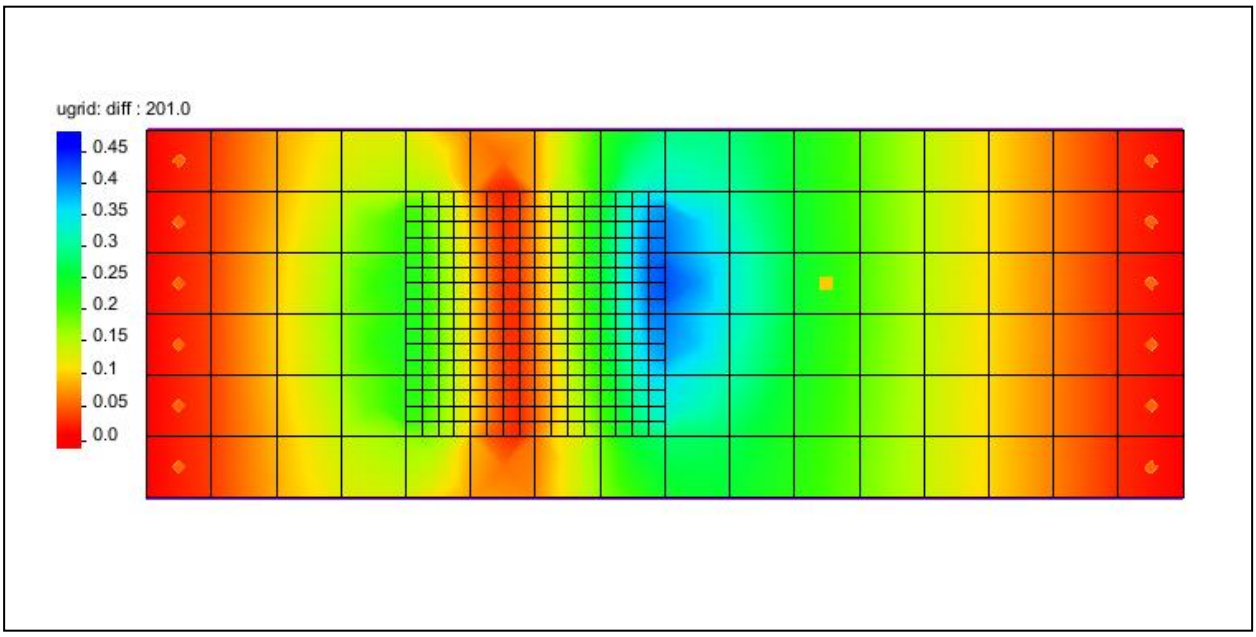
GMS v. 10.5

GMS 10.5 Tutorial

MODFLOW-USG – TVM Package

Use the Time-Variant Materials package (TVM) in GMS



Objectives

Learn how to use the Time-Variant Materials package (TVM) with MODFLOW-USG Transport.

Prerequisite Tutorials

- MODFLOW-USG Transport

Required Components

- Map Module
- Grid Module
- MODFLOW-USG Transport

Time

- 20–30 minutes

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1 Introduction

The Time-Variant Materials package (TVM) works with MODLOW-USG Transport. The TVM package allows hydraulic conductivity and storage values to be changed as a step function between stress periods or in a continuous manner through a transient simulation.

This tutorial demonstrates how the TVM package can be used with a MODFLOW-USG Transport simulation.

The problem in this tutorial consists of a two layer unstructured grid (UGrid) with a MODFLOW-USG Transport simulation. The UGrid contains a well on the second layer set with a constant pumping rate.

This tutorial will demonstrate the following topics:

1. Opening an existing MODFLOW-USG Transport simulation.
2. Create a transient conductivity coverage and dataset.
3. Activating the TVM package.
4. Running the simulation and examining the results.

2 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.
3. Click **Open** (or *File* | **Open…**) to bring up the *Open* dialog.
4. Browse to the *Tutorials\MODFLOW-USG-Transport\TVM* directory and select "start.gpr".
5. Click **Open** to import the file and close the *Open* dialog.

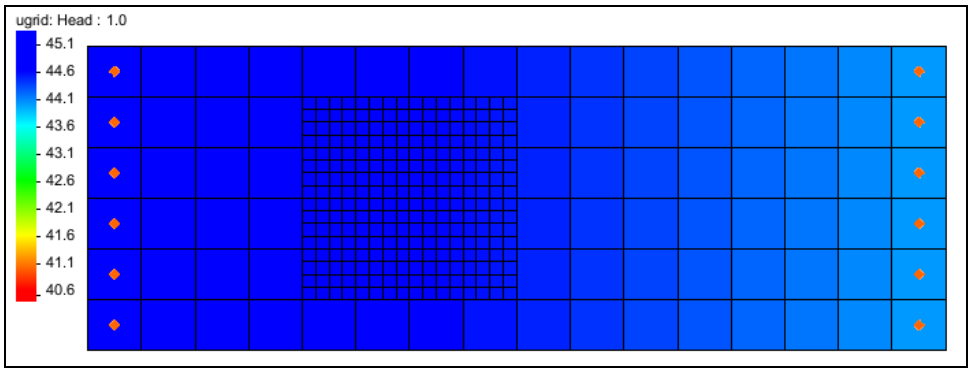

Figure 1 Imported MODFLOW-USG Transport model

The Graphics Window should appear as in Figure 1. This model has a two layer UGrid with a refined zone. General heads have been set at each end. There is a well on the second layer.

Before continuing, save the project with a new name.

1. Select *File* | **Save As…** to bring up the *Save As* dialog.
2. Browse to the *Tutorials\MODFLOW-USG-Transport\TVM* directory.
3. Enter "model-tvm.gpr" as the *File name*.
4. Select "Project Files (*.gpr)" from the *Save as type* drop-down.
5. Click **Save** to save the project file and close the *Save As* dialog.

3 Changing the Conductivity

Before activating the TVM package, start with creating a time-variant dataset for the refined area of the UGrid. This will be done using a separate map coverage which will then be added to the model.

1. Right-click on the "  model" conceptual model and select **New Coverage…** to bring up the *Coverage Setup* dialog.
2. Enter "tvm_hk" for the *Coverage name*.
3. In the *Areal Properties* column, turn on *Datasets*.
4. Click the **Datasets…** button to open the *Datasets* dialog.
5. Click the **Insert Row**  button
6. In the new row, enter "TVM_HK".
7. Click **OK** to close the *Datasets* dialog.

8. Click **OK** to close the *Coverage Setup* dialog.

With the new "tvm-hk" coverage created, time-variant data needs to be added to the refined area of the UGrid.

9. Make certain the "tvm-hk" coverage is active in the Project Explorer.

10. Using the **Create Arcs** tool, create four arcs around the refined area of the UGrid as in Figure 2 below.

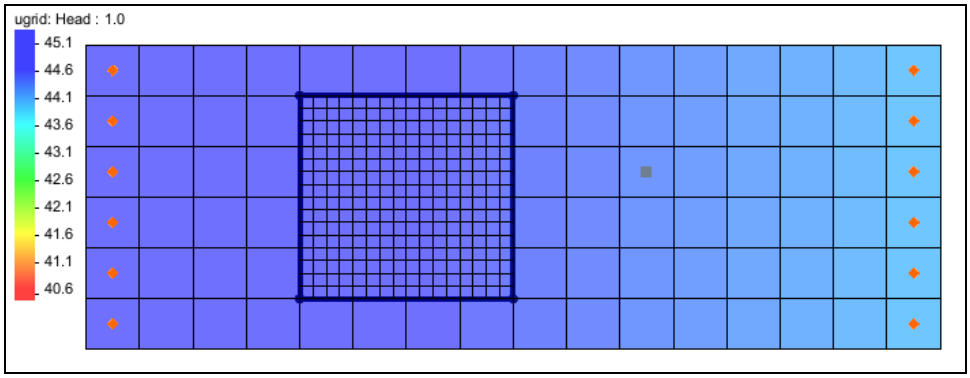

Figure 2 Arcs drawn around refined around of the UGrid

11. Select the **Build Polygons** macro.

12. Using the **Select Polygon** tool, double-click on the polygon to open the *Attribute Table* dialog.

13. Change the *TVM_HK* column to be "<transient>".

14. Click the button to open the *XY Series Editor*.

15. Enter the values in the table below to create a time series:

Time (d)	TVM_HK
0.0	1.5
1.0	1.5
1.0	3.0
101.0	3.0
101.0	6.0
201.0	6.0

16. Click **OK** to close the *XY Series Editor*.

17. Click **OK** to close the *Attribute Table* dialog.

The "tvm_hk" coverage now contains time-variant material data that can be added to the MODFLOW-USG Transport simulation.

4 Map to MODFLOW

The data added in the conceptual model needs to be mapped to the UGrid model.

1. Right-click on the "  model" conceptual model and select *Map To* | **MODFLOW/MODPATH** to open the *Map → Model* dialog.
2. Select *All applicable coverages* and click **OK** to close the *Map → Model* dialog.

A new dataset, "  TVM_HK", should appear in the Project Explorer in the MODFLOW simulation.

5 Activating the TVM Package

With the horizontal conductivity data available, the TVM package can now be activated and added to the MODFLOW simulation. To activate the TVM package:

1. Select *MODFLOW* | **Global Options…** to bring up the *MODFLOW Global/Basic Package* dialog.
2. Click **Packages…** to bring up the *MODFLOW Packages / Processes* dialog.
3. In the *Optional packages / processes* section, turn on *TVM – Time Varying Materials*.
4. Leave all other packages at their defaults.
5. Click **OK** to exit the *MODFLOW Packages / Processes* dialog.
6. Click **OK** to exit the *MODFLOW Global/Basic Package* dialog.

6 Defining the TVM Package

With the time varying dataset mapped to the simulation and the TVM package activated, the parameters for the TVM package can now be defined.

1. Select *MODFLOW* | *Optional Packages* | **TVM – Time Varying Materials…** to bring up the *TVM Package* dialog.
2. In the list on the left, select *HK*.
3. Select **Dataset to Array** to bring up the *Select Dataset* dialog.
4. Under *Solution*, select "  TVM_HK".
5. Turn on *All time steps*.

6. Click **OK** to close the *Select Dataset* dialog.
7. Click **OK** to close the *TVM Package* dialog.

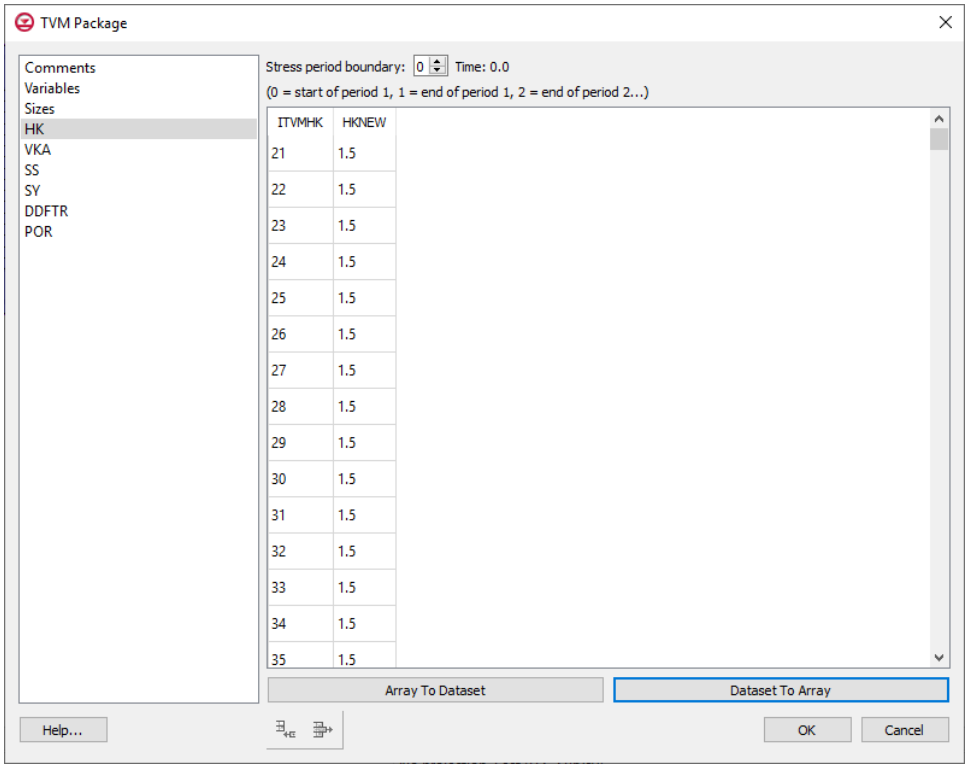

Figure 3 TVMPackage dialog

7 Saving and Running MODFLOW

The changes should now be saved before running MODFLOW-USG Transport.

1. Click **Save** to save the project.
2. Click the **Run MODFLOW** macro in the toolbar to bring up the *MODFLOW* model wrapper dialog.
3. When MODFLOW finishes, check the *Read solution on exit* and *Turn on contours (if not on already)* boxes.
4. Click **Close** to close the *MODFLOW* model wrapper dialog.
5. Click **Save** to save the project with the new solution.

The solution set should appear in the Project Explorer.

8 Examining the Results

In order to more clearly see how the TVM package impacted the simulation, compare the results. This can be done by using the *Data Calculator* to create a dataset that compares the solution set with the TVM package to the previous solution set.

1. Click the **Data Calculator** macro to open the *Data Calculator* dialog.
2. In the *Datasets* section, select the "Head" dataset under the "start (MODFLOW)" folder.
3. In the *Time steps* section, turn on *Use all time steps*.
4. Click **Add to Expression**.
5. Click the **minus (-)** button.
6. In the *Datasets* section, select the "Head" dataset under the "model-tvm (MODFLOW)" folder.
7. Click **Add to Expression**.
8. Enter "diff" in the *Result* field.
9. Click **Compute**.
10. Click **Done** to close the *Data Calculator* dialog.
11. Select the "diff" dataset in the Project Explorer.
12. In the *Time Steps* window, use the down arrow key to step through the time steps and watch how the contours change.

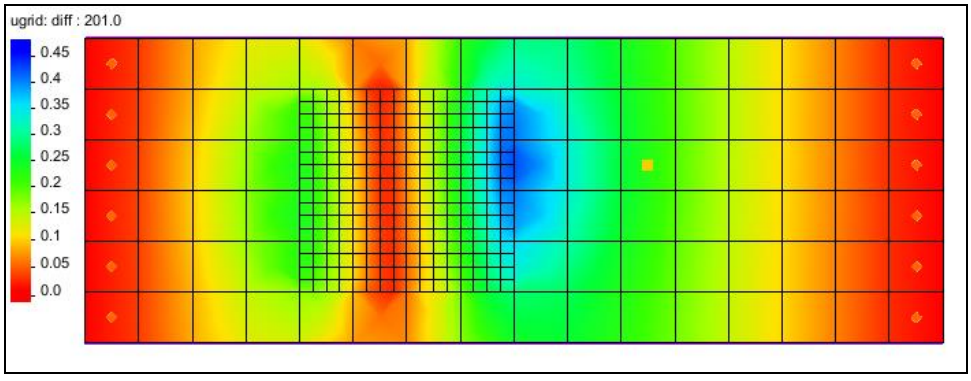

Figure 4 Last time step of the difference dataset showing the results of the TMV package.

9 Conclusion

This concludes the tutorial. Here are the key concepts from this tutorial:

- Using the TVM Package to add time varying materials to a MODFLOW-USG Transport simulation.
- Creating a time variant dataset the **Map** module.
- Activating the TVM package for a MODFLOW simulation.