Accounting For Climate Change Uncertainty In Greenhouse Gas Inventories Verification Compliance And Trading

Wildlife across the globe is beginning to show dramatic and unidirectional responses to anthropogenic climate change. With continued and accelerated changes likely in the future, we expect to see even greater shifts in species phenology, community composition and our ability to manage the most threatened components of our natural heritage. While a changing climate is inevitable to some extent, the magnitude of the environmental shifts and species' responses to these changes are still coming into focus for climate scientists. Using the NatureServe Climate Change Vulnerability Index and 46 focal species from the Willamette Valley in Oregon, we demonstrate one approach to identifying those species most susceptible to climate change while accounting for areas of uncertainty in climate change projections. We found that among the six taxonomic groups, butterflies, fishes, and plants are the most vulnerable to climate change, while herptiles, mammals, and birds tend to be less vulnerable. Furthermore, an analysis of the uncertainties inherent in such vulnerability

assessments showed that variability among global circulation models contributed more to vulnerability score uncertainty than did variability among emissions scenarios. Vulnerability assessments such as this one are valuable tools for helping conservation managers prioritize and shape climate change adaptation strategies. A better understanding of the uncertainties associated with forecasting future climates should be used to build flexibility into conservation plans and direct future research.

This body of work consists of four essays studying topics in environmental economics and international economics. The main interests in this thesis are to evaluate the effects of different government policies. Particularly, we explore the effects the optimal abatement policy for the world economy and the foreign exchange policy in China. My first essay studies the effect of potentially severe climate change on optimal climate change policy, accounting for learning and uncertainty in the climate system. In particular, we test how fat upper tailed uncertainty over the temperature change from a doubling of greenhouse gases (the climate sensitivity), affects economic growth and emissions policy. In addition, we examine whether and how fast uncertainties could be diminished through Bayesian learning. Our results indicate that while overall learning is slow, the mass of the fat tail diminishes quickly, since observations near the mean

provide evidence against fat tails. We denote as "partial learning" the case where the planner rejects high values of the climate sensitivity with high confidence, even though significant uncertainty remains. Fat tailed uncertainty without learning reduces current emissions by 38% relative to certainty, indicating significant climate insurance, or paying to limit emissions today to reduce the risk of very high temperature changes, is optimal. However, learning reduces climate insurance by about 50%. The optimal abatement policy is strongly influenced by the current state of knowledge, even though greenhouse gas (GHG) emissions are difficult to reverse. Non-fat tailed uncertainty is largely irrelevant for optimal emissions policy. My second essay provides a new solution algorithm for discrete time stochastic models of climate and the economy, relying on a nonparametric approximation of the value function. It is known by the dynamic programming theory that the value function is globally increasing and concave, but such information is not exploited by conventional approximation methods. This presents a challenge for solving the integrated assessment models numerically because climate change models have a large state space. The curse of dimensionality limits the size of the grid used in typical solution methods. Without concavity, local maxima can form in areas of the state space where grid points are sparse, which slows convergence. Therefore we establish a general

approach to impose shape preserving constraints based on nonparametric econometrics by solving a quadratic programming problem. Then we illustrate stability and accuracy of the algorithm using an optimal growth model and a simple integrated assessment model with analytical solutions. My third essay evaluates China's neutralization policy by monthly estimations based on the central bank balance sheet from 1999:6 to 2011:6. Our results suggest that China effectively neutralizes 66% of the change of net foreign assets under a pegged currency regime. Consequently, a purchase of one yuan of net foreign assets leads to an effective increase of 1.4 yuan in the money supply, rather than 4 yuan in the absence of neutralization. In the face of rapid growth of foreign reserves, neutralization in China is becoming increasingly difficult, consistent with Mundell's hypothesis that monetary authorities can fix the exchange rate and let the money supply float, or fix the money supply and let the exchange rate float: but it cannot fix both the exchange rate and the money supply. My fourth essay estimates China's demand for foreign reserves from 1994:1 to 2007:4. Using a monetary model for China's reserve demand, we take into account the People's Bank of China's systematic neutralization policy to reduce inflation. While ultimately inconsistent, this policy has led to a growth in foreign exchange reserves that seems limitless: a neutralization coefficient of 0.57 leading to a

magnification effect on the increase in reserves of 2.3. That is, a purchase of foreign reserves leads to a contraction of domestic credit of 57% of the foreign exchange purchase, which in turn magnifies the surplus under a stable exchange rate.

Climate change is occurring, is caused largely by human activities, and poses significant risks for--and in many cases is already affecting--a broad range of human and natural systems. The compelling case for these conclusions is provided in Advancing the Science of Climate Change, part of a congressionally requested suite of studies known as America's Climate Choices. While noting that there is always more to learn and that the scientific process is never closed, the book shows that hypotheses about climate change are supported by multiple lines of evidence and have stood firm in the face of serious debate and careful evaluation of alternative explanations. As decision makers respond to these risks, the nation's scientific enterprise can contribute through research that improves understanding of the causes and consequences of climate change and also is useful to decision makers at the local, regional, national, and international levels. The book identifies decisions being made in 12 sectors, ranging from agriculture to transportation, to identify decisions being made in response to climate change. Advancing the Science of Climate Change calls for a single federal entity or

program to coordinate a national, multidisciplinary research effort aimed at improving both understanding and responses to climate change. Seven cross-cutting research themes are identified to support this scientific enterprise. In addition, leaders of federal climate research should redouble efforts to deploy a comprehensive climate observing system, improve climate models and other analytical tools, invest in human capital, and improve linkages between research and decisions by forming partnerships with action-oriented programs.

This book presents a wide and comprehensive range of issues and problems in various fields of science and engineering, from both theoretical and applied perspectives. The desire to develop more effective and efficient tools and techniques for dealing with complex processes and systems has been a natural inspiration for the emergence of numerous fields of science and technology, in particular control and automation and, more recently, robotics. The contributions gathered here concern the development of methods and algorithms to determine best practices regarding broadly perceived decisions or controls. From an engineering standpoint, many of them focus on how to automate a specific process or complex system. From a tools-based perspective, several contributions address the development of analytic and algorithmic methods and techniques, devices and systems that make it possible to develop and

subsequently implement the automation and robotization of crucial areas of human activity. All topics discussed are illustrated with sample applications.

When it comes to climate change, the greatest difficulty we face is that we do not know the likely degree of change or its cost, which means that environmental policy decisions have to be made under uncertainty. This book offers an accessible philosophical treatment of the broad range of ethical and policy challenges posed by climate change uncertainty. Drawing on both the philosophy of science and ethics, Martin Bunzl shows how tackling climate change revolves around weighing up our interests now against those of future generations, which requires that we examine our assumptions about the value of present costs versus future benefits. In an engaging, conversational style, Bunzl looks at questions such as our responsibility towards non-human life, the interests of the developing and developed worlds, and how the circumstances of poverty shape the perception of risk, ultimate developing and defending a view of humanity and its place in the world that makes sense of our duty to Nature without treating it as a rights bearer. This book will be of interest to students and scholars of environmental studies, philosophy, politics and sociology as well as policy makers.

What does successful adaptation look like? This is a question we are frequently

asked by planners, policy makers and other professionals charged with the task of developing and implementing adaptation strategies. While adaptation is increasingly recognized as an important climate risk management strategy, and on-the-ground adaptation planning activity is becoming more common-place, there is no clear guidance as to what success would look like, what to aim for and how to judge progress. This edited volume makes significant progress toward unpacking the question of successful adaptation, offering both scientifically informed and practice-relevant answers from various sectors and regions of the world. It brings together 18 chapters from leading experts within the field to present careful analyses of different cases and situations, questioning throughout commonly avowed truisms and unspoken assumptions that have pervaded climate adaptation science and practice to date. This book offers not one answer but demonstrates how the question of success in important ways is normative and context specific. It identifies the various dimensions of success, such as economic, political, institutional, ecological, and social, explores the tensions between them, and compiles encouraging evidence that resolutions can be found. The book appraises how climatic and non-climatic stressors play a role, what role science does and can play in adaptation decision making, and how trade-offs and other concerns and priorities shape adaptation planning and

implementation on the ground. This is timely interdisciplinary text sheds light on key issues that arise in on-the-ground adaptation to climate change. It bridges the gap between science and practical application of successful adaptation strategies and will be of interest to both students, academics and practitioners.
Changes in climate are driven by natural and human-induced perturbations of the Earth's energy balance. These climate drivers or "forcings" include variations in greenhouse gases, aerosols, land use, and the amount of energy Earth receives from the Sun. Although climate throughout Earth's history has varied from "snowball" conditions with global ice cover to "hothouse" conditions when glaciers all but disappeared, the climate over the past 10,000 years has been remarkably stable and favorable to human civilization. Increasing evidence points to a large human impact on global climate over the past century. The report reviews current knowledge of climate forcings and recommends critical research needed to improve understanding. Whereas emphasis to date has been on how these climate forcings affect global mean temperature, the report finds that regional variation and climate impacts other than temperature deserve increased attention.
Global climate change is one of America's most significant long-term policy challenges. Human activity--especially the use of fossil fuels, industrial

processes, livestock production, waste disposal, and land use change--is affecting global average temperatures, snow and ice cover, sea-level, ocean acidity, growing seasons and precipitation patterns, ecosystems, and human health. Climate-related decisions are being carried out by almost every agency of the federal government, as well as many state and local government leaders and agencies, businesses and individual citizens. Decision makers must contend with the availability and quality of information, the efficacy of proposed solutions, the unanticipated consequences resulting from decisions, the challenge of implementing chosen actions, and must consider how to sustain the action over time and respond to new information. Informing an Effective Response to Climate Change, a volume in the America's Climate Choices series, describes and assesses different activities, products, strategies, and tools for informing decision makers about climate change and helping them plan and execute effective, integrated responses. It discusses who is making decisions (on the local, state, and national levels), who should be providing information to make decisions, and how that information should be provided. It covers all levels of decision making, including international, state, and individual decision making. While most existing research has focused on the physical aspect of climate change, Informing an Effective Response to Climate Change employs theory and case study to

describe the efforts undertaken so far, and to guide the development of future decision-making resources. Informing an Effective Response to Climate Change offers much-needed guidance to those creating public policy and assists in implementing that policy. The information presented in this book will be invaluable to the research community, especially social scientists studying climate change; practitioners of decision-making assistance, including advocacy organizations, non-profits, and government agencies; and college-level teachers and students.

The assessment of greenhouse gases emitted to and removed from the atmosphere is high on the international political and scientific agendas. Growing international concern and cooperation regarding the climate change problem have increased the need for policy-oriented solutions to the issue of uncertainty in, and related to, inventories of greenhouse gas (GHG) emissions. The approaches to addressing uncertainty discussed here reflect attempts to improve national inventories, not only for their own sake but also from a wider, systems analytical perspective — a perspective that seeks to strengthen the usefulness of national inventories under a compliance and/or global monitoring and reporting framework. These approaches demonstrate the benefits of including inventory uncertainty in policy analyses. The authors of the contributed papers show that considering uncertainty helps avoid situations that can, for example, create a false sense of certainty or lead to invalid views of subsystems. This may eventually prevent related errors from showing up in analyses. However, considering

uncertainty does not come for free. Proper treatment of uncertainty is costly and demanding because it forces us to make the step from “simple to complex” and only then to discuss potential simplifications. Finally, comprehensive treatment of uncertainty does not offer policymakers quick and easy solutions.

This book provides a collection of the state-of-the-art methodologies and approaches suggested for detecting extremes, trend analysis, accounting for nonstationarities, and uncertainties associated with extreme value analysis in a changing climate. This volume is designed so that it can be used as the primary reference on the available methodologies for analysis of climate extremes. Furthermore, the book addresses current hydrometeorologic global data sets and their applications for global scale analysis of extremes. While the main objective is to deliver recent theoretical concepts, several case studies on extreme climate conditions are provided. Audience The book is suitable for teaching in graduate courses in the disciplines of Civil and Environmental Engineering, Earth System Science, Meteorology and Atmospheric Sciences.

This book contains revised versions of papers presented on scientific workshop “Modeling Multi-commodity Trade: Information exchange methods”, which took place in November 2010 atWarsaw University of Technology. It summarizes results of the research work supported so far by scientific grant “Methods and architectures of information interchange for electronic trade on infrastructural markets” (see page xi), and some earlier research work on multi-commodity markets modeling. Though partial results of the research were published earlier, the book gives the most complete view on results of our research in the field of modeling the trade on complex multi-commodity infrastructural markets.

Abstract: A growing body of economics research projects the effects of global climate change on economic outcomes. Climate scientists often criticize these articles because nearly all ignore the well-established uncertainty in future temperature and rainfall changes, and therefore appear likely to have downward biased standard errors and potentially misleading point estimates. This paper incorporates climate uncertainty into estimates of climate change impacts on U.S. agriculture. Accounting for climate uncertainty leads to a much wider range of projected impacts on agricultural profits, with the 95% confidence interval featuring drops of between 17% to 88%. An application to African agriculture yields similar results.

Confronting Climate Uncertainty in Water Resources Planning and Project Design describes an approach to facing two fundamental and unavoidable issues brought about by climate change uncertainty in water resources planning and project design. The first is a risk assessment problem. The second relates to risk management. This book provides background on the risks relevant in water systems planning, the different approaches to scenario definition in water system planning, and an introduction to the decision-scaling methodology upon which the decision tree is based. The decision tree is described as a scientifically defensible, repeatable, direct and clear method for demonstrating the robustness of a project to climate change. While applicable to all water resources projects, it allocates effort to projects in a way that is consistent with their potential sensitivity to climate risk. The process was designed to be hierarchical, with different stages or phases of analysis triggered based on the findings of the previous phase. An application example is provided followed by a descriptions of some of the tools available for decision making under uncertainty and methods available for climate risk management. The tool was designed for the World Bank but can be applicable in other

scenarios where similar challenges arise.

General Circulation Models (GCMs) are tools designed to simulate time series of climate variables globally, accounting for e.

There exist large uncertainties in projecting future climate and understanding how climate change projections relate to water supply. Non-traditional water sources (e.g., stormwater harvesting), which are emerging as adaptation options to augment stressed water supply systems, further complicate the simulation of these systems. However, in assessing a city's water supply security, there is no framework explicitly acknowledging and accounting for both the additional complexities and uncertainties associated with non-traditional water sources and climate change impacts. Furthermore, mitigation and adaptation measures to climate change should be considered. However, minimising GHG emissions (and thus considering mitigation) is likely to conflict with other objectives of water supply system planning. Hence, a multi-objective evolutionary algorithm (MOEA) approach is necessary to balance multiple objectives, as well as to efficiently search many feasible alternatives to find Pareto-optimal solutions. However, for cities, MOEA studies incorporating GHG emissions and thus focussing on both mitigating and adapting to climate change do not exist. The main aim of this thesis is to develop methods for assessing and improving urban water supply security planning under climate change to better understand: (1) the relative magnitudes of uncertainty sources in assessing climate change impacts; (2) enhanced simulation complexity of non-traditional water sources and increased uncertainty of climate change impacts; and (3) adaptation and mitigation responses to climate change. Consequently, major contributions of this research include: (1) developing a scenario-based sensitivity analysis to understand the relative

magnitudes of uncertainty sources in assessing the impacts of climate change on water supply systems; (2) developing a generalised framework for a city's water supply system that outlines the additional complexities due to the incorporation of non-traditional water sources and the additional uncertainties due to climate change impacts; and (3) incorporating GHG emissions as an objective function within a MOEA framework to take into consideration both adaptation and mitigation responses to climate change. Furthermore, while these frameworks could readily be applied to any city, Adelaide's southern water supply system is used as a real-life case study to illustrate the practical management implications. The methods developed in the thesis were found to be effective when applied to Adelaide's southern water supply system. Results indicate that studies analysing the impact of climate change on water supply security should consider uncertainties other than those associated with climate change and hydrological modelling, as these could have as great, if not greater, impacts on water supply security projections. Furthermore, trade-offs exist between cost and supply security for solutions that use desalination and harvested stormwater to augment water supply; however, use of rainwater tanks is undesirable, as they are an expensive source. In terms of the trade-off between economic cost and GHG emissions, the main drivers are the presence of rainwater tanks and the desalination plant - rainwater tanks are an expensive option, while desalination is a GHG emission intensive option. Consequently, while desalination may be a good adaptation option, other water sources may be better mitigation measures. Accounting for GHG emissions is thus important to ensure mitigation measures are considered.

The warming of the Earth has been the subject of intense debate and concern for many scientists, policy-makers, and citizens for at least the past decade. Climate Change Science:

An Analysis of Some Key Questions, a new report by a committee of the National Research Council, characterizes the global warming trend over the last 100 years, and examines what may be in store for the 21st century and the extent to which warming may be attributable to human activity.

Numerous studies have highlighted that water resources and hydrologic extremes are sensitive to climate change. An interesting research question is what the role of climate change is in occurrence of extreme events. More importantly, how climate extremes may change under future climate conditions and emission scenarios. Therefore, there exists a strong need to study water resources and hydrologic cycle under different climate change scenarios at the global scale. In the past decades, numerous methods and models have been developed for assessing climate change impacts on water resources. However, there are still major research gaps from uncertainties in climate model simulations to limitations in the current large scale water cycle (or global hydrologic) models. Some of the current research gaps include: (I) high uncertainty of climate model simulations; (II) limitations and high uncertainties of the global hydrologic model simulations because of calibration challenges at the global scale; and (III) lack of frameworks for accounting for the local resilience and man-made infrastructure in climate impact assessment studies. The overarching goal of this study is to address the above mentioned research gaps. In this dissertation, several novel evaluation metrics are introduced that can be used for evaluation of errors and biases in input data which

is a key factor in the overall uncertainty of climate change studies. Furthermore, this study leads to a better representation of the hydrologic cycle at the global scale through a comprehensive multi-objective calibration framework for global hydrologic models. Then, a modeling framework is presented for accounting for local resilience in climate change studies. Finally, this study outlines a framework for combining top-down and bottom-up approaches for climate change impact assessment.

Climate change will exacerbate the challenges associated with environmental conditions, especially weather variability and extremes, in developing countries. These challenges play important, if as yet poorly understood roles in the development prospects of affected regions. As such, climate change reinforces the development case for investment in disaster risk management. Uncertainty about how climate change will affect particular locations makes optimal investment planning more difficult. In particular, the inability to derive meaningful probabilities from climate models limits the usefulness of standard project evaluation techniques, such as cost-benefit analysis. Although the deep uncertainty associated with climate change complicates disaster risk management investment decisions, the analysis presented here shows that these considerations are only relevant for a relatively limited set of investment circumstances. The paper offers a simple decision framework that enables policy makers to identify the particular circumstances under which uncertainty about future climate change becomes critical for disaster risk management investment decisions. Accounting for climate

uncertainty is likely to shift the optimal balance of disaster risk management strategies toward more flexible, low-regret type interventions, especially those that seek to promote "development first" or "risk-coping" objectives. Such investments are likely to confer additional development dividends, regardless of the climate future that materializes in a given location. Importantly, the analysis here also demonstrates that climate uncertainty does not necessarily motivate a "wait and see" approach. Instead, where opportunities exist to avail of adaptation co-benefits, climate uncertainty provides additional motivation for early investment in disaster risk management initiatives.
Many of the challenges that decision-makers grapple with in relation to climate change are governance related. Planning and decision-making is evolving in ambiguous institutional environments, in which many key issues remain unresolved, including relationships between different actors; funding arrangements; and the sources and procedures for vetting data. These issues are particularly acute at this juncture, as climate adaptation moves from broad planning processes to the management of infrastructure systems. Concrete decisions must be made. Adapting Infrastructure to Climate Change draws on case studies of three coastal cities situated within very different governance regimes: neo-corporatist Rotterdam, neo-pluralist Boston and semi-authoritarian Singapore. The book examines how infrastructure managers and other stakeholders grappling with complex and uncertain climate risks are likely to make project-level decisions in practice, and how more effective decision-making can

be supported. The differences across governance regimes are currently unaccounted for in adaptation planning, but are crucial as best practices are devised. These lessons are also applicable to infrastructure planning and decision-making in other contexts. This book will be of great interest to scholars of climate change and environmental policy and governance, particularly in the context of infrastructure management.
Mathematical modelling has become in recent years an essential tool for the prediction of environmental change and for the development of sustainable policies. Yet, many of the uncertainties associated with modelling efforts appear poorly understood by many, especially by policy makers. This book attempts for the first time to cover the full range of issues related to model uncertainties, from the subjectivity of setting up a conceptual model of a given system, all the way to communicating the nature of model uncertainties to non-scientists and accounting for model uncertainties in policy decisions. Theoretical chapters, providing background information on specific steps in the modelling process and in the adoption of models by end-users, are complemented by illustrative case studies dealing with soils and global climate change. All the chapters are authored by recognized experts in their respective disciplines, and provide a timely and uniquely comprehensive coverage of an important field.
Abstract: The decision on how to manage a forest under climate change is subject to deep and dynamic uncertainties. The classic approach to analyze this decision adopts a predefined strategy, tests its robustness to uncertainties, but neglects their dynamic

nature (i.e., that decision-makers can learn and adjust the strategy). Accounting for learning through dynamic adaptive strategies (DAS) can drastically improve expected performance and robustness to deep uncertainties. The benefits of considering DAS hinge on identifying critical uncertainties and translating them to detectable signposts to signal when to change course. This study advances the DAS approach to forest management as a novel application domain by showcasing methods to identify potential signposts for adaptation on a case study of a classic European beech management strategy in South-West Germany. We analyze the strategy's robustness to uncertainties about model forcings and parameters. We then identify uncertainties that critically impact its economic and ecological performance by confronting a forest growth model with a large sample of time-varying scenarios. The case study results illustrate the potential of designing DAS for forest management and provide insights on key uncertainties and potential signposts. Specifically, economic uncertainties are the main driver of the strategy's robustness and impact the strategy's performance more critically than climate uncertainty. Besides economic metrics, the forest stand's past volume growth is a promising signpost metric. It mirrors the effect of both climatic and model parameter uncertainty. The regular forest inventory and planning cycle provides an ideal basis for adapting a strategy in response to these signposts

A must-read for anyone who makes business decisions that have amajor financial impact. As the recent collapse on Wall Street shows, we are oftenill-equipped to deal

with uncertainty and risk. Yet every day webase our personal and business plans on uncertainties, whether theybe next month's sales, next year's costs, ortomorrow's stock price. In The Flaw of Averages, SamSavageknown for his creative exposition of difficultsubjects describes common avoidable mistakes in assessingrisk in the face of uncertainty. Along the way, he shows why plansbased on average assumptions are wrong, on average, in areas asdiverse as healthcare, accounting, the War on Terror, and climatechange. In his chapter on Sex and the Central Limit Theorem, hebravely grasps the literary third rail of gender differences. Instead of statistical jargon, Savage presents complex conceptsin plain English. In addition, a tightly integrated web sitecontains numerous animations and simulations to further connect theseat of the reader's intellect to the seat of theirpants. The Flaw of Averages typically results when someone plugsa single number into a spreadsheet to represent an uncertain futurequantity. Savage finishes the book with a discussion of theemerging field of Probability Management, which cures this problemthough a new technology that can pack thousands of numbers into asingle spreadsheet cell. Praise for The Flaw of Averages "Statistical uncertainties are pervasive in decisions wemake every day in business, government, and our personal lives. SamSavage's lively and engaging book gives any interested readerthe insight and the tools to deal effectively with thoseuncertainties. I highly recommend The Flaw ofAverages." —William J. Perry, Former U.S. Secretary ofDefense "Enterprise analysis under uncertainty has long been

anacademic ideal. . . . In this profound and entertaining book,Professor Savage shows how to make all this practical, practicable,and comprehensible." —Harry Markowitz, Nobel Laureate inEconomics

Climate change is occurring. It is very likely caused by the emission of greenhouse gases from human activities, and poses significant risks for a range of human and natural systems. And these emissions continue to increase, which will result in further change and greater risks. America's Climate Choices makes the case that the environmental, economic, and humanitarian risks posed by climate change indicate a pressing need for substantial action now to limit the magnitude of climate change and to prepare for adapting to its impacts. Although there is some uncertainty about future risk, acting now will reduce the risks posed by climate change and the pressure to make larger, more rapid, and potentially more expensive reductions later. Most actions taken to reduce vulnerability to climate change impacts are common sense investments that will offer protection against natural climate variations and extreme events. In addition, crucial investment decisions made now about equipment and infrastructure can "lock in" commitments to greenhouse gas emissions for decades to come. Finally, while it may be possible to scale back or reverse many responses to climate change, it is difficult or impossible to "undo" climate change, once manifested. Current efforts of local, state, and private-sector actors are important, but not likely to yield progress comparable to what could be achieved with the addition of strong federal policies that

establish coherent national goals and incentives, and that promote strong U.S. engagement in international-level response efforts. The inherent complexities and uncertainties of climate change are best met by applying an iterative risk management framework and making efforts to significantly reduce greenhouse gas emissions; prepare for adapting to impacts; invest in scientific research, technology development, and information systems; and facilitate engagement between scientific and technical experts and the many types of stakeholders making America's climate choices.

This book is based on the 2014 Special Issue 124(3) of Climatic Change. It brings together 16 key papers presented at, or produced, subsequent to the 2010 (3rd) International Workshop on Uncertainty in Greenhouse Gas Inventories. The Workshop was jointly organized by the Lviv Polytechnic National University (http://www.lp.edu.ua/en), Ukraine; the Systems Research Institute of the Polish Academy of Sciences (http://www.ibspan.waw.pl/glowna/en); and the International Institute for Applied Systems Analysis (http://www.iiasa.ac.at/), Austria. This book has been written to enhance understanding of the uncertainty encountered in estimating greenhouse gas (GHG) emissions and in dealing with the challenges resulting from those estimates. Such challenges include, but are not limited to i) monitoring emissions; ii) adhering to emission commitments; iii) securing the proper functioning of emission trading markets; and iv) meeting low-carbon or low-GHG futures in the long term.

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addresses the following limitations of climate change impact research: (i) limited availability of observed historical information; (ii) limited research on the detection of changes in hydrologic extremes; and (iii) coarse spatio-temporal resolution of AOGCMs for use at regional or local scale. Downscaled output from a single AOGCM with a single emission scenario represents only a single trajectory of all possible future climate realizations and cannot be representative of the full extent of climate change. Present research, therefore addresses the following questions: (i) how should the AOGCM outputs be selected to assess the severity of extreme climate events?; (ii) should climate research adopt equal weights from AOGCM outputs to generate future climate?; and (iii) what is the probability of the future extreme events to be more severe? Assessment of regional reanalysis hydroclimatic data has shown promising potential as an addition to the observed data in data scarce regions. A new approach using statistical downscaling based nonparametric datadriven kernel estimator is developed for quantifying uncertainties from multiple AOGCMs and emission scenarios. The results are compared with a Bayesian reliability ensemble average method. The generated future climate scenarios represent the nature and progression of uncertainties from several global climate models and their emission scenarios. Treating the extreme precipitation indices as independent realization at every time step, the kernel estimator provides variable weights to the multi-model quantification of uncertainties. The probabilities of the extreme indices have added useful insight into

future climate conditions. Finally, the current method of developing future rainfall intensity-duration-frequency curves is extended by introducing a probabilistic weighted curve to include AOGCM and emission scenario uncertainties using the plug-in kernel. Present research has thus expanded the existing knowledge of dealing with the uncertainties of extreme events.

The provision of water supply and sanitation services is particularly vulnerable to projected changes in climate conditions (temperature and precipitation among others), in the frequency and intensity of extreme weather events, as well as and in the projected rise in sea-level and the intensification of storm surges. The process of climate proofing investment projects aims both at assessing the climate risk to a project's future costs and benefits, and undertaking a technical and economic analysis of options to alleviate or mitigate those risks. Accounting for climate change at the outset of the project cycle implies that decisions about project design, and the adoption and timing of climate-proofing measures be informed with the possible impacts of climate change in the initial phases of the project cycle so that decisions of an irreversible nature will be avoided. This publication presents a step-by-step methodological approach to assist project teams in managing climate change risk in the context of water supply and sanitation investment projects.

Climate change presents perhaps the most profound challenge ever confronted by human society. This volume is a definitive analysis drawing on the best thinking on

questions of how climate change affects human systems, and how societies can, do, and should respond. Key topics covered include the history of the issues, social and political reception of climate science, the denial of that science by individuals and organized interests, the nature of the social disruptions caused by climate change, the economics of those disruptions and possible responses to them, questions of human security and social justice, obligations to future generations, policy instruments for reducing greenhouse gas emissions, and governance at local, regional, national, international, and global levels.

Accounting for Climate ChangeUncertainty in Greenhouse Gas Inventories - Verification, Compliance, and TradingSpringer Science & Business Media

This publication examines how uncertainty in climate change policy may affect investment behaviour in the power sector and how the costs of transition to a low-carbon economy may be addressed. For power companies, where capital stock is intensive and long-lived, those risks rank among the biggest and can create an incentive to delay investment. The analysis show that the risk premiums of climate change uncertainty can add 40 per cent of construction costs of the plant for power investors, and 10 per cent of price surcharges for the electricity end-users. It also looks at the sensitivity of different power sector investment decisions to different risks and considers the implications for policy development and design.

Support for addressing the on-going global changes needs solutions for new scientific

problems which in turn require new concepts and tools. A key issue concerns a vast variety of irreducible uncertainties, including extreme events of high multidimensional consequences, e.g., the climate change. The dilemma is concerned with enormous costs versus massive uncertainties of extreme impacts. Traditional scientific approaches rely on real observations and experiments. Yet no sufficient observations exist for new problems, and "pure" experiments, and learning by doing may be expensive, dangerous, or impossible. In addition, the available historical observations are often contaminated by past actions, and policies. Thus, tools are presented for the explicit treatment of uncertainties using "synthetic" information composed of available "hard" data from historical observations, the results of possible experiments, and scientific facts, as well as "soft" data from experts' opinions, and scenarios.

The U.S. Environmental Protection Agency (EPA) is one of several federal agencies responsible for protecting Americans against significant risks to human health and the environment. As part of that mission, EPA estimates the nature, magnitude, and likelihood of risks to human health and the environment; identifies the potential regulatory actions that will mitigate those risks and protect public health1 and the environment; and uses that information to decide on appropriate regulatory action. Uncertainties, both qualitative and quantitative, in the data and analyses on which these decisions are based enter into the process at each step. As a result, the informed identification and use of the uncertainties inherent in the process is an essential feature

of environmental decision making. EPA requested that the Institute of Medicine (IOM) convene a committee to provide guidance to its decision makers and their partners in states and localities on approaches to managing risk in different contexts when uncertainty is present. It also sought guidance on how information on uncertainty should be presented to help risk managers make sound decisions and to increase transparency in its communications with the public about those decisions. Given that its charge is not limited to human health risk assessment and includes broad questions about managing risks and decision making, in this report the committee examines the analysis of uncertainty in those other areas in addition to human health risks. Environmental Decisions in the Face of Uncertainty explains the statement of task and summarizes the findings of the committee.

This new edition incorporates revised guidance from H.M Treasury which is designed to promote efficient policy development and resource allocation across government through the use of a thorough, long-term and analytically robust approach to the appraisal and evaluation of public service projects before significant funds are committed. It is the first edition to have been aided by a consultation process in order to ensure the guidance is clearer and more closely tailored to suit the needs of users.

As the Kyoto Protocol limps along without the participation of the US and

Australia, on-going climate negotiations are plagued by competing national and business interests that are creating stumbling blocks to success. Climate Change Negotiations: A Guide to Resolving Disputes and Facilitating Multilateral Cooperation asks how these persistent obstacles can be down-scaled, approaching them from five professional perspectives: a top policy-maker, a senior negotiator, a leading scientist, an international lawyer, and a sociologist who is observing the process. The authors identify the major problems, including great power strategies (the EU, the US and Russia), leadership, the role of NGOs, capacity and knowledge-building, airline industry emissions, insurance and risk transfer instruments, problems of cost benefit analysis, the IPCC in the post-Kyoto situation, and verification and institutional design. A new key concept is introduced: strategic facilitation. 'Strategic facilitation' has a long time frame, a forward-looking orientation and aims to support the overall negotiation process rather than individual actors. This book is aimed at academics, university students and practitioners who are directly or indirectly engaged in the international climate negotiation as policy makers, diplomats or experts.
Future climatic and agro-ecological changes in Africa are uncertain and associated with high degrees of spatial and temporal variability and this change is differently simulated within divergent climate-crop models and in controlled

crop breeding stations. Furthermore, uncertainty emerges in local contexts, not just in response to climatic systems, but to social, economic, and political systems, and often with implications for the appropriateness and adoption of technologies or the success of alternative cropping systems. This book examines the challenges of adaptation in smallholder farming in Africa, analysing the social, economic, political and climatic uncertainties that impact on agriculture in the region and the range of solutions proposed. Drawing on case studies of genetically modified crops, conservation agriculture, and other 'climate smart' solutions in eastern and southern Africa, the book identifies how uncertainties are framed 'from above' as well experienced 'from below', by farmers themselves. It provides a compelling insight into why ideas about adaptation emerge, from whom, and with what implications. This book offers a unique perspective and will be highly relevant to students of climate change adaptation, food security and poverty alleviation, as well as policy-makers and field practitioners in international development and agronomy.

Uncertainty analysis is a key component of national greenhouse gases inventory analyses. The issues that are raised by the authors in this volume, and the role that uncertainty analysis plays in many of their arguments and/or proposals, highlight the importance of such efforts. Coverage includes: bottom-up versus top-

down emission inventory approaches, compliance and verification issues, and the role of uncertainty in emissions trading schemes.

This book brings together diverse perspectives concerning uncertainty and climate change in India. Uncertainty is a key factor shaping climate and environmental policy at international, national, and local levels. Climate change and events such as cyclones, floods, droughts and changing rainfall patterns create uncertainties that planners, resource managers and local populations are regularly confronted with. In this context, uncertainty has emerged as a wicked problem for scientists and policymakers, resulting in highly debated and disputed decision-making. The book focuses on India, one of the most climatically vulnerable countries in the world, where there are stark socio-economic inequalities in addition to diverse geographic and climatic settings. Based on empirical research, it covers case studies from coastal Mumbai to dryland Kutch and the Sundarbans delta in West Bengal. These localities offer ecological contrasts, rural-urban diversity, varied exposure to different climate events and diverse state and official responses. The book unpacks the diverse discourses, practices and politics of uncertainty and demonstrates profound differences through which the above, middle and below understand and experience climate change and uncertainty and makes a case for bringing together diverse

knowledges and approaches to understand and embrace climate-related uncertainties in order to facilitate transformative change. Appealing to a broad professional and student audience, the book draws on wide-ranging theoretical and conceptual approaches from climate science, historical analysis, science technology and society studies, development studies and environmental studies. By looking at the intersection between local and diverse understandings of climate change and uncertainty with politics, culture, history, and ecology, the book argues for plural and socially just ways to tackle climate change in India and beyond.

This enriching book presents a holistic overview of climate change uncertainty and offers a number of pathways that could be used to account for such uncertainties in the stated preference valuation research. It shows that uncertainty plays an important role in determining the values of climate change mitigation benefits and, as the authors say, 'If this uncertainty remains unaccounted for, there is a potential danger that the estimated economic values will misrepresent social preferences for public policy interventions to manage environmental externalities.' Valuing Climate Change Mitigation discusses the role of uncertainty in valuing the benefits of climate change mitigation policies using contingent valuation and choice experiments techniques. It treats climate

change using three dimensions of uncertainty: scenario, policy and preference. Conceptual frameworks are advanced to account simultaneously for these various dimensions of uncertainty. The authors then explore the impact of introducing these uncertainties into benefit estimates for the Australian Carbon Pollutions Reduction Scheme. The authors present frameworks to account for multiple uncertainty in environmental decision analysis that will prove invaluable for academics and students in the fields of environmental economics and management. Policy makers will also gain invaluable methodological insight.
Future climate change has emerged as a national and a global security threat. To carry out the needed adaptation and mitigation steps, a quantification of the expected level of climate change is needed, both at the global and the regional scale; in the end, the impact of climate change is felt at the local/regional level. An important part of such climate change assessment is uncertainty quantification. Decision and policy makers are not only interested in 'best guesses' of expected climate change, but rather probabilistic quantification (e.g., Rougier, 2007). For example, consider the following question: What is the probability that the average summer temperature will increase by at least 4 C in region R if global CO2 emission increases by P% from current levels by time T? It is a simple question, but one that remains very difficult to answer. It is

answering these kind of questions that is the focus of this effort. The uncertainty associated with future climate change can be attributed to three major factors: (1) Uncertainty about future emission of green house gasses (GHG). (2) Given a future GHG emission scenario, what is its impact on the global climate? (3) Given a particular evolution of the global climate, what does it mean for a particular location/region? In what follows, we assume a particular GHG emission scenario has been selected. Given the GHG emission scenario, the current batch of the state-of-the-art global climate models (GCMs) is used to simulate future climate under this scenario, yielding an ensemble of future climate projections (which reflect, to some degree our uncertainty of being able to simulate future climate give a particular GHG scenario). Due to the coarse-resolution nature of the GCM projections, they need to be spatially downscaled for regional impact assessments. To downscale a given GCM projection, two methods have emerged: dynamical downscaling and statistical (empirical) downscaling (SDS). Dynamic downscaling involves configuring and running a regional climate model (RCM) nested within a given GCM projection (i.e., the GCM provides bounder conditions for the RCM). On the other hand, statistical downscaling aims at establishing a statistical relationship between observed local/regional climate variables of interest and synoptic (GCM-scale) climate predictors. The resulting

empirical relationship is then applied to future GCM projections. A comparison of the pros and cons of dynamical versus statistical downscaling is outside the scope of this effort, but has been extensively studied and the reader is referred to Wilby et al. (1998); Murphy (1999); Wood et al. (2004); Benestad et al. (2007); Fowler et al. (2007), and references within those. The scope of this effort is to study methodology, a statistical framework, to propagate and account for GCM uncertainty in regional statistical downscaling assessment. In particular, we will explore how to leverage an ensemble of GCM projections to quantify the impact of the GCM uncertainty in such an assessment. There are three main component to this effort: (1) gather the necessary climate-related data for a regional SDS study, including multiple GCM projections, (2) carry out SDS, and (3) assess the uncertainty. The first step is carried out using tools written in the Python programming language, while analysis tools were developed in the statistical programming language R; see Figure 1.

The ability to accurately monitor, record, report and verify greenhouse gas emissions is the cornerstone of any effective policy to mitigate climate change. Accounting for Carbon provides the first authoritative overview of the monitoring, reporting and verification (MRV) of emissions from the industrial site, project and company level to the regional and national level. It describes the MRV

procedures in place in more than fifteen of the most important policy frameworks - such as emissions trading systems in Europe, Australia, California and China, and the United Nations Framework Convention on Climate Change - and compares them along key criteria such as scope, cost, uncertainty and flexibility. This book draws on the work of engineers and economists to provide a practical guide to help government and non-governmental policymakers and key stakeholders in industry to better understand different MRV requirements, the key trade-offs faced by regulators and the choices made by up-and-running carbon pricing initiatives.