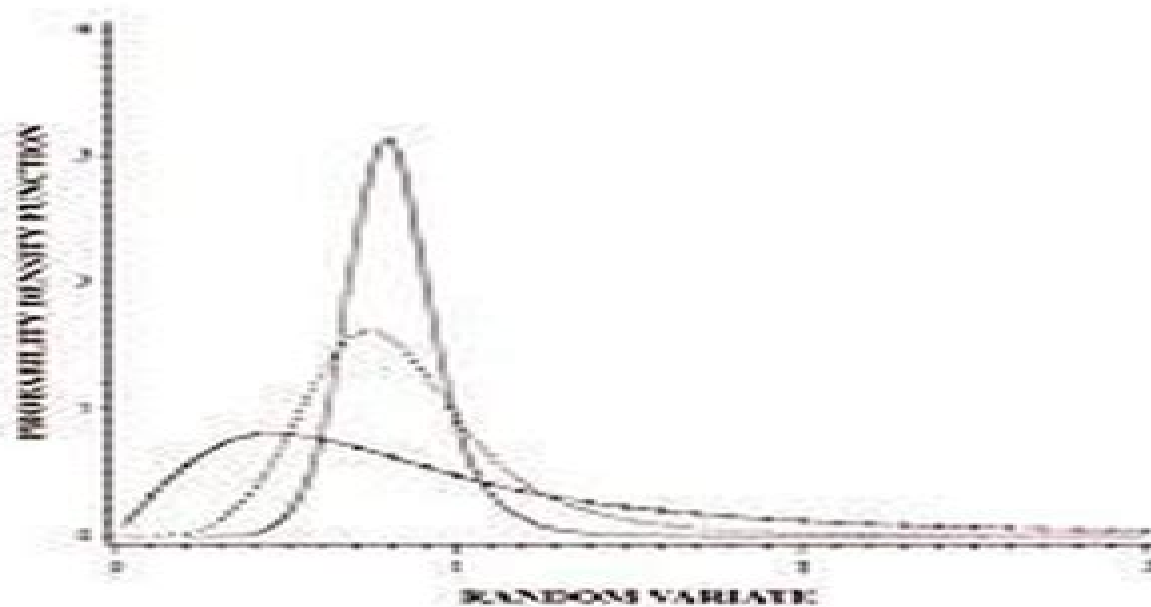


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# ENTROPY-BASED PARAMETER ESTIMATION IN HYDROLOGY

by  
Vijay P. Singh



# Entropy Based Parameter Estimation In Hydrology

**Russell S. Harmon**



## **Entropy Based Parameter Estimation In Hydrology:**

Entropy-Based Parameter Estimation in Hydrology V.P. Singh, 2013-04-17 Since the pioneering work of Shannon in the late 1940s on the development of the theory of entropy and the landmark contributions of Jaynes a decade later leading to the development of the principle of maximum entropy POME the concept of entropy has been increasingly applied in a wide spectrum of areas including chemistry electronics and communications engineering data acquisition and storage and retrieval data monitoring network design ecology economics environmental engineering earth sciences fluid mechanics genetics geology geomorphology geophysics geotechnical engineering hydraulics hydrology image processing management sciences operations research pattern recognition and identification photogrammetry psychology physics and quantum mechanics reliability analysis reservoir engineering statistical mechanics thermodynamics topology transportation engineering turbulence modeling and so on New areas finding application of entropy have since continued to unfold The entropy concept is indeed versatile and its applicability widespread In the area of hydrology and water resources a range of applications of entropy have been reported during the past three decades or so This book focuses on parameter estimation using entropy for a number of distributions frequently used in hydrology In the entropy based parameter estimation the distribution parameters are expressed in terms of the given information called constraints Thus the method lends itself to a physical interpretation of the parameters Because the information to be specified usually constitutes sufficient statistics for the distribution under consideration the entropy method provides a quantitative way to express the information contained in the distribution

*Entropy-Based Parameter Estimation in Hydrology* Vijay Singh, 2014-03-14 Since the pioneering work of Shannon in the late 1940s on the development of the theory of entropy and the landmark contributions of Jaynes a decade later leading to the development of the principle of maximum entropy POME the concept of entropy has been increasingly applied in a wide spectrum of areas including chemistry electronics and communications engineering data acquisition and storage and retrieval data monitoring network design ecology economics environmental engineering earth sciences fluid mechanics genetics geology geomorphology geophysics geotechnical engineering hydraulics hydrology image processing management sciences operations research pattern recognition and identification photogrammetry psychology physics and quantum mechanics reliability analysis reservoir engineering statistical mechanics thermodynamics topology transportation engineering turbulence modeling and so on New areas finding application of entropy have since continued to unfold The entropy concept is indeed versatile and its applicability widespread In the area of hydrology and water resources a range of applications of entropy have been reported during the past three decades or so This book focuses on parameter estimation using entropy for a number of distributions frequently used in hydrology In the entropy based parameter estimation the distribution parameters are expressed in terms of the given information called constraints Thus the method lends itself to a physical interpretation of the parameters Because the information to be specified usually constitutes sufficient statistics for

the distribution under consideration the entropy method provides a quantitative way to express the information contained in the distribution

*Entropy Applications in Environmental and Water Engineering* Huijuan Cui, Bellie Sivakumar, Vijay P. Singh, 2019-03-07 Entropy theory has wide applications to a range of problems in the fields of environmental and water engineering including river hydraulic geometry fluvial hydraulics water monitoring network design river flow forecasting floods and droughts river network analysis infiltration soil moisture sediment transport surface water and groundwater quality modeling ecosystems modeling water distribution networks environmental and water resources management and parameter estimation Such applications have used several different entropy formulations such as Shannon Tsallis Rnyi Burg Kolmogorov Kapur configurational and relative entropies which can be derived in time space or frequency domains More recently entropy based concepts have been coupled with other theories including copula and wavelets to study various issues associated with environmental and water resources systems Recent studies indicate the enormous scope and potential of entropy theory in advancing research in the fields of environmental and water engineering including establishing and explaining physical connections between theory and reality The objective of this Special Issue is to provide a platform for compiling important recent and current research on the applications of entropy theory in environmental and water engineering The contributions to this Special Issue have addressed many aspects associated with entropy theory applications and have shown the enormous scope and potential of entropy theory in advancing research in the fields of environmental and water engineering

*Distributed Hydrologic Modeling Using GIS* Baxter E. Vieux, 2016-08-19 This book presents a unified approach for modeling hydrologic processes distributed in space and time using geographic information systems GIS This Third Edition focuses on the principles of implementing a distributed model using geospatial data to simulate hydrologic processes in urban rural and peri urban watersheds The author describes fully distributed representations of hydrologic processes where physics is the basis for modeling and geospatial data forms the cornerstone of parameter and process representation A physics based approach involves conservation laws that govern the movement of water ranging from precipitation over a river basin to flow in a river Global geospatial data have become readily available in GIS format and a modeling approach that can utilize this data for hydrology offers numerous possibilities GIS data formats spatial interpolation and resolution have important effects on the hydrologic simulation of the major hydrologic components of a watershed and the book provides examples illustrating how to represent a watershed with spatially distributed data along with the many pitfalls inherent in such an undertaking Since the First and Second Editions software development and applications have created a richer set of examples and a deeper understanding of how to perform distributed hydrologic analysis and prediction This Third Edition describes the development of geospatial data for use in Vflo physics based distributed modeling

**Artificial Neural Networks in Hydrology** R.S. Govindaraju, A.R. Rao, 2013-03-09 R S GOVINDARAJU and ARAMACHANDRA RAO School of Civil Engineering Purdue University West Lafayette IN USA Background and Motivation

The basic notion of artificial neural networks ANNs as we understand them today was perhaps first formalized by McCulloch and Pitts 1943 in their model of an artificial neuron Research in this field remained somewhat dormant in the early years perhaps because of the limited capabilities of this method and because there was no clear indication of its potential uses However interest in this area picked up momentum in a dramatic fashion with the works of Hopfield 1982 and Rumelhart et al 1986 Not only did these studies place artificial neural networks on a firmer mathematical footing but also opened the door to a host of potential applications for this computational tool Consequently neural network computing has progressed rapidly along all fronts theoretical development of different learning algorithms computing capabilities and applications to diverse areas from neurophysiology to the stock market Initial studies on artificial neural networks were prompted by a desire to have computers mimic human learning As a result the jargon associated with the technical literature on this subject is replete with expressions such as excitation and inhibition of neurons strength of synaptic connections learning rates training and network experience ANNs have also been referred to as neurocomputers by people who want to preserve this analogy

**Entropy Theory in Hydrologic Science and Engineering** Vijay P. Singh, 2014-09-22 A THOROUGH INTRODUCTION TO ENTROPY THEORY AND ITS APPLICATIONS IN HYDROLOGIC SCIENCE AND ENGINEERING This comprehensive volume addresses basic concepts of entropy theory from a hydrologic engineering perspective The application of these concepts to a wide range of hydrologic engineering problems is discussed in detail The book is divided into sections preliminaries rainfall and evapotranspiration subsurface flow surface flow and environmental considerations Helpful equations solutions tables and diagrams are included throughout this practical resource Entropy Theory in Hydrologic Science and Engineering covers Introduction to entropy theory Maximum entropy production principle Performance measures Morphological analysis Evaluation and design of sampling and measurement networks Precipitation variability Rainfall frequency distributions Evaluation of precipitation forecasting schemes Assessment of potential water resources availability Evaporation Infiltration Soil moisture Groundwater flow Rainfall runoff modeling Streamflow simulation Hydrologic frequency analysis Streamflow forecasting River flow regime classification Sediment yield Eco index Generalized Frequency Distributions for Environmental and Water Engineering Vijay P. Singh, Lan Zhang, 2022-04-07 Overview of systems of frequency distributions their properties applications to the fields of water resources and environmental engineering *Regionalization of Watersheds* A.R. Rao, V. V. Srinivas, 2008-04-18 Design of water control structures reservoir management economic evaluation of flood protection projects land use planning and management flood insurance assessment and other projects rely on knowledge of magnitude and frequency of floods Often estimation of floods is not easy because of lack of flood records at the target sites Regional flood frequency analysis RFFA alleviates this problem by utilizing flood records pooled from other watersheds which are similar to the watershed of the target site in flood characteristics Clustering techniques are used to identify groups of watersheds which have similar flood characteristics This book is a comprehensive reference on how to use

these techniques for RFFA and is the first of its kind It provides a detailed account of several recently developed clustering techniques including those based on fuzzy set theory and artificial neural networks It also documents research findings on application of clustering techniques to RFFA that remain scattered in various hydrology and water resources journals The optimal number of groups defined in an area is based on cluster validation measures and L moment based homogeneity tests These form the bases to check the regions for homogeneity The subjectivity involved and the effort needed to identify homogeneous groups of watersheds with conventional approaches are greatly reduced by using efficient clustering techniques discussed in this book Furthermore better flood estimates with smaller confidence intervals are obtained by analysis of data from homogeneous watersheds Consequently the problem of over or under designing by using these flood estimates is reduced This leads to optimal economic design of structures The advantages of better regionalization of watersheds and their utility are entering into hydrologic practice Audience This book will be of interest to researchers in stochastic hydrology practitioners in hydrology and graduate students

*Risk Analysis and Management - Trends, Challenges and Emerging Issues* Ales Bernatik, Chongfu Huang, Olivier Salvi, 2017-06-26 This book collects the papers presented at the 6th International Conference on Risk Analysis and Crisis Response RACR 2017 held in Ostrava Prague Czech Republic on June 5-9 2017 organized by VSB Technical University of Ostrava Czech Republic The overall theme of the sixth international conference on risk analysis and crisis response is Risk Analysis and Management Trends Challenges and Emerging Issues highlighting science and technology to improve risk analysis capabilities and to optimize crisis response strategy This book contains primarily research articles of risk issues Underlying topics include natural hazards and major chemical accidents prevention disaster risk reduction and society resilience information and communication technologies safety and cybersecurity modern trends in crisis management energy and resources security critical infrastructure nanotechnology safety and others All topics include aspects of multidisciplinary and complexity of safety in education and research The book should be valuable to professors engineers officials businessmen and graduate students in risk analysis and risk management About the book series Communications in Cybernetics Systems Science and Engineering Proceedings CCSSEP is a cross disciplinary book series devoted to theoretical and applied research contributions that cater to a rapidly growing worldwide interest in a cybernetic and systemic methodology with an ever increasing capacity to deal with new challenges in a way that traditional science cannot The series aims to become a comprehensive reference work on and guide to developments within the field and strategies required for better implementation of advances with a view to environmental protection and sustainable social and economic development The CCSSE series targets all working in theoretical and applied fields of cybernetics systems science and engineering e g academics researchers and consultants computer and information scientists development and systems engineers mathematicians management cyberneticists and systemists medical scientists and intelligent and manufacturing engineers in industry as well as leading decision and policy makers Series editor Jeffrey Yi

Lin Forrest     Statistical Analysis of Environmental Space-Time Processes Nhu D. Le, James V. Zidek, 2006-09-13 This book presents knowledge gained by the authors along with methods they developed over more than 30 years of experience measuring modeling and mapping environmental space time fields That experience embraces both large continentwide spatial domains and small In part it comes from their research working with students as well as coinvestigators But much was gained from all sorts of interactions with many individuals who have had to contend with the challenges these fields present They include statistical as well as subject area scientists in areas as diverse as analytical chemistry air sampling atmospheric science environmental epidemiology environmental risk management and occupational health among others We have collaborated and consulted with government scientists as well as policy makers in all a large group of individuals from whom we have learned a lot and to whom we are indebted We hope all in these diverse groups will find something of value in this book We believe it will also benefit graduate students both in statistics and subject areas who must deal with the analysis of environmental fields In fact we have given a successful statistics graduate course based on it The book and course reflect our conviction about the need for statistical scientist to learn about the phenomenon they purport to explain To the extent feasible we have covered important nonstatistical issues involved in dealing with environmental processes Thus in writing the book we have tried to strike a balance between important qualitative and quantitative aspects of the subject Much of the most technical statistical mathematical material has been placed in the starred sections chapters and appendices

**Copulas and Their Applications in Water Resources Engineering** Lan Zhang, V. P. Singh, 2019-01-10 Illustration of copula theory with detailed real world case study examples in the fields of hydrology and water resources engineering

**Proceedings of the Canadian Society of Civil Engineering Annual Conference 2021** Scott Walbridge, Mazdak Nik-Bakht, Kelvin Tsun Wai Ng, Manas Shome, M. Shahria Alam, Ashraf el Damatty, Gordon Lovegrove, 2022-05-31 This book comprises the proceedings of the Annual Conference of the Canadian Society of Civil Engineering 2021 The contents of this volume focus on specialty conferences in construction environmental hydrotechnical materials structures transportation engineering etc This volume will prove a valuable resource for those in academia and industry

**The Ganges Water Diversion: Environmental Effects and Implications** M. Monirul Qader Mirza, 2006-02-03 This book deals with environmental effects on both sides of the border between Bangladesh and India caused by the Ganges water diversion This issue came to my attention in early 1976 when news media in Bangladesh and overseas began publications of articles on the unilateral withdrawal of a huge quantity of water from the Ganges River through the commissioning of the Farakka Barrage in India I first pursued the subject professionally in 1984 while working as a contributor for Bangladesh Today Holiday and New Nation During the next two decades I followed the protracted hydro political negotiations between the riparian countries in the Ganges basin and I traveled extensively to observe the environmental and ecological changes in Bangladesh as well as India that occurred due to the water diversion The Ganges

one of the longest rivers of the world originates at the Gangotri glacier in the Himalayas and flows across the plains of North India Eventually the river splits into two main branches and empties into the Bay of Bengal The conflict of diversion and sharing of the Ganges water arose in the middle of the last century when the government of India decided to implement a barrage at Farakka to resolve a navigation problem at the Kolkata Port

**Soil Conservation Service Curve Number (SCS-CN) Methodology** S.K. Mishra,V.P. Singh,2013-03-14 The Soil Conservation Service SCS curve number CN method is one of the most popular methods for computing the runoff volume from a rainstorm It is popular because it is simple easy to understand and apply and stable and accounts for most of the runoff producing watershed characteristics such as soil type land use hydrologic condition and antecedent moisture condition The SCS CN method was originally developed for its use on small agricultural watersheds and has since been extended and applied to rural forest and urban watersheds Since the inception of the method it has been applied to a wide range of environments In recent years the method has received much attention in the hydrologic literature The SCS CN method was first published in 1956 in Section 4 of the National Engineering Handbook of Soil Conservation Service now called the Natural Resources Conservation Service U S Department of Agriculture The publication has since been revised several times However the contents of the methodology have been nonetheless more or less the same Being an agency methodology the method has not passed through the process of a peer review and is in general accepted in the form it exists Despite several limitations of the method and even questionable credibility at times it has been in continuous use for the simple reason that it works fairly well at the field level

**Groundwater Recharge from Run-off, Infiltration and Percolation** K.-P. Seiler,J.R. Gat,2007-09-20 Groundwater constitute the most important reservoir of available clean water Due to its overexploitation some anthropogenic mismanagement on the surface and the overloading of the cleanup potential of subsurface many of the groundwater systems used for water supply are in jeopardy The problem is very severe in dry lands but also in urban industrial agricultural and traffic areas This book first discusses the recharge fluxes relating both to the quantity and quality of groundwater In order to face the threats to the water supply and to be able to maintain a sustainable water management policy detailed knowledge is needed in between others on the surface to subsurface transformation link in the water cycle Secondly the presentation and comparison of both the traditional and modern approach to determine groundwater recharge is discussed The traditional approach to determine groundwater recharge is based on water balance estimates and hydraulic considerations which yield instantaneous values at best but do not integrate the totality of recharge pathways in time and space In contrast environmental tracers do integrate these factors Finally the fate of groundwater recharge in the subsurface by hydraulic and geologic means is discussed in detail in order to stimulate adapted groundwater management strategies and to better assess consequences of climate changes on groundwater resources as a whole Audience This book will be of interest to hydrologists hydro geologists engineers geographers agronomists soil scientists groundwater modellers environmental physicists



limnologists

**Managing Urban Water Supply** D.E. Agthe, R.B. Billings, N. Buras, 2013-06-29 We the editors have long believed that a strong knowledge of relatively simple economic and engineering concepts is valuable in solving water management problems. The lack of such knowledge has been apparent to us in some of the journal articles, research proposals and books we have reviewed. The articles which have been written concerning specific local water economies and management issues are scattered over a wide variety of journals making them hard to access. Most of the extensive water resources literature is concerned with large regional water projects or with narrow technical and regional issues. This book was written to make practical economic and engineering concepts readily available to urban water supply managers thereby filling a gap in the available literature. It is concerned with decisions made daily, monthly or annually by managers of urban water supply systems. The book includes basic chapters presenting supply and cost concepts, calculation of demand elasticities, use of marketing concepts, public goods analysis, water markets, industrial water demand and the use of price in water conservation. The authors have included multiple examples of how these concepts can aid in managing urban water supply. The water provider is generally a governmental entity or regulated private utility. Most books on public utilities and their management emphasize gas, electricity or telephone rather than water. Water is different because of many variations in quality by source and the necessity for proper disposal of waste water.

*Hilbert-Huang Transform Analysis of Hydrological and Environmental Time Series* A.R. Rao, E.-C. Hsu, 2008-01-08 The Hilbert-Huang Transform (HHT) is a recently developed technique used to analyze nonstationary data. This book uses methods based on the Hilbert-Huang Transform to analyze hydrological and environmental time series. These results are compared to the results from the traditional methods such as those based on Fourier transform and other classical statistical tests.

**Methods and Tools for Drought Analysis and Management** Giuseppe Rossi, Teodoro Vega, Brunella Bonaccorso, 2007-07-26 Implementation of effective drought management policies requires both advanced technologies and appropriate methods. Monitoring and forecasting systems, practical tools for risk assessment as well as simple and objective criteria to select and implement appropriate drought mitigation measures are key elements for a successful drought management strategy. These key issues have been tackled by universities and public agencies involved in the EU projects Sedemed and Sedemed II, Programme Interreg IIIB MEDOCC aimed at the definition of an integrated network for real time monitoring of drought, the development of common methodologies for drought analysis and forecasting as well as the definition of proper mitigation strategies for the Mediterranean countries. The book presents the main outcomes of such projects with a special focus on drought monitoring and forecasting techniques at different spatial scales, new or modified agrometeorological indices and remote sensing technique for drought identification and characterization, tools to improve surface water resources management under drought conditions, methods and tools for groundwater resources monitoring and management based on hydrogeological and hydrodynamics characteristics of aquifers, general criteria to select and implement mitigation strategies to prevent or

minimize drought impacts      *Extremes in Nature* Gianfausto Salvadori, Carlo De Michele, Nathabandu T. Kottegoda, Renzo Rosso, 2007-06-01 This book is about the theoretical and practical aspects of the statistics of Extreme Events in Nature Most importantly this is the first text in which Copulas are introduced and used in Geophysics Several topics are fully original and show how standard models and calculations can be improved by exploiting the opportunities offered by Copulas In addition new quantities useful for design and risk assessment are introduced      **The Rio Chagres, Panama** Russell S. Harmon, 2005-06-14 This book examines one of the most important and complex of the world's tropical rainforest regions the greater Panama Canal Watershed The Rio Chagres is the primary water source for operating the Canal and supplies potable water for municipal use and electricity generation but science has left this important national resource largely unstudied The text promotes understanding of the physical and ecological components of an isolated and largely pristine tropical rainforest

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## **Table of Contents Entropy Based Parameter Estimation In Hydrology**

1. Understanding the eBook Entropy Based Parameter Estimation In Hydrology
  - The Rise of Digital Reading Entropy Based Parameter Estimation In Hydrology
  - Advantages of eBooks Over Traditional Books
2. Identifying Entropy Based Parameter Estimation In Hydrology
  - Exploring Different Genres
  - Considering Fiction vs. Non-Fiction
  - Determining Your Reading Goals
3. Choosing the Right eBook Platform
  - Popular eBook Platforms
  - Features to Look for in an Entropy Based Parameter Estimation In Hydrology
  - User-Friendly Interface
4. Exploring eBook Recommendations from Entropy Based Parameter Estimation In Hydrology
  - Personalized Recommendations
  - Entropy Based Parameter Estimation In Hydrology User Reviews and Ratings
  - Entropy Based Parameter Estimation In Hydrology and Bestseller Lists
5. Accessing Entropy Based Parameter Estimation In Hydrology Free and Paid eBooks
  - Entropy Based Parameter Estimation In Hydrology Public Domain eBooks
  - Entropy Based Parameter Estimation In Hydrology eBook Subscription Services

- Entropy Based Parameter Estimation In Hydrology Budget-Friendly Options
- 6. Navigating Entropy Based Parameter Estimation In Hydrology eBook Formats
  - ePub, PDF, MOBI, and More
  - Entropy Based Parameter Estimation In Hydrology Compatibility with Devices
  - Entropy Based Parameter Estimation In Hydrology Enhanced eBook Features
- 7. Enhancing Your Reading Experience
  - Adjustable Fonts and Text Sizes of Entropy Based Parameter Estimation In Hydrology
  - Highlighting and Note-Taking Entropy Based Parameter Estimation In Hydrology
  - Interactive Elements Entropy Based Parameter Estimation In Hydrology
- 8. Staying Engaged with Entropy Based Parameter Estimation In Hydrology
  - Joining Online Reading Communities
  - Participating in Virtual Book Clubs
  - Following Authors and Publishers Entropy Based Parameter Estimation In Hydrology
- 9. Balancing eBooks and Physical Books Entropy Based Parameter Estimation In Hydrology
  - Benefits of a Digital Library
  - Creating a Diverse Reading Collection Entropy Based Parameter Estimation In Hydrology
- 10. Overcoming Reading Challenges
  - Dealing with Digital Eye Strain
  - Minimizing Distractions
  - Managing Screen Time
- 11. Cultivating a Reading Routine Entropy Based Parameter Estimation In Hydrology
  - Setting Reading Goals Entropy Based Parameter Estimation In Hydrology
  - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Entropy Based Parameter Estimation In Hydrology
  - Fact-Checking eBook Content of Entropy Based Parameter Estimation In Hydrology
  - Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
  - Utilizing eBooks for Skill Development
  - Exploring Educational eBooks
- 14. Embracing eBook Trends

- Integration of Multimedia Elements
- Interactive and Gamified eBooks

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