Statistical Methods In Hydrology

Objectives The current global environmental crisis has reinforced the need for developing flexible mathematical models to obtain a better understanding of environmental problems so that effective remedial action can be taken. Because natural phenomena occurring in hydrology and environmental engineering usually behave in random and probabilistic fashions, stochastic and statistical models have major roles to play in the protection and restoration of our natural environment. Consequently, the main objective of this edited volume is to present some of the most up-to-date and promising approaches to stochastic and statistical modelling, especially with respect to groundwater and surface water applications. Contents As shown in the Table of Contents, the book is subdivided into the following main parts: GENERAL ISSUES PART I PART II GROUNDWATER PART III SURFACE WATER PART IV STOCHASTIC OPTIMIZATION PART V MOMENT ANALYSIS PART VI OTHER TOPICS Part I raises some thought-provoking issues about probabilistic modelling of hydro logical and environmental systems. The first two papers in Part I are, in fact, keynote papers delivered at an international environmetrics conference held at the University of Waterloo in June, 1993, in honour of Professor T. E. Unny. In his keynote pa per, Dr. S. J. Burges of the University of Washington places into perspective the historical and future roles of stochastic modelling in hydrology and environmental engineering. Additionally, Dr. Burges stresses the need for developing a sound scien tific basis for the field of hydrology. Professor P. E.

The unusual frequency of hydro-meteorological events in recent decades, often with catastrophic consequences for society and the environment, require new methods for designing water management projects and the structures meant to protect us from natural hazards. These methods and techniques are often based on the statistical modeling techniques of frequency analysis. Predictive Hydrology: A Frequency Analysis Approach is the first book to address both the theoretical concepts and the methodological approaches used in frequency hydrology—spelling out the fundamental methods to consider, providing concise instruction on the techniques that are involved, and including examples and critiques based on practical applications. It explores some of the recent research developments in the field. Published originally in French, this English translation targets students in civil engineering, environmental sciences and technology, hydrology, geography, geology and ecology. This book will also serve as a useful reference not only for teachers and researchers, but for engineering practitioners, who are constantly faced with the problems of handling data, but often find themselves without the appropriate analytical tools.

Pick up any hydrology textbook and it will not be long before you encounter pages listing sequences of equations representing complex mathematical concepts. Students and practitioners of hydrology will not find this very helpful, as their aim, generally, is to study and understand hydrology, and not to find themselves confronted with material that even students of mathematics would find challenging. Often, equations appear to be copied and pasted into hydrological texts in an attempt to give a more rigorous scientific basis to the narrative. However, they are commonly wrong, poorly explained, without context or background, and more likely to confuse and distance the reader than to enlighten and engage them in the topic. Understanding Mathematical and Statistical Techniques in Hydrology provides full and detailed expositions of such equations and mathematical concepts, commonly used in hydrology. In contrast to other hydrological texts, instead of presenting abstract mathematical hydrology, the essential mathematics is explained with the help of real-world hydrological examples.

Statistical Postprocessing of Ensemble Forecasts brings together chapters contributed by international subject-matter experts describing the current state of the art in the statistical postprocessing of ensemble forecasts. The book illustrates the use of these methods in several important applications including weather, hydrological and climate forecasts, and renewable energy forecasting. After an introductory section on ensemble forecasts and prediction systems, the second section of the book is devoted to exposition of the methods available for statistical postprocessing of ensemble forecasts: univariate and multivariate ensemble postprocessing are first reviewed by Wilks (Chapters 3), then Schefzik and Möller (Chapter 4), and the more specialized perspective necessary for postprocessing forecasts for extremes is presented by Friederichs, Wahl, and Buschow (Chapter 5). The second section concludes with a discussion of forecast verification methods devised specifically for evaluation of ensemble forecasts (Chapter 6 by Thorarinsdottir and Schuhen). The third section of this book is devoted to applications of ensemble postprocessing. Practical aspects of ensemble postprocessing are first detailed in Chapter 7 (Hamill), including an extended and illustrative case study. Chapters 8 (Hemri), 9 (Pinson and Messner), and 10 (Van Schaeybroeck and Vannitsem) discuss ensemble postprocessing specifically for hydrological applications, postprocessing in support of renewable energy applications, and postprocessing of long-range forecasts from months to decades. Finally, Chapter 11 (Messner) provides a guide to the ensemble-postprocessing software available in the R programming language, which should greatly help readers implement many of the ideas presented in this book. Edited by three experts with strong and complementary expertise in statistical postprocessing of ensemble forecasts, this book assesses the new and rapidly developing field of ensemble forecast postprocessing as an extension of the use of statistical corrections to traditional deterministic forecasts. Statistical Postprocessing of Ensemble Forecasts is an essential resource for researchers, operational practitioners, and students in weather, seasonal, and climate forecasting, as well as users of such forecasts in fields involving renewable energy, conventional energy, hydrology, environmental engineering, and agriculture. Consolidates, for the first time, the methodologies and applications of ensemble forecasts in one succinct place Provides real-world examples of methods used to formulate forecasts Presents the tools needed to make the best use of multiple model forecasts in a timely and efficient manner

This presents practical techniques for interpolation and estimation problems when analysing data from field observations.
This book provides a compilation of statistical analysis methods used to analyze and assess critical variables in the hydrological cycle.
Statistical Methods in Hydrology and HydroclimatologySpringer
This textbook covers the main applications of statistical methods in hydrology. It is written for upper undergraduate and graduate students but can be used as a helpful guide for hydrologists, geographers, meteorologists and engineers. The book is very useful for teaching, as it covers the main topics of the subject and contains many worked out examples and proposed exercises. Starting from simple notions of the essential graphical examination of hydrological data, the book gives a complete account of the role that probability considerations must play during modelling, diagnosis of model fit, prediction and evaluating the uncertainty in model predictions, including the essence of Bayesian application in hydrology and statistical methods under nonstationarity. The book also offers a comprehensive and useful discussion on subjective topics, such as the selection of probability distributions suitable for hydrological variables. On a practical level, it explains MS Excel charting and computing capabilities, demonstrates the use of Winbugs free software to solve Monte Carlo Markov Chain (MCMC) simulations, and gives examples of free R code to solve nonstationary models with nonlinear link functions with climate covariates.
This book communicates some contemporary mathematical and statistical developments in river basin hydrology as they pertain to space-time rainfall, spatial landform and network structures and their role in understanding averages and fluctuations in the hydrologic water balance of river basins. While many of the mathematical and statistical nations have quite classical mathematical roots, the river basin data structure has led to many variations on the problems and theory.
The revised edition of this classic text presents basic statistical principles for students of hydrology. The book incorporates updated techniques and includes increased discussion of applied statistics and new/expanded sections on geostatistics, risk analysis, the use of computer computers in statistical analysis, and the use of statistics in hydrologic and water quality modeling. Copyright © Libri GmbH. All rights reserved.
Hydrology is the science through which man tries to understand the properties and the distribution of water. Frequency analysis is a set of mathematical and statistical techniques used to describe the probability of occurrence of events. Every year, floods and droughts cause loss of life and millions of dollar's worth of damage in many countries of the world. In many cases, these consequences could be reduced either by nonstructural means such as restricting building in flood plains and by limiting water abstractions, or by better design of regulatory structures to reduce flood peaks and increase low flows. In all these cases, the key is knowledge of the distribution of flows in the river. Frequency and Risk Analyses in Hydrologydescribes some of the methods currently used to apply frequency analysis techniques to hydrological data in order to provide planners and engineers with figures that they can use in practice to reduce the losses caused by flood and drought. Risk analysis is an extension of the technique used to assess the probability that the estimated design event will differ from the actual event.
Data on water quality and other environmental issues are being collected at an ever-increasing rate. In the past, however, the techniques used by scientists to interpret this data have not progressed as quickly. This is a book of modern statistical methods for analysis of practical problems in water quality and water resources. The last fifteen years have seen major advances in the fields of exploratory data analysis (EDA) and robust statistical methods. The 'real-life' characteristics of environmental data tend to drive analysis towards the use of these methods. These advances are presented in a practical and relevant format. Alternate methods are compared, highlighting the strengths and weaknesses of each as applied to environmental data. Techniques for trend analysis and dealing with water below the detection limit are topics covered, which are of great interest to consultants in water-quality and hydrology, scientists in state, provincial and federal water resources, and geological survey agencies. The practising water resources scientist will find the worked examples using actual field data from case studies of environmental problems, of real value. Exercises at the end of each chapter enable the mechanics of the methodological process to be fully understood, with data sets included on diskette for easy use. The result is a book that is both up-to-date and immediately relevant to ongoing work in the environmental and water sciences.
Hydrological extremes have become a major concern because of their devastating consequences and their increased risk as a result of climate change and the growing concentration of people and infrastructure in high-risk zones. The analysis of hydrological extremes is challenging due to their rarity and small sample size, and the interconnections between different types of extremes and becomes further complicated by the untrustworthy representation of meso-scale processes involved in extreme events by coarse spatial and temporal scale models as well as biased or missing observations due to technical difficulties during extreme conditions. The complexity of analyzing hydrological extremes calls for robust statistical methods for the treatment of such events. This Special Issue is motivated by the need to apply and develop innovative stochastic and statistical approaches to analyze hydrological extremes under current and future climate conditions. The papers of this Special Issue focus on six topics associated with hydrological extremes: Historical changes in hydrological extremes; Projected changes in hydrological extremes; Downscaling of hydrological extremes; Early warning and forecasting systems for drought and flood; Interconnections of hydrological extremes; Applicability of satellite data for hydrological studies.
Hydrology and water resources analysis can be looked at together, but this is the only book which presents the relevant material and which bridges the gap between scientific processes and applications in one text. New methods and programs for solving hydrological problems are outlined in a concise and readily accessible form. Hydrology and Water Resource Systems Analysis includes a number of illustrations and tables, with fully solved example problems integrated within the text. It describes a systematic treatment of various surface water estimation techniques;

and provides detailed treatment of theory and applications of groundwater flow for both steady-state and unsteady-state conditions; time series analysis and hydrological simulation; floodplain management; reservoir and stream flow routing; sedimentation and erosion hydraulics; urban hydrology; the hydrological design of basic hydraulic structures; storage spillways and energy dissipation for flood control, optimization techniques for water management projects; and methods for uncertainty analysis. It is written for advanced undergraduate and graduate students and for practitioners. Hydrologists and water-related professionals will be helped with an unfamiliar term or a new subject area, or be given a formula, the procedure for solving a problem, or guidance on the computer packages which are available, or shown how to obtain values from a table of data. For them it is a compendium of hydrological practice rather than science, but sufficient scientific background is provided to enable them to understand the hydrological processes in a given problem, and to appreciate the limitations of the methods presented for solving it.

From earth tectonics and meteorology to risk, responsibility, and the role of government, this comprehensive and detailed book reviews current practices in designing dams to withstand extreme hydrologic and seismic events. Recommendations for action and for further research to improve dam safety evaluations are presented.

The statistical analysis of extreme data is important for various disciplines, including hydrology, insurance, finance, engineering and environmental sciences. This book provides a self-contained introduction to the parametric modeling, exploratory analysis and statistical interference for extreme values. The entire text of this third edition has been thoroughly updated and rearranged to meet the new requirements. Additional sections and chapters, elaborated on more than 100 pages, are particularly concerned with topics like dependencies, the conditional analysis and the multivariate modeling of extreme data. Parts I–III about the basic extreme value methodology remain unchanged to some larger extent, yet notable are, e.g., the new sections about "An Overview of Reduced-Bias Estimation" (co-authored by M.I. Gomes), "The Spectral Decomposition Methodology", and "About Tail Independence" (co-authored by M. Frick), and the new chapter about "Extreme Value Statistics of Dependent Random Variables" (co-authored by H. Drees). Other new topics, e.g., a chapter about "Environmental Sciences", (co--authored by R.W. Katz), are collected within Parts IV–VI.

The application of statistics in hydrologic engineering is described and illustrated. The subject matter covers the following items: (1) A concise review of the basic concepts of probability and correlation analyses that are applicable in hydrologic engineering, with a guide to supplemental reading for further treatment; (2) Presentation of detailed computation procedures and supporting justifications and computation aids for derivation of probability of frequency estimates based on analysis of hydrologic records that have been adjusted as required to conform with selected reference base conditions; and (3) A summary of procedures for developing 'regionalized' hydrologic frequency estimates, based on analyses of hydrologic records available at stream gaging stations, adjusted to provide generalized flood-frequency relations that are considered most representative of long-period hydrologic characteristics in various drainage areas in the region. Also, illustrations and explanations of simple generalization procedures for use where these are adequate and advantageous are given.

International experts from around the globe present a rich variety of intriguing developments in time series analysis in hydrology and environmental engineering. Climatic change is of great concern to everyone and significant contributions to this challenging research topic are put forward by internationally renowned authors. A range of interesting applications in hydrological forecasting are given for case studies in reservoir operation in North America, Asia and South America. Additionally, progress in entropy research is described and entropy concepts are applied to various water resource systems problems. Neural networks are employed for forecasting runoff and water demand. Moreover, graphical, nonparametric and parametric trend analyses methods are compared and applied to water quality time series. Other topics covered in this landmark volume include spatial analyses, spectral analyses and different methods for stream-flow modelling. Audience The book constitutes an invaluable resource for researchers, teachers, students and practitioners who wish to be at the forefront of time series analysis in the environmental sciences.

A comprehensive and practical guide, providing technical background and user context for researchers, graduate students, practitioners and decision makers. This book presents the main approaches and describes their underlying assumptions, skill and limitations. Guidelines for the application of downscaling and the use of downscaled information in practice complete the volume.

The need to understand and quantify change is fundamental throughout the environmental sciences. This might involve describing past variation, understanding the mechanisms underlying observed changes, making projections of possible future change, or monitoring the effect of intervening in some environmental system. This book provides an overview of modern statistical techniques that may be relevant in problems of this nature. Practitioners studying environmental change will be familiar with many classical statistical procedures for the detection and estimation of trends. However, the ever increasing capacity to collect and process vast amounts of environmental information has led to growing awareness that such procedures are limited in the insights that they can deliver. At the same time, significant developments in statistical methodology have often been widely dispersed in the statistical literature and have therefore received limited exposure in the environmental science community. This book aims to provide a thorough but accessible review of these developments. It is split into two parts: the first provides an introduction to this area and the second part presents a collection of case studies illustrating the practical application of modern statistical approaches to the analysis of trends in real studies. Key Features: Presents a thorough introduction to the practical application and methodology of trend analysis in environmental science. Explores non-parametric estimation and testing as well as parametric techniques. Methods are illustrated using case studies from a variety of environmental application areas. Looks at trends in all aspects of a process including mean, percentiles and extremes. Supported by an accompanying website featuring datasets and R code. The book is designed to be accessible to readers with some basic statistical training, but also contains sufficient detail to serve as a reference for practising statisticians. It will therefore be of use to postgraduate students and researchers both in the environmental sciences and in statistics.

Spatio-temporal Analysis of Extreme Hydrological Events offers an extensive view of the experiences and applications of the latest developments and methodologies for analyzing and understanding extreme environmental and hydrological events. The book addresses the topic using spatio-temporal methods, such as space-time geostatistics, machine learning, statistical theory, hydrological modelling, neural network and evolutionary algorithms. This important resource for both hydrologists and statisticians interested in the framework of spatial and temporal

analysis of hydrological events will provide users with an enhanced understanding of the relationship between magnitude, dynamics and the probability of extreme hydrological events. Presents spatio-temporal processes, including multivariate dynamic modelling Provides varying methodological approaches, giving the readers multiple hydrological modelling information to use in their work Includes a variety of case studies making the context of the book relatable to everyday working situations

While most books examine only the classical aspects of hydrology, this three-volume set covers multiple aspects of hydrology, and includes contributions from experts from more than 30 countries. It examines new approaches, addresses growing concerns about hydrological and ecological connectivity, and considers the worldwide impact of climate change. It also provides updated material on hydrological science and engineering, discussing recent developments as well as classic approaches. Published in three books, Fundamentals and Applications; Modeling, Climate Change, and Variability; and Environmental Hydrology and Water Management, the entire set consists of 87 chapters, and contains 29 chapters in each book. Students, practitioners, policy makers, consultants and researchers can benefit from the use of this text.

This book focuses on the application of statistical methods in the field of hydrology and hydroclimatology. Among the latest theories being used in these fields, the book introduces the theory of copulas and its applications in this context. The purpose is to develop an understanding and illustrate the usefulness of the statistical techniques with detailed theory and numerous worked out examples. Apart from this, MATLAB-based codes and solutions of some worked out examples are also provided to assist the readers to handle real life data. This book presents a comprehensive knowledge of statistical techniques combining the basics of probability and the current advances in stochastic hydrology. Besides serving as a textbook for graduate courses on stochastic modeling in hydrology and related disciplines, the book offers valuable resources for researchers and professionals involved in the field of hydrology and climatology.

Accurate prediction of hydrological variables is essential for efficient water resources planning and management. Proper understanding of the characteristics of the time series may help in improving the simulation and forecasting accuracy of hydrological variables. This book presents a detailed description and application of multiscale time-frequency characterization tool for the spectral analysis of hydrological time series. It presents spectral analysis methods for hydrological applications through a wide variety of illustrative case studies including Wavelet transforms, Hilbert Huang Transform and their extensions.

Stochastic hydrology is an essential base of water resources systems analysis, due to the inherent randomness of the input, and consequently of the results. These results have to be incorporated in a decision-making process regarding the planning and management of water systems. It is through this application that stochastic hydrology finds its true meaning, otherwise it becomes merely an academic exercise. A set of well known specialists from both stochastic hydrology and water resources systems present a synthesis of the actual knowledge currently used in real-world planning and management. The book is intended for both practitioners and researchers who are willing to apply advanced approaches for incorporating hydrological randomness and uncertainty into the simulation and optimization of water resources systems. (abstract) Stochastic hydrology is a basic tool for water resources systems analysis, due to inherent randomness of the hydrologic cycle. This book contains actual techniques in use for water resources planning and management, incorporating randomness into the decision making process. Optimization and simulation, the classical systems-analysis technologies, are revisited under up-to-date statistical hydrology findings backed by real world applications.

This book presents an overview of copula theory and its application in hydrology, and provides valuable insights, useful methods and practical applications for multivariate hydrological analysis using copulas. In addition, it extends the traditional bivariate model to trivariate or multivariate models. The specific applications covered include the study of flood frequency analysis, drought frequency analysis, dependence analysis, flood coincidence risk analysis and statistical simulation using copulas. The book offers a valuable guide for researchers, scientists and engineers working in hydrology and water resources, and will also benefit graduate or doctoral students with a basic grasp of copula functions who want to learn about the latest research developments in the field.

Applications in Hydrogeology for Geoscientists presents the most recent scientific developments in the field that are accessible yet rigorous enough for industry professionals and academic researchers alike. A multi-contributed reference that features the knowledge and experience of the field’s experts, the book’s chapters span the full scope of hydrogeology, introducing new approaches and progress in conceptualization, simulation of groundwater flow and transport, and progressive hydro-geophysical methods. Each chapter includes examples of recent developments in hydrogeology, groundwater, and hydrology that are underscored with perspectives regarding the challenges that are facing industry professionals, researchers, and academia. Several sub-themes—including theoretical advances in conceptualization and modeling of hydro-geologic challenges—connect the chapters and weave the topics together holistically. Advances in research are aided by insights arising from observations from both field and laboratory work. Introduces new approaches and progress in hydrogeology, including conceptualization, simulated groundwater flow and transport, and cutting edge hydro-geophysical methods Features more than 100 figures, diagrams, and illustrations to highlight major themes and aid in the retention of key concepts Presents a holistic approach to advances in hydrogeology, from the most recent developments in reservoirs and hydraulics to analytic modeling of transient multi-layer flow and aquifer flow theory Integrates real life data, examples and processes, making the content practical and immediately implementable

Fractional Operators with Constant and Variable Order with Application to Geo-hydrology provides a physical review of fractional operators, fractional variable order operators, and uncertain derivatives to groundwater flow and environmental remediation. It presents a formal set of mathematical equations for the description of groundwater flow and pollution problems using the concept of non-integer order derivative. Both advantages and disadvantages of models with fractional operators are discussed. Based on the author’s analyses, the book proposes new techniques for groundwater remediation, including guidelines on how chemical companies can be positioned in any city to avoid groundwater pollution. Proposes new aquifer derivatives for leaky, confined and unconfined formations Presents useful aids for applied scientists and engineers seeking to solve complex problems that cannot be handled using constant fractional order derivatives Provides a real physical interpretation of operators relevant to groundwater flow problems Models both fractional and variable order derivatives, presented together with uncertainties analysis

Within this landmark collection of papers, highly respected scientists and engineers from around the world present some of the latest research results in extreme value analyses for floods and

droughts. Two approaches that are commonly employed in flood frequency analyses are the maximum annual flood and partial duration series or peak over threshold procedures. Recent theoretical advances as well as illustrative applications are described in detail for each of these approaches. Additionally, droughts and storms are systematically studied using appropriate probabilistic models. A major part of the volume is devoted to frequency analyses and fitting extreme value distributions to hydrological data. Other thought-provoking topics include regionalization techniques, distributed models, entropy and fractal analysis. Audience The book is of interest to researchers, teachers, students and practitioners who wish to place themselves at the leading edge of flood frequency and drought analyses.