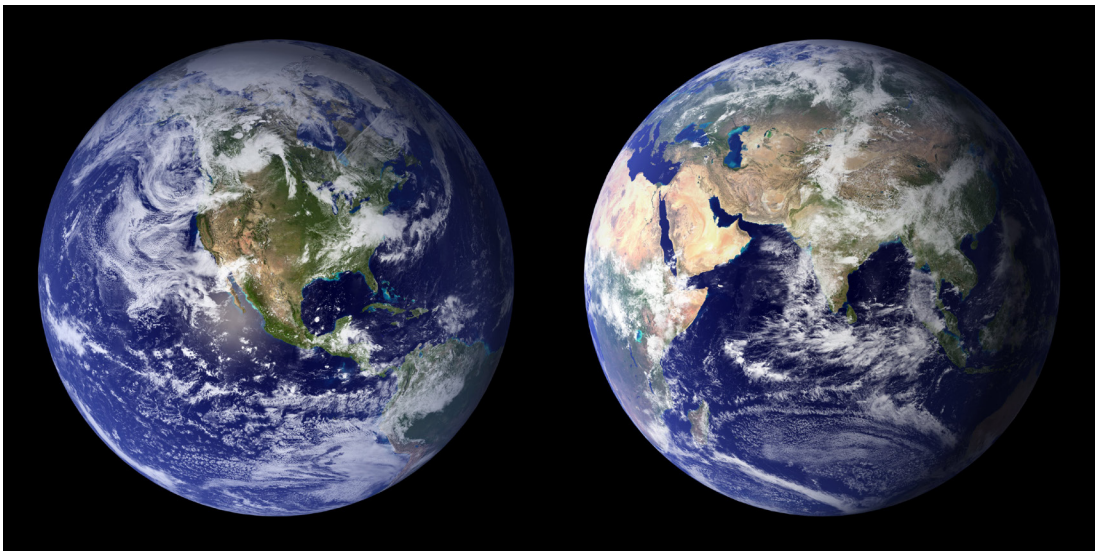
The Teacher-Friendly Guide™

to Climate Change



Edited by Ingrid H. H. Zabel, Don Duggan-Haas, & Robert M. Ross

Paleontological Research Institution
2017

ISBN 978-0-87710-519-0
Library of Congress no. 2017940300

PRI Special Publication no. 53

1259 Trumansburg Road
Ithaca, New York 14850 USA
priweb.org

First printing May 2017

This material is based upon work supported by the National Science Foundation under grant 1049033. Any opinions, findings, and conclusions or recommendations are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Layout and design by Jonathan R. Hendricks. The interactive online version of this *Teacher-Friendly Guide*™ (including downloadable pdfs) can be found at http://teacherfriendlyguide.org. Web version by Brian Gollands.

The *Teacher-Friendly Guide*™ series was originally conceived by Robert M. Ross and Warren D. Allmon.

Cite this book as:
Zabel, I. H. H., D. Duggan-Haas, and R. M. Ross (eds.), 2017, *The Teacher-Friendly Guide to Climate Change*. Paleontological Research Institution, Ithaca, New York, 284 pp.

Cite one chapter as (example):
Duggan-Haas, D., 2017, Why Teach about Climate Change? Pages 1–8, in: Zabel, I. H. H., D. Duggan-Haas, and R. M. Ross (eds.), 2016, *The Teacher-Friendly Guide to Climate Change*. Paleontological Research Institution, Ithaca, New York.

On the front cover: the "Blue Marble." Composite images produced by NASA in 2001-2002.

On the back cover: Atmospheric CO_2 concentration at Mauna Loa Observatory from 1958 to 2014 (NOAA).

Chapter 1: Why Teach About Climate Change?

Weather tells you what clothes to wear and climate tells you what clothes to own.[1] In most places, a look out the window can provide good insights into the local climate (*Box 1.1*). The Earth's climate is changing, and the changes are primarily the result of human activities. **Climate change**[2] is a real and serious problem for our environment and for humanity, and we can take actions that will make the problems less serious. These issues, which are expected to influence the lives of our students for decades to come, make climate change an important topic for the classroom.

climate change • *the current increase in the average surface temperature worldwide, caused by the buildup of greenhouse gases in the atmosphere, and the related changes to other aspects of climate such as precipitation patterns and storm strength. See also GLOBAL WARMING.*

As a teacher, your starting point in planning to teach about climate change depends upon a mixture of very local and personal factors. Questions to ask yourself as you move forward include:

- What do I know about climate?
- What do the learners I'm working with know about climate?
- What relevant misconceptions do my students and I hold?
- What district, state, and national standards do I need to attend to?
- How has climate shaped my community, my region, my country, and the world?
- How is climate change likely to affect things in the coming decades?
- How do I navigate the interconnected scientific, political, economic, and psychological factors connected to this incredibly complex problem?
- What are the most important facts and ideas for my students to know and understand about climate change?

This book will help you begin to answer these questions. Some of the questions, however, are richly complex and areas of ongoing research and affected by ongoing societal change, and thus will involve a lifetime of learning.

[1] In practice, climate scientists define climate based on weather averaged over a span of 30 years or more.

[2] In this volume we generally use the term "climate change" rather than the approximate synonym "global warming," since the climate change the Earth experiences involves more than just temperature increase. Technical scientific literature tends to use "climate change."

CHAPTER AUTHOR

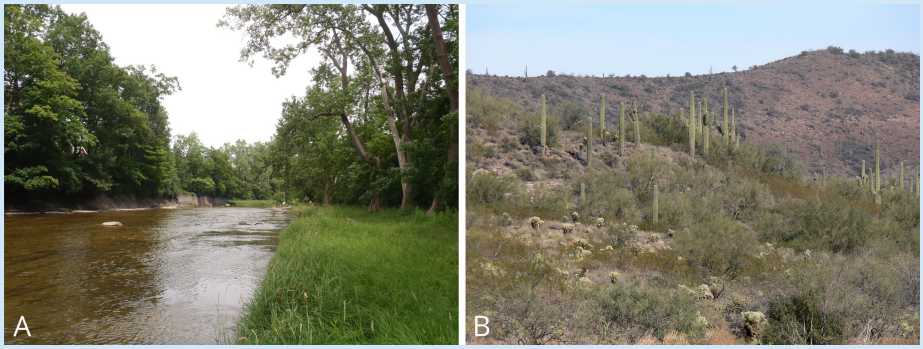
Don Duggan-Haas

Why Teach Climate Change?

Box 1.1: Climate out my window

Weather is the face of climate. Look out the nearest window to look it in the eye. How has the climate shaped what you see? What do the plant life, the types of buildings, the weather right now, the vehicles that you see, and the clothes people wear indicate about the climate?

Climate's fingerprints likely cover much of the view out your window. Animals, plants, people, and infrastructure are all adapted to the climate. Anytime of year, the area around Buffalo, New York looks very different from the area around Phoenix, Arizona. It doesn't need to be a winter day to be able to tell that a place probably gets below freezing in the winter. Even if it's raining, you might be able to identify a place that doesn't get much rain. What are climate's telltale signs?



(A) Deciduous forest (near Buffalo, NY). (B) A desert setting (near Phoenix, AZ). What visual clues tell you these places differ in their climates, even though the weather on the days these photographs were taken may have been fairly similar?

See Chapter 3: What is Climate? for a more detailed explanation of weather and climate.

1. Why Teaching About Climate Change Matters

> *"We basically have three choices: mitigation, adaptation, or suffering. We're going to do some of each. The question is what the mix is going to be. The more mitigation we do, the less adaptation will be required and the less suffering there will be."*
>
> *- John Holdren, 2007*

John Holdren was president of the American Association for the Advancement of Science when he made these remarks. His summation of the problem of climate change concisely describes the choices we face and does so without the level of pessimism sometimes included in such pronouncements. When it comes to climate change there *is* reason for pessimism, but there is also reason for hope. We have the capacity to act, and many of the actions we might take have benefits beyond climate. They also have the potential to save money in both the short and long term and to improve health and other measures of quality of life.

Why Teach Climate Change?

Figure 1.1: View of Earth from outside the Solar System, at a distance of about 6 billion kilometers, from the Voyager 1 spacecraft. The image was taken at the request of astronomer and educator Carl Sagan.

Scientific study of the size and age of the universe, and of the geological and fossil record on Earth, have helped us to understand that humanity is a blip in time on a speck in space[3] (*Figure 1.1*). Because everyone we know and love is encapsulated in this blip and speck, we treasure it deeply and want to preserve its richness, its diversity, and its life-supporting aspects. We are profoundly lucky to live *right here* and *right now*. We have a duty to preserve our luck for future generations. This does not speak to the absence or presence of forces beyond nature, but it does speak to the awesomeness and wonder of nature. Understanding the science of Earth systems may deepen our sense of wonder and of our responsibility for sharing it forward.

We educators are lucky to do what we do.

2. Science Learning, Its Application, and Politics

Effective and up-to-date teaching of the *science* of climate change is of paramount importance to good science education, but simply sharing scientifically accurate content is not the same as good teaching, and is not sufficient to build meaningful understandings. The science does make clear that the biggest challenges we will face in the coming decades will be related to climate, energy, water, and soil, which are inextricably linked with each other.

[3] In 1994 Carl Sagan and Ann Druyan published the book Pale Blue Dot: A Vision of the Human Future in Space. It focused on perspectives of Earth given our understanding of space.

1

Biases

Why Teach Climate Change?

Society depends upon a fairly stable climate, clean water, energy to power our way of life, and soil to provide the food we need.[4]

This book addresses the science of climate change, how to teach it, and climate change's interdisciplinary nature. And much more than that. All readers of this book are also well aware that climate change is a deeply socially and politically contentious issue, thus effective climate change teaching also requires an understanding of how people decide what is true and worth acting on. This means we must delve into the fields of sociology and psychology, to come to a deeper understanding of how our students think, why they think the way they do, and how to consider our own influences and biases.

There is an important philosophical distinction between educating about the science of climate change, and educating about the sorts of actions people can take to mitigate or adapt to climate change. The latter, in focusing on personal actions, may be perceived as encroaching upon political advocacy[5]. Effective science education, however, should be relevant to learners' lives, and climate change is a defining aspect of our current world. No matter what their political leaning, students will need to make lifestyle choices, make sense of the news, and vote; a scientifically literate citizenry will make better, more informed choices about science issues.

While teaching climate change we must, of course, be careful not to tread into political advocacy. Effective discourse and learning requires that students consider the classroom a safe place where their (and their families') world views will be respected. Working with other teachers may permit, however, exploring change from different social and economic perspectives. For example, students might explore how the implications of climate change will vary among professions (farmers, insurance brokers, military strategists, social workers, environmentalists, investors, or bankers), regions of the US, demographic setting (urban versus rural), and so on.

And we must communicate to our students that climate change is politically but *not scientifically* controversial. More than 97% of climate scientists agree that climate change is caused by human activity. Many in the general public believe scientists are divided, and that science teaching ought to address this (perceived) divide. There is uncertainty and disagreement about many of the finer details of climate change, but the overarching question of whether human-induced climate change is occurring is not questioned by a large percentage of climate scientists.

[4] Co-founder of Earth Day, Senator Gaylord Nelson noted, "The economy is a wholly owned subsidiary of the environment." An opportunity for cross-curriculum discussion with social studies, history, and economics could include mapping out how these environmental variables have influenced US and world history, and how they might influence the future.

[5] You can read a more in-depth review of these issues in Christopher Schlottmann's article "Climate Change and Education" in the book Canned Heat: Ethics and Politics of Global Climate Change (Ethics, Human Rights and Global Political Thought) (eds. Marcello Di Paola and Gianfranco Pellegrino), August 2014.

3. We All Have Biases

This book also gives attention to why many people have a difficult time accepting the scientific consensus behind climate change specifically, and, more generally, why perhaps everyone believes some refutable ideas. There are a wide range of reasons why people believe things that aren't true due to various kinds of **cognitive biases** and **logical fallacies**. Among the most important with respect to climate change are the closely related ideas of "**identity protective cognition**" and "motivated reasoning." These are the unintentional thought practices that help us preserve how we see the world and how we stay in good graces with people who think like we do—our "tribe."

There are obvious advantages to both fitting in with those we affiliate with and to maintaining internal consistency among our ways of thinking (worldview) about our community, the broader world, and ourselves. When new evidence threatens our worldview, we may find clever ways to discount the data to maintain our conceptions. When we cannot create explanations for data that seem to conflict with our views, we may instead compartmentalize our beliefs and thereby hold onto perceptions of the way the world works that are in conflict with one another.

Ultimately, we are likely to trust information from our own tribe, including solutions for maintaining our view in conflict with ample evidence. Determining the difference between reliable and unreliable information is a struggle that has persisted throughout human history and the amount of misinformation available related to both climate and energy is substantial. Problematic arguments (in climate change and elsewhere) stem from both sincere but incorrect information and explanations, and from intent to misinform; though we may blame people with different worldviews for the latter, the former is much more common. Responding to intentional falsehoods—lies—may require a different kind of response than falsehoods that are believed by the person making the argument.

See Chapter 10: Obstacles to Addressing Climate Change, for a more extensive discussion of cognitive issues.

4. Systems and Scales

To understand climate change deeply requires a systems perspective. You, the climate, and the Earth are all systems of systems. Understanding **systems**—the connections among individual components—is as important as understanding those components in isolation. Seeing things from a systems perspective requires some understanding of **feedback loops**, **tipping points**, the history of the system, and the ability to think across multiple scales (*Figure 1.2*). In terms of decision-making, it includes attention to the notion that advocating against a particular course of action often unintentionally carries advocacy for a course of action not considered.

The abstractions related to understanding very large and very small scales weakens our abilities to make sense of the science and mathematics of climate change and energy. For example, it is cognitively extremely challenging to

cognitive bias • *a holding on to incorrect thinking even in the presence of contrary information, because of beliefs or points of view one has.*

logical fallacy • *incorrect reasoning due to faulty logic.*

identity protective cognition • *a way of thinking that drives us to select the evidence that is consistent with the worldview of our social groups, sometimes leading us to believe certain things that are demonstrably false.*

system • *a combination of interacting parts whose interaction creates behaviors that might not occur if each part were isolated.*

feedback loop • *a repeating process where some of the output of a system becomes input as well.*

tipping point • *an event after which the behavior of a system changes or a phenomenon occurs. See also THRESHOLD.*

Why Teach Climate Change?

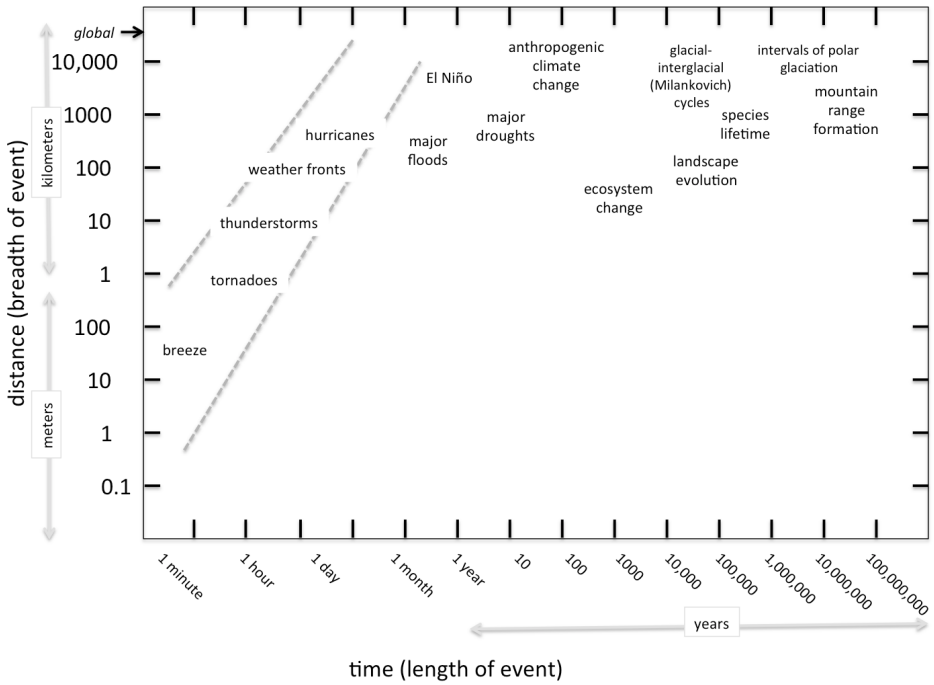


Figure 1.2: Weather and climate events in time and space, with other Earth system events for comparison, using logarithmic scales. On this plot events in time occur over a span of 15 orders of magnitude and in space over 7 orders of magnitude.

conceive of and compare large numbers such as a thousand, million, billion, and trillion. Time and space scales smaller and larger than common individual human experiences make it difficult to understand intuitively the importance of atmospheric greenhouse gases and the collective global impact of billions of individuals each influencing the environment in minor ways over decades. We ask our students and the general public to trust the idea that molecules they cannot see are real, that small percentages of the atmospheric composition nonetheless represent billions of trillions of molecules per liter, and that changes in the amount of these molecules over timescales stretching thousands to billions of years have influenced the history of Earth's climate.

Because systems and scales are inherently difficult concepts, we must find models and activities to help students past these hurdles. For these reasons and others we will need different approaches to education than traditional didactic and discipline-focused approaches.

5. Love and Beauty Will Persist

Engaging in the important work of climate and energy education can be profoundly depressing. Understanding the environmental challenges we face means confronting challenges that are on a scale perhaps never faced by humanity. Civilization and agriculture arose and came to thrive in a relatively stable climate, and it was the general stability of the climate that allowed the rise of civilizations. The climate is no longer as stable as it was, and is changing in some ways that will be difficult to adapt to and some that are difficult to predict. Teaching about it is also, however, an opportunity for full engagement in a purposeful life.

Why Teach Climate Change?

Figure 1.3: Aerial photograph taken in 1938 of land near Ithaca, NY and satellite photograph of the same area taken in recent years. This regrowth of forests is typical of many parts of the Northeastern US.

And though climate is changing, and we will almost certainly lose some wonderful environments, species, and human settlements, we won't lose it all, and to at least some degree new ones will also emerge. If the work gets you down, consider, for example, spending time in a natural environment. Many places that we consider of great beauty and value have been impacted by humans, such as in the widespread forests of the Northeastern US. Regrettably, almost none of this forest is original "old growth"—that was lost a few generations ago to humanity's hunger for fuel, building materials, and other land use. But in certain respects there is more nature in these areas than there was a century ago (*Figure 1.3*). And some of the lakes and rivers in the region are much cleaner than they were fifty years ago, as is the air of many cities. These are just a few examples of many stories in which increased scientific awareness, understanding, and change that people worked together to make have made a positive difference.

Why Teach Climate Change?

Resources

Books

Children's book author Lynne Cherry and photojournalist Gary Braasch offer an excellent introduction to climate change for middle grade students. Scientist detectives uncover mysteries of the Earth's climate history through mud cores, ice cores and tree rings and much more. The book is solution-focused and includes ways that kids can reduce their carbon footprints and emissions within their communities. Cherry, Lynne & Braasch, Gary. How We Know What We Know about Our Changing Climate: Scientists and Kids Explore Global Warming. Nevada City, CA: Dawn Publications, 2008.

Award-winning climate scientist Michael Mann and Pulitzer-Prize winning cartoonist Tom Toles offer rich insights into the science of climate change and how to communicate it with a sense of humor. Mann, Michael E., and Tom Toles. The Madhouse Effect: How Climate Change Denial Is Threatening Our Planet, Destroying Our Politics, and Driving Us Crazy. Columbia University Press, 2016.

Online Resources

The Skeptical Science website, https://www.skepticalscience.com/, offers a wide range of resources to investigate skepticism of climate skepticism.

The Debunking Handbook, https://skepticalscience.com/docs/Debunking_Handbook.pdf, is offered through Skeptical Science and carefully lays out strategies to avoid the backfire effect and more generally how to engage with people who disagree with the scientific consensus about human contributions to climate change.

Climate Change Evidence and Causes, The Royal Society and The National Academy of Sciences (2014), provides answers to frequently asked questions about climate change science: https://royalsociety.org/~/media/Royal_Society_Content/policy/projects/climate-evidence-causes/climate-change-evidence-causes.pdf.