

## Preface

The ModelCARE conferences are a forum where scientists and engineers come together to demonstrate new ideas and solutions, and to address the continuing difficulties in the development of groundwater models. The models of concern represent groundwater systems, arguably the most difficult of earth system models because the systems are inaccessible and, as they are a source of drinking water, very detailed knowledge is required. The usefulness of predictive simulations obtained by groundwater models is often hampered by the inability to indicate and quantify the reliability of model results. Uncertainty in model predictions primarily stems from a number of errors relating to the model formulation such as:

- inadequate conceptualization of processes and interactions;
- inadequate description of processes and interactions;
- inadequate description of spatial and temporal variability;
- inadequate description of the state of the system (geometry, initial and boundary conditions, system stresses);
- incorrect coefficient values (parameter values) and improper specification of error bounds.

In recent years, significant research has been conducted which has resulted in a variety of approaches that can be used to incorporate the information about these errors into the modelling process and to establish the level of uncertainty in model-based decision making. Increasingly, these new techniques are being applied to a variety of problems and sites.

This (postpublished) volume is an outcome of the International Conference on Calibration and Reliability in Groundwater Modelling: A Few Steps Closer to Reality (ModelCARE 2002) held in Prague, Czech Republic, in June 2002. As at the three previous conferences in the series, ModelCARE 90<sup>1</sup> (held in The Hague, the Netherlands, 1990), ModelCARE 96<sup>2</sup> (held in Golden, Colorado, USA, 1996) and ModelCARE 99<sup>3</sup> (held in Zürich, Switzerland, 1999), the major objectives of ModelCARE 2002 were to again provide an international forum for state-of-the-art presentations on relevant methodologies and techniques, and to identify the needs for future development. The conference also attempted to illustrate the applicability of various techniques through advanced case studies on calibration and reliability assessment.

A major feature was the discussion of both deterministic and stochastic methods of investigation. For any given groundwater system, some things about the system are known relatively well and it is most advantageous to represent them in a model definitively, or deterministically. Other things are less clearly known or little known, and it is important to represent them using stochastic methods to obtain an honest evaluation of what can be said about the system. Thus, both deterministic and stochastic methods are important. Yet, progress in the two approaches most often proceeds independently, and sometimes divisively.

<sup>1</sup> The proceedings of ModelCARE 90, held in The Hague, The Netherlands, September 1990, were published as IAHS Publ. 195, *Calibration and Reliability in Groundwater Modelling* (ed. by K. Kovar).

<sup>2</sup> The proceedings of ModelCARE 96, held in Golden, Colorado, USA, September 1996, were published as IAHS Publ. 237, *Calibration and Reliability in Groundwater Modelling* (ed. by K. Kovar & P. K. M. van der Heijde).

<sup>3</sup> The proceedings of ModelCARE 99, held in Zurich, Switzerland, September 1999, were published as IAHS Publ. 265, *Calibration and Reliability in Groundwater Modelling: Coping with Uncertainty* (ed. by F. Stauffer, W. Kinzelbach, K. Kovar & E. Hoehn).

The conference started with talks about stochastic methods presented by the leaders of the field (Dagan, Tartakovsky, Fiori, and others), which received substantial attention. The presentations and questions revealed both the mathematical difficulty of stochastic hydrology and the difficulty of conveying its results. However, the difficulties are important to overcome because the results are so crucial to coping with the uncertainty inherent in groundwater modelling. Two clear conclusions presented were:

- the importance of dimensionality and accounting for the inherent three-dimensional nature of natural systems;
- the importance of contrasts in material properties observed in the subsurface.

The remainder of the conference was dominated by deterministic methods with some use of regression, sensitivity, and statistical approaches to address model development, calibration, and uncertainty issues. New challenges involved the following issues. (a) Integration of groundwater and surface processes. (b) Addressing scale issues in a number of ways, including local grid refinement as suggested by Mehl & Hill. (c) Including the dynamics and errors of systems with complex processes (multiphase flow, anaerobic bioremediation of hydrocarbons, DNAPLs), as suggested by Shoemaker, Abriola, Poeter, and others. (d) Improving model calibration methods, as suggested in Olsthoorn *et al.* by evaluating a model calibrated by trial and error alone using sensitivity analysis and regression, and by Hill & Tiedeman by addressing confusion about weighting observations. (e) Accounting for conceptual model uncertainty, as attempted by Neuman using maximum likelihood Bayesian model averaging. (f) Quantifying model reliability, for which Christensen & Cooley and Vesselinov *et al.* discussed new methods for calculating confidence intervals for our pervasively nonlinear models (nonlinear with respect to the parameters). Finally, important papers were presented on the ‘comprehensive use of field information’ and ‘methods and tools for assessment of well-head protection zones’.

This volume contains 68 papers grouped into seven topics. The papers were chosen from the 80 papers pre-selected for oral and poster presentations at the conference. The selection was performed by the Editors based on two to three reviews of each paper. The reviewers consisted in general of one member of the Scientific Advisory Committee and one or two authors of candidate papers. The final version of the paper was again checked by the Editors. The overall procedure enabled, without doubt, a significant increase in the quality of the selected papers and therefore of the present volume. The Editors would like to thank the reviewers for their efforts.

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