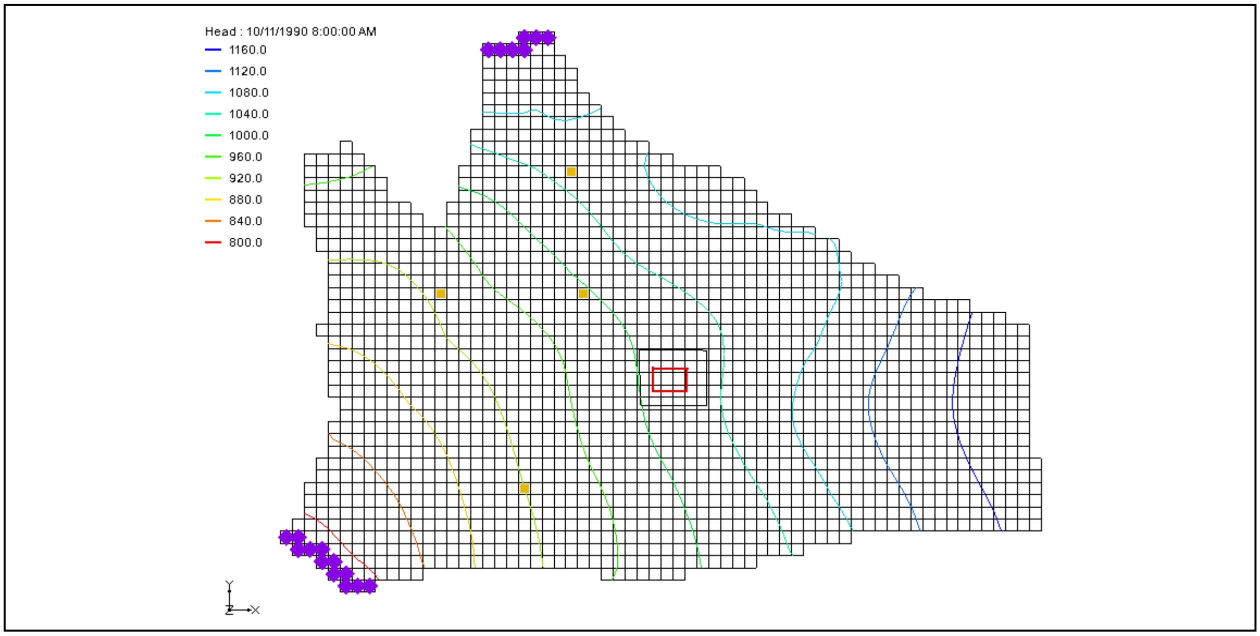
v. 10.0

GMS 10.0 Tutorial

MODFLOW – Regional to Local Model Conversion, Steady State

Create a local model from a regional model using convenient tools provided in GMS



Objectives

Use the convenient tools provided in GMS to perform the steps involved in a typical regional to local model conversion. This tutorial uses a steady state model. A transient example is provided in the "MODFLOW – Regional to Local Model Conversion, Transient" tutorial.

Prerequisite Tutorials

- MODFLOW – Conceptual Model Approach II

Required Components

- Grid Module
- Geostatistics
- Map Module
- MODFLOW

Time

- 25-40 minutes

1 Introduction

For many modeling studies, determining an appropriate set of boundary conditions can be difficult. It is often the case that classical boundaries such as rock outcroppings, rivers, lakes, and groundwater divides, may be located at a great distance from the site of interest. In such cases, it is often convenient to perform the modeling study in two phases. In the first phase, a large, regional scale model is constructed and the model is extended to well-defined boundaries. During the second stage, a second, smaller, local scale model is constructed that occupies a small area within the regional model. The groundwater elevations computed from the regional model are applied as specified head boundary conditions to the local scale model. The layer data, including elevations and transmissivities, are also interpolated from the regional to the local model. A more detailed representation of the local flow conditions, including low capacity wells and barriers not included in the regional flow model can be constructed in the local scale model. Regional to local model conversion is often referred to as “telescopic grid refinement."

GMS provides a convenient set of tools that can be used for regional to local model conversion. This tutorial describes the steps involved in a typical regional-to-local model conversion using MODFLOW.

1.1 Outline

Here are the steps of this tutorial:

1. Open a regional conceptual model.

2. Convert the layer data to a scatter point set.
3. Build a local conceptual model and map to a 3D grid.
4. Map the conceptual model to a MODFLOW simulation.
5. Interpolate the layer data.
6. Run MODFLOW.
7. Run MODAEM.
8. Using the MODAEM head instead of the specified head, rerun MODFLOW.

2 Description of Problem

The site modeled in this tutorial is shown in Figure 1. The main features of the regional model are shown. Most of the boundaries are no-flow boundaries corresponding to groundwater flow divides, bedrock outcroppings, and natural flow boundaries. A river runs through the left side of the model. The narrow regions where the river enters and exits the model are modeled as specified head boundaries. There are four major production wells in the region. The site will be modeled using two layers: a lower confined layer and an upper unconfined layer.

The local site is situated in the interior of the model. The local site corresponds to a chemical plant with a small spill. Once the regional model is completed, a local scale model is to be developed and then used to analyze a number of injection/extraction well placement scenarios. The wells are part of a treatment system that is being designed.

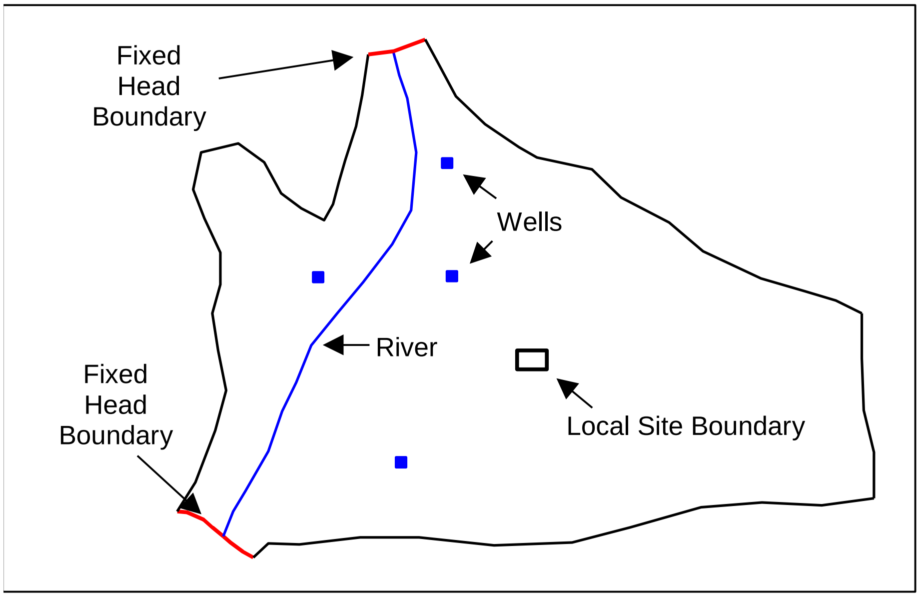


Figure 1 Regional model

The basic goal of the regional to local model conversion process is to create a 2D scatter point set containing the heads and layer data arrays from the regional model, create the local model, and interpolate the heads and layer data to the local model. A 2D scatter point set is used since the MODFLOW arrays should be interpolated on a layer by layer basis using 2D interpolation. GMS provides a set of tools that greatly simplify this process. The basic steps are as follows:

1. Generate the regional model and compute a solution.
2. Use the **MODFLOW Layers → 2D Scatter Points** command to create the scatter point set with the layer and head data from the regional model.
3. Create the 3D grid for the local scale model.
4. Interpolate the heads and layer data values from the scatter points to the MODFLOW layer arrays for the local scale model.

Each of these steps will be described in more detail below.

3 Getting Started

Do the following to get started:

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

4 Reading in the Regional Model

The first step in the model conversion process is to build a regional model. Since the focus of this tutorial is primarily on the conversion process, the user will read in a previously constructed model.

1. Select the **Open** button.
2. Locate the folder entitled *Tutorials\MODFLOW\reg2loc_ss.*
3. Select the “regmod.gpr” file.
4. Click **Open.**

The user is now viewing the top layer of the two-layer model. The user may wish to use the arrow buttons in the *Tool Palette* to view the bottom layer. The wells are located in the bottom layer. When finished, return to the top layer.

This model was constructed using the conceptual model approach. The boundary of the local site is indicated with a red rectangle. The conceptual model consists of three coverages. The coverage being viewed is for the sources and sinks. There is also a coverage defining recharge zones and a coverage defining hydraulic conductivity zones for the top layer.

The project that the user imported includes the solution for the regional model. The user should see contours of computed head.

5 Converting the Layer Data to a Scatter Point Set

The first step in converting the regional model to a local model is to convert the MODFLOW layer data to a 2D scatter point set.

1. Select the “3D Grid Data” folder in the Project Explorer.
2. Select the *Grid* | **MODFLOW Layers → 2D Scatter Points** command.
3. In the *MODFLOW Layers → Scatter Points* dialog, change the scatter point set name to “Regional Data.”
4. Turn on the following options:
    - *Layer elevations*
    - *Computed heads*
5. Click the **Select Dataset** button.
6. In the *Select Dataset* dialog, select the “Head” dataset under the “regmod (MODFLOW)” solution.
7. Click **OK** to exit the *Select Dataset* dialog.
8. Select the **OK** button to exit the *MODFLOW Layers → Scatter Points* dialog.

The user should see a set of scatter points appear at the location of the cell centroids. This scatter point set has a dataset for the computed heads and for the top and bottom elevations of the model layers.

6 Approach to Building the Local Model

Next, the user will build the local model. There are numerous approaches to building the local model. A common approach is to mark the boundaries of the local model as specified head boundaries using the computed head values from the regional model. The following method accomplishes this objective:

A rectangular grid is constructed where two opposite boundaries are parallel to head contours from the regional model (i.e., a constant head value along each boundary). The other two boundaries are no-flow boundaries and are perpendicular to the head contours from the regional model.

7 Building the Local Conceptual Model

The simplest way to build the local model is to create a conceptual model in the *Map* module. To do this, the user will create a new conceptual model.

1. If necessary expand the “Map Data” folder in the Project Explorer by clicking on the plus symbol next to the item.
2. Right-click on the “Regional Model” item and select the *Duplicate* command.
3. Right-click on the new conceptual model.
4. Select **Properties** from the popup menu.
5. In the *Conceptual Model Properties* dialog, change the name of the new conceptual model to to “Local Model.”
6. Click **OK.**

7.1 Creating a New Coverage

Next, the user will create a new source/sink coverage.

1. If necessary expand the “Local Model” item in the Project Explorer by clicking on the plus symbol next to the item.
2. Right-click on the “ss” coverage.
3. Select the **Delete** command from the menu.
4. Right-click on “Local Model” item in the Project Explorer.
5. Select the **New Coverage** command.
6. In the *Coverage Setup* dialog, change the name of the coverage to “local ss.”
7. In the *Sources/Sinks/BCs* spread sheet, toggle on *Layer Range* and *Specified Head (CHD)*.
8. Change the *Default layer range* to be “1” to “2.”
9. Select the **OK** button.

Note that this tutorial did not instruct the user to delete the recharge and hydraulic conductivity coverages. These coverages will be used to construct the local model. The boundaries of the coverages are larger than they need to be, but that does not matter.

7.2 Creating the Boundary Arcs

Next, the user will create the boundary arcs. First, it is necessary to zoom in on the local site model:

1. Select the ***Zoom*** tool.
2. Drag a box around the local site boundary (the red rectangle).
3. Select the "local ss" coverage in the Project Explorer to make it the active coverage.

Create the boundaries as follows:

4. Select the **Create Arc** tool.
5. Create four arcs, two parallel to the contours, and two perpendicular to the contours as shown in Figure 2. Double-click on the corners to end each arc. Be sure to create all the nodes (circles) and vertices (squares) as shown in the figure.

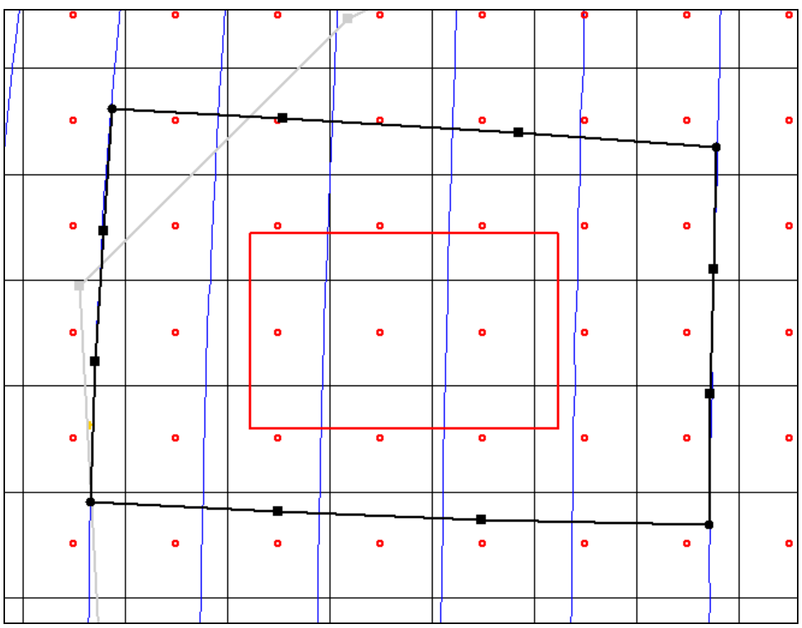


Figure 2 Arcs to be created on boundary of local model

7.3 Building the Polygon

Next, the user will use the arcs to build a polygon defining the model domain.

1. Select the **Build Polygons** button.

7.4 Marking the Specified Head Arcs

The next step is to mark the specified head boundaries.

1. Select the **Select Arcs** tool.
2. While holding the *Shift* key, select the arcs on the left and right sides of the model.
3. Select **Properties** button to open the *Attribute Table* dialog.
4. In the *All* row of the spreadsheet, change the *Type* to "spec. head (CHD)." This will make both arcs specified head arcs.
5. Select the **OK** button.

At this point, the user needs to select the nodes of the specified head arcs and assign a head value.

6. Select the **Select Points/Nodes** tool.
7. Select the two nodes on the left side of the model.
8. Select **Properties** button to open the *Attribute Table* dialog.
9. In the *Head-Stage* column, enter a head value of "1050" for the *spec. head (CHD)* rows for both nodes.
10. Select the **OK** button.
11. Repeat this process for the two nodes on the right side of the model, but assign a head value of "1100."

8 Creating the Local MODFLOW Model

It is now possible to convert the conceptual model to a grid model. First, the user will create a new grid frame that fits the local model.

1. In the Project Explorer, right-click on the empty space.
2. From the pop-up menu, select the *New* | **Grid Frame** command.
3. Right-click on the *Grid Frame* in the Project Explorer.
4. Select the *Fit to Active Coverage* command from the pop-up menu.

5. If desired, use the Grid Frame tool to position the grid frame to better match the local grid boundary.

8.1 Creating the Grid

Next, create the grid.

1. In the Project Explorer, right-click on the *Grid Frame* and select the *Map To* | **3D Grid** command.
2. Select *OK* twice to confirm deletion of the existing grid and the MODFLOW data.
3. In the *Create Finite Difference Grid* dialog, enter “60” for the number of cells in the *X-Dimension*.
4. Then enter “50” for the number of cells in the *Y-Dimension*.
5. Finally, enter “2” for the number of cells in the *Z-Dimension*.
6. Select **OK** to create the grid.

The user should see a grid appear. Now zoom in to examine the grid.

7. Select the **Zoom** tool.
8. Drag a box around the grid.

8.2 Activating the Cells

Next, inactivate the exterior cells.

1. Select the “3D Grid Data” folder in the Project Explorer.
2. Select the *MODFLOW* | **New Simulation** command.
3. Select **OK** to accept the defaults in the *MODFLOW Global / Basic Package* dialog.
4. Select the “Map Data” folder in the Project Explorer.
5. Select the *Feature Objects* | **Activate Cells in Coverage(s)** command from the menu. If the arcs match the grid boundary closely, the user may not see any cells inactivated. If, however, the grid extends significantly beyond the arcs, some cells will be inactivated.
6. Click **OK** at the prompt.

8.3 Mapping the Properties

Next, the user will convert the MODFLOW data to the grid.

1. Right-click on the “Local Model” conceptual model in the Project Explorer.
2. Select the *Map to* | **MODFLOW/MODPATH** command from the menu.
3. Select **OK** at the prompt to map *All applicable coverages*.

Note: At this point, our local scale model does not include the wells involved in the pump and treat system. These could be added at a later time.

9 Interpolating the Layer Data

The final step in the conversion process is to interpolate the regional data from the scatter points to the MODFLOW layer arrays.

1. Right-click on the “Regional Data” scatter set in the Project Explorer.
2. Select the *Interpolate To* | **MODFLOW Layers** command.
3. Select the **OK** button.

Now that the user is done using the scatter points, turn them off to make it easier to see the grid.

4. Uncheck the box in the Project Explorer next to the “2D Scatter Data” folder.

10 Saving and Running the Local Model

It is now possible to save the MODFLOW model and run the simulation.

1. Select the “3D Grid Data” folder in the Project Explorer.
2. Select the *File* | **Save As** command.
3. Change the project name to “locmod.”
4. Click the **Save** button.

To run MODFLOW:

5. Select the *MODFLOW* | **Run MODFLOW** command.
6. When the simulation is finished, select the **Close** button.

The user should see a set of head contours that closely resemble the head contours from the regional model. At this point, the local flow model is complete and the injection and extraction wells could be added for the pump and treat simulations.

11 MODAEM Regional Model

A regional MODAEM model can also be used to create a local MODFLOW model. For a more detailed description of MODAEM see the "MODAEM" tutorial. Instead of using a specified head boundary in the "local ss" coverage to assign heads to the MODFLOW model, this tutorial will use a MODAEM head boundary. A MODAEM head boundary condition is linked to a MODAEM conceptual model. When the **Map → MODFLOW** command is selected, the locations of all of the cells associated with the MODAEM head boundary are found. Then a MODAEM model runs in the background and computes the head at the cell locations. Also, MODAEM computes the flow across the MODAEM head boundary. In summary, the MODAEM head boundary not only assigns heads to the MODFLOW model, but it also creates a flow observation.

11.1 Running MODAEM

Notice that there is now a "Reg MODAEM" conceptual model below the "Map Data" folder in the Project Explorer. The user will now run the MODAEM model to see the head contours.

1. Expand the "Reg MODAEM" conceptual model in the Project Explorer by double-clicking on it.
2. Select the "ss" coverage to make it the active coverage.
3. Select the F5 key. This will run the MODAEM model for the "Reg MODAEM" conceptual model.
4. When MODAEM is finished, select the **Close** button on the MODAEM dialog.

The user should now see the head contours from the "Reg MODAEM" conceptual model.

11.2 Adjusting the Coverage Setup

The user will now change the "local ss" coverage of the "Local Model" conceptual model to use a MODAEM head boundary instead of a specified head boundary.

1. Expand the "Local Model" conceptual model by double-clicking it.
2. Select the "local ss" coverage in the Project Explorer to make it active.
3. Double-click on the "local ss" coverage to bring up the *Coverage Setup* dialog.
4. In the *Sources/Sinks/BCs* section, toggle on *MODAEM Head*.

5. In the *MODAEM models* drop-down box, select “Reg MODAEM.”
6. Select **OK** to exit the dialog.
7. Choose the **Select Arc** tool and select the two specified head arcs.
8. Select the **Properties** button to open the *Attribute Table* dialog.
9. In the *Type* column of the *All* row, select “MODAEM head” as the type.
10. Select **OK** to exit the dialog.

11.3 Running the Local Model

It is now possible to convert the local conceptual model to the 3D Grid.

1. Right-click on the “Local Model” conceptual model in the Project Explorer.
2. Select *Map to* | **MODFLOW/MODPATH** command from the pop-up menu.
3. Select **OK** at the prompt to use all applicable coverages.
4. Select the *File* | **Save As** command.
5. Change the project name to “locmod2.”
6. Click **Save**.
7. Select the “3D Grid Data” folder in the Project Explorer.
8. Select the *MODFLOW* | **Run MODFLOW** command.
9. Select the **Close** button when MODFLOW is finished running.

The user should see a set of head contours that are similar to the head contours from the regional model. The head contours from the regional MODAEM model are slightly different from the MODFLOW regional model, so the sides of the local flow model that should represent parallel flow are most likely not perpendicular to the head contours from the MODAEM regional model. For this reason, the head contours do not match as well as they did for the conversion from the MODFLOW regional model.

12 Conclusion

This concludes the “MODFLOW – Regional to Local Model Conversion, Steady State” tutorial. Here are the key concepts in this tutorial:

- The *Grid* | **MODFLOW Layers → 2D Scatter Points** command converts the MODFLOW elevation data into scatter points.

- The basic steps for doing regional-to-local model conversion in GMS are:

    1. Generate the regional model and compute a solution.

    2. Use the **MODFLOW Layers → 2D Scatter Points** command to create the scatter point set with the layer and head data from the regional model.

    3. Create the 3D grid for the local scale model.

    4. Interpolate the heads and layer data values from the scatter points to the MODFLOW layer arrays for the local scale model.

- A local MODFLOW model can be constructed from a regional MODAEM model.

