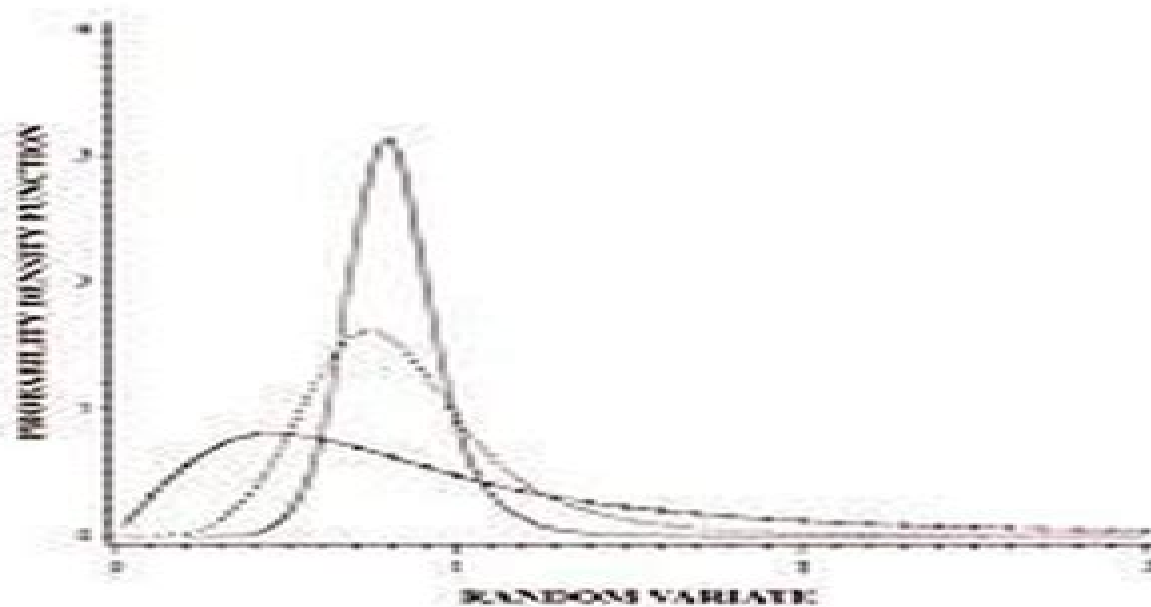


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# ENTROPY-BASED PARAMETER ESTIMATION IN HYDROLOGY

by  
Vijay P. Singh



# Entropy Based Parameter Estimation In Hydrology

**Vijay Singh**



## **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

*Entropy Theory and its Application in Environmental and Water Engineering* Vijay P. Singh, 2013-01-10 Entropy Theory and its Application in Environmental and Water Engineering responds to the need for a book that deals with basic concepts of entropy theory from a hydrologic and water engineering perspective and then for a book that deals with applications of these concepts to a range of water engineering problems The range of applications of entropy is constantly expanding and new areas finding a use for the theory are continually emerging The applications of concepts and techniques vary across different subject areas and this book aims to relate them directly to practical problems of environmental and water engineering The book presents and explains the Principle of Maximum Entropy POME and the Principle of Minimum Cross Entropy POMCE and their applications to different types of probability distributions Spatial and inverse spatial entropy are important for urban planning and are presented with clarity Maximum entropy spectral analysis and minimum cross entropy spectral analysis are powerful techniques for addressing a variety of problems faced by environmental and water scientists and engineers and are described here with illustrative examples Giving a thorough introduction to the use of entropy to measure the unpredictability in environmental and water systems this book will add an essential statistical method to the toolkit of postgraduates researchers and academic hydrologists water resource managers environmental scientists and engineers It will also offer a valuable resource for professionals in the same areas governmental organizations private companies as well as students in earth sciences civil and agricultural engineering and agricultural and

rangeland sciences This book Provides a thorough introduction to entropy for beginners and more experienced users Uses numerous examples to illustrate the applications of the theoretical principles Allows the reader to apply entropy theory to the solution of practical problems Assumes minimal existing mathematical knowledge Discusses the theory and its various aspects in both univariate and bivariate cases Covers newly expanding areas including neural networks from an entropy perspective and future developments

### **Entropy Measures, Maximum Entropy Principle and Emerging Applications**

Karmeshu,2012-10-01 The last two decades have witnessed an enormous growth with regard to applications of information theoretic framework in areas of physical biological engineering and even social sciences In particular growth has been spectacular in the field of information technology soft computing nonlinear systems and molecular biology Claude Shannon in 1948 laid the foundation of the field of information theory in the context of communication theory It is indeed remarkable that his framework is as relevant today as was when he first proposed it Shannon died on Feb 24 2001 Arun Netravali observes As if assuming that inexpensive high speed processing would come to pass Shannon figured out the upper limits on communication rates First in telephone channels then in optical communications and now in wireless Shannon has had the utmost value in defining the engineering limits we face Shannon introduced the concept of entropy The notable feature of the entropy framework is that it enables quantification of uncertainty present in a system In many realistic situations one is confronted only with partial or incomplete information in the form of moment or bounds on these values etc and it is then required to construct a probabilistic model from this partial information In such situations the principle of maximum entropy provides a rational basis for constructing a probabilistic model It is thus necessary and important to keep track of advances in the applications of maximum entropy principle to ever expanding areas of knowledge

### **Chaos in Hydrology**

Bellie Sivakumar,2016-11-16 This authoritative book presents a comprehensive account of the essential roles of nonlinear dynamic and chaos theories in understanding modeling and forecasting hydrologic systems This is done through a systematic presentation of 1 information on the salient characteristics of hydrologic systems and on the existing theories for their modeling 2 the fundamentals of nonlinear dynamic and chaos theories methods for chaos identification and prediction and associated issues 3 a review of the applications of chaos theory in hydrology and 4 the scope and potential directions for the future This book bridges the divide between the deterministic and the stochastic schools in hydrology and is well suited as a textbook for hydrology courses

### ***Copulas and their Applications in Water Resources Engineering* Lan Zhang,V. P.**

Singh,2019-01-10 Complex environmental and hydrological processes are characterized by more than one correlated random variable These events are multivariate and their treatment requires multivariate frequency analysis Traditional analysis methods are however too restrictive and do not apply in many cases Recent years have therefore witnessed numerous applications of copulas to multivariate hydrologic frequency analyses This book describes the basic concepts of copulas and outlines current trends and developments in copula methodology and applications It includes an accessible discussion of the

methods alongside simple step by step sample calculations Detailed case studies with real world data are included and are organized based on applications such as flood frequency analysis and water quality analysis Illustrating how to apply the copula method to multivariate frequency analysis engineering design and risk and uncertainty analysis this book is ideal for researchers professionals and graduate students in hydrology and water resources engineering Drought Management on Farmland Joan Sydney Whitmore,2013-03-14 At last integrated management of drought on farms is dealt with in one comprehensive book Although drought is a highly variable near universal natural phenomenon which has repercussions on a country's water and food supplies and many other sectors of the economy there are many ways of avoiding resisting and mitigating the effects of drought Pro active preparedness entails using the principles of risk management to upgrade the drought resistance of a farm systematically and to have auxiliary contingency plans at the ready for use during unusually long droughts The book provides tools for these strategies as it covers the management of water soils crops rangeland fodder and livestock and many other drought related topics Audience This book will be an important source of information for university and college staff and students in agricultural sciences water and land use environmental management geography and risk management and also farmers agricultural advisors and policy makers Information Theory and Artificial Intelligence to Manage Uncertainty in Hydrodynamic and Hydrological Models Abebe Andualem Jemberie,2014-04-21 The complementary nature of physically based and data driven models in their demand for physical insight and historical data leads to the notion that the predictions of a physically based model can be improved and the associated uncertainty can be systematically reduced through the conjunctive use of a data driven model of the residuals The objective of this thesis is to minimise the inevitable mismatch between physically based models and the actual processes as described by the mismatch between predictions and observations The complementary modelling approach is applied to various hydrodynamic and hydrological models **Introduction to Environmental Data Science** William W. Hsieh,2023-03-23 A comprehensive guide to machine learning and statistics for students and researchers of environmental data science **The Decline Effect** Dean Brooks,2023-01-31 A crisis is coming for everyone who uses math and science For decades now the classical model of probability the indifference principle and the Gaussian distribution has been breaking down and revealing its limitations in fields from economics to epidemiology Now a new approach has revealed the underlying non classical principle behind all these anomalous laws Pareto's law of elite incomes Zipf's law of word frequencies Lotka's law of scientific publications Kleiber's law of metabolic rates the Clausewitz Dupuy law of combat friction Moore's law of computing costs the Wright Henderson cost law Weibull's law of electronics failures the Flynn Effect in IQ scores Benford's law of digit frequencies Farr's law of epidemics Hubbell's neutral theory of biodiversity Rogers law of innovation classes Wilson's law of island biogeography Smeed's law of traffic fatalities The general law behind all these particular laws and countless others is the decline effect As a system ages or grows in size the rules of probability subtly change Entropy increases rare items become

rarer and average performance measures decline The human meaning of a decline may be positive decreasing costs falling epidemic mortality or negative lower customer loyalty decreasing efficiency but the mathematical pattern is always the same The implications are enormous as these examples show All epidemic diseases decline in infectiousness and in lethality HIV AIDS went from a highly infectious 95 percent fatal disease to a survivable condition with a latency of decades COVID 19 went from a death rate of 7 percent in early 2020 to under 2 percent in 2022 Hereditary dynasties around the world declined smoothly in lifespan from hundreds of years to tens of years When democracies replaced monarchies the decline in spans of party control continued

Handbook of Hydraulic Geometry Vijay P. Singh, 2022-12-08 An introduction to hydraulic geometry discussion of different related theories and their application in river engineering Handbook of Hydraulic Geometry provides an excellent summary for hydraulic engineers as well as graduate students and researchers in fluvial geomorphology and environmental engineering

**Drought Management Planning in Water Supply Systems** Enrique Cabrera, Jorge García-Serra, 2013-06-29 During the past decade many countries in the world have experienced droughts with severe impacts on water urban supply systems Because droughts are natural phenomena water utilities must design and implement drought management plans This topic was selected for the International Course on Drought Management Planning in Water Supply Systems which took place in Valencia Spain on 9 12 December 1997 and was hosted by the Universidad Internacional Menéndez y Pelayo UIMP The contributions in this book have been carefully selected and presented in four sections Introduction Water Supply Systems Modernization Drought Management in an Urban Context Practical Cases Israel USA Italy Spain To achieve a well balanced approach authors were invited from academia as well as from consultancies and water utilities and have wide experience in the subject The book is mainly aimed at water supply engineers working in utilities and consultancies

**Water, Environment and Society in Times of Climatic Change** Arie S. Issar, N. Brown, 2013-04-17 Since the greenhouse effect emerged as a predictable threat necessitating the evaluation of its future impact on the environment in the various parts of the globe interest in the climate changes during the Holocene has gained momentum The background can be summarized by the sentence The past is a key to the future As a matter of fact this sentence is in the opposite direction on the dimension of time to the principle adopted by the founders of the science of geology They proposed that geological processes in the present should be used as a key for understanding the past Another reason for the interest in the history of the climate of the Holocene can be described as the renaissance of a modified deterministic approach to the inter relation between physical and human geography This relates in the first place to the fact that various investigations especially as carried out by Hubert Lamb showed that the sequence of climate changes previously suggested by Blytt and Sernander for Europe and adopted by most Holocene climatologists was far too general and that there were more climate changes during recent history than previously taken account of In the second place it was found out that these changes had had an impact on the history of human communities Thus one can conclude that once the taboo on

geographical determinism i e 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

Environmental Systems - Volume II Achim Sydow, 2010-09-27 Environmental Systems is a component of Encyclopedia of Environmental and Ecological Sciences Engineering and Technology Resources in the global Encyclopedia of Life Support Systems EOLSS which is an integrated compendium of twenty one Encyclopedias Environmental Systems is something about data handling modeling and decision making in the field of environmental systems It includes related basic knowledge on measurement techniques modeling techniques and models and their applications for decisions making Environmental engineering research are based on measurement techniques and related knowledge of natural and life sciences Developed mathematical and numerical simulation models are tools and strictly purpose oriented that means suitable for decision making The three volumes on Environmental Systems are aimed at the following five major target audiences University and College students Educators Professional practitioners Research personnel and Policy analysts managers and decision makers and NGOs Geotechnical Reliability Analysis Jie Zhang, Te Xiao, Jian Ji, Peng Zeng, Zijun Cao, 2023-09-14 This textbook



systematically introduces the theories methods and algorithms for geotechnical reliability analysis There are a lot of illustrative examples in the textbook such that readers can easily grasp the concepts and theories related to geotechnical reliability analysis A unique feature of the textbook is that computer codes are also provided through carefully designed examples such that the methods and the algorithms described in the textbook can be easily understood In addition the computer codes are flexible and can be conveniently extended to analyze different types of realistic problems with little additional efforts

**Planning and Evaluation of Irrigation Projects** Raveendra Kumar Rai,Vijay P. Singh,Alka Upadhyay,2017-04-06 Planning and Evaluation of Irrigation Projects Methods and Implementation presents the considerations options and factors necessary for effective implementation of irrigation strategies going further to provide methods for evaluating the efficiency of systems in place for remedial correction as needed As the first book to take this lifecycle approach to agricultural irrigation it includes real world examples not only on natural resource availability concerns but also on financial impacts and measurements With 21 chapters divided into two sections this book is a valuable resource for agricultural and hydrology engineers conservation scientists and anyone seeking to implement and maintain irrigation systems Uses real world examples to present practical insights Incorporates both planning and evaluation for full scope understanding and application Illustrates both potential benefits and limitations of irrigation solutions Provides potential means to increase crop productivity that can result in improved farm income

*Mathematical Statistics and Applications* Constance van Eeden,Marc Moore,2003

*Generalized Frequency Distributions for Environmental and Water Engineering* Vijay P. Singh,Lan Zhang,2022-04-07 A multitude of processes in hydrology and environmental engineering are either random or entail random components which are characterized by random variables These variables are described by frequency distributions This book provides an overview of different systems of frequency distributions their properties and applications to the fields of water resources and environmental engineering A variety of systems are covered including the Pearson system Burr system and systems commonly applied in economics such as the D Addario Dagum Stoppa and Esteban systems The latter chapters focus on the Singh system and the frequency distributions deduced from Bessel functions maximum entropy theory and the transformations of random variables The final chapter introduces the genetic theory of frequency distributions Using real world data this book provides a valuable reference for researchers graduate students and professionals interested in frequency analysis

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