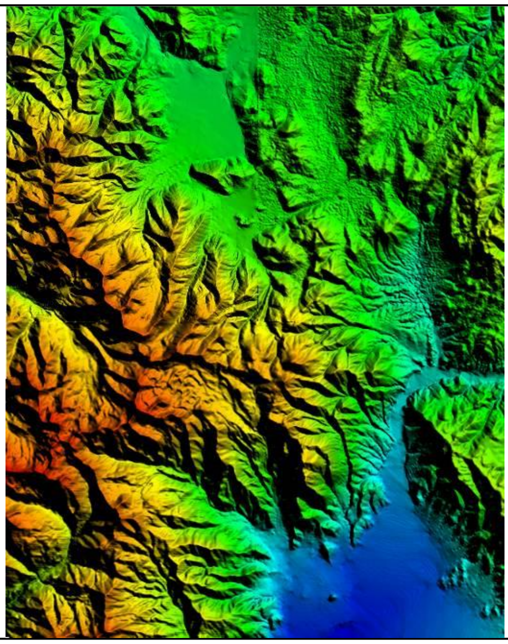
GMS

v. 10.3

GMS 10.3 Tutorial

Rasters

Using rasters for interpolation and visualization in GMS



Objectives

This tutorial teaches how GMS uses rasters to support all kinds of digital elevation models and how rasters can be used for interpolation in GMS.

Prerequisite Tutorials

- Geostatistics – 2D

Required Components

- None

Time

- 15–30 minutes

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1 Introduction

Rasters are regularly spaced, gridded data. In GMS, the term “raster” is typically used to refer to an image containing elevation data. A Digital Elevation Model, or DEM, is one type of a raster and is used to represent the surface of a terrain. DEM data is useful when building a groundwater model because it can be used to determine the ground surface elevation and the elevation of surface features such as drains and streams. DEMs can be used to represent the geologic layers beneath the surface, or they can be used like scatter points to represent any 2D dataset such as concentration of a contaminant in *X* and *Y*, flow rates, and so on.

In this tutorial, some DEM files representing the area around Park City, Utah, will be imported and used in various ways. Topics covered include importing DEMs, changing the display options, interpolating scatter points, MODFLOW layers, and feature objects, converting DEMs to scatter points, and creating a raster from scatter points.

1.1 Getting Started

Do the following to get started:

1. If necessary, launch GMS.
2. If GMS is already running, select *File* | **New** to ensure that the program settings are restored to their default state.

2 Importing Lidar Data as a Point Cloud

Now open a file containing lidar data. Lidar data is typically very dense and the files can be very large.

1. Click **Open** to bring up the *Open* dialog.
2. Browse to the *Tutorials\GIS\rasters* directory
3. Select "Raster/DEM Files" from the *Files of type* drop-down and select "points.las".
4. Click **Open** to close the *Open* dialog and bring up the *Lidar Load Options* dialog (Figure 1).

Note that in the *Open* dialog, the *Files of type* was set to "Raster/DEM Files". The extensions included in this list are the most common extensions for DEM files, but there are many others. If the DEM file has an extension not listed there, change the *Files of type* to "All Files (*.*)" and attempt to open it.

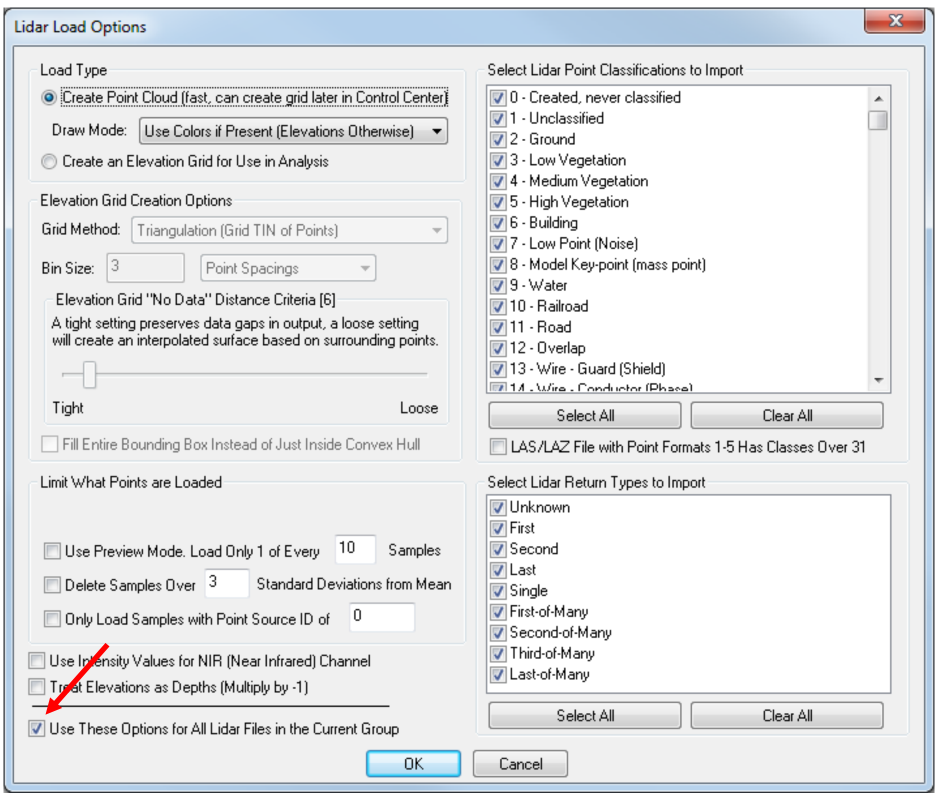


Figure 1 Lidar Load Options dialog

Notice the option at the top left is to create a point cloud.

5. At the bottom left of the dialog, turn off *Use These Options for All Lidar Files in the Current Group* and click **OK** to close the *Lidar Load Options* dialog.

If this option is left on, future lidar files that are imported into GMS will not cause this dialog to be opened. Restart GMS to get the dialog to appear again.

The Graphics Window should appear similar to Figure 2. The display may look different depending on the zoom level because individual points are shown, not a gridded image.

Figure 2 LiDAR data in GMS

6. Zoom in and out on the raster using the mouse wheel or **Zoom** . If zooming in far enough, individual points can be seen as in Figure 3.

Notice the icon in the Project Explorer. This icon indicates what kind of data is present in the file; in this case there is image data (colors from the aerial photo) and vector data (*xyz* point locations). Although the lidar file contains discrete points and not gridded data, it is still refered to it as a "raster" in GMS.

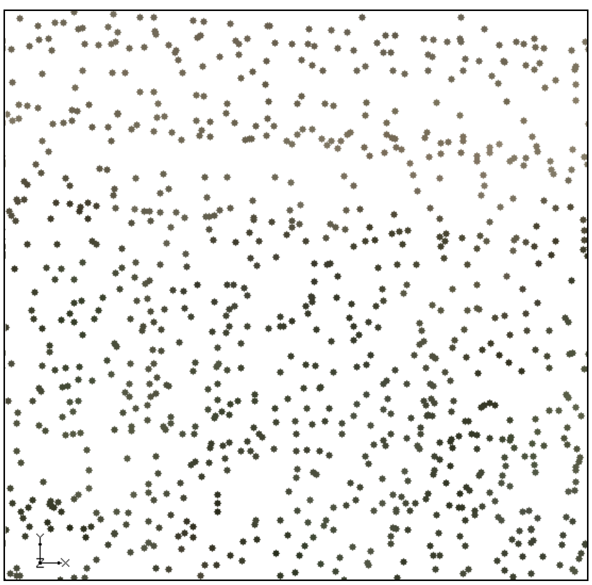


Figure 3 Lidar points

3 Viewing the Lidar Properties

Raster properties can be viewed and changed in the *Image Properties* dialog.

1. In the Project Explorer, double-click on “points.las” to bring up the *Image Properties* dialog (Figure 4).

Notice that the path to the file on disk is shown along with the image type (LIDAR_LAS), extents in *X* and *Y*, the number of lidar points (about 1.5 million), and the projection (UTM).

2. Click **Done** to exit the *Image Properties* dialog.

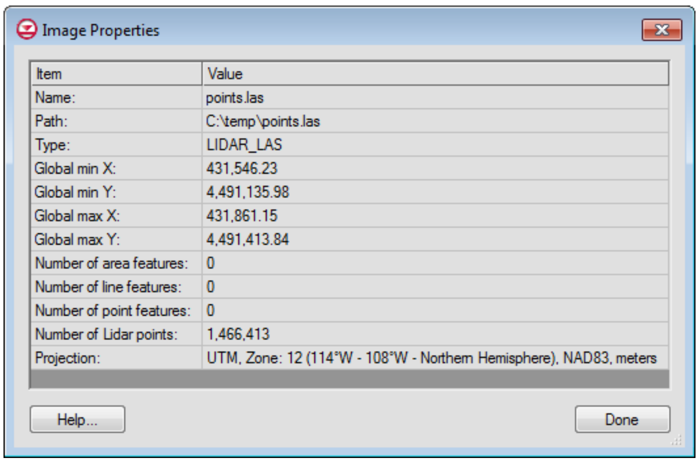


Figure 4 Image properties

4 Importing Lidar as a Raster Image

GMS can also import lidar data as a gridded, raster image. Reimport the “points.las” file to demonstrate this.

1. Click **New** to delete the existing data. Select **Don’t Save** at the prompt.
2. Click **Open** to bring up the *Open* dialog.
3. Select “Raster/DEM Files” from the *Files of type* drop-down and select “points.las”.
4. Click **Open** to import the file, close the *Open* dialog, and open the *Lidar Load Options* dialog.
5. In the Load Type section, select Create an Elevation Grid for Use in Analysis.
6. At the bottom left of the dialog, turn off *Use These Options for All Lidar Files in the Current Group* and click **OK** to close the *Lidar Load Options* dialog.

The Graphics Window should appear similar to Figure 5.

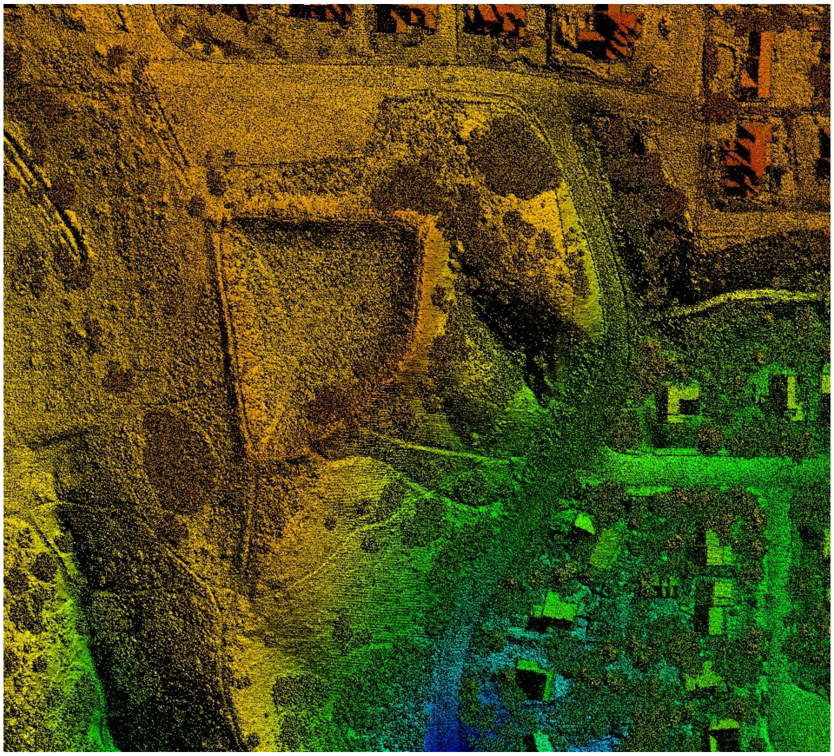


Figure 5 Lidar file as gridded data

The lidar file is no longer rendered with the colors from the aerial photo but with colors corresponding to the elevation of the data. Features such as trees and houses are still clearly visible.

5 Raster Display Options

The way rasters are rendered can be adjusted a number of different ways.

5.1 Hill Shading

1. Click **Display Options** to bring up the *Display Options* dialog.
2. Select " GIS Data" from the list on the left.
3. On the *GIS* tab in the *Rasters* section, uncheck *Enable hill shading*.
4. Click **OK** to close the *Display Options* dialog. The Graphics Window should appear similar to Figure 6.

Hill shading creates shadows which make the image appear 3D, despite the fact that it is really 2D. The shadows associated with hill shading have nothing to do with the lighting model and light direction that is available with other 3D surface type objects in GMS. Thus, changing the lighting model will not change the hill shading.

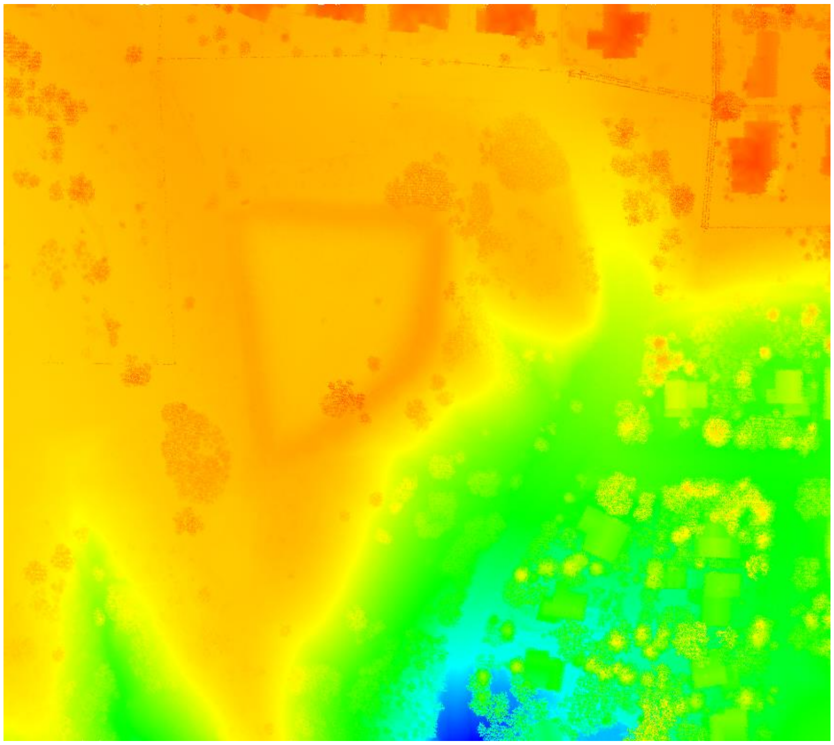


Figure 6 Lidar without hill shading

5.2 Comparing 2D and 3D

Raster data is usually quite dense and can consume a considerable amount of disk space and memory. Although a raster could be represented using the 2D object types in GMS (TIN, 2D Grid, 2D Mesh, 2D Scatter Points), rasters are rendered as images due to the large amount of data they contain. This requires less memory and allows for fast rendering.

The disadvantage with this approach is that the raster is only visible in plan view and is not a true 3D surface. With hill shading on, the rasters appear to be 3D. However, a true 3D surface would require more memory and GMS has not implemented true 3D surfaces for rasters at this time.

This is demonstrated by doing the following:

1. Switch to **Oblique View** .

Notice that nothing is displayed. Rasters, like images, are only rendered in 2D in the background while in plan view.

2. Switch to **Plan View** . The loaded raster is once again visible.

Display as 3D Points

Although rasters are not 3D surfaces, they can be rendered as 3D points.

1. Click **Display Options** to bring up the *Display Options* dialog.
2. Select " GIS Data" from the list on the left.
3. On the *GIS* tab in the *Rasters* section, select the *Display as 3D points* option.
4. Click **OK** to close the *Display Options* dialog.
5. Switch to **Oblique View** . The display should appear as shown in Figure 7. Points are not shaded so the shadow effect is not available now.

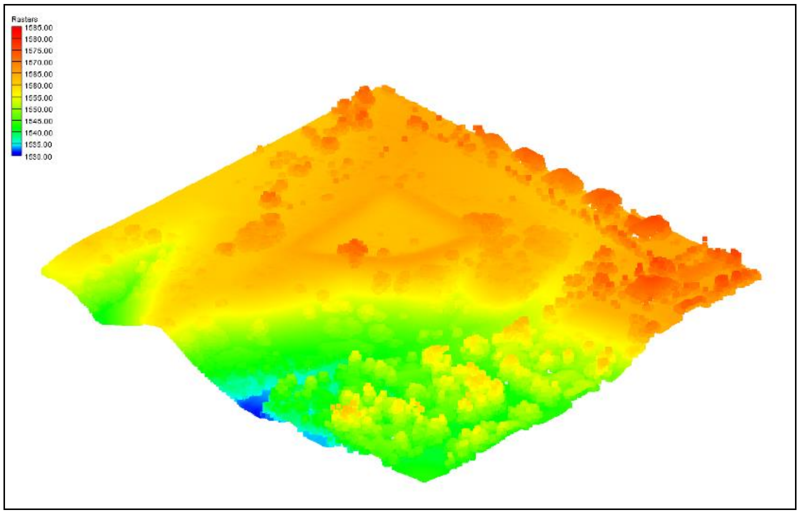


Figure 7 Displayed as 3D points

The trees are clearly identifiable in this view.

6. Zoom in on the raster using the mouse wheel or **Zoom** .

The individual points become visible as the magnification increases (Figure 8).

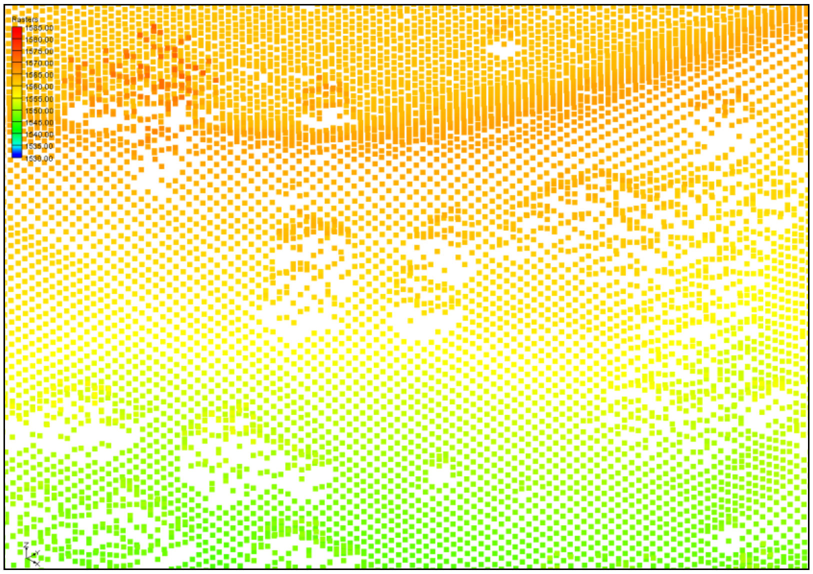


Figure 8 Individual 3D points

Reset the display back to 2D by doing the following

7. Switch to **Plan View** .
8. Click **Display Options** to bring up the *Display Options* dialog.
9. Select " GIS Data" from the list on the left.
10. On the *GIS* tab in the *Rasters* section, select the *Display as 2D image* option.
11. Click **OK** to close the *Display Options* dialog.

6 Open a Starting Project

Now open a project that has some existing data.

1. Select **New** to delete the existing data. Select **Don't Save** at the prompt.
2. Click **Open** to bring up the *Open* dialog.
3. Select "Project Files (*.gpr)" from the *Files of type* drop-down.
4. Browse to the *Tutorials\GIS\rasters* directory and select "start.gpr".
5. Click **Open** to import the file and close the *Open* dialog.

This project contains a TIN and a coverage, but they are both turned off so nothing appears in the Graphics Window. The project also has the projection set to UTM.

7 Importing Using Drag and Drop

It is often easier to drag and drop DEM files into GMS.

1. Browse to the *Tutorials\GIS\rasters* folder in Windows Explorer.
2. Select the following files (pay close attention to the file extensions as they aren't all the same), then drag and drop them into the GMS Graphics Window:
   - "Brighton.tif"
   - "HeberCity.tif"
   - "PkCityE.flt"
   - "PkCityW.bil"

The display should appear similar to Figure 9:

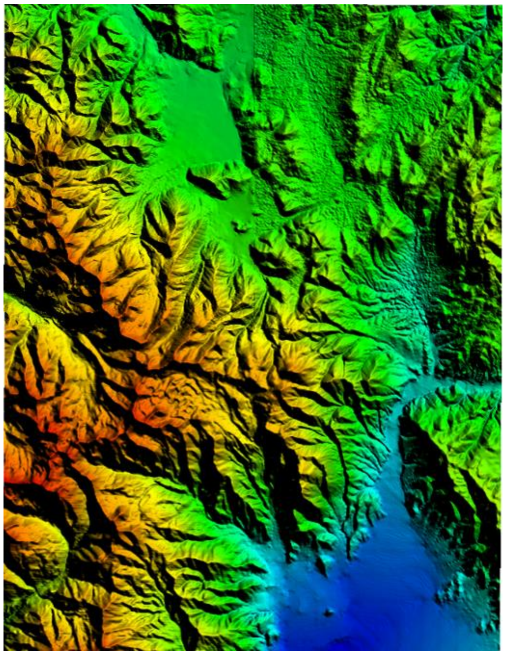


Figure 9 Multiple DEMs loaded into GMS

Notice the raster icon in the Project Explorer which indicates the files contain elevation data. The DEMs were created in a geographic projection, meaning latitude and longitude, but GMS projects them on the fly to the UTM projection that GMS is already using so that they are displayed in the right place. The four rasters are located as shown in Figure 10.

PkCityW.bil	PkCityE.flt
Brighton.tif	HeberCity.tif

Figure 10 Placement of rasters

8 Viewing the Raster Properties

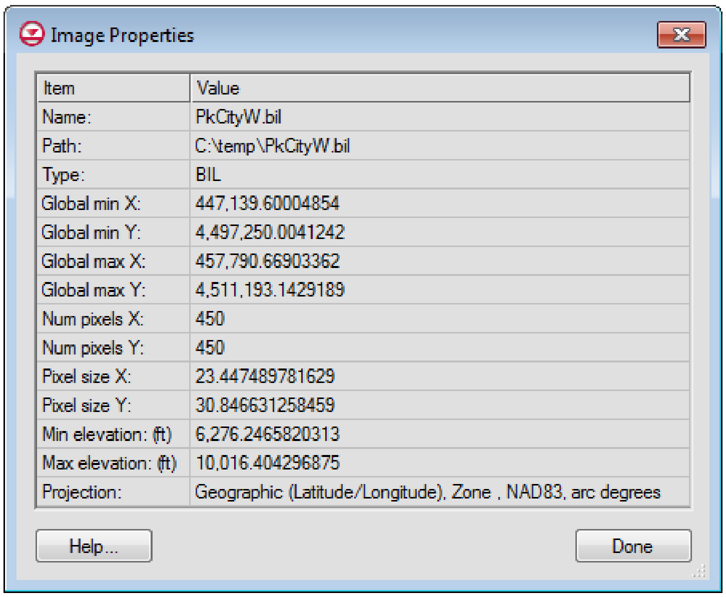
Review the *Image Properties* dialog again.

1. In the Project Explorer, right-click on "PkCityW.bil" and select **Properties…** to bring up the *Image Properties* dialog (Figure 11).

In addition to the information seen the last time this dialog was opened (Figure 4), notice that the pixel resolution and size shown as well as elevation data. In this case, the type is BIL and the pixel size is 30 meters (in the Y direction).

2. Click **Done** to exit the *Image Properties* dialog.
3. Repeat steps 1–2 for each of the remaining three rasters under GIS Layers.

Notice that the results are three different DEM types (BIL, FLOATGRID, and GEOTIFF) with two different pixel sizes (10m, and 30m).



Item	Value
Name:	PkCityW.bil
Path:	C:\temp\PkCityW.bil
Type:	BIL
Global min X:	447,139.60004854
Global min Y:	4,497,250.0041242
Global max X:	457,790.66903362
Global max Y:	4,511,193.1429189
Num pixels X:	450
Num pixels Y:	450
Pixel size X:	23.447489781629
Pixel size Y:	30.846631258459
Min elevation: (ft)	6,276.2465820313
Max elevation: (ft)	10,016.404296875
Projection:	Geographic (Latitude/Longitude), Zone , NAD83, arc degrees

Figure 11 Image properties

9 Raster Shaders

Now look at the raster display options again.

1. **Frame Image** to see all the raster data.
2. Click **Display Options** to bring up the *Display Options* dialog.
3. Select " GIS Data" from the list on the left.
4. On the *GIS* tab in the *Rasters* section, select "HSV Shader" from the *Shader* drop-down.

5. Click **OK** to close the *Display Options* dialog.
6. Repeat steps 1–4 to try the “Color Ramp Shader” and the “Global Shader”.

The options in the *Rasters* section are currently the only display options available for rasters in GMS. Now reset the display options to what they were previously:

7. Click **Display Options** to bring up the *Display Options* dialog.
8. Select “ GIS Data” from the list on the left.
9. On the *GIS* tab in the *Rasters* section, check *Enable hill shading*.
10. Select “Atlas Shader” from the *Shader* drop-down
11. Click **OK** to close the *Display Options* dialog.

10 Downloading Elevation Data

Elevation data for the area can be downloaded using the Online Maps feature. An internet connection is required for this next section to work correctly. A separate tutorial explains more about this feature.

1. Click **Add Online Maps** to bring up the *Get Online Maps* dialog.
2. Scroll to the right and select the thumbnail entitled “United States Elevation Data (NED) (10m Resolution)”.
3. Click **OK** to close the *Get Online Maps* dialog.

After a few moments, a new item will appear in the Project Explorer indicating that an online map is being downloaded. This map is different from the other available maps because it contains elevation data. It is possible to right-click on this map and export it to a local file that can be used like the other rasters used in this tutorial. This map is not required for this tutorial, so it can be deleted by doing the following:

4. Right-click on “United States Elevation Data (NED) (10m Resolution)” in the Project Explorer and select **Delete**.
5. If deletion confirmations are turned on, click **OK** to confirm deletion of the online map.

11 Manipulating Rasters

11.1 Resampling

Rasters can be resampled to different resolutions. The Heber City raster is a higher resolution than the adjacent rasters, so it will be resampled to a lower resolution to demonstrate this feature.

1. In the Project Explorer, right-click on “HeberCity.tif” and select *Convert To* **| Resampled Raster** to bring up the *Resample and Export Raster* dialog.
2. Enter “450” in both the *Num pixels X* and *Num pixels Y* fields.
3. Click **OK** to close the *Resample and Export Raster* dialog and open the *Save As* dialog.
4. Enter "HeberCity2.tif" in the *File name* field.
5. Select “GeoTIFF Files (*.tif)” from the *Save as type* drop-down.
6. Click **Save** to export the resampled raster and close the *Save As* dialog.

The new "HeberCity2.tif" raster should appear in the Project Explorer.

7. Right-click on the new "HeberCity2.tif" and select **Properties…** to bring up the *Image Properties* dialog.

Notice the *Num pixels X* and *Num pixels Y* are now both “450”.

8. Click **Done** to close the *Image Properties* dialog.

11.2 Merging Rasters

Multiple rasters can be combined into one raster by first selecting multiple rasters in the Project Explorer:

1. In the Project Explorer, select “Brighton.tif” and "HeberCity.tif" while holding the *Ctrl* key.
2. Right-click on either selected raster and select *Convert To* | **Merged Raster** to bring up the *Save As* dialog.
3. Enter "Brighton_merge.tif" in the *File name* field.
4. Select “GeoTIFF Files (*.tif)” from the *Save as type* drop-down.
5. Click **Save** to save the merged raster and close the *Save As* dialog.
6. Uncheck all the rasters except "Brighton_merge.tif" to verify it covers the area covered by the individual “Brighton.tif” and “HeberCity.tif” rasters (Figure 12).

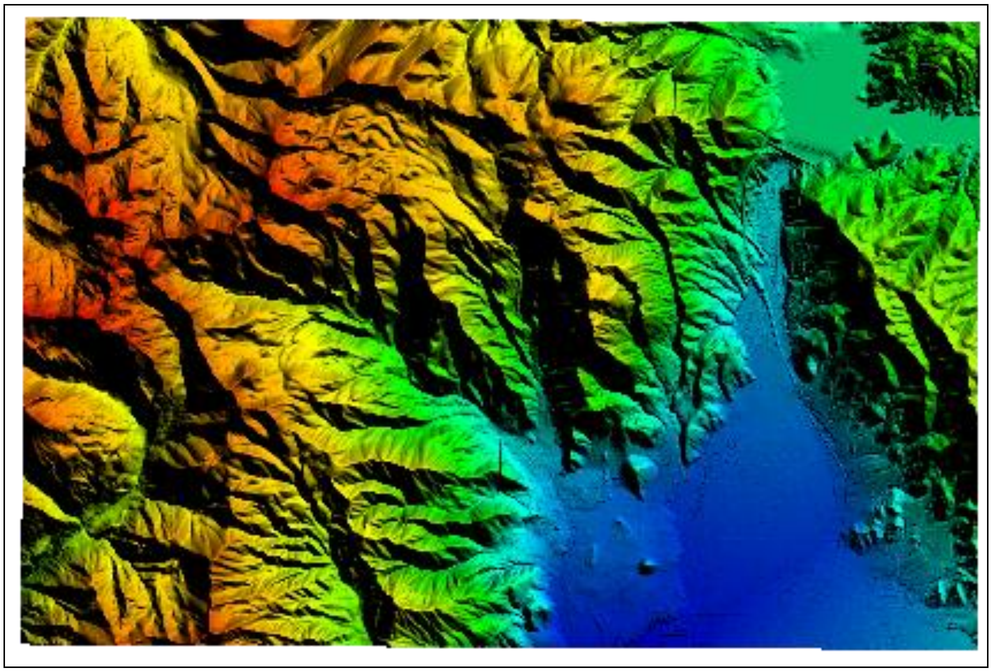


Figure 12 Area covered by the merged rasters

11.3 Trimming

A smaller raster can be created from a larger raster. This is called trimming.

1. In the Project Explorer, expand the "Map Data" folder, check the box next to "default coverage", and select it to make it active.
2. Using the **Select Polygons** tool, select all the polygons in the coverage by pressing *Ctrl-A* (or using *Edit* | **Select All**).
3. Right-click "Brighton_merge.tif" and select *Convert To* | **Trimmed Raster** to bring up the *Save As* dialog.
4. Enter "Brighton_merge_trim.tif" as the *File name*.
5. Select "GeoTIFF Files (*.tif)" from the *Save as type* drop-down.
6. Click **Save** to export the raster and close the *Save As* dialog.
7. Turn off all rasters except for the new one ("Brighton_merge_trim.tif").

Notice that the new raster was trimmed to fit within the bounding box of the selected polygons in the coverage (Figure 13).

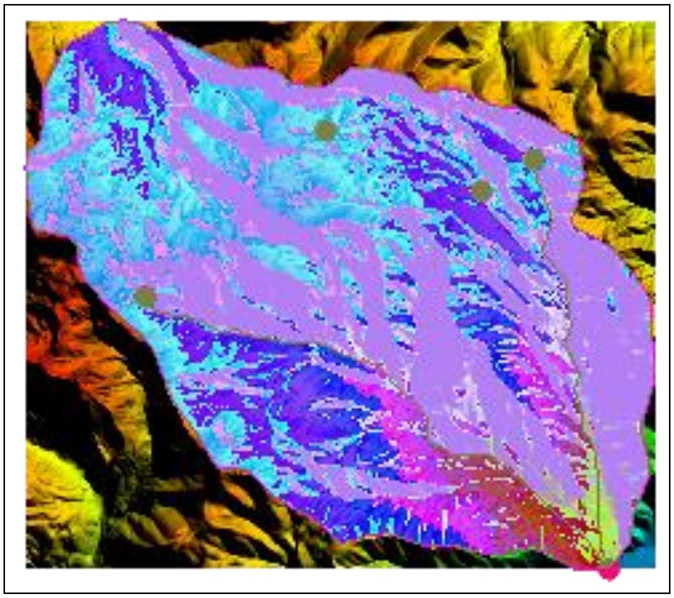


Figure 13 The TIF trimmed to the bounding box of the coverage

Rasters are trimmed to the bounding box of the selected polygons.

12 Converting and Interpolating Rasters

Raster data can be converted into 2D scatter points, a 2D grid, TINs, and a UGrid. Scatter points can be converted into a raster.

12.1 Converting a Raster to 2D Scatter Points

Convert a raster to 2D scatter points by doing the following:

1. Uncheck all rasters in the Project Explorer and press *Ctrl-U* to unselect all polygons.
2. In the Project Explorer, right-click on the "PkCityW.bil" item and select *Convert To* | **2D Scatter** to bring up the *Raster → Scatter* dialog.
3. Click **OK** to create a new scatter point set and close the *Raster → Scatter* dialog.
4. Switch to **Oblique View** to see the psuedo-3D view of the scatter points (Figure 14). Using **Zoom** will reveal the surface is made of a large number of points.

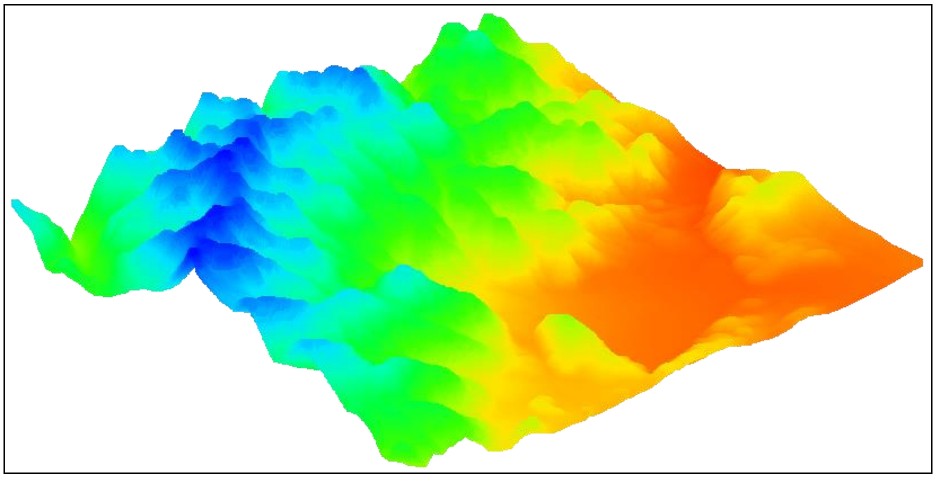


Figure 14 Scatter points in oblique view

The process for converting to a 2D grid or UGrid is similar to the steps above, but will not be covered in this tutorial.

12.2 Convert Scatter Points to Rasters

Scatter points can be converted to one or more rasters by doing the following:

1. Switch to **Plan View** .
2. In the Project Explorer, right-click on the " PkCityW.bil" 2D scatter set and select *Convert To* | **New Raster…** to bring up the *Scatter →Raster* dialog.

In this dialog, the interpolation scheme, the cell size of the raster, and how to define the boundary of the raster can all be set.

3. In the *Current interpolation options* section, click **Interpolation Options…** to bring up the *2D Interpolation Options* dialog. This dialog is always used to specify 2D interpolation options in GMS, though these options are not used in this case.
4. Click **Cancel** to close the *2D Interpolation Options* dialog.

If more than one dataset is associated with the scatter set, then the *Create rasters for* drop-down can be used to specify all datasets or just the active dataset. If choosing all datasets, a separate raster will be created for each dataset.

The raster that these scatter points were created from had a cell size around 30 meters. The next steps will create a raster that is less dense by specifying a bigger cell size.

5. Enter "100.0" for the *Cell size*.
6. In the *Raster extents* section, select "Scatter set extents" from the drop-down.

It is possible to limit the extents of the new raster(s) by using polygons defined in a coverage. The raster will always be created as a rectangle, but if a polygon is used to define the extents, it is possible to optionally mask (or inactivate) the areas of the raster outside the polygon. For this tutorial, just use the extents of the scatter points.

7. Click **OK** to close the *Scatter →Raster* dialog and bring up the *Save As* dialog.
8. Enter "default_idw_grad.tif" in the *File name* field.
9. Select "Tiff Files (*.tif)" from the *Save as type* drop-down.
10. Click **Save** to close the *Save As* dialog.

A new raster file is created on disk and automatically loaded into GMS. Compare it to the original raster it is derived from.

11. Uncheck the " PkCityW.bil" 2D scatter dataset.
12. Turn on the "PrkCityW.bil" raster.
13. Turn on and off the new "default_idw_grad.tif" raster.

Notice that the new raster is a lot less sharp than the original "PkCityW.bil" raster because when the "PkCityW.bil" raster was converted to scatter points, every other row was skipped and a larger cell size was used when interpolating the scatter points back to a raster.

12.3 Interpolate to a TIN

The elevations of the raster can be interpolated to several other GMS data types. The next step is to interpolate to a TIN.

1. In the Project Explorer, expand and turn on the " TIN Data" folder to reveal the " watershed" TIN.

The " watershed" TIN is in a canyon that covers two rasters: "Brighton.tif" and "HeberCity.tif". Notice it has a default dataset in which all the values are zero.

2. Uncheck all GIS layers except for "HeberCity.tif" and "Brighton.tif".
3. While pressing the *Ctrl* key, select both the "Brighton.tif" raster and the "HeberCity.tif" raster.
4. Right-click one of the selected rasters and select *Interpolate To* | **TIN**.

Two new datasets were created on the TIN, one for each raster that was selected. From the TIN contours, notice that for the "Brighton.tif" dataset, only the eastern portion is active, up to the edge of the "Brighton" raster (Figure 15).

> When interpolating from multiple rasters, multiple datasets are created.

5. Select the new " HeberCity.tif" dataset under the " watershed" TIN.

Notice that only the western portion of the dataset is active, up to the edge of the "HeberCity.tif" raster.

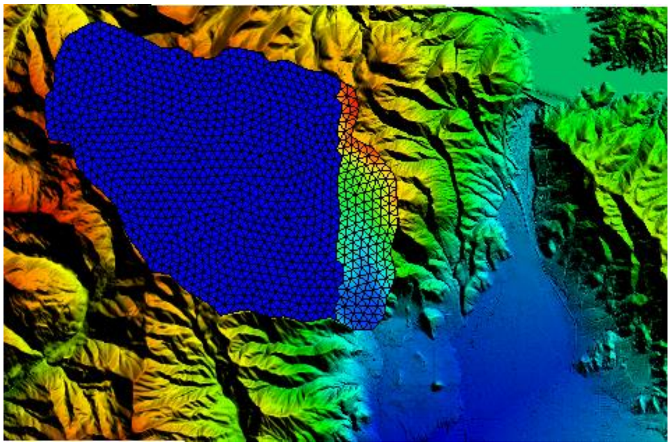


Figure 15 Interpolated TIN dataset with inactive points outside the raster boundary

12.4 Raster Catalogs

Instead of two TIN datasets, one dataset that spans both the Brighton.tif and HeberCity.tif rasters is desired. For this use a raster catalog. A raster catalog is simply multiple rasters grouped together for purposes of interpolation or for use with the **Horizons** → **Solids** command.

1. Select all the rasters in the Project Explorer by selecting the first one, and the selecting the last one while holding down the *Shift* key.
2. Right-click on any of the selected rasters and select **New Raster Catalog** to bring up the *Raster Catalog* dialog.
3. Notice that all of the selected rasters are part of the catalog. Click **OK** to close the *Raster Catalog* dialog.

Now interpolate to the TIN again, but this time use the raster catalog.

4. Right-click on the " Raster Catalog" and select *Interpolate To* | **TIN** to create a new "default_idw_grad.tif" TIN dataset.

The contours on the new TIN match the elevations of the rasters. The TIN also crosses over the boundaries of two rasters and GMS uses all the selected rasters to interpolate to the TIN (Figure 16).

When interpolating from a raster catalog, one dataset is created.

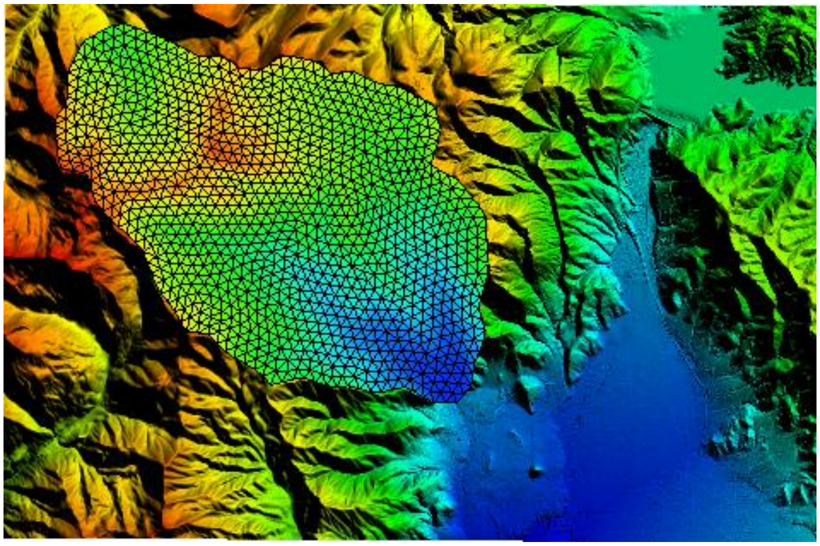


Figure 16 Interpolated TIN based on raster catalog

12.5 Interpolate to Feature Objects

It is also possible to interpolate from rasters to the *Z* values of feature objects.

1. In the Project Explorer, right-click in the empty space and select **Uncheck All** to hide everything.
2. Turn on the " Map Data" folder.
3. Switch to **Front View** .

Notice that the feature objects in the coverage are all at an elevation of zero.

4. Select all the rasters in the Project Explorer by selecting the first one, and the selecting the last one while holding down the *Shift* key.
5. Right-click on any of the selected rasters and select *Interpolate To* **| Active Coverage**.
6. Click **Frame Image** .

Notice that the elevations of the feature objects in the coverage have been changed to match the elevation data from the rasters (Figure 17). In this case the raster catalog wasn't used, although it could have been and the results would have been the same. Since coverages cannot have multiple datasets like TINs can, there is no need to use the raster catalog in this case.

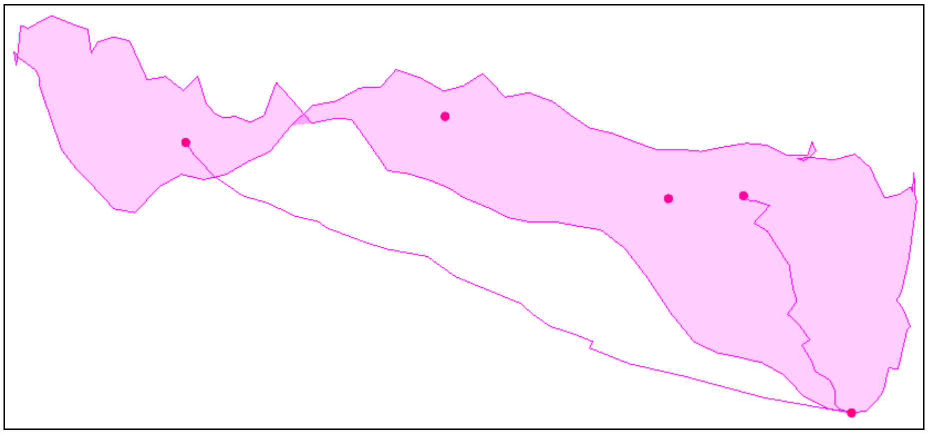


Figure 17 Interpolated from rasters to Z values

12.6 Interpolate to MODFLOW Layers

Scatter point data can be interpolated to MODFLOW top and bottom layer elevation arrays. This is covered in more detail in the “MODFLOW – Interpolating Layer Data” tutorial. Raster data can also be interpolated to MODFLOW elevation arrays, which will be done in this case:

1. Select **New** and click **Don’t Save** when asked to save the current project.
2. Click **Open** to bring up the *Open* dialog.
3. Browse to the *Tutorials\GIS\rasters* directory and select “Project Files (*.gpr)” from the *Files of type* drop-down.
4. Select “points.gpr” and click **Open** to import the project file and close the *Open* dialog.

This project is similar to the one from the “MODFLOW – Interpolating Layer Data” tutorial, but instead of scatter points, it uses rasters. Notice that the MODFLOW model layers are completely flat (Figure 18).

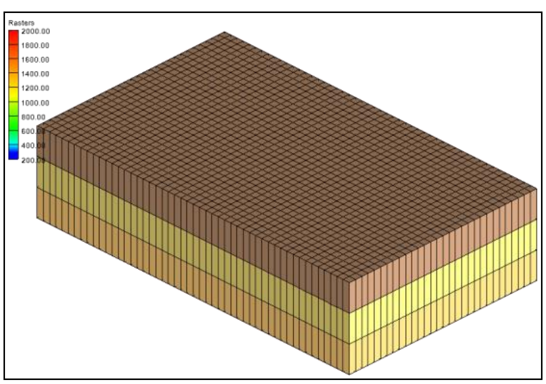


Figure 18 MODFLOW layers

5. Expand the “ GIS Layers” folder to see the rasters.

6. Select all the rasters in the Project Explorer by selecting the first one, and the selecting the last one while holding down the *Shift* key.

7. Right-click on a selected raster and select *Interpolate To* **| MODFLOW Layers…** to bring up the *Interpolate to MODFLOW Layers* dialog.

The mapping in the lower part of the dialog should already be set up. GMS automatically mapped the appropriate raster to the appropriate MODFLOW layer array based on the names of the rasters. For more information on this dialog, refer to the "MODFLOW – Interpolating Layer Data" tutorial.

8. Click **OK** to close the *Interpolate to MODFLOW Layers* dialog.

9. Click **Frame Image** .The layer elevations are no longer flat (Figure 19).

The raster catalog could have been used in this case and the results would have been the same.

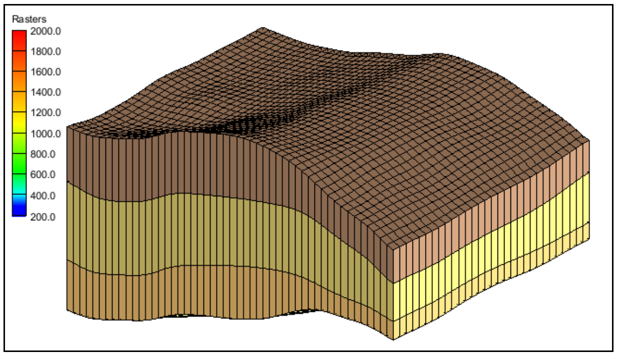


Figure 19 MODFLOW layers after interpolating elevation data

13 Conclusion

This concludes the GMS "Rasters" tutorial. The following topics were discussed and demonstrated:

- Rasters are images with elevation data.
- Rasters, like images, are 2D and only drawn in the background when in plan view, but they can appear 3D if hill shading is enabled.
- Rasters can be downloaded using the Online Maps feature.
- Rasters can be converted to 2D scatter sets and 2D grids.
- 2D scatter points can be converted into rasters.
- Rasters can be interpolated to many other GMS object types.
- When interpolating from multiple rasters, multiple datasets are created.
- When interpolating from a raster catalog, one dataset is created.

