Statistical Downscaling And Bias Correction For

Global climate change is typically understood and modeled using global climate models (GCMs), but the outputs of these models in terms of hydrological variables are only available on coarse or large spatial and time scales, while finer spatial and temporal resolutions are needed to reliably assess the hydro-environmental impacts of climate change. To reliably obtain the required resolutions of hydrological variables, statistical downscaling is typically employed. Statistical Downscaling for Hydrological and Environmental Applications presents statistical downscaling techniques in a practical manner so that both students and practitioners can readily utilize them. Numerous methods are presented, and all are illustrated with practical examples. The book is written so that no prior background in statistics is needed, and it will be useful to graduate students, college faculty, and researchers in hydrology, hydroclimatology, agricultural and environmental sciences, and watershed management. It will also be of interest to environmental policymakers at the local, state, and national levels, as well as readers interested in climate change and its related hydrologic impacts. Features: Examines how to model hydrological events such as extreme rainfall, floods, and droughts at the local, watershed level. Explains how to properly correct for significant biases with the observational data normally found in current Global Climate Models (GCMs). Presents temporal downscaling from daily to hourly with a nonparametric approach. Discusses the myriad effects of climate change on hydrological processes.

Regional climate impact assessments require high-resolution projections to resolve local factors that modify the impact of global-scale forcing. To generate these projections, global climate model simulations are commonly downscaled using a variety of statistical and dynamical techniques. Despite the essential role of downscaling in regional assessments, there is no standard approach to evaluating various downscaling methods. Hence, impact communities often have little awareness of limitations and uncertainties associated with downscaled projections. To develop a standardized framework for evaluating and comparing downscaling approaches, I first identify three primary characteristics of a distribution directly relevant to impact analyses that can be used to evaluate a simulated variable such as temperature or precipitation at a given location: (1) annual, seasonal, and monthly mean values; (2) thresholds, extreme values, and accumulated quantities such as 24h precipitation or degree-days; and (3) persistence, reflecting multi-day events such as heat waves, cold spells, and wet periods. Based on a survey of the literature and solicitation of expert opinion, I select a set of ten statistical tests to evaluate these characteristics, including measures of error, skill, and correlation. I apply this framework to evaluate the skill of four downscaling methods, from a simple delta approach to a complex asynchronous quantile regression, in simulating daily temperature at twenty stations across North America. Identical global model fields force each downscaling method, and the historical observational record at each location is randomly divided by year into two equal parts, such that each statistical method is trained on one set of historical observations, and evaluated on an entirely independent set of observations. Biases relative to observations are calculated for the historical evaluation period, and differences between projections for the future. Application of the framework to this broad range of downscaling methods and locations is successful in that: (1) the downscaling method used is identified as a more important determinant of data quality than station location or GCM; and (2) key differences between downscaling methods are made apparent. For tests focusing on the general distribution of the variable, all methods except bias correction are relatively successful in simulating observed climate, suggesting that if an impact is most sensitive to changes in the mean, even a relatively simple downscaling approach such as 0??delta0?+ will significantly improve simulation of local-scale climate. For tests that focus on the tails

of the distribution, however, differences do arise between simple vs. quantile-based downscaling methods. Specifically, the latter appears less sensitive to location and more consistently able to reproduce observed climate. In terms of future projections, the most notable differences between downscaling methods becomes apparent at the right-hand tail of the distribution, where simple methods tend to simulate much greater increases (up to double the extreme heat days, for some locations) than more complex downscaling methods. I conclude by discussing how a standardized evaluation framework may advance our understanding of regional climate impact studies in understanding biases and limitations in results, as well as providing critical input into the selection of downscaling methods for future assessments. Given the potential exhibited by this initial test, I explore how this evaluation framework could be expanded in the future to make it even more useful: to the regional scale, for example, by including tests for spatial correlations and forcing relationships; or across variables, to capture interactions directly relevant to impact studies, such as heat waves (a function of temperature and humidity, affecting human health, energy demand, and agriculture) or snow amounts (a function of precipitation and temperature, affecting infrastructure and ecosystems); or to evaluate a broader selection of climate variables, downscaling methods, and predictor fields.

Hydroclimatic extremes, such as floods and droughts, affect aspects of our lives and the environment including energy, hydropower, agriculture, transportation, urban life, and human health and safety. Climate studies indicate that the risk of increased flooding and/or more severe droughts will be higher in the future than today, causing increased fatalities, environmental degradation, and economic losses. Using a suite of innovative approaches this book quantifies the changes in projected hydroclimatic extremes and illustrates their impacts in several locations in North America, Asia, and Europe.

This book presents the main hydrological methods and techniques used in the design and operation of hydraulic projects and the management of water resources and associated natural risks. It covers the key topics of water resources engineering, from the estimation of runoff volumes and unit hydrographs to the routing of flows along a river and throu

This book is a collection of overview articles showing how space-based observations, combined with hydrological modeling, have considerably improved our knowledge of the continental water cycle and its sensitivity to climate change. Two main issues are highlighted: (1) the use in combination of space observations for monitoring water storage changes in river basins worldwide, and (2) the use of space data in hydrological modeling either through data assimilation or as external constraints. The water resources aspect is also addressed, as well as the impacts of direct anthropogenic forcing on land hydrology (e.g. ground water depletion, dam building on rivers, crop irrigation, changes in land use and agricultural practices, etc.). Remote sensing observations offer important new information on this important topic as well, which is highly useful for achieving water management objectives. Over the past 15 years, remote sensing techniques have increasingly demonstrated their capability to monitor components of the water balance of large river basins on time scales ranging from months to decades: satellite altimetry routinely monitors water level changes in large rivers, lakes and floodplains. When combined with satellite imagery, this technique can also measure surface water volume variations. Passive and active microwave sensors offer important information on soil moisture (e.g. the SMOS mission) as well as wetlands and snowpack. The GRACE space gravity mission offers, for the first time, the possibility of directly measuring spatio-temporal variations in the total vertically integrated terrestrial water storage. When combined with other space observations (e.g. from satellite altimetry and SMOS) or model estimates of surface waters and soil moisture, space gravity data can effectively measure groundwater storage variations. New satellite missions, planned for the coming years, will complement the constellation of satellites monitoring waters on land. This is particularly the case for the SWOT mission, which is expected to revolutionize land surface

hydrology. Previously published in Surveys in Geophysics, Volume 37, No. 2, 2016

The World population will reach 9 billion by 2050, with the majority of this growth occurring in developing countries. On the other hand, one in nine of the World's population suffers from chronic hunger, the vast majority of which live in developing countries. We therefore need to find new and sustainable solutions to feed this increasing population and alleviate the predicted negative impact of global changes on crop production. This e-Book deals with new strategies to improve food security and livelihoods in rural communities, reduce vulnerability, increase resilience and mitigate lthe impact of climate change and land degradation on agriculture. This collection of 18 articles addresses the major abiotic factors limiting crop production worldwide, how to characterize and exploit the available plant biodiversity to increase production and sustainability in agrosystems, and the use of beneficial microbes to improve production and reduce the use of fertilizers and pesticides.

This book describes thoroughly the North American Climate of the past 65 million years, with special emphasis on the last 21,000 years, as revealed by paleoclimatic observations and climate models. It analyzes weather observations over the past century and satellite measurements of the last few decades to develop a picture of more recent climatic trends. It explains how global climate models are used to simulate and project climate, and presents the application of these models to reproduce recent climate variations and predict future North American climate. It answers the critical question of whether observed climate change is due to natural variations or human activity.

This book presents the result of an innovative challenge, to create a systematic literature overview driven by machine-generated content. Questions and related keywords were prepared for the machine to query, discover, collate and structure by Artificial Intelligence (AI) clustering. The AI-based approach seemed especially suitable to provide an innovative perspective as the topics are indeed both complex, interdisciplinary and multidisciplinary, for example, climate, planetary and evolution sciences. Springer Nature has published much on these topics in its journals over the years, so the challenge was for the machine to identify the most relevant content and present it in a structured way that the reader would find useful. The automatically generated literature summaries in this book are intended as a springboard to further discoverability. They are particularly useful to readers with limited time, looking to learn more about the subject quickly and especially if they are new to the topics. Springer Nature seeks to support anyone who needs a fast and effective start in their content discovery journey, from the undergraduate student exploring interdisciplinary content, to Master- or PhD-thesis developing research questions, to the practitioner seeking support materials, this book can serve as an inspiration, to name a few examples. It is important to us as a publisher to make the advances in technology easily accessible to our authors and find new ways of AI-based author services that allow human-machine interaction to generate readable, usable, collated, research content.

This book presents advanced knowledge on the relationships between climate change and agriculture, and various adaptation techniques such as low tillage, salt-adapted beneficial microbes and closed systems. Climate change is unavoidable but adaptation is possible. Climate change and agriculture are interrelated processes, both of which take place on a global scale. Climate change affects agriculture through changes in average temperatures, rainfall and climate extremes; changes in pests and diseases; changes in atmospheric carbon dioxide; changes in the nutritional quality of some foods; and changes in sea level. Various modeling methodologies are available to aid planning and operational decision making: this book synthesises these, with an emphasis on methodologies applicable in data scarce regions, such as developing countries. Problems included in each chapter, and supported by links to available online data sets and modeling tools, engage the reader with practical applications of

the models. Academic researchers in the fields of hydrology, climate change, and environmental science and hazards, and professionals and policy-makers working in hazard mitigation, remote sensing and hydrological engineering will find this an invaluable resource. This volume is the second in a collection of four books on flood disaster management theory and practice within the context of anthropogenic climate change. The others are: Floods in a Changing Climate: Extreme Precipitation by Ramesh Teegavarapu, Floods in a Changing Climate: Inundation Modelling by Giuliano Di Baldassarre and Floods in a Changing Climate: Risk Management by Slodoban P. Simonovi?.

This book presents several complex case studies related to water management and planning in the context of pollution, growing demands, and global climate change in Mexico, but which are also relevant for other countries in Latin America. These concerns are of critical importance for policymakers who are coping with multiple conflicting interests. Water availability in Mexico is polarized, with abundant rainfall and large rivers in the south, and desert-like conditions in the north. The central region, which is the most industrialized, is overpopulated. Mexico City pours millions of cubic meters of "blackwater" into the northern valley daily and receives its clean water from the south. To address these unsustainable conditions, the world's 4th biggest water treatment plant went into operation in 2018. The water infrastructure and governance must satisfy the demands of all sectors, including agricultural, urban, and economic activities. At the same time, water resources are affected by drought, and climate change puts constraints on the supply. As such, regulation and monitoring are important when it comes to adherence to agreed plans and priorities. The book is divided into four sections. 1: Water Availability discusses quantitative aspects, such as supply, methods of calculation, and fracking. 2: Water Quality highlights pollution risks and diagnosis of water resources. 3: Water Allocation examines the sectoral demands and vulnerability due to unsustainable irrigation. 4: Water Governance and Management focuses on laws, urban rules, national parks, planning, and integrated water resources management, among other topics. The chapters include illustrative case studies in Mexico, such as basins, cities, reservoirs, and aquifers, water supply demand assessment, planning, and management.

This book provides an interdisciplinary view of how to prepare the ecological and socio-economic systems to the reality of climate change. Scientifically sound tools are needed to predict its effects on regional, rather than global, scales, as it is the level at which socio-economic plans are designed and natural ecosystem reacts. The first section of this book describes a series of methods and models to downscale the global predictions of climate change, estimate its effects on biophysical systems and monitor the changes as they occur. To reduce the magnitude of these changes, new ways of economic activity must be implemented. The second section of this book explores different options to reduce greenhouse emissions from activities such as forestry, industry and urban development. However, it is becoming increasingly clear that climate change can be minimized, but not avoided, and therefore the socio-economic systems around the world will have to adapt to the new conditions to reduce the adverse impacts to the minimum. The last section of this book explores some options for adaptation.

Provides measurement, analysis and modeling methods for assessment of trends in extreme precipitation events, for academic

researchers and professionals.

?This book is an update of the first BACC assessment, published in 2008. It offers new and updated scientific findings in regional climate research for the Baltic Sea basin. These include climate changes since the last glaciation (approx. 12,000 years ago), changes in the recent past (the last 200 years), climate projections up until 2100 using state-of-the-art regional climate models and an assessment of climate-change impacts on terrestrial, freshwater and marine ecosystems. There are dedicated new chapters on sea-level rise, coastal erosion and impacts on urban areas. A new set of chapters deals with possible causes of regional climate change along with the global effects of increased greenhouse gas concentrations, namely atmospheric aerosols and land-cover change. The evidence collected and presented in this book shows that the regional climate has already started to change and this is expected to continue. Projections of potential future climates show that the region will probably become considerably warmer and wetter in some parts, but dryer in others. Terrestrial and aquatic ecosystems have already shown adjustments to increased temperatures and are expected to undergo further changes in the near future. The BACC II Author Team consists of 141 scientists from 12 countries, covering various disciplines related to climate research and related impacts. BACC II is a project of the Baltic Earth research network and contributes to the World Climate Research Programme.

The Earth's average temperature has risen by 1.4°F over the past century, and computer models project that it will rise much more over the next hundred years, with significant impacts on weather, climate, and human society. Many climate scientists attribute these increases to the build up of greenhouse gases produced by the burning of fossil fuels and to the anthropogenic production of short-lived climate pollutants. Climate Change Modeling Methodologies: Selected Entries from the Encyclopaedia of Sustainability Science and Technology provides readers with an introduction to the tools and analysis techniques used by climate change scientists to interpret the role of these forcing agents on climate. Readers will also gain a deeper understanding of the strengths and weaknesses of these models and how to test and assess them. The contributions include a glossary of key terms and a concise definition of the subject for each topic, as well as recommendations for sources of more detailed information.

This book offers an up-to-date review of our current understanding of climate change in the North Sea and adjacent areas, as well as its impact on ecosystems and socio-economic sectors. It provides a detailed assessment of climate change based on published scientific work compiled by independent international experts from climate-related disciplines such as oceanography, atmospheric sciences, marine and terrestrial ecology, using a regional evaluation and review process similar to that of the Intergovernmental Panel on Climate Change (IPCC). It provides a comprehensive overview of all aspects of our changing climate, discussing a wide range of topics including past, current and future climate change, and climate-related changes in marine, terrestrial and freshwater ecosystems. It also explores the impact of climate change on socio-economic sectors such as fisheries, agriculture, coastal zone management, coastal protection, urban climate, recreation/tourism, offshore activities/energy, and air pollution.

Statistical Downscaling and Bias Correction for Climate ResearchCambridge University Press

This book provides essential insights into methods and practices of 'Climate-smart Agriculture,' which is driven by the

principles of climate resilience and smart resource use in agricultural production. Climate-smart agriculture is a key policy instrument for achieving poverty eradication and a hunger-free world, as well as mitigating the effects of climate change. This book discusses in detail climate-smart agricultural technologies and practices that can reduce the vulnerability of agricultural systems, improve the livelihoods of farmers and other stakeholders, and reduce the greenhouse gas emissions from crop production and livestock husbandry. The agriculture, forestry and other land use (AFOLU) sector produces roughly 10–12 gigatons of CO_2-equivalent per year; therefore, sustainable practices for agriculture and related land use hold immense potential to mitigate climate change. The potential impacts of climate variability and climate change on agriculture are extensively documented and articulated, especially with regard to global and national environmental agendas that call for innovation, transformation and climate-resilient advances in agriculture. As the book demonstrates, climate-smart agriculture offers an excellent tool for boosting agricultural output to feed the growing global population; for reducing greenhouse gases emissions from agriculture and other land use; and for protecting agricultural production systems from the impending dangers of climate change.

This volume constitutes the refereed post-conference proceedings of the International Conference on Theoretical Computer Science and Discrete Mathematics, held in Krishnankoil, India, in December 2016. The 57 revised full papers were carefully reviewed and selected from 210 submissions. The papers cover a broad range of topics such as line graphs and its generalizations, large graphs of given degree and diameter, graphoidal covers, adjacency spectrum, distance spectrum, b-coloring, separation dimension of graphs and hypergraphs, domination in graphs, graph labeling problems, subsequences of words and Parike matrices, lambda-design conjecture, graph algorithms and interference model for wireless sensor networks.

Using accessible farming practices to meet the growing demands on agriculture is likely to result in more intense competition for natural resources, increased greenhouse gas emissions, and further deforestation and land degradation, which will in turn produce additional stress in the soil-water-plant-animal continuum. Stress refers to any unfavorable force or condition that inhibits customary functioning in plants. Concurrent manifestations of different stresses (biotic and abiotic) are very frequent in the environment of plants, which consequently reduces yield. Better understanding stress not only changes our perspective on the current environment, but can also bring a wealth of benefits, like improving sustainable agriculture and human beings' living standards. Innovative systems are called for that protect and enhance the natural resource base, while increasing productivity via 'holistic' approaches, such as agroecology, agro-forestry, climate-smart agriculture and conservation agriculture, which also incorporate indigenous and traditional knowledge. The book 'New Frontiers in Stress Management for Durable Agriculture' details the current state of knowledge and highlights

scientific advances concerning novel aspects of plant biology research on stress, biotic and abiotic stress responses, as well as emergent amelioration and reclamation technologies to restore normal functioning in agroecology.

In recent decades, population growth and global warming consequent to greenhouse gas emissions because of human activities, has changed the atmospheric composition leading to intensifying extreme climate phenomena and overall increase of extreme events. These extreme events have caused human suffering and devastating effects in recent record-breaking warming years. To mitigate adverse consequences arising from global warming, the best strategy is to project the future probabilistic behavior of extreme climate phenomena under changing environment. The first contribution of this research is to improve the predictive power of regression-based statistical downscaling processes to accurately project the future behavior of extreme climate phenomena. First, a supervised dimensionality reduction algorithm is proposed for the statistical downscaling to derive a low-dimensional manifold representing climate change signals encoding of high-dimensional atmospheric variables. Such an algorithm is novel in climate change studies as past literature has focused on deriving low-dimensional principal components from large-scale atmospheric projectors without taking into account the target hydro-climate variables. The new algorithm called Supervised Principal Component analysis (Supervised PCA) outperforms all of the existing state-of-the-art dimensionality reduction algorithms. The model improves the performance of the statistical downscaling modelling through deriving subspaces that have maximum dependency with the target hydro-climate variables. A kernel version of Supervised PCA is also introduced to reduce nonlinear dimensionality and capture all of the nonlinear and complex variabilities between hydro-climate response variable and atmospheric projectors. To address the biases arising from difference between observed and simulated large-scale atmospheric projectors, and to represent anomalies of low frequency variability of teleconnections in General Circulation Models (GCMs), a Multivariate Recursive Nesting Bias Correction (MRNBC) is proposed to the regression-based statistical downscaling. The proposed method is able to use multiple variables in multiple locations to simultaneously correct temporal and spatial biases in cross dependent multi-projectors. To reduce another source of uncertainty arising from complexity and nonlinearity in quantitative empirical relationships in the statistical downscaling, the results demonstrate the superiority of a Bayesian machine-learning algorithm. The predictive power of the statistical downscaling is therefore improved through addressing the aforementioned sources of uncertainty. This results in improvement of the projection of the global warming impacts on the probabilistic behavior of hydro-climate variables using future multi-model ensemble GCMs under forcing climate change scenarios. The results of two Design-of-Experiments also reveal that the proposed comprehensive statistical downscaling is credible and adjustable to the changes under non-stationary conditions arising from climate change. Under the impact of climate change arising from anthropogenic global warming, it is demonstrated

that the nature and the risk of extreme climate phenomena are changed over time. It is also well known that the extreme climate processes are multi-dimensional by their very nature characterized by multi-dimensions that are highly dependent. Accordingly, to strength the reliability of infrastructure designs and the management of water systems in the changing climate, it is of crucial importance to update the risk concept to a new adaptive multi-dimensional time-varying one to integrate anomalies of dynamic anthropogenically forced environments. The main contribution of this research is to develop a new generation of multivariate time-varying risk concept for an adaptive design framework in non-stationary conditions arising from climate change. This research develops a Bayesian, dynamic conditional copula model describing time-varying dependence structure between mixed continuous and discrete marginals of extreme multi-dimensional climate phenomena. The framework is able to integrate any anomalies in extreme multi-dimensional events in non-stationary conditions arising from climate change. It generates iterative samples using a Markov Chain Monte Carlo (MCMC) method from the full conditional marginals and joint distribution in a fully likelihood-based Bayesian inference. The framework also introduces a fully Bayesian, time-varying Joint Return Period (JRP) concept to quantify the extent of changes in the nature and the risk of extreme multi-dimensional events over time under the impact of climate change. The proposed generalized time-dependent risk framework can be applied to all stochastic multi-dimensional climate systems that are under the influence of changing environments.

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.

Impacts of Climate Change on Rainfall Extremes and Urban Drainage Systems provides a state-of-the-art overview of existing methodologies and relevant results related to the assessment of the climate change impacts on urban rainfall extremes as well as on urban hydrology and hydraulics.

"A lot of research has been carried out using statistical methods in downscaling large-scale GCM outputs to the local site or small-scale region. Using statistical methods, empirical relationships are developed between the large-scale GCM outputs and the local site weather variables. In this methodology, it is assumed that these empirical relationships will also hold true even in the future periods of time. Environmental assessment studies for the future decade under the influence of a changing climate is the need of the hour. In order to identify the future synoptic weather types, future daily and hourly projections of the weather variables are required. Hence, this research is motivated by the lack of a comprehensive and statistically significant downscaling methodology for the various weather variables. The present study is based on the

various statistical downscaling techniques developed by the researchers in the past using linear regression model because of the advantage of being less computationally intensive. In addition, an attempt has been made to develop an improved statistical downscaling methodology by combining different techniques to develop a robust method with a detailed performance assessment of the models. Linear Regression models are derived to downscale daily climate scenarios using NCEP reanalysis datasets for the predictors and weather station data available at Trudeau International Airport for the predictands during the reference period 1958-2001. The NCEP predictors are regridded to the GCM scale as the GCM outputs are to be used for deriving future climate projections. Standardization and Deseasonalization of the predictor variables are carried out followed by principal component analysis prior to their introduction into the stepwise regression model. CANESM2 is selected as the GCM model in the present work whose outputs are used as predictors in the NCEP derived regression models. A Bias Correction procedure is used to correct the systematic biases present using a quantile-quantile mapping technique on the downscaled variable using CANESM2 predictors. After downscaling the daily climate variables, hourly downscaling transfer functions are derived based on the historical relationships of the hourly values with its daily mean as well as other weather predictors where appropriate. For the future climate projections, RCP2.6, 4.5 and 8.5 are used as greenhouse gas trajectories representing the change in climate in the future decade." --

Water resources systems provide multiple services and, if managed properly, can contribute significantly to social well-being and economic growth. However, extreme or unexpected hydroclimatic conditions, such as droughts and floods, can adversely affect or even completely interrupt these services. This manual seeks to provide knowledge, resources and techniques for water resources professionals to manage the risks and opportunities arising from hydroclimatic variability and change. Managing Climate Risk in Water Supply Systems provides materials and tools designed to empower technical professionals to better understand the key issues in water supply systems. These materials are part of a suite of resources that are developed to share climate risk knowledge related to a range of sectors and climate-related problems. The text motivates students by providing practical exercises and it stimulates readers or workshop participants to consider options and analyses that will highlight opportunities for better management in the water systems in which they are stakeholders. Managing Climate Risk in Water Supply Systems provides a hands-on approach to learning key concepts in hydrology and climate science as they relate to climate risk management in water supply systems. The primary audience is technical professionals in water resources management and provides a practical approach to training.

This unique, engaging, and highly authoritative volume enlightens readers on changes needed in the way society accesses, provides, and uses water. It further shines a light on changes needed in the way we use food, energy, and other goods and services in relation to water, and offers projections and recommendations, up to 2050, that apply to water access challenges

facing the poor and the common misuse of water in industry, agriculture, and municipalities. Written by an unparalleled slate of experts convened by the Calouste Gulbenkian Foundation, the book takes on one of the most critical issues on the planet today. In a frank yet optimistic assessment of major developmental challenges, but also opportunities, facing future generations, the author elucidates linkages between water and a range of other drivers from various disciplinary and stakeholder perspectives. Ultimately portraying the belief that Humanity can harness its visionary abilities, technologies, and economic resources for increased wellbeing and sound stewardship of resources, the book presents an optimistic statement stressing actions scientists, policy makers, and consumers can and must take to meet the water management challenges of a warming planet anticipating nine billion inhabitants by 2050. Gulbenkian Think Tank on Water and the Future of Humanity: Benedito Braga, Pres. World Water Council & Prof. of Civil Engineering, Univ. of São Paulo, Brazil; Colin Chatres, Director General of the International Water Management Institute, Sri Lanka; William J. Cosgrove, Pres. of Ecoconsult Inc. & Senior Adviser for the UN World Water Development Report, Canada; Luis Veiga da Cunha, Prof. Environmental Science and Engineering, Universidade Nova de Lisboa, Portugal; Peter Gleick, Pres. of the Pacific Institute, USA; Pavel Kabat, Director, International Institute for Applied Systems Analysis, Austria; and Prof. & Chair, Earth Systems Science, Wageningen University, The Netherlands; Mohamed Ait Kadi, President of the General Council of Agricultural Development, Morocco; Daniel P. Loucks, Prof. of Civil Engineering, Cornell Univ. USA; Jan Lundqvist, Senior Scientific Advisor, Stockholm International Water Institute, Sweden; Sunita Narain, Director, Center for Science & Environment, New Delhi, India; Jun Xia, Pres., International Water Resources Association, Chair Prof. & Dean, The Research Institute for Water Security (RIWS), Wuhan University, China.

Global Climate Models (GCMs) are the typical sources of future climate data required for impact assessments of climate change. However, GCM outputs are related to model-related uncertainties and involve a great deal of biases. Bias correction of model outputs is, therefore, necessary before their use in impact studies. The coarse resolution of GCM simulations is another hindrance to their direct use in fine-scale impact analysis of climate change. Although downscaling of GCM outputs can be performed by dynamical downscaling using Regional Climate Models (RCMs), it requires large computational capacity. When daily climate data from multiple GCMs are required to be downscaled, dynamical downscaling may not be a feasible option. Statistical downscaling, in contrast, can be efficiently used to downscale a large number of GCM outputs at a fine temporal and spatial scale. This study performs the bias correction and statistical downscaling of daily maximum and minimum temperature and daily precipitation data from six GCM and four RCM simulations for the northeast United Stated (US). The spatial resolution of the data set is 1/8°x 1/8° and it spans from 2046 to 2065. This fine-scale daily climate data set, which has been created using Bias Correction and Spatial Downscaling (BCSD) approach, can be directly used in regional impact studies for the northeast US. Using both raw and bias corrected daily precipitation data from two GCMs and two RCMs, one extreme precipitation index has been analyzed for the observed climate. The comparison between the results demonstrates that bias correction is important not only for GCM outputs, but also for RCM outputs. When the same analysis has been performed for future climate, bias correction has led to a larger level

of agreements among the models in predicting the magnitude and capturing the spatial trend for the extreme precipitation index. Moreover, five extreme climate indices have been analyzed at 1/8° spatial resolution for future climate using the bias corrected and statically downscaled data from multiple GCMs and RCMs. The incorporation of dynamical downscaling as an intermediate step has not led to any considerable changes from the results of statistical downscaling. Statistical downscaling with bias correction has been sufficient to create a fine-scale daily climate data set to be directly used in impact studies. The future means of five extreme climate indices, which have been calculated from GCM and RCM ensembles, have been compared to their observed means. The decrease in total number of frost days because of the future warming will be similar over the entire northeast region. The earlier arrival of spring will lead to an extended growing season and the magnitude of the changes will be larger in the coastal area. The comparison of precipitation extreme indices indicates an increase in the heavy precipitation events in future climate for most of the region.

Covering the various aspects of water and climate change, Climate Change and Water Resources presents the principles of climate change science and its effects on earth's water supply. Utilizing the knowledge and expertise from well-known experts in the field, the text provides a broad outline of the many interrelated aspects of climate variations,

- Water resources management should be assessed under climate change conditions, as historic data cannot replicate future climatic conditions. - Climate change impacts on water resources are bound to affect all water uses, i.e., irrigated agriculture, domestic and industrial water supply, hydropower generation, and environmental flow (of streams and rivers) and water level (of lakes). - Bottom-up approaches, i.e., the forcing of hydrologic simulation models with climate change models' outputs, are the most common engineering practices and considered as climate-resilient water management approaches. - Hydrologic simulations forced by climate change scenarios derived from regional climate models (RCMs) can provide accurate assessments of the future water regime at basin scales. - Irrigated agriculture requires special attention as it is the principal water consumer and alterations of both precipitation and temperature patterns will directly affect agriculture yields and incomes. - Integrated water resources management (IWRM) requires multidisciplinary and interdisciplinary approaches, with climate change to be an emerging cornerstone in the IWRM concept.

This edited collection of works by leading climate scientists and philosophers introduces readers to issues in the foundations, evaluation, confirmation, and application of climate models. It engages with important topics directly affecting public policy, including the role of doubt, the use of satellite data, and the robustness of models. Climate Modelling provides an early and significant contribution to the burgeoning Philosophy of Climate Science field that will help to shape our understanding of these topics in both philosophy and the wider scientific context. It offers insight into the reasons we should believe what climate models say about the world but addresses the issues that inform how reliable and well-confirmed these models are. This book will be of interest to students of climate science, philosophy of science, and of particular relevance to policy makers who depend on the models that forecast future states of the climate and ocean in order to make public policy decisions.

Published by the American Geophysical Union as part of the Geophysical Monograph Series, Volume 191. Rainfall: State of the Science offers the most up-to-date knowledge on the fundamental and practical aspects of rainfall. Each chapter, self-contained and written by prominent scientists in their respective fields, provides three forms of information: fundamental principles, detailed overview of current knowledge and description of existing methods, and emerging techniques and future research directions. The book discusses Rainfall microphysics: raindrop morphodynamics, interactions, size distribution, and evolution Rainfall measurement and estimation: ground-based direct measurement (disdrometer and rain gauge), weather radar rainfall estimation, polarimetric radar rainfall estimation, and satellite rainfall estimation Statistical analyses: intensity-duration-frequency curves, frequency analysis of extreme events, spatial analyses, simulation and disaggregation, ensemble approach for radar rainfall uncertainty, and uncertainty analysis of satellite rainfall products The book is tailored to be an indispensable reference for researchers, practitioners, and graduate students who study any aspect of rainfall or utilize rainfall information in various science and engineering disciplines.

This book provides an overview of the GLOWA-Danube research project from 2001 to 2011, a transdisciplinary initiative which explores the future of water resources in the Upper Danube Basin. It documents the purpose and unique approach, architecture, methodologies, scenarios and results of the project, creating a scientific knowledge base for the dialogue of stakeholders and scientists. The book offers a possible blueprint for successful global change science through integrative and transdisciplinary co-creation of knowledge and orientation for regional adaptation within the context of the Future Earth research program.

A practical guide to understanding, using and producing downscaled climate data, for researchers, graduate students, policy makers and practitioners.

The Ebro is a typical Mediterranean river characterized by seasonal low flows and extreme flush effects, with important agricultural and industrial activity that has caused heavy contamination problems. This volume deals with soil-sediment-groundwater related issues in the Ebro river basin and summarizes the results generated within the European Union-funded project AquaTerra. The following topics are highlighted: Hydrology and sediment transport and their alterations due to climate change, aquatic and riparian biodiversity in the Ebro watershed, occurrence and distribution of a wide range of priority and emerging contaminants, effects of chemical pollution on biota and integration of climate change scenarios with several aspects of the Ebro's hydrology and potential impacts of climate change on pollution. The primary objective of the book is to lay the foundation for a better understanding of the behavior of environmental pollutants and their fluxes with respect to climate and land use changes.

Volume 1 of a three-volume final report describes, synthesizes and analyzes the results of the four-year Integrated Research Project CIRCE – Climate Change and Impact Research: Mediterranean Environment, funded by the EU 6th Framework Programme. Conducted under the auspices of the National Institute of Geophysics and Volcanology in Rome, Italy, CIRCE was designed to predict and to quantify the physical impacts of climate change in the Mediterranean, and to assess the most influential consequences for the region's population. This volume incorporates the first two parts of the report, reviewing current knowledge of observed climate variability and trends in the Mediterranean, and including descriptions of available temperature and precipitation station and gridded data sets.

Empirical-statistical downscaling (ESD) is a method for estimating how local climatic variables are affected by large-scale climatic conditions. ESD has been applied to local climate/weather studies for years, but there are few — if any — textbooks on the subject. It is also anticipated that ESD will become more important and commonplace in the future, as anthropogenic global warming proceeds. Thus, a textbook on ESD will be important for next-generation climate scientists.

"Building upon the rapidly-growing body of literature documenting how natural systems are responding to, and are at risk from, human-induced climate change, this book provides case-study examples of how a diverse range of species and ecological systems in California are changing with the climate. These case studies originate from multiple ecological fields (genetics, population biology, habitat studies, community ecology, landscape ecology, paleobiology) and are framed by chapters describing approaches and tools for climate-adaptation planning, reviewing climate impacts and biological responses, and encouraging the use of historical data. This framing emphasizes the need for partnerships between researchers and resource managers in addressing climate-related challenges, and highlights how communication strengthens these partnerships with 'conversations' between chapter authors and managers. Such connections help move advances in science from research reports to 'on the ground' changes that help protect species, and support all life"--Provided by publisher.

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