

# Status of MODFLOW Versions and MODFLOW-Related Programs Available on USGS Web Pages

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MODFLOW is the U.S. Geological Survey's three-dimensional finite-difference groundwater model first published in 1984. Although originally conceived solely as a groundwater-flow simulation code, MODFLOW's modular structure has provided a robust framework for integration of additional simulation capabilities that build on and enhance its original scope. The family of MODFLOW-related programs now includes capabilities to simulate coupled groundwater/surface-water systems, solute transport, variable-density and unsaturated-zone flow, aquifer-system compaction and land subsidence, parameter estimation, and groundwater management.

This document provides a brief background on the history of MODFLOW releases and a summary of the versions of MODFLOW and related programs currently available on the USGS "MODFLOW and Related Programs" (<http://water.usgs.gov/nrp/gwsoftware/modflow.html>) and "Water Resources Groundwater Software" (<http://water.usgs.gov/software/lists/groundwater/>) Internet sites. Bold text is used to identify specific programs (for example, **MODFLOW-2005**). More detailed descriptions and simulation capabilities of each of the programs are provided in the documentation reports found on each program's respective web page.

**IMPORTANT:** MODFLOW and related programs are routinely modified and updated. In some instances, input instructions may change and new features may be added that are not described in the original documentation. Users should check the doc folder included with the software distribution (as well as the text files in the main directory of each distribution) for the most up-to-date information on program input instructions and features. This information will be contained in readme files and other accompanying documents.

## History of MODFLOW Releases

There have been four major releases of MODFLOW since its initial release in 1984: **MODFLOW-88**, **MODFLOW-96**, **MODFLOW-2000**, and **MODFLOW-2005**. The first two versions of the code, **MODFLOW-88** and **MODFLOW-96**, were based on the initial conceptualization of the program as a groundwater-flow model only. Specific aspects of a groundwater-flow system are simulated by these codes by use of independent, modular-programming components called "Packages," such as the Well Package and River Package. MODFLOW's modular design was further expanded with the release of **MODFLOW-2000** by the addition of "Processes," which are defined as parts of the code that solve a major equation or set of related equations and that consist of sets of the underlying packages. The part of the code that solves the groundwater-flow equation became the Groundwater

Flow (GWF) Process. Although additional processes have been developed for MODFLOW, the GWF Process remains the core process on which other MODFLOW simulation capabilities are built.

The most recent version of MODFLOW is **MODFLOW-2005**. The primary change in **MODFLOW-2005** from **MODFLOW-2000** is the approach used by **MODFLOW-2005** for managing internal data. This new approach provides a means to define multiple grids in a single MODFLOW simulation, which is the basis for the local grid refinement capability available with **MODFLOW-LGR**. **MODFLOW-LGR** allows the user to simulate flow in one or more higher-resolution local grids (referred to as a child models) within a larger, coarser-grid parent model.

## Current Availability of MODFLOW

A single version of MODFLOW that would include all of the available processes that have been developed for the code would become quite large and complex. Therefore, the USGS provides multiple versions of MODFLOW on its web pages that consist of various combinations of processes, rather than a single version containing all processes. The availability of multiple versions of MODFLOW also reflects the distributed nature of MODFLOW's development within the USGS, wherein code developers frequently write, test, and distribute different versions of the code independently of one another. Thus, MODFLOW is not a single program, but all MODFLOW programs include the GWF Process.

The USGS continues to add new capabilities and to correct bugs for **MODFLOW-2005** and **MODFLOW-LGR**. **MODFLOW-2000**, **MODFLOW-88** and **MODFLOW-96** are considered to be legacy software superseded by **MODFLOW-2005** and have been moved to the Legacy and Superseded Software section of the "MODFLOW and Related Programs" web page.

**MODFLOW-2005** currently consists of the GWF Process and the Observation Process, the latter of which is used to generate model-calculated values such as heads and streamflows for comparison with measured quantities. A complete summary of the current functionality of **MODFLOW-2005** is provided in the 'Summary of MODFLOW-2005' file on the **MODFLOW-2005** website.

Several MODFLOW releases are available that incorporate processes extending beyond the core GWF Process. A brief synopsis of each of the programs available for the **MODFLOW-2000** and (or) **MODFLOW-2005** versions of the code follows:

- Conduit Flow Process (**CFP**) for MODFLOW-2005: Simulates laminar and turbulent flow conditions within preferential-flow layers and within single- and dual-porosity aquifers such as occur in karst, fractured rock, and basalt aquifers.
- **GSFLOW**: A coupled Groundwater and Surface-Water flow model based on the integration of MODFLOW-2005 with the USGS Precipitation-Runoff Modeling System (PRMS). The code simulates flow across the land surface, within subsurface saturated and unsaturated materials, and within streams and lakes for one or more watersheds.
- The Farm Process for MODFLOW-2000 (**MK2K-FMP**) and MODFLOW-2005 (**MF2005-FMP2**): Dynamically simulates conjunctive use of surface water and groundwater for systems where water use by vegetation is an important component of the water budget, such as in areas of irrigated agriculture.
- The Groundwater Management Process for MODFLOW-2000 (**GWM-2000**) and MODFLOW-2005 (**GWM-2005**): These codes provide the capability to solve many types of linear, nonlinear, and mixed-binary linear groundwater-management problems with MODFLOW-2000 or MODFLOW-2005.

- **MF2K-GWT:** The Groundwater Transport Process for MODFLOW-2000 provides the capability to simulate three-dimensional solute-transport and compute changes in concentration of a dissolved chemical constituent due to advection, hydrodynamic dispersion, retardation, decay, matrix diffusion, and mixing with multiple fluid sources.
- **SEAWAT:** A computer program based on MODFLOW-2000 and MT3DMS to simulate three-dimensional variable-density groundwater flow such as can occur in coastal aquifers coupled with multi-species solute and heat transport.

## Online MODFLOW Guides

The USGS provides online guides for several MODFLOW versions. The guides can be found online at:

*<http://water.usgs.gov/nrp/gwsoftware/modflow2005/Guide/index.html> for **MODFLOW-2005***

*<http://water.usgs.gov/nrp/gwsoftware/modflow2000/Guide/index.html> for **MODFLOW-2000***

*[http://water.usgs.gov/nrp/gwsoftware/modflow2005\\_lgr/Guide/index.html](http://water.usgs.gov/nrp/gwsoftware/modflow2005_lgr/Guide/index.html) for **MODFLOW-LGR***

A guide containing the combined instructions for these different MODFLOW versions can be found at:

*<http://water.usgs.gov/nrp/gwsoftware/modflow2000/MFDOC/index.html>*

## Related MODFLOW Programs

The USGS also has developed several programs that can be used to assist with MODFLOW simulations. These include programs for model calibration and sensitivity analysis (such as the Sensitivity Analysis and Parameter-Estimation Processes of **MODFLOW-2000**, and the **UCODE\_2005** and **JUPITER API** programs), several graphical user interfaces and pre- and post-processors to facilitate input-file preparation and presentation of simulation results, a particle-tracking post-processing package that computes three-dimensional flow paths throughout a simulation domain (**MODPATH**), and a program for computing detailed subregional water budgets (**ZONEBUDGET**). All of these programs are listed on the “MODFLOW and Related Programs” and (or) “Water Resources Groundwater Software” Internet sites.