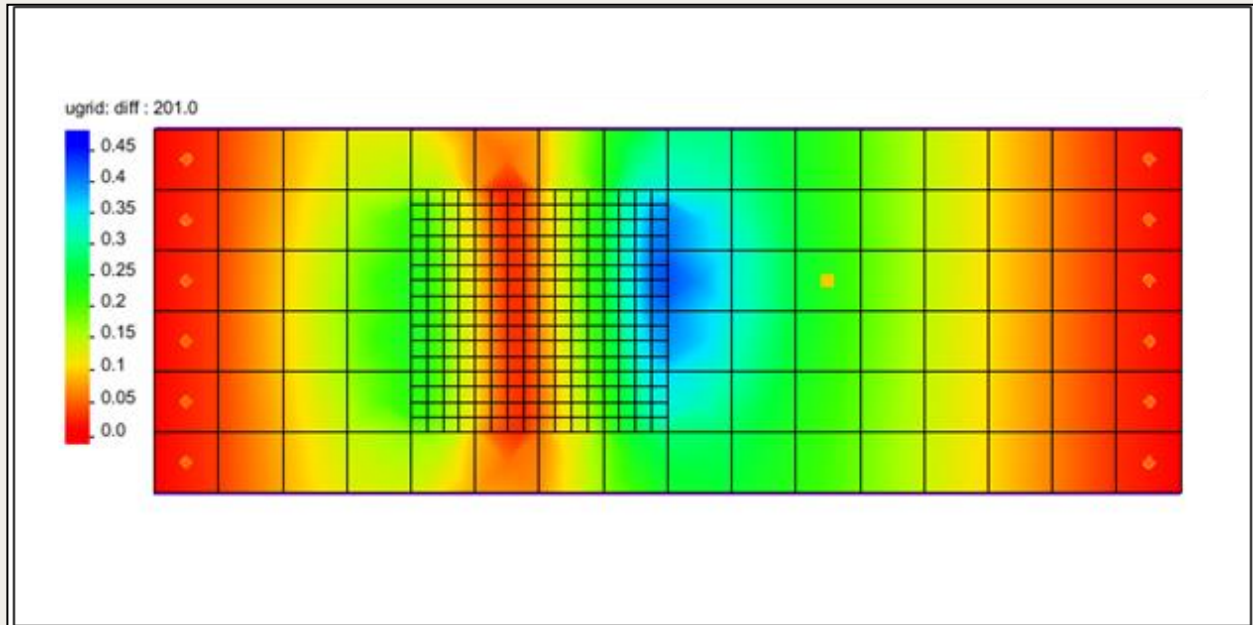*GMS 10.8 Tutorial*

MODFLOW-USG Transport – 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

- GMS Core
- MODFLOW-USG Transport

Time

- 20–30 minutes

AQUAVEO™

1   Introduction

The Time-Variant Materials package (TVM) works with MODFLOW-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. Creating 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 data files for this tutorial and select "start.gpr".

5. Click **Open** to import the file and close the *Open* dialog.

6. In the Project Explorer, select the "🔢 Head" dataset.
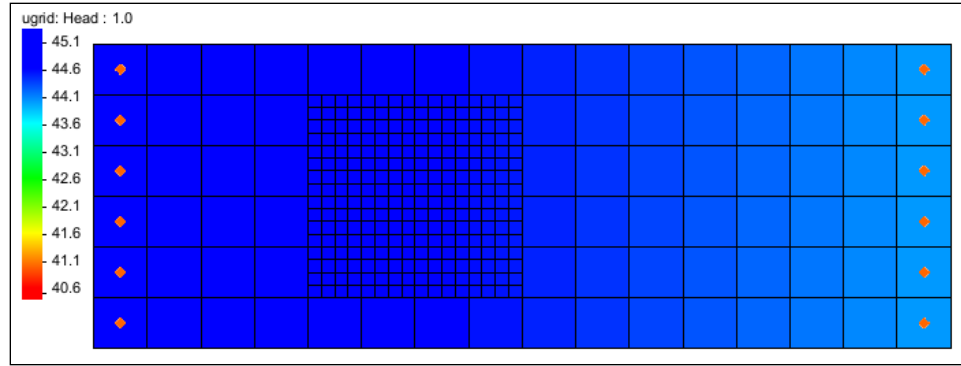
Figure 1   Imported MODFLOW-USG Transport model

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.

7.   Select *File |* **Save As…** to bring up the *Save As* dialog.

8.   Browse to the directory for this tutorial.

9.   Enter "model-tvm.gpr" as the *File name*.

10. Select "Project Files (*.gpr)" from the *Save as type* drop-down.

11. 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 *Area 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 Arc** ⌒ tool, create four arcs around the refined area of the UGrid as in Figure 2 below.
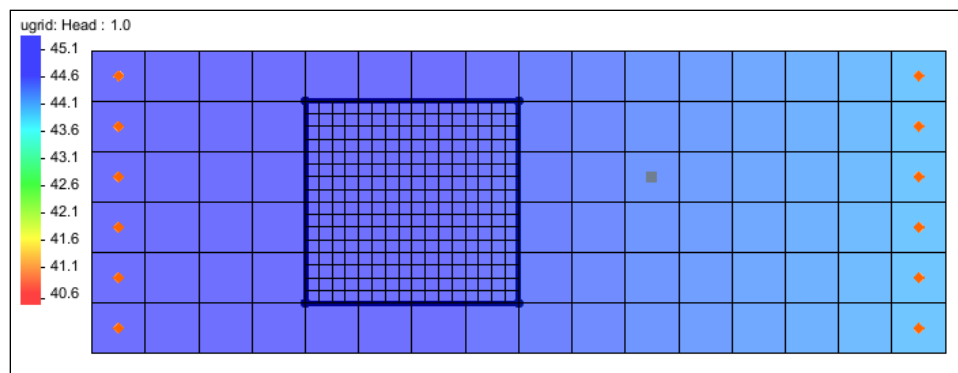
Figure 2   Arcs drawn around refined area of the UGrid

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

12. Using the **Select Polygons** 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 in the *TVM_HK* column to open the *XY Series Editor*.

15. Enter the values in Table 1 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

Table 1   Time series

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. Check *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. Switch to the **UGrid** ⬦ module.

2. Select *MODFLOW | **Global Options…*** to bring up the *MODFLOW Global/Basic Package* dialog.

3. Click **Packages…** to bring up the *MODFLOW Packages / Processes* dialog.

4. In the *Optional packages / processes* section, turn on *TVM – Time Varying Materials*.

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.
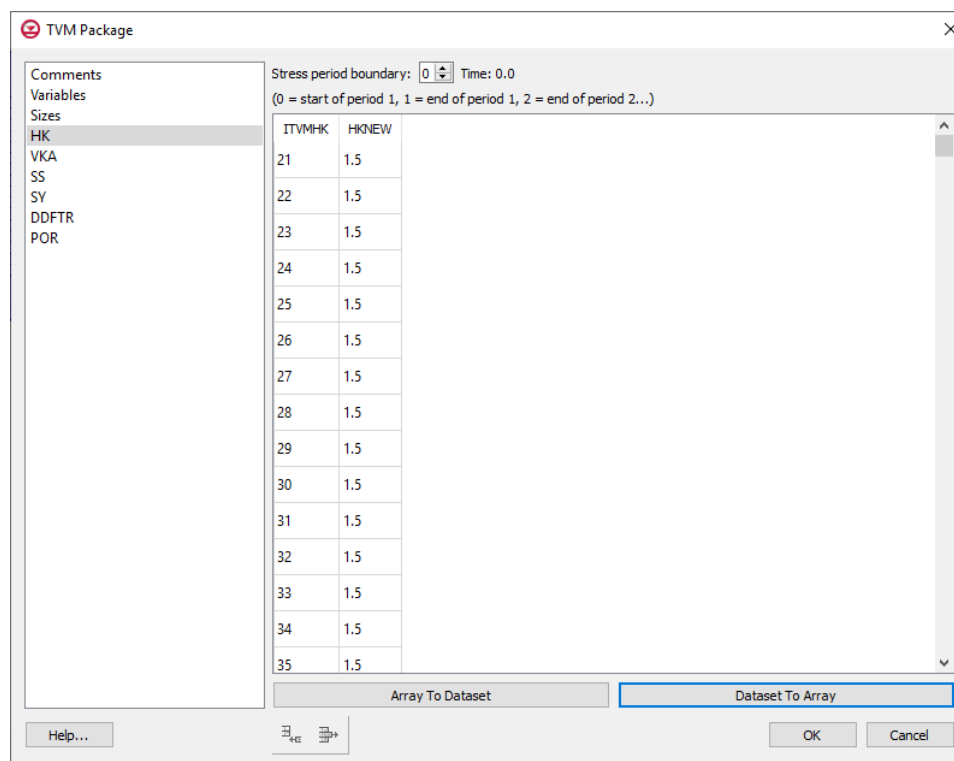
7. Click **OK** to close the *TVM Package* dialog.

Figure 3   TVM Package 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 on 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*.

2.   In the *Datasets* section, select the "🗐 Head" dataset under the "🗁 start (MODFLOW)" folder.

3. 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. For *Result*, enter "diff".

9. Click **Compute**.

10. Click **Done**.

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.
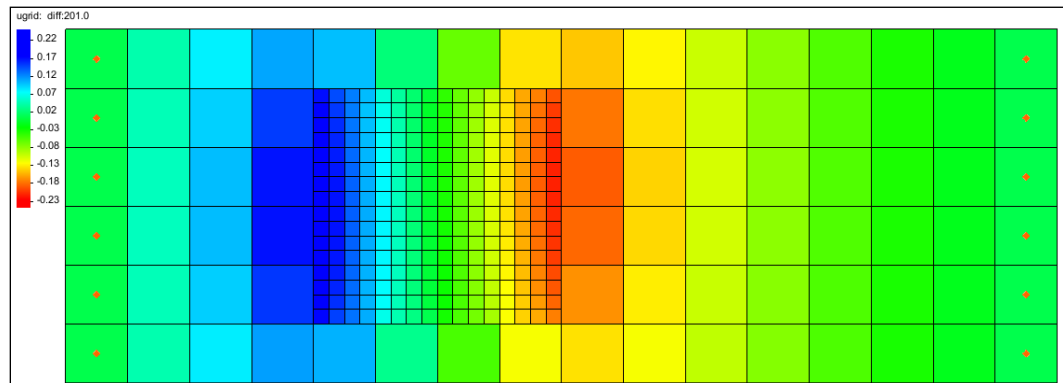

Figure 4   Last time step of the difference dataset showing the results of the TMV package.

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 using the Map module.

- Activating the TVM package for a MODFLOW simulation.