number of frames to be included in your flyby animation. Software MPEG playback on a fast machine will be at a rate of 20 frames per second. Faster machines or hardware MPEG acceleration can result in greater frame rates.

FLYBY SPEED

Flyby speed is the distance in meters over the terrain between each animation frame. You will probably need large flyby speeds for very high altitude flybys and lower speeds for flybys close to the terrain surface. Experiment with flyby speed during real-time flyby to choose a speed that is matched to the altitude and scale of the terrain below.

ALTITUDE

Viewpoint altitude can be adjusted to improve the field of view during a flyby. The initial value will be a high above the landscape surface. Lower values can be chosen depending on the terrain. For flybys, terrain tilt is determined by the altitude so that the surface of the DEM fills the field of view.

TERRAIN TILT, VERT MAGNIFICATION & FIELD OF VIEW

These controls are available from the dialog boxes for Terrain Projection Parameters and Flyby Projection Parameters and are used to adjust the appearance of the final 3D rendering.

TERRAIN TILT

For fixed 3D scenes, terrain tilt is adjustable using the Terrain Position Dialog Box after the scene has been generated.

During Flyby, terrain tilt is automatically adjusted based on altitude above the surface. The Flyby Projection Parameters show the value of terrain tilt for the altitude at the start of the flyby. Lower flyby altitude results in a smaller automatic value of terrain tilt.

TERRAIN VERT MAGNIFICATION

Large scale DEMs and DTMs often show very low relief features. Vertical magnification increases the height of surface features to make them more visible in the three dimensional projection. Don't hesitate to use magnifications of 200% to 300% to improve the appearance of your scene. The default value of vertical magnification is 100%, but you should change this value if you are not satisfied with the appearance of the 3D projection.

FIELD OF VIEW

The field of view, in conjunction with viewpoint altitude and scene tilt, will determine the surface area included in the 3DEM scene. The field of view can be adjusted from 20 degrees to 45 degrees, with 30 degrees being the recommended value. Too large a field of view will result in the edges of the selected DEM area being visible in the scene. Too small a field of view will restrict the scene to a small area of the DEM surface. Experiment with these values to obtain the best results.

TERRAIN RESOLUTION, ILLUMINATION, AND POSITION

These controls are available from the dialog boxes for Terrain Projection Parameters and Flyby Projection Parameters and are used to adjust the appearance of the final 3D rendering.

TERRAIN RESOLUTION

3DEM creates a 3D landscape scene by constructing a grid of elevation data from the DEM map. The density of points in this grid determines the final scene resolution produced by OpenGL. A resolution of one indicates that every adjacent point from the DEM map is used in constructing the OpenGL grid. This is the highest resolution possible and will require the longest time to compute. Faster computation can be achieved at the expense of scene resolution. A resolution of two indicates that every second point from the DEM map is used giving a low resolution scene which can be computed quickly.

TERRAIN RESOLUTION (VIEW FLYBY)

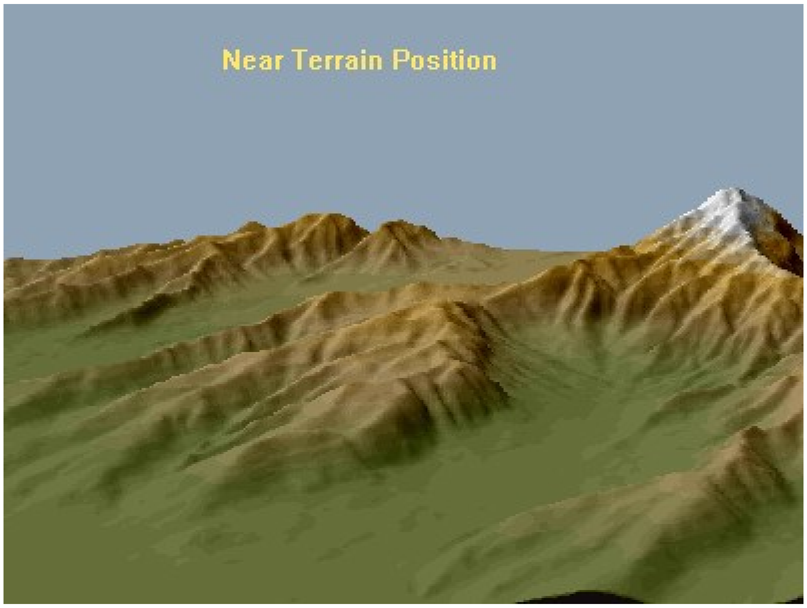
Choose here the resolution of the OpenGL terrain rendering for viewing a flyby in real time. Choice of resolution will depend almost entirely on the speed of your computer graphics hardware. A resolution of four indicates that OpenGL creates a terrain scene using every forth point from the DEM elevation map. This is a very low resolution that should be used with slower machines or with software only implementations of OpenGL. A resolution of two uses every second point from the DEM elevation map. This is a high resolution that can only be supported in real time by the very fastest hardware implementations of OpenGL.

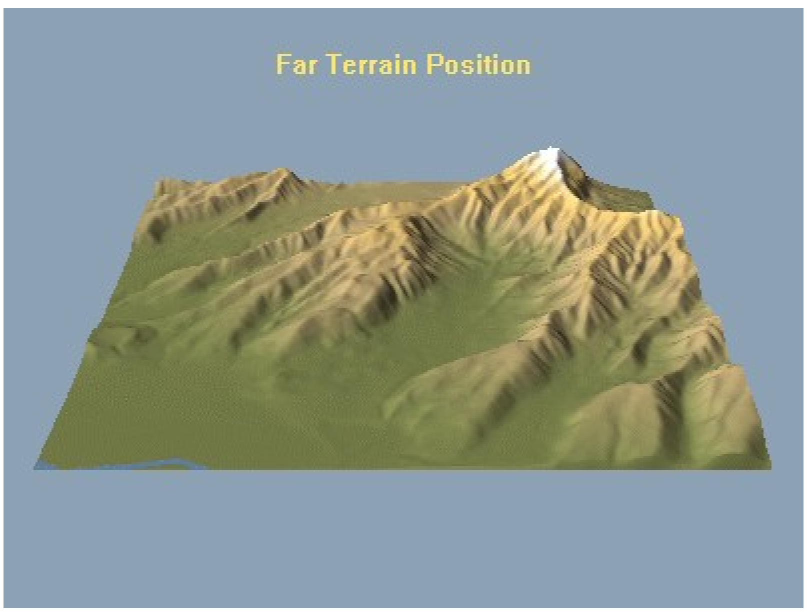
TERRAIN ILLUMINATION

OpenGL rendering uses one source of illumination at the azimuth and elevation angles chosen here. These directions are relative to the geographic north at all times. Zero degrees azimuth indicates a source directly from the north, while 180 degrees azimuth indicates a source directly from the south. Zero degrees elevation indicates a source on the horizon, while 90 degrees elevation indicates a source directly overhead. Thus the default values of 240 degrees azimuth and 60 degrees elevation indicate an illumination source from the south west. Experiment with these values if you find a need to change the appearance of light and shadow in your three dimensional projection.

TERRAIN POSITION

The position of the terrain model can be chosen to be “Near” or “Far” relative to the observer. A Near terrain position will fill the 3D scene with a large scale view of the selected area. A Far terrain position will produce a miniature view of the entire selected area. Examples of the Near and Far terrain positions are shown below.


Near Terrain Position


Far Terrain Position

TERRAIN TYPE

This control is available from the dialog boxes for Terrain Projection Parameters and Flyby Projection Parameters and is used to adjust the appearance of the final 3D rendering.

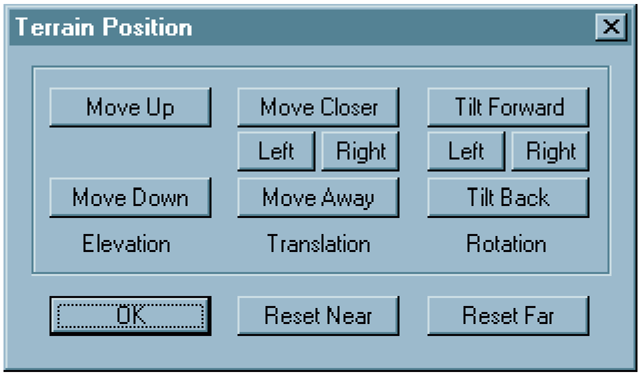
Normally, terrain is a combination of mountains and plains with lighting determined by the azimuth and elevation of the illumination source. However, if you are developing a scene containing the ocean's surface you may want the sea to appear as a uniform ocean color rather than appear as a brightly lighted plane. Choose "Mountain/Plain" for normal scenery, or "Island/Ocean" for scenery including the ocean's surface. You can also use the "Island/Ocean" setting for scenes in which there are rivers or lakes.

If you are developing an island and ocean scene, the shape of the shore line may be adjusted by selection of a "Sea Level" value. You may need to experiment by raising or lowering the sea level to achieve the proper shore line or river bank. If the surface of a wide area of ocean appears streaked or mottled, try raising the sea level a few meters at a time to properly cover the entire ocean surface. This setting is ignored for a mountain and plain scene. See the illustrations of terrain type below.


Island/OceanTerrain Type

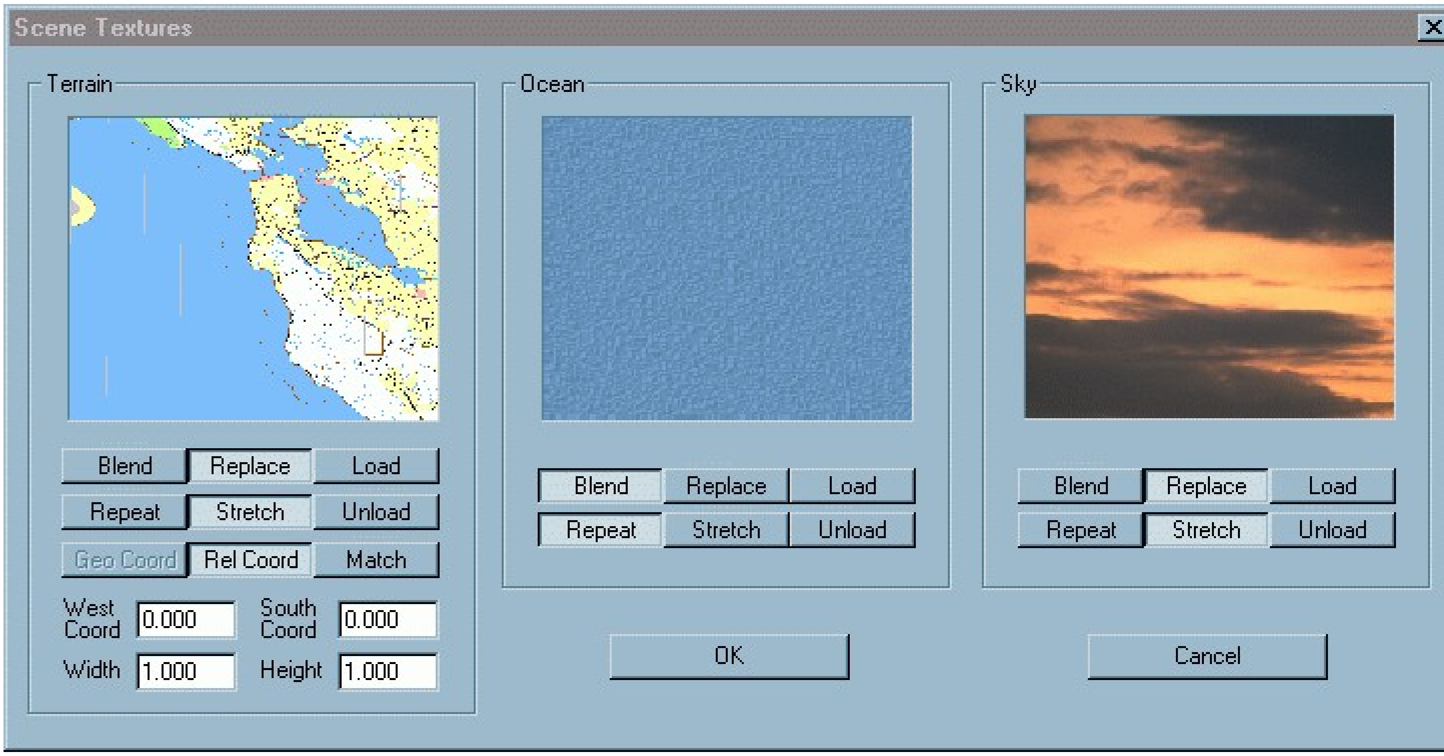
TERRAIN POSITION DIALOG BOX

Once a terrain scene has been created, its position in space relative to the observer can be modified using the Terrain Position Dialog Box. After rendering a terrain scene, choose "Operation - Modify Position" from the OpenGL View menu (or function key "F5").



- The Elevation of the terrain scene, relative to the observer, can be adjusted up or down using the "Move Up" or "Move Down" elevation buttons.
- Translation of the terrain scene, relative to the observer, is possible by use of the "Left, Right" or "Move Closer, Move Away" translation buttons.
- Rotation of the terrain scene, relative to the observer, is possible by use of the "Left, Right" or "Tilt Forward, Tilt Back" rotation buttons.
- The "Reset Near" and "Reset Far" buttons reset the terrain position to fixed near and far positions.

SCENE TEXTURES DIALOG BOX



3DEM allows you to apply texture bitmaps or JPEGs to the surfaces of the terrain, ocean, and sky. Choose "Operation - Modify Textures" from the OpenGL View menu (or function key "F3") to bring up the Scene Textures Dialog Box for choosing texture bitmaps. Click on any control on the dialog box above for an explanation of each function.

OPTIONS FOR TEXTURE APPLICATION

These controls are available from the Scene Textures Dialog Box and are used to select textures for application to the scene terrain, ocean, and sky.

BLEND OR REPLACE

Textures can be applied so that their colors either blend with the underlying terrain, or replace the colors of the underlying terrain. The "Blend" and "Replace" buttons are used to make this selection. In either case, the resulting surface is deformed and shaded to match the peaks and valleys of the underlying terrain.

REPEAT OR STRETCH

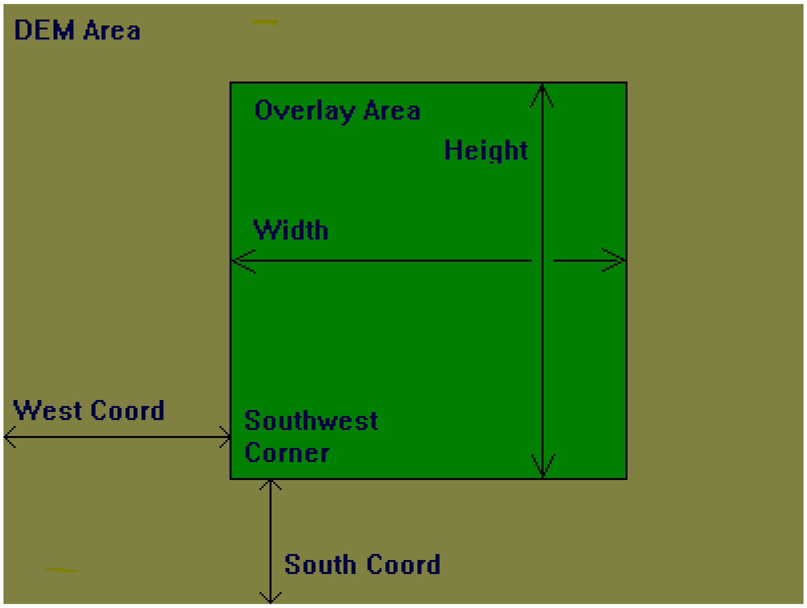
Textures can either repeat many times across a surface, or stretch so that the texture exactly matches the surface and is only repeated once. The "Repeat" and "Stretch" buttons are used to make this selection. Choose "Repeat" where you wish to apply a very fine pattern across an entire surface. Choose "Stretch" where you have a large texture image that you wish to apply as a fixed background (such as clouds for the sky or a surface map overlay for the terrain). Note that if you plan to use textures in generating a flyby animation that you must use the stretch option to fix the texture to the underlying terrain surface. Otherwise, the texture image will move and flicker from frame to frame during the animation.

LOAD AND UNLOAD

Use the "Load" and "Unload" buttons to choose a texture or discard a texture for either the terrain, ocean, or sky. The texture you choose will be previewed in the small window above the selection buttons. Textures may be either Windows bitmaps or JPEG files of any dimension. Note that if you are using JPEG textures, 3DEM will create a bitmap file of the same name in the file directory of the original JPEG file.

TEXTURE COORDINATES

These controls are available from the Scene Textures Dialog Box and are used to select textures for application to the scene terrain, ocean, and sky.



Texture coordinates are used to specify the position of a surface map overlay, which will be applied to the DEM as a texture in exact alignment with the underlying terrain features. A surface map overlay is a bitmap or JPEG, which overlaps the same area as the underlying DEM. The surface map and the DEM are aligned by specifying the relative coordinates of the southwest corner and the width and height of the map overlay relative to the underlying DEM. These values are defined as follows:

West Coord = (Distance, west edge of DEM to west edge of map overlay)/(Total DEM Width)
South Coord = (Distance, south edge of DEM to south edge of map overlay)/(Total DEM Height)
Width = (Width of map overlay)/(Total DEM Width)
Height = (Height of map overlay)/(Total DEM Height)

By definition, if the underlying DEM and the map overlay are perfectly matched, then

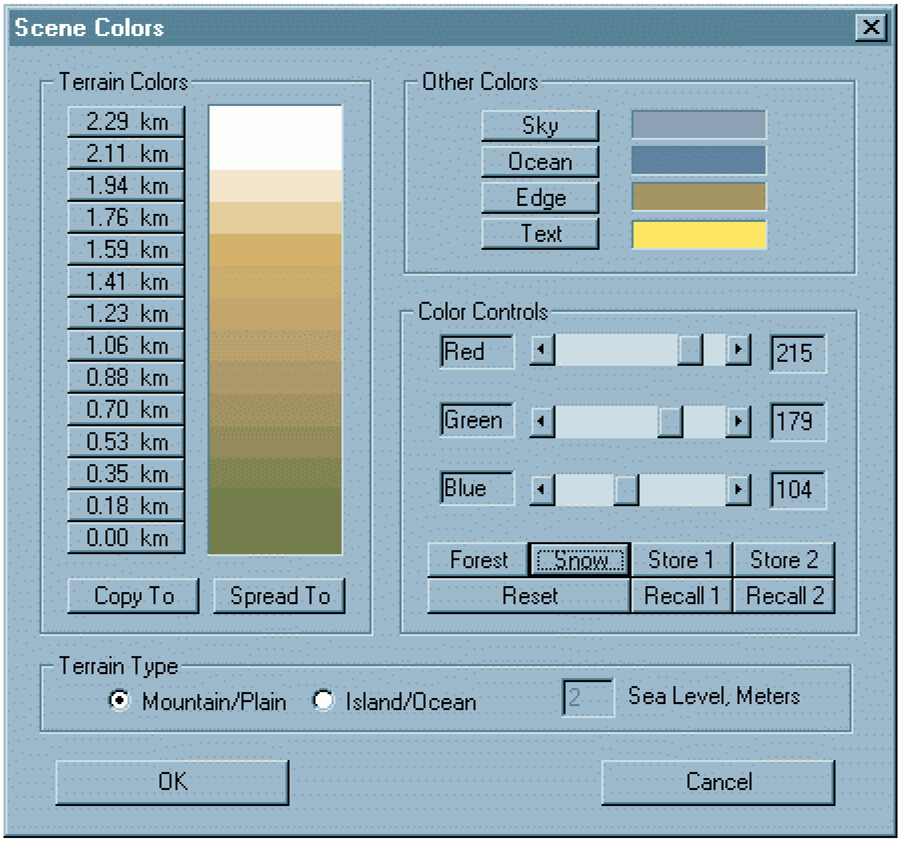
West Coord = 0.0	South Coord = 0.0
Width = 1.0	Height = 1.0

It is also possible to match the map overlay to the DEM using geographic coordinates. Choose "Geo Coord" and the values to be entered can be expressed in degrees of latitude and longitude as follows:

West Coord = Longitude (decimal degrees) of the west edge of the map overlay
(Remember that longitude is negative in the Western Hemisphere)
South Coord = Latitude (decimal degrees) of the south edge of the map overlay
Width = Width (decimal degrees) of the map overlay
Height = Height (decimal degrees) of the map overlay

Currently, 3DEM allows the use of geographic coordinates only with USGS one degree DEMs.

SCENE COLORS DIALOG BOX



You can adjust the colors of many features of either the overhead view or the 3D scene. Choose "Operation - Modify Colors" from the menu of the OpenGL View window (or function key "F2") to bring up the Scene Colors dialog box for selection of the terrain color scale. Here you can select the terrain color at each of fourteen altitude steps. Altitude is measured from the lowest point on the surface (not from sea level). The objective is to choose a range of colors to be spread from the lowest to the highest elevation on the surface. Select an altitude using its button in Terrain Colors, and adjust its color using the Color Controls RGB sliders.

You can also copy a color from one altitude to another, or create a smooth transition (or Spread) between colors at different altitudes. To copy a color, choose its altitude button in Terrain Colors, press the "Copy To" button, and then select the altitude button at the point you wish to copy the color. To spread colors, choose a starting point from the altitude buttons in Terrain Colors, press the "Spread To" button, and then select the desired end point from the altitude buttons to create a smooth transition of colors.

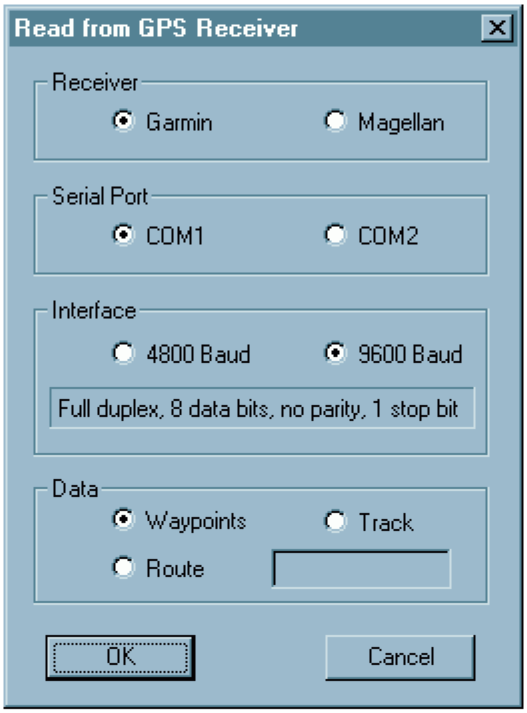
You also have the option of adjusting the colors of the sky, the ocean, the edge of a projection, or the text of the scene legend using the Other Colors buttons.

And finally, you can select the Terrain Type for the 3D Scene. Normally, terrain is a combination of mountains and plains with lighting determined by the azimuth and elevation of the illumination source. However, if you are developing a scene containing the ocean's surface you may want the sea to appear as a uniform ocean color rather than appear as a brightly lighted plane. Choose Mountain/Plain for normal scenery, or Island/Ocean for scenery including the ocean's surface. You can also use the Island/Ocean setting for scenes in which there are rivers or lakes.

Once you have defined scene colors, you can store the color assignment for future recall. The Scene Colors dialog box gives you the capability to store and recall two different scene color assignments. When you close the 3DEM program, these two color assignments will be saved in a file named “3dem.ini” in the same directory as the 3DEM program. Then when you run 3DEM again, these stored colors will be available for recall and use.

GLOBAL POSITIONING SYSTEM (GPS) INTERFACE

3DEM can download position data (waypoints, routes, and tracks) from Garmin and Magellan handheld GPS receivers via a serial data connection. These points are then displayed as a continuous line on the overhead view and in all 3D projections and animations. Choose “GPS - Download from GPS receiver” to bring up the GPS interface dialog box as shown below.



Either a Garmin or Magellan receiver may be selected. Garmin receivers must be set up for GRMN/GRMN interface using the internal system menu and always operate at 9600 baud. Magellan receivers must be set up for either 4800 or 9600 baud both at the receiver and here for 3DEM. Then serial data transfer can be established using either COM1 or COM2 serial ports on your computer. The interface operates with full duplex data transfer using 8 data bits, no parity, and 1 stop bit.

3DEM will display waypoints, routes, or tracks stored in the GPS receiver. Waypoints and routes are made up of individual points that have been entered by the user to mark position along a trail. Tracks consist of the internal track log of the GPS receiver used to plot a smooth track curve on the GPS display. In general, a track will be made up of hundreds of individual points. 3DEM will plot up to 2000 track points.

GLOBAL POSITIONING SYSTEM (GPS) WAYPOINTS

3DEM can also load and display GPS waypoints stored as a file. To load GPS waypoints from a file, choose "GPS - Read Waypoints from File" and either "Gardown text" or "Lat Lon text."

A Gardown waypoint text file consists of latitude and longitude values stored as text in the format used by Gardown, a shareware program for downloading waypoints from Garmin GPS receivers. A sample of this format is given below for a path through the Grand Canyon.

```
W   001 N36 14.5134 W112 23.6298 Sat Nov 20 21:56:20 1999
W   002 N36 13.9416 W112 24.9186 Sat Nov 20 21:56:38 1999
W   003 N36 12.8940 W112 24.9186 Sat Nov 20 21:56:50 1999
W   004 N36 12.0372 W112 25.9734 Sat Nov 20 21:57:07 1999
W   005 N36 12.2274 W112 27.0282 Sat Nov 20 21:57:17 1999
W   006 N36 13.0848 W112 26.9112 Sat Nov 20 21:57:30 1999
W   007 N36 13.8462 W112 27.3798 Sat Nov 20 21:58:03 1999
W   008 N36 14.2272 W112 28.4346 Sat Nov 20 21:58:13 1999
```

A Lat Lon waypoint text file consists of latitude and longitude pairs separated by spaces and stored as text without any other punctuation. A sample of this format is given below for the same path as described above.

```
036.24189000    -112.39382998
036.23236000    -112.41530998
036.21490000    -112.41530998
036.20062000    -112.43288998
036.20379000    -112.45046998
036.21808000    -112.44851998
036.23077000    -112.45632998
036.23712000    -112.47390998
```

3DEM will connect these waypoints with a solid line in the order in which they appear in the waypoint file. This allows you to record GPS waypoints during a trek through the wilderness, and then visualize the traveled path on the overhead view and 3D projection of the terrain.

3DEM also provides the option of entering waypoints manually. Choose "GPS - Enter Waypoints by Mouse," and then click the left mouse button to enter waypoints in sequence.

OVERHEAD VIEW COLOR SCALE

Choose “Color Scale - Show Scale” from the main menu to show a color scale for the overhead view. This color scale matches colors to altitude on terrain surface. Altitude is measured from the lowest point on the surface (not from sea level). The objective is to choose a range of colors to be spread from the lowest to the highest elevation on the surface.

Choose “Color Scale - Modify Scale” to modify the color scale. See the previous description of the Scene Colors dialog box for instructions on adjusting colors.

SAVING TERRAIN DATA

Terrain data can be saved for future use with 3DEM or other applications.   It is particularly useful after merging a large number of USGS DEMs to save the entire surface as a terrain matrix file.   This compact file can then replace all of the individual merged DEMs.

Choose “File - Save Terrain Matrix” to save the entire terrain as a binary terrain matrix file with associated ASCII header file.   See the description of terrain matrix files that follows.

SAVING TERRAGEN TERRAIN FILES

3DEM can export data files for use by the Terragen terrain rendering program. Terragen can produce spectacular clouds and atmospheric effects and also provides advanced surface texturing capability. Terragin can be found at http://www.planetside.co.uk/terragen/ on the Internet.

To create Terragen terrain files, load a terrain digital model into 3DEM. Choose the area to be converted from the overhead view by rotating and sizing the black outline rectangle. Then render a 3D scene by choosing "Operation – View Scene." Once you are satisfied with the scene selection, choose "File – Save Terragen Terrain" from the OpenGL View Menu. 3DEM will then save a terrain *.ter file which can be opened and displayed by Terragen.

3DEM will export Terragen terrain in sizes up to 4097 by 4097 in support of Terragen version 0.8 and higher. 3DEM attempts to find the best match between the dimension chosen in 3DEM and the fixed dimension allowed by Terragen (257, 513, 1025, etc). The rules for dimension matching are as follows:

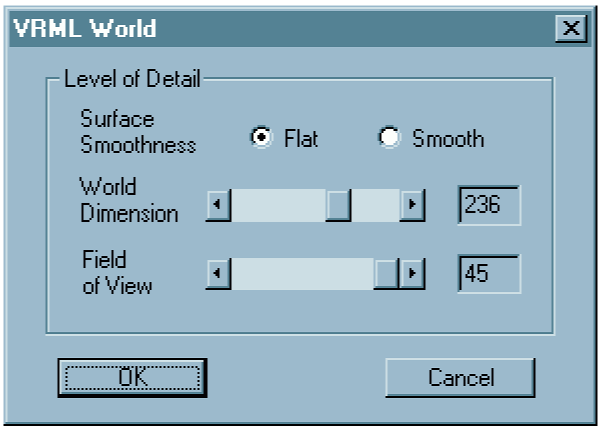
3DEM less than 383 results in Terragen 257;
3DEM from 384 to 767 results in Terragen 513;
3DEM from 768 to 1535 results in Terragen 1025;
3DEM from 1536 to 3071 results in Terragen 2049;
3DEM greater than 3072 results in Terragen 4097.

You can directly measure the dimension chosen in 3DEM using the overhead view color scale. Choose "Color Scale - Show Scale - Meters" and read the scene width in meters at the bottom of the scale. For 30 meter SDTS DEMs, divide the scene width by 30 meters to get the 3DEM dimension. For the large 1 degree USGS DEMs, divide the scene width by 90 meters to get the 3DEM dimension.

SAVING VRML WORLDS

3DEM can save a 3D scene as a Virtual Reality Modeling Language (VRML) world file (*.wrl) which can then be viewed and explored in real time over the Internet using a VRML plug-in to your web browser. The Silicon Graphics COSMO player available at http://cosmosoftware.com is highly recommended.

Once you have generated a 3D scene choose "File - Save VRML World" from the OpenGL View menu. Then you will be presented with the VRML dialog box for selection of the level of detail in the VRML world.



Surface Smoothness can be chosen to be either "Flat" or "Smooth," which indicates either flat face or smooth shading in the rendering produced by the VRML player. Smooth shading improves the appearance of the surface somewhat, but at an enormous increase in the size of the world file. Flat shading is recommended for any world file that will be downloaded via the Internet in order to keep the download time to a reasonable limit. You can use smooth shading on your local machine for improved appearance when download times are not a concern.

World Dimension is the number of points per side which make up the VRML terrain grid. If N is the world dimension chosen, the number of individual triangular faces making up the VRML world is 2*(N-1)*(N-1). So a VRML world with a dimension of 200 will be made up of almost 80000 faces. Obviously, World Dimension requires a trade-off between level of detail and the size of the resulting world file.

Field of view is the angular field of view, which will be used by the VRML player. A value of 45 degrees is normal, but you can choose narrower fields if necessary to improve the appearance of the scene. Note that this field of view is independent of the field of view that you have selected within 3DEM for the 3D scene rendering.

3DEM creates the VRML world by first constructing a terrain grid of elevation values and then by rendering a JPEG overhead image of the selected terrain. The terrain grid is saved in the *.wrl file, and the JPEG image is saved separately as a *.jpg file. Both of these files are then used by the VRML player to display the world. The terrain grid defines the surface elevation at each point in the world, and the JPEG image is applied as a texture overlay to define the colors at each point in the world. If you plan to use the VRML on a web page, be sure that the associated JPEG file is also available and can be located by the VRML player.

When creating VRML worlds, use the largest screen size that your monitor will support. 1600 by 1200 is good if you can reach it. It is desirable to create the largest and most detailed JPEG texture overlay possible since this image defines the smallest visible details in the world surface. OpenGL needs the entire surface of the monitor to produce this image, so the largest screen size possible should be used in creating the VRML world. However viewing of the VRML world can be done at any screen resolution.

SAVING BITMAP OR JPEG IMAGES

3DEM has several options for saving images as bitmaps or jpeg files. The overhead view image can be saved in entirety as a Windows bitmap or JPEG. Choose "File - Save Map Image" from the overhead view menu. Then choose either a bitmap or jpeg file format, an image quality (for jpeg only), and an image magnification to be applied.

Image magnification is provided as an option where the bitmap or jpeg image is to be printed or displayed in another application. Often an image printed at a high value of dots per inch will appear much smaller than on your computer screen. Use the “Size When Printed” controls to predict the final printed size of your image as determined by magnification and the dots per inch of your printer.

The overhead view can also be saved as a 16 bit targa bitmap or height field which will allow you to import elevation data into the POV-Ray 3D ray tracing software. Choose "File - Save Height Field." First you will be presented with a dialog box for selection of the amplitude scale of the height field data. Amplitude may be scaled to a maximum value of 65535. After selecting the amplitude scale, a file save dialog box will appear. Enter a *.tga filename, and the entire overhead view will be saved as a 16 bit targa height field. Experiment with the choice of amplitude scale to obtain the best height field data for use in POV-Ray.

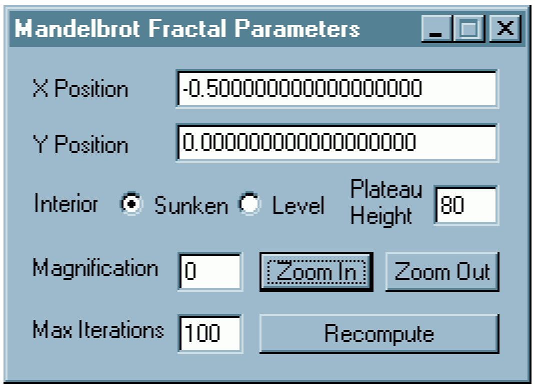
Similarly, any 3D projection in either color or red-blue imaging, can be saved as a Windows bitmap or JPEG. After rendering a landscape scene, choose "File - Save Scene Image" from OpenGL View menu.

PRINTING IMAGES

Once you have created a 3D image, you can send it directly to a printer by selecting "File - Print Scene Image" from the OpenGL View window menu. This will bring up a standard Windows Print Dialog Box for selection of the printer and page setup. The size of the printed image will be automatically adjusted to match the size the paper being used.

MANDELBROT FRACTALS

3DEM can produce 3D projections and flyby animations from Mandelbrot Fractals.   Choose "File - Load Terrain - Mandelbrot Set" from the menu of the overhead view window to generate a random fractal landscape.



You will be presented with dialog boxes for choosing the position, magnification, and number of iterations used in calculating the fractal image.   The use of each of these controls is as follows:

X Position, Y Position, X Start and Y Start specify the starting location for calculation of the fractal.   If you already know the needed parameters for a particular fractal location then they can be entered here.   Otherwise, these values are selected by clicking the mouse on an area of interested on the overhead view of the fractal.

Interior points of the fractal can be chosen to be either sunken or level with the upper surface.   This characteristic will only be visible in the 3D image and not in the overhead view of the fractal.   This selection is available to improve the appearance of the 3D image.

Plateau Height determines the shape and color of the highest elevations of the fractal 3D image.   3DEM displays these fractals using the mathematical “Continuous Potential” method which results in images with large peaks and smoothly sloping sides.   The plateau is defined as a flattened area at the peak elevations upon which the colored fractal image is drawn.   Experiment with the Plateau Height to obtain the most satisfactory images.

Magnification here is the number of times the scale of the fractal has been doubled.   A magnification of zero gives the widest view of the fractal.   A magnification of 1 increases the scale by a factor of two.   A magnification of 2 increases the scale by a factor of 4.   A magnification of 6 increases the scale by a factor of 64, and so forth

The Zoom In and Zoom Out buttons add or subtract one from the value of magnification.

Max Iterations is the number of iterations used in the calculation of the fractal surface.   Larger values will increase the detail visible in the fractal at the expense of a great increase in computation time.   Keep this value as low as possible to achieve the detail needed in the fractal surface.

The Recompute button recalculates the fractal surface using the magnification and position values that you have entered.

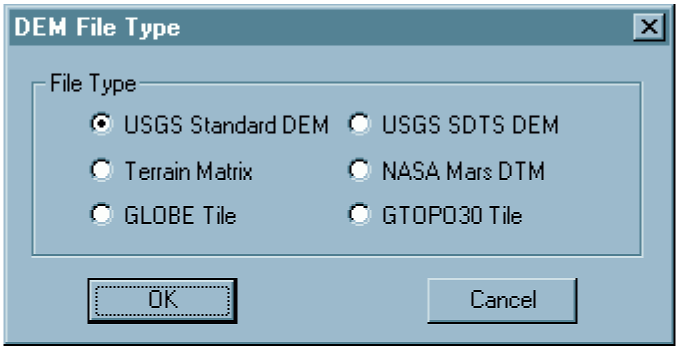
Once you have found an interesting area of the fractal in the overhead view, choose “Operation -View Scene” from overhead view menu to render a 3D image of the selected area.

FRACTAL LANDSCAPE SCENES

3DEM can produce 3D projections and flyby animations from random fractal landscapes. Choose "File - Load Terrain - Fractal Surface" from the overhead view menu to generate a random fractal landscape. You will be presented with a dialog box for choosing the "Seed" value for the computer's random number generator and the number of random elements (from 64 to 512) used in synthesis of the fractal surface. Each Seed value will result in a unique surface. Increasing the number of elements increases the roughness of the surface. Experiment with these two controls to see the effect that they have on the surface produced.

3DEM FILE SELECTION

Choose “File - Load Terrain Model - Digital Model” from the main menu to bring up a dialog box for selection of the type of input data to be used. Each of these selections represents DEM data which is freely available on the Internet. Click on any data item in the figure below for a detailed description.



USGS DIGITAL ELEVATION MODEL (DEM) FILES

SOURCES OF DATA - DEM files are available via ftp for most of the United States and many other areas of the globe. The USGS offers a large selection of 1 degree DEM files at

http://edcwww.cr.usgs.gov/glis/hyper/guide/1_dgr_demfig/states.html.

A good choice is Grand Canyon East in the Arizona listing. Be sure to download the compressed version. The uncompressed DEM is about 10 MB. You can use WinZip to decompress these files. However, you MUST disable "TAR File Smart CR/LF Conversion" in "Options - Configuration." Otherwise, the decompressed file will have added bytes and will not be readable by 3DEM. Also, you must rename the decompressed file by adding a ".dem" file extension in order for it to be recognized by 3DEM.

USING DEM FILES - Choose "File - Load Terrain - Digital Model" from the overhead view menu to bring up the "Open DEM File" dialog box. Then select the USGS DEM file type from the "Files of Type" listing. Locate the desired file and click "Open."

USGS SDTS DEM FILES

SOURCES OF DATA – 7.5 minute SDTS DEMs for the entire United States are available for download from the USGS at http://edcwww.cr.usgs.gov/doc/edchome/ndcdb/ndcdb.html. These files are downloaded in *.tar.gz" format and must be decompressed into a group of 18 files which make up a spatial data transfer. You can use WinZip to decompress these files. However, you MUST disable "TAR File Smart CR/LF Conversion" in "Options - Configuration." Otherwise, the decompressed file will have added bytes and will not be readable by 3DEM. Also, please note that the downloaded archive must have a file name that ends with ".tar.gz". Some browsers will change this filename on download to end with "_tar.gz" and WinZip will fail. Please correct the file name if necessary before using WinZip to decompress the SDTS files.

USING SDTS DEM FILES – The 18 files which make up the spatial data transfer must be converted into a single standard DEM file before use by 3DEM. This conversion capability is built into 3DEM and operates as follows. Choose "File - Load Terrain - Digital Model" from the overhead view menu to bring up the "Open DEM File" dialog box, and then select "USGS SDTS DEM. Then you can select any one of the 18 *.ddf" files which make up the spatial data transfer and click "Open." 3DEM will ask you for a filename of the conversion DEM and then proceed to convert the spatial data transfer into a standard DEM file, load the converted DEM, and display an overhead view.

Also please note that all of the 18 files that make up the spatial data transfer will end with ".DDF". To use these files, you must see a file named something like xxxCELO.DDF. If you have a file with a name something like xxxxLE##.DDF then this is in a SDTS Digital Line Graph (DLG) directory and will not work with 3DEM. Refer to ftp://ftp.blm.gov/pub/gis/ for utilities to convert DLG files.

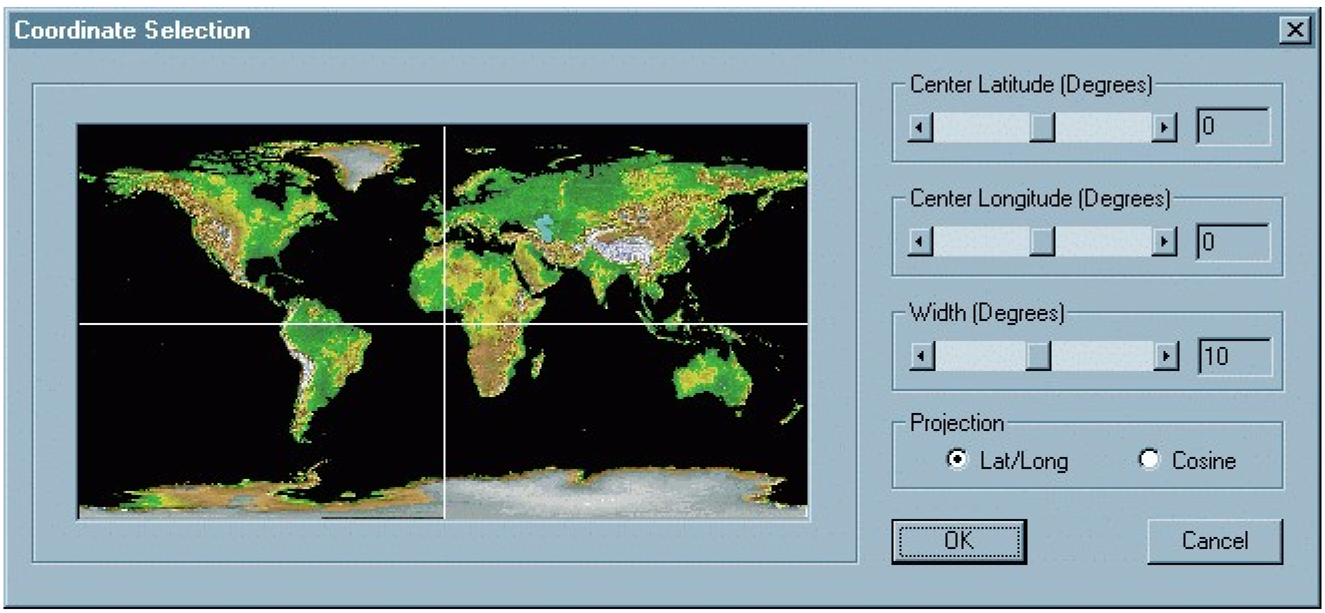
USGS GTOPO30 DEM FILES

SOURCES OF DATA - Global 30 Arc Second Elevation Data Sets consisting of elevation measurements at intervals of 30 by 30 arc seconds (about 1KM) are available for the entire globe from

http://edcwww.cr.usgs.gov/landdaac/gtopo30/gtopo30.html

GTOPO30 DEMs are downloaded in compressed .tar.z format. You can use Winzip to decompress these files. However, you MUST disable "TAR File Smart CR/LF Conversion" in "Options - Configuration." Otherwise, the decompressed file will have added bytes and will not be readable by 3DEM. You only need to decompress the *.dem and *.hdr files from the compressed archive file. Both the DEM file and the header file must be present in the same directory for use by 3DEM.

USING GTOPO30 DEM FILES - 3DEM is designed to merge together multiple GTOPO30 DEM files to provide continuous surface coverage of the entire globe. Choose "File - Load Terrain Model - Digital Model" from the overhead view menu to bring up the "DEM File Type" dialog box. Then select "GTOPO30 Tile" and you will be presented with the "Coordinate Selection" dialog box for selection of the geographical position and width (in degrees) of the area to be mapped.



Select a geographical location by clicking on the map of world. Make fine adjustments in latitude and longitude using the slider controls provided. Once you have selected a geographical position and map width, click "OK" and 3DEM will prompt you in sequence to locate and load the GTOPO30 DEM files which are needed to construct the desired map. A file dialog, with the name of the file to be located contained in the title bar, will appear for each file in sequence. You must locate and load each file that is named in the title bar of the file dialog. Once all files have been loaded, 3DEM will proceed to draw an overhead view of the selected area.

3DEM provides a choice of either "Lat/Long" or "Cosine" map projection when loading GTOPO30 DEMs. The Lat/Long projection produces a rectangular surface grid with equal extension in latitude and longitude. The disadvantage of the Lat/Long projection is distortion at high latitudes. If you are creating images at high latitudes, try the Cosine projection, which produces a surface grid corrected for latitude and a more realistic overhead view and 3D projection.

NOAA GLOBE DEM FILES

SOURCES OF DATA - Global Land One-km Base Elevation (GLOBE) files consisting of elevation measurements at intervals of 30 by 30 arc seconds (about 1KM) are available from

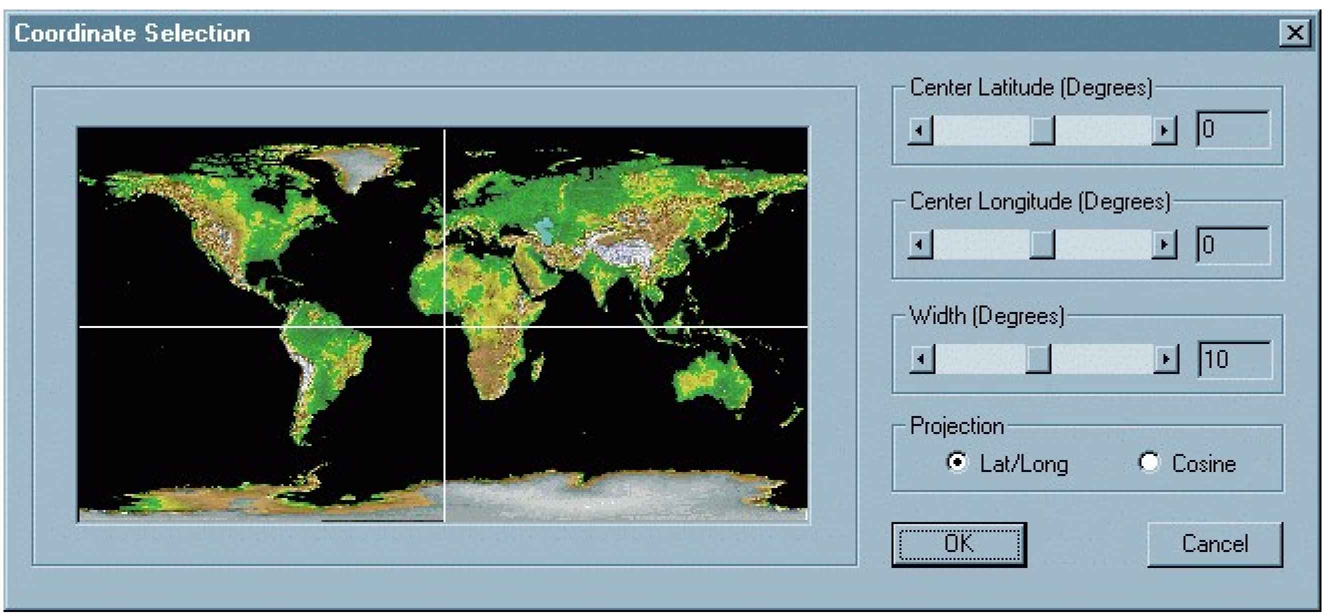
http://www.ngdc.noaa.gov/seg/topo/globe.shtml

GLOBE files are downloaded in compressed tar.z format. You can use Winzip to decompress these files. However, you MUST disable "TAR File Smart CR/LF Conversion" in "Options - Configuration." Otherwise, the decompressed file will have added bytes and will not be readable by 3DEM.

There are two ways to obtain GLOBE terrain data. You can either download complete GLOBE tiles with dimensions of approximately 40 degrees in latitude and 90 degrees in longitude, or you can interactively select a smaller area to be download as a binary terrain matrix (*.bin) and a corresponding file header (*.hdr).

USING GLOBE TERRAIN MATRIX FILES - When you select a subset or smaller area from a complete GLOBE tile to be downloaded, you will receive a terrain matrix file (*.bin) and a header file (*.hdr). These files can be read directly by 3DEM. See the description of Terrain Matrix Files that follows.

USING GLOBE TILES - If you are able to download complete GLOBE tiles, 3DEM can be used to merge these tiles together to provide continuous surface coverage of the entire globe. Choose "File - Load Terrain Model - Digital Model" from the overhead view menu to bring up the “DEM File Type” dialog box. Then select “GLOBE Tile” and you will be presented with the “Coordinate Selection” dialog box for selection of the geographical position and width (in degrees) of the area to be mapped.



Select a geographical location by clicking on the map of world. Make fine adjustments in latitude and longitude using the slider controls provided. Once you have selected a geographical position and map width, click “OK” and 3DEM will prompt you in sequence to locate and load the GLOBE Tiles which are needed to construct the desired map. A file dialog, with the name of the file to be located contained in the title bar, will appear for each file in sequence. You must locate and load each file that is named in the title bar of the file dialog. Once all files have been loaded, 3DEM will proceed to draw an overhead view of the selected area.

3DEM provides a choice of either “Lat/Long” or “Cosine” map projection when loading GLOBE DEMs. The Lat/Long projection produces a rectangular surface grid with equal extension in latitude and longitude. The disadvantage of the Lat/Long projection is distortion at high latitudes. If you are creating images at high latitudes, try the Cosine projection, which produces a surface grid corrected for latitude and a more realistic overhead view and 3D projection.

NASA MARS VIKING ORBITER DIGITAL TERRAIN MODEL (DTM) FILES

SOURCES OF DATA - DTM files for Martian landscapes are available on NASA CDROM. Volume 7 of the 14 Volume Mars Digital Image Map collection contains the Digital Topographic Map of the entire surface of Mars. This CDROM is available for a modest price from the National Space Science Center. Contact request@nssdca.gsfc.nasa.gov to request a copy of the NSSDC CDROM catalog.

DTM files on the NASA CDROM are named as "tg00n000.img" or "tg00s000.img" where "00n" or "00s" are degrees latitude (north or south) and "000" is degrees west longitude. Note that 3DEM will also process the large scale "te" and "tc" DTMs on the NASA CDROM. However, these files are so large that you should not attempt them without 16MB of RAM. The CDROM also contains digital photographic images of the surface of Mars named as "mg00n000.img" or "mg00s000.img." Don't confuse these photo files with the digital topographic map files.

DTM files for Martian landscapes are freely available on line at

http://www-pdsimage.jpl.nasa.gov/jbcache/viking/vo_2007/

Here you will see a large group of folders with names beginning with the letters "mg" and "tg". Always choose a "tg" folder to get digital maps ("mg" files are photo images). The following files are good choices:

tg15S067.img	Valles Marineris area
tg00N067.img	Valles Marineris area
tg45S010.img	Crater Lohse
tg45S270.img	Crater Krishtofovich
tg45N070.img	Crater Tanais

Your best approach is to know in advance the latitude and longitude of a feature you wish to explore, and then select the appropriate map for downloading.

USING DTM FILES - Choose "File - Load Terrain - Digital Model" from the overhead view menu to bring up the “Open DEM File” dialog box. Then select the NASA MARS DTM file type from the “Files of Type” listing. Locate the desired file and click “Open.” DTM files must be named *.img to be recognized by the program.

TERRAIN MATRIX FILES

Terrain matrix files are the most flexible and efficient way to store and retrieve terrain data for use by 3DEM. These binary files are made up of a sequence of elevation measurements stored row by row (that is row 1, followed by row 2, etc). Elevation measurements are stored as 16 bit integers. Terrain matrix files usually have an associated ASCII header file (*.hdr) which stores information about the number of rows and columns, latitude and longitude limits, map projection, etc. 3DEM uses the concept of a binary terrain matrix file and header file when saving its own terrain data for future use.

SOURCES OF DATA - Good examples of terrain matrix files are the NOAA GLOBE DEMs available on the Internet at

http://www.ngdc.noaa.gov/seg/topo/globe.shtml

From this location, terrain matrix files containing terrain measurements at 1000 meter resolution for any selected area of the globe can be downloaded at no cost. An associated ASCII header file is also included.

An example of the ASCII header file format for GLOBE binary terrain matrix files is given below. This same header format is used when saving any terrain matrix file with 3DEM.

```
file_title             = Greece
data_type              = raster
grid_cell_registration = center
map_projection         = Lat/Lon
left_map_x             = 19.99999992000
right_map_x            = 26.00000006160
upper_map_y            = 42.00000001920
lower_map_y            = 35.99999994960
number_of_rows         = 720
number_of_columns      = 720
grid_size              = 0.00833333333
elev_m_unit            = meters
elev_m_minimum         = 1
elev_m_maximum         = 2882
elev_m_missing_flag    = -500
```

USING TERRAIN MATRIX FILES - Choose "File - Load Terrain Model - Digital Model" from the overhead view menu to bring up the dialog box for selection of file type. Then select “Terrain Matrix File” and the filename of interest. If a corresponding header file is also present, 3DEM will read both files and proceed to complete an overhead view of the terrain. If the header file is not present, then you will be prompted to enter the needed parameters such as number of rows and columns, etc. See below.

USING OTHER MATRIX FILES OR FILES WITHOUT HEADERS - 3DEM will also read terrain matrix files containing data elements of other types (floating point, ASCII, long integers) or files without an associated file header. In this case, you will be prompted to enter the needed values of row and column, data type, etc. as described below.

DATA FORMAT AND OFFSET - Elevation data must be defined as signed or unsigned 16 bit integers (INT OR UINT), 32 bit integers (INT), 32 bit floating point values (FLOAT), or as ASCII integers (ASCII INT). Also, if the start of the terrain data is offset from the start of the file, enter the offset size in bytes here.

DATA BYTE ORDER - You must also specify the byte order of the elevation data. Most data files produced by machines with Intel processors will contain "Little Endian" data in which the least significant byte is first in the data word. Other computers (such as the Macintosh) will produce files of "Big Endian" data in which the most significant data byte is first in the data word. You will find topographic data of both types on the Internet, and this selection gives you the option of processing both.

MISSING DATA - Some matrix data files will fill in missing data points with a fixed value other than zero. Sometimes a large negative number such as -9999 is used to distinguish missing data points. If you know this value, enter it here. Otherwise enter zero.

MATRIX DIMENSIONS - You must also specify the matrix size as number of columns (width) and number of rows (height). Column order may be specified as West to East, or East to West. Row order may be specified as North to South, or South to North.

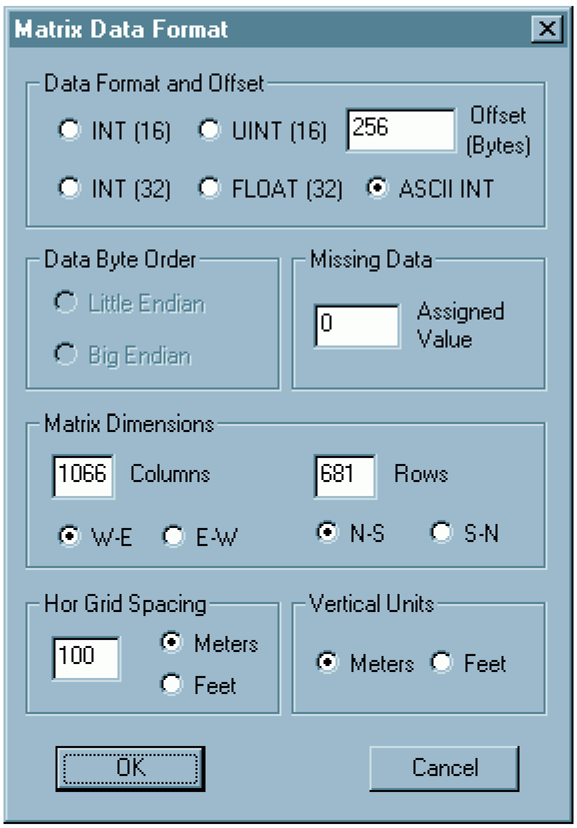
HORIZONTAL GRID SPACING - You must also specify the horizontal grid spacing for the data matrix. This is just the physical distance between map grid points in the horizontal plane and usually varies from 10 meters to 500 meters or more.

VERTICAL UNITS - Finally, you must specify the unit of measure of elevation data stored in the data matrix (meters or feet).

OTHER CONSIDERATIONS - You may find large matrix files which require more system memory than you have available, or are so large that processing time is excessive. When this happens, you can choose to load a partial matrix consisting of a limited group of matrix rows. Choose a byte offset to the start of a row of interest, and then choose a limited number of rows to be analyzed. The number of columns should always be equal to the full column dimension of the matrix file.

OTHER MATRIX FILE FORMATS

3DEM can also read and display other matrix data file which are organized as rows and columns of elevation values. Elevation values can be read as ASCII integers, binary 16 bit integers, or binary 32 bit floating point numbers. Elevation values in the file must have been stored sequentially row by row (that is, row one followed by row two, etc) where each row is made up of sequential columns. Choose "File - Load Terrain - Digital Model" from the overhead view menu, and select "Terrain Matrix" to bring up the "Open Terrain Matrix" dialog box. Choose "Files of Type - All Files" and then select the desired matrix data file. Note that if 3DEM finds a header file *.hdr of the same name as the matrix data file, it will assume that you are loading a terrain matrix file as described above. Otherwise, you will be presented with the "Matrix Data Format" dialog box for entry of the number of rows and columns, data format, grid spacing, etc. as described below.



DATA FORMAT AND OFFSET - Elevation data must be defined as signed or unsigned 16 bit integers (INT OR UINT), 32 bit integers (INT), 32 bit floating point values (FLOAT), or as ASCII integers (ASCII INT). Also, if the matrix data file has a header section prior to the start of the elevation data, specify the header size here as "Offset" in bytes.

DATA BYTE ORDER - You must also specify the byte order of the elevation data. Most data files produced by machines with Intel processors will contain "Little Endian" data in which the least significant byte is first in the data word. Other computers (such as the Macintosh) will produce files of "Big Endian" data in which the most significant data byte is first in the data word. You will find topographic data of both types on the Internet, and this selection gives you the option of processing both.

MISSING DATA - Some matrix data files will fill in missing data points with a fixed value other than zero.

Sometimes a large negative number such as -9999 is used to distinguish missing data points. If you know this value, enter it here. Otherwise enter zero.

MATRIX DIMENSIONS - You must also specify the matrix size as number of columns (width) and number of rows (height). Column order may be specified as West to East, or East to West. Row order may be specified as North to South, or South to North.

HORIZONTAL GRID SPACING - You must also specify the horizontal grid spacing for the data matrix. This is just the physical distance between map grid points in the horizontal plane and usually varies from 10 meters to 500 meters or more.

VERTICAL UNITS - Finally, you must specify the unit of measure of elevation data stored in the data matrix (meters or feet).

OTHER CONSIDERATIONS - You may find large matrix files, which require more system memory than you have available, or are so large that processing time is excessive. When this happens, you can choose to load a partial matrix consisting of a limited group of matrix rows. Choose a byte offset to the start of a row of interest, and then choose a limited number of rows to be analyzed. The number of columns should always be equal to the full column dimension of the matrix file.

MERGING DEMS

3DEM provides the capability to merge multiple DEMs to cover a large surface area at high resolution.

For USGS 7.5 minute and 1 degree DEMs, choose “File - Load Terrain Model - Digital Model” and select “USGS Standard DEM.” Then you can select multiple DEM files (from a common directory) to be merged into one overhead view. That is, all of the DEMs to be merged must be contained in the same file directory. To select multiple files, highlight each file required using the mouse, and then click OK to load all files into 3DEM. The only limit to the number of DEMs that can be merged is memory in your computer. Note that if you are merging a large number of DEMs (greater than 10), it is best to keep all of the filenames short. A large number of very long filenames will overflow the memory space that Windows allows for selection of multiple filenames, resulting in “Cannot Open File” or “Not Enough Memory” error messages.

DEMs to be merged must be adjacent to each other and must be of the same type (7.5 minute or 1 degree). Note that merged DEMs do not always match perfectly at their boundaries since the quality and accuracy of each DEM can vary widely. 3DEM makes the best match possible with the selected DEMs.

For USGS SDTS DEMs, it is first necessary to convert from the SDTS format to the standard DEM format before merging can take place. For each SDTS DEM, choose “File - Load Terrain Model - Digital Model” and select “USGS SDTS DEM.” 3DEM will convert the SDTS DEM to a standard format DEM that must then be stored in a common directory for merging with other standard format DEMs.

For GTOPO30 and GLOBE DEMs, 3DEM will automatically determine which DEM tiles must be merged to cover the surface area selected. See the previous description of GTOPO30 DEMs and GLOBE DEMs.

COMMON PROBLEMS

MISSING Opengl32.dll

If your Windows 95 system does not have Opengl32.dll installed, you will receive an error message upon program startup. You can download the missing files from the 3DEM home page at

http://www.monumental.com/rshorne/3dem.html

OPENGL RENDERING FAILURE

3DEM is designed to work with the Win95/98/NT software implementation of OpenGL, which includes opengl32.dll and glu32.dll. 3DEM may not always work correctly with other OpenGL software drivers or with OpenGL hardware acceleration provided by some advanced graphics cards. Symptoms of this kind of failure are either a completely black OpenGL window or a scrambled image in the OpenGL window. In this case, the only solution may be to disable hardware acceleration and return to use of the original Windows software implementation of OpenGL.

FILES NOT RECOGNIZED BY 3DEM

File extensions must be of the proper type before files will load correctly. 3DEM expects that USGS DEM and GTOPO30 DEM files will be named *.dem, and DTM files will be named *.img. If a DEM or GTOPO30 DEM file which you download does not have the ".dem" file extension, you must rename the file before loading it into 3DEM. Terrain matrix files must be named *.bin and have an associated header file named *.hdr.

FAILURE TO CONVERT SDTS DEM

SDTS DEMs are downloaded in compressed .tar.gz format. The filename of the compressed file must end in ".tar.gz". Some browsers will change the file extension on download to "_tar.gz". In this case, you must manually correct the filename to correctly decompress the SDTS file. Also, if you use Winzip to decompress these files, you MUST disable "TAR File Smart CR/LF Conversion" in "Options - Configuration." Otherwise, the decompressed file will have added bytes and will not be readable by 3DEM. Correct decompression by Winzip will result in 18 files with a ".ddf" filename extension. Choose "File - Load Terrain - Digital Model," choose "USGS SDTS DEM" and select any one of the 18 .ddf files. 3DEM will then find all of the other necessary files and convert them into a standard DEM.

FAILURE TO LOAD GTOPO30 DEM

The GTOPO30 DEMs are downloaded in compressed .tar.z format. If you use Winzip to decompress these files, you MUST disable "TAR File Smart CR/LF Conversion" in "Options - Configuration." Otherwise, the decompressed file will have added bytes and will not be readable by 3DEM. The usual symptom of this problem is an "Improper Rows or Columns" message when loading a GTOPO30 DEM.

COMMON PROBLEMS (Continued)

MEMORY USAGE

3DEM requires a large amount of memory, particularly if you are working with large texture overlays. The program will run with only 32 Mbytes of memory, but will require a great deal of patience. 64 Mbytes is a practical lower limit, but 128 Mbytes is recommended.

When memory is in short supply, Windows programs will attempt to use the hard drive as virtual memory. When this happens to 3DEM, speed of operation becomes very slow. The best remedy for this situation is to take action to reduce the memory shortfall. This includes closing other running programs, choosing smaller sized maps, and of course installing more memory.

MPEG FILES WHICH DO NOT PLAY

Not all mpeg players are created equal. If you are having problems playing mpegs from 3DEM, please get a copy of VMPEG (freeware) available at http://www.mpeg.org/index.html/MSSG/#source.

CREDITS

The following organizations or persons have provided free software via the Internet, which has greatly contributed to the capabilities of the 3DEM program.

Mr. Sol Katz provided the SDTS to DEM conversion code and contributed the large library of useful GIS utilities at ftp://ftp.blm.gov/pub/gis/sdts/dem.

The code for conversion between UTM and Latitude-Longitude was developed by Mr. Chuck Gantz and is available at http://www.gpsy.com/gpsinfo/geotoutm/.

JPEG compression code was developed by the Independent JPEG Group and distributed from http://www.ijg.org/ as the IJG JPEG library.

MPEG animation code was developed by the MPEG Software Simulation Group. See http://www.mpeg.org/MPEG/MSSG/VMPEG/.

The global terrain image used in the Coordinate Selection dialog box for GTOPO30 and GLOBE DEMs was derived from GLOBE Documentation (ver 1.0).

Hastings, David A., and Paula K. Dunbar, 1999. Global Land One-kilometer Base Elevation (GLOBE) Digital Elevation Model, Documentation, Version 1.0. Key to Geophysical Records Documentation (KGRD) 34. National Oceanic and Atmospheric Administration, National Geophysical Data Center, 325 Broadway, Boulder, Colorado 80303, U.S.A.