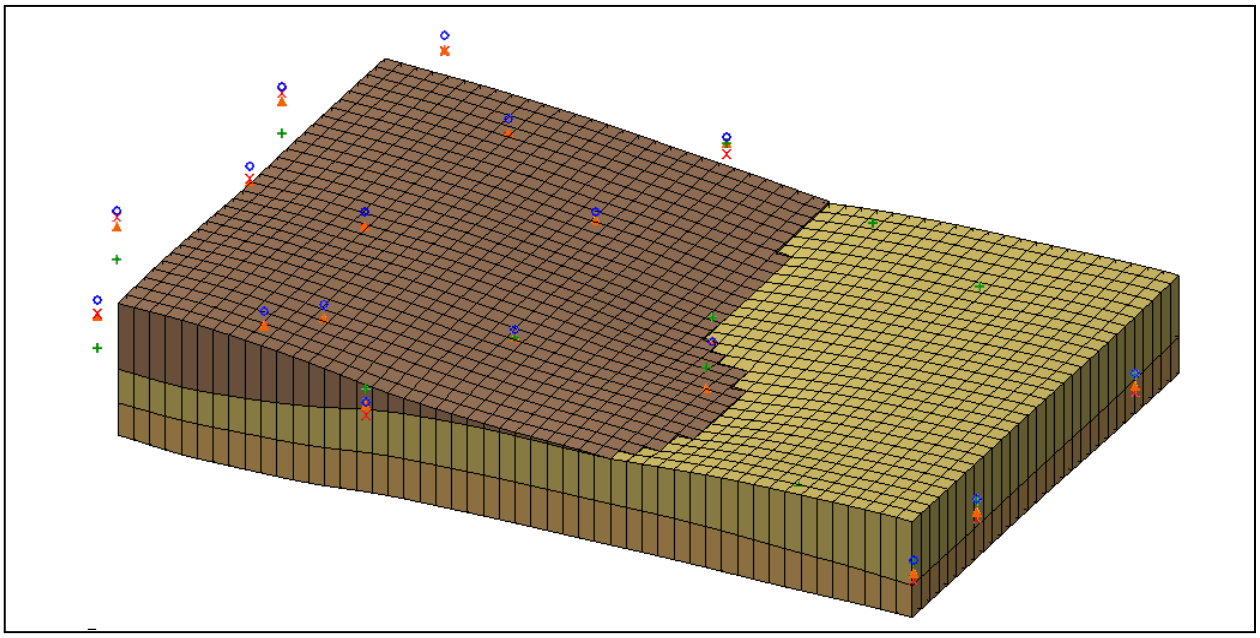
GMS v. 9.2

GMS 9.2 Tutorial

MODFLOW – Interpolating Layer Data

Interpolating MODFLOW elevations and other data from discrete points



Objectives

Learn how to effectively use GMS tools to interpolate MODFLOW layer elevation data and other MODFLOW data from scatter points. With these tools, even complex geologic strata can be modeled quickly and easily.

Prerequisite Tutorials

- None

Required Components

- Grid
- Geostatistics

Time

- 30-60 minutes

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1 Contents

2 Introduction

For sites with complex stratigraphy and three-dimensional flow, a multi-layer MODFLOW model can be much more accurate than a one layer, two-dimensional model. When creating multi-layer models, defining layer data can be challenging. This is particularly true for cases involving embedded seams, pinchouts, and truncations. Fortunately, GMS contains a suite of tools for interpolating and manipulating layer elevation data. With these tools, even complex geologic strata can be modeled quickly and easily. This tutorial describes how to use these tools most effectively.

This tutorial involves the use of scatter points, interpolation and MODFLOW. Therefore, a familiarity with MODFLOW and scatter points is helpful. Although not required, it would be a good idea to have completed the *2D Geostatistics* tutorial as well as either the *MODFLOW - Grid Approach* or *MODFLOW - Conceptual Model Approach* tutorials before completing this tutorial.

2.1 Outline

This is what you will do:

1. Import scatter point sets.

2. Interpolate elevation values and correct the layer elevations for the following cases:

   - Complete layers
   - Embedded Seam
   - Outcropping
   - Bedrock truncation

3 Getting Started

Let's get started.

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

4 Interpolating to MODFLOW Layers

One of the ways that the top and bottom elevation arrays for each MODFLOW layer can be created is by interpolating from a set of scatter points. The interpolation can be performed directly to the MODFLOW arrays using the *Interpolation* | *Interpolate* → *2D Grid* menu command in the *2D Scatter Point* module.

The scatter points can be imported from a tabular scatter point file. For regions with complex stratigraphy such as embedded seams or outcroppings, the scatter point data must be defined carefully. Once interpolated, the scatter point data may result in overlapping layers. These errors can be automatically corrected using the *Model Checker*.

5 Sample Problems

To illustrate the process of interpolating the elevations, and fixing errors, we will look at a series of example problems. Each example illustrates a different problem and describes a simple approach for correctly modeling the stratigraphy.

6 Case 1 – Complete Layers

The first case we will examine is shown in Figure 1. This is the simplest of the cases examined in this tutorial. The site has three layers and all three layers extend over the entire domain of the model.

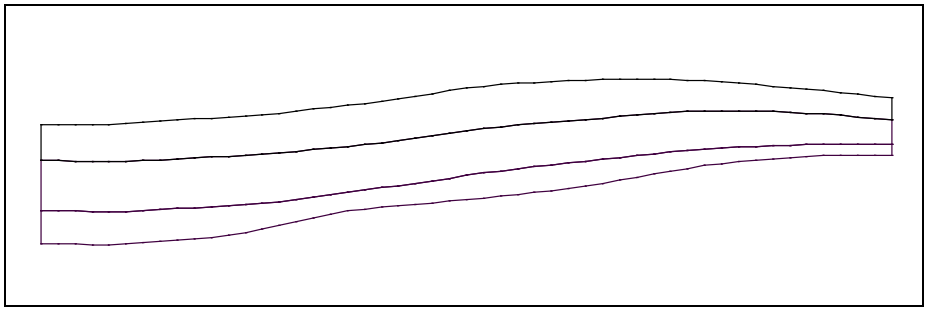

Figure 1. Typical East/West cross section for case 1.

6.1 Importing the Scatter Point Sets

The first step in defining the layer data is to create a grid. The next step is to create a set of points at various xy locations in the model. Each point has an elevation for the top and bottom of each layer. In a real problem, these data would come from sources such as exploratory boreholes. The data are entered into a tabular text file, typically through the use of a spreadsheet such as *Microsoft Excel*. Then, the *Import Wizard* is used to import the tabular text file into GMS. The *2D Geostatistics* tutorial teaches how to do this in detail.

We will look at 4 different scenarios in this tutorial, and four different scatter point sets have been prepared in advance using the technique described above. In the interest of time, the files have already been imported to GMS and saved as a native GMS project. To read in the project:

1. Select the *Open* button .
2. Locate and open the directory entitled **Tutorials\MODFLOW\layerdata**
3. Select the file called **points.gpr** and select the *Open* button.

6.2 Switch to Front View

Before we interpolate, we will change the view so that we are looking at a cross section of the grid. That way we will immediately see the results of our interpolation. Before switching the view, we will first select a cell in the interior of the model. If a cell is selected when switching views, the new view will change to the row or column passing through the selected cell.

1. Select the *Select Cells* tool .
2. Select a cell near the middle of the grid.
3. Select the *Front View* button .

Notice the grid layers are flat.

6.3 Interpolating the Elevation Values

You should see a set of points appear on the screen. The scatter point sets each have four data sets: top1, bot1, bot2, and bot3. The next step is to interpolate each of these data sets to the appropriate layer in the MODFLOW array. Before interpolating the points, we need to initialize the MODFLOW data.

1. If necessary, expand the *3D Grid Data* Folder in the *Project Explorer*.
2. In the *Project Explorer* right-click on *grid* and then, from the pop-up menu, select the *New MODFLOW* command.
3. Select the *OK* button.

To interpolate the elevation values:

4. In the *Project Explorer*, expand the *2D Scatter Data* folder.
5. To see the data sets, expand the *Case 1* scatter point set, if necessary, by clicking on the + sign.
6. Right-click on the *Case 1* scatter point set in the *Project Explorer* and select the *Interpolate To* | *MODFLOW layers* menu command.

The dialog you now see is used to define which scatter point data sets are interpolated to which MODFLOW arrays. The data sets are listed at the top left and the MODFLOW arrays are listed at the top right of the dialog. The "mapped" relationships are listed at the bottom of the dialog. GMS tries to automatically map the relationships based on the data set names. In this case, all of the relationships were correctly mapped and we can continue.

7. Select the *OK* button.

Notice that the interpolated layers match the cross section shown in Figure 1. You may wish to use the arrow buttons in the *Mini-Grid Display* to view the cross sections along other rows.

7 Case 2 – Embedded Seam

The next case we will examine is illustrated in Figure 2. In this case, the middle layer is an embedded seam that only exists on the left (West) side of the model. This type of layer is more difficult to model with MODFLOW since a full array of K values must be defined for each layer. Making the cells in the second layer inactive on the right side of the model will not work since this will result in a no-flow boundary between the first and third layers. To model the seam correctly, we will use a three layer model and the second layer will extend throughout the entire model domain. However, we will adjust the layer thickness of the second layer so that the cells will be very small on the right side of the model, thus simulating the pinchout.

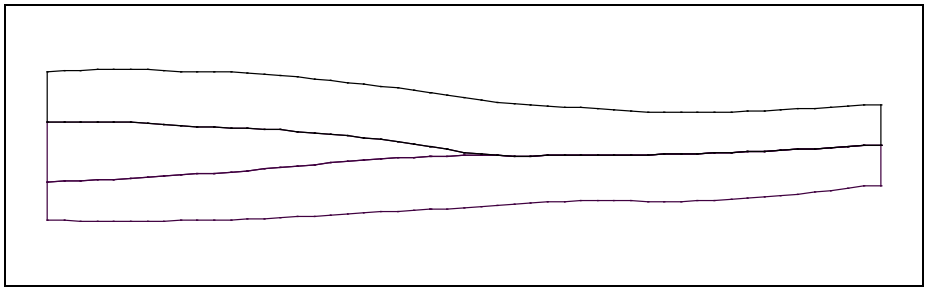

Figure 2. Typical East/West cross section through site with embedded seam.

Next, we will interpolate the data from the scatter points for Case 2. The elevations for the second layer on the right side of the model are adjusted so that the bottom of layer 2 is ABOVE the top of layer 2. This overlap will be fixed after the values are interpolated.

7.1 Interpolating the Values

To interpolate the values:

1. Select the *Case 2* scatter point set in the *Project Explorer*.
2. Right-click on the *Case 2* scatter point set in the *Project Explorer* and select the *Interpolate To* | *MODFLOW layers* menu command.
3. Select the *OK* button.

Note how the middle layer becomes inverted on the right side of the model.

7.2 Correcting the Layer Data

The next step is to fix the overlap on the right side of the model using the layer data tools in the MODFLOW model checker.

1. Select the *MODFLOW* | *Check Simulation* menu command.
2. Select the *Run Check* button.
3. Scroll down to where the errors for the Basic package are shown. Note that several layer elevation warnings are shown.
4. Select the *Fix Layer Errors* button.

The *Fix Layer Errors* dialog provides several options for correcting layer errors. Notice that several errors are listed for layer 2. The correction options are shown on the left. For this case, we will use the *Average* option. This method computes the average of the top and bottom elevation for each cell and moves the top elevation to be just above the average and the bottom elevation to be just below the average. The final difference between the top and the bottom is set to the *Minimum thickness* value shown in the dialog.

5. Select the *Average* option.
6. Select *Layer 2* in the list on the right side of the dialog.
7. Select the *Fix Selected Layer* button.
8. Select *OK* to exit the *Fix Layer Errors* dialog.
9. Select *Done* to exit the *Model Checker* dialog.

Note that the seam is now properly modeled. It appears that the middle layer pinches out, but in actuality it only becomes very thin and continues throughout the grid. You may wish to use the arrow buttons in the *Mini-Grid Display* to view the cross sections along other rows.

8 Case 3 – Outcropping

The next case we will examine is shown in Figure 3. In this case, the top layer is an outcropping that only exists on the left side of the model. We will model this case using a three layer model and adjusting the thickness of the top layer so that it goes to a very small value on the right side of the model.

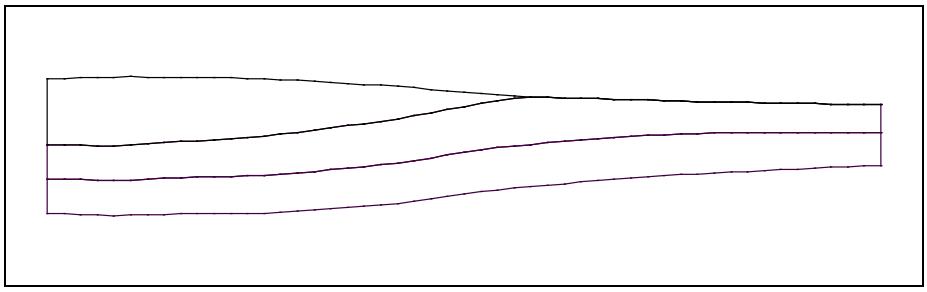

Figure 3. Typical East/West cross section through site with outcropping.

In this case, the elevations for the scatter points have been adjusted so that the bottom of the first layer extends above the top of the second layer on the right side of the model. After interpolating the values, we will then adjust the elevations.

8.1 Interpolating the Values

To interpolate the values:

1. Select the *Case 3* scatter point set in the *Project Explorer*.
2. Right-click on the *Case 3* scatter point set in the *Project Explorer* and select the *Interpolate To* | *MODFLOW layers* menu command.
3. Select the *OK* button.

Note how the bottom of the first layer extends above the ground surface on the right side of the model.

8.2 Correcting the Layer Values

To correct the layer errors:

1. Select the MODFLOW | Check Simulation menu command.
2. Select the *Run Check* menu command.
3. Select the *Fix Layer Errors* button.

In this case, we wish to fix the errors for layer one by moving the bottom of layer one down to where it is just below the ground surface. This can be accomplished using the *Preserve top* option.

4. Select the *Preserve* top option.
5. Make sure *Layer 1* is selected in the list.
6. Make sure the *Inactivate thin cells* option is on.

With this option, instead of having a thin layer extend across the top of the grid, the thin cells are inactivated. This is useful since thin cells on the top of the grid often go dry.

7. Select the *Fix Selected* Layer button.
8. Exit both dialogs.

Notice how the outcropping is now properly modeled. When finished viewing the cross section:

9. Select the *Plan View* button  .

9 Case 4 – Bedrock Truncation

The final case we will examine is shown in Figure 4. The site has three layers but the layers are truncated by the bedrock on the sides of the model. We will model this situation by inactivating the cells on the perimeter of the model that are below the bedrock elevation. We will also adjust the layer bottom elevations as necessary to accurately model the bedrock.

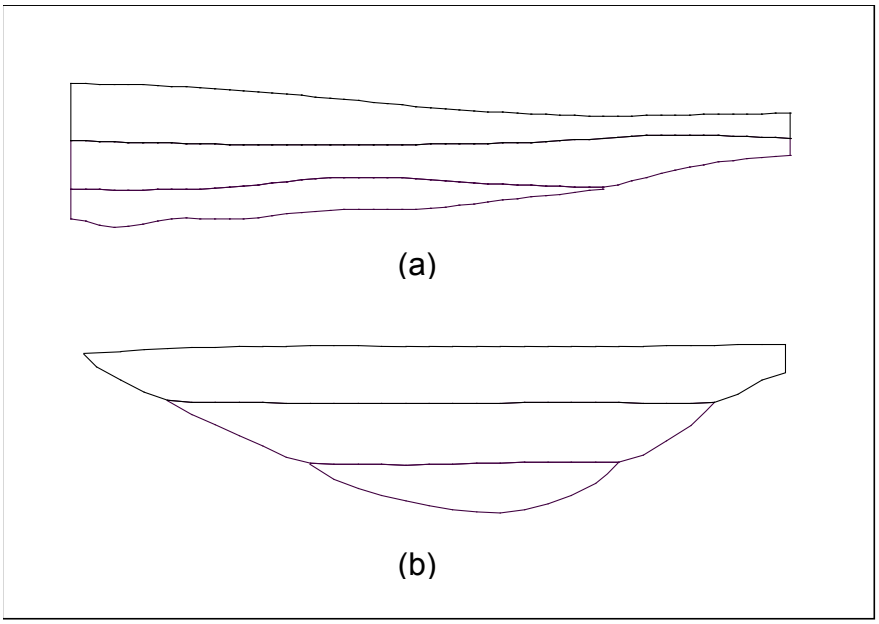

Figure 4. Typical a) East/West and b) North/South cross section through site with layers truncated by bedrock.

9.1 Activating the Inactive Cells

The last interpolation caused cells on the top layer to become inactive. We must first activate those cells.

1. Select the *MODFLOW* | *Global Options* menu command.
2. Click the IBOUND button.
3. Select the *Constant* → *Grid* button.
4. Enter a **1** for the value and click *OK*.
5. Click *OK* repeatedly to exit all dialogs.

9.2 Interpolating the Values

To interpolate the values:

1. Select the *Case 4* scatter point set in the *Project Explorer*.
2. Right-click on the *Case 4* scatter point set in the *Project Explorer* and select the *Interpolate To* | *MODFLOW layers* menu command.
3. Select the *OK* button.

9.3 Viewing the Results

To view the results:

1. Select the *3D Grid Data* folder  .
2. Select a cell near the middle of the grid.
3. Select the *Front View* button  .
4. Select the *Side View* button  .

Note how the bottom of the third layer (the top of the bedrock) cuts into the upper layers.

9.4 Correcting the Layer Values

To correct the layer errors:

1. Select the *MODFLOW* | *Check Simulation* menu command.
2. Select the *Run Check* menu command.
3. Select the *Fix Layer Errors* button.

In this case, a customized option called *Truncate to bedrock* is perfectly suited to our problem. This method examines the elevations for each cell and if the bedrock elevation (the bottom elevation for the bottom layer) is above the top elevation of the cell, the cell is made inactive. If the bedrock elevation is below the top of the cell but above the bottom, the bottom elevation is adjusted to match the bedrock elevation.

4. Select the *Truncate to bedrock* option.
5. Select the *Fix Affected Layers* button.
6. Exit both dialogs.

9.5 Viewing the Corrected Layers

Notice how the outcropping is now properly modeled. To view the cross sections:

1. Use the arrow buttons in the *Mini-Grid Display* to view the grid along different columns.
2. Select the *Front View* button  .
3. Use the arrow buttons to view the grid along different rows.

Next, we will switch to plan view and see how the cells on the perimeter of the grid have been made inactive.

4. Select the *Plan View* button .
5. Use the arrow buttons to view the grid on different layers.

Finally, we will view the grid in general mode to see a 3D plot of the stratigraphy:

6. Unselect the *Ortho Mode* button .
7. Select the *Oblique View* button .

You may wish to use the *Rotate* tool to view the grid from different viewpoints.

10 Conclusion

This concludes the tutorial. Here are some of the key concepts in this tutorial:

- You can interpolate from 2D scatter points directly to MODFLOW elevation data arrays.
- Interpolating to MODFLOW elevation data can result in layers that overlap.
- You can correct overlap errors by using the *Fix Layer Errors* dialog, available via the *MODFLOW* | *Check Simulation* menu command.
- There are different ways to fix layer errors and you can pick the method that best suits your particular problem.