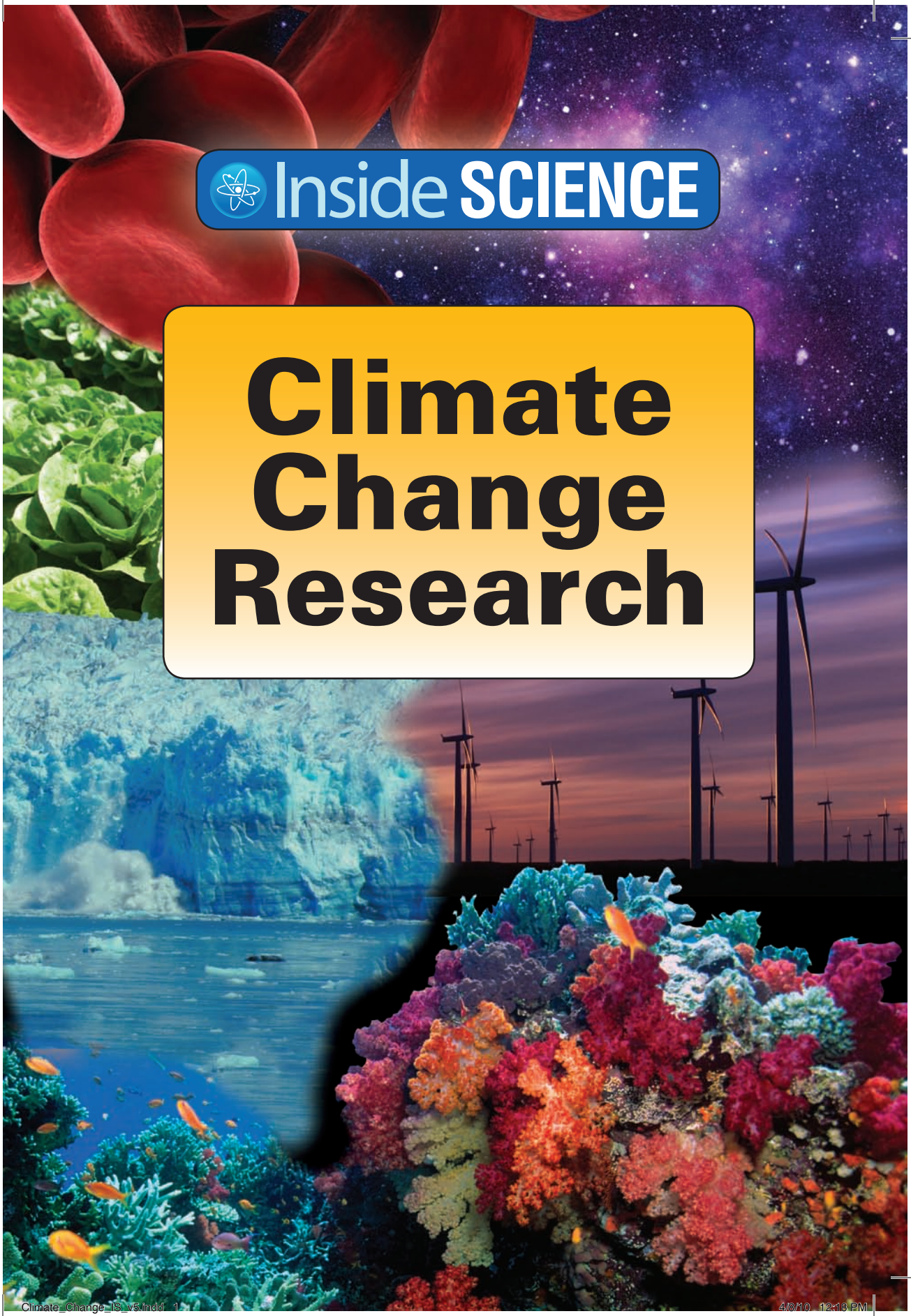

Climate_Change_IS_v5.indd 1 4/8/10 12:18 PM

Contents

Important Events in Climate Change

1896
Swedish chemist Svante Arrhenius makes the first connection between levels of carbon dioxide (CO_2) in the atmosphere and the earth's temperature. He was the first to suggest that CO_2 emissions from the burning of fossil fuels would cause global warming.

1990
The first IPCC report says the world has been warming and future warming seems likely. Some scientists disagree.

1988
Intergovernmental Panel on Climate Change (IPCC) is established.

1900 1930 1960 1990

1950s
U.S. oceanographer Roger Revelle begins studying the interaction between CO_2 and the earth's oceans.

1976
Chlorofluorocarbons (CFCs), methane, and nitrous oxide are identified as greenhouse gases.

1982
Strong global warming since mid-1970s is reported, with 1981 the warmest year on record.

1991
Mount Pinatubo erupts in the Philippines, dropping global temperatures by approximately 1°F (between 0.5° and 0.6°C) because of aerosol particulates in the atmosphere blocking some of the solar radiation from reaching the earth's surface.

IMPORTANT EVENTS

Climate_Change_IS_v5.indd 8 4/8/10 12:18 PM

1995
The second IPCC report detects a "signature" of human-caused greenhouse effect warming and declares that serious warming is likely in the coming century.

2001
The third IPCC report states boldly that global warming, unprecedented since the end of the last Ice Age, is very likely, with possible severe surprises for the future.

2005
2005 was the hottest year on record (as of 2010).

2006
A new generation of climate modeling is developed. The Flexible Modeling System incorporates weather, seasonal predictions, and human-made climate changes.

2007
The fourth IPCC report warns that serious effects of warming have become evident. The level of CO_2 in the atmosphere reaches 382 ppm. Mean global temperature (five-year average) is 58.1°F (14.5°C), the warmest in hundreds, perhaps thousands, of years.

1995 1998 2001 2004 2007

1997
The National Aeronautics and Space Administration launches the Tropical Rainfall Measuring Mission satellite, primarily for measuring precipitation in the tropics and subtropics.

2005
Kyoto treaty goes into effect, signed by all major industrial nations except the United States.

2008
The Jason-2 satellite is launched to measure sea level, wave heights, wind speed, and amounts of water vapor.

2009
The United Nations Climate Change Conference meets in Copenhagen, Denmark. The Copenhagen Accord, an agreement on reducing greenhouse gas emissions for the twenty-first century, is signed.

Climate_Change_IS_v5.indd 9 4/8/10 12:18 PM

were propelled into the stratosphere, the second layer of earth's atmosphere that extends from an altitude of 6 miles (10km) to an altitude of 31 miles (50km). Within a year of the eruption, the aerosol cloud covered the planet, reducing global temperatures. In 1992 and 1993 the average temperature in the Northern Hemisphere cooled 0.7º to 0.9ºF (0.4º to 0.5ºC). The most drastic temperature changes occurred during the summer of 1992. According to Jason Wolfe of the NASA Earth Observatory:

stratosphere

Second layer of the earth's atmosphere, extending from the troposphere to the mesosphere and characterized by the presence of ozone gas in the ozone layer and by temperatures that rise slightly with altitude.

> Following eruptions, these aerosol particles [containing sulfuric acid] can linger as long as three to four years in the stratosphere.
>
> Major eruptions alter the Earth's radiative [heat] balance because volcanic aerosol clouds absorb terrestrial radiation [heat from landmasses], and scatter a significant amount of the incoming solar radiation . . . that can last from two to three years following a volcanic eruption.[7]

Surprisingly, after the Pinatubo eruption, winter temperatures were higher than anticipated, which did not seem to fit with the overall global cooling caused by the volcano. According to a study conducted by professors from Rutgers University and researchers from the Max Planck Institute for Meteorology: "The pattern of winter warming following [Pinatubo] is practically identical to a pattern of winter surface temperature change caused by global warming."[8] The researchers add that human-made emissions can worsen the consequences of volcanic eruptions on the global climate system. Normally, individual volcanic eruptions do not change the earth's climate, but exceptionally massive ones—or an unusually large number of eruptions within a short period of time—can.

A massive ash plume rises from Mount St. Helens volcano in this hand-colored photograph. The volcano, located in Washington State, erupted in 1980. Volcanic activity is one of the most dramatic effects of the movement of tectonic plates.

Climate_Change_IS_v5.indd 20 4/8/10 12:18 PM

Climate_Change_IS_v5.indd 21 4/8/10 12:18 PM

Reading Climate Change in the Earth

Climate change cannot be measured without years, decades, or even centuries of accumulated data. Enormous amounts of data must be gathered, interpreted, cross-referenced, and compared. Scientists and experts in numerous fields can then study the data and formulate conclusions about how climate has changed and is continuing to change based on scientific fact, and not on speculation. To reach those conclusions, they study tree rings, sediment layers, coral rings, changes in the earth's sea levels, ice cores, and biomass—living and recently dead plant and animal matter.

biomass

The total mass of living matter that exists within a given environmental area, including all vegetation and animal life.

Numerous types of measuring devices are used around the world to gather this data. They range from a simple thermometer to highly advanced satellite imagery and are placed on land, beneath the sea, in the atmosphere, and in space. Once gathered, the climatic data is analyzed by a vast network of scientists, representing disciplines ranging from oceanography to meteorology to geology—each of which approach the task from a different perspective. According to Stephen K. Ewings, author of *Global Warming: What You Can Do:*

> The annual averages of the global mean sea level . . . are based on reconstructed sea level fields . . . tide gauge measurements [and] satellite altimetry. . . By combining these three different approaches, scientists are able to build a clear picture of rising sea level that would not be possible if each was presented independently.[12]

Each of these disciplines focuses on climate data in different ways. Only a combination of all the data can produce an accurate picture of how climate has changed since measurements began and what the

CHAPTER TWO

Climate_Change_IS_v5.indd 29 4/8/10 12:18 PM

A glaciologist extracts a cylindrical ice core obtained by drilling deep within the Antarctic ice sheet. By examining and analyzing the sample, scientists can develop a time line of changes in the earth's climate.

The deepest ice core ever studied was obtained during a joint project involving the United States and France at the Russian Vostok Station, near the South Geomagnetic Pole, at the center of the East Antarctic ice sheet. Drilling there reached an incredible depth of 2.25 miles (3.6km) in January 1998. The ice core taken from that depth was more than 400,000 years old. Other ice-drilling projects have included the Greenland Ice Core Project, which revealed rapid climate changes during the last glacial period (some 10,000 to 15,000 years ago); the North Greenland Ice Core Project, which was a multinational effort; and the West Antarctic Ice Sheet Divide, which was funded by the National Science Foundation.

Climate_Change_IS_v5.indd 39 4/8/10 12:18 PM

Source Notes

Introduction: Science in Action

1. Quoted in Mark Lynas, *Six Degrees: Our Future on a Hotter Planet*. Washington, DC: National Geographic Society, 2008, p. 133.
2. Lynas, *Six Degrees*, p. 133.

Chapter One: What Is Climate Change?

3. Shishmaref Erosion & Relocation Coalition, "We Are Worth Saving." www.shishmarefrelocation.com.
4. Gavin Schmidt and Joshua Wolfe, *Climate Change: Picturing the Science*. New York: Norton, 2009, p. 1.
5. Quoted in Schmidt and Wolfe, *Climate Change*, 2009, p. 135.
6. Cartographic Division, "The Earth's Fractured Surface," map supplement, *National Geographic*, April 1995.
7. Jason Wolfe, "Volcanoes & Climate Change," NASA Earth Observatory, September 5, 2000. http://earthobservatory.nasa.gov.
8. Quoted in Wolfe, "Volcanoes & Climate Change."
9. Tom O'Neill, "Changing Climate," map supplement, *National Geographic*, October 2007.
10. Quoted in Noel Wanner, "Sunspots: The Effects of Sunspots on the Earth's Climate," Exploratorium, 1998. www.exploratorium.edu.
11. Quoted in Schmidt and Wolfe, *Climate Change*, p. 137.

Chapter Two: Reading Climate Change in the Earth

12. Stephen K. Ewings, "Measuring Climate Change," Global Warming, Climate Change, Greenhouse Effect, 2007. www.global-greenhouse-warming.com.
13. European Space Agency, "ESA Investigates New Methods of Mapping Tropical Forest from Space," August 21, 2009. www.esa.int.
14. Keith Briffa, "Trees as Indicators of Climate Change," Lustia Dendrochronology Project, January 1, 2004. http://lustiag.pp.fi.

Climate_Change_IS_v5.indd 77 4/8/10 12:18 PM

Facts About Climate Change

Signs of Global Warming

- There are three essential numbers related to global warming: 280, 385, and 350. Until about 1850, earth's atmosphere contained 280 parts per million (ppm) of carbon dioxide. Today it contains 385 ppm. Leading scientists feel 350 ppm is the highest safe level for living things on earth.
- The average global temperature has climbed 1.4°F (0.8°C) since the late 1800s. Scientists estimate the average temperature will rise an additional 2.5 to 10.4°F (1.4° to 5.8°C) by 2100.
- The first decade of the twenty-first century was the hottest in 400 years. The 10 warmest years on record world-wide (as of 2010) occurred between 1998 and 2009.
- On September 12, 2008, the average minimum coverage of Arctic sea ice dropped to 1.74 million square miles (4.52 million sq. km). This was 860,000 square miles (2.24 million sq. km) below the 1979 to 2000 average minimum.
- Montana's Glacier National Park has only 26 glaciers now, and all of them are shrinking in size. In 1850, at the end of the Little Ice Age, there were 150.
- In 1998, the forth-hottest year on record (as of 2010), 16 percent of all coral reefs died from warmer ocean temperatures.
- The number of Category 4 and 5 hurricanes has doubled over the past 30 years. A record of four Category 5 hurricanes formed in 2005. In 2007 two Category 5 hurricanes made landfall in Central America, another seasonal record.

Effects of Climate Change in the Twenty-First Century

- Greenhouse gases remain in the atmosphere for a long time, so even if emissions ceased today, global warming would continue for decades.

Climate_Change_IS_v5.indd 81 4/8/10 12:18 PM

Related Organizations

Center for the Study of Carbon Dioxide and Global Change

PO Box 25697
Tempe, AZ 85285-5697
phone: (480) 966-3719
Web site: www.co2science.org

The Center for the Study of Carbon Dioxide and Global Change publishes a weekly online magazine, *CO_2 Science*, with editorials and reviews of current publications, including scientific journals, books, and other educational materials. The group's stated goal is to separate fantasy from reality in the climate change debate.

The Climate Project

2100 West End Ave., Suite 600
Nashville, TN 37203
phone: (615) 327-7577
e-mail: info@theclimateproject.org
Web site: www.theclimateproject.org

The Climate Project is a nonprofit organization that consists of more than 3,000 diverse and dedicated volunteers worldwide who have been personally trained by former U.S. vice president and Nobel laureate Al Gore to educate the public and to raise awareness about climate change.

The Earth Lab Foundation

625 Fourth Ave., #200
Kirkland, WA 98033
phone: (425) 284-4265
fax: (425) 294-4266
e-mail: info@earthlab.com
Web site: www.earthlabfoundation.org

Climate_Change_IS_v5.indd 84 4/8/10 12:18 PM

For Further Research

Books

David Archer, *The Long Thaw: How Humans Are Changing the Next 100,000 Years of Earth's Climate*. Princeton, NJ: Princeton University Press, 2009.

Kirstin Dow and Thomas E. Downing, *The Atlas of Climate Change: Mapping the World's Greatest Challenge*. Berkeley and Los Angeles: University of California Press, 2007.

Al Gore, *An Inconvenient Truth: The Planetary Emergency of Global Warming and What We Can Do About It*. New York: Rodale, 2006.

Mark Lynas, *Six Degrees: Our Future on a Hotter Planet*. Washington DC: National Geographic Society, 2008.

Gavin Schmidt and Joshua Wolfe, *Climate Change: Picturing the Science*. New York: Norton, 2009.

Web Sites

Climate Change, Environmental Protection Agency (www.epa.gov/climatechange). The Environmental Protection Agency's Climate Change site offers comprehensive information on the issue of climate change in a way that is accessible and meaningful to all parts of society—communities, individuals, businesses, states and localities, and governments.

Exploratorium (www.exploratorium.edu). At this Web site, students can explore scientific data relating to the atmosphere, the oceans, the areas covered by ice and snow, and the living organisms in all these domains. Students will also get a sense of how scientists study natural phenomena—how researchers gather evidence, test theories, and come to conclusions.

The Nature Conservancy: Climate Change (www.nature.org/initiatives/climatechange). Information on how climate change affects wildlife.

New Scientist: Climate Change (www.newscientist.com/topic/climate-change). What is climate change, how do we know it is happening,

Climate_Change_IS_v5.indd 87 4/8/10 12:18 PM

Index

Climate_Change_IS_v5.indd 89 4/8/10 12:18 PM