Book Reviews

Calibration and Reliability in Groundwater Modelling: Coping with Uncertainty

Edited by: F. Stauffer, W. Kinzelbach, K. Kovar, and E. Hoehn, 2000. IAHS Publication no. 265, 524 p., ISBN 1-901502-36-8.

The book is an edited set of papers presented at the ModelCARE Conference held in Zurich in 1999. Of 91 papers presented at the conference, 74 are included in the book. The book has the strengths and weaknesses you might expect from a collection of conference papers. The book includes state-of-the-art papers by leading practitioners; however, the reader is left to assemble an overall picture of this field of study from a series of fine brushstrokes.

The quality of the papers is high, but those new to the issues of calibration and reliability in groundwater modelling (like me) will find it difficult to learn quickly from the book. One difficulty is that, although all 74 papers presented relate to groundwater modelling, only about half of them relate directly to calibration and reliability. A second difficulty is that the book has the briefest of prefaces, no author or subject index, and no unifying "keynote" papers. A final difficulty is that each paper is tantalisingly short (about 7 pages each), with never enough detail to adequately understand the method used.

The issues of calibration and reliability in groundwater modelling merit a more coherent treatment. A cursory literature review turned up a book and a few journal articles that might give more background to those entering this topic anew. The most relevant book seems to be *Inverse Problems in Groundwater Modeling* by N.Z. Sun (Kluwer, 1994). A seminal article with more of an emphasis on the uncertainty in groundwater modelling is "First order analysis of uncertainty in numerical models of groundwater flow" by Dettinger and Wilson (*Water Resources Research*, v. 17, p. 149-61, 1981). Both of these references use detailed mathematics with little effort made to make the results relevant to practitioners. David Scott (Environment Canterbury) suggests that practitioners start with the chapter on calibration in the 1992 book *Applied Groundwater Modelling* by Anderson and Woessner.

One of the leading practitioners in the field of calibration and reliability in groundwater modelling is Mary C. Hill of the U.S.G.S. Her 1998 U.S.G.S. report entitled "Methods and guidelines for effective model calibration" also seems a useful starting point for practitioners. David Scott tells me

that this report is available for download at *water.usgs.gov/software/ucode.html* along with calibration software. I have paraphrased here what she considers to be the steps in effective model calibration:

- Start simply and build complexity slowly
- Use a broad range of information to constrain the problem
- Maintain a well-posed, comprehensive regression problem to fit parameters
- Use prior information carefully
- Assign weights to reflect measurement errors
- Evaluate model fit with summary statistics and graphics
- Consider making the model more hydrogeologically accurate to improve calibration
- Evaluate the plausibility of optimised parameters
- Test alternative models for model fit and plausibility
- Consider the inclusion of potential new data
- Evaluate the potential for additional estimated parameters to improve calibration
- Develop confidence/prediction intervals to indicate uncertainty in parameters
- Assess whether the calibration can be modified to better match decision needs

If many of these steps interest you, I suggest you arrange to thumb through the book for ideas from the leaders in the field. The book is well produced with high quality paper, good editing, high quality graphs, and complete references.

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Isotope Tracers in Catchment Hydrology

Edited by: Carol Kendall and Jeffrey J. McDonnell, 1998.
Elsevier, Amsterdam, 839 pages.

This book on isotope tracers in catchment hydrology edited by Carol Kendall and Jeffrey McDonnell is an excellent state of the art summary of isotope tracer techniques used on a small catchment scale. The book has particular importance to New Zealand as McDonnell is a University of Canterbury doctoral graduate, and Carol Kendall has visited New Zealand a couple of times to teach courses and interact with our isotope scientists. Two of the chapters were written by Neil Ingraham when he was at the University of Auckland and New Zealand isotope tracer studies (mostly in the Maimai catchment) are used as examples throughout the book. Therefore New Zealand scientists should find a considerable amount of information that is pertinent to their field areas.

The book is divided into five parts and twenty-two chapters. The first part provides background hydrology and isotope geochemistry aimed at readers at the senior undergraduate or beginning graduate student level. The first chapter provides a glossary, which may be very useful to those readers just beginning to come to grips with the subject. Part two provides five chapters on the details of important topics that deal with variability in the isotopic composition of water and solutes. Parts three and four are according to the editors the "core": of the book. These chapters provide specific case studies of applications of isotopes to understanding small catchments. Part three illustrates isotope hydrological studies and part four illustrates isotope geochemical studies. The last part contains two synthesis chapters on the use of modelling techniques to understand isotope catchment studies and one on the use of isotopes as indicators of environmental change.

Each chapter is exceptionally well illustrated and provides abundant references to important work. The book covers a myriad of isotopes including the isotopes of O, H, S, C, B, Cl, N, I, He, Kr, Be, Pb, Cs, and Sr to name just a few. Arid zone catchments, humid and temperate catchments, forested catchments and agricultural catchments are all illustrated in addition to many other environments. It is impossible to review everything that is covered in such a comprehensive 839 page book. Many chapters are very detailed, perhaps too detailed for the reader with a casual interest in isotope hydrology, but these chapters will be invaluable to readers who would like a "one-stop shop" for the important references in any given field in isotope catchment hydrology. The stated aim of the editors is to be a reference book on the subject, and I believe they have fulfilled their aim admirably. The chapters that stand out to me as being exceptionally useful (perhaps because I knew the least about these subjects before I read the book) are the chapters on

dissolved gases in subsurface hydrology, snowmelt-dominated systems, and the use of stable isotopes in evaluating sulfur biogeochemstry of forest ecosystems. Other chapters on nitrogen isotopes, the carbon cycle, and groundwater-surface water interactions are also well written. In addition, the two synthesis chapters provide excellent summaries of many of the methods used throughout the book.

The paperback book is presented exceptionally well and the figures and layout are of the highest quality. There are over 70 authors contributing to this book from all over the world (although dominantly from North America), all of whom are of international calibre. The fundamental detail and explanations of isotope tracer techniques as well as the plentiful real world examples from all parts of the globe and every conceivable environment make this book an excellent reference and a must for hydrologists, students and even isotope hydrology specialists. I heartily recommend this book to those interested in the use of isotope tracers in New Zealand and anywhere else in the world. The book is available from Elsevier at P.O. Box 211, 1000 AE Amsterdam, The Netherlands.

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