

EFFECTIVE GROUNDWATER MODEL CALIBRATION: With Analysis Of Data, Sensitivities, Predictions, and Uncertainty

By Mary C. Hill and Claire R. Tiedeman

Computer Instructions for using GW_Chart and ModelViewer for the exercises.

This document contains instructions for using the public domain computer programs GW_Chart (Winston, 2000) and ModelViewer (Hsieh and Winston, 2002) to perform exercises in the book.

Installation and Execution

GW_Chart and ModelViewer can be installed on your computer by downloading the zip files and unzipping them in directories called gw_chart and modelviewer, respectively.

GW_Chart and ModelViewer can be run by clicking on the executable or clicking on a shortcut created on your desktop.

Create shortcuts on the desktop of a computer with the Windows operating system as follows.

In Windows' File Explorer, right click and drag each executable from Explorer to the desktop and select "Create Shortcuts Here". From then on, start the program by double-clicking on the shortcut icon.

Versions of GW_Chart and ModelViewer are provided on the web site associated with Hill and Tiedeman (2007). Users of the book are encouraged to use these versions because they have been tested for this application and are consistent with the provided instructions. More recent versions may be available at the web sites listed with the references for the documentation of these programs at the end of this document.

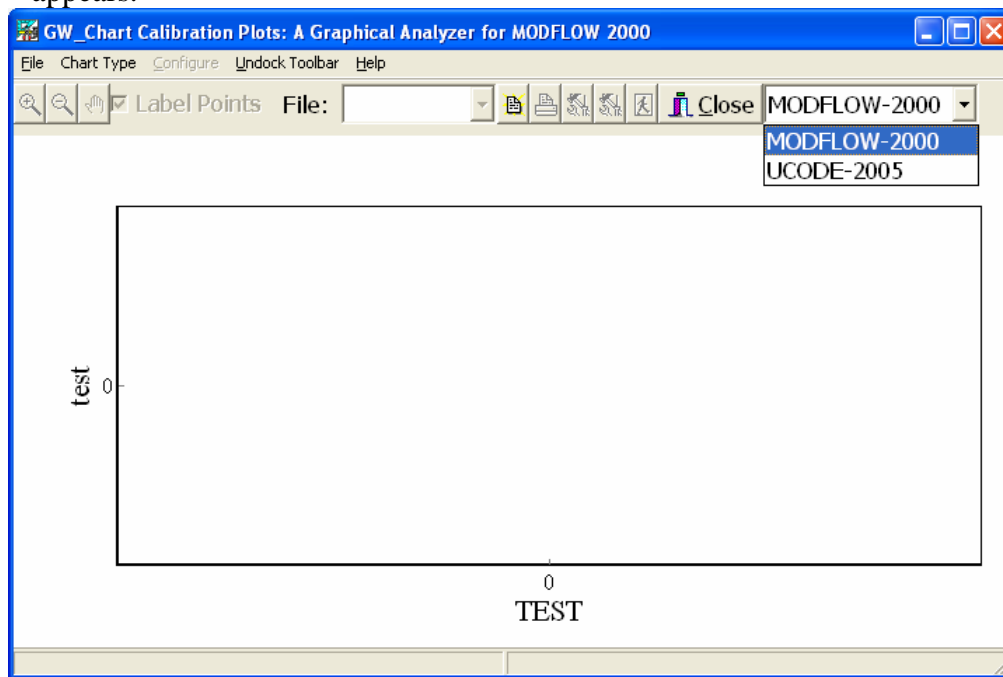
GW_Chart

GW_Chart is most often used to produce the following graphs for the exercises:

- Composite and dimensionless scaled sensitivities for the exercises in Chapters 4, 7, and 9.
- Updated parameter values for exercises in Chapters 5 and 9.
- The residual analysis for the exercises in Chapters 6 and 9, and
- Parameter values and their confidence intervals in Chapters 7 and 9.

GW_Chart requires the following steps.

1. Start the program as described in the previous section. The following window appears.



2. Identify the program that produced the files to be plotted in a drop-down menu on the top right (MODFLOW-2000 or UCODE_2005)
3. **File** dialog box: select **Open File**. Navigate to the directory containing the files of interest. Open one file. GW_Chart looks for other files in that directory with the same filename prefix and filename extensions that it recognizes. These files are listed in the dropdown menu labeled **File:** in the upper middle part of the window. The filename extensions and the associated file content are described in the documentation of MODFLOW-2000 (Hill and others, 2000, p. 28-29) and UCODE_2005 (Poeter and Hill, 2005, p. 231-233).
4. Graphs of other data sets are obtained by choosing other files from the drop-down menu labeled **Files:**

The following three issues are discussed next: (1) What to do if the expected files are not being produced, (2) The graph options provided by GW_Chart, and (3) One aspect of the graph produced for the file with extension `_ws`.

(1) If files with the appropriate extensions are not in the expected directory, check to be sure that the input to the program specified that the files be produced. In MODFLOW-2000, check the contents of the file for all observations (Hill and others, 2000, p. 27). In UCODE_2005, check the keyword DataExchange in the UCODE_Control_Data input block (Poeter and Hill, 2005, p. 58).

(2) For many of the graphs, the user is provided choices about how the graph is to be constructed. These choices are presented using a window that pops up when the file is chosen. The windows are largely self-explanatory and the same file can be reselected to provide the opportunity to make other selections.

(3) The file with extension `_ws` produces a graph of weighted residuals against weighted or unweighted simulated values (MODFLOW-2000 uses weighted simulated values; UCODE_2005 uses unweighted simulated values). When the `_ws` file is chosen, the major tick marks on the vertical axis against which weighted residuals are measured are assigned values equal to multiples of the standard error of the regression. This is advantageous because if the weighted residuals are random and normally distributed, it is expected that about 5 percent (about 5 out of 100) of the weighted residuals will be more than two standard errors away from zero, and 0.2 to 0.3 percent (2 to 3 out of 1,000) will be more than three standard errors away from zero. Thus, using the standard error to mark the weighted residual axis makes it very easy to evaluate not only how randomly the weighted residuals fall around zero, but also whether there are more outliers than would be expected. For more information, see Hill and Tiedeman (2007, p. 100-104).

ModelViewer

ModelViewer supports three-dimensional visualization of input or output for a suite of models, including MODFLOW-2000, MODFLOW-2000 with Ground-Water Transport Process, MODFLOW-96, MOC3D, MODPATH, MT3DMS, SUTRA, and PHAST

ModelViewer can be used to visualize hydraulic heads and hydraulic conductivities from the MODFLOW runs used in the exercises regardless of the program used to conduct the sensitivity analysis and parameter estimation. It can be used to visualize a sum-of-squared objective function using a data-exchange file with file extension `_sos` produced by UCODE_2005 in exercise 5.1.

To use ModelViewer to visualize heads and hydraulic conductivity, the following steps are needed.

- Execute **ModelViewer**.
- Start with visualizing hydraulic heads.
- Under the **File** menu item, select **New**.
- **Model Selection** dialog box: select **Modflow 2000**.
- **Modflow 2000 Data Files** dialog box: browse to the desired directory. Click on the exercise name file (for example, `ex3.2.nam`).
- **Data Selection** dialog box: keep defaults. The model domain appears.
- **Show** menu item: select **Solid**, then **Model Features**.
- **Model Features** dialog box: select both model features.
- **Toolbox** menu item: select **Geometry** and set `z` to 10 to specify 10x vertical exaggeration. See a floodmap of hydraulic heads.
- **Show** menu item: select **Colorbar**
- Rotate by clicking and dragging any corner. To return to original, under the **Action** menu item click **View From Direction** and choose `+z`.
- Now, visualize hydraulic conductivity (K).
- **Toolbox** menu item: select **Data** and choose **K along rows**.
- **Toolbox** menu item: select **Solid**, select **Blocky**.
- **Toolbox** menu item: select **Crop**. Reduce the **Max** for **Z** until you can see first the hydraulic conductivity of the confining unit, and then of the lower model layer.

To use ModelViewer to visualize the objective function for exercise 5.1 using UCODE_2005, the following steps are needed. Exercise 5.1 can not be done with MODFLOW-2000.

- Execute **ModelViewer**.
- Under the **File** menu item, select **New**.
- **Model Selection** dialog box: select **UCODE 2005 - SOS**.
- **UCODE Data File** dialog box: browse to the ex5.1 directory. Click on the _sos file.
- **Data Selection** dialog box: keep defaults. See the parameter domain.
- **Show** menu item: select **Solid**.
- **Toolbox** menu item: select **Data**. Select **log(data)** in the dialog box..
- **Show** menu item: select **Colorbar**
- **Toolbox** menu item: select Colorbar. Change value at red limit to 4, then 2.3. At this resolution there are discretization effects, but the long-narrow minimum is evident.
- **Show** menu item: select **isosurfaces**.
- **Data** menu item: select **isosurfaces**. In the **isosurface window**, increase the number of surfaces by 10 repeatedly until there are 40. Work with the isosurface and colorbar menus to investigate the minima.

References

- Hill, M.C., Banta, E.R., Harbaugh, A.W., and Anderman, E.R., 2000, MODFLOW-2000, the U.S. Geological Survey modular ground-water model, User's guide to the Observation, Sensitivity, and Parameter-Estimation Process and three post-processing programs: U.S. Geological Survey Open-File Report 00-184, 209 p.
<http://water.usgs.gov/nrp/gwsoftware/modflow2000/modflow2000.html>
- Hsieh, PA, Winston, RB. (2002) User's guide to model viewer, a program for three-dimensional visualization of ground-water model results: US Geological Survey Open-File Report 02-106, 18p.
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- Poeter, E.P., Hill, M.C., Banta, E.R., Mehl, Steffen and Christensen, Steen, 2005, UCODE_2005 and six other computer codes for universal sensitivity analysis, calibration, and uncertainty evaluation: U.S. Geological Survey Techniques and Methods 6-A11, 283p.
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http://water.usgs.gov/nrp/gwsoftware/GW_Chart/GW_Chart.html