ground water

Software Spotlight/

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Ground Water Vistas: A Graphical User Interface for the MODFLOW Family of Ground Water Flow and Transport Models

reviewed by Christian D. Langevin[1] and David M. Bean[2]

Introduction

For many ground water modeling applications, the time and effort spent on preprocessing of input data and postprocessing of output results may far exceed that spent on other project activities. Since the early 1990s, several graphical user interfaces that greatly facilitate the pre- and postprocessing tasks have become available and have been continually improved. Ground Water Vistas (GWV) is one such graphical user interface that supports several commonly used ground water flow and solute transport modeling programs, as well as related programs for sensitivity analysis, parameter estimation, and management optimization. GWV is developed by Environmental Simulations International and is available on the Web site *http://www.groundwatermodels.com*.

How We Tested

One reviewer tested version 4.16 of the GWV software on a laptop computer with a 1.7-GHz Intel Pentium-M processor and 1-GB random-access memory (RAM). The other reviewer upgraded an earlier installation to version 4.16 on a desktop computer with a 3.0-GHz Pentium-4 processor and a 1-GB RAM. Both computers use the Microsoft Windows XP Professional operating system. The main installation program (74.5 MB) was downloaded from the software vendor's Web site, along with an update program (13.4 MB). Once the installation was completed, GWV operated in student mode, which is restricted to 50 rows, 50 columns, and 4 layers. There are two licensing options for accessing the full version of the software. Users can install a physical hardware key called a "dongle" on the parallel or USB port, or request a software key, which cannot be moved to another computer without a special request to the developer. Full installation required ~10 min and used ~170 MB of hard disk space.

The reviewers tested GWV by running through the tutorial provided with the software and by importing existing model data sets. First, the data sets from an existing MODFLOW and MT3DMS model were imported, and no problems were encountered. Next, several of the data sets distributed with MODFLOW-2000 were imported, and again, no problems were encountered. Finally several of the utilities for importing boundary conditions (BCs) and property values from ASCII data files were tested successfully.

What We Found

When started, GWV presents the user with the typical array of Windows pull down menus across the top of the screen (Figure 1). The user starts a new model by clicking on the "File/New" button. This opens a dialog box to specify the number and spacing for rows, columns, and layers, as well as default (uniform) aquifer properties. The same dialog box is open when importing existing MODFLOW data sets. A base map can be imported to aid in the design of the model grid. GWV quickly builds the model grid and populates the aquifer property arrays with the default values. The model grid can be modified using the various options available under the "Grid" pull down menu. Rows, columns, and layers can be added or deleted relatively easily with the click of the mouse.

GWV provides the user with several options to enter aquifer properties under the "Props" menu. Aquifer properties can be specified in terms of "property zones" by cell, window, or digitized polygon for each layer of the model. In addition, aquifer properties can be imported from external files using a variety of formats including XYZ files, ArcView Shapefiles, and Surfer grids, among others. Several options are also available to enter and modify model BCs under the "BCs" menu. BCs such as Constant-Head, General-Head, and No-Flow can be specified by cell, window, digitized polyline, or digitized polygon for each layer of the model. When digitizing a

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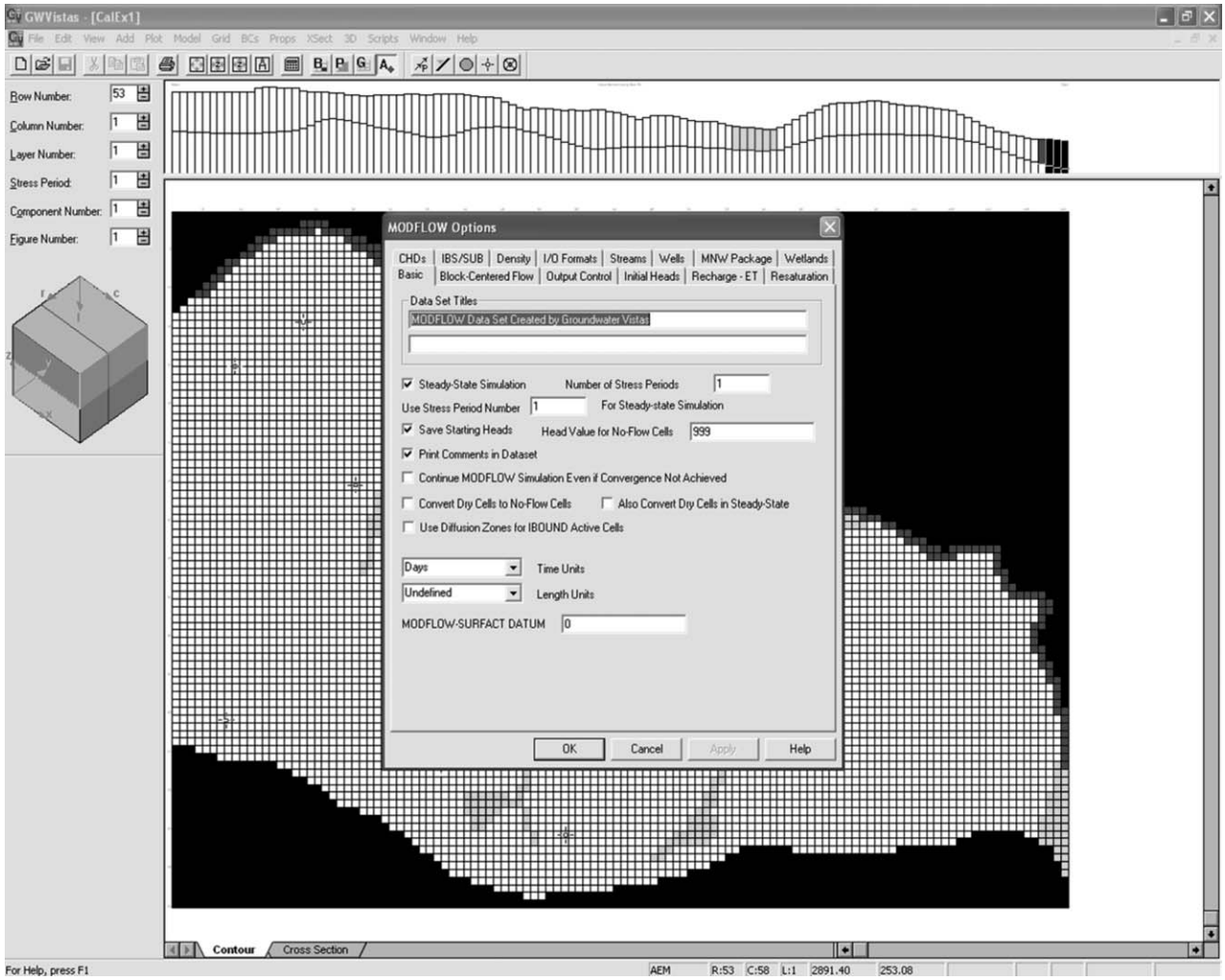

Figure 1. A screen capture of a program window for the GWV software.

polyline, GWV will prompt the user for the endmember properties and then linearly interpolate the BC properties between them.

GWV contains a number of visualization tools to evaluate model results (Figure 2). Simulated heads, concentrations, and particle paths can be easily imported and displayed in plan view and cross-sectional view. Heads and concentrations can be displayed with user-defined contour lines or color flood of cells. Particle paths can be displayed as different color lines in different model layers, along with travel times. Model results and visualizations may be exported in a variety of formats including Surfer, DXF, Shapefiles, EVS, and WMF formats, among others. GWV also supports export of model results to the three-dimensional visualization software TecPlot.

Model calibration with GWV can be done either using the traditional trial and error approach or using model-independent calibration software such as PEST and UCODE. Alternatively, a model can be calibrated using MODFLOW-2000. GWV also comes with its own automatic calibration utilities for MODFLOW. During the calibration process, GWV outputs a number of calibration statistics, as well as plots of observed vs. simulated values. The target observed and residual statistics may also be exported as a text file for further processing in Excel or other programs.

GWV also provides a number of utilities to simplify evaluation of model sensitivity. A model parameter is selected from a pull down list, and the number and range of parameter multipliers are specified. GWV will then run the model the specified number of times, changing the selected parameter by the multiplier each time. Using a script file, a sensitivity analysis can be run sequentially on any number of model parameters. The results of the sensitivity analysis can be exported as a table or displayed as a plot.

The degree to which a new GWV user would find the program intuitive or not will likely depend on his or her level of modeling experience. Most experienced ground water modelers will probably find that the GWV software is intuitive, fast, easy to use, and stable. Those designing large-scale, complex regional models, or models that require the use of a package not supported by GWV (e.g., the Hydrogeologic Unit Flow [HUF] Package), will probably design certain model packages with a geographic information system, spreadsheets, and custom scripts. In that case, GWV would still be useful for constructing many of the packages and for visualizing model results.

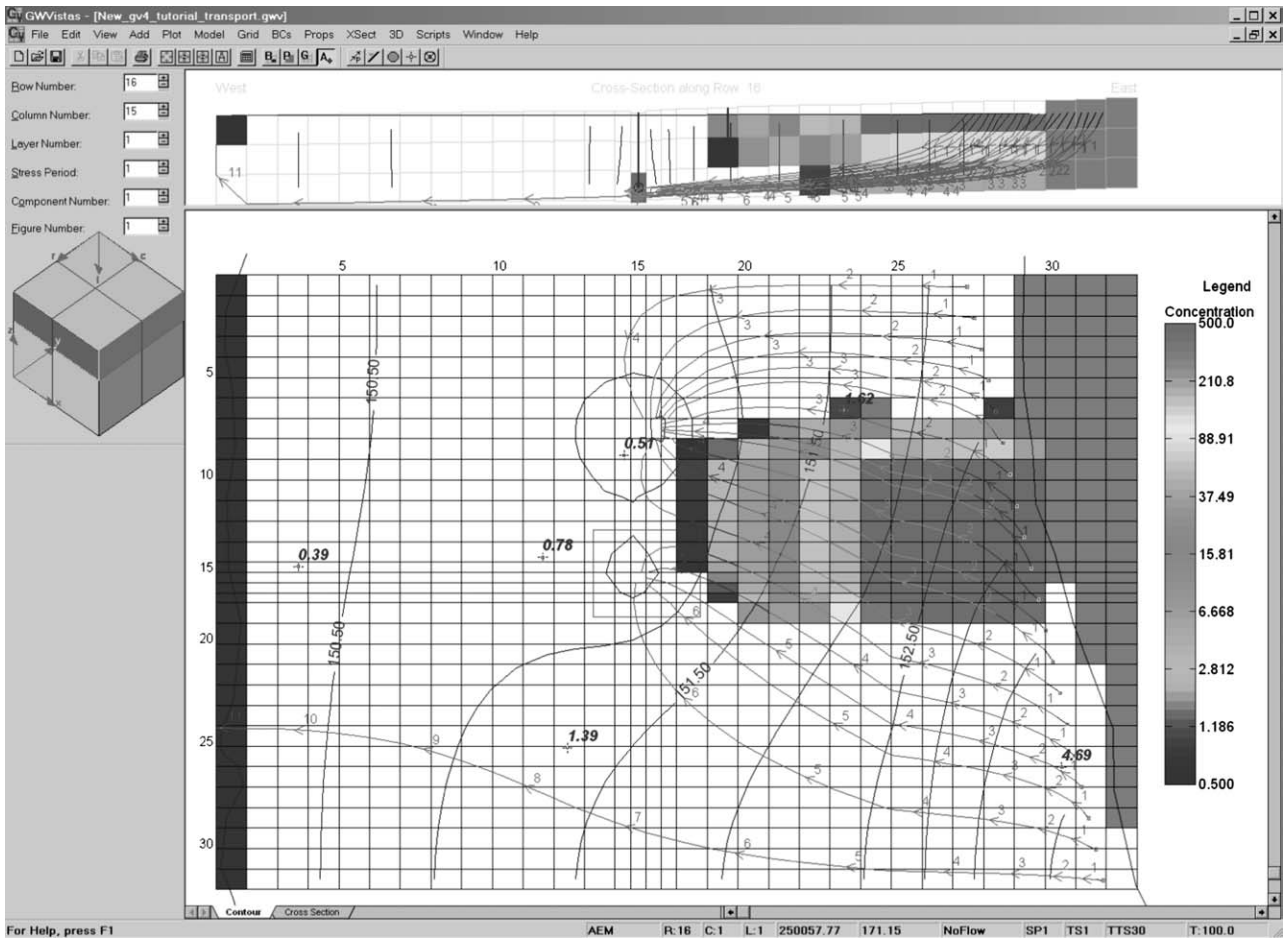

Figure 2. An output screen capture of the GWV software.

The documentation for GWV comes in printed form and is also distributed electronically. The documentation is thorough and well written and contains a detailed tutorial, which is highly recommended for those not familiar with the software. The on-line help is significantly improved over previous versions, but some of the menu options are not included, and the list of topics under the index tab remains incomplete.

Support for GWV remains among the best. If the user has a problem that cannot be resolved by examining the documentation, an e-mail to *support@groundwatermodels.com* is often all it takes. Calls to the vendor are returned immediately, and requests for bug fixes or added functionality are always handled in a timely manner.

What We Liked

For the experienced numerical modeler, the GWV software is logically organized and easy to use. If electronic data are available for a site, a preliminary flow and transport model can be developed in a matter of hours. Compared to similar software, the operations in GWV are very fast and stable.

One of the most impressive features of the software is the ability to import and export data using a wide range of file types. Aquifer properties and steady-state or transient BCs can be imported from an ASCII text file, an existing MODFLOW file, a Surfer file, or from a Shapefile. The import utilities were found to be extremely flexible and included options for skipping lines at the beginning of the file, changing the column order for tabular data, and working in site coordinates instead of layer, row, and column indices. Another option found to be highly useful was the ability to copy tabular data from a spreadsheet and paste directly into GWV. The export utility under the File menu supports more than 20 different file types, and additional export utilities are also located under other menus. Another feature of GWV that facilitates the rapid design of ground water models is the tab structure of the model menus that allows the user to quickly browse and modify options for the supported model codes.

In previous versions of GWV, the assignment of aquifer properties was based solely on the concept of zones, which meant that a zone number was assigned to each model cell, and aquifer values were set in a corresponding zone database. This caused problems in some circumstances, particularly for spatially varying elevations or other kriged parameters, where the number of required zones was often similar to the number of cells. A significant improvement in version 4 is the addition of a spreadsheet utility for editing selected aquifer properties—an efficient alternative to the zone approach.

GWV also contains other advanced features that are highly useful. The mass balance analysis tools are particularly useful for showing the simulated water budget. The end point analysis for MODPATH provides a unique tool for mapping capture zones, contributing areas, and contamination zones. The software also contains support for the various versions of MODFLOW and MT3D, including codes such as RT3D and SEAWAT. In addition to public domain models, GWV also supports several proprietary models including MODFLOW-SURFACT, MODFLOWT, and SWIFT.

What We Did Not Like

A potential weakness of the GWV software is the likelihood that an inexperienced modeler will perform simulations that may not reflect the intended conceptual model. When performing simulations with MODFLOW-2000, many of the options are set under a separate MODFLOW menu, and, for example, in the case of the steady-state option, it is not intuitive as to which setting takes precedence. The MT3D/RT3D menus can also be confusing due to the support of five different versions of MT3D. A partial fix might be implemented by "graying out" model options that are not available for the selected MODFLOW or MT3D version.

A limitation encountered by one reviewer was the inability to intersect a three-dimensional hydrogeologic framework with a finite-difference model grid. The software does have the capability to inactivate model cells located below a specified aquifer bottom surface, but true intersection capabilities, either through the support of the HUF Package or through a GWV function, were not found.

Another main shortcoming in GWV is the quality of the output graphics. GWV-generated plots and hydrographs are created with the utility First Impression and are typically not suitable for publication. Likewise, the built-in options for labeling, annotating, and printing map views or cross-sectional view of results are relatively crude and also typically not suitable for publication. As a result, it is often necessary to export tabular model results into Excel to generate report-ready plots and hydrographs and export maps as Windows metafiles for import and annotation in PowerPoint or other graphical editing programs. Significant improvement in the output graphics should be considered in a future release.

Other minor limitations included the lack of support for the Flow and Head Boundary Package, a lack of an undo option, a directory path setting that does not update when a GWV file is copied to another computer or subdirectory, and the absence of utilities for rapidly copying BCs to all layers of a multilayer model. These features would be welcome additions in future updates.

Both reviewers noted that for users with limited ground water modeling experience, the GWV software might seem intimidating because of the large number of options, the possibility of overlooking an important option, and the freedom to design a numerical model in a nonstructured haphazard manner. Moreover, the updates to GWV are relatively frequent, while the documentation of the changes at the vendor's Web site is typically not up to date, leaving the user to discover changes on their own.

Overall

GWV is an excellent tool for ground water flow and solute transport modeling using the MODFLOW suite of models. The intuitive user interface and robust nature of the import and export utilities allow the user to focus on the important parts of model development (calibration, sensitivity analysis, parameter estimation, etc.) without spending a significant amount of time manipulating data into various formats. The software developer offers superb technical support and is willing to incorporate additional features as requested by the users. GWV should be very attractive to anyone involved in ground water flow modeling.

Rankings

The reviewers ranked the software's capability, reliability, ease of use, and technical support on a scale of 1 (worst) to 5 (best). The following rankings are the average of three sets of scores from both reviewers and the editor:

Capability—4.5
Reliability—4.7
Ease of use—4.5
Technical support—5.0

How to Obtain the Software

For more information on how to purchase GWV, visit the Web site of Environmental Simulations International Inc. at *http://www.groundwatermodels.com*. The company's U.S. office is located at 300 Mountain Top Road, Reinholds, PA 17569; (610) 670-3400; fax (610) 670 9239. The list prices for GWV version 4 are $995 and $1,595 for the standard and advanced versions, respectively. The advanced version includes everything in the standard version plus stochastic versions of MODFLOW, MT3DMS, and MODPATH in addition to support for SWIFT and for distributed computing on multiple PCs. A student version restricted to a model size of 50 rows, 50 columns, and 4 layers is available at no cost.

Our Mission

The goal of "Software Spotlight" is to help readers identify well-written, intuitive, and useful software. Independent reviewers from government, industry, and academia try out full working versions of software packages and provide readers with a concise summary of their experiences and opinions regarding the capability, stability, and ease of use of these packages.

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