
Preface

Water is vital for the Earth and all the life forms on it, thus the importance of hydrology—the science of water—goes without saying. Water resources involve interplay between geologic, hydrologic, chemical, atmospheric, and biological processes. To study the occurrence, movement, distribution, and quality of water throughout our globe is clearly a challenging task, which requires a joining force between the different branches of hydrology, from hydrometeorology, surface water hydrology to hydrogeology and hydrochemistry as well as hydrogeophysics and hydroecology, to just mention a few. Besides a conceptual understanding, quantitative monitoring, characterization, predictions and management must resort to collaborative mathematical models and numerical algorithms, often together with computer simulations.

In recent years, massive amounts of high-quality hydrologic field data are being collected at various spatial-temporal scales using a variety of new techniques. Availability of these massive amounts of data has begun to call for a quantitative integration of geologic, hydrologic, chemical, atmospheric, and biological information to characterize and predict natural systems in hydrological sciences. Intelligent computation and information fusion as such become a key to the future hydrological sciences. We envision this subject to become a new research field that will dramatically improve the traditional approach of only qualitatively characterizing natural systems.

This edited volume contains eight chapters written by some of the leading researchers in hydrological sciences. The chapters address some of the most important ingredients for quantitative hydrological information fusion. The book aims to provide both established scientists and graduate students with a summary of recent developments in this new research direction, while shedding some light into the future.

The eight chapters can be divided into three mutually overlapping parts. The first part consists of Chapters 1 and 2 which mainly address the methodological issues. In particular, Chapter 1 discusses different data fusion techniques for integrating hydrological models, where the discussion is carried out from the perspective of hydroinformatics and computational intelligence.

Chapter 2 depicts an advanced computational environment that enables interactive and real-time 3D groundwater modeling. The combined power of parallel computing, dynamic visualization, and computational steering enables a fusion of flow modeling, transport modeling, subscale modeling, uncertainty modeling, geostatistical simulation, and GIS mapping.

As the second theme of the book, Chapters 3-6 concentrate on some mathematical and numerical methods. Using the Kalman filter based on Karhunen-Loève decomposition, the authors of Chapter 3 show how to reduce the uncertainty in characterizing hydraulic medium properties and system responses. Chapter 4 presents efficient data analysis tools using trajectory-based methods, which also offer insight into inverse modeling of flow and transport. In close relation, Chapter 5 describes streamline methods that are capable of reconciling 3D geological models to dynamic reservoir responses. Another numerical technique in inverse modeling is given in Chapter 6, which addresses a systematic regularized inversion approach to incorporating geophysical information into the analysis of tomographic pumping tests.

The third part of the present book focuses on real-life applications of hydrological information fusion. Chapter 7 is about using satellite rainfall datasets and hydrologic process controls for flood prediction in ungauged basins, whereas Chapter 8 reports an engineering case of groundwater management by integrating large-scale zoning of aquifer parameters and a sedimentary structure-based heterogeneous description of the aquifer properties.

The idea of the present book was conceived following a warm suggestion by Prof. Dr. Janusz Kacprzyk, Series Editor of Studies in Computational Intelligence at Springer. We are therefore greatly indebted to Prof. Kacprzyk for his advice and encouragement. Engineering Editor Dr. Thomas Ditzinger and Heather King at Springer's Engineering Editorial Department, in particular, deserve our sincere thanks for their patient guidance and technical support throughout the editorial process. We are of course tremendously grateful to all the contributed authors for carefully preparing their chapters. Moreover, positive response from numerous researchers to our call-for-chapters is acknowledged, although they were not able to contribute in the end due to the tight time schedule.

Last but not least, we wish to express our heartfelt gratitude to a large number of anonymous reviewers, who carefully read through the earlier versions of the book chapters and provided valuable suggestions for improvement. There is no exaggeration in saying that this book project has been a team work from start to finish. We sincerely hope that this book will give the reader an equal amount of pleasure as it has given us during the editing work.

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