International Groundwater Modeling Center

Newsletter

Volume XVII ISSUE 1 Spring 1999

MODFLOW'98 was a SPECTACULAR SUCCESS!

Since its initial release by the U.S. Geological Survey in the early 1980s, MODFLOW, the modular three-dimensional finite-difference groundwater flow model, has come closer to being an international standard than any other code in the brief history of groundwater modeling.

In early October, over 250 ground-water modelers gathered in the Green Center on the CSM campus to discuss MODFLOW, its add-ons, extensions, plug-ins, spin-offs, interfaces, shells, applications, etc. Many reported that it was the best conference they had ever attended.

The conference "motto" evolved to be:

It ain't what you don't know that hurts you, it's what you think you know that ain't so!
-- Will Rogers

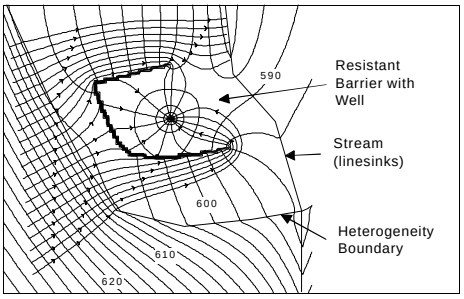
The message had a two-fold meaning. One meaning: We can no longer rely on the results of trial-and-error calibrated models because we are "fooling" ourselves into thinking that we know more about the ground water system than we actually know. Practical inversion tools now allow for rigorous determination of optimal parameter values and what the data really are, and aren't, supporting. Sometimes we wish we didn't know about the insensitivity of parameters to the available calibration data and the correlation of parameters to one another that prevents independent estimation of their values. However, we are actually better off when we have such knowledge, because then we know what we don't know. Then, we can determine whether it is appropriate to gather more field data or finalize a decision in an uncertain situation. Statistics resulting from inverse modeling can be used to determine the type and location of data that will be most helpful in improving sensitivity and reducing correlation.

The second meaning: Although we are all familiar with MODLFOW, enhancements are ever evolving, and there may be capabilities available of which we are unaware. The new capabilities may allow us to represent a problem more accurately. If we thought we knew everything about MODFLOW before the conference, but didn't, this might hurt us by leaving us with a less accurate models than could be achieved if the latest tools were used.

The Conference featured presentations by: Mary Hill; Michael McDonald; Gordon Bennett; Emil Frind; Jeff Holland; Chunmiao Zheng; John Doherty; Arlen Harbaugh; and Mary P. Anderson. IGWMC appreciates the efforts of the steering committee, including: Eileen Poeter, Chunmiao Zheng, and Mary Hill, and the organizing committee, including: Mary Anderson; Gordon Bennet; John Doherty; Emil Frind; Arlen Harbaugh; Jeff Holland; Leonard Konikow; David Lerner; Keith Turner; and David Burden. Their contribution, as well as the high quality work submitted by the participants made this an outstanding conference and one that will be remembered for a long time.

POPULAR SOFTWARE TWODAN Revised for Windows

TWODAN, two-dimensional analytic flow modeling software from Fitts GeoSolutions, was upgraded to a 32-bit Windows application, with a simple, intuitive interface. The principle advantages of this method are its simple input, accuracy, speed, and lack of a fixed grid, allowing a large area to be modeled with accuracy in small regions. Coordinates are digitized using the mouse and a DXF basemap overlay with capability to zoom and pan during the digitizing operation; one can continuously digitize multiple points, lines, or circles; use clipboard features; and output to any device supported by the Windows.



TWODAN uses the analytic method described by Strack (1989). The aquifer can consist of one or two hydraulically connected layers; with confined and/or unconfined conditions. In addition to the basic analytic element model features TWODAN has heterogeneity and barrier elements. Heterogeneities are closed polygon regions, each with a distinct set of aquifer properties. Impermeable and resistant barriers are modeled as open or closed strings of line segments.

TWODAN gives standard calibration statistics, but also plots residuals at the coordinates of observations with positive and negative values being a different color for rapid assessment of patterns.

For more information on TWODAN visit http://www.mines.edu/igwmc/software/igwmcsoft/ or contact IGWMC. TWODAN is software item TPS-11, $595.

For more information on analytical element modeling, refer to: **Fitts**,1997. Analytic Modeling of Impermeable and Resistant Barriers. Ground Water 35(4). **Strack**, 1989. Groundwater Mechanics. Prentice-Hall. **Haitjema**, 1995. Analytic Element Modeling of Groundwater Flow, Academic Press, San Diego.

igwmc Newsletter

For Membership Benefits See Page 3

IGWMC MEMBERSHIP FORM and /or SHORT COURSE REGISTRATION
Please return with payment to: IGWMC, CSM, Golden, CO 80401
for membership & course information : 303-273-3103; for register: 303-273-3321

Short Course Registration: ID:_____ $_____; ID:_____ $_____; ID:_____ $_____
Annual Membership: I will support the IGWMC at the level of:
___ $50 Professional;___ $200 Corporate;___ $500 Sponsor;___ $1000+ Benefactor
___ $20 Student Advisor's name/signature _____ enclose copy of valid ID
___ check enclosed; ___ credit card, card type: ____, #: _____, exp. _____

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Street Address:_____ City:_____ State/Province_____
Zip/Postal Code:_____ Country: _____ Phone:_____ Fax:_____
e-mail :_____ URL-(WWW):_____

NOTICE OF THE RELEASE OF THE PUBLIC-DOMAIN, USGS CODE: UCODE, A Computer Code for Universal Inverse Modeling

DOWNLOAD FREEWARE http://water.usgs.gov/software/ground_water.html

UCODE was developed by Eileen Poeter of the International Ground Water Modeling Center, Colorado School of Mines and Mary Hill of the U.S. Geological Survey in cooperation with the U.S. Army Waterways Experiment Station. Historically, when computer models needed to be calibrated to observed data, users of groundwater modeling programs would go through a trial-and-error methodology. However, many combinations of parameters often led to an apparently satisfactory calibration. Now, automated calibration programs such as UCODE utilize regression concepts to perform inverse modeling, where model parameters are systemimatically adjusted by the code to minimize differences between data and computer output. UCODE's automated calibration program applies to any combination of computer models that need to be calibrated to observed data. Statistics are calculated and printed for use in (1) diagnosing inadequate data and identifying parameters that probably cannot be estimated; (2) evaluating estimated parameter values; (3) evaluating the model representation of the actual processes; and (4) quantifying the likely uncertainty of model simulated values. UCODE may be used on PCs, MACs, and UNIX computers, because it is platform independent. A number of the common ground-water modeling GUI's will soon include UCODE. Download from URL under title.

CALIBRATION AND UNCERTAINTY OF GROUND-WATER MODELS

May 10-13, 1999 Short Course #99-2

Numerical models are used extensively to evaluate ground-water systems and to predict their response to such things as changes in pumpage and proposed remediation efforts. Model calibration has historically been achieved by trial and error alone, but these methods provide less insight than can be achieved. This course teaches how nonlinear regression and associated statistics can be used to dramatically improve how data are used to calibrate and test ground-water models. For example, parameters which cannot be estimated accurately and uniquely with the available data and the likely utility of potential new data are clearly and quickly identified. Parameter values that produce the best fit between simulated and observed hydraulic heads, flows, and concentrations can be determined using nonlinear regression. Measures of prediction uncertainty are a natural consequence of regression methods. The computer code UCODE will be used for class exercises. MODFLOWP and PEST will be described briefly.

Mary Hill is a research scientist with the USGS, and is the author of MODFLOWP and is co-author of UCODE. She has conducted and consulted on numerous ground-water investigations involving numerical modeling nationally and internationally over the last 20 years.

Richard Cooley is a Research Hydrologist in the National Research Program of the USGS. He is the author of some of the first publications on application of nonlinear regression methodology to calibration and uncertainty analysis of ground-water models. He received the O.E. Meinzer Award of the Geological Society of America for his 1979 paper on this topic. He has published in a wide variety of topics, ranging from variably saturated flow to geomorphology and recharge. He has taught technical short courses for 30 years.

Eileen Poeter: see MODFLOW course.

Claire Tiedeman is a research scientist at the USGS. She has applied parameter-estimation methods to numerical simulation of complex ground-water flow systems characterized by fractured and porous media. She has taught parameter-estimation methods for three years, is the co-developer of the exercises used in the course, and holds an MS from Stanford University.

GEOCHEMICAL MODELING OF AQUEOUS SYSTEMS USING EQ3/6

May 19-21, 1999 Short Course #99-3

This course will provide theoretical background and practical experience in the use of chemical speciation and reaction path models. The instructors use the EQ3/6 computer program to progressively build user ability through a wide variety of applications. Class exercises will include problems in chemical weathering, groundwater evolution in carbonate systems, temperature and pressure reaction paths, leachate generation from uranium mill tailings, trace metal behavior under various redox conditions, acid mine drainage (AMD) generation and treatment technologies, and thermodynamic data quality evaluation.

Wendy J. Harrison is a professor at the CSM with 21 years experience working with geochemical models and 11 years experience teaching aqueous geochemistry and geochemical modeling including EQ3/6.

Suzanne S. Paschke is a consultant with 15 years of hydrogeologic field and modeling experience. Her research emphasizes geochemical and reaction transport modeling using a variety of computer tools including EQ3/6 and PHREEQC.

ADVANCED GROUND-WATER MODELING USING MODFLOW

June 15-18, 1999 Short Course #99-4

This course is designed to provide significant detail on advanced ground-water flow modeling concepts and techniques. It explores development of conceptual models for complex sites or regions, how to convert these conceptual models to appropriate ground-water flow models, and how to apply supplemental MODFLOW modules to effectively solve such problems. The course revolves around a series of realistic problem sets that serve as a basis for comparing alternative approaches to solving various types of problems. This course is intended for individuals with previous modeling experience or course work.

Peter F. Andersen is Vice President and Principal Engineer of HSI GeoTrans, Inc., in charge of the Atlanta, Georgia office. He developed of instructional MODFLOW manual for EPA.

Robert M. Greenwald is a Principal Hydrogeologist at HSI GeoTrans, Inc., in charge of the Freehold, New Jersey office. He developed an optimization module for MODFLOW (MODMAN) for ground-water management applications; interface software for models based on commercial GIS and CAD software; and applied ground-water models at numerous RCRA and CERCLA sites.

APPLIED ENVIRONMENTAL STATISTICS

June 21-25, 1999 Short Course #99-5

This practical course develops hands-on expertise for environmental scientists who interpret data and present their findings to others. Hypothesis tests are explained in the light of data with non-detects, outliers, and skewed distributions. Methods for estimation and prediction are illustrated along with their common pitfalls. Hands on exercises follow each lecture. The course emphasizes:
when each method is appropriate; how to plot and present data; assumptions behind statistical tests, and their implications; how to build a good regression model, and trend analysis with common pitfalls. This course is intended for individuals with little or no previous experience applying statistics to environmental data.

Dennis Helsel (Ph.D., Virginia Tech) has 20 years experience applying statistics to practical issues in water resources. He authored numerous articles on statistical methods for interpreting water quality and quantity, as well as investigations of nutrient, trace metal, and acid mine drainage problems. Dr. Helsel co-authored "Statistical Methods in Water Resources" (Elsevier, 1992).
Ed Gilroy (Ph.D., Catholic Univ.) has 30 years experience as a consulting statistician for water resources staff within the USGS, and coordinated their statistical training. Dr. Gilroy now teaches at colleges in the Denver area, and consults. Dr. Gilroy co-authored Statistical Analysis chapter with Dr. Helsel for McGraw-Hill's Handbook of Hydrology.

GEOCHEMICAL MODELING OF AQUEOUS SYSTEMS USING PHREEQC

Oct. 21-23, 1999 Short Course #99-6

This course provides theoretical background and hands-on experience with the geochemical code PHREEQC. Lectures and computer sessions focus on important geochemical reactions in aquifers and teach the fundamentals of PHREEQC capabilities. Modeling topics include water mixing, adsorption, redox problems, inverse chemical modeling, and one-dimensional reaction transport modeling. Applications include chemical weathering, sediment diagenesis, ground-water quality evolution, contaminant geochemistry, acid mine drainage, and thermodynamic data quality evaluation. The PHREEQC code and all documentation are provided to students. **Suzanne Paschke & Wendy Harrison** see EQ3/6 course, page 2.

UCODE: UNIVERSAL INVERSION CODE FOR AUTOMATED CALIBRATION

Oct. 22-23, 1999 Short Course #99-8

UCODE is a universal inversion code, which was jointly sponsored by the U.S. Department of Defense, International Ground Water Modeling Center, and the U.S. Geological Survey. UCODE performs inverse modeling, posed as a parameter-estimation problem, using nonlinear regression. UCODE is not limited to inverting ground-water problems, but the course is presented as an approach to ground-water model calibration. The course includes an introduction to inversion theory and hands-on exercises with UCODE, demonstrating parameter estimation, conceptual model evaluation and determination of confidence intervals on predictions. See article, page 2.
Eileen Poeter: see MODFLOW above.

IGWMC Annual Memberships

Government agencies are no longer supporting entities such as the IGWMC. Yet, if many groundwater oriented professionals and companies maintain a membership in the center, the IGWMC can continue to provide valuable advising, teaching, information dissemination, software distribution and research services to the profession. Maintaining a membership in IGWMC provides stable support to ensure that IGWMC services are there when you want them, assists groundwater students, and provides you with reduced rates.

Member Benefits (forms on page1)

Student ($20)
* Listing on the job coordination web page
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* Research abstract on the web page

Professional ($50)
* All of above and
* 5% discount(conferences and courses)
* WEB listing with a two line description

Corporate ($200)
* All of above and
* 5% discount for up to 5 employees
* Listing on membership page with up to a five line description of the corporation

Sponsor ($500)
* All of above and
* 10% discount on advisory services
* WEB listing with 10-line description

Benefactors ($1000 and up)
* All above and our undying gratitude!
* 20% discount on advisory services
* WEB listing with 20-line description

MODFLOW : Introduction To Numerical Modeling

Oct. 20-23, 1999 Short Course #99-7

This course introduces groundwater professionals to numerical modeling. Basic modeling concepts: conceptual model development, definition of boundary and initial conditions, parameter specification, finite differencing, griding, time stepping, solution control, calibration, prediction, and uncertainty assessment are presented using MODFLOW96 and UCODE. Basic modules of MODFLOW are explained and concepts are reinforced with hands-on exercises. Calibration is presented with UCODE, a public domain, universal inversion USGS code.
Eileen Poeter is Director of IGWMC and a Professor at Colorado School of Mines. She has been modeling in the academic and consulting arena for 23 years, teaching modeling for 17 years, is the primary author of UCODE, and authored over 75 publications.

SUBSRUFACE MULTIPHASE FLUID FLOW AND REMEDIATION MODELING

Oct. 28-30, 1999 Short Course #99-9

This course presents the concepts of subsurface multiphase fluid flow modeling using the multi-dimensional multiphase flow code TOUGH2/T2VOC. Topics include development of conceptual models for vadose zone flow and transport, flow and interphase partitioning of nonaqueous-phase liquids (NAPLs) in the saturated and unsaturated zones, simulation of remediation techniques at NAPL-contaminated sites, and how to apply TOUGH2 and T2VOC to effectively solve realistic problems. Additional information on the codes may be accessed at http://ccs.lbl.gov/TOUGH2.

John McCray is an Assistant Professor at Colorado School of Mines. He has practiced and taught applied modeling in academia and consulting for 6 years, published several journal papers using T2VOC, and authored over 30 publications. **Karsten Pruess** is a senior scientist at Lawrence Berkeley National Laboratory. He is the original author of the TOUGH family of codes, with over 20 years of experience in multiphase flow and heat transfer. He has authored approximately 100 publications. **Ron Falta** is an Associate Professor at Clemson University. He is the primary author of T2VOC, has over 12 years of experience with subsurface multiphase flow and remediation, and has authored approximately 90 publications.

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IGWMC SHORT COURSES

COURSE (Short descriptions are provided on previous pages)	**Instructors**	**Start Date No. of Days**	**End Date Times**	**Fee Late Fee/Date**
Calibration and Uncertainty of Ground-water Models **ID # 99-2**	Mary Hill Richard Cooley Eileen Poeter Claire Tiedeman	May 10 4 days	May 13 8:30am-5:30pm	$1195 $1395/Apr.26
Geochemical Modeling of Aqueous Systems Using EQ3/6 **ID # 99-3**	Wendy Harrison Suzanne Paschke	May 19 3 days	May 21 8am-5pm	$1095 $1295/May.7
Advanced Groundwater Modeling Using MODFLOW **ID # 99-4**	Peter Anderson Robert Green-wald	June 15 4 days	June 18 8am-5pm	$1345 $1545/Jun.4
Applied Environmental Statistics **ID # 99-5**	Dennis Helsel Ed Gilroy	June 21 4.5 days	June 25 8am-5pm	$1295 $1495/Jun.4
PHREEQC: Geochemical and Reaction Transport Modeling **ID # 99-6**	Suzanne Paschke Wendy Harrison	October 21 3 days	October 23 8am-5pm	$1095 $1295/Oct.9
MODFLOW: Introduction to Numerical Modeling **ID # 99-7**	Eileen Poeter	October 20 4 days	October 23 8am-5pm	$1345 $1545/Oct.9
UCODE - Universal Inversion Code for Automated Calibration of "Any" Code **ID # 99-8**	Eileen Poeter	October 22 2 days	October 23 8am-5pm	$995 $1195/Oct.10
Subsurface Multiphase Fluid Flow and Remediation Modeling **ID # 99-9**	John E. McCray Karsten Pruess Ronald W. Falta	October 28 3 days	October 30 8am-5pm	$1095 $1295/Oct.15