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978-1-107-09682-0 - Introduction to Modern Climate Change: Second Edition
Andrew Dessler
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More information

Introduction to Modern Climate Change, Second Edition

This is an invaluable textbook for any introductory survey course on the science and policy of climate change, for both non–science majors and introductory science students. The second edition has been thoroughly updated to reflect the most recent science from the latest IPCC reports, and many illustrations include new data. The new edition also reflects advances in the political debate over climate change. Unique among textbooks on climate change, this text combines an introduction to the science with an introduction to economic and policy issues, and it focuses closely on anthropogenic climate change. It contains the necessary quantitative depth for students to properly understand the science of climate change. It supports students in using algebra to understand simple equations and to solve end-of-chapter problems. Supplementary online resources include a complete set of PowerPoint figures for instructors, solutions to exercises, videos of the author's lectures, and additional computer exercises.

Andrew Dessler is a climate scientist who studies both the science and politics of climate change. His scientific research revolves around climate feedbacks, in particular how water vapor and clouds act to amplify warming from the carbon dioxide that human activities emit. During the last year of the Clinton administration, he served as a senior policy analyst in the White House Office of Science and Technology Policy. Based on his research and policy experience, he has authored two books on climate change: this textbook and *The Science and Politics of Global Climate Change: A Guide to the Debate* (co-written with Edward Parson; second edition published in 2010). This textbook won the 2014 American Meteorological Society Louis J. Battan Author's Award. In recognition of his work on outreach, in 2011 he was named a Google Science Communication Fellow. He is presently a professor of atmospheric sciences at Texas A&M University. His educational background includes a B.A. in physics from Rice University and a Ph.D. in chemistry from Harvard University. He also undertook postdoctoral work at NASA's Goddard Space Flight Center and spent nine years on the research faculty of the University of Maryland.

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For Michael and Alex

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Contents

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Preface

Future generations may well view climate change as the defining issue of our time. The worst-case scenarios of climate change are truly terrible, but even middle-of-the-road scenarios portend environmental change without precedent for human society. When future generations look back on our time in charge of the planet, they will either cheer our foresight in dealing with this issue or curse our lack of it.

Yet despite the stakes, the world has done basically nothing to address this risk. The reasons are obvious: The threat of climate change is really a threat to future generations, not the present one, so actions taken by our generation will mostly benefit them and not us. Moreover, such actions may be expensive – reducing emissions means rebuilding our energy infrastructure, and we have no idea how much that will cost. In such a situation, it is easiest to do nothing and wait for disaster to strike – which is why dams are frequently built after the flood, not before. Nevertheless, pushing this problem off onto future generations is a poor strategy. The impacts of climate change are global and mainly irreversible; by the time we have unambiguous evidence that the climate is changing and its impacts are serious, it will be too late to avoid these serious impacts. The only hope that future generations have to avoid serious climate change is us.

I fully believe that the cornerstone of good policy is an electorate that is educated on the issues, and this belief provided me the motivation for writing this book. The goal of this book is to cover the human-induced climate change problem from stem to stern, covering not just the physics of climate change but also the economic, policy, and moral dimensions of the problem. This sets it apart from most other climate change books, which typically do not have a tight focus on human-induced climate change or do not cover the nonscience aspects of the problem.

Such complete coverage of the climate change problem is essential. The science clearly underlies all discussion of the problem, and an understanding of the science is essential to an understanding of why so many people are so worried about it. Climate change, however, is no longer just a scientific problem. Virtually every government in the world now accepts the reality of climate change, and the debate has, to a great extent, moved on to policy questions, including the economic and ethical issues. Thus, one must also understand nonscience aspects of the problem to be truly informed on this issue.

The first seven chapters of the book focus on the science of climate change. Chapter 1 defines the problem and provides definitions of weather, climate, and climate change. It also addresses an issue that most textbooks do not have to address: why the reader should believe this book as opposed to Web sites and other sources that give a completely different view of the climate problem. Chapter 2 explains the evidence that the Earth is warming. The evidence is so overwhelming that there is

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little argument anymore over this point, and my goal is for readers to come away from the chapter understanding this.

Chapter 3 covers the basic physics of electromagnetic radiation necessary to understand the climate. I use familiar examples in this chapter, such as glowing metal in a blacksmith shop and the incandescent light bulb, to help the reader understand these important concepts. In Chapter 4, a simple energy-balance climate model is derived. It is shown how this simple model successfully explains the Earth's climate as well as the climates of Mercury, Venus, and Mars. Chapter 5 covers the carbon cycle, and feedbacks, radiative forcing, and climate sensitivity are all discussed in Chapter 6. Finally, Chapter 7 explains why scientists are so confident that humans are to blame for the recent warming that the Earth has experienced.

Chapter 8 begins an inexorable shift from physics to nonscience issues. It discusses emissions scenarios and the social factors that control them, as well as what these scenarios mean for our climate over the next century. Chapter 9 covers the impacts of these changes on humans and on the world in which we live. Chapter 10 covers exponential math. Exponential growth is a key factor in almost all fields of science, as well as in real life. In this chapter, I cover the math of exponential growth and explain the concept of exponential discounting. I also touch briefly on the social cost of carbon.

Starting with Chapter 11, the discussion is entirely on the policy aspects of the problem. Chapter 11 discusses the three classes of responses to climate change, namely adaptation, mitigation, and geoengineering, and their advantages, disadvantages, and trade-offs. The most contentious arguments over climate change policy are over mitigation, and Chapter 12 discusses in detail the two main policies advanced to reduce emissions: carbon taxes and cap-and-trade systems.

Chapter 13 provides a brief history of climate science and a history of the political debate over this issue, including discussions of the United Nations' Framework Convention on Climate Change and the Kyoto Protocol. Finally, Chapter 14 pulls the last three chapters together by discussing how to decide which of our options we should adopt, particularly given the pervasive uncertainty in the problem.

Overall, it should be possible to cover each chapter in three hours of lecture. This makes it feasible to cover the entire book in one fifteen-week semester. At Texas A&M, the material in this book is being used in a one-semester class for nonscience majors that satisfies the university's science distribution requirement. Thus, it is appropriate for undergraduates with any academic background and at any point in their college career.

Any serious understanding of climate change must be quantitative. Therefore, the book assumes a knowledge of simple algebra. No higher math is required. The book also assumes no prior knowledge of any field of science, just an open mind and a willingness to learn. To aid in the student's development of a numerate understanding of the climate, there are quantitative questions at the end of many of the chapters, and every chapter also has more open-ended, qualitative questions. In addition, there is a chapter summary at the end of each chapter that reviews and summarizes the most important takeaway messages from the chapter. A list of important terms is also provided at the end of each chapter. I've put additional readings, video recordings of my lectures, and computer exercises on my Web site, www.andrewdessler.com.

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This is not an advocacy book. This is not to say that I do not have opinions. I do, and strong ones. I recognize, though, that shrill advocacy is frequently less effective than a dispassionate presentation of the facts. Thus, my strategy in this book is to simply explain the science and then lay out the possible solutions and trade-offs among them. I firmly believe that an unbiased assessment of the facts will bring the majority of people to see things the way I do: that climate change poses a serious risk and that we should therefore be heading off that risk by reducing our emissions of greenhouse gases.

Every year that our society does nothing to address climate change makes solving the problem both harder and more expensive. I am still optimistic, though, because problems often appear intractable at first. In the 1980s, as evidence mounted that industrial chemicals were depleting the ozone, it was not at all clear that we could avoid serious ozone depletion at a reasonable cost. The chemicals causing the ozone loss, namely chlorofluorocarbons, played an important role in our everyday life – in refrigeration, air conditioning, and many industrial processes – just like the main cause of climate change, fossil fuels, also plays an important role in our society. But the cleverness of humans prevailed. A substitute chemical was developed and it seamlessly and cheaply replaced the ozone-destroying halocarbons – at a cost so low that hardly anyone noticed when the substitution took place.

Solving the climate change problem will be harder than solving the ozone depletion problem – how much harder, no one knows. I am confident, though, that the ingenuity and creativeness of humans is such that we can solve this problem without damaging our standard of living. However, there is only one way to find out, and that is to try to do it.

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This book could not have been written without the incredible work of the climate science community. Ignored by many, demonized by some, I believe that future generations will look back and say, "They nailed it." I hope this book does justice to all of our hard work. The first edition of the book was written while I was on faculty development leave from Texas A&M University during Fall 2010. I thank the university for this support.

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