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Short communication

Interactive Ground Water (IGW)

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Abstract

IGW is a software environment for real-time 2D and 3D groundwater modeling. The software functions as a "numerical laboratory" in which the modeler can freely explore: visually creating an aquifer of desired configurations and then immediately investigating and visualizing the groundwater system. IGW allows the modeler's thought processes to progress naturally and intuitively with the information visualized, overlaid, and compared at the instant it is required for analysis, providing a real sense of continuous active exploration and engaged problem solving.

Keywords: Groundwater modeling; Real-time modeling; Stochastic modeling

Software availability

Software Name: Interactive Groundwater (IGW)
Developers: Shu-Guang Li, Qun Liu
Contact: A133 Research Complex – Engineering, Department of Civil & Environmental Engineering, Michigan State University, East Lansing, MI 48824. E-mail: lishug@egr.msu.edu
Year first available: 1997
Hardware required: IBM compatible PC
Software required: Microsoft Windows (NT4/95/98/ME/2000/XP/Server 2003)
Programming language: Microsoft Visual Basic 6; Visual FORTRAN 5; Borland C++ Builder 6; Borland Delphi 5
Program size: 150 MB
Availability: Downloadable with manual and supporting material from http://www.egr.msu.edu/igw/igw_download.html
Available since: July 1997
Online documentation: http://www.egr.msu.edu/igw/
License: IGW version 3.x is Free

1. Overview

Taking advantage of recent developments in hydrological research, numerical techniques and computer, visualization, image processing, and GIS technologies, we have recently developed a sophisticated software environment, IGW, for real-time, unified deterministic and stochastic groundwater modeling. Based on efficient computational algorithms, IGW allows simulating complex 2D and 3D flow and transport in saturated aquifers subject to systematic and "random" stresses and geological and chemical heterogeneity (Liao et al., 2003). Adopting a new computing paradigm, the software eliminates bottlenecks in the fragmented traditional modeling technologies and allows fully utilizing today's dramatically increased computing power (Li and Liu, 2003). For the first time, IGW enables, for many problems, real-time modeling, visualization, and analysis.

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IGW provides an ideal tool for iterative exploratory research and conceptual modeling. It changes the role of the modeler in integrated and complex problem solving. IGW shifts the modeler's focus away from determining how to move data between various models and pre-/post-processors to critical thinking and cognitive decision-making tasks. The seamless model and data integration, visualization, and real-time processing and communication capability allow the modeler to focus on critical conceptual issues and to quickly and iteratively examine approximations and hypotheses, to identify dominant processes, to assess data worth, and to experiment in real-time with sampling, management, and remedial options.

IGW allows the modeler's thought processes to progress naturally and intuitively with the information visualized, overlaid, and compared at the instant it is required for analysis, providing a real sense of continuous active exploration and engaged problem solving. Being able to visualize flow, transport, and transformation as they evolve over time and the complex interrelationships among hydrological and environmental variables sparks pivotal insights, giving rise to an intuitive grasp of the hydrogeological and chemical processes that cannot be readily obtained otherwise.

2. Capabilities

IGW provides the following specific capabilities:

- ☐ Real-time conceptual modeling. Graphical specification and editing of aquifer domain, properties and stresses over any areas at any time during model construction, simulation, and analysis. Interactive hierarchical organization of conceptual features. Automatic grid generation and conversion from conceptual to numerical model.
- ☐ Real-time flow and transport modeling. Real-time flow simulation and visualization in response to deterministic/stochastic stresses. Real-time particle tracking, random walk, and transport modeling in both systematically and randomly fluctuating flow. Graphical release of particles in polygons, along polylines, and around wells, real-time forward/backward particle tracking with or without dispersion, real-time conversion of particles to concentration plumes and vice versa, real-time capture zone modeling. Real-time visualization of aquifer transition from confined to unconfined to partially dry and rewetting.
- ☐ Real-time hierarchical modeling. On-the-fly initiation of hierarchies of submodels that allow "zooming" incrementally into critical areas without having to solve large matrix systems; dynamic coupling of "parent" model and its "children"; real-time visualization of multiple subscale flow/transport models.
- ☐ Real-time stochastic modeling. Interactive and visual unconditional/conditional simulation of hydrogeochemical properties; exploratory data analysis; built-in variogram modeling with automatic/manual fitting; interactive spatial interpolation, regression, and smoothing/filtering, multi-scale Kriging and random field generation; real-time conditional Monte Carlo simulation. On-the-fly results processing – recursive computation of the means, variances, covariances, probabilities, and other statistics. Real-time stochastic capture zone delineation.
- ☐ Real-time GIS mapping. Built-in GIS mapping, automatic conversion of GIS to model objects; automatic and customizable GIS overlays of model inputs/outputs, computational grid, conceptual features, IGW drawings and text annotations, and multiple basemaps in mixed raster and/or vector formats; automatic continuous screen capture.
- ☐ Real-time model analysis. Dynamic visualization of water and mass balance over interactively specified zones. Real-time monitoring of temporal variation of head, concentration and seepage/solute fluxes and comparison with observations. Real-time monitoring of model inputs/outputs at cursor location; real-time visualization of means, standard deviations, and covariances. Real-time visual presentation of probability distributions of variables at user specified locations and temporal processes (e.g. head, flux, and concentration) with confidence intervals.

3. Summary

With 4 GHz desktops available now, 10 GHz microprocessor technology in the labs and faster than 20 GHz technology clearly in sight, actively-visualized subsurface flow dynamics and contaminant hydrogeology incorporating live-linked component technologies promises potentially significant scientific, economic, and societal benefits. IGW eliminates the fragmentation in the problem solving process and narrows the gap between what is technologically possible and what is practically implementable. Our actual ability to model, to investigate, and to discover may finally increase in pace with the rapidly advancing computer technologies.

References

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