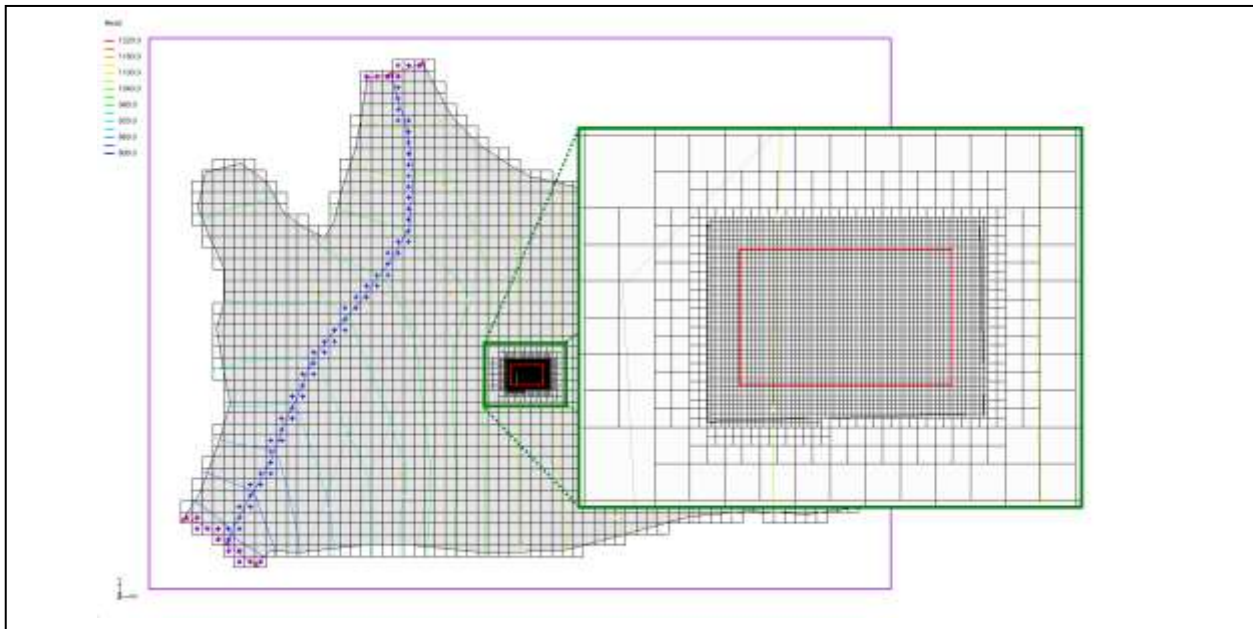


GMS 10.0 Tutorial

MODFLOW-USG – Regional to Local Model Conversion

Create a locally refined area in a regional model using MODFLOW-USG and GMS



Objectives

Use the tools provided in GMS to locally refine an area in a regional model.

Prerequisite Tutorials

- MODFLOW – Conceptual Model Approach I
- MODFLOW-USG – Quadtree
- UGrid Creation

Required Components

- Grid Module
- Geostatistics
- Map Module
- MODFLOW

Time

- 15–30 minutes



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1 Introduction

MODFLOW–USG (or UnStructured Grid), was developed to support a wide variety of structured and unstructured grid types, including nested grids and grids based on prismatic triangles, rectangles, hexagons, and other cell shapes. Flexibility in grid design can be used to focus resolution along rivers and around wells, for example, or to subdiscretize individual layers to better represent hydrostratigraphic units.¹

The following image is taken from the MODFLOW-USG documentation. Notice the grid labeled H. This is an example of a nested grid. This is essentially what the user will want to accomplish with a Regional to Local Model conversion. MODFLOW-LGR allows for multiple nested grids and runs two or more coupled MODFLOW simulations. With MODFLOW-USG, the user can just refine the grid around the area of interest and end up with only one MODFLOW simulation to run.

1. Panday, S., Langevin, C.D., Niswonger, R.G., Ibaraki, M., and Hughes, J.D. (2013). MODFLOW–USG version 1: An unstructured grid version of MODFLOW for simulating groundwater flow and tightly coupled processes using a control volume finite-difference formulation: U.S. Geological Survey Techniques and Methods, book 6, chap. A45, 66 p., <http://pubs.usgs.gov/tm/06/a45>.

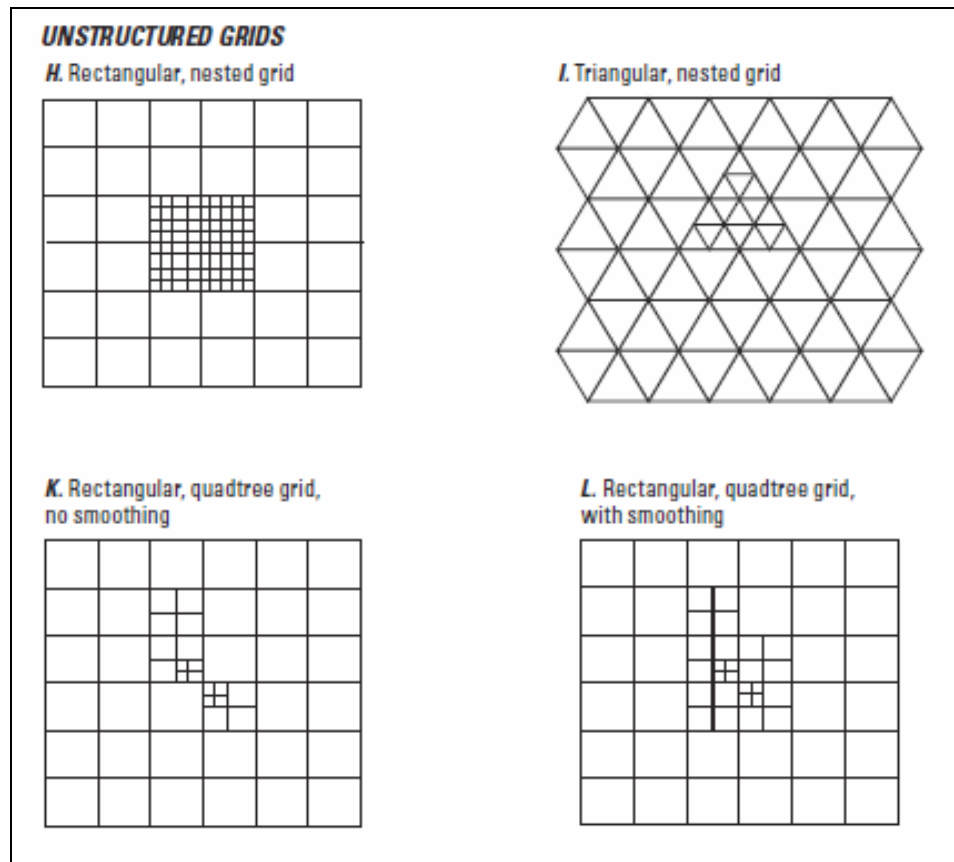


Figure 1 Examples of unstructured grids from MODFLOW-USG documentation

In this tutorial, the user will start with a regional MODFLOW 2000 model and create a MODFLOW-USG model with local refinement. This tutorial assumes that the user is familiar with conceptual modeling, MODFLOW-USG, and unstructured grid generation. The user should complete the tutorials listed as prerequisites (on the cover page of this document) prior to starting this tutorial.

1.1 Outline

Here are the steps to this tutorial:

1. Open a regional conceptual model.
2. Create a locally refined UGrid.
3. Create a MODFLOW-USG simulation.
4. Convert the layer data to a scatter point set.
5. Interpolate the layer data.
6. Map the conceptual model to a MODFLOW.

7. Run MODFLOW-USG.


2 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.

3 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 directory entitled *Tutorials\MODFLOW-USG\Reg2Loc*.
3. Select the file entitled “regmod.gpr.”
4. Click **Open**.

The user should see a model similar to the next figure.

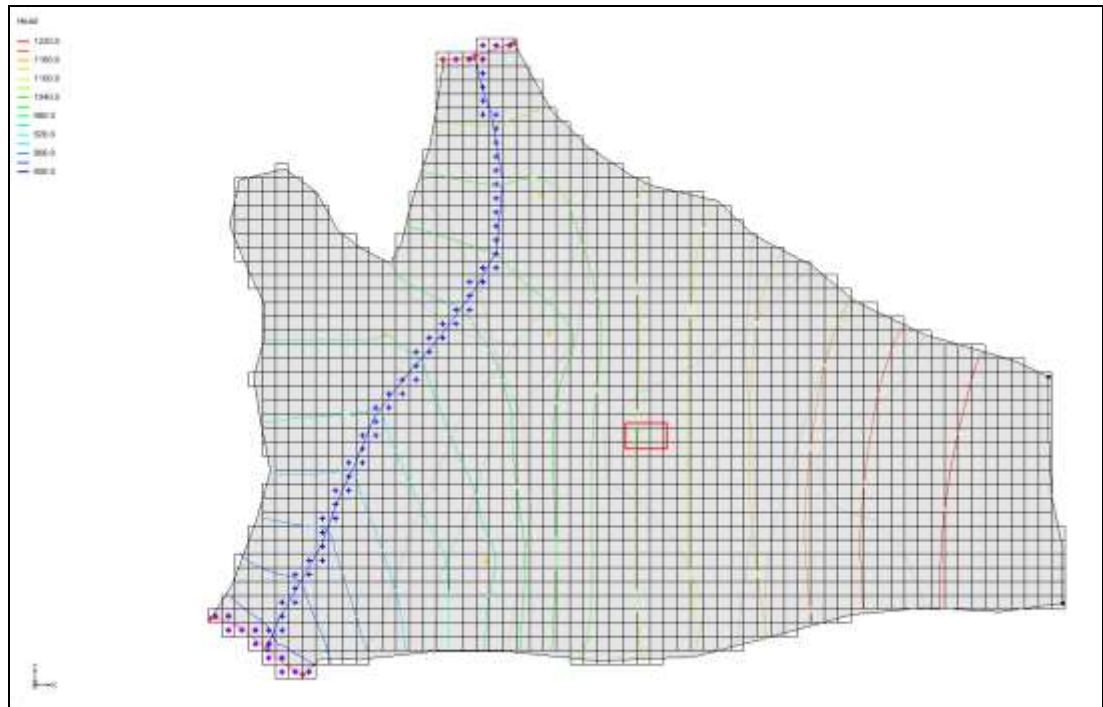



Figure 2 Regional MODFLOW 2000 model

The user is now viewing the top layer of the two layer model. This model was constructed using the conceptual model approach. The boundary of the local site is indicated with a red rectangle. The imported project includes the solution for the regional MODFLOW 2000 model.

4 Saving with a Different Name



Before making any changes, save the project under a new name.

1. Select the *File* / **Save As** command.
2. Change the project name to “refined.gpr.”
3. Click **Save**.

Now hit the **Save**  button periodically as the model is developed.

5 Creating a UGrid

Now the user is going to create a 3D UGrid. This grid needs to match the MODFLOW 2000 (mf2k) grid except that the user will refine the grid around the local site. The user will use a grid frame with the same origin and extents as the mf2k grid. Then the user will use a map polygon to define the refined area around the local site.

1. Right-click in the blank space in the Project Explorer.
2. Select *New / Grid Frame*.
3. Right-click on the “Grid Frame” in the Project Explorer.
4. Select the **Fit to Active Coverage** command.
5. Expand the “3D Grid Data”  item in the Project Explorer.
6. Right-click on the “grid”  item in the Project Explorer.
7. Select the **Properties** menu command to open the *Properties* dialog.
8. Multi-select the cells in the spreadsheet from the *X origin* field to the *Length in Z* field as shown in the following figure.

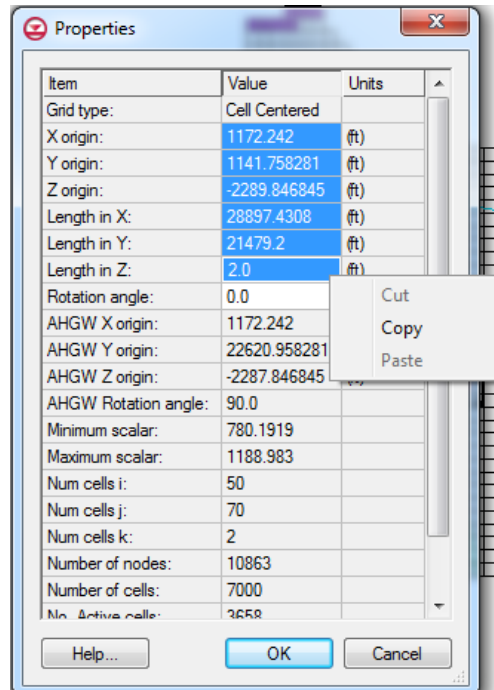








Figure 3 3D Grid Properties Dialog

9. Right-click on the selection and select the **Copy** menu command.
10. Click **Cancel** to exit the dialog.
11. Right-click on the “Grid Frame” .
12. Select the **Properties** menu command to open the *Properties* dialog.
13. Select the spreadsheet cells in the *Value* column from the *Origin x* row to the *Dimension z* row.

14. Right-click on the selected cells.
15. Select the **Paste** menu command.
16. Select **OK** to exit the dialog.
17. Select the **Frame**  button to view the entire model area with the grid frame.

5.1 Defining the Refined Area

It is now possible to define the refined area around the local site. The user will do this by editing the “ss” coverage.

1. Expand the “Regional Model”  item in the Project Explorer.
2. Double-click on the “ss”  coverage in the Project Explorer to bring up the *Coverage Setup* dialog.
3. Turn on the *Refinement* item in the *Sources/Sinks/BCs* list.
4. Select **OK** to exit the dialog.
5. Uncheck the “grid”  item in the Project Explorer to hide the 3D Grid.
6. Select the **Create Arc** tool  and click out a polygon that surrounds the local site (the red rectangle). The following figure shows an example polygon.

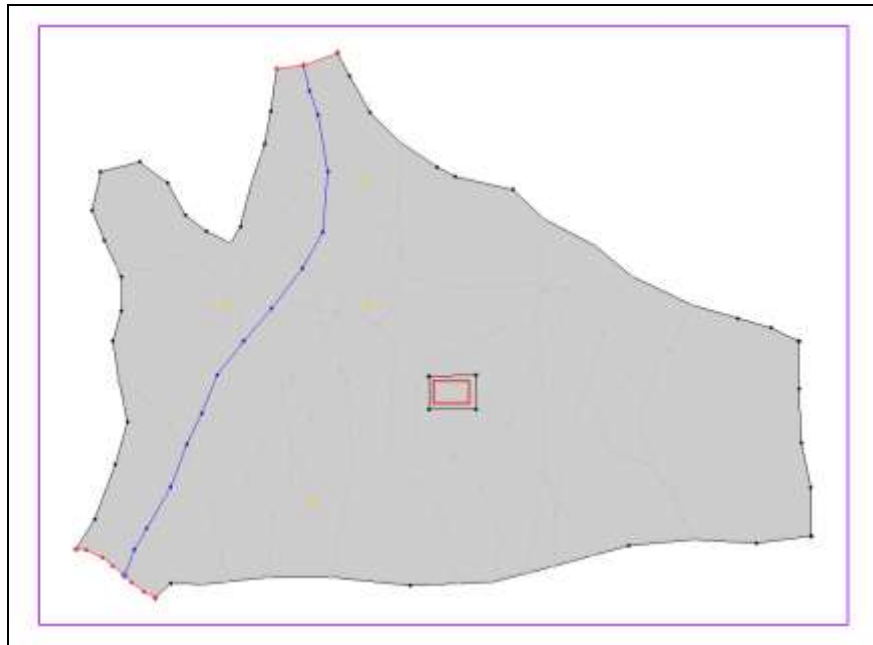





Figure 4 New polygon digitized around the local site

7. Select the **Build Polygons**  button. This will make the newly digitized arc into a polygon.
8. Select the **Select Polygon**  tool.
9. Double-click on the new polygon. This will bring up the *Attribute Table* dialog.
10. Click the check box in the *Refine* field.
11. Enter a value of “50.0” for the *Base size*.
12. Select **OK** to exit the dialog.

5.2 Creating a 3D Refined UGrid

Now the user will create the 3D refined UGrid.

1. Right-click on the “Grid Frame” .
2. Select the *Map to* | **UGrid** menu command.
3. Make sure the *Dimension* dropdown is set to “3D.”
4. Change the *UGrid type* to “Quadtree/Octree.”
5. Under *X-Dimension*, enter “70” for the *Number of cells*.
6. Under *Y-Dimension*, enter “50” for the *Number of cells*.
7. Under *Z-Dimension*, enter “2” for the *Number of cells*.
8. Click **OK** to exit the dialog and create the UGrid.

The user should see a UGrid appear in the graphics window similar to the following figure.

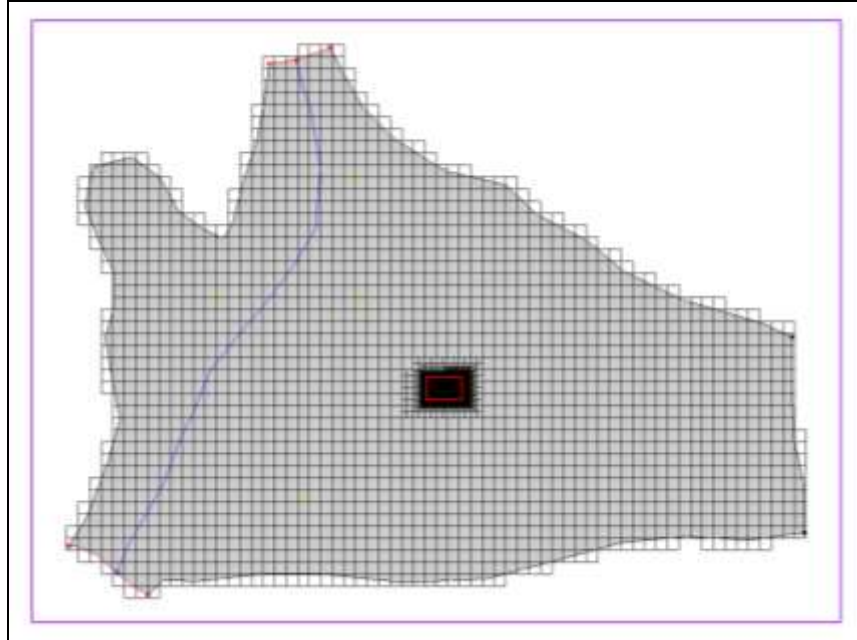


Figure 5 Locally refined UGrid

The larger cells in the UGrid exactly match the mf2k grid; the cells gradually become smaller around the area of interest. If the user zooms in on the local site, the user should see something similar to the following figure.

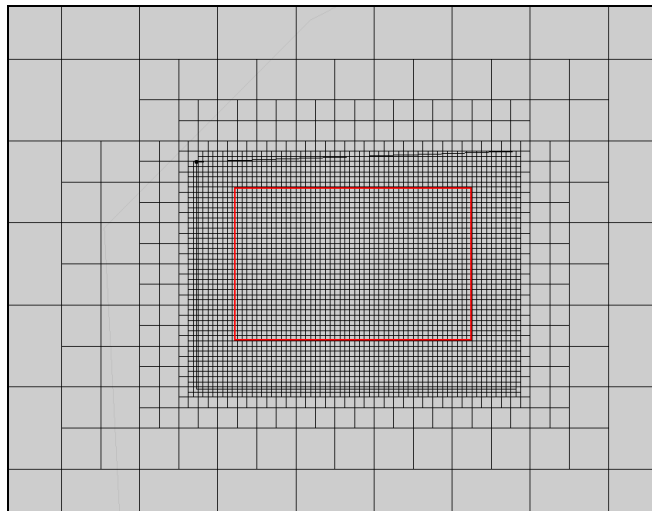



Figure 6 Local refinement of a 3D UGrid

9. Select the **Frame**  button to view the entire model area.

6 Converting the Layer Data to a Scatter Point Set


Now the user will convert the MODFLOW 2000 layer elevation information to a scatter point set so that it is possible to interpolate the elevations to the UGrid. The user will use

the *MODFLOW Layers → Scatter Points* dialog to do this. By default, the command will create a new scatter set with the MODFLOW top and bottom elevations as datasets.

1. Select the “3D Grid Data”  folder in the Project Explorer.
2. Select the *Grid / MODFLOW Layers → 2D Scatter Points* command to open the *MODFLOW Layers → Scatter Points* dialog.
3. Select **OK** to exit the dialog and create the layer elevation scatter points.



7 Creating a MODFLOW-USG Model

Now it is necessary to create a MODFLOW-USG model on the UGrid before the user can interpolate the elevations.

1. Right-click on the “ugrid”  item in the Project Explorer.
2. Select the **New MODFLOW** command.
3. Click **OK** to accept the default model settings and exit the dialog.


8 Interpolating Layer Elevations

Next, the user will interpolate the layer elevations. The *Interpolate to MODFLOW Layers* dialog enables interpolation directly to MODFLOW arrays. This dialog can automatically associate MODFLOW arrays with datasets named *Top 1*, *Bot 1*, etc. The user can just accept the defaults in the dialog and the layer elevations will be interpolated to the correct MODFLOW array.

1. Right-click on “Layers”  scatter set item in the Project Explorer.
2. Select the *Interpolate To / MODFLOW Layers* command.
3. Click **OK** to exit the dialog and interpolate the layer elevations.
4. Uncheck the “Layers”  scatter set item in the Project Explorer to hide the scatter set.

9 Mapping to MODFLOW

Next, the user will assign the MODFLOW boundary conditions and the aquifer properties.



1. Right-click on the “Regional Model”  conceptual model in the Project Explorer.

2. Select the *Map To / MODFLOW/MODPATH* command.
3. In the *Map → Model* dialog, leave the values at their defaults.
4. Click on the **OK** button.

Boundary condition symbols for specified head, rivers, and wells should appear.

10 Saving and Running MODFLOW

Now it is possible to run MODFLOW.

1. Click the **Save**  button.
2. Click the **Run MODFLOW**  button.
3. When the model finishes, click **Close**.

GMS will read in the solution and display the contours similar to the figure below.

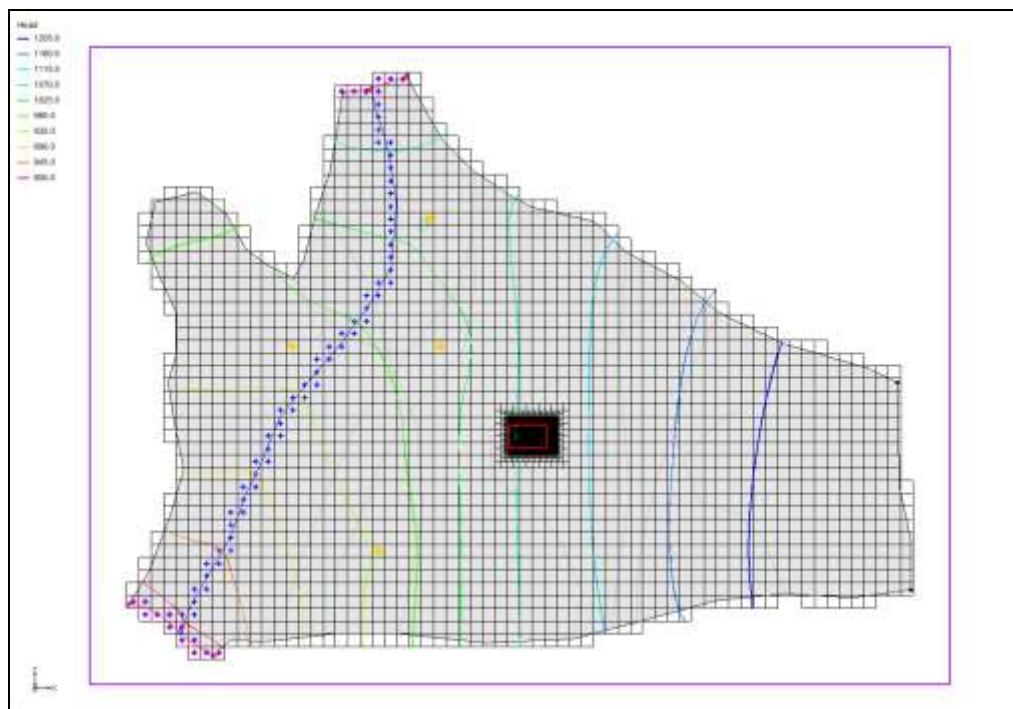


Figure 7 MODFLOW-USG Head Contours

11 Conclusion

This concludes the *Transient Regional to Local Model Conversion* tutorial. Here are the key concepts in this tutorial:

- MODFLOW-USG supports locally refined grids.
- The user can create locally refined UGrids in GMS.