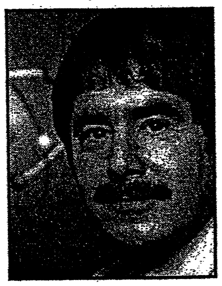

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Guidebook Contents

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Cover image: Earth Eclipsing the Sun.
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Lecture One
Is Earth Warming?

Scope: Earth's climate is changing. Recent decades have seen a steep rise in global temperatures. Thermometer-based temperature records show a pattern of temperature variation that spans 150 years, from the mid-19th century to the present. What does this pattern tell us? How do we take our planet's temperature? This lecture explores these scientific questions and shows how climate scientists arrive at values for global temperatures.

Questions about climate change and its causes are squarely in the realm of science. Questions of what to do about climate change are in the realm of public policy. With climate change, issues of science, policy, and political opinion often become muddled. This course is about science, and what's presented here is based on solid scientific evidence developed through the course of research, peer-reviewed publication, and the emergence of scientific consensus. Science can help guide policy, but science alone can't dictate the best policy decisions. This first lecture includes an introduction to the course that clearly distinguishes the realms of science and policy.

Outline

I. This course deals with *climate*, not *weather*. *Climate* refers to long-term trends; *weather*, to short-term variations in atmospheric conditions. We jump right in with a look at Earth's average temperature over the past 150 years.

A. There will be lots of graphs in this course! My obligation is to explain clearly what each graph shows, what the axes are, what units are used, where the data come from, and what the uncertainties are.

B. We begin by looking at global average temperatures since 1860, expressed as deviations from the 1961–1990 average temperature. See Figure 1.

1. Temperatures are in degrees Celsius, used almost universally in science; 1 degree Celsius is 1.8 degrees Fahrenheit.
2. It is easier to measure temperature changes accurately than to measure temperature itself; thus, climate trends are often shown as deviations.
3. Data are from thermometers; more on this shortly.
4. Temperature deviations in the early decades are good to about ±0.2°C; by 1950, this uncertainty in the global temperature record drops to roughly ±0.05°C.

C. The 150-year temperature record shows a lot of variation but can be divided into several major sections:

1. A roughly constant average temperature in the late 19th century.
2. A rise in the early 20th century.
3. A leveling off or slight decline in the mid-20th century.
4. A steep rise in the final decades of the 20th century, continuing into the 21st century.

D. What causes this pattern of temperature variation, and how typical is it for our planet? That's a major theme of this course, but here's a quick summary:

1. Variations in the early part of the 150-year temperature record are largely explainable by natural variations within the climate system, by volcanic eruptions, and by variations in the Sun's energy output.
2. Variations in recent decades are largely the result of human activities, predominantly but not exclusively the burning of fossil fuels. The second half of the course will detail the evidence for a human impact on Earth's climate.

E. So far, we've discussed only the global average temperature. Regional temperatures show considerably greater variability, and land temperatures have risen more than ocean temperatures. The temperature increase has also been greater at high latitudes. (Take another look at Figure 1, which also shows Northern Hemisphere land temperatures.)

F. The bottom line is that Earth's average temperature has risen about 0.65°C since the start of the 20th century, with nearly all regions of the globe experiencing a temperature increase. This may not seem like much, but we'll see in subsequent lectures why even such a small rise in the global average temperature is climatologically significant.

II. How do we take Earth's temperature?

A. A single thermometer won't do! But since the mid-19th century, there have been enough data available from thermometer-based measurements to compute an average global temperature at Earth's surface. Data sources include:

1. Air temperatures from land-based weather stations (surface air temperature, or SAT), with thermometers usually placed 1–2 meters above the surface.
2. Marine air temperature (MAT), taken just above the sea surface from ships and buoys.
3. Sea-surface water temperature (SST), taken from ships.

B. All these measurements require corrections to ensure accurate global averages:

1. Corrections for instrumentation and placement.

Readings:

Glantz, Michael. *Climate Aj* 2003. A general-audience di social scientist who is the fo Impacts Group at the Nation

Harvey, L. D. D. *Global Wa* Hall, 2000. A thorough expl Doesn't spare the math but r reader is free to skip.

Houghton, John. *Global Wa* Cambridge University Press, of climate change by a forme Group of the Intergovernmer

Intergovernmental Panel on ((IPCC 2005). Cambridge: Ca suggesting that CCS could pl effects of fossil-fuel combust http://www.ipcc.ch.

———. *Climate Change 20(* Cambridge University Press, third assessment report—a cc at the turn of the 21st century. background information. Als

———. *Climate Change 200* Cambridge: Cambridge Univ IPCC's fourth assessment rep climate science in the early 2

Lovins, Amory B., E. K. Datt *Winning the Oil Endgame: In* Snowmass, CO: Rocky Moun documented report showing h climate-changing fossil fuels. http://www.oilendgame.com.

Pacala, Stephen, and Robert S Climate Problem for the Next 305 (13 August 2004), pp. 96 might break the seemingly ins pieces.

Parmesan, Camille, and Gary Climate Change Impacts Acro

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1 watt is 1 joule
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2. Corrections for water-temperature sampling.
3. Corrections for the *urban heat island effect.*

III. Now let's turn to a discussion of science, policy, and this course.

A. Science deals with the facts and governing principles of physical reality. Science is never 100% certain, but neither is anything else. Science develops through observation, experimentation, theorizing, and publication in open, peer-reviewed literature. Scientific consensus emerges when the results of observation and experiments overwhelmingly support a given idea or hypothesis. Science can be quite certain of "big picture" ideas without being certain of every detail. Such is the case with the state of climate science today.

B. Public policy involves society's decisions about what to do in the face of many factors—including the findings of science. Science can guide policy by providing factual information and projections of future conditions, but science alone can't determine the right policy decisions.

C. Ongoing changes in Earth's climate have significant implications for public policy. This situation has led to a muddling of science and policy questions in the minds of the public and of many policymakers. This course is about climate science, not politics or policy debates.

D. The two halves of this course deal with:

1. Our basic scientific understanding of Earth's climate system, including a look at past climates and the principles that determine climate.
2. Our evidence for a human impact on climate, our understanding of the causes of that impact, and the implications for future climate and for human use of energy.

Suggested Reading:

Houghton, chapter 1.

Wolfson, chapter 14, section 14.1 (skip "Going Further Back").

Going Deeper:

Harvey, chapter 5.

Intergovernmental Panel on Climate Change (IPCC) 4, chapter 3, section 2.

Web Sites to Visit:

Climatic Research Unit, University of East Anglia, http://www.cru.uea.ac.uk/. Probably the most authoritative source for the instrumental temperature record discussed in this lecture.

Questions to Consider:

1. Can you tell if the 150-year global temperature record discussed in this lecture represents anything unusual in the history of Earth's climate? If not, what additional information would you need to decide whether or not recent climate change is unusual?
2. Describe two of the difficulties in arriving at an accurate value for the global average temperature and tell how scientists correct for these difficulties.

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