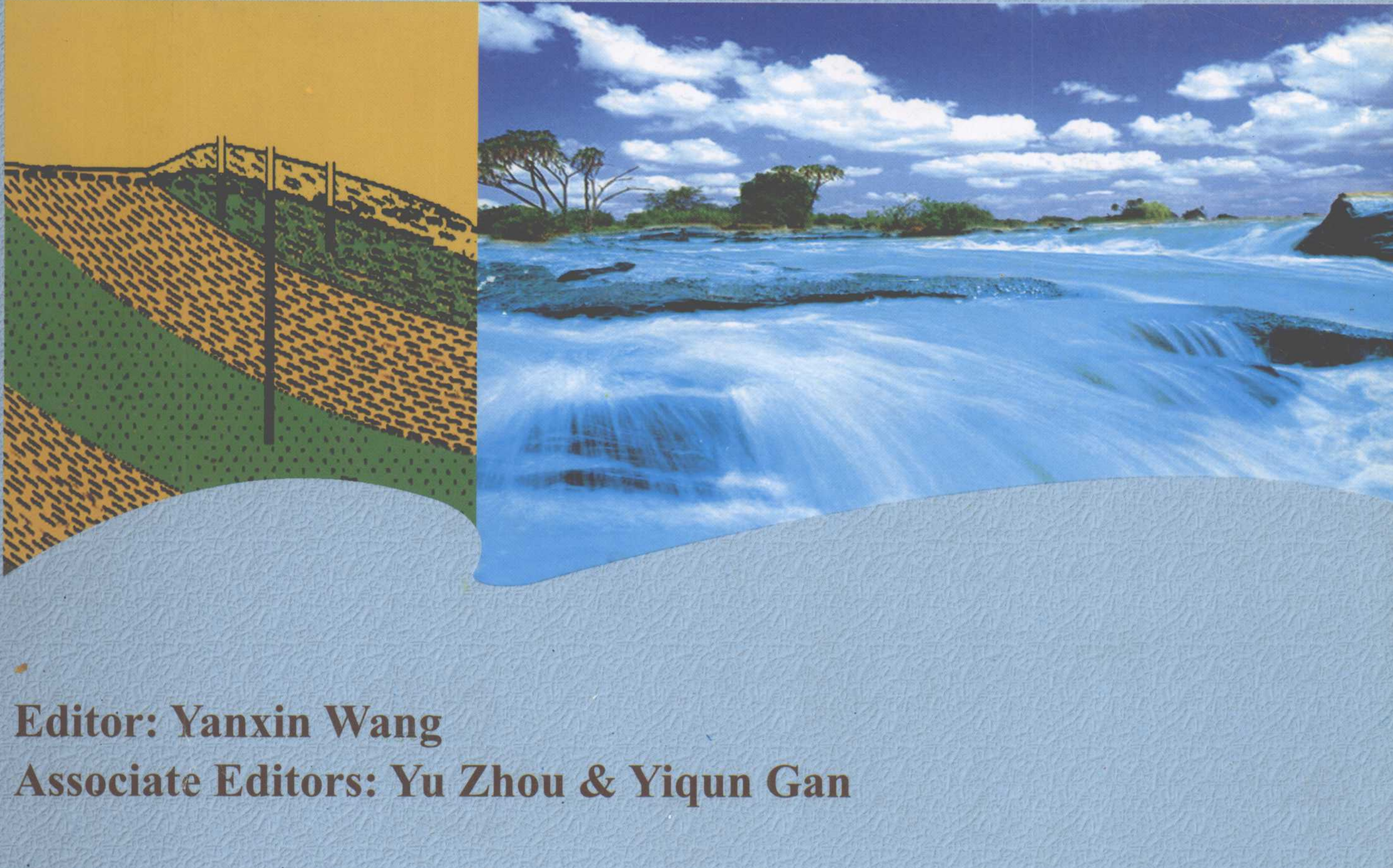
CALIBRATION AND RELIABILITY IN GROUNDWATER MODELING "MANAGING GROUNDWATER AND THE ENVIRONMENT"



Editor: Yanxin Wang

Associate Editors: Yu Zhou & Yiqun Gan

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ModelCARE2009, WUHAN, CHINA, SEPTEMBER 20-23 2009

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"Managing Groundwater and the Environment"

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Calibration and Reliability in Groundwater Modeling
“Managing Groundwater and the Environment”

Editor: *Yanxin Wang*
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Preface

The 7th International Conference on Calibration and Reliability in Groundwater Modeling (ModelCARE2009) was held in Wuhan, China from September 20-23, 2009. The conference addressed the applicability of various approaches to real-world problems through case studies and identified future needs and paths toward progress for research and development. The conference theme was "Managing Groundwater and the Environment". Within the context of model calibration and reliability, issues of groundwater quantity and quality were also addressed.

The conference was organized by the International Commission for Groundwater (ICGW) of the International Association of Hydrological Sciences (IAHS) and China University of Geosciences. I would like to thank our sponsors: China University of Geosciences (Wuhan), China Geological Survey (CGS); Xi'an Center of Geological Survey, CGS; National Natural Science Foundation of China; and International Research Center on Karst (Guilin, China).

This volume contains nearly 140 manuscripts (and abstracts) submitted by colleagues from over 17 countries. The manuscripts include theoretical, laboratory, and field-based studies. The volume begins with the plenary keynote lectures, followed by contributions to four sessions of the symposium as follows:

- Advances and innovations in model calibration, prediction, and uncertainty analysis
- Using models to evaluate sustainability of and manage groundwater resources
- Well hydraulics and numerical modeling for system characterization and prediction
- Modeling, calibration, and uncertainty of reactive transport, groundwater contamination and remediation
- CO_2 sequestration modeling and uncertainty assessment
- Geologic and engineering applications for improving groundwater models

We especially recognized the efforts of our 16 keynote speakers to update the theory and methodology of groundwater modeling.

Abstracts of all the manuscripts have been peer-reviewed by our SAC (Scientific Advisory Committee) members:

- Corinna Abesser, British Geological Survey, UK; Vice-President of ICGW
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- Jianmei Cheng, China University of Geosciences-Wuhan, China
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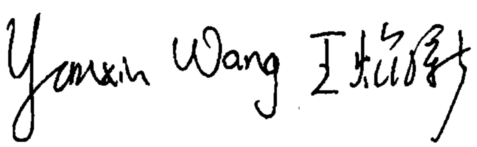
- Yuesuo Yang, Jilin University, China
- William Yeh, University of California-Los Angeles, USA
- Xun Zhou, China University of Geosciences-Beijing, China

Special thanks must go to the tremendous help of my assistants: Dr. Yiqun Gan, Dr. Yu Zhou and Ms. Xinxin Guo. And I wish to thank Mary Hill and Chunmiao Zheng for their constant and firm support throughout the organization process of this conference.



Yanxin Wang
Editor & Chairman, ModelCARE2009

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Shemin Ge, University of Colorado-Boulder

Secretariat: Yiqun Gan, Yu Zhou and Xinxin Guo, China University of Geosciences-Wuhan

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Section 6

Geologic and engineering applications for improving groundwater models

Section 1

Advances and innovations in model calibration, prediction, and uncertainty analysis

Automatic calibration of seawater intrusion modeling using genetic algorithm

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ABSTRACT: An attempt at inverse modeling of a seawater intrusion system is made by using genetic algorithm method as the optimization procedure. The auto-calibration objective function is defined with the root mean square errors (RMSE) between the observed and the simulated values. The observed data are consisted of both hydraulic heads and concentrations obtained from observation wells. Firstly, the SEAWAT code has been used for forward solution part of salt water intrusion phenomena and then a program is written in MATLAB for coupling the forward and inverse processes. This structure is applied in a real case aquifer near Tashk Salt Lake with an EC of 61420 μmhos/cm in Northeast of Fars province in Iran. In last two decades, due to a sharp increase mostly in agricultural water demand, the overexploitation of groundwater has caused a major water level drawdown and consequently the saltwater intrusion. In the developed code, the flow and transport parameters are estimated simultaneously in steady and transient states. The comparison between observed and simulated water level and concentration show an acceptable value. It can be concluded that GA is a helpful tool for automatic calibration of variable density fluid systems such as seawater intrusion problem.

1 INTRODUCTION

Identifying groundwater parameters is based on seeking the values of aquifer parameters which minimize an objective function that computes the differences between the observed and the simulated values of state variables (i.e., hydraulic heads and solute concentrations). Apart from classical optimization methods that many scientific efforts were done to use them in the process of parameter estimation, a variety of approaches called "evolutionary algorithms" have been considered recently. Genetic algorithms are one of these global optimization techniques which have received a lot of attention during the past few decades. These are applied in many groundwater and surface water hydrology problems and played the role of appropriate tool in optimization procedures. Here, it is tried to use genetic algorithm in the frame of inverse modeling with the purpose of parameter estimation.

Reviewing the literature shows that inverse modeling of groundwater flow problems is a usual task among scientists. Moreover, the inverse problem of parameter identification in groundwater contaminant transport has been studied extensively during the last two decades (Yeh, 1986); but the use of inverse modeling for variable-density fluid flow and solute transport, such as occurs in seawater intrusion into aquifers, is even more uncommon (Iribar et al. considered only constant-density flow during intrusion and Shoemaker made an initial attempt at variable-density inverse modeling using sparse data) (Sanz & Voss, 2006). The intention of this work is to estimate some unknown variable-density groundwater flow parameters by using the inverse modeling concept and emphasizing on automatic calibration of a real coastal aquifer case located in Iran by means of coupling SEAWAT as forward code and GA as optimization inversion method.

2 MATERIALS AND METHODS

2.1 *Forward Modeling*

Forward modeling of variable-density groundwater system is accomplished by using SEAWAT code. The SEAWAT program was developed by the USGS to simulate three-dimensional, variable-density, transient groundwater flow in porous media. The source code for SEAWAT combines USGS MODFLOW and MT3DMS codes into a single program that solves the coupled flow and solute transport equations. The variable-density groundwater flow equation is solved using a finite-difference approximation based on MODFLOW-88. MODFLOW was modified to conserve fluid mass rather than fluid volume and uses equivalent freshwater head as the primary dependent variable. In the revised form of MODFLOW, the cell-by-cell flow is calculated from freshwater head gradients and relative density difference terms. The resulting flow field is passed to a solute transport module in MT3DMS; an updated density field is then calculated from the new solute concentrations and incorporated back into MODFLOW.

The general form of the partial differential equation for variable-density groundwater flow in porous media is formulated as:

$$-\nabla.(\rho\ \vec{q}) + \bar{\rho}\ q_s = \rho\ S_P \frac{\partial P}{\partial t} + \theta \frac{\partial \rho}{\partial C} \frac{\partial C}{\partial t} \tag{1}$$

Where ∇ is the gradient operator, ρ is the fluid density, $\vec{q}$ is the specific discharge vector, $\bar{\rho}$ is the density of water entering from a source or leaving through a sink, q_s is the volumetric flow rate per unit volume of aquifer representing sources and sinks, S_p is the specific storage in terms of pressure, P is fluid pore pressure, θ is porosity, C is solute concentration. In addition to the flow equation, a second partial differential equation is required to describe solute transport in the aquifer. The movement of groundwater and the transport of solutes in the aquifer are coupled processes, and the two equations must be solved jointly. Solute