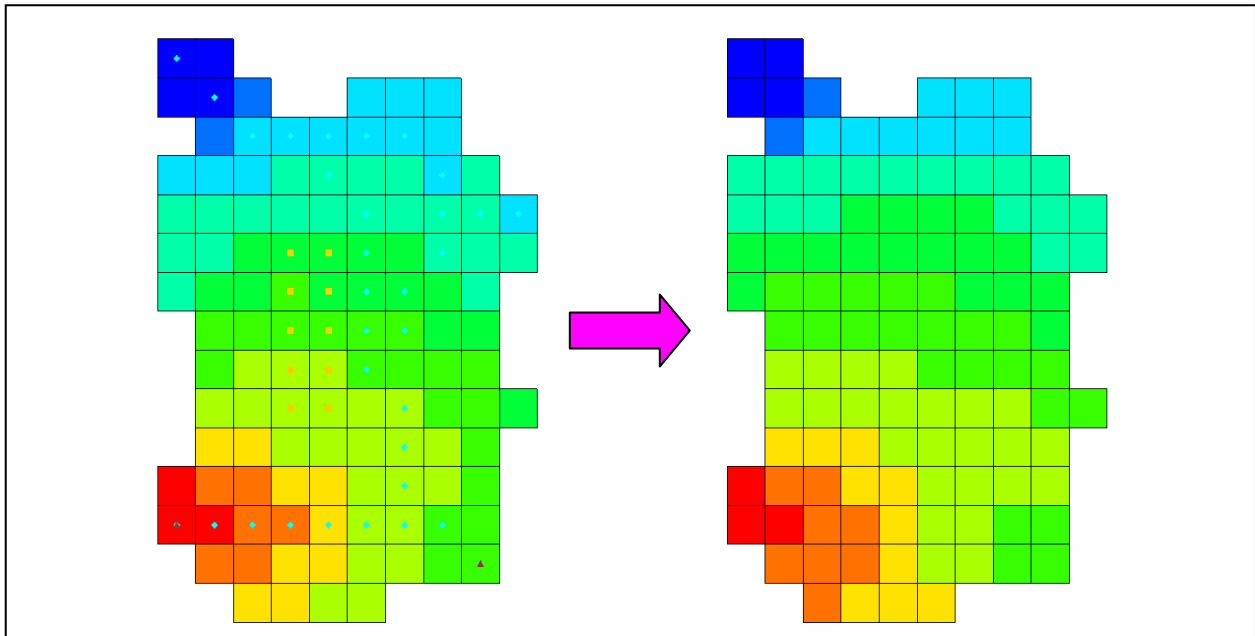


GMS 10.1 Tutorial

MODFLOW-USG - Converting from MODFLOW-2005

How to convert a non-MODFLOW-USG model into a MODFLOW-USG model.



Objectives

Learn how easy it is to create a MODFLOW-USG model from an existing, non-MODFLOW-USG model in GMS.

Prerequisite Tutorials

- MODFLOW – Grid Approach

Required Components

- MODFLOW 2005
- MODFLOW-USG

Time

- 15–30 minutes



1	Introduction	2
1.1	Getting Started	2
2	Importing a MODFLOW-2005 Model	3
2.1	Saving and Running MODFLOW-2005.....	4
3	Changing to MODFLOW-USG	5
3.1	Saving and Running MODFLOW-USG.....	5
3.2	Comparing Results	5
4	Importing a MODFLOW-2005 Model and Converting to a UGrid	7
4.1	Saving and Running MODFLOW-2005.....	8
5	Converting from a 3D Grid to a UGrid	8
5.1	Comparing Grids	9
5.2	Saving and Running MODFLOW-USG.....	9
5.3	Comparing Results	10
6	Conclusion	11

1 Introduction

MODFLOW-USG supports most of the packages from MODFLOW-2005. It can import and use structured grid model files from MODFLOW-2000 and MODFLOW-2005. For simple models, it is easy to convert them for use in MODFLOW-USG. The GMS interface makes this process simple.

Converting the model from using a structured grid to an unstructured grid requires a bit more work, including the creation of a DISU file. In GMS, the model must first be converted to a new type of unstructured grid object (i.e., a UGrid). This conversion is handled automatically by GMS, which creates the DISU file automatically so no manual file editing is needed.

This tutorial discusses and demonstrates importing a model built for MODFLOW-2005, saving it, running it, and reviewing the results. The model is then switched to use MODFLOW-USG using a structured grid, the model is saved, MODFLOW is run, and the results are reviewed. The tutorial then compares the MODFLOW-2005 and MODFLOW-USG results.

The tutorial then imports a more complex MODFLOW-2005 model, saves it, runs it, and reviews the results. The model is converted to use MODFLOW-USG using an unstructured grid, then saved, run, and the results are reviewed. Finally the MODFLOW-2005 and MODFLOW-USG results are compared.


1.1 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.

2 Importing a MODFLOW-2005 Model

Start by opening a MODFLOW-2005 model. This model is one of the USGS sample models shipped with MODFLOW-2005.

1. Click **Open**  to bring up the *Open* dialog.
2. Select “MODFLOW Name Files (*.mfn;*.nam)” from the *Files of type* drop-down.
3. Browse to the *Tutorials\MODFLOW-USG\usg-from-mf2005\test1ss* directory and select “test1ss.nam”.
4. Click **Open** to exit the *Open* dialog and bring up the *MODFLOW Translator* dialog.
5. Select *MODFLOW 2005* and click **OK** to begin the translation process.
6. When it finishes translating the file into a standard GMS format, click **Done** to close the *MODFLOW Translator* dialog.

A simple, steady-state model should appear (Figure 1). It uses the Streamflow Routing, General-Head Boundary, Recharge, and Evapotranspiration packages.

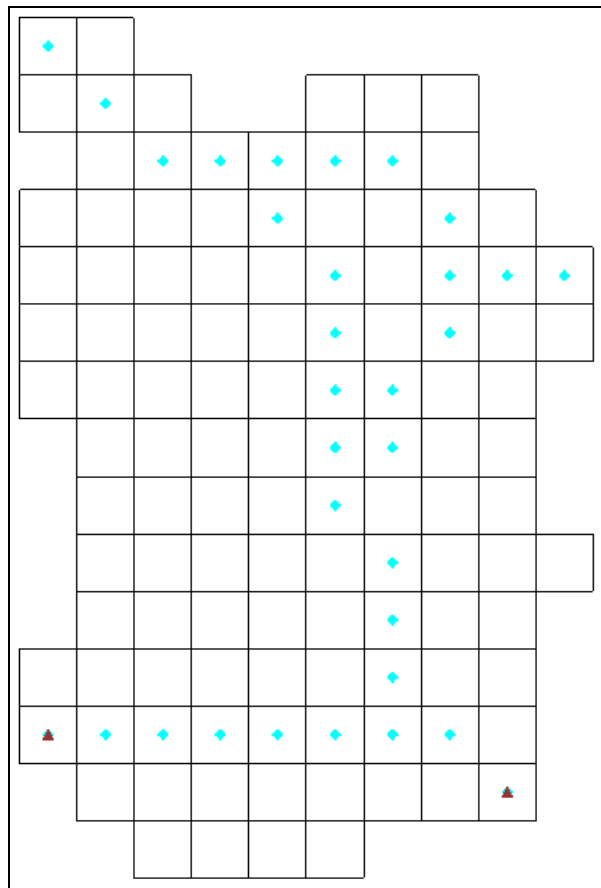





Figure 1 The imported model

2.1 Saving and Running MODFLOW-2005

Now save the project and run MODFLOW 2005.

1. Click **Save**  to open the *Save As* dialog.
2. Select “Project Files (*.gpr)” from the *Save as type* drop-down.
3. Click **Up One Level**  to go to the *Tutorials\MODFLOW-USG\usg-from-mf2005* folder.
4. Enter “test1ss.gpr” as the *File name*.
5. Click **Save** to save the project under the new name and close the *Save As* dialog.
6. Click **Run MODFLOW**  to bring up the *MODFLOW* model wrapper dialog.
7. When it finishes, turn on *Read solution on exit* and *Turn on contours (if not on already)*.
8. Click **Close** to import the solution and close the *MODFLOW* Model Wrapper dialog.

Block fill contours should be visible on the model, similar to Figure 2.

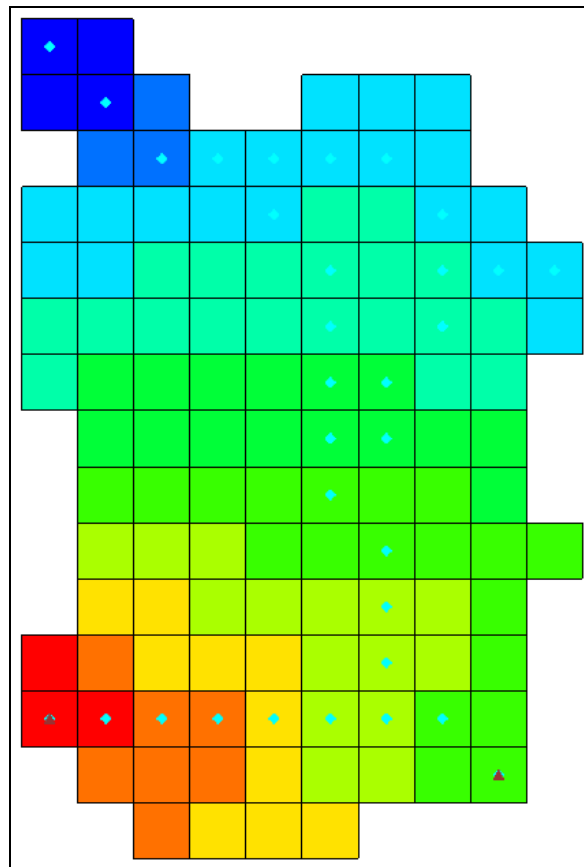


Figure 2 Block fill contours after obtaining a solution

3 Changing to MODFLOW-USG

Now change the model to use MODFLOW-USG. Other than changing the solver, no other changes should be made to the model. The model will still use the same structured grid.


1. Select *MODFLOW / Global Options...* to open the *MODFLOW Global/Basic Package* dialog.
2. In the *MODFLOW version* section, select *USG*.
3. Click **OK** to close the *MODFLOW Global/Basic Package* dialog.

A warning will appear stating that MODFLOW-USG only supports the SMS solver. This is because MODFLOW-USG uses the SMS Sparse Matrix solver developed by the USGS.¹


4. Click **OK** to close the warning dialog.

3.1 Saving and Running MODFLOW-USG

Now run MODFLOW again, and compare the results.

1. Select *File / Save As...* to bring up the *Save As* dialog.
2. Select “Project Files (*.gpr)” from the *Files of type* drop-down.
3. Enter “test1ss-usg.gpr” as the *File name*.
4. Click **Save** to save the file under the new name and close the *Save As* dialog.
5. Click **Run MODFLOW**  to bring up the *MODFLOW* model wrapper dialog.
6. When it finishes, turn on *Read solution on exit* and *Turn on contours (if not on already)*.
7. Click **Close** to import the solution and close the *MODFLOW* model wrapper dialog.



Notice that the block-fill contours are still visible.

8. **Save**  the project with the new solution.



3.2 Comparing Results

Now compare the results.

¹ The LMG (or SAMG) solver developed by Fraunhofer SCAI also works with MODFLOW-USG and may also be available in the GMS license. Contact Aquaveo at <http://www.aquaveo.com/> for licensing information.

1. In the Project Explorer, alternately click on the “test1ss (MODFLOW)”  solution and the “test1ss-usg (MODFLOW)”  solution.

Notice that the solutions appear to be identical.

2. Double-click the “ test1ss.out” file in the Project Explorer to bring up the *View Data File* dialog. Note that if the *Never ask this again* option was previously checked in this dialog, this dialog will not appear. In this case, skip to step 4.
3. Select the desired text editor from the Open with drop-down and click OK to open the file in that text editor.
4. Repeat steps 2-3 with the “ test1ss-usg.out” file in the Project Explorer.
5. In the external text editor, scroll to the bottom of each file and compare the volumetric budget results (Figure 3).

Notice that the results are very similar, though not exactly the same. This demonstrates that a MODFLOW-2005 model using a structured grid can be converted to MODFLOW-USG and produce very similar results with very little effort, so long as the original model does not use any packages that are not supported by MODFLOW-USG.



6. When finished examining the files, close both and return to GMS.

CUMULATIVE VOLUMES	L**3	CUMULATIVE VOLUMES	L**3
-----		-----	
IN:		IN:	
---		---	
STORAGE =	0.0000	STORAGE =	0.0000
CONSTANT HEAD =	0.0000	CONSTANT HEAD =	0.0000
ET =	0.0000	ET =	0.0000
HEAD DEP BOUNDS =	0.2153	HEAD DEP BOUNDS =	0.2153
RECHARGE =	1.7937	RECHARGE =	1.7937
STREAM LEAKAGE =	43.3705	STREAM LEAKAGE =	43.3599
TOTAL IN =	45.3795	TOTAL IN =	45.3689
OUT:		OUT:	
----		----	
STORAGE =	0.0000	STORAGE =	0.0000
CONSTANT HEAD =	0.0000	CONSTANT HEAD =	0.0000
ET =	35.8332	ET =	35.8535
HEAD DEP BOUNDS =	0.2483	HEAD DEP BOUNDS =	0.2483
RECHARGE =	0.0000	RECHARGE =	0.0000
STREAM LEAKAGE =	9.2975	STREAM LEAKAGE =	9.3004
TOTAL OUT =	45.3790	TOTAL OUT =	45.4022
IN - OUT =	4.8447E-04	IN - OUT =	-3.3301E-02
PERCENT DISCREPANCY =	0.00	PERCENT DISCREPANCY =	-0.07

Figure 3 Comparing the volumetric budget results

4 Importing a MODFLOW-2005 Model and Converting to a UGrid

Now open another MODFLOW-2005 model that uses the UZF package. This package is not supported by MODFLOW-USG. In this case, the structured grid will be converted into an unstructured grid.

1. Click **New**  to start a new project and reset back to default settings. If asked to save, click **No**.
2. Click **Open**  to bring up the *Open* dialog.
3. Select “MODFLOW Name Files (*.mfn;*.nam)” from the *Files of type* drop-down.
4. Browse to the *Tutorials\MODFLOW-USG\usg-from-mf2005\UZFtest2* directory and select “UZFtest2.nam”.
5. Click **Open** to close the *Open* dialog and bring up the *MODFLOW Translator* dialog.
6. Select *MODFLOW 2005* and click **OK** to begin the translation into the standard GMS format.
7. When it finishes, click **Done** to close the *MODFLOW Translator* dialog.

A model similar to the one shown in Figure 1 should now be visible, but with some additional symbols (Figure 4). This model uses the same grid layout as before. However, this model is transient and uses the UZF and Well packages instead of the Recharge and Evapotranspiration packages.

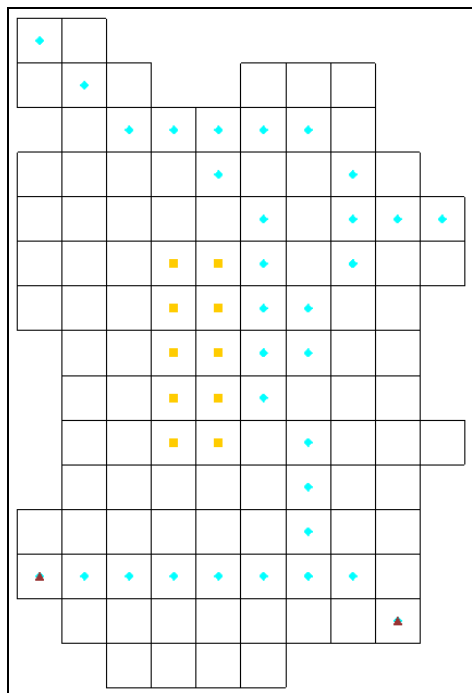





Figure 4 Model is slightly different than in Figure 1

4.1 Saving and Running MODFLOW-2005

Save the project and run MODFLOW-2005.


1. Click **Save**  to open the *Save As* dialog.
2. Select “Project Files (*.gpr)” from the *Save as type* drop-down.
3. Click **Up One Level**  to go to the *Tutorials\MODFLOW-USG\usg-from-mf2005* folder.
4. Enter “UZFtest2.gpr” as the *File name*.
5. Click **Save** to save the project under the new name and close the *Save As* dialog.
6. Click **Run MODFLOW**  to bring up the *MODFLOW* model wrapper dialog.
7. When it finishes, turn on *Read solution on exit* and *Turn on contours (if not on already)*.
8. Click **Close** to import the solution and close the *MODFLOW* model wrapper dialog.




The model should have block-fill contours similar to those shown in Figure 2 will be visible on the model.

9. **Save**  the project with the solution.

5 Converting from a 3D Grid to a UGrid

MODFLOW-USG supports unstructured grids, or grids with all different kinds of cells and discontinuous layers. GMS provides support for these types of grids using an unstructured grid—or UGrid—object. This tutorial will now demonstrate converting the model from using a structured grid to an unstructured grid. No new cell types will be introduced into the model, and no discontinuous layers will be created, but the model will use a grid that supports this.

1. Right-click on “ MODFLOW” in the Project Explorer and select **Convert to MODFLOW-USG Simulation**.
2. Click **No** when asked to include inactive cells in the new UGrid.
3. Click **OK** when advised that the SIP and UZF packages are not supported by MODFLOW-USG.


Notice that GMS created a new Project Explorer folder called “ UGrid Data”. This folder contains one “ UGrid” containing (among other things) a new “ MODFLOW” simulation.

5.1 Comparing Grids

GMS created the UGrid from only the active cells of the structured, 3D grid. Therefore, the grids have a different number of cells.

1. Right-click on the structured “ grid” in the Project Explorer and select **Properties...** to open the *Properties* dialog.

Notice the *Number of cells* is “150” (scroll down the list if needed).

2. Click **OK** to exit the *Properties* dialog.
3. Right-click on the “ ugrid” and select **Properties...** to open the *Properties* dialog.

Notice the *Number of cells* is “116”. The number is lower because the inactive cells in the structured grid were not preserved in the UGrid.





4. Click **Done** to exit the *Properties* dialog.

Now hide the old model while working with the new model.

5. Turn off “ 3D Grid Data” in the Project Explorer to hide the old model.

5.2 Saving and Running MODFLOW-USG

Save the project and run MODFLOW-USG.

1. **Save**  the project.
2. Select the “ MODFLOW” simulation under “ ugrid” in the Project Explorer to make it active.
3. Click **Run MODFLOW**  to bring up the *MODFLOW* model wrapper dialog.
4. When MODFLOW-USG finishes, turn on *Read solution on exit* and *Turn on contours (if not on already)*.
5. Click **Close** to import the solution and exit the *MODFLOW* model wrapper dialog.

Block-fill contours similar to those shown in Figure 2 should now be visible (Figure 5).

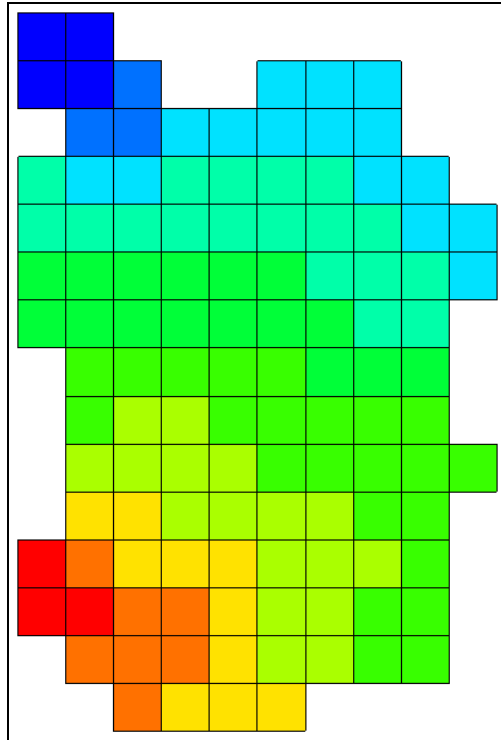




Figure 5 Block fill similar to Figure 2

5.3 Comparing Results

Now compare the results of the two models.

1. Double-click “ UZFtest2.out” under the 3D Grid MODFLOW solution to bring up the *View Data File* dialog. If the *Never ask this again* option was previously turned on, this dialog will not appear. In this case, skip to step 3.
2. Select the desired text editor from the *Open with* drop-down and click **OK** to close the *View Data File* dialog and open the file in the selected external text editor.
3. Follow steps 1-2 for the “ UZFtest2.out” file under the UGrid MODFLOW solution.
4. Scroll to the bottom of each file and compare the volumetric budget results.

Notice that the results are quite different. The new USG model doesn’t include the UZF package, so there is no Recharge or ET. The Recharge and EVT packages in the new model could be used to mimic what the UZF package is doing in the old model. However, that goes beyond the scope of this tutorial.

Version 1.3 (released in December 2015) of MODFLOW-USG does not support the HUF, MNW1, MNW2, and UZF MODFLOW-2005 packages.

6 Conclusion

This concludes the “MODFLOW-USG: Converting from MODFLOW-2005” tutorial. The following key concepts were discussed and demonstrated in this tutorial:

- A model can be converted to MODFLOW-USG and run with a structured grid by simply changing an option in the *MODFLOW Global/Basic Package* dialog.
- To convert a model to an unstructured grid, right-click on the model and select the **Convert to MODFLOW-USG Simulation** command. This creates a new UGrid and MODFLOW simulation.
- Some MODFLOW-2005 packages, such as UZF, are not supported in MODFLOW-USG.