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# Global Climate Change: Turning Knowledge into Action

David E. Kitchen

University of Richmond, [dkitchen@richmond.edu](mailto:dkitchen@richmond.edu)

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# GLOBAL CLIMATE CHANGE

TURNING KNOWLEDGE INTO ACTION

**DAVID KITCHEN**

*University of Richmond*

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# Preface

*The danger is that global warming may become self-sustaining, if it has not done so already. The melting of the Arctic and Antarctic ice caps reduces the fraction of solar energy reflected back into space, and so increases the temperature further. Climate change may kill off the Amazon and other rain forests, and so eliminate one of the main ways in which carbon dioxide is removed from the atmosphere. The rise in sea temperature may trigger the release of large quantities of carbon dioxide, trapped as hydrates on the ocean floor. Both these phenomena would increase the greenhouse effect, and so global warming, further. We have to reverse global warming urgently, if we still can.*

**STEPHEN HAWKING, ABC News interview,  
Aug. 16, 2006**

**Every major scientific body in the world now accepts that human-caused global warming is almost certain to cause significant climate change before the end of the 21st century.** In 2007, The United Nations Intergovernmental Panel on Climate Change (IPCC) concluded, "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level."

Recent years have only deepened this concern. In 2012 many climate records were shattered, including a new minimum extent for summer ice in the Arctic and the expansive melting of surface ice on Greenland. In the United States, record temperatures started to dominate the eastern two-thirds of the nation by March, and 2012 became the all-time warmest year on record. These high temperatures created drought and wildfires that affected large parts of the nation and the largest hurricane on record hit the northeast coast of the United States late in the season, wreaking havoc in New York and New Jersey. As the year ended, record precipitation in parts of the Pacific Northwest delivered more rain in a few days than normally falls over the entire year. The physical evidence of global climate change is overwhelming, but a vociferous minority still refuses to believe that it has anything to do with human activity. For the average person who wants to understand global climate change and global warming, the debate is very confusing. Many of the facts and figures are complex and hard to understand, and different groups seem to interpret the same data in such different ways. Who should we believe?

The climate change debate has shown us that most scientists lack the skills necessary to communicate a complex and nuanced message to policymakers and the general public, especially when a determined minority is committed to undermining their message. Scientists, industrialists, politicians, and the general public are all valid stakeholders in this important debate, but when extreme views are given unwarranted attention, public confusion and dangerous inaction result.

The world does not have decades to settle outstanding questions about climate change before taking decisive action. Our action (or inaction) today will have very real social, economic, political, and environmental consequences in the future—and our children and grandchildren will hold us accountable.

As an Earth scientist, I understand that Earth's climate and ecosystems are subject to natural changes. The geological evidence is clear that sometime over the next 20,000 years, in the absence of human intervention, we will return to the frozen world that predated modern civilization. Much farther back in time, during the Cretaceous Period, it is equally clear that the world was so warm that deciduous forests stretched almost as far as the poles. Climate change can be natural, but today it is not entirely natural, and for those facing the risk of climate change, the question is almost irrelevant. If the climate is changing, for whatever reason, it places the lives of hundreds of thousands in peril and the welfare of millions more at risk. There is a major humanitarian crisis looming in the near future, and it demands earnest engagement and prudent action.

This book will help you reach an informed decision about global warming and climate change. Your decision will be based on a scientific foundation that separates fact from hypothesis and reason from conjecture. You will not find all the answers in these pages, but you should find yourself prepared to ask more of the right questions.

There is still hope. Your reading and research will illuminate many possible solutions. It is a fascinating journey from science through economics to psychology and politics. It is a path festooned with hyperbole and speculation, specious conjecture, and professional rivalry, and, at the end, the final destination is still not clear. This is as much a moral, ethical, economic, and political issue as it is a scientific issue, and progress depends on the active engagement of people and governments around the world. We take a serious risk by ignoring the early symptoms of climate change. Wishful inaction has a very poor historical record of success. Whatever the cost—and there will be a cost—we all need to ask ourselves "What are we willing to pay?"

## To the Student

This book examines what scientists know about global warming and climate change and considers political and economic solutions that will balance the competing needs of people around the world. It does not answer every question it raises, but it invites you to discover answers for yourself. The text contains brief *Checkpoints* to help you review the material as you read and short *Pause for Thought* sections that ask you to consider some topics in a broader context. By addressing *Critical Thinking* questions at the end of each chapter, you are challenged to think about each problem from the contrasting perspectives of different stakeholders in the debate. This can be achieved through role-play in class and online discussion, where you can examine the arguments proposed by each stakeholder group and analyze their discussions with a professor.

Throughout the book, you are encouraged to learn and apply the scientific method to your study. You are encouraged to think in terms of observing, recording, analyzing, and synthesizing data before developing and testing hypotheses. As with any other scientific debate, you must consider all the available facts about climate change issues before reaching a conclusion.

Climate change is an urgent concern that will impact your life and the lives of your children. I hope you will go out and get involved in the debate after reading this book because, whatever your political opinion, we need informed, engaged, and active citizens who are prepared to take up new positions of leadership in society. The cost of inappropriate action could be measured in trillions of dollars, tens of thousands of lost jobs, and many lost opportunities for economic development. It is equally true that the cost of inaction will be measured by the loss of millions of lives and by a level of environmental destruction and species extinction unseen for millions of years.

## To the Teacher

This book is an introductory text for students with a limited background in science, but it has enough content to be suitable for more advanced classes. Unlike most other textbooks on global climate change and global warming, the content does not only focus on the science but also includes extensive coverage of social, economic, political, and environmental aspects of climate change.

This book is optimal for classes where there is time for discussion and debate. Many stakeholders are involved in the climate debate, and many opportunities

exist for students to role-play and discuss climate change from different perspectives. Role-playing is a great way to understand why the subject is so divisive, and it encourages students to find answers through further reading, research, and collaborative interaction inside and outside class.

Throughout the book, but especially in Chapters 1 through 6, students are encouraged to learn and apply the scientific method to their study. The overall thrust of the text is to encourage critical thinking and analysis and leave students with a deeper understanding of how climate change will impact all levels of society. The data used in this book are the most up-to-date available at time of writing and publication and take into consideration the anticipated conclusions of the IPCC 5th Assessment Report.

## Chapter Features

Each chapter contains the following features and tools:

- **Learning Outcomes** at the start of each chapter help students focus on priority concepts and topics.
- **Checkpoint** questions integrated throughout chapter sections help students check their understanding as they read.
- **Pause for Thought** questions throughout the chapters ask students to consider topics in a broader context.
- **Summary** sections revisit the main chapter topics and Learning Outcomes.
- **Why Should We Care?** sections emphasize the most important chapter themes and present brief closing thoughts on the chapter topics.
- **Looking Ahead** sections provide a bridge to and preview of the next chapter's topics and themes.
- **Critical thinking Questions** help students to extend and apply their understanding of chapter topics and themes with higher-order activities that can be done alone or as group work.
- A list of **Key Terms** with references to chapter page numbers reinforce important vocabulary. The Key Terms are also defined in the back of book Glossary, and Flashcard versions of the Key Terms Glossary are available at the [www.mygeoscienceplace.com](http://www.mygeoscienceplace.com) website.
- **mygeoscienceplace.com** references at the end of each chapter encourage students to log in to the book website and extend learning with a variety of study resources, including Animations, Videos, MapMaster Interactive Maps, references, *In the News* RSS Feeds, quizzing, a Pearson eText version of the book, and more.

## Chapter Organization

The chapters of this book are grouped into five sections that address specific aspects of the climate change debate.

### Part One: The Evidence: Is This Normal?

Is the climate change we observe today part of a natural cycle or due to the emission of heat-trapping greenhouse gases by human activity?

**Chapter 1: So What's Up with the Weather?** begins with a discussion of the global climate change and global warming debate and introduces some important distinctions between climate and weather. Looking back into the deep history of climate change, it becomes clear that some climate change is normal and natural, but greenhouse gases released into the atmosphere by human activity have driven recent changes.

**Chapter 2: The Evidence: Observing Climate Change** investigates the physical evidence of global climate change. Data collected by satellite combined with direct measurements from the land and oceans show that the temperature of Earth is rising due to an imbalance between the amount of energy entering and leaving Earth's atmosphere. From this discussion, it becomes clear that we need to explore more of the science behind Earth's climate system if we want to differentiate between the natural and anthropogenic (human-made) factors that drive climate change.

### Part Two: Follow the Energy: Atmosphere, Oceans, and Climate

The energy that arrives on Earth from the Sun drives a complex climate machine, where a small change in just one part can have global consequences.

**Chapter 3: Earth's Climate System** focuses on the physical science of global warming and introduces students to complex interactions between the Sun, atmosphere, hydrosphere, lithosphere, cryosphere, and biosphere that determine how Earth's climate changes. The focus is on the flow of energy through Earth's climate system and how even small changes in the balance between incoming and outgoing energy can be amplified into significant changes in climate.

**Chapter 4: Understanding Weather and Climate** investigates how these changes in the energy content of Earth's climate system are translated into changes in regional climate and weather through the movement of mass and energy in the atmosphere and oceans.

### Part Three: Deep Time: A Long History of Natural Climate Change

The best way to predict the future behavior of any system is to understand how it has behaved in the past.

**Chapter 5: Revealing Ancient Climate** introduces the tools that scientists use to investigate the history of ancient climate change. These tools range from a simple hand lens that can be used to identify rocks and fossils in the field to highly specialized and expensive analytical equipment that delivers quantitative data on the nature of ancient climate.

**Chapter 6: Climate History** considers three periods of Earth history when the climate was so extreme that life on Earth nearly came to an end. This chapter also traces the evolution of Earth's climate from the hothouse of the Cretaceous world to the icehouse of today. The chapter covers the last 150,000 years of climate history in more detail, focuses on the origin of long and short-term climate cycles, and investigates the rate at which climate changes.

### Part Four: The Impact of Climate Change: From Polar Bears to Politics

Our knowledge of the risks associated with climate change grows each year, but turning this knowledge into effective political action has not been easy.

**Chapter 7: The Global Impact of Climate Change** investigates the physical and environmental impacts of climate change over the past 150 years and the possible impact of continued warming on future climate. The chapter focuses on the social and economic impact of projected climate change, using case studies from around the world to illustrate the many dimensions of the climate problem.

**Chapter 8: Politics and People** considers how growing awareness of climate change made global warming an important political issue around the world, culminating in the formation of the United Nations Framework Convention on Climate Change and the Kyoto Protocol. This chapter considers the history of the Kyoto Protocol, reflects on our inability to make further progress with it, and illustrates the role of major stakeholders in the climate debate. The chapter stresses the major social, political, economic, and ethical issues involved in the climate debate and will stimulate discussion about science, society, and the role of the media in determining public opinion.

## Part Five: Global Solutions: Managing the Crisis

At a time when global action to prevent climate change is more important than ever before, the world is increasingly distracted by an urgent demand for economic growth in the developing world and by the emergence of new geopolitical rivalries.

**Chapter 9: The Energy Crisis** introduces the energy crisis that is driven by population growth, and the urgent need to avoid damaging climate change. The chapter identifies energy poverty as a moral and ethical challenge for a world that wants to cut greenhouse gas emissions. Countries such as China and India still lag far behind the developed nations in per capita gross domestic product (GDP), and they need to make use of cheap and abundant coal reserves to generate enough power to support their economic growth. This chapter looks at all the major sources of energy available to meet this rising demand for energy, and considers how different priorities and changing government subsidies could encourage the more rapid development of clean, renewable energy technologies.

**Chapter 10: Turning Knowledge into Action** looks for ways to balance the competing priorities of economic growth and emissions reduction in a world where rapid population growth is expected to continue well into this century. The chapter considers whether it is possible to minimize greenhouse gas emissions without harming economic development and still prepare the world to adapt to the inevitable climate change that is already locked into Earth's climate system.

There is an immense amount of useful NASA, NOAA, and USGS original data available to students, and **Online Exercises** associated with this book were developed with the help of the National Council for Science and the Environment and a NASA Climate Change Education Program grant that is gratefully acknowledged. The book website at [www.mygeoscienceplace.com](http://www.mygeoscienceplace.com) includes these and a variety of other study resources, including Animations, Videos, MapMaster Interactive Maps, references, *In the News* RSS Feeds, quizzing, a Pearson eText version of the book, and more.

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David Kitchen  
*University of Richmond*  
[kitchenclimatebook@gmail.com](mailto:kitchenclimatebook@gmail.com)