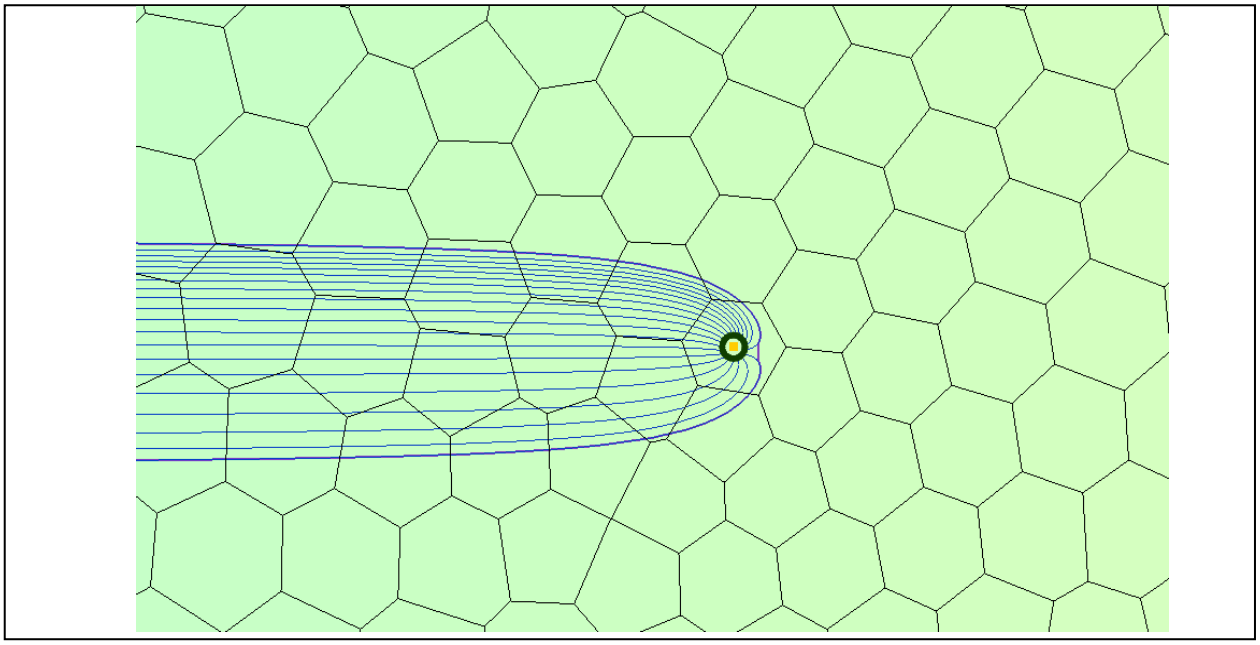
GMS

v. 10.3

GMS 10.3 Tutorial

mod-PATH3DU

A particle tracking program for MODFLOW-USG



Objectives

Become familiar with GMS's interface for mod-PATH3DU.

Prerequisite Tutorials

- MODPATH

Required Components

- MODFLOW-USG
- MP3DU

Time

- 15–30 minutes

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1 Introduction

The mod-PATH3DU model is a particle tracking program written by Chris Muffles at S.S. Papadopulos & Associates. It works with structured and unstructured grids, as well as MODFLOW-USG. It is similar to MODPATH, so be familiar with the MODPATH tutorial before starting this tutorial.

This tutorial opens a model containing a MODFLOW-USG model, saves a native text copy of the model, and runs MODFLOW on the native text. Next, a new backward tracking mod-PATH3DU model with points at the well is created, the new model is saved, mod-PATH3DU is run, and the solution is read. Finally, a new forward tracking mod-PATH3DU model with points on the side will be created.

1.1 Getting Started

To start:

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 Opening an Existing Model

The first step is to open a MODFLOW-USG model based on an example problem included with mod-PATH3DU. It is a one-layer Voronoi model. Flow is from left to right with the cells on the left side set as constant head cells with a value of "50.0". The cells on the right side as also set as constant head cells with a value of "49.0". There is one CLN well in the middle of the model that extracts water. Transparent, continuous, color-filled contours of head are turned on.

1. Click **Open** to bring up the *Open* dialog.

2. Select "Project Files (*.gpr)" from the *Files of type* drop-down.
3. Browse to the *\VoronoiModel\VoronoiModel* folder and select "Voronoi.gpr".
4. Click **Open** to import the project and exit the *Open* dialog.

The project should appear similar to Figure 1.

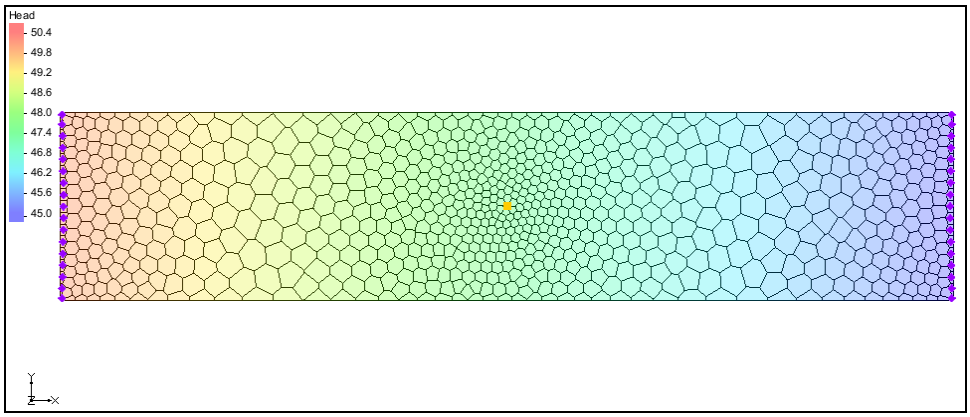

Figure 1 Starting MODFLOW-USG model from mod-PATH3DU examples

Now save the project with a new name.

5. Select *File* | **Save As…** to open the *Save As* dialog.
6. Select "Project Files (*.gpr)" from the *Save as type* drop-down.
7. Enter"mp3du.gpr" as the *File name*.
8. Click **Save** to save the project under the new name and close the *Save As* dialog.

3 Saving a Native Text Copy

Because mod-PATH3DU reads MODFLOW files and uses its own internal version of MODFLOW to do so, it cannot read the GMS-formatted MODFLOW files which use HDF5 to store array data. Save a native text copy of the MODFLOW simulation for use by mod-PATH3DU.

1. In the Project Explorer, double-click on "Global" to bring up the *MODFLOW Global/Basic Package* dialog.
2. In the *MODFLOW version* section, turn on *Save native text copy*.
3. Click **OK** to close the *MODFLOW Global/Basic Package* dialog.
4. **Save** the project so that the text copy of MODFLOW will be saved.

mod-PATH3DU requires a native text version of the MODFLOW model.

4 Running MODFLOW

MODFLOW must now be run to generate a solution for the native text copy version of the model. The typical way to run MODFLOW uses the GMS-formatted copy of the model, so MODFLOW needs to run in a different way.

1. Select *MODFLOW* | *Advanced* | **Run MODFLOW Dialog…** to bring up the *Run Modflow* dialog.
2. In the *MODFLOW version* section, turn on *USG*.
3. Click **Name file** to bring up an *Open* dialog.
4. Navigate up one directory and open the *mp3du_MODFLOW-Voronoi_text* folder.
5. Select "mp3du.mfn" and click **Open** to exit the *Open* dialog.

The dialog should appear similar to Figure 2.

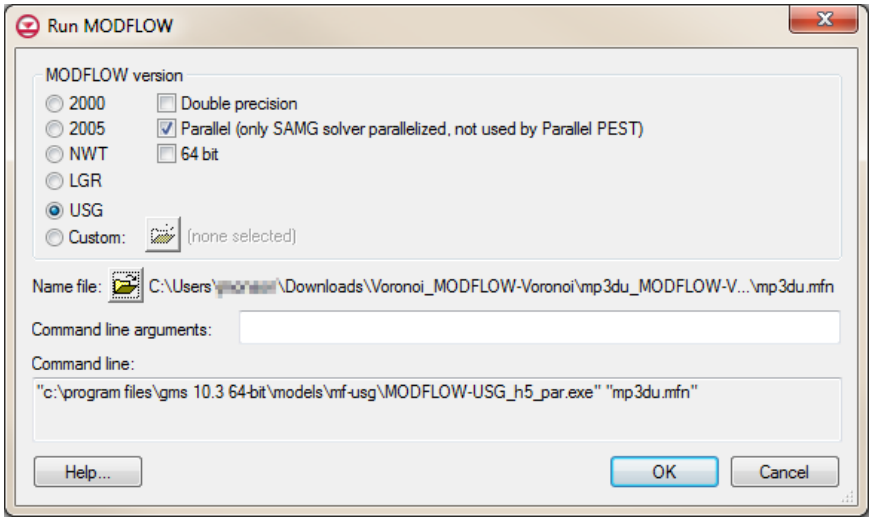

Figure 2 Run MODFLOW dialog

6. Click **OK** to run MODFLOW and bring up a command prompt window.
7. When MODFLOW finishes running, close the command window by pressing any key.

The *MODFLOW* | *Advanced* | **Run MODFLOW Dialog** menu command can be used to run MODFLOW using any version of MODFLOW on any name file.

5 Creating a Backward Tracking mod-PATH3DU Model

The next step is to create the mod-PATH3DU model.

1. In the Project Explorer, right-click "Voronoi" and select **New mod-PATH3DU** to create a new "Voronoi" mod-PATH3DU model.
2. Right-click "Voronoi" and select **Rename**.
3. Enter "backward" and press *Enter* to set the new name.

5.1 Adding Starting Locations

1. Right-click "backward" and select **Create Particles at Wells…** to bring up the *Generate Particles at Wells* dialog.
2. Click **OK** to accept the defaults and close the *Generate Particles at Wells* dialog

Starting locations can be generated at wells using the **Create Particles at Wells…** command.

When using MODPATH normally, at this point GMS would automatically save and run MODPATH and import the pathlines. Because GMS does not automatically run mod-PATH3DU, it must be done manually. This will be done in the next section.

mod-PATH3DU does not run automatically, unlike MODPATH.

3. **Zoom** in to the cell containing the well.

Notice the ring of starting locations created around the well (Figure 3).

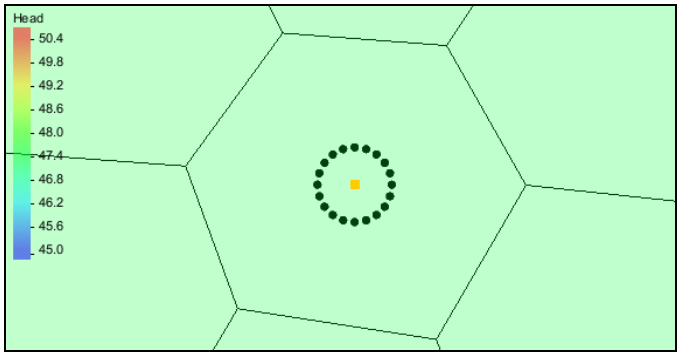

Figure 3 Ring of starting locations created around the well

4. **Frame** the project to return to the previous view.

5.2 Changing to Backward Tracking

With starting locations at the well, the next task is creating a backward tracking simulation.

1. Right-click "backward" and select **Options…** to bring up the *mod-PATH3DU Options* dialog.
2. Select "Options" from the list on the left.
3. Select "(2) Backward" from the *TrackingDirection* drop-down (Figure 4).
4. Click **OK** to exit the *mod-PATH3DU Options* dialog.

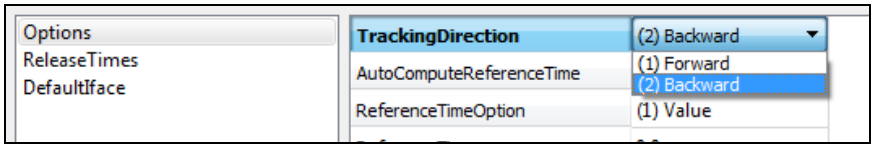

Figure 4 Selecting the tracking direction

6 Saving and Running mod-PATH3DU

Before running mod-PATH3DU, it is recommended to save the project.

1. **Save** the project. This will include the mod-PATH3DU input files.
2. Right-click "backward" and select **Run mod-PATH3DU** to bring up the *MP3DU* model wrapper dialog (Figure 5).

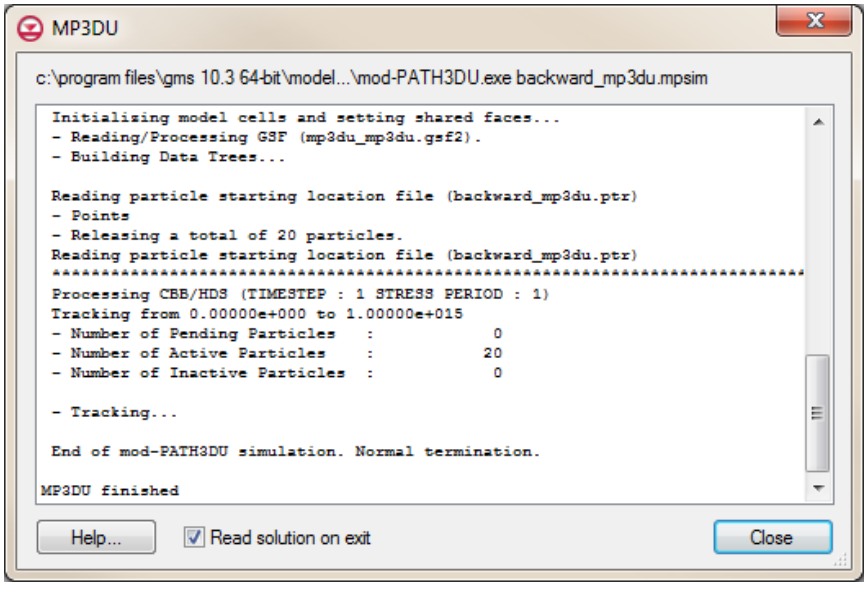

Figure 5 mod-PATH3DU model wrapper

When mod-PATH3DU finishes, the line "End of mod-PATH3DU simulation. Normal termination" should appear near the bottom of the *MP3DU* model wrapper dialog.

3. When mod-PATH3DU finishes, turn on *Read solution on exit* and click Close to exit the *MP3DU* model wrapper dialog.

GMS will import the pathline solution file and display the pathlines. The result should appear similar to Figure 6.

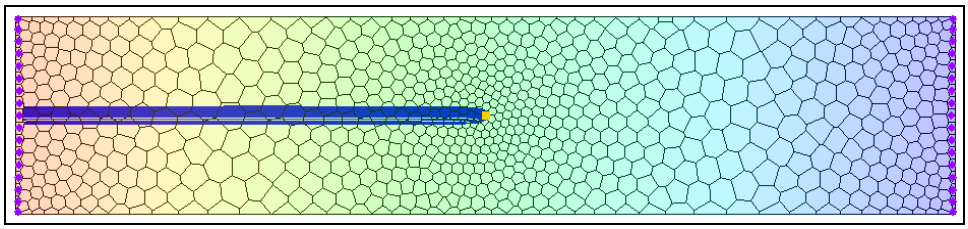

Figure 6 Pathline solution showing pathlines tracking backward from the well

4. If desired, **Zoom** in and examine the pathlines.
5. Click the **Save** macro to save the project with the solution.

7 Creating a Forward Tracking mod-PATH3DU Model

Now create another mod-PATH3DU model with starting locations on the left edge of the model that track forward.

1. In the Project Explorer, right-click "Voronoi" and select **New mod-PATH3DU…** to create a new "Voronoi" mod-PATH3DU model.
2. Right-click "Voronoi" and select **Rename**.
3. Enter "forward" and press *Enter* to set the new name.

Multiple mod-PATH3DU simulations can exist in GMS at the same time.

7.1 Adding Starting Locations

1. **Zoom** in on the left side of the UGrid.
2. Using the **Select Cells** tool, drag a box that selects the cells on the left side of the grid in the area where the existing pathlines are, including two cells above and below the cells the pathlines touch (Figure 7).

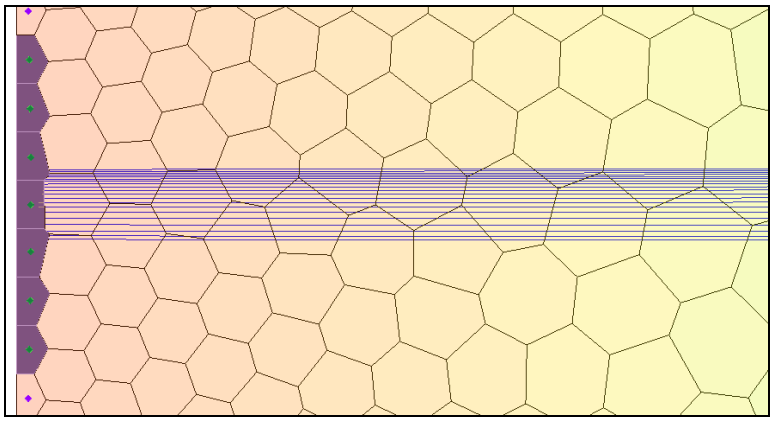

Figure 7 Selected cells on the left side of the UGrid

3. Right-click on any selected cell and select **Create mod-PATH3DU Particles…** to bring up the *Generate Particles* dialog.
4. Move the slider under *Number of particles* to change it to "4".
5. Click **OK** to close the *Generate Particles* dialog.

Each cell now contains up to four starting locations (Figure 8).

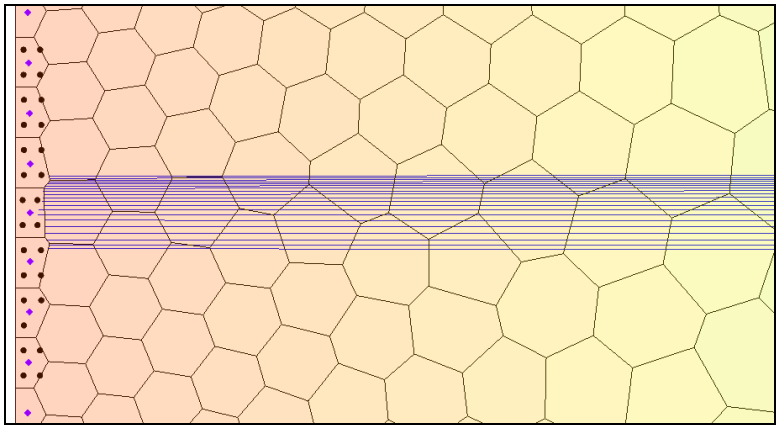

Figure 8 Starting locations in the selected cells

6. If desired, **Zoom** in and see how GMS arranged the starting locations.

Because Voronoi cells are irregularly shaped, some cells will end up with fewer particles because GMS creates them in a square pattern using the cell extents as a guide, and then eliminates particles that end up outside the cell borders.

Starting locations can be created inside cells by selecting cells and using the **Create mod-PATH3DU Particles…** command.

8 Saving and Running mod-PATH3DU

Before running mod-PATH3DU again, it is recommended to save the project.

1. **Save** the project.
2. Right-click "forward" and select **Run mod-PATH3DU** to bring up the *MP3DU* model wrapper dialog.
3. When mod-PATH3DU finishes, turn on *Read solution on exit* and click **Close** to exit the *MP3DU* model wrapper dialog.

GMS then imports the pathline solution file and displays the pathlines (Figure 9).

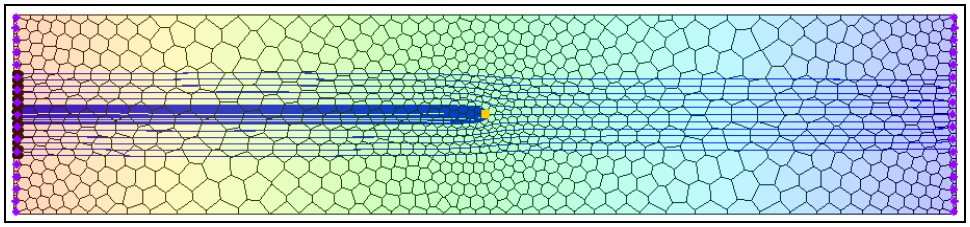

Figure 9 Pathline solution showing pathlines tracking backward from the well

4. If desired, **Zoom** in and examine the pathlines.
5. **Save** the project with the solution.

9 Examining the Solution

Now take a closer look at the pathlines.

1. Turn off "backward" in the Project Explorer.
2. **Zoom** in on the well (Figure 10).

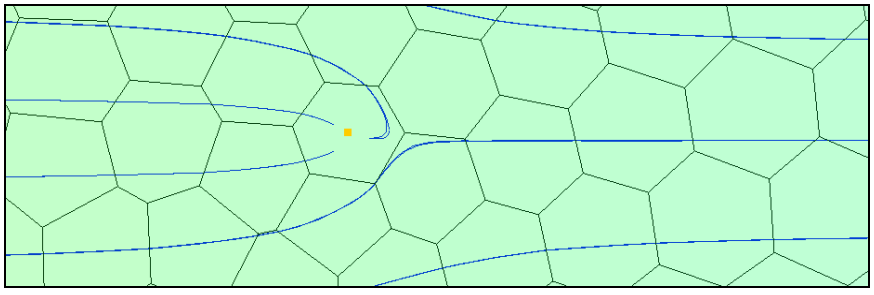

Figure 10 Forward tracking pathlines around the well

Notice that some pathlines were captured by the well and some continued to flow past the well.

3. **Frame** the project.

4. Click **Display Options** to bring up the *Display Options* dialog.
5. Select "UGrid Data" from the list on the left.
6. On the *Particles* tab, turn on *Direction arrows*.

A number of other display options related to starting locations and pathlines are available here.

7. Click **OK** to close the *Display Options* dialog.

Flow direction is now shown (Figure 11).

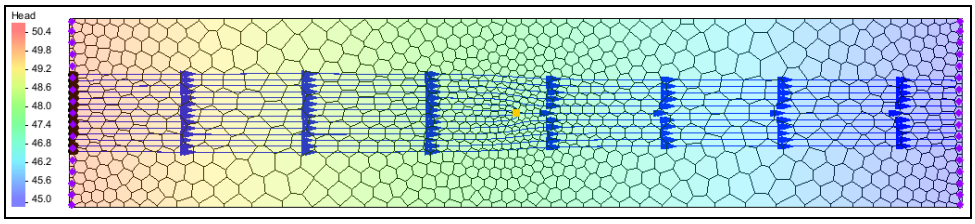

Figure 11 Flow direction arrows are visible

10 Conclusion

This concludes the "mod-PATH3DU" tutorial. The following key concepts were discussed and demonstrated:

- GMS includes an interface to mod-PATH3DU.
- mod-PATH3DU requires a native text version of the MODFLOW model.
- The *MODFLOW* | *Advanced* | **Run MODFLOW Dialog…** menu command can be used to run MODFLOW using any version of MODFLOW on any name file.
- Startling locations can be generated at wells using the **Create Particles at Wells…** command.
- mod-PATH3DU does not run automatically like MODPATH.
- Multiple mod-PATH3DU simulations can exist in GMS at the same time.
- Starting locations can be created inside cells by selecting cells and using the **Create mod-PATH3DU Particles…** command.

